Fortescue Marsh Feral Cat Baiting Program

(Christmas Creek Water Management Scheme)

Year 3

Annual Report

November 2014

Department of Parks and Wildlife

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Front cover images: Feral cat FMGm13 at treatment camera location C7 prior to baiting.

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Permits obtained to conduct this work:

- The capture and radio collaring of feral cats was conducted under Department of Parks and Wildlife Animal Ethics Committee permit AEC2012/41
- The Australian Pesticides and Veterinary Medicines Authority issued PER14102ver2 allowing the use of the unregistered bait product on Fortescue Marsh

Contents

Summary

Investigations into the use of the toxic *Eradicat*® cat bait to control the feral cat (*Felis catus)* is being undertaken at a number of locations in Western Australia under the Australian Pesticides and Veterinary Medicines Authority research permit PER14102. The work being conducted on the Fortescue Marsh is being implemented in an adaptive framework to determine the most efficient and cost effective method to target feral cats in this environment.

Fortescue Metals Group is aiming to reduce feral cat abundance on the Fortescue Marsh as part of the environmental conditions of the Environmental Protection and Biodiversity Conservation Act (EPBC Act). In doing so, provide respite to the native fauna of this environment, particular the threatened species listed under the Act. This five-year program began in 2012 with monitoring of baiting efficacy through a camera surveillance and radio-telemetry collars.

In 2014, *Eradicat*® baits were aerially distributed over a 920 km² area of the Fortescue Marsh in June. Fifteen feral cats trapped within the baited area were monitored with radio-collars and the probability of occupancy was assessed prior to, and following baiting using remote surveillance cameras at 56 treatment and 30 control sites.

Eradicat® baiting of the Fortescue Marsh in 2014 resulted in a highly effective knock-down of feral cats. Significant mortality (85%) of radio-collared cats was achieved within three weeks of aerial bait delivery. This impact was supported by occupancy modelling using remote camera data, which also demonstrated a highly significant effect of baiting in the treatment cell when compared to a control. Models were run with previously collected camera data and methods which confirmed the significance of the baiting treatment in 2012 and 2013, and also the value of remote cameras for occupancy modelling to be used as a method of monitoring baiting efficacy.

Focussed effort on detecting EPBC listed species including the Bilby, Mulgara and Night Parrot were not successful.

1 Background

The Department of Parks and Wildlife is implementing Fortescue Metals Group's Fortescue Marsh Baiting Plan (FMG, 2011) to satisfy Condition 16 of the EPBC Act approval 2010/5706, which is aimed at improving protection and long-term conservation of EPBC Act listed species in the Fortescue Marsh. The baiting program is meeting specific targets for Fortescue (loc. cit) which include:

a) comprehensive landscape scale feral cat baiting program (across a minimum 150,000ha) on the area proposed as conservation estate on the Fortescue Marsh;
b) a baiting program developed with expert advice , defining intensity and frequency of baiting in order to maximise the benefits of removal of feral cats to EPBC Act listed threatened and migratory species;
c) monitoring of feral cat populations and EPBC Act listed threatened and migratory species.

The Fortescue Marsh is currently covered by a number of pastoral leases. In July 2015 portions of the leases will be relinquished and returned to the State as Unallocated Crown land (UCL). This UCL will be managed by Parks and Wildlife for conservation purposes.

Landscape scale baiting of feral cats is still in an experimental phase (this project covered under Experimental Permit issued by the Australian Pesticides and Veterinary Medicines Authority No. PER14102). The delivery of this project was designed in an adaptive management framework, and with consideration of similar projects managed by the Department of Parks and Wildlife elsewhere in Western Australia in order to maximise learning outcomes.

The baiting program commenced in 2012 with a total area of 838 km^2 baited with the feral cat bait *Eradicat*®. In 2013 the same area as 2012 was baited again, and in 2014 an area of 920 km^2 further north was baited.

1.1 Site Description

The Fortescue Marsh is an extensive intermittent wetland situated at 22^0 26' 44" S, 119^0 26' 38" E, in the Pilbara region of Western Australia. It is located in the Pilbara Craton (Hamersley Basin) and has the form of a broad valley or small plain that lies between the Chichester and Hamersley Ranges. The Marsh occupies an area of approximately 1,000 km^2 when in flood (DEWHA 2008b) (Figure 1).

McKenzie *et al*. (2009) provide a succinct summary of the vegetation, climate and physiographic environment of the Pilbara as it relates to the biota. Climatic conditions in the Pilbara are influenced by tropical cyclone systems that predominately occur between January and March. The majority of rainfall received in the Pilbara is associated with these systems. The long-term average annual rainfall is 312 mm at Newman (Fortescue 2009). Temperatures are high, with summer maxima typically 35–40 °C and winter maxima 22–30°C.

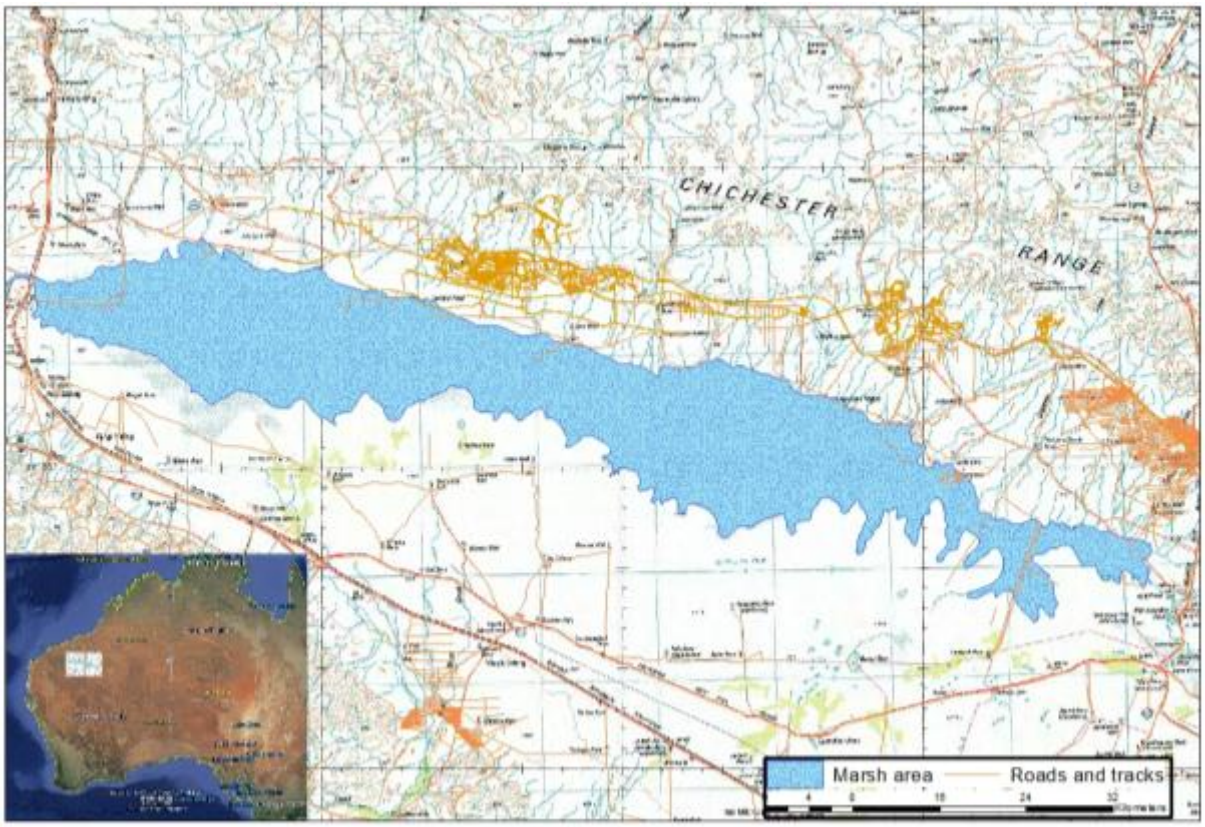


Figure 1. Location and regional setting of the Fortescue Marsh

Botanical surveys conducted for Fortescue's Cloud Break Iron Ore Project Public Environmental Review included descriptions of the fringing vegetation of the Marsh. Five distinct vegetation communities identified by Mattiske Consulting Services (2005), (cited in Fortescue 2009), have been used to describe the vegetation at each monitoring site. These include the following vegetation descriptions:

1. Low woodland to low open forest which occurs within the creek and drainage lines leading into the Marsh;
2. Hummock grassland of *Triodia angusta* with patches of *Acacia*;
3. Low halophytic shrubland of *Tecticornia auriculata* and *T. indica* with associated chenopods. This vegetation community adjoins the low woodland to low open forest;
4. Low halophytic shrubland of *T. auriculata*, *T. indica*, *T. halocnemoides* with patches of *Frankenia* species. This is the predominant vegetation community along the fringes of the Marsh; and
5. Hummock grassland of *Triodia angusta* with patches of *Acacia victoriae* over *Atriplex codonocarpa* and mixed chenopods and Poaceae species.

1.2 Planned Actions and Achievements

The Proposed Management Plan for Baiting Feral Cats on the Fortescue Marsh (Christmas Creek Water Management Scheme), 2011 suggested an indicative works plan (Table 1) which was approved by the Commonwealth as part of Fortescue Metals Group's offset conditions. This plan has been the basis for the annual works program that has been adapted according to contemporary findings.

Table 1 Works program as per Algar et al (2011) with timings and achievements for 2014

Activity	*Action*	*Completion Date*	*Achievement*
Planning	• Baiting approvals and Risk assessment. • Department of Parks and Wildlife invoice Fortescue for funding to support current years baiting program. • Evidence of Fortescue funding support for the plan provided to Department of Parks and Wildlife.	• 1 May • 1 Feb • 15 Feb	• Risk Assessments completed • Funds transferred • Liaison through email
Stakeholder liaison	• Consent and indemnity letters	• 1 May	• Completed
Monitoring and survey program	• Select and establish treatment and control sites. • Set up camera trap monitoring stations. • Complete cat trapping and radio-collaring. • Establish surveyed trapping grids for Northern Quoll and Mulgara. • Complete Northern Quoll radio-collar monitoring. • Service monitoring trap stations	• 5 – 22 May • 5 – 22 May • 5 – 22 May • 11 – 16 Jun (Mulgara and Bilby cameras) • Not applicable • 11 – 16 Jun	• 56 and 30 cameras established as Treatment and Control Cells respectively • 16 feral cats captured, 15 collared • 5 cameras set at burrows in sand dunes • Cameras turned off and lures removed
Monitoring flights	• Conduct monitoring flights/ground traverses to locate and ensure all radio-collared animals are alive prior to bait delivery.	• 13 Jun	• 11/14 collars detected. 3 cats deceased.

Activity	*Action*	*Completion Date*	*Achievement*
Bait delivery	• Bait preparation	• 24 & 25 Jun	• 45,950 baits delivered across 92,000 ha over two days
Bird surveys	• Set up program and conduct surveys. • Service monitoring trap stations.	• 16 June – 4 Jul	• 18 Automated Recording Units deployed
Monitoring flights	• Conduct monitoring flights/ground traverses to ensure the status of collard animal • Radio collar retrieval • Bird surveys	• 29 Jul • 29 July • 5 May – 1 Aug	• 7/10 collar located and retrieved. • See bird list in Appendix
Complete Program	• Complete bird surveys • Retrieve cameras	• 5 May – 1 Aug • 5 May – 1 Aug	• 17/18 recorded information • 3761 camera trap-nights
Program Evaluation	• Baiting efficacy results review • Activity and patterns of home range use • Review of monitoring data for radio-collared Northern Quolls and Mulgara	• Sept – Oct • Sept – Oct • Not applicable	• This report • This report
Reporting to FMG	• Report prepared on previous 12 months of activity and submitted to Fortescue	• This report	
Report to DSEWPaC	• Annual report of results from implementation of the plan and monitoring effectiveness submitted by Fortescue to Department of the Environment. • Annual monitoring results published on the web by Fortescue.	• This report • To be completed by Fortescue	

A review of the 2012 and 2013 operations resulted in the following recommendations being agreed to for the 2014 program:

- The delivery of baits should be conducted no later than the last week June/first week of July each year, and remain flexible based on prevailing weather conditions;
- The use of remote cameras has proved invaluable, and in 2014 this will be repeated with a control area maintained to improve robustness of models;
- Feral cats will continue to be radio-collared with GPS collars to increase information on efficacy of baiting and habitat use, with efforts made to target animals occupying habitat further away from existing infrastructure.

2 Method

2.1 Timing

The field work for this project is based on the optimal time for baiting, that is, when feral cats are most likely to encounter and consume a bait. This has been determined as mid-winter to minimise the chance of rainfall and to reduce the loss of baits to non-target reptiles. With this in mind, trapping and collaring of feral cats and establishing the camera surveillance grid needs to occur in autumn.

2.2 Study Area

In 2014, the study area has remained the same as per Tiller *et al*. 2012. Although not recorded directly on the Marsh, high rainfalls in summer and again in early autumn resulted in the presence of surface water in May and through the winter. This limited access to the south and the east of the Marsh as per the conditions in 2012.

The design of a treatment cell, where Eradicat baits would be distributed and a control cell (where no baits are distributed) was again employed in 2014.

2.2.1 Treatment Cell

The designated area for baiting was determined in the first year of the study based on the understanding that variable water levels would impact on the actual area baited each year. The overall treatment cell encompasses an area of 1,240 km² (Figure 2) and is located at the eastern end of the study area, where the Marsh is at its widest.

In 2014, working with limited inundation information gathered from a reconnaissance in early May, an area of 1,000 km² was earmarked as the years' bait cell. This was with the understanding that the true area available for baiting would be smaller due to the large pools of water present but the final area could only be determined once the baiting flight was conducted. The overall area to be baited in 2014 would be further north, and cover a greater area than 2012 and 2013 (850 km²).

2.2.2 Control Cell

The Control cell encompasses an area of 436 km². Access to the area that had previously been used as the control was less affected by surface water, ensuring the cell used in 2013 could be re-used (Figure 2). To enable independence between the treatment and control sites, a buffer of a minimum 5 km was used to separate treatment and control monitoring sites. This distance is estimated to be at least one average feral cat home range (D. Algar unpub. data)

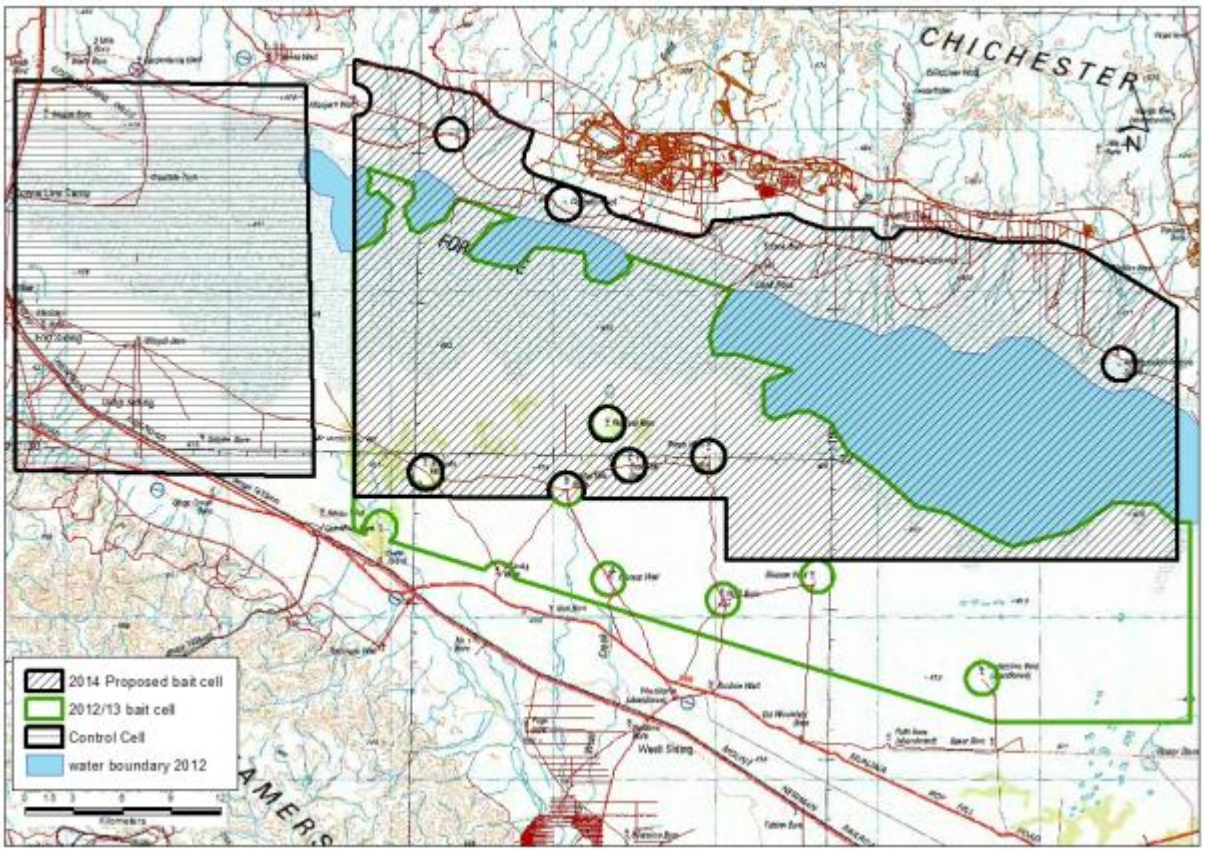


Figure 2 The survey area for 2014 (black) overlaid with the 2012/13 treatment cell (green) and where water was mapped after cyclonic rainfalls in 2012. The circles are bait exclusion areas around active water bores and well.

2.3 Weather & Climatic Influences

There is limited access to accurate climatic data for the Marsh. The nearest weather station with reasonable information is the Cloudbreak gauge that is located within the mining footprint. This data is not available for public access and has been supplied by the Environmental Division of Fortescue Metals Group.

Meteorological data for this study is focussed around the time of baiting as precipitation (>5 mm) and relative humidity (>60%) can impact on the effectiveness of bait uptake due to reduced palatability and toxicity of the *Eradicat*® baits.

In late October 2013, a lightning strike started a wildfire 50 km west of the Cloudbreak mining camp. The fire burned over four days and burnt out over 14,500 ha adjoining the camp. Studies have shown that intense fire can influence habitat use by feral cats (Johnson 2012, McGregor 2014). No study sites in Fortescue Marsh were burnt, however feral cats movement patterns may alter in 2015 as a result of the fire.

2.4 Baits and Baiting

The feral cat baits (*Eradicat*®) used in the Fortescue Marsh baiting program are manufactured at the Department of Parks and Wildlife's Bait Manufacturing Facility at Harvey, Western Australia. The bait is similar to a chipolata sausage in appearance, approximately 20g wet-weight, dried to 15g, blanched and then frozen. This bait is composed of 70% kangaroo meat mince, 20% chicken fat and 10% digest and flavour enhancers (Patent No. AU 781829). Toxic feral cat baits are dosed at 4.5mg of sodium fluoro-acetate (compound 1080) per bait. All feral cat baits are sprayed during

the sweating process with an ant deterrent compound (Coopex®) at a concentration of 12.5g l^{-1} as per the manufacturer's instructions. This process is aimed at preventing bait degradation by ant attack and enhancing acceptance of baits to cats by limiting the physical presence of ants on and around the bait.

Baiting operations were conducted under an 'Experimental Permit' (Permit No. PER14102ver2) issued by the Australian Pesticides and Veterinary Medicines Authority and governed by the 'Code of Practice on the Use and Management of 1080' (Health Department, Western Australia) and associated '1080 Baiting Risk Assessment'.

Frozen baits were transported to the Munjina airstrip in the dedicated Western Shield bait truck. On the morning of 24 June, 45,950 baits were arranged on established bait racks at the Munjina airstrip such that they were in direct sunlight to thaw and 'sweat'. This process causes the oils and lipid-soluble digest material to exude from the surface of the bait making the bait more attractive to feral cats. A Beechcraft Baron B58 twin-engine aircraft (Thunderbird Aero Service, Western Australia) fitted with computerised, GPS-linked equipment was used to deploy the baits to ensure accurate application. A series of panel lights indicates to the bombardier when to release the baits, with a GPS-linked mechanism used to prevent the application of baits outside the programmed bait cell. The location of the aircraft was logged each time baits were released. Fifty baits per km^2 are distribution through a carousel to give an approximate 200 m long by 40 m wide bait swathe.

2.5 Feral Cats

As with previous years, a two-pronged approach to measuring baiting efficacy was implemented. Firstly a measure of direct mortality was obtained from radio-collared cats, and secondly a measure of site-occupancy indices of pre- and post-baiting was obtained through remote-camera trapping.

Genetic analysis can assist with identifying the relationship of animals located in areas with significant infrastructure to the feral cat population within the Marsh. Although beyond the scope of the annual program, samples were (and will continue to be) collected and analysed in the final year of the program.

2.5.1 Trapping and GPS/VHS Collaring

Feral cat trapping was conducted under ethics approval AEC2012/41. The trapping technique involved the use of padded leg-hold traps Victor 'Soft Catch'® traps №3 (Woodstream Corp., Lititz, Pa.; U.S.A.) with cat faeces used as the attractant. Trap sets were parallel to tracks along the verge every 0.5 km. Open-ended trap sets were employed with two traps positioned lengthwise (adjoining springs touching) and vegetation/sticks used as a barrier along the trap sides. Analysis of the 2013 post-bait camera data assisted with determining the area for trapping. Two trap transects were established, one on the north of the Marsh and the second on the south side of the Marsh. (Figure 3)

Trapped cats were sedated with an intramuscular injection of 4mg/kg Zoletil 100® (Virbac, Milperra; Australia). All animals captured were sexed, weighed and had coat colour recorded. A broad estimation of age (either kitten, juvenile or adult) was registered using weight and signs of breeding as a proxy for age. Hair samples and an ear notch were collected for DNA analysis. A GPS/VHF radio-telemetry collar with mortality signal (Sirtrack, Hawkes Bay, New Zealand) and

remote download capabilities was fitted to each feral cat caught that had a weight over 1800 g. The collars were programmed to take a location fix every 60 minutes and where a Timed Collar Release (TCR) was fitted these collars were set to drop off on July 28. All cats were released at the site of capture.

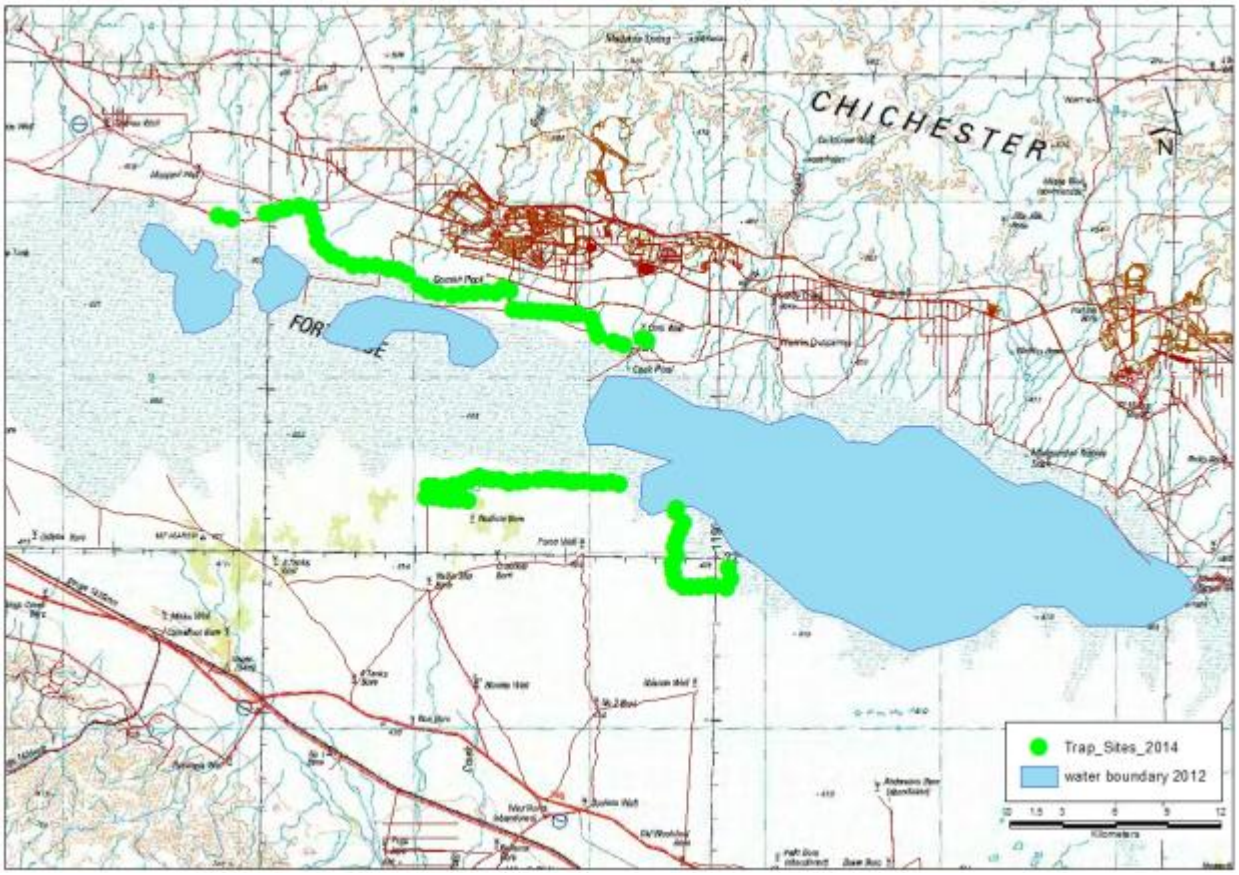


Figure 3 Trapping transects at Fortescue Marsh in May 2014

2.5.2 Monitoring and Recovery of Radio-collars

Monitoring of collars was scheduled, with two helicopter flights sub-contracted to the Department of Agriculture and Food, WA. The first flight was approximately ten days prior to baiting and the second was four weeks after baiting; to allow for collar retrieval. In between these flights, opportunistic locating of collars was attempted from the ground, during other scheduled works.

GPS data obtained from collars were filtered to remove points from the day of collar attachment (to remove bias caused by the stress of capture and anaesthetic), points after the day the collar was recorded motionless, all points where the collar failed to collect a location (e.g. cat in sheltered den site) and points where the Horizontal Dilution of Precision HDOP >5.0. Filtered data was projected and manipulated using the Animove for Sextante extension 1.8.0 in Lisboa GiS 10.1 and home range analysis was conducted using Home Range Tool (Rodgers and Carr, 2010)

Home range sizes were calculated using the minimum convex polygon (MCP) method, which creates a convex polygon around the smallest polygon that encompasses a specific proportion of the GPS locations for that animal (White and Garrot, 1991). In this study 95% and 100% of points were used. The MCP100, which uses all data points to calculate home range, is sensitive to sample size and outliers. To combat the issue of sample size, only samples with a minimum of three weeks

data (i.e. 504 data points) were used. To minimise the impact of outliers on home range estimates, MCP95 is also provided, which reduces the sample by removing the 5% of data points furthest from the sample mean.

2.5.3 Site Occupancy using Remote Surveillance Cameras

Detection of a species at a site confirms that the species is present at the site, but non-detection at the site does not necessarily mean that the species is absent (MacKenzie *et al*. 2006; Boitani and Powell 2012). An occupancy model using detection histories at camera sites across the Marsh was used to generate a probability of a particular site being occupied by a feral cat rather than just presence/absence. To determine the impact of the baiting program the camera grid was operating in both the treatment and control sites allowing the calculation of occupancy before and after baiting.

Occupancy modelling addresses the inherent difficulties in estimating numbers of cryptic, secretive, far ranging carnivore species that occur in low abundances. Occupancy is often used as a metric for estimating occurrence for various species and is a function of abundance as it describes the probability of a particular animal being at a given site, in this case a camera trap.

In 2013, site occupancy was determined using a Bayesian occupancy model with modelled random effects. Bayesian modelling was chosen for occupancy modelling rather than conventional software (such as Presence) as Bayesian techniques offer the potential to model spatial autocorrelation and can utilise datasets where data may be incomplete. For example, activation of the cameras in the field may take place over two days, using Bayesian methods the full dataset can be utilised even though the first day's data may be missing for some cameras. One of the assumptions of occupancy modelling is that an individual will not appear on more than one camera. Incorporating a spatial autocorrelation variable allows the model to compensate for any possible movements of cats between cameras. The model can also incorporate a random effects component which accounts for any unaccounted heterogeneity (e.g. habitat factors not included in the model).

In 2014 two occupancy models were used to examine the impact of baiting on the feral cat populations. The first includes a random effects component (i.e. it assumes that detection probability of not constant) and the second model incorporates a spatial component to model the potential impact of an individual cat appearing on more than one camera. Both models were run with a burn in of 5,000 iterations before sampling for 5,000 iterations for both pre and post-baiting data.

The probability of detection is based on meeting four assumptions as detailed in MacKenzie *et al*. (2006): population closure; no un-modelled heterogeneity in occupancy; no un-modelled heterogeneity in detection and detection histories at each site are independent. In the first year of the Fortescue Marsh feral cat baiting program, the focus was primarily on developing the appropriate methodology for the application of these robust techniques to camera-trapping data (Tiller *et al*. 2012). The second year of the program focused on improving these methodologies and techniques to provide improved feedback for the baiting program.

For the Fortescue cat baiting work, each year will be treated as an independent event testing the impact of cat baiting. Therefore, comparison of baiting efficacy pre- and post-bait delivery in the year of treatment is the aim of occupancy modelling, rather than comparison between years. Comparisons between years do not give an accurate assessment of long term cat baiting, as the

system is not closed and cats are able to migrate into the areas left unoccupied by individuals killed by bating. However, with a sustained baiting effort it can be expected that occupancy would decrease over time.

During 17–21 May, the treatment and control camera-trap grids were established on 3 km square spacing. A total of 30 camera-trap survey sites were established as the control cell and 56 sites were established as the treatment or baited cell (Figure 4). Survey sites in the control cells were located a minimum of 5 km (which is the estimated home range of a feral cat) from the boundary of the baited cell.

The camera surveys were conducted from mid-May to August 2014. The 56 treatment cell and 30 control cell cameras were operational for approximately three weeks, before they were decommissioned ten days prior to baiting and for ten days after baiting. Cameras and lures were then reinstated for another three weeks of monitoring in July.

Cameras (HC600; Reconyx, Wisconsin, USA) were set horizontally, approximately 30 cm from the ground (Photo 1). Cameras were set on “Scrape” program which records five pictures per trigger, and picture interval is on “RapidFire” which is two frames per second. There is no quiet period.

Lures for the camera-trap surveys are set at approximately 3 m from the camera. A 100 millilitre glass jar with holed sifter lid containing an oil-based scented lure (‘Catastrophic’, Outfoxed, Victoria) was attached to a wooden stake approximately 30 cm from the ground. A 1.5 m long bamboo cane was joined to the wooden stake, with white synthetic turkey feathers connected to the cane approximately 30 cm above the scented lure and a strip of wired silver tinsel was taped to the top of the cane (Photo 1).

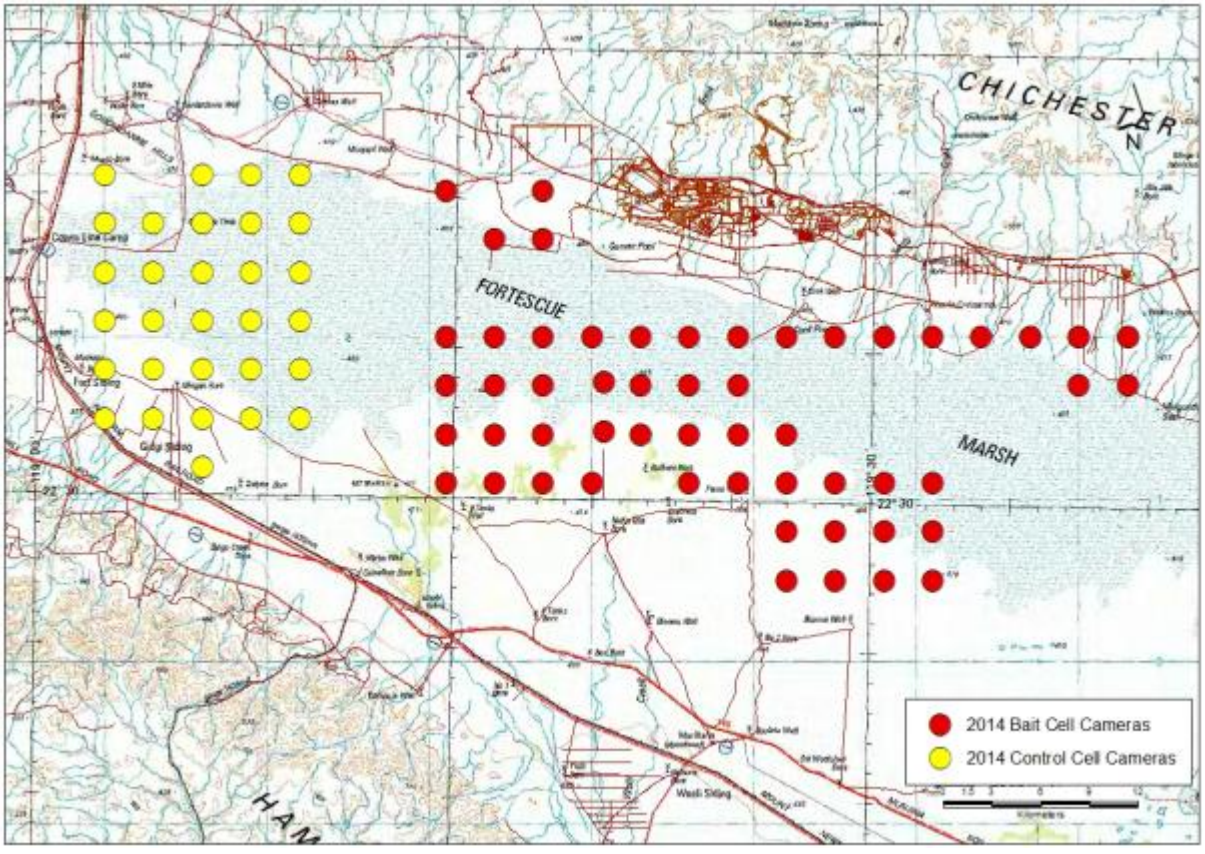


Figure 4 Remote surveillance camera grids for the control and treatment cells.

Photo 1 Remote-camera setup in Samphire habitat

2.6 Non-target Species

2.6.1 Birds

Sites selected for bird surveys followed from the method employed in 2013 where Autonomous Recording Units (ARUs) (Song Meter SM2+, Wildlife Acoustics, Massachusetts, USA) were placed close to existing camera-trap survey locations. These sites were selected on the basis of habitat characteristics with the assumption that relationships with habitat diversity (i.e. species and structure) would be correlated for both cats and birds. Each camera-trap survey point was ranked on vegetation coverage, structure and type. Locations with high coverage of native vegetation (e.g. spinifex (*Triodia* spp.)) and structural diversity were given preference over locations with non-native species (e.g. buffel grass (*Cenchrus ciliaris*)), low coverage and low structural diversity (e.g. bare ground) (Figure 5).

Eighteen ARUs were set to record daily from 13–28 June with two, three hour periods each day. The first period started one hour prior to sunrise and the second would begin two hours prior to sunset thus incorporating one hour after dark and possibly the time when Night Parrots (*Pezoporus occidentalis*) would be calling (Blyth 1996).

Analysis employed the use of sound recognition software SoundID (version 6.00.1), to screening ARU recordings for the calls of specific bird species. Bird species selected for analysis were those identified as potential monitoring targets in the Fortescue Marsh Baiting Plan (Algar *et al.* 2011).

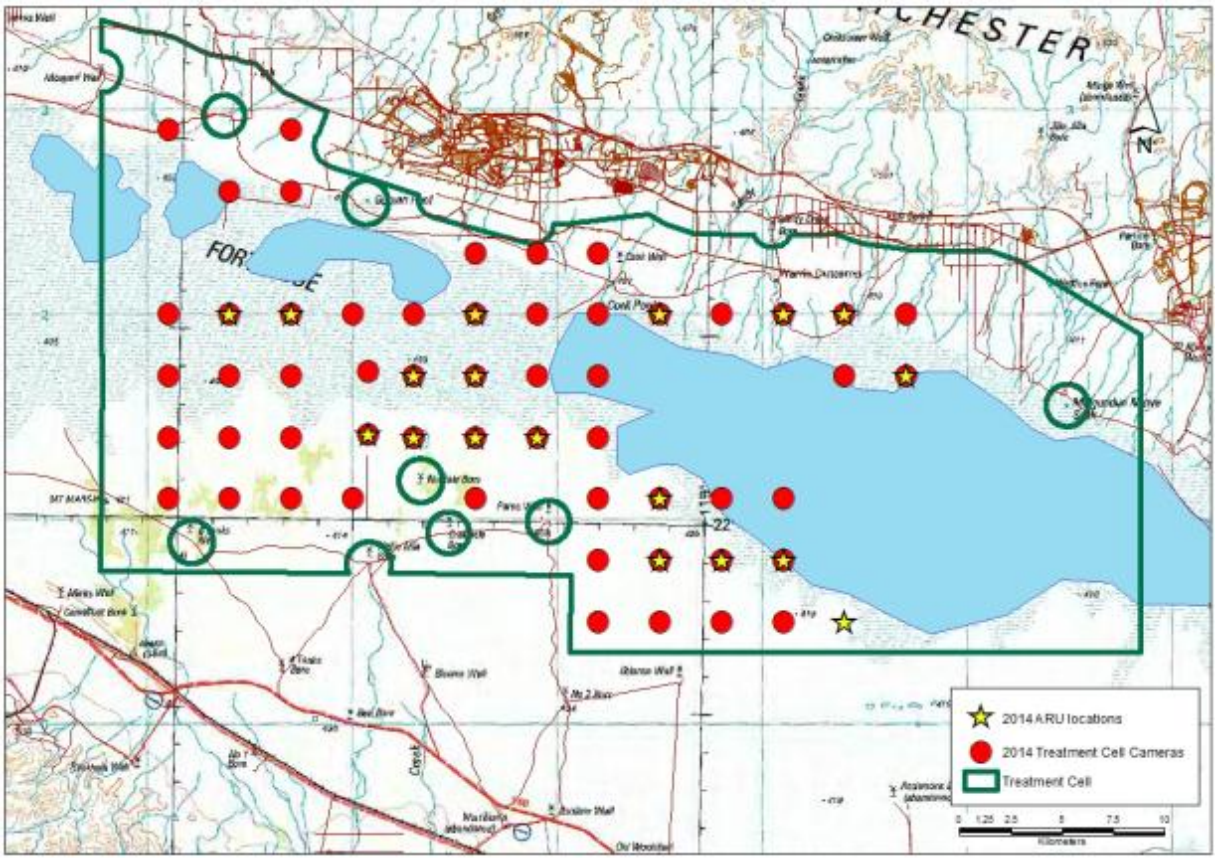


Figure 5 Automated Recording Units (ARU) locations in relation to Treatment Cell cameras.

SoundID requires good quality, 'clean' reference calls to develop a reference library to use in the analysis. In 2012, the IFRP field team recorded the calls of a number of species using a Marantz recording unit. Of these calls, only a few were of potential monitoring targets and of sufficient quality to use in a reference library. The development and testing of the reference libraries was time-consuming but now established, can be used to analyse future recordings as well as recordings from 2013.

The three best reference libraries that were constructed using these recordings were for Crested Pigeon (*Ocyphaps lophotes*), Variegated Fairy-wren (*Malurus lamberti*) and Red-capped Robin (*Petroica goodenovii*). Crested Pigeons are not generally vocal but their wings in flight produce a very distinctive sound, which was used as a 'reference' call. Testing found that Variegated Fairy-wren reference calls could also be used to recognise calls of White-winged Fairy-wren (*Malurus leucopterus*), which is also a potential monitoring target.

In addition to species observed/heard directly during the course of the 2014 Fortescue Marsh program, a number of bird species were recorded on camera-traps. These records were included in the overall species list for the area. Camera-traps provide an additional source of data as shown in previous years, where some bird species were only recorded on cameras.

2.6.2 EPBC Act Listed Mammals

The Northern Quoll (*Dasyurus hallucatus*), Greater Bilby (*Macrotis lagotis*) and Crest-tailed Mulgara (*Dasycercus cristicauda*) have been recorded in proximity to the survey area in the last twenty years (Davis 2005). In the first year of this program (2012), a search was conducted to within 5 km of the survey area for critical Northern Quoll habitat. No suitable habitat was found and no further effort has been made to detect this species other than through incidental findings.

Since this project began there have been over 11,188 feral cat-targeted camera-trap nights with only one Bilby being detected. Efforts were made this year to target detecting this species and Mulgara species with remote-camera surveillance.

Reconnaissance surveys were conducted across the study area to determine locations that may yield positive results through passive remote-camera surveys. Possible Bilby habitat was identified in the west of the study area (Figure 6) and possible Mulgara burrows and pop-holes were identified in a small area within the treatment cell (Figure 7).

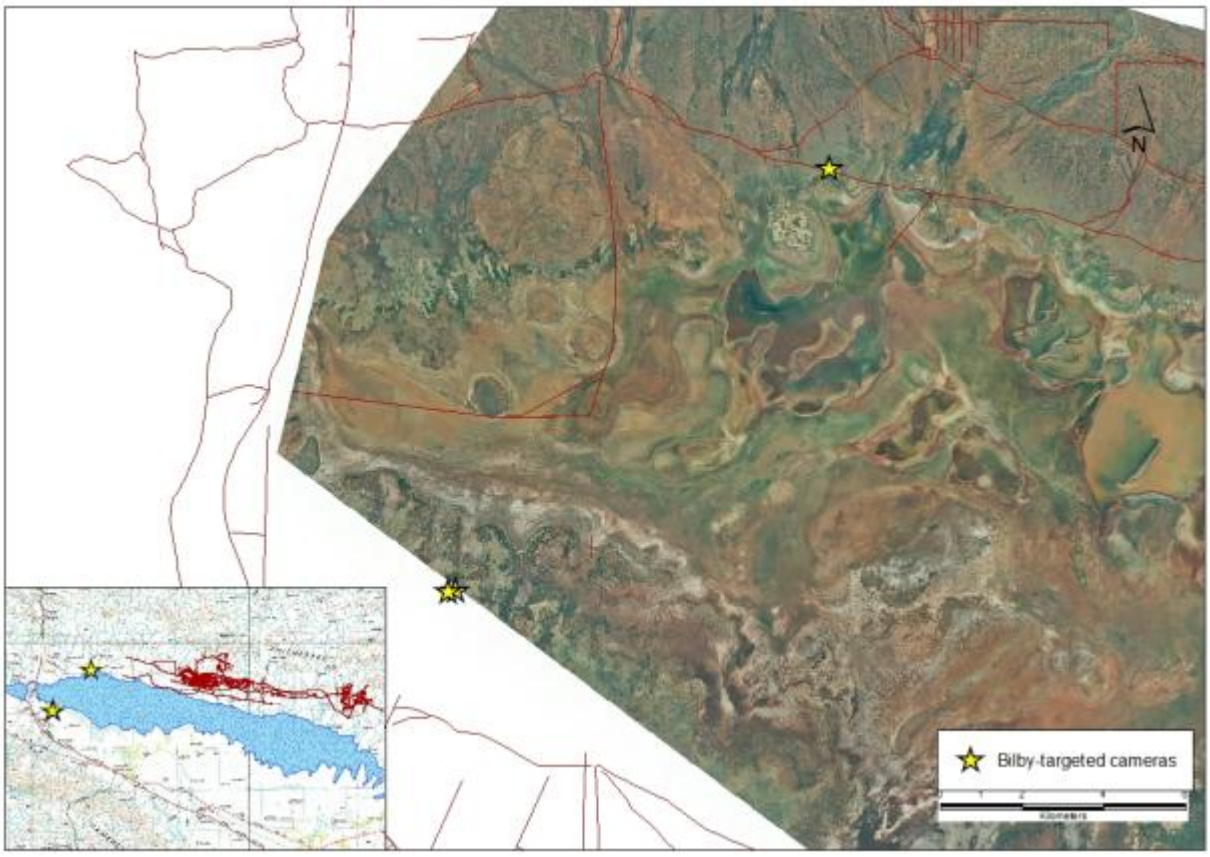


Figure 6 Location of cameras in possible Bilby habitat.

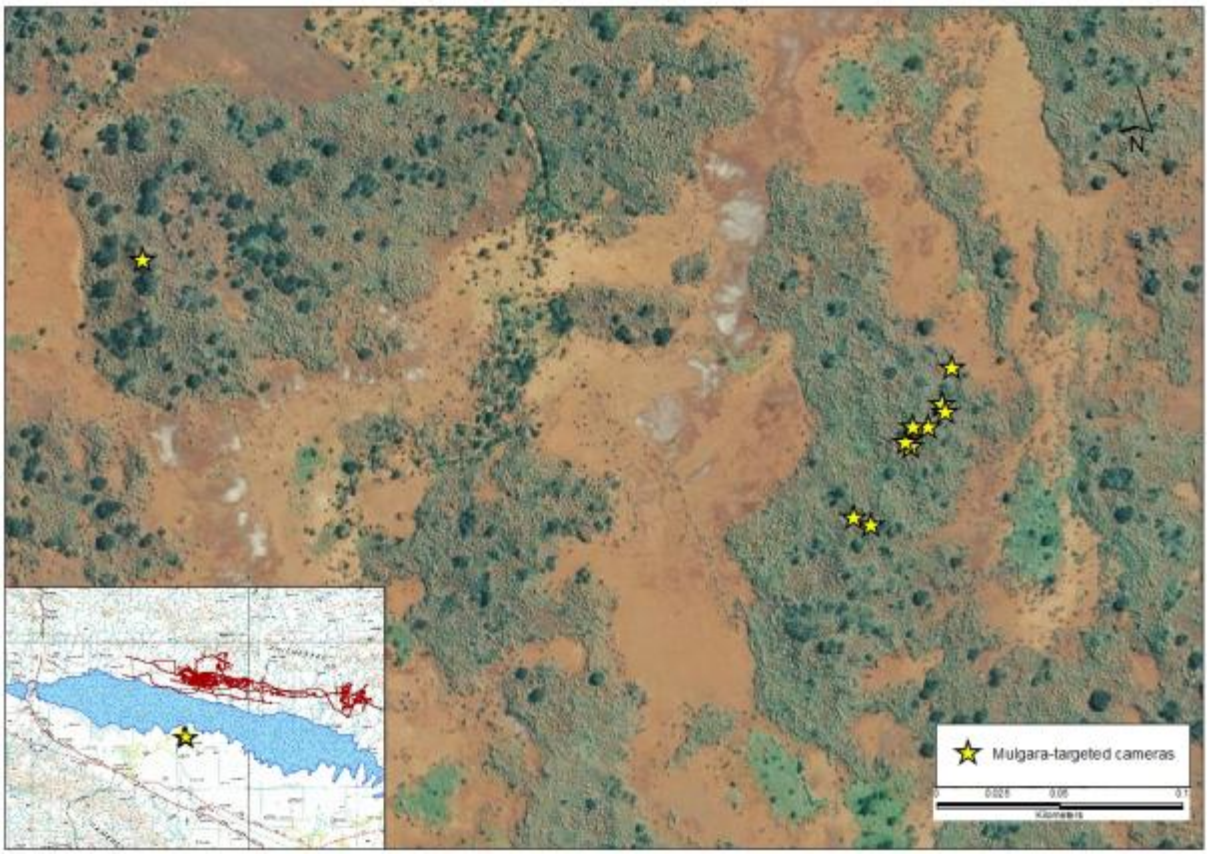


Figure 7 Location of Mulgara-targeted cameras – within the treatment cell, at Fortescue Marsh.

Five Mulgara-targeted cameras (HC600; Reconyx, Wisconsin, USA) were placed in a 5 ha area where they were mounted on pegs approximately 15 cm above the ground, facing a burrow, a pop-hole or a high traffic area for small mammals. These were set 2 m from the target for the duration of the larger remote-camera survey. An additional five white flash cameras (HC550; Reconyx, Wisconsin, USA) were deployed during the quiet period 12 June – 9 July when the main camera grid was inactive. All cameras were set to "Scrape" program which records five pictures per trigger, and picture interval is on "RapidFire" which is two frames per second with no quiet period.

Three Bilby-targeted white flash cameras were placed at what was perceived as the most likely Bilby habitat within the study area. These were also set to the "Scrape" and "Rapidfire" settings and were deployed from 15 June – 5 July.

2.6.3 Incidental Records

Incidental records (sightings, scats, tracks, diggings and through remote-camera surveys) of non-target native species, particularly listed threatened species, were also collected.

Records were designated either as in the treatment and/or control cells or solely recorded in areas immediately adjacent to these cells (e.g. Kardardarrie Well; Cloudbreak Mine and camp).

3 Results

3.1 Weather

The large areas still inundated by water on the Marsh during winter were attributed to significant rainfall events from the previous cyclone season. Over 500 mm fell in summer (December and January) as recorded by the Cloudbreak weather station. This occurrence resulted in areas of the Marsh still being inundated when work began in May and continued to have an effect through the rest of the study period. From February to June less than 25 mm of rain was recorded.

Rainfall and relative humidity are factors that will affect the success of a baiting program due to their impact on bait toxicity and palatability. The day before baiting began, 11 mm of rainfall was recorded at Cloudbreak (Figure 8), however reports from the three nearest Bureau of Meteorology weather stations with data (Newman, Marillana and Bonney Downs) recorded less than 3 mm.

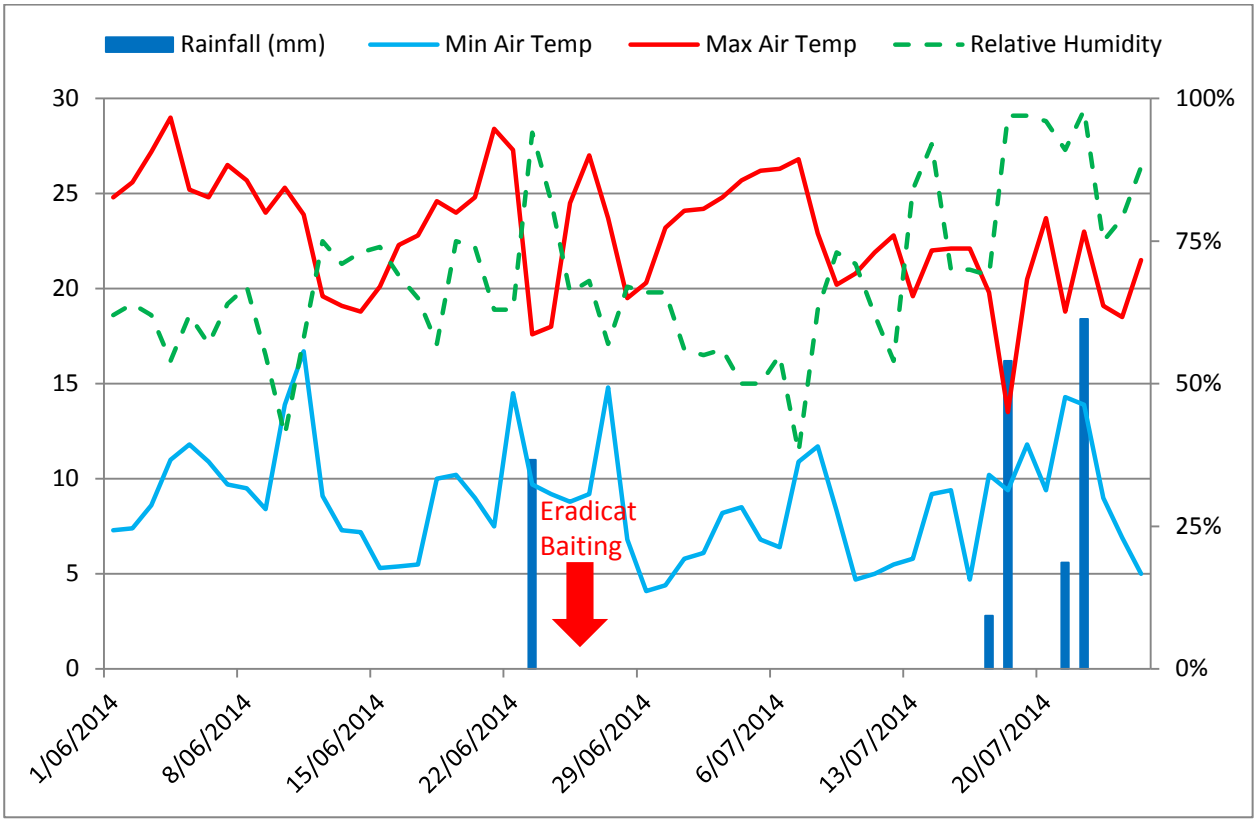


Figure 8 Climatic data for 25 days preceding baiting and 30 days post-baiting. Collected by the Cloudbreak weather station (Fortescue).

3.2 Baits and Baiting

The area proposed for baiting in 2014 was 1,000 km² - excluding the buffer areas around the active bore and well sites (Figure 2). This area was calculated with the knowledge that it would not all be baited due to the existing natural pools of water that were unlikely to have dried out by the end of June. The final area would be determined from the air at the time of baiting, when the staff in the bait plane had the best view of where baits would hit the ground rather than water. The total area baited was 980 km² (Figure 9).

The aircraft operated in the afternoon of 24 June and the morning of 25 June at approximately 160 knots at a height of 500 ft, flying east-west transects across the Fortescue Marsh bait cell.

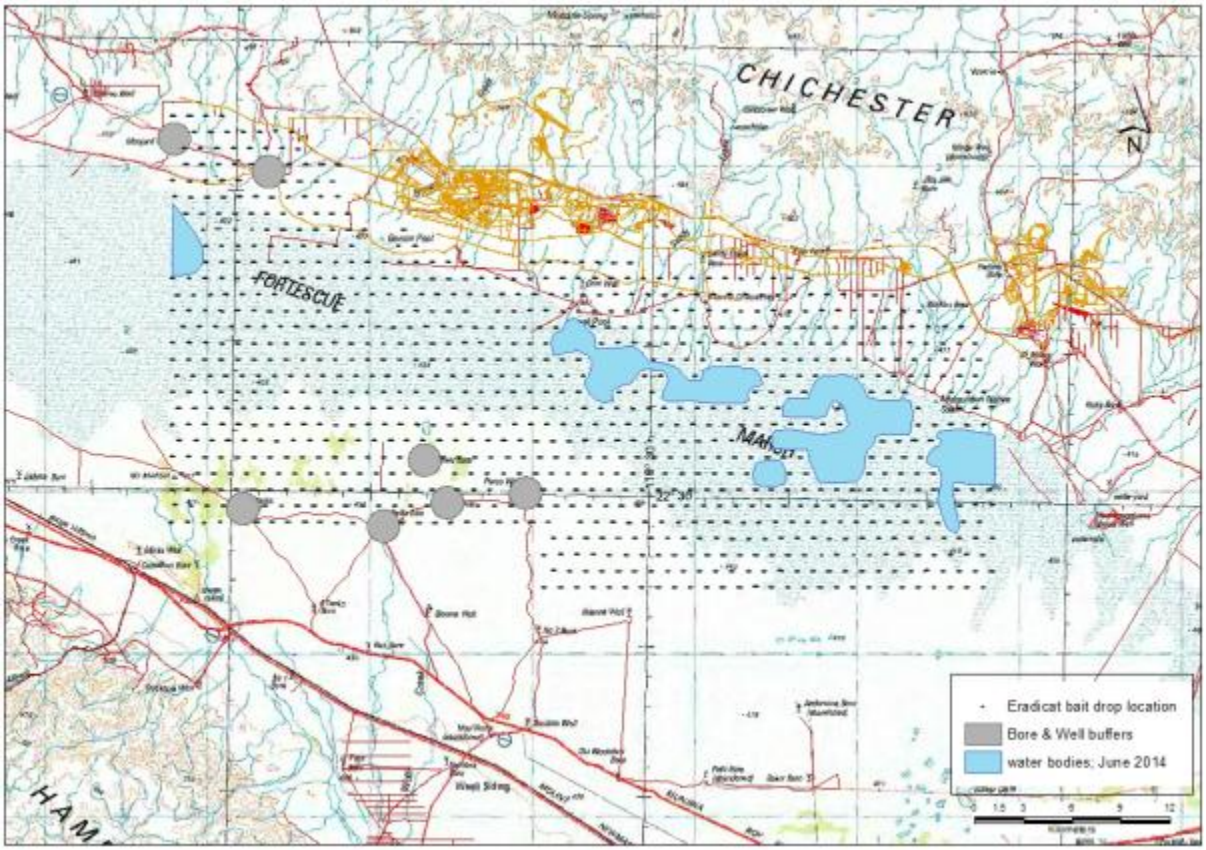


Figure 9 Distribution of baits on 24–25 June with bait cell exclusion areas.

3.3 Feral Cats

3.3.1 Trapping and Radio-collaring

Sixteen feral cats were captured over 739 trap-nights (capture success rate 2.17%), nine males and seven females. One sub-adult female (FMGf08) broke its leg when trapped and was euthanized at the site of capture. (Table 2 and Figure 10). Bodyweight (mean ± SE) of the males was 4000 ±200 g and the females were 2400 ±200 g.

Table 2 Capture records for feral cat on Fortescue Marsh, 7–18 May, 2014.

Identifier	Trap No	Capture Date	Sex	Location to Marsh	Weight (g)	Coat Colour	Age	VHF Freq
FMGm01	NW16	09/05/14	♂	north	3600	Ginger	Adult	150.180
FMGm02	NW28	10/05/14	♂	north	3600	Black	Adult	150.380
FMGf03	SW05	10/05/14	♀	south	1900	Tabby	Subadult	150.019
FMGm04	NW30	11/05/14	♂	north	3900	Tabby	Adult	150.039
FMGm05	SE10	11/05/14	♂	south	3750	Tabby	Adult	150.299
FMGf06	SW20	12/05/14	♀	south	2900	Tabby	Adult	150.579
FMGf07	SE20	12/05/14	♀	south	2750	Tabby	Adult	150.699
FMGf08	NW13	12/05/14	♀	north	1500	Tabby	Subadult	nil
FMGm09	NW01	13/05/14	♂	north	3500	Black	Adult	150.239
FMGm10	SW15	14/05/14	♂	south	4650	Tabby	Adult	150.519
FMGf11	SW19	14/05/14	♀	south	2800	Tabby	Adult	150.479
FMGf12	SW24	14/05/14	♀	south	2300	Tabby	Adult	150.159
FMGm13	NW09	14/05/14	♂	north	4500	Tabby	Adult	150.280
FMGm14	NW13	14/05/14	♂	north	3400	Tabby	Adult	150.100
FMGf15	SW01	15/05/14	♀	south	2650	Tabby	Adult	150.079
FMGm16	SE12	15/05/14	♂	south	5000	Tabby	Adult	150.360

The number of captures on each side of the Marsh were comparable, however more nights were spent trapping on the north side as this line was established earlier due to the initial water associated difficulties in accessing south of the Marsh.

Figure 10 Location of the feral cat captures

Non-target captures (Table 3) were either deceased on inspection or required euthanasia as they were either too injured for release or are a declared feral species.

Table 3 Non-target captures for 7–18 May, 2014

Species	**№ of Individuals**	**Trap Number**
Australian Bustard (*Ardeotis australis)*	1	NW05
Yellow-spotted monitor(*Varanus panoptes*)	1	SE05
European Red Fox (*Vulpes vulpes*)	1	SE16
European rabbit (*Oryctolagus cuniculus*)	2	SE08, NW13
Wild Dog (*Canis familiaris familiaris*)	1	NE07

3.3.2 Recovery, Monitoring of GPS/VHF Radio-collars and Bait Uptake

Four cats died prior to baiting from various causes and a fifth cat scratched its collar off, as evidenced by the located damaged collar. One of four cats that died prior to baiting was found predated on, within a week of being released. This was evidenced by the eagle pellet at the location of the remains. Two cats died of unknown causes within two weeks of being captured and released and the third cat died three weeks after capture (Table 4).

Table 4 Feral cat radio-collar activity and recovery details.

Identifier	Duration of filtered data	Total № of fixes	Average distance per day(m) ±sd	Home Range (ha)		Retrieval Method	Cat Outcome
				MCP100	MCP95		
FMGm01	10 May - 27 June	1083	7451 ±1417	2982	2312	Quad bike	Died from bait
FMGm02	11 May - 11 May	0	N/A	N/A	N/A	Car	Died from predation
FMGf03	11 May - 21 May	234	3751 ±1549	N/A	N/A	Helicopter	Died prior to baiting
FMGm04	no data	N/A	N/A	N/A	N/A	not retrieved	unknown - last detected 11/5
FMGm05	12 May - 12 July	1379	6470 ±2883	4606	4098	Helicopter	Died from bait
FMGf06	13 May - 13 May	21	N/A	N/A	N/A	Helicopter	Died prior to baiting
FMGf07	13 May - 18 July	1459	3373 ±1155	1167	932	Helicopter	Died from bait
FMGf08	not collared	N/A	N/A	N/A	N/A	N/A	Euthanased - 12/5
FMGm09	14 May - 26 June	979	5734 ±2664	20806	15553	Helicopter	Died from bait
FMGm10	15 May - 8 June	567	7519 ±2046	2165	1372	Helicopter	unknown - slipped collar
FMGf11	15 May - 29 July	1671	3777±1079	744	663	Helicopter	Survived baiting; shot 29/7
FMGf12	15 May - 8 July	1213	3208 ±897	374	232	Helicopter	Died from bait
FMGm13	no data	N/A	N/A	N/A	N/A	not retrieved	unknown - last detected 8/7
FMGm14	15 May - 8 July	1206	7119 ±2518	4097	2131	Helicopter	Died from bait
FMGf15	16 May - 12 June	596	3772 ±1023	1017	930	Quad bike	Died prior to baiting
FMGm16	no data	N/A	N/A	N/A	N/A	not retrieved	unknown - last detected 8/7

At the time of final collar retrieval there were ten collared cats remaining. Three of these were unable to be located from the helicopter after three hours of flying time and several hours spent tracking from a vehicle at their last known locations.

Of the remaining seven cats, one was still alive, this cat was shot and the collar retrieved. All other cats were found dead with their collars intact with the carcass.

An un-collared feral cat was also found dead (MGA: 50K 742405 7513463) when tracking for a collar that was in mortality mode. The state of the carcass and the proximity of this dead cat to the site of the nearest bait drop (~200 m) suggest that this cat had also succumbed to baiting.

Five of six post-baiting feral cats died, with carcasses found within 600 m of a bait drop location and within two hours of passing this location. (Figure 11) The sixth mortality was within 1700 m of the bait drop location and had died within three hours of passing this location. This individual (FMGm14) was also one of the furthest roaming individuals, having a daily average movement of over 7000 m.

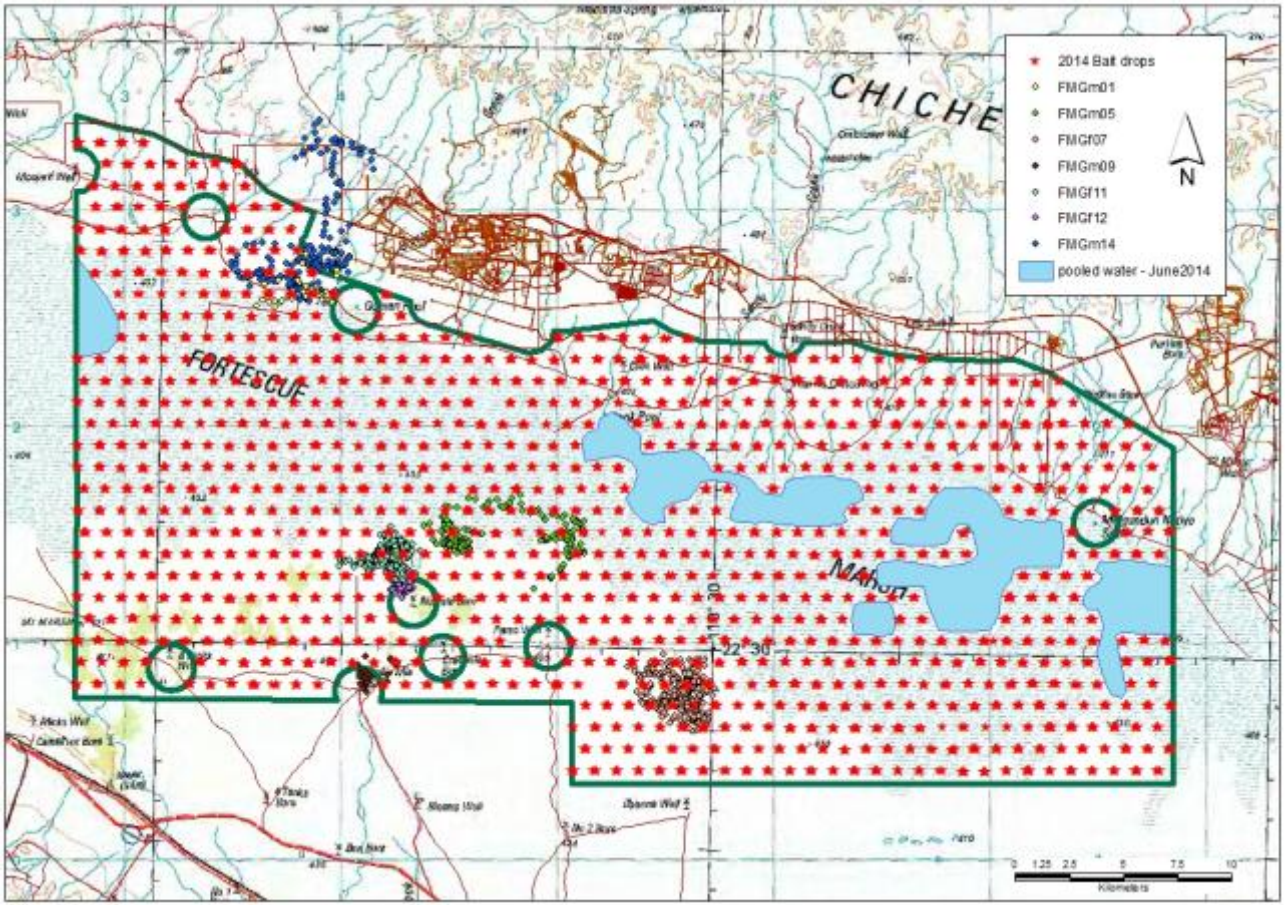


Figure 11 Activity of feral cats that were still alive at the time of baiting in relation to bait drop locations.

The average daily distances travelled by collared cats was consistent within sexes with females averaging 3.6 km/day (range: 3.2 – 3.8) and the males 6.9 km/day (range: 5.7 – 7.5).

Of the ten collars that had data, nine had collected sufficient GPS fixes (>500) to be analysed to establish home range size.

Minimum convex polygons were run for 95 and 100% of GPS fixes (Table 4 and Figure 12). There was substantial overlap of individuals on the south of the Marsh with a couple of females being fully encompassed by male home ranges. The average (±SE) of the MCP95 for males was 5,093.2 ha (±2653) and females was 689.3 ha (±165).

Male FMGm09 (green in Figure 12) travelled over 18,000 m on one individual day, crossing from the north to the south side of the Marsh, after which it spent the rest of its time around Nellie Mia bore.

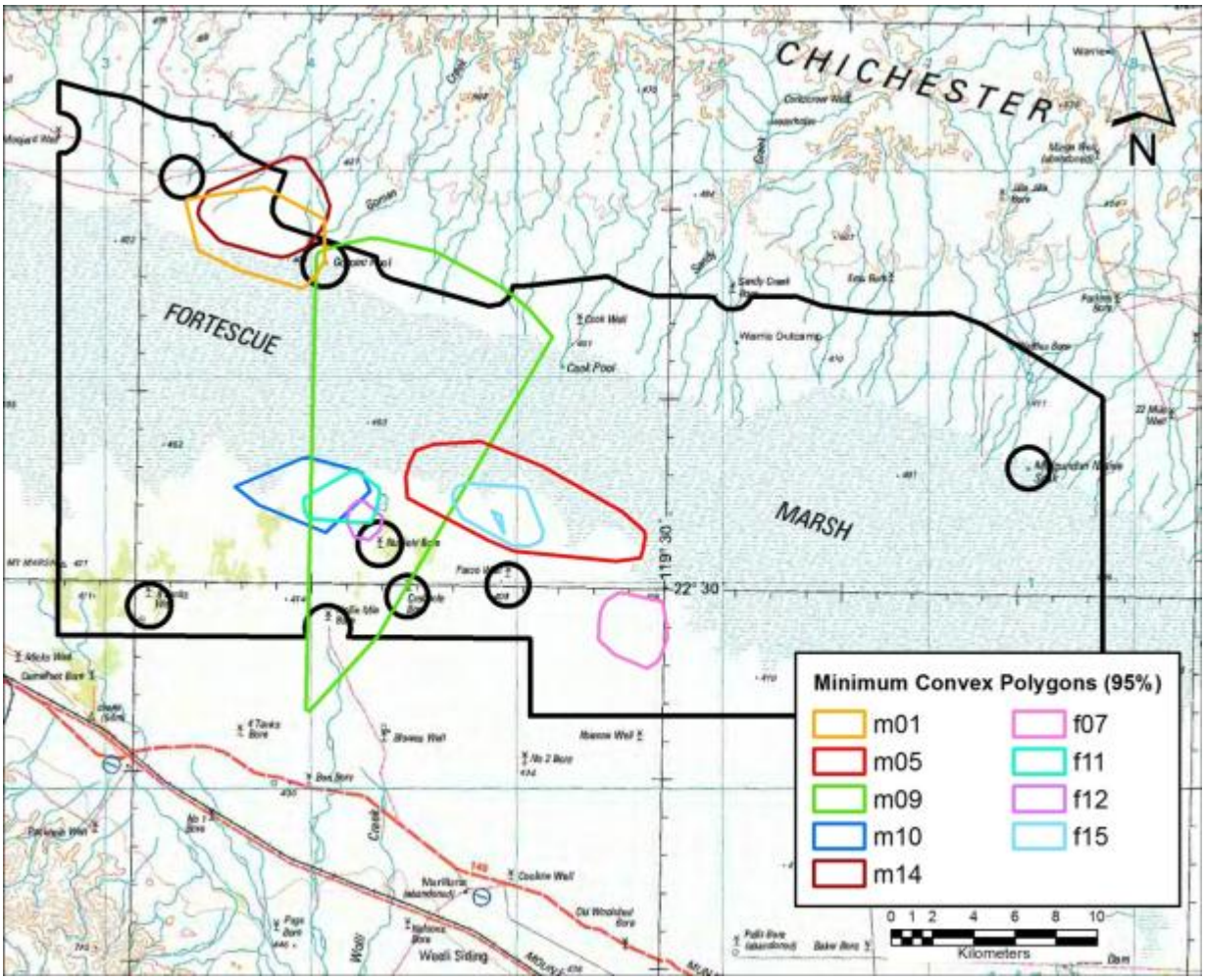


Figure 12 Feral cat home range as defined by 95% Minimum Convex Polygons showing the area of use by the collared feral cats.

Analysis of temporal movements of collared cats in 2014 was conducted for ten individuals. Peak activity occurred at sunset, with a secondary peak at sunrise. Average hourly activity for males (n=5) (range: 161-501m) increased substantially compared with the recorded activity of males in 2013 (n=4) (range: 65-297m) (Figure 13). Females had subtle bimodal peaks at sunrise and sunset and average hourly activity had an inverse activity peak between 2013 and 2014, changing from dusk to dawn.

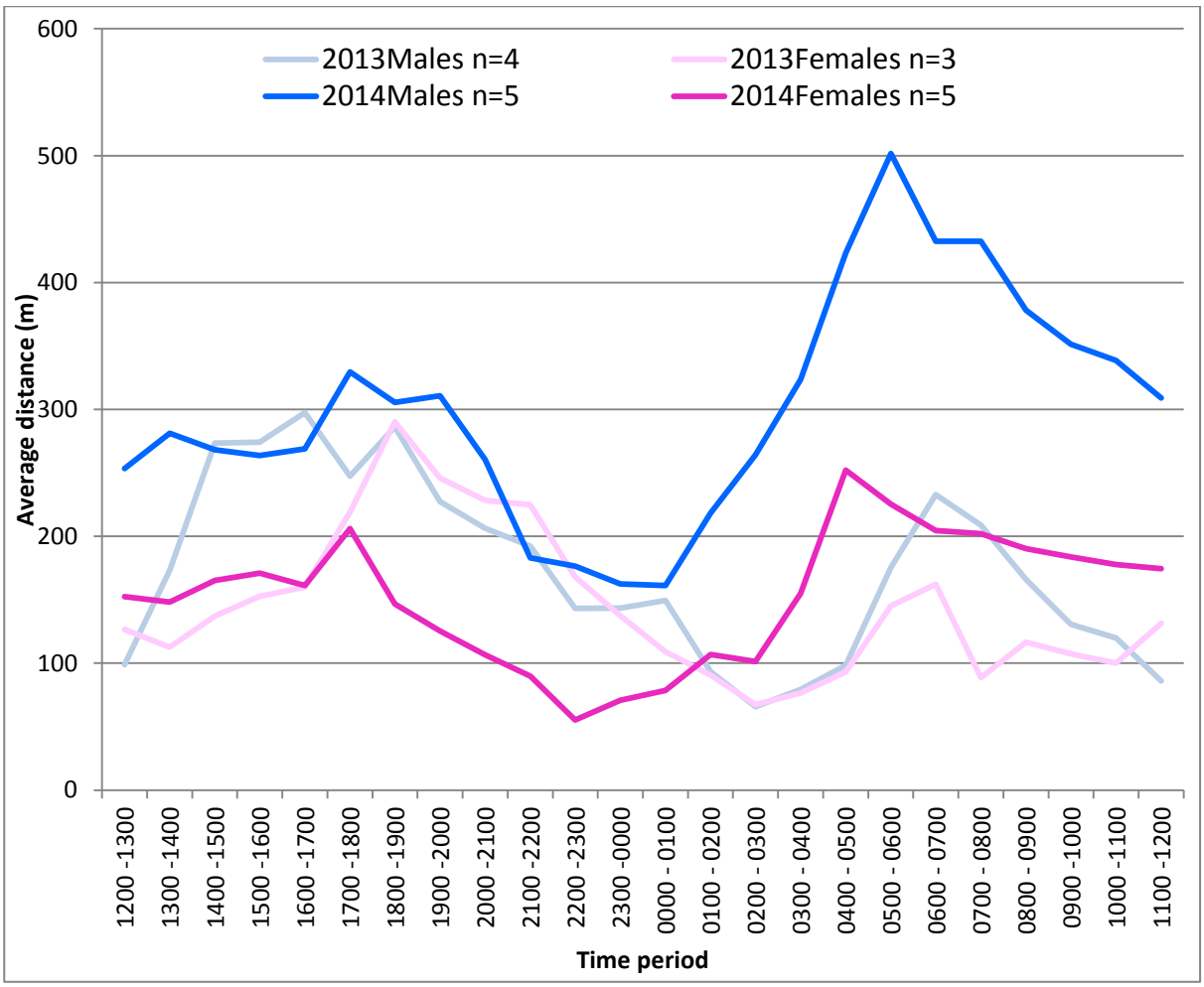


Figure 13 Temporal movement pattern of collared feral cats at Fortescue Marsh for 2013 and 2014. (627 samples per hourly time period)

3.3.3 Site Occupancy

A total of 3,761 camera trap-nights (Table 5) were conducted resulting in 31 out of 86 cameras recording feral cats (Figure 14).

Table 5 Camera trap-nights for survey areas.

	Pre-bait	Post-bait
Control (n=30)	720	600
Treatment (n=56)	1,318	1,123

Feral cat detections during the camera surveys showed a concentration (pre-& post-occurrences) in the centre of the Marsh, in the areas where the pooling water evaporated from first (Figure 14).

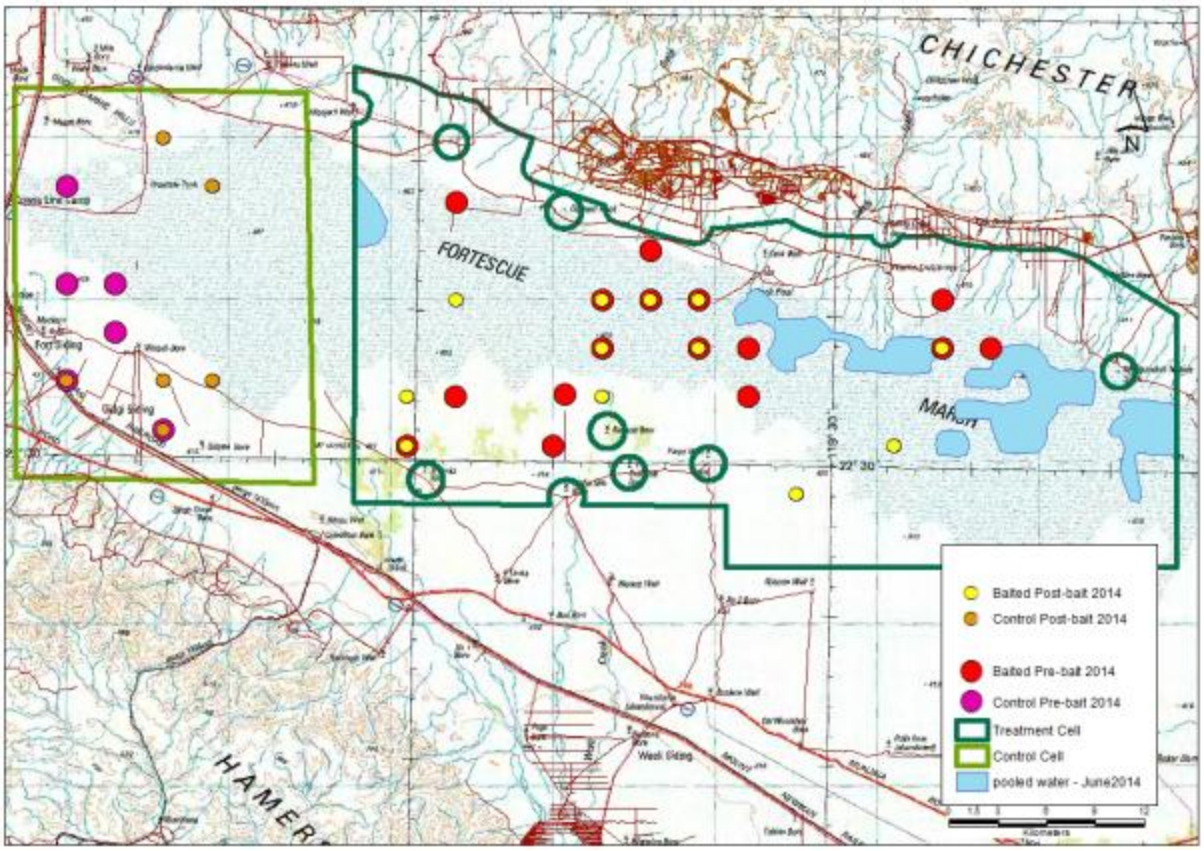
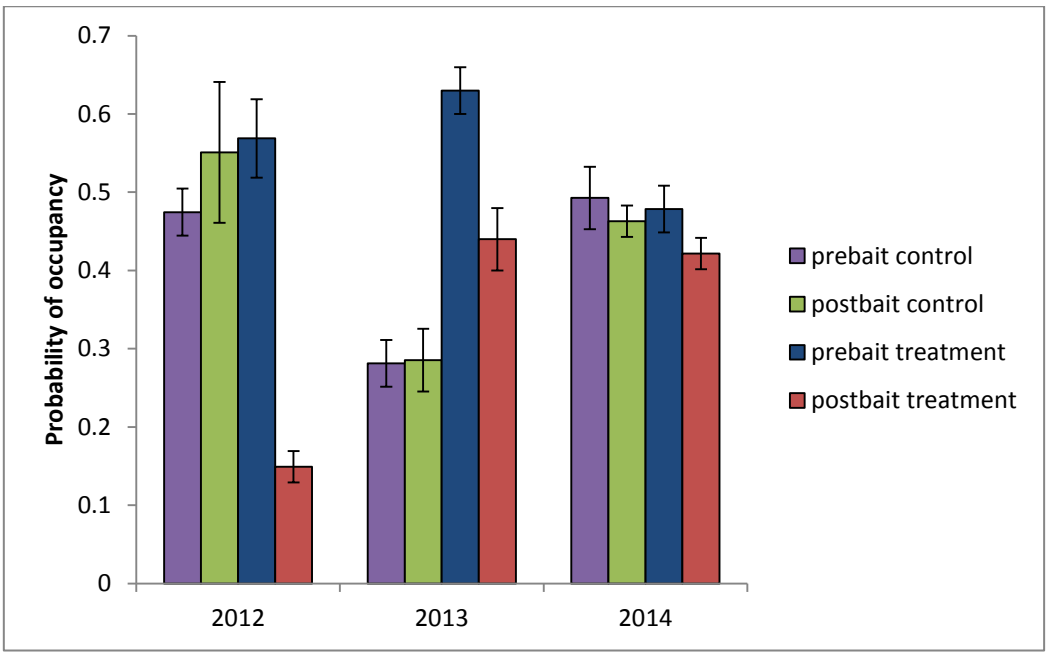


Figure 14 Location of feral cats recorded on remote-surveillance cameras in 2014

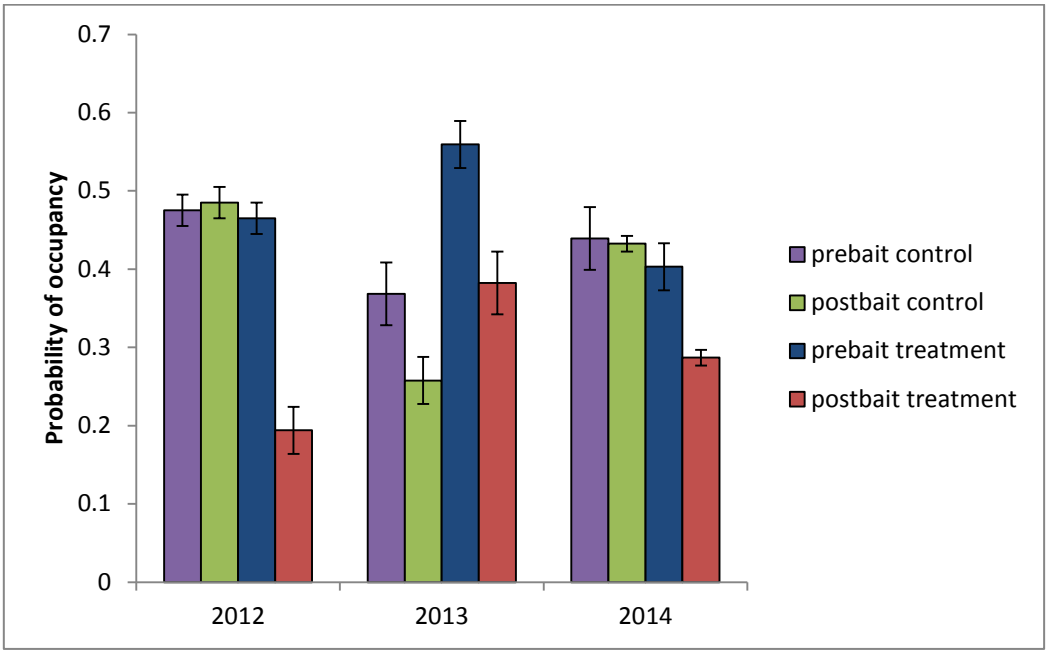
Table 6 Probability of occupancy ± (95%CI) with no habitat covariates.

		Pre-bait		Post-bait	
Model	Year	Control (n)	Treatment(n)	Control (n)	Treatment(n)
Random	2012	0.4747±0.1527 (29)	0.5687±0.6250 (49)	0.5511±0.2286 (29)	0.1491±0.1324 (49)
Random	2013	0.2813±0.1900 (31)	0.6298±.0190 (29)	0.2845±0.1640 (31)	0.4399±0.2335 (29)
Random	2014	0.4927±0.2042 (30)	0.4785±0.1283 (56)	0.4628±0.1891 (30)	0.4215±0.1642 (56)
Spatial	2013	0.4853±0.1106 (29)	0.4649±0.1446 (49)	0.4852±0.08388 (29)	0.194±0.1696 (49)
Spatial	2012	0.3684±0.2383 (31)	0.5593±0.1836 (29)	0.2577±0.1670 (31)	0.3824±0.2030 (29)
Spatial	2014	0.4393±0.1958 (30)	0.4031±0.08309 (56)	0.4325±0.1898 (30)	0.287±0.05595 (56)

The occupancy of control and treatment sites was calculated before and after baiting for data from all years (2012, 2013 and 2014) using both random effects and spatial models. In 2014 both models showed a significant decrease in the treatment cell, with occupancy in the control site not changing (random effects: t-test, $p<0.05$ for treatment and $p> 0.5$ for control; spatial effects: t-test, $p<0.01$ for treatment and $p>0.8$ for treatment). In 2012 and 2013 there was a significant decrease (10%) in the calculated occupancy post-baiting in the treatment site using the spatial model (t-test, $p<0.01$) while occupancy in the control site did not alter (t-test, $p>0.05$) (Figure 15).A similar result was obtained modelling random effects when 2012 data was reanalysed with these models: t-test $p<0.01$ for treatment and $p>0.1$ for control).



a) modelled random effects



b) modelled spatial component

Figure 15: Site occupancy (mean ±SE) pre and post baiting for 2012, 2013 and 2014 with random effects (15a) and spatial component (15b).

3.4 Non-target Species

3.4.1 Birds

Of the 18 ARUs deployed, one failed to record, resulting in total recordings of 1,326 hours (442 sessions of 3 h, morning and evening).

All ARU recordings were analysed using SoundID (using the Recognition 1-D module in the 64bit beta version) for all four targeted species. Presence/absence within the survey period at a particular location was recorded in binary (Table 7).

Eight of the 17 ARUs were located at sites where feral cats were also detected.

Table 7 Results showing presumed occupancy of four bird species at 17 ARU locations in Fortescue Marsh, June 2014

Location	Unit No	Crested Pigeon	White-winged Fairy-wren	Variegated Fairy-wren	Red-capped Robin
C2	IFRP 08	0	0	0	0
C3	IFRP 07	0	1	0	0
C6	IFRP 22	0	1	0	0
C9	IFRP 39	0	0	1	0
C11	IFRP 20	0	0	1	0
D5	IFRP 33	0	1	0	0
D6	IFRP 34	0	1	0	0
D13	IFRP 40	0	1	0	0
E4	IFRP 29	0	0	0	0
E5	IFRP 30	0	1	0	0
E6	IFRP 10	0	0	1	0
E7	IFRP 09	0	1	0	0
F9	IFRP 01	0	1	1	0
G9	IFRP 02	0	0	0	0
G10	IFRP 21	0	1	0	0
G11	IFRP 35	0	0	0	0
H12	IFRP 36	0	0	0	0

3.4.2 Bilby and Mulgara

A 250ha sand dune area was searched for suitable Mulgara habitat. Within this area only small pockets of dunes exist that have not been infested by Buffel grass. Fifty hectares was identified as worthy of sampling. The area covered by ten cameras was around 5 ha, as per the national survey guidelines for this species (DSEWPaC 2011). A total of 431 camera-nights were surveyed with no detections of Mulgara.

The Bilby-targeted cameras were operational for 57 camera-nights with no detections of the target species.

Non-target species detected through these remote-cameras were dominated by the Spinifex hopping mice (Table 8).

Table 8 Summary of species captured on remote surveillance cameras targeting Mulgara and Bilby.

Common	Species	№ events	№ cameras	% cameras
Brown Quail	*Coturnix ypsilophora*	2	1	7.69
Cat	*Felis catus*	13	5	38.46
Central Military Dragon	*Ctenophorus isolepis*	3	2	15.38
Collared Sparrowhawk	*Accipiter cirrocephalus*	2	1	7.69
Desert Mouse	*Pseudomys desertor*	40	1	7.69
Dunnart	*Sminthopsis sp.*	1	1	7.69
Little Button-quail	*Turnix velox*	5	3	23.08
Little Red Kaluta	*Dasykaluta rosamondae*	2	2	15.38
Pygmy Desert Monitor	*Varanus eremius*	8	4	30.77
Unidentified small mammal		435	10	76.92
Spinifex Hopping-Mouse	*Notomys alexis*	1146	10	76.92
Stripe-faced Dunnart	*Sminthopsis macroura*	1	1	7.69
White-winged Fairy-wren	*Malurus leucopterus*	6	3	23.08
Zebra Finch	*Taeniopygia guttata*	4	2	15.38

3.4.3 Incidental records

Birds sighted and heard during the course of the field work are listed in Appendix 1.

No individuals or evidence of EPBC Act listed mammal species were recorded during the field work or on remote surveillance cameras (Table 9).

Table 9 Percentage of Non-target captures on remote-camera surveys for the 2014 season.

Common Name	Scientific Name	Treatment		Control	
		% Pre-bait cameras	% Post-bait cameras	% Pre-bait cameras	% Post-bait cameras
Camel	*Camelus dromedarius*	0	1	0	0
Cat	*Felis catus*	16	12	6	6
Cattle	*Bos taurus*	9	9	0	3
Dog	*Canis lupus familiaris*	1	1	0	0
dunnart	*Smithopsis spp.*	0	1	1	0
European Rabbit	*Oryctolagus cuniculus*	4	1	1	1
Little Red Kaluta	*Dasykaluta rosamondae*	4	2	2	1
other small mammal*	n/a	12	17	3	4
Red Fox	*Vulpes vulpes*	0	0	0	1
Red Kangaroo	*Macropus rufus*	10	16	5	10
Short-beaked Echidna	*Tachyglossus aculeatus*	1	1	0	0
Spinifex Hopping-mouse	*Notomys alexis*	5	4	1	0

A flying-fox carcass was found caught in a fence on Marillana station, on the south of the Marsh. Its presumed to have been a Black Flying-fox (*Pteropus alecto*) as this is the nearest known *Pteropus* taxa. Although a common species this is a good record as it is some distance from the known distribution of this species.

4 Discussion

The main intent of this program is to ascertain an effective and cost efficient method of controlling feral cats on the Fortescue Marsh. In this, the third year, there was a significant decline in the number of radio-collared cats, with an 85% knock-down of animals following aerial bait delivery.

The results of remote camera surveillance and analysis of data with occupancy models, using both spatial and random effects models, also demonstrated a significant effect of baiting in effecting feral cat numbers in 2014. Application of the same Bayesian models to previous years' data also supports the value of the remote camera technique for detecting effects of baiting on the Fortescue Marsh. Both random effects and spatial models show a similar pattern in that the control sites do not vary pre- and post-baiting (except for the spatial model in 2013) and the treatment sites show a decline in occupancy post-baiting. It should be noted that there can never be a 'correct' model; all models are just an approximation. The value of this technique in supporting monitoring of baiting treatment efficacy is significant, and further work will be carried out to determine which models give best indication of impacts of baiting. Further work will also be done on incorporation of covariates (such as distance to track and water) into the models.

The seven feral cat deaths attributed to baiting were determined as such by proximity and time of death to a bait drop location. Six out of seven carcasses (including the un-collared cat) were within 600 m of a bait and the seventh (FMGm14) was 1700 m. Although FMG14m was some distance from a bait drop this is insignificant when compared to the average daily distances for males (6900 m). Moving less than a third of this distance in a few hours is not insurmountable.

There were four feral cat mortalities recorded prior to baiting. Two of these premature mortalities are most likely due to the trapping, with death occurring within 24 hours of capture. One of these individuals was predated by a bird of prey which would be due to the cat's inability to recover sufficiently to escape an attack, after all four of its legs were caught in the trap. The second carcass was found in an open exposed area and was beyond determination for cause of death. The other two cats died 10 and 28 days respectively after being trapped, conclusive cause of death was unable to be determined for these individuals.

The conditions for bait delivery were within limits of the protocols with some precipitation on the proposed date of delivery. Even though the rainfall was below the limit, the bait drop was delayed by a day to ensure as good a result as possible. Following baiting there was no significant (>5 mm) rainfall until 23 days after baiting. Relative humidity ranged between 36% and 76% up until 19 days post-baiting before exceeding 90%. These climatic conditions meant that baits should have remained palatable and toxic for at least 19 days and even up till the day it rained, at day 23.

The conditions in 2014 were such that access across the Marsh by wildlife was restricted due to the large areas still being inundated from rains in December-January. This may have impacted on available food resources, with fewer small terrestrial species being available and a higher than average waterbird presence. The home range areas used by collared feral cats, was primarily on the margins of the Marsh however this is also where the cats were captured. The camera surveys indicated that feral cats were using all habitats across the survey area but with a focus on the fringes of the Marsh and the edges of the inundated areas.

Home ranges are consistent with expectations on arid cat movements with males ranging between 1000–5500 ha and females between 300–1000 ha. The large average daily distances recorded (over 7 km for some males) is likely due to the difficulty in finding prey in an arid environment. Average daily movements were higher in 2014 than 2013. This could be an influence of reduced overall numbers of feral cats on the Marsh, allowing extant feral cats greater movement across absent territories.

Cats, despite being opportunistic predators, will only consume a food item if they are hungry (Bradshaw 1992; Algar *et al*. 2013). The observed peak activity times had a strong peak for males at pre-dawn with a second, more subtle peak at dusk. These times also correspond to the crepuscular movements of most native mammals.

Fairy-wrens of either species were recorded at 12/17 sites compared to 14/17 in 2013. However, these data are not directly comparable as in 2013 the ARU data was analysed manually and even faint calls (which would most likely be missed in an automated set-up) were recorded. Red-capped Robins and Crested Pigeons were not recorded at any sites. In the case of the robin, which was not recorded at all in manual analyses in 2013, it is likely that it did not occur in the vicinity of the ARUs and this species was not recorded at all by any survey method in 2014. Crested Pigeon was recorded regularly in 2014 and is likely to have occurred in the vicinity of ARUs during the survey period. However, it was only recorded on two ARUs in 2013 and therefore cannot necessarily be expected to be recorded in 2014. However, with an improved reference library the ARU data can be re-analysed to assess the occurrence of the species.

Suitable Mulgara habitat was found to be quite limited in the study area due to the presence of buffel grass (*Cenchrus ciliaris*) in what might otherwise have been good Mulgara sand dunes. The results of the camera survey indicate that the burrows surveyed were actually inhabited by Spinifex Hopping Mice rather than Mulgara. *Dasycerus* species are subject to large fluctuations in abundance and may currently be in low period making detection very difficult.

Recent studies by Woolley *et al* 2013 suggest that the known distribution of Crest-tailed Mulgara (*Dasycercus criticauda*) was limited to the eastern Pilbara but is now extinct in Western Australia. Records of Brush-tailed Mulgara (*Dasycercus blythi*) are more readily known near the study area with an understanding of the taxa present in the Pilbara still being assessed.

4.1 Recommendations

1) An unusually high number (four) of feral cat mortalities occurred prior to baiting. At least two of these are most likely due to the trapping. One individual was predated by a bird of prey which is likely due to the cat's inability to recover sufficiently to escape and attack after having all four legs caught in the trap. In future, №1.5 leg-hold traps will be employed to minimise the impact of injury during trapping.
2) Establish a temporary weather station on the Marsh for the period just prior to baiting and for three weeks afterwards.
3) SoundID provides a unique and useful tool for the analysis of ARU recordings for bird calls. It was highly efficient at detecting the calls of fairy-wrens, even on poor quality recordings (i.e. with wind or other interference). However, the process can be time consuming, especially when only poor quality recordings are available for developing reference libraries. Future work should concentrate on acquiring better recordings of other potential monitoring targets (e.g. Night Parrot (*Pezoporus occidentalis*), Crested Bellbird (*Oreoica gutturalis*), Australasian Pipit (*Anthus novaeseelandiae*), Spinifexbird (*Eremiornis carteri*)), as well as augmenting existing reference libraries for other species. The process of developing an automated approach to ARU analysis has also informed the approach that future ARU surveys should use (i.e. ARU settings).
4) Further targeted camera surveys to be conducted for Mulgara and Bilby

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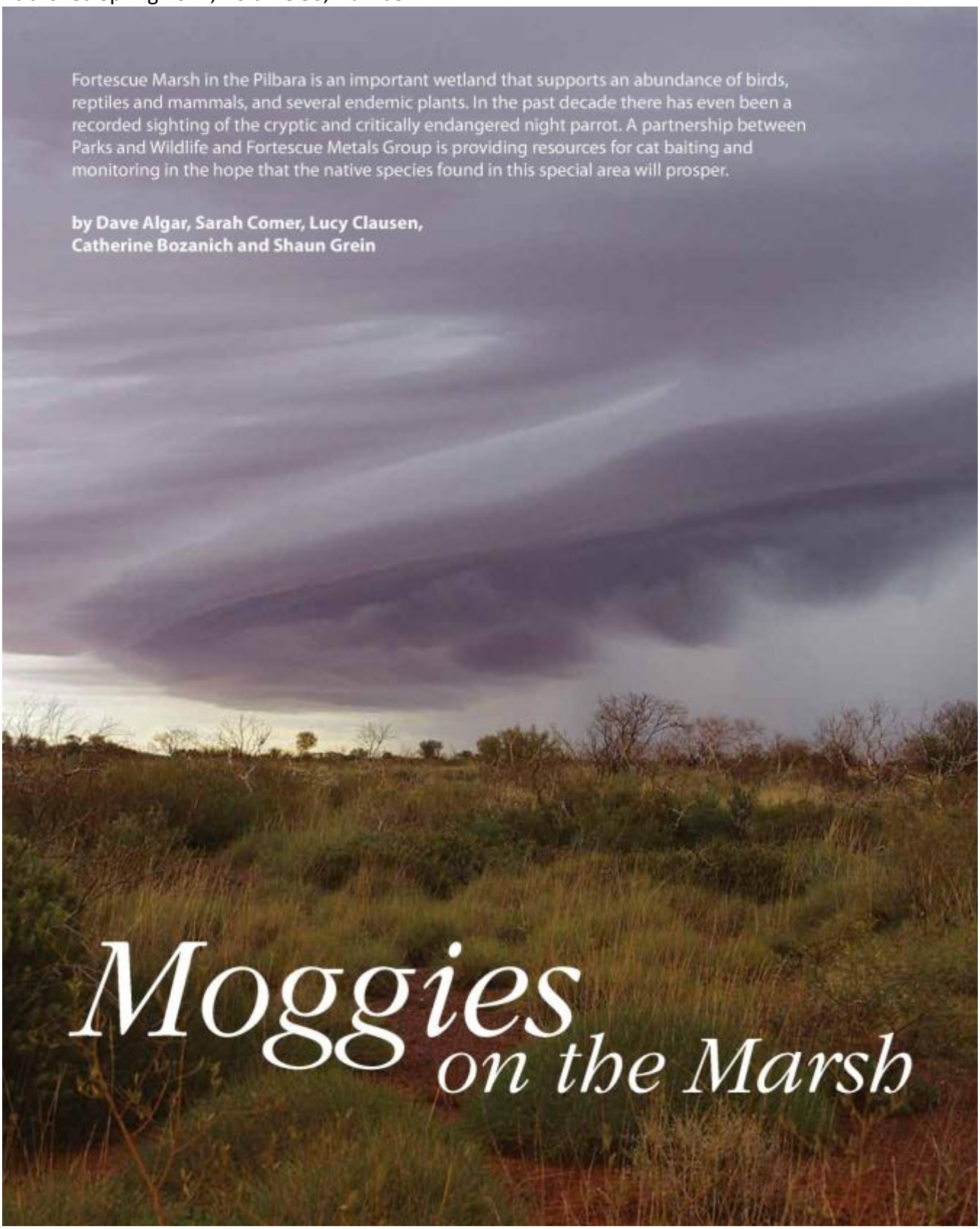
Appendices

5.1 Appendix 1 – Landscope Article 'Moggies on the Marsh'

Published Spring 2014, Volume 30, Number1.



Fortescue Marsh is an extensive intermittent wetland that occupies an area of 1000km² when in flood. The marsh is about 100km north-west of Newman in the Pilbara and is located in the Fortescue subregion between the Chichester and Hamersley ranges. There are plans for the marsh to be nominated as a Ramsar site and it is listed on the Directory of Important Wetlands because, when in flood, it supports several hundred thousand waterbirds. It is known to harbour populations of threatened species such as the bilby (*Macrotis lagotis*) and has several plant species that are endemic to the samphire shrubland that are integral to the wetland. Most notably, the marsh is the location of one of the very few confirmed sightings of the critically endangered night parrot (*Pezoporus occidentalis*) in the past decade. The marsh is also at the centre of an important mining hub, is a significant pastoral area and has considerable cultural and heritage importance to the local Aboriginal communities.

Previous page
Main A storm brewing over Fortescue Marsh.
Photo – Sarah Comer/Parks and Wildlife

Above The expansive plains of the Fortescue Marsh.
Photo – Louisa Bell/Parks and Wildlife

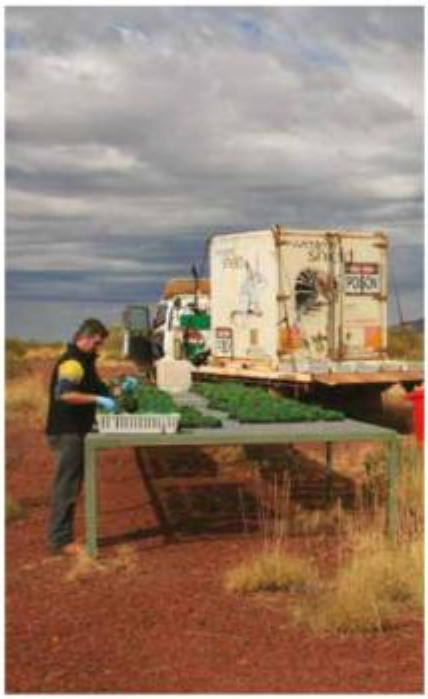
ACTING FOR CONSERVATION

Parks and Wildlife has been collaborating with Fortescue Metals Group in a feral cat baiting campaign at the Fortescue Marsh as part of environmental conditions under the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act. This aims to reduce cat abundance and improve protection and long-term conservation of species listed in the Act, specifically the bilby, night parrot and also migratory bird species. The baiting program is being conducted at a landscape scale on the area of the marsh that is a proposed conservation reserve. It is hoped the five-year baiting program will establish methods for the most effective regimes to control feral cats in this important conservation area.

The optimum method to deploy baits for landscape-scale control of feral cats, using the feral cat bait *Eradicat®*, is still being developed (see 'Controlling cats: the work continues', *LANDSCOPE*, Autumn 2013). The Fortescue Marsh project was designed to be dynamic so it could be adapted as necessary, in a similar way to other projects managed by Parks and Wildlife. The project team comprises Parks and Wildlife staff from its Science and Conservation Division and Pilbara and South Coast regions. The South Coast staff bring experience gleaned from their work in a similar landscape-scale cat control program between Two Peoples Bay and Israelite Bay where they survey for cryptic fauna relevant to this project including the critically endangered western ground parrot (*Pezoporus flaviventris*) (see 'Kyloring, cats and conservation: the race to save the western ground parrot', *LANDSCOPE*, Summer 2013).

LAYING THE BAITS

Baiting was started in 2012 over an area of 832km² and a second program was carried out in 2013 over a similar, but slightly larger site. The size of the 2012 baiting program had to be modified due to the surface water brought by tropical cyclone Lua. Baiting was conducted in mid-winter when the weather conditions were cool and dry to maximise bait uptake by cats. In mid-winter, the abundance and activity of all prey types, in particular predator-vulnerable young mammals and reptiles, are at their lowest and bait degradation due to rainfall, ants and hot, dry weather is significantly reduced. The baiting was conducted from a plane, which deployed the baits at predetermined drop



Far left Collecting samples from a feral cat.
Photo – Lucy Clausen/Parks and Wildlife

Left Preparing the *Eradicat*® baits.
Photo – Rob Brazell/Parks and Wildlife

Above Experience gleaned from surveying for western ground parrots has been brought to the project.
Photo – Abby Berryman/Parks and Wildlife

"There are plans for the marsh to be nominated as a Ramsar site and it is listed on the Directory of Important Wetlands because, when in flood, it supports several hundred thousand waterbirds. It is known to harbour populations of threatened species such as the bilby and has several plant species that are endemic to the samphire shrubland that are integral to the wetland."

points. The plane flew at a nominal speed of 130 knots at 500 feet and a GPS point was recorded on the flight plan each time a cluster of baits was dropped. The 'bombardier' released 50 baits into each 1km map grid, along flight transects 1km apart to achieve a ground spacing of baits of about 200m by 50m.

MEASURING RESULTS

Two ways of measuring baiting efficacy were proposed. Firstly, the number of deaths of radio-collared cats was counted and, secondly, changes in the site occupancy of feral cats before and after baiting, based on remote camera detection was observed. Data from radio-collared animals was, unfortunately, precluded due to a combination of issues, including technical failures. However, 'occupancy modelling' provided adequate results. Occupancy modelling addresses the inherent difficulties in estimating numbers of cryptic, secretive, far-ranging carnivores that occur in low abundances. Determining occupancy levels is often used as a surrogate measure when determining actual abundance is not practical. It calculates the probability of a particular animal being at a given site, in this case a camera trap. In addition, occupancy surveys support lower sample sizes than abundance surveys. In 2012, 2767 'camera nights' were achieved while, in 2013, 4660 camera nights were achieved. The images collected provided data on feral cat presence and also a suite of other fauna species.

A significant decline in site occupancy by feral cats in the baited area was observed in both years after baiting. These results are similar to the cat declines observed following baiting campaigns in other sites, from the rangelands to the South Coast. Of particular relevance was the data collected by the team from Cape Arid National Park on the South Coast following feral cat baiting programs conducted during the past four years. Populations of the critically endangered western ground parrot, the most closely related species to the night parrot, appear to have stabilised and populations of the southern brown bandicoot or quenda (*Isoodon obesulus*) increased significantly.

Despite the initial problems with the GPS radio-collars, some very useful data on feral cat activity patterns and habitat use is emerging. The data that has already been collected, combined with what is expected to be collected in the future, will form the basis of a more strategic approach to baiting to replace the blanket operation currently being employed. This information will be combined with knowledge of the presence

and extent of water in the marsh, which occurs irregularly and is variable, but is also important in defining feral cat habitat preferences. Knowledge of cat movement patterns and habitat use will enable a more focused approach to baiting activities, making them more effective and cost-efficient.

A GREATER PERSPECTIVE

In addition to the feral cat work being conducted on the marsh, the project team is evaluating the area for threatened mammal and bird species listed under the EPBC Act. Due to their obvious scarcity, there are tremendous challenges in both detecting and monitoring these species. Surveys have been conducted for suitable northern quoll (*Dasyurus hallucatus*) habitat, and none was identified in the marsh project area. Signs of the bilby, a highly nomadic species, were observed when remote camera trapping sites were established. A single animal was detected on a remote camera in 2012. Signs of bilbies are uncommon in the marsh, and monitoring of areas of activity will be increased in future years. Brush-tailed mulgara (*Dasycercus blythi*) habitat occurs throughout the baiting area, although no animals have been detected and previous surveys have only found this species in small areas outside the baiting area.

In 2013 Parks and Wildlife teams started surveying the area for birds, using distance sampling and deployment of autonomous recording units (ARUs). The information collected provides baseline data to help measure the impact that feral cat control can have on populations of native birds. Of the birds listed in the EPBC Act that were previously recorded at the marsh, only one species – the rainbow bee-eater (*Merops ornatus*) – was observed. No other listed species – which includes the night parrot, sighted once in 2006, and the fork-tailed swift (*Apus pacificus*), a summer migrant to Australia – were recorded. While many of the rarer birds are likely to benefit from feral cat control, their low numbers mean they are often difficult to detect. So the project team has identified a number of more common ground-dwelling birds that are also likely to respond positively to a decrease in predation pressure from cats. These species will be monitored using cameras and ARUs to track their trends.

The group also hopes that recordings from the ARUs will help to detect other birds of conservation interest, in particular the night parrot.

Although still in its early days, the research conducted so far shows considerable promise for the provision of long-term, sustained and effective feral cat control at Fortescue Marsh. The program demonstrates that collaboration between a conservation agency and a mining company can potentially provide the first step to the reconstruction and conservation of biodiversity for this important area in northern WA where night parrots may eventually become a more commonly seen bird.

Above right Plumed whistling ducks (*Dendrocygna eytoni*) at Minga Well.
Photo – Sarah Comer/Parks and Wildlife

Right *Eradicat*® baits.
Photo – Louisa Bell/Parks and Wildlife

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5.2 Appendix 2 – Full list of birds recorded on Fortescue Marsh

Species	Scientific Name	Cons. Status	Calls Recorded	2014						2013						2012			
				On Camera	On ARU	6/5 - 22/5	12/6 - 16/6	4/7 - 9/7	25/7 - 31/7	On Camera	On ARU	18/5 - 31/5	16/6 - 23/6	15/7 - 20/7	16/8 - 27/8	On Camera	4/7 - 15/7	7/8 - 12/8	31/8 - 15/9
Australasian Grebe	*Tachybaptus novaehollandiae*					A	A							A	A				
Australasian Pipit	*Anthus novaeseelandiae*			Y		Y	Y	Y	Y	Y	Y	Y	Y	B		Y	Y	Y	Y
Australian Bustard	*Ardeotis australis*	P4		Y		Y	Y	Y	B	Y		Y	B	B		Y	Y	Y	Y
Australian Darter	*Anhinga novaehollandiae*											B						A	
Australian Hobby	*Falco longipennis*					B		A				B	B				B	C	A
Australian Magpie	*Gymnorhina tibicen*					A										Y	B	B	A
Australian Owlet-nightjar	*Aegotheles cristatus*					B				Y									
Australian Pelican	*Pelecanus conspicillatus*					B	B	B										A	
Australian Pratincole	*Stiltia isabella*							B			Y		B					B	
Australian Ringneck	*Barnardius zonarius*		Y			B	B	Y	B		Y	B	B	B	A			B	
Australian Shelduck	*Tadorna tadornoides*		Y			B	B		B				B					A	
Australian White Ibis	*Threskiornis molucca*						B												
Black Falcon	*Falco subniger*						A					B	B				A	C	A
Black Honeyeater	*Sugomel niger*		Y				B				Y		B	B			B	B	
Black Kite	*Milvus migrans*					B	A	B	B			A	A	B	B		A	B	A
Black Swan	*Cygnus atratrus*					B	B	B											
Black-breasted Buzzard	*Hamirostra melanosternon*					B							Y					B	
Black-chinned Honeyeater	*Melithreptus gularis*												?B						
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		Y			Y	B	B	B			B	B		B		Y	Y	Y
Black-faced Woodswallow	*Artamus cinereus*		Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	B	Y	Y	Y	Y

Species	Scientific Name	Cons. Status	Calls Recorded	2014						2013						2012			
				On Camera	On ARU	6/5 - 22/5	12/6 - 16/6	4/7 - 9/7	25/7 - 31/7	On Camera	On ARU	18/5 - 31/5	16/6 - 23/6	15/7 - 20/7	16/8 - 27/8	On Camera	4/7 - 15/7	7/8 - 12/8	31/8 - 15/9
Black-fronted Dotterel	*Elseyornis melanops*					A	A	B	B			B	B	B	A		C	A	A
Black-shouldered Kite	*Elanus axillaris*							C	B			B	B		B		B	C	C
Black-tailed Native-hen	*Tribonyx ventralis*												B	B	B				
Black-winged Stilt	*Himantopus himantopus*					B	B	B							B			A	
Blue-winged Kookaburra	*Dacelo leachii*							A?										A	
Bourke's Parrot	*Neopsephotus bourkii*					Y	C	B	C			Y	Y	B	A	Y			
Brown Falcon	*Falco berigora*					Y	Y	Y	Y			Y	Y	B	B	Y	Y	Y	Y
Brown Goshawk	*Accipiter fasciatus*					A		A	B	Y		B	Y	B		Y	B	Y	B
Brown Honeyeater	*Lichmera indistincta*		Y			B		A					Y				B	B	B
Brown Quail	*Coturnix ypsilophora*					B	B	C	B	Y						Y		B	
Brown Songlark	*Cincloramphus cruralis*			Y		Y	B	B	B	Y	Y	Y	B	B		Y		Y	Y
Caspian Tern	*Hydroprogne caspia*							B											
Chestnut-breasted Quail-thrush	*Cinclosoma castaneothorax*					B							B						
Chestnut-rumped Thornbill	*Acanthiza uropygialis*					B	B	B	B		Y		B	B	B				
Cockatiel	*Nymphicus hollandicus*		Y			Y	B	Y	Y		Y	B	B	B	B	Y	Y	Y	Y
Collared Sparrowhawk	*Accipiter cirrocephalus*			Y								B				Y		A	B
Common Bronzewing	*Phaps chalcoptera*			Y		B		B	Y	Y			B	B		Y	A	A	Y
Crested Bellbird	*Oreoica gutturalis*		Y	Y		Y	B	Y	Y		Y	Y	Y	B	B	Y	Y	Y	Y
Crested Pigeon	*Ocyphaps lophotes*		Y	Y		Y	Y	Y	Y		Y	Y	Y	Y	B	Y	Y	Y	Y
Crimson Chat	*Epthianura tricolor*		Y	Y		Y	B	B	Y	Y	Y	Y	Y	B	B	Y	Y	Y	Y
Diamond Dove	*Geopelia cuneata*		Y			Y	Y	Y	Y	Y		Y	Y	Y	B	Y	Y	Y	Y

Species	Scientific Name	Cons. Status	Calls Recorded	2014						2013						2012			
				On Camera	On ARU	6/5 - 22/5	12/6 - 16/6	4/7 - 9/7	25/7 - 31/7	On Camera	On ARU	18/5 - 31/5	16/6 - 23/6	15/7 - 20/7	16/8 - 27/8	On Camera	4/7 - 15/7	7/8 - 12/8	31/8 - 15/9
Eastern Barn Owl	*Tyto javanica*											B							
Eastern Great Egret	*Ardea modesta*	3*				B		B										C	
Elegant Parrot	*Neophema elegans*					B						B	B	B					
Emu	*Dromaius novahollandiae*			Y						Y			B				B	B	B
Fairy Martin	*Petrochelidon ariel*														B			A	C
Galah	*Eolophus roseicapillus*		Y	Y		B	B	B	Y	Y		Y	Y	Y	B	Y	Y	Y	Y
Great Cormorant	*Phalacrocorax carbo*					B		B											
Grey Butcherbird	*Cracticus torquatus*			Y		B		B					B	B					
Grey Falcon	*Falco hypoleucos*	1				A	B	B							A				
Grey Honeyeater	*Conopophila whitei*												?B				?B		
Grey Teal	*Anas gracilis*					B	B	B	B			B	B	B	B				A
Grey-crowned Babbler	*Pomatostomus temporalis*		Y			B					Y	B	A	B				A	Y
Grey-headed Honeyeater	*Lichenostomus keartlandi*					A	A	A	A			A	B		A				A
Ground Cuckoo-shrike	*Coracina maxima*					A										Y		C	
Gull-billed Tern	*Gelochelidon nilotica*						B												
Hooded Robin	*Melanodryas cucullata*					B						B	B			Y	B		
Horsfield's Bronze-cuckoo	*Chalcites basalis*										Y		B						
Horsfield's Bushlark	*Mirafra javanica*			Y		B	Y				Y	Y	Y	B		Y	Y	Y	Y
Little Black Cormorant	*Phalacrocorax sulcirostris*						B	B										A	
Little Button-quail	*Turnix velox*			Y		B	B	Y	Y	Y		B	Y			Y	Y	Y	Y
Little Corella	*Cacatua sanguinea*					B	B	B	B			B	B	B	B		B	B	Y
Little Crow	*Corvus bennetti*												B			?	B	B	A
Little Eagle	*Hieraaetus*					B							B				B	A	B

Species	Scientific Name	Cons. Status	Calls Recorded	2014						2013						2012			
				On Camera	On ARU	6/5 - 22/5	12/6 - 16/6	4/7 - 9/7	25/7 - 31/7	On Camera	On ARU	18/5 - 31/5	16/6 - 23/6	15/7 - 20/7	16/8 - 27/8	On Camera	4/7 - 15/7	7/8 - 12/8	31/8 - 15/9
	morphnoides																		
Magpie-Lark	*Grallina cyanoleuca*		Y	Y		A	B	B	B		Y	Y	Y	B	B	Y	B	B	Y
Masked Woodswallow	*Artamus personatus*		Y				B		B		Y	Y	Y	B	B			B	Y
Mistletoebird	*Dicaeum hirundinaceum*												B						
Nankeen Kestrel	*Falco cenchroides*			Y		Y	Y	Y	Y	Y		Y	Y	Y	B	Y	Y	Y	Y
Orange Chat	*Epthianura aurifrons*			Y		B		B	B				B	B				C	
Oriental Plover	*Charadrius veredus*	3*																	B
Pacific Black Duck	*Anas superciliosa*						B	B							A			A	
Painted Finch	*Emblema pictum*					A	A								A				
Pallid Cuckoo	*Cacomantis pallidus*					B			C			A							
Peaceful Dove	*Geopelia striata*		Y															A	
Peregrine Falcon	*Falco peregrinus*					B													
Pied Butcherbird	*Cracticus nigrogularis*		Y	Y		B	B	B	B		Y	B	Y	B	A	Y	Y	Y	Y
Pied Honeyeater	*Certhionyx variegatus*		Y								Y		B	B			?B		
Pink-eared Duck	*Malacorhynchus membranaceus*											A	B	B					
Plumed Whistling-duck	*Dendrocygna eytoni*											B		B	B		A		
Rainbow Bee-eater	*Merops ornatus*	3*	Y			B	B		B			Y	B	B	B		B	A	B
Red-backed Kingfisher	*Todiramphus pyrrhopygius*					B		B	Y			B	B		B		Y	B	A
Red-browed Pardalote	*Pardalotus rubricatus*					A	A	A	A			A	B				B	B	A
Red-capped Plover	*Charadrius ruficapillus*																	C	
Red-capped Robin	*Petroica goodenovii*		Y									B	B		B	Y	B	Y	B
Red-kneed Dotterel	*Erythrogonys cinctus*											B	B	B	B				

Species	Scientific Name	Cons. Status	Calls Recorded	2014						2013						2012			
				On Camera	On ARU	6/5 - 22/5	12/6 - 16/6	4/7 - 9/7	25/7 - 31/7	On Camera	On ARU	18/5 - 31/5	16/6 - 23/6	15/7 - 20/7	16/8 - 27/8	On Camera	4/7 - 15/7	7/8 - 12/8	31/8 - 15/9
Red-necked Stint	*Calidris ruficollis*	3*				B												C	
Redthroat	*Pyrrholaemus brunneus*		Y										B					B	
Rufous Whistler	*Pachycephala rufiventris*		Y			Y	B				Y	B	B	B	B		Y	Y	Y
Sacred Kingfisher	*Todiramphus sanctus*																	A	
Singing Honeyeater	*Lichenostomus virescens*		Y			Y	B	Y	Y	Y	Y	Y	Y	B		Y	Y	Y	Y
Slaty-backed Thornbill	*Acanthiza robustirostris*		Y					B	B			Y	B				Y	Y	Y
Southern Boobook	*Ninox novaeseelandiae*															Y			A
Spinifex Pigeon	*Geophaps plumifera*					A	A	A	A			A			B				
Spinifexbird	*Eremiornis carteri*		Y			B	B	B	B		Y	Y	A		B		B	Y	B
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		Y			Y	Y	Y	Y		Y	B	B	Y	B		Y	Y	Y
Spotted Harrier	*Circus assimilis*			Y		Y	Y	Y	Y			Y	B	B	B		Y	Y	Y
Spotted Nightjar	*Eurostopodus argus*			Y		B											A		
Straw-necked Ibis	*Threskiornis spinicollis*		Y	Y		B	B	B				B			B			C	B
Striated Grasswren	*Amytornis striatus*	P4				A													
Stubble Quail	*Coturnix pectoralis*			Y		B										Y			
Swamp Harrier	*Circus approximans*						B									?			
Tawny Frogmouth	*Podargus strigoides*															Y		B	
Torresian Crow	*Corvus orru*		Y	Y		B	B	B	B	Y	Y	Y	Y	B	B	Y	Y	Y	Y
Tree Martin	*Petrochelidon nigricans*												B						
Variegated Fairy-wren	*Malurus lamberti*		Y	Y		B	B	B	B		Y	Y	B		A		C	Y	Y
Wedge-tailed Eagle	*Aquila audax*			Y		Y	B		B			Y	B		B	Y	B	A	B
Weebill	*Smicrornis brevirostris*		Y			A	A	A				B	Y				B	C	

Species	Scientific Name	Cons. Status	Calls Recorded	2014						2013						2012			
				On Camera	On ARU	6/5 - 22/5	12/6 - 16/6	4/7 - 9/7	25/7 - 31/7	On Camera	On ARU	18/5 - 31/5	16/6 - 23/6	15/7 - 20/7	16/8 - 27/8	On Camera	4/7 - 15/7	7/8 - 12/8	31/8 - 15/9
Western Bowerbird	*Ptilonorhynchus guttatus*									Y		B	A			Y			
Western Gerygone	*Gerygone fusca*					C		B					B						
Whiskered Tern	*Chlidonias hybrida*					B?		B?											
Whistling Kite	*Haliastur sphenurus*		Y	Y		Y	B	B	B			Y	Y	B	B	Y	Y	Y	Y
White-bellied Sea-eagle	*Haliaeetus leucogaster*	3*				B													A
White-browed Babbler	*Pomatostomus superciliosus*					B	C	B	B			B	B			Y	C	C	
White-faced Heron	*Egretta novaehollandiae*			Y		B	B	B				B						C	
White-fronted Honeyeater	*Purnella albifrons*										Y		C						
White-necked Heron	*Ardea pacifica*			Y		B	B	B				B	B					A	
White-plumed Honeyeater	*Lichenostomus penicillatus*		Y			Y	B	B	B		Y	Y	B		B		B	B	A
White-winged Fairy-wren	*Malurus leucopterus*		Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	B	B	Y	Y	Y	Y
White-winged Triller	*Lalage sueurii*					B			B			B	B	B	B		Y	Y	Y
Willie Wagtail	*Rhipidura leucophrys*		Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	B	B	Y	Y	Y	Y
Yellow-billed Spoonbill	*Platalea flavipes*					B		B										A	
Yellow-throated Miner	*Manorina flavigula*		Y			B	B	B	Y			Y	B		B	Y	B	Y	Y
Zebra Finch	*Taeniopygia guttata*		Y	Y		Y	Y	Y	Y	Y	Y	Y	Y	Y		Y	Y	Y	Y

Codes

A	Adjacent to either B or C but presumed that species may use study area (N.B. B or C overrides A in table)
B	Baited cell only
C	Control only
Y	Both B and C

?	Possible sighting (not definite)
1	Conservation Code: Included under Schedule 1 of WA Wildlife Conservation Act (1950) (updated November 2012)
3	Conservation Code: Included under Schedule 3 of WA Wildlife Conservation Act (1950) (updated November 2012)
*	Conservation Code: Included under EPBC Migratory Species List (JAMBA/CAMBA/Bonn Convention)
P4	Conservation Code: Priority 4 under WA Wildlife Conservation Act (1950)