Fortescue Marsh Feral Cat Baiting Program
(Christmas Creek Water Management Scheme)
Year 5
Annual Report

November 2016

Department of
Parks and Wildlife

Prepared by

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Front cover Plate 1: Samphire *(Tecticornia indica bidens)* community   L. Clausen/DPAW

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The following permits were obtained to conduct this work:

- Capture and radio collaring of feral cats was conducted under Department of Parks and Wildlife Animal Ethics Committee permit AEC 2012/42, AEC 2013/07 and AEC 2016/25
- The Australian Pesticides and Veterinary Medicines Authority issued PER14102ver2 allowing the use of the feral cat bait *Eradicat®* on the Fortescue Marsh
- ATV on and off track use, Department of Transport ref:10V28C7ZQ3

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 PER14102ver2. The work conducted on the Fortescue Marsh was implemented in an adaptive framework to determine the most efficient and cost-effective method to target feral cats in this environment.

Fortescue Metals Group (Fortescue) 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, this program aimed to reduce predation impacts from feral cats on the native fauna of this environment, in particular, the threatened species listed under the Act. This program began in 2012 with monitoring of baiting efficacy through camera surveillance and radio-telemetry collars with an additional measure through genetic analysis, conducted in 2016.

This report discusses the methods and results of 2016 with a summary of the results of the five year feral cat baiting project on Fortescue Marsh.

In 2016, *Eradicat®* baits were aerially distributed over a 998 km² area of the Fortescue Marsh in late-July. Seventeen feral cats trapped within the treatment area were monitored with radio-collars and the probability of occupancy was assessed prior to, and following baiting using camera traps at 64 treatment and 30 control sites.

Eradicat® baiting of the Fortescue Marsh resulted in an 82% knockdown of radio-collared feral cats. This impact was supported by occupancy modelling using remote camera data, which also demonstrated a significant effect of baiting in the treatment cell when compared to a control. Both the random and spatial models detected a decline in occupancy of approximately 50%.

Over the life of the project, annual baiting has had a statistically significant impact on the population of feral cats (Table 1). The level of this impact is influenced by the timing of the bait delivery and the environmental conditions with drier conditions resulting in a greater knockdown effect. The 2012 results differ from this trend but these results are skewed by the location of the cameras which were positioned south of the Marsh (where personnel were camped) due to wet conditions limiting access to the north.

Table 1. Baiting impact determined from radio- collars and occupancy modelling, 2012-2016.

	% impact		
	Collars	**Random Model**	**Spatial Model**
2012	na	75	60
2013	na	30	30
2014	70	10	25
2015	37	20	15
2016	82	50	50

Survey for EPBC listed species including the Bilby (*Macrotis lagotis*), Mulgara (*Dasycercus cristicauda*) were targeted with camera-traps located in suitable habitat. Neither of these species were detected in 2016.

Audio units programmed to specifically target Night Parrots (*Pezoporus occidentalis*) were set during July. The data from these units have been analysed for other target bird species but the analysis for Night Parrots is to be conducted outside of this project.

An incidental Ghost bat (*Macroderma gigas*) record was collected, where an individual was found dead, caught in a barbed wire fence near Minga Bore. This species had previously not been identified as present on Marsh but is listed as Vulnerable under the EPBC Act.

1 Background

On behalf of Fortescue Metals Group, the Department of Parks and Wildlife implemented the 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 which include:

a) comprehensive landscape scale feral cat baiting program (across a minimum 150,000 ha (1,500 km²) 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 was covered by a number of pastoral leases until July 2015, when portions of the leases were relinquished and returned to the State as Unallocated Crown Land (UCL), Figure 1.

Until early 2015, landscape-scale baiting of feral cats using *Eradicat*® was in an experimental phase with this project covered under Experimental Permit issued by the Australian Pesticides and Veterinary Medicines Authority No. PER14102. The registration of *Eradicat*® in January 2015 did not alter the way in which the rest of this project was delivered.

The total project area was designed with a treatment cell of 1,240 km² and a control cell of 436 km² and risk assessed area of 1,000 km² to be treated with baits in any one year (Figure 1). The treatment cell is located at the eastern end of the study area, where the Marsh is at its widest. In 2016, the total area treated was 998 km².

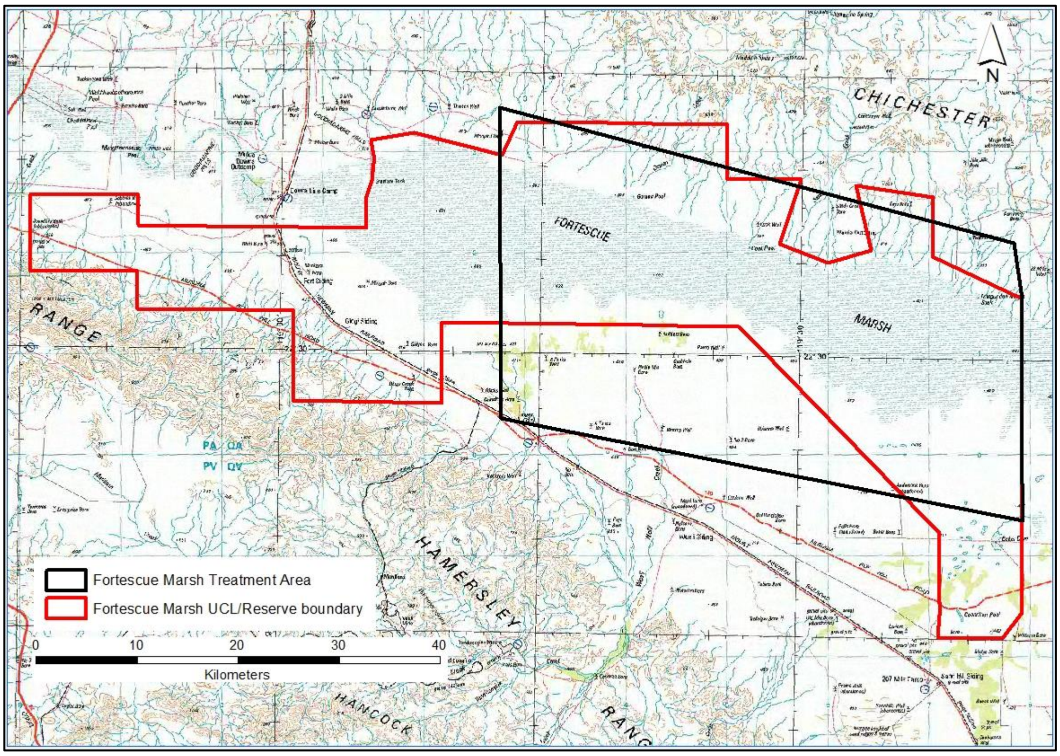


Figure 1. The treatment area for the last five years (black) with the area of land (red) that was relinquished from pastoral leases in 2015.

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 2).

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 330 mm at Newman. Temperatures are high, with summer maxima typically 37–39 °C and winter maxima 23–26 °C (BoM 2016).

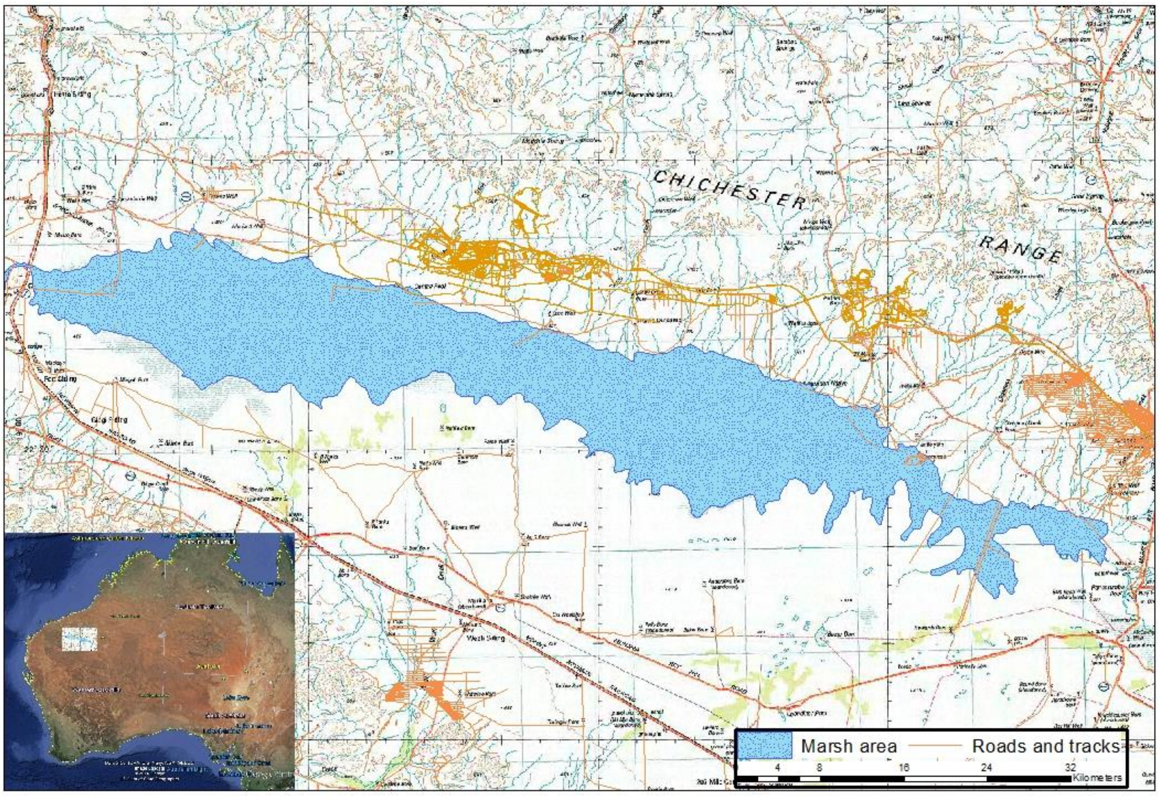


Figure 2. Location and regional setting of the Fortescue Marsh

Botanical surveys conducted for Fortescue's Cloudbreak Iron Ore Project Public Environmental Review included descriptions of the fringing vegetation of the Marsh with five distinct vegetation communities identified by Mattiske Consulting Services (2005) (cited in Fortescue 2009). Markey *et al*. (2016) re-mapped the vegetation communities and floristic values of the Marsh between 2014 and 2016, producing a product to compliment other work being carried out on the Marsh. Twenty-one floristic community units were identified in the Marsh with 128 permanent monitoring plots established.

1) *Tecticornia pergranulata* dominated low shrublands;
2) *Tecticornia medusa/Tecticornia pergranulata* low shrublands;

3) *Tecticornia globifera/Tecticornia pergranulata/Tecticornia indica* subsp. *bidens* samphire shrublands;
4) Species poor *T. auriculata* dominated samphires;
5) *Tecticornia indica* subsp. *bidens, Eromophila spongiocarpa* mixed samphire shrublands;
6) *Marginal Tecticornia indica* subsp. *bidens, Eromophila spongiocarpa* mixed samphire shrublands;
7) Low *Tecticornia* sp. Dennys Crossing samphire shrublands;
8) Tall *Melaleuca xerophila* over samphires and chenopods marginal shrublands;
9) *Eragrostis dielsii, Tecticornia indica* subsp. *bidens, Tecticornia indica subsp. leiostachya, Atriplex amnicola, Cullen cinereum* on margins, eastern distribution, poorly sampled;
10) *Eragrostis dielsii, Tecticornia indica* subsp. *bidens, Tecticornia auriculata,* widespread, more samphire taxa;
11) *Eragrostis dielsii, Muellerolimon salicorniaceum* and/or *Tecticornia indica* subsp. *bidens* shrublands to shrubby *Eragrostis dielsii* grasslands, widespread;
12) *Muellerolimon salicorniaceum* and *Tecticornia indica* subsp. *bidens* samphire shrublands, inundated and widespread;
13) *Muellerolimon salicorniaceum* and mixed *Tecticornia* samphire shrublands;
14) *Eucalyptus camalduensis* subsp*. obtuse* woodland */ Acacia ampliceps* shrubland;
15) Floodplain alluvial *Eucalyptus victrix, Acacia coriacea* open woodland and saltbush/lignum shrublands;
16) Lignum (*Duma florulenta*) and samphire shrublands / *Sporobolis* grasslands;
17) *Eucalyptus victrix, Acacia synchronicia*, lignum (*Duma*) and samphire shrublands and woodlands;
18) Gypsum outcrop shrublands*;*
19) *Acacia* shrublands over succulent chenopods on stony plains;
20) Alluvial *Acacia synchronicia /* saltbush shrublands on ephemeral drainage lines*;*
21) Triodia hummock grasslands or Acacia shrubands / Triodia grasslands.

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 2) 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, and has been adjusted to incorporate contemporary findings. For preceding years, similar tables can be found in each annual report.

Table 2. Works program as per Algar *et al*. (2011) with timings and achievements for 2016 unless otherwise specified.

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	• 2012 • 2012 • Feb – annually	• Risk Assessments completed • Funds transferred • Liaison through email

Activity	Action	Completion Date	Achievement
	to Department of Parks and Wildlife.		
Stakeholder liaison	• Consent and indemnity letters	• 1 May 2012	• 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	• 13 – 22 May • 4 – 10 June • 5 – 22 May • May - Sept ('Native' - Mulgara and Bilby cameras) • Not applicable 15 Jun – 20 Jun	• 64 and 30 cameras established as Treatment and Control Cells respectively • 19 feral cats captured, 17 collared • 25 cameras set at older plant communities, targeting fresh diggings • 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.	• 26 July	• First post-bait flight. 13/17 collars detected. 7 cat deceased, 6 from baits.
Bait delivery	• Bait preparation	• 21 & 22 July	• All baits (no wet areas) delivered across 99,800 ha (998 km^2) over 1.5 days
Bird surveys	• Set up program and conduct surveys. • Service monitoring trap stations.	• 20 June – 3 Aug	• 18 Autonomous Recording Units (ARU) deployed
Monitoring flights	• Conduct monitoring flights/ground traverses to ensure the status of collared animal • Radio collar retrieval	• 30 Sept • See above	• 12/17 collars located and retrieved. Two additional bait deaths confirmed • See above
Complete	• Complete bird surveys	• 5 May – 30 Aug	• 14/18 ARUs recorded

Activity	Action	Completion Date	Achievement
Program	• Complete camera survey	• 22 May – 30 Aug	for whole survey, 4 units malfunctioned • 3507 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 • Camera surveys instead May - Sept	• This report • This report • 2384 camera trap-nights
Reporting to FMG	• Report prepared on previous 12 months of activity and submitted to Fortescue	• This report	
Report to DoE	• 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	

An examination of the 2015 results provided the basis for the following recommendations being suggested for incorporation of the 2016 program:

1) *GPS collar data retrieved from cats data to be reviewed to determine if there are preferences for habitat that can inform bait delivery strategies can be refined to improve efficacy of delivery;*
2) *Continue the native species (EPBC Act species) monitoring through un-lured camera trap detections;*
3) *Focus on collaring cats in the centre and south of the Marsh (to provide additional GPS datasets from vegetation assemblages not well represented in data collected between 2013–15).*

2 Method

2.1 Timing

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 reptiles (Algar *et al*. 2007) when working in arid zones. 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

The study area (Figure 1) has been consistent for the five years of this project with a treatment (where *Eradicat*® baits would be distributed) and a control cell (where no baits are deployed) located in the relinquished pastoral leases of 2015.

Ground access around the study area in 2016 was unimpeded by environmental conditions, with little summer rainfall and few winter showers.

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 Marsh water levels would impact on the actual area baited each year. The overall treatment area encompasses 1,240 km² with no more than 1,000 km² being baited in any one year. At the request of station managers, a buffer zone of 1 km for both baiting and monitoring activities was provided around active bores and wells within the treatment cell.

The treatment cell in 2016 was identical to 2015, with an area of 998 km² targeted for baiting (Figure 3), and baits delivered with the understanding that the true area available for baiting could be less to allow for space taken by the surface water at the time of bait delivery.

2.2.2 Control Cell

The control cell was established for camera monitoring, and encompasses an area of 436 km² (Figure 3). The independence between the treatment and control cells was maintained with a buffer of a minimum of 5 km to separate treatment and control monitoring sites. This distance was estimated to be at least one average feral cat home range (D. Algar *unpub. data*) at the beginning of the project, and has been used for the duration of the project.

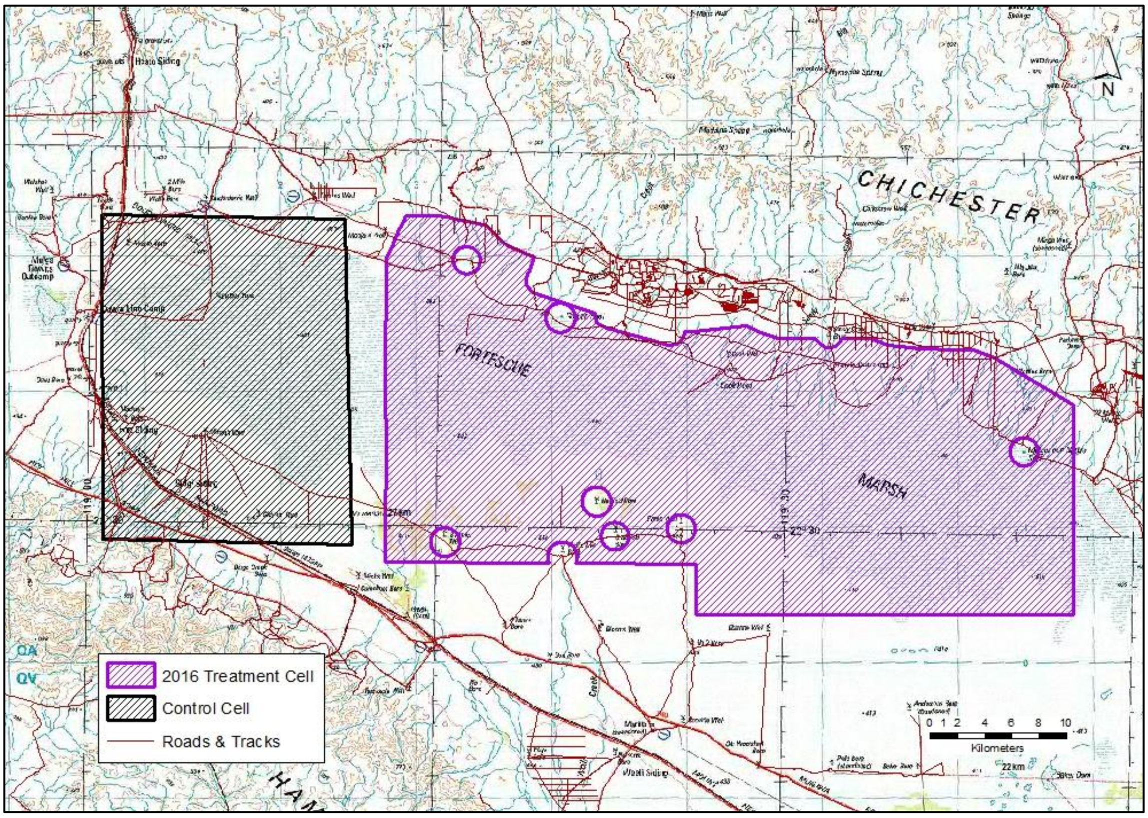


Figure 3.The 2016 study area. Bait exclusion areas around active water bores and wells are represented as circles.

2.3 Weather and Climatic Influences

Plate 2. A temporary weather station was erected in May in the centre of the treatment cell to gather data on climatic conditions during the baiting period. **Photo: L. Clausen**

There has been limited access to accurate climatic data for the Marsh, however in the last 12 months the data from the Fortescue owned weather stations at Cloudbreak and Christmas Creek mining sites have been made readily accessible on the Bureau of Meteorology website.

To obtain more specific climatic data for the Marsh, a temporary weather station (Davis Vantage Vue Wireless Weather Station, Davis Instruments, Cowes Vic) was again installed in the centre of the Marsh for the 2016 season. In previous years, attempts to obtain this site specific climatic data have resulted in errors and corruption of data downloaded from this station. This year, the station was established and tested well before the baiting period in an effort to ensure reliable operation for the crucial time, that is, post baiting.

In 2016, the portable weather station was installed at 50H E 749430 N 7514410 (Plate 2) and was operating from 17 May to 28 August. On two occasions (16 June and 4 August) the unit was brought in from the field to download data and check functionality.

Meteorological data required for this study are focussed around the time of baiting to monitor for precipitation and relative humidity both of which, if at high enough levels, can impact on the effectiveness of bait uptake due to reduced palatability and toxicity of the *Eradicat®* baits.

2.4 Baits and Baiting

The feral cat bait *Eradicat®* used in the Fortescue Marsh baiting program is 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 20 g wet-weight, dried to 15 g, 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 a rate of 4.5 mg of sodium fluoroacetate (compound 1080) per bait. All feral cat baits are sprayed during the sweating process with an ant deterrent compound (Coopex®) at a concentration of 12.5 g 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 Pilbara in the dedicated ''Western Shield'' bait truck, with the Munjina airstrip being used for the first four years. The general use of this airstrip diminished over time resulting in maintenance concerns for the long-term. As a consequence the bait operation was moved to Karijini airstrip in 2016.

On the morning of 21 July, 50,000 baits were arranged on established bait racks at the Karijini 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 distributed through a carousel to give an approximate 200 m long by 40 m wide bait swathe. The baiting operation was conducted over two days, the 21 and 22 July.

2.5 Feral Cats

A three-pronged approach to measuring baiting efficacy was implemented. Firstly, a measure of direct mortality was obtained from radio-collared cats; secondly, site-occupancy indices of pre- and post-baiting were obtained through camera trapping in treatment and control sites and thirdly, analysis of captured cat genetics were used to determine changes to genetic diversity and to estimate effective population changes over the five years. The first two measures were conducted annually with the genetic work requiring an accumulation of samples before a reasonable sample set could be analysed.

2.5.1 Trapping and GPS/VHS Collaring

Feral cat trapping was conducted under ethics approval AEC 2013/07. The trapping technique involved the use of padded leg-hold traps Victor 'Soft Catch'® traps № 1.5 (Woodstream Corp., Lititz, Pa.; U.S.A.), the smaller trap was employed as per *2014 Recommendation 1*, with cat faeces and urine used as the attractant. Trap sets were parallel to tracks, along the verge, every 0.5 km – 1.0 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. Locations of trapping transects were based on the previous years' post-bait camera data and collar data. Three transects were established, one on the north of the Marsh, one in the middle and to the west of the treatment cell and the third on the south side of the Marsh (Figure 4).

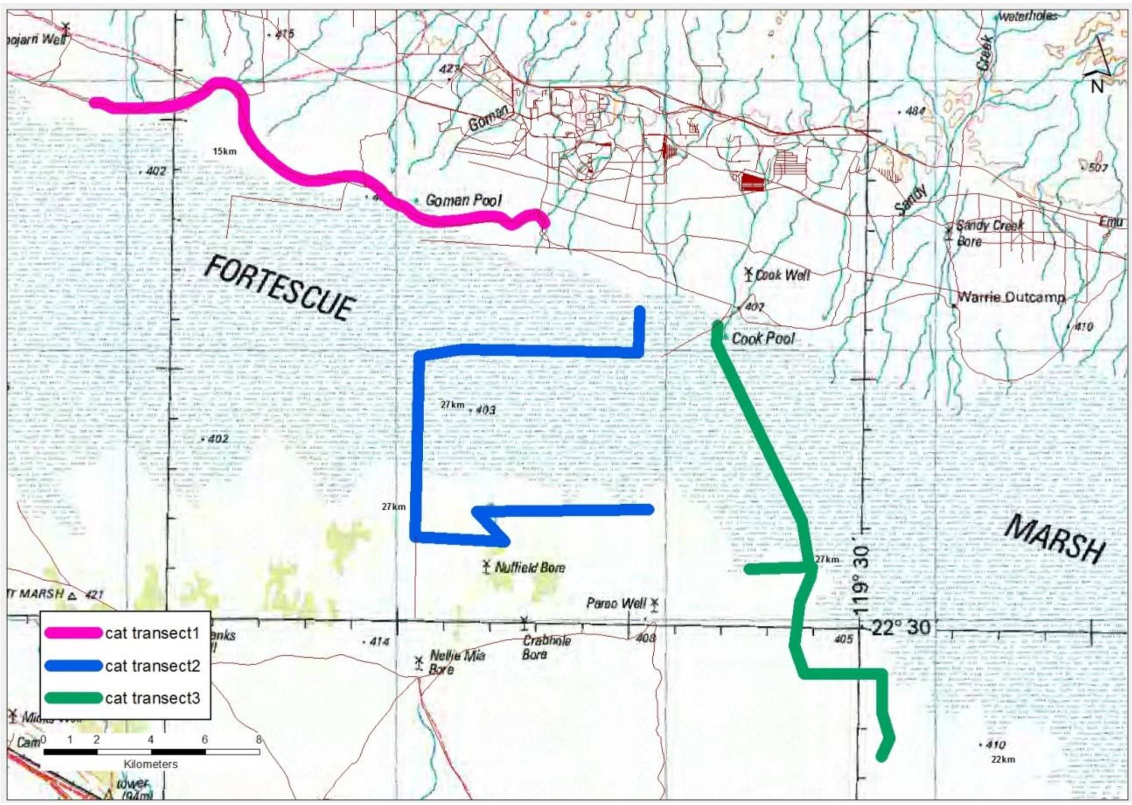


Figure 4. The three feral cat trapping transects operated for nine nights in May, 2016

Trapped cats were sedated with an intramuscular injection of 4 mg/kg Zoletil 100® (Virbac, Milperra, Australia). All animals captured were sexed, weighed and had coat colour recorded. A broad estimation of age (either juvenile, sub-adult or adult) was determined 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 (ATS, Minnesota, USA) and remote download capabilities was fitted to each feral cat caught that had a weight over 1800 g. The collars were programmed to take 24 GPS fixes per day from May until September and to go into mortality mode following 12 hours of inactivity. All cats were released at the site of capture.

2.5.2 Monitoring and Recovery of Radio-collars

Monitoring of collars was primarily conducted from a helicopter in order to maximise the possibility of detection. Two flights were conducted, the first was prior to baiting to ascertain the presence of collared cats in the treatment area and the second, several weeks after baiting was to locate mortalities, download data from animals that survived baiting, and to assist with collar retrieval. In between these flights, during other scheduled works, opportunistic locating of collars was attempted from the ground. In 2016, both flights were scheduled to be post-bait, as the data retrieved from the collars would demonstrate whether the individual was alive or dead at the time of baiting and to double the opportunity of locating post-bait mortalities.

GPS data obtained from collars were filtered to remove points from 1) the day of collar attachment until the day when 24 fixes started; 2) points after the day the collar was recorded motionless; 3) all points where the collar failed to collect a location (e.g. cat in sheltered den site) and 4) inaccurate points where the Horizontal Dilution of Precision (HDOP) was greater than five.

Analysis of collar data was conducted to calculate feral cat activity in determining distances moved per hour, distances moved per day, time of death, movement post bait uptake and home ranges.

Distances moved per hour and distances travelled per day were calculated for each individual (where collar data was retrieved) using Microsoft Excel to ascertain peak activity times and to confirm day of death for the annual cohort.

Bait deaths were determined with analysis of activity data using ArcGIS 10.1, for the period in which the baits had been delivered to when the collar showed inactivity. A time estimate was given for bait uptake based on when the first two hourly movements intersect a bait drop location after the delivery time and prior to the collar becoming stationary. Estimates were calculated for time to death post bait uptake.

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% of points were used, where 5% of data points furthest from the sample mean were removed. This was to reduce the impact of outliers on home range estimates. Only samples with a minimum of three weeks data (i.e. 504 data points) were used. Home range analysis was completed using the Animove for QGIS 1.4.2 Plugin in Quantum 2.8.1 Wien.

2.5.3 Site Occupancy using Remote Surveillance Cameras

Bayesian occupancy models using detection histories at camera sites across the Marsh were 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.

The two occupancy models were run in WinBUGS 1.4 (statistical software used for Bayesian analysis) 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 is 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. Methods followed those used in previous years, and described in Comer *et al*. (in prep.).

In 2016, the treatment and control camera trap grids were established on 3 km^2 spacing, 19–22 May. Thirty camera trap survey sites were established as the control cell and 64 sites were established as the treatment or baited cell (Figure 5). Survey sites in the control cell were located a minimum of 5 km from the boundary of the baited cell.

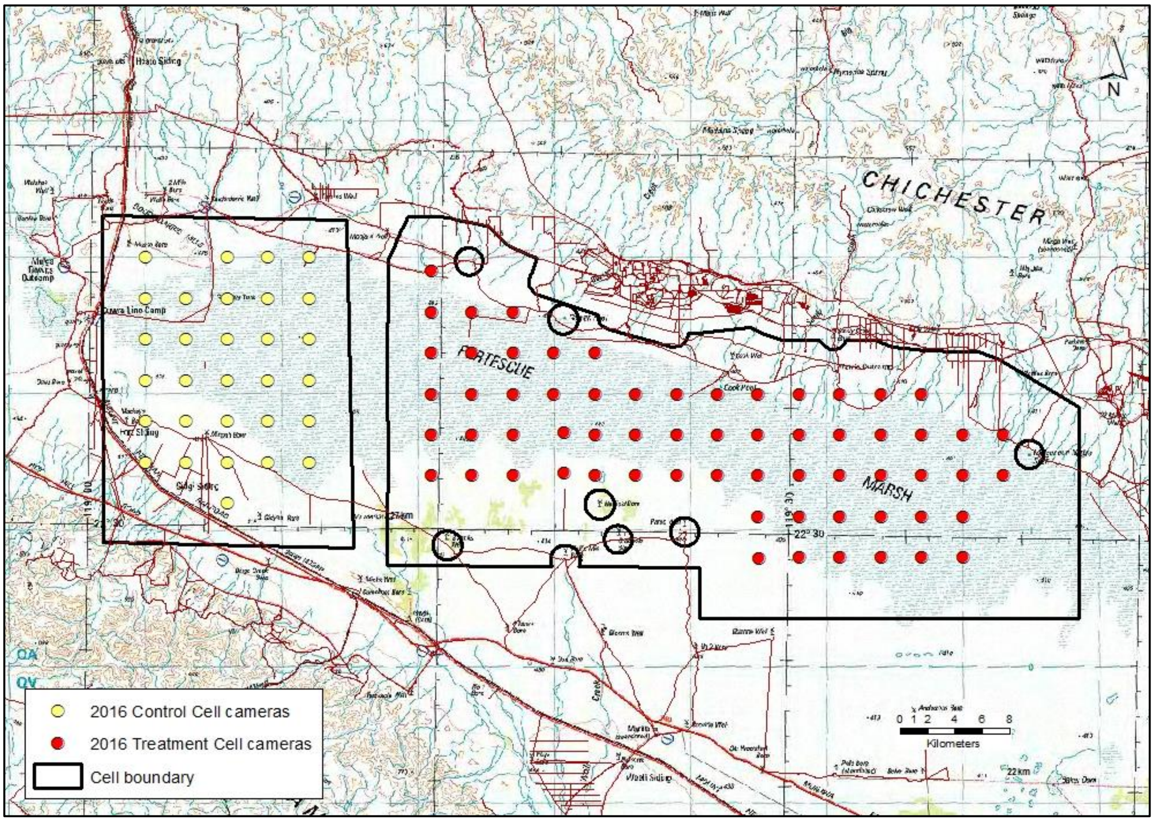


Figure 5. Remote surveillance camera grids for the control and treatment cells in 2016.

Cameras (HC600; Reconyx, Wisconsin, USA) were set horizontally, approximately 30 cm from the ground. Cameras were set on "Scrape" program which records five images per trigger, and image 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 ml glass jar with holed sifter lid containing approximately 15 ml of an oil-based scented lure ('Catastrophic', Outfoxed, Victoria) was attached to a wooden stake approximately 30 cm from the ground. A 1.2 m long bamboo cane was joined to the wooden stake, with white 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 (Plate).

For the occupancy modelling, a capture event is considered as no more than a five minute interval between images within a 24 hour period - from midday to midday - with a presence/absence result recorded.

Plate 3. A remote-camera trap with three lures setup in the control cell. **Photo: L. Clausen/DPAW**

2.5.4 Genetics

Genetic analysis can assist with identifying the relationship of animals located in areas with significant human infrastructure to the feral cat population within the Marsh. Cat ear tissue samples were collected annually from cats trapped on the Marsh and opportunistically from cats captured in the camps.

Samples were prepared for analysis by Yvette Hitchen at Helix Molecular Solutions and were screened for 11 individual short-tandem repeat (microsatellite) loci that were previously characterised for felids (Menotti-Raymond *et al*. 1999; Menotti-Raymond *et al*. 2005) using PCR/fragment analysis. Sixty-five individuals sampled from the Marsh area between 2012 and 2016 were analysed, as well as 14 individuals captured either by Parks and Wildlife or Fortescue personnel around Cloudbreak and Christmas Creek mining infrastructure. These two sample sets were treated as separate populations, Fortescue Marsh (FM) and Fortescue Camps (FC). The locations of sampling sites are shown in (Figure 6).

GENEPOP (version 4.2) (Raymond and Rousset 1995) was used to analyse genetic diversity using departure from Hardy-Weinberg Equilibrium (HWE), F-statistics (FST and FIS) and migration rate (Nm). HP-RARE (Kalinowski 2005) was used to construct allele rarefaction curves as an estimate of the proportion of available genetic diversity that had been captured by the given sample sizes, as well as calculating allelic richness between cohorts. NeEstimator (version 2.01) (Do *et al*. 2014) was used to estimate Effective Population Size (Ne) (the population of reproductive individuals contributing to the next generation) using the Linkage Disequilibrium (LD) and Molecular Coancestry (MCo) methods. The FM sample set was divided into three cohorts (2012–14, 2015 and 2016 captures) and Ne was estimated for each cohort and compared. STRUCTURE (version 2.3.4) (Pritchard *et al*. 2000) was used to infer geographic population structure using a Bayesian model computation. Populations (version 1.2.31) (Langella 1999) was used to produce a phylogenetic tree (Neighbour-Joining) for genetic distance between individuals, which was visualised and edited in MEGA (version 6.06) (Tamura *et al*. 2013).

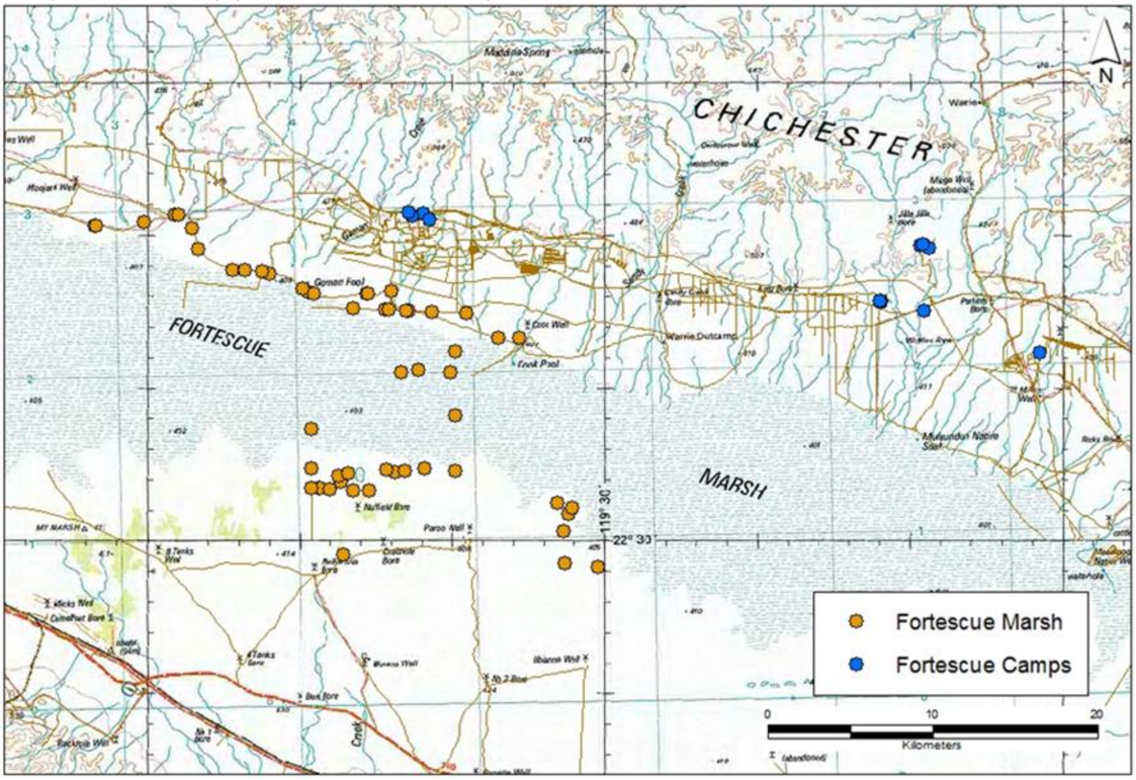


Figure 6. Distribution of collected feral cat tissue samples used in genetic analysis, 2012 – 2016.

2.5.5 Diet Analysis

The diet of introduced predators and their selection of prey can assist with understanding prey community dynamics. It can also be the source for difficult to detect cryptic species that otherwise remain undetected (Paltridge 2002). For the purposes of this project, stomachs were collected opportunistically from introduced predators that were euthanized through the process of trapping and collar retrieval.

Stomach content was weighed, with indigestible material (bones, hair, feathers and exoskeletons) assessed for identification. Hair was identified using the whole mounted and cross-section techniques and the program Hair ID methods (Brunner and Triggs 2002). The remaining material was examined using a dissecting microscope and compared with reference material and texts. For each sample, identification down to the lowest taxonomic level (species) was done undertaken wherever possible.

2.6 Non-target Species

2.6.1 Birds

Sites selected for bird surveys followed on from the method employed in previous years where Autonomous Recording Units (ARUs) (Song Meter SM2+, Wildlife Acoustics, Massachusetts, USA) were placed close to existing camera trap survey locations. ARU 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 7).

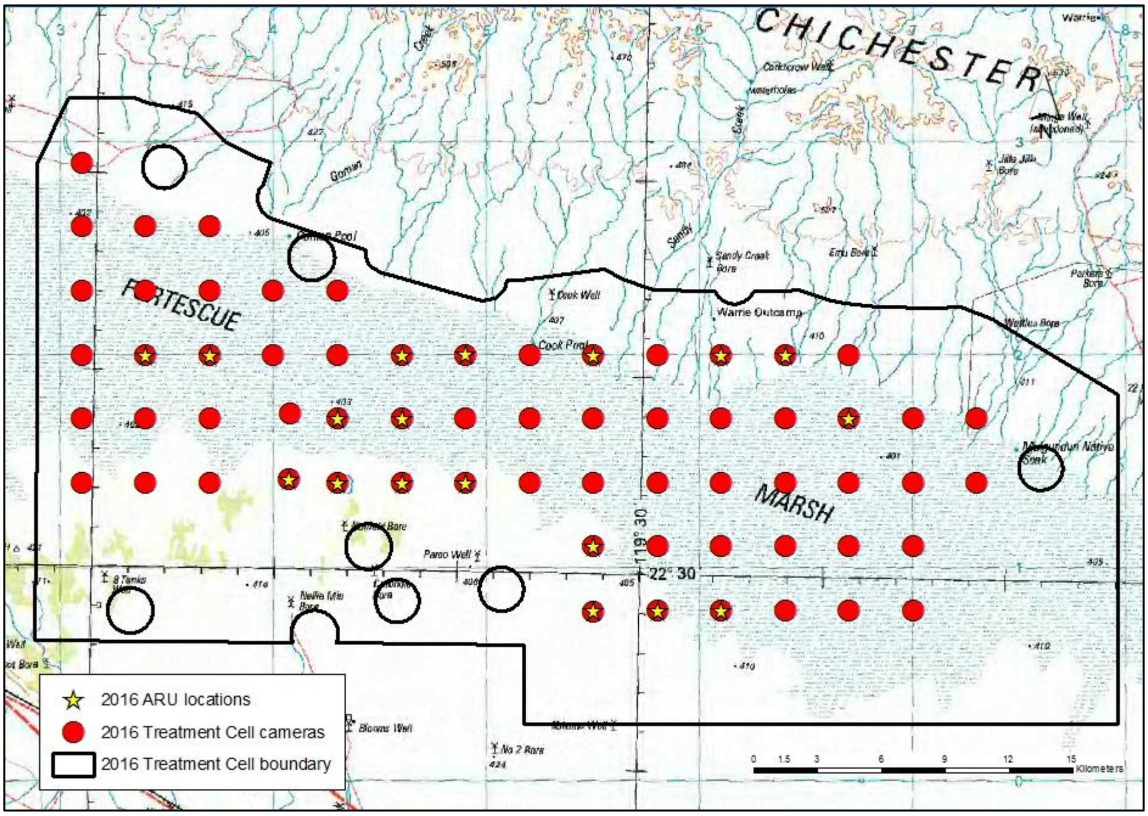


Figure 7. Autonomous Recording Unit (ARU) locations in relation to treatment cell cameras.

Eighteen ARUs were deployed at camera sites with appropriately diverse vegetation communities from 16 June – 6 August and were set to record for three hours at dawn and dusk (incorporating two hours before sunrise and after sunset, thought to be the main time Night Parrots (*Pezoporus occidentalis*) would be calling (Murphy 2015).

Analysis employed the use of sound recognition software SoundID (version 6.00.1) using the Recognition 1-D module in the 64bit beta version. In previous years, multiple bird species were selected for analysis, as identified as potential monitoring targets in the Fortescue Marsh Baiting Plan (Algar *et al*. 2011). However, since previous analyses have recorded relatively low numbers of positive records for most species, in 2016 audio files were only screened for White-winged (*Malurus leucopterus*) (WWFW) and Variegated Fairy-wrens (*M. lamberti*) (VFW) - the most commonly recorded species. This method was used to produce a comparable dataset between the four years when systematic bird surveys have occurred. ARU recordings made in 2013 were also analysed using this method as this had previously been analysed manually (Tiller *et al.* 2013). Furthermore, the Threshold of Distance (ToD) in the SoundID module was standardised across all analyses to 1.75 degrees. The ToD relates to the quantitative difference between a reference call for a species and any sound of identical length in an audio file. Any positive records above the ToD are ignored by the software and this technique aids the discrimination of false positives. The ToD was set at 1.75 degrees as this value was found to be optimal for discerning true and false positives using the original 2013 dataset. To ensure all files were analysed consistently, data from 2014 and 2015 were re-analysed using the ToD of 1.75 degrees.

In addition to ARU recordings, species observed/heard directly during the course of the 2016 field work were noted as well as a number of species which were captured on camera traps.

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 *et al*. 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 observations.

Camera-traps were used in an attempt to detect Bilby or Mulgara at locations that were had floristic complexity and deemed rich with small mammal activity. Five cameras (HC600; Reconyx, Wisconsin, USA) were deployed at five sites (Figure 8), targeting native species across a 2 ha area. All cameras were mounted on pegs approximately 15 cm above the ground, facing an area where there were diggings or an area where an animal might be funnelled by natural features. These were set 3 m from the target for the duration of the feral cat camera-trap survey. All cameras were set to the 'Scrape' program which records five pictures per trigger, and picture interval was on 'RapidFire' which is two frames per second with no quiet period. No cameras were actively lured. A capture event is determined as the presence of an animal, on a single occasion at a camera trap with an independence interval of five minutes.

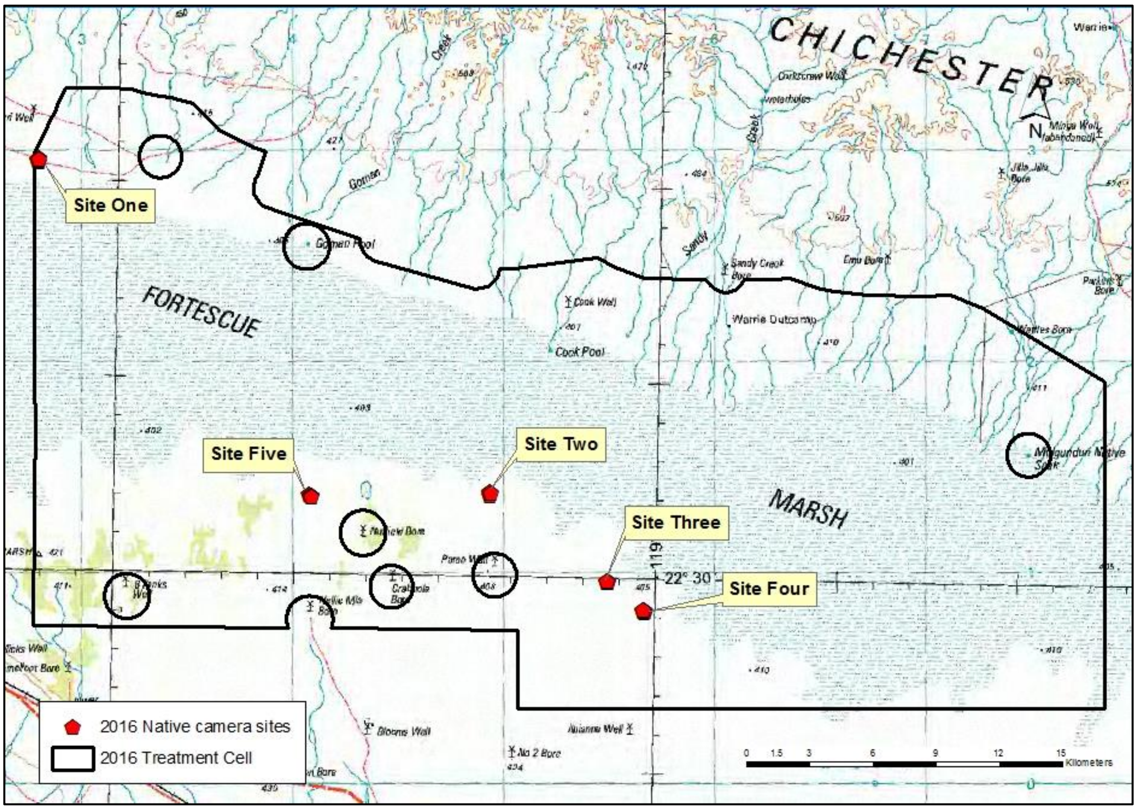


Figure 8. Location of Bilby/Mulgara-targeted cameras for 2016

2.6.3 Incidental Records

Incidental records (sightings, scats, tracks, diggings and images obtained through non-targeted camera-trap surveys) of non-target native species, particularly listed threatened species, were also collected opportunistically during survey work. 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 or Cloudbreak Mine and camp).

Predator scats were collected opportunistically in 2016 as requested by Fortescue. Analysis of material was conducted (G. Story, Scats About, Majors Creek, Australia) to support identification of the predator and consumed prey species. A percentage estimate of each prey species was determined as the quantity of the total sample and where possible multiple individuals of the same species were noted.

3 Results

3.1 Weather and baiting

The Marsh was relatively dry in the context of the 2016 project period (Figure 9), with no effective cyclone events during the preceding wet season and few rainfall events after April. This allowed easy access to all areas of the Marsh for both the field personnel and the cattle (*Bos taurus*) still present within the recently declared Unclassified Crown Land (UCL).

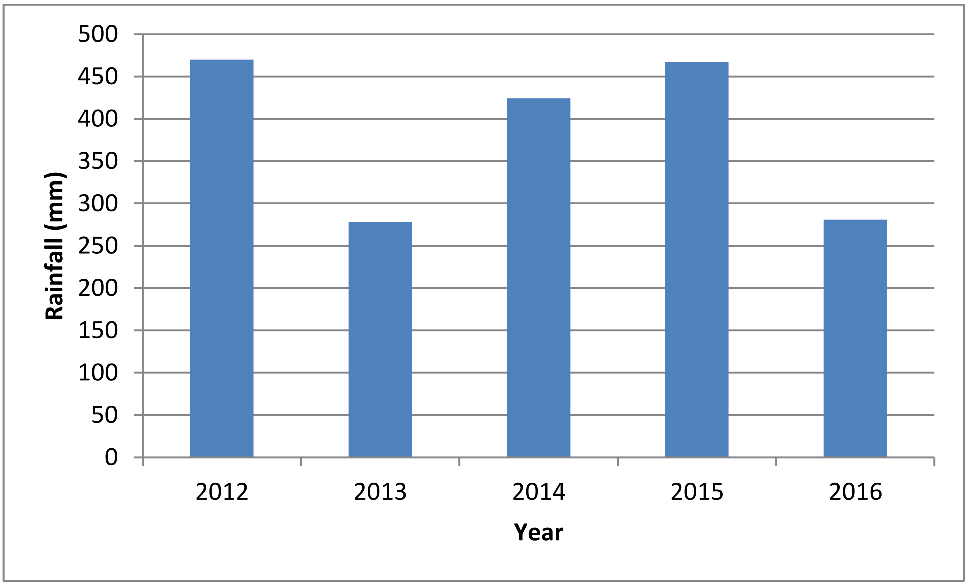


Figure 9. Preceding (October - April) rainfall totals for the period of the project (2012 – 2016) as determined from the nearest rain gauge with complete data; Marillana (BoM 005009)

Bait delivery for 2016 was scheduled for early July but in the lead up to this time there were several coastal fronts of varying intensity that resulted in widespread rain in the west Pilbara (Figure 10). These conditions caused delays to baiting for all the Pilbara projects and as a result the bait delivery for the Marsh was postponed until the end of July.

The portable weather station failed to record data after it was downloaded on 4 August, however there was no further rainfall recorded in the vicinity of the Marsh until 29 August.

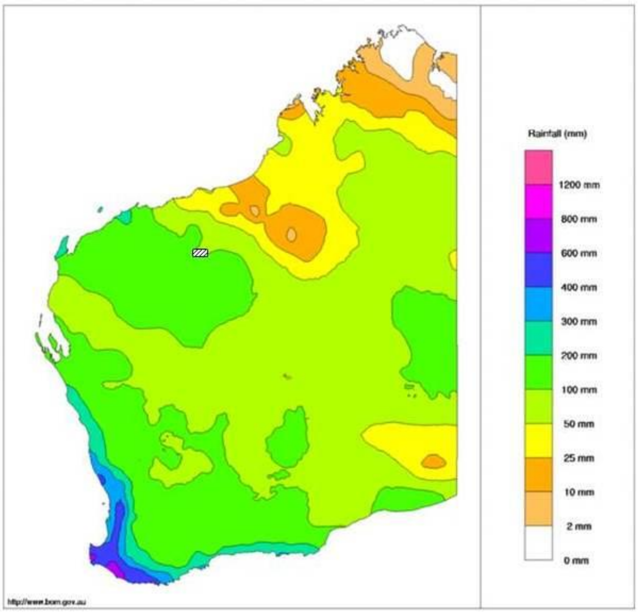


Figure 10. Western Australian rainfall totals (mm) for 1 June – 31 August, 2016 (Australian Bureau of Meteorology) with the Marsh survey area marked (hatched).

Rainfall and relative humidity are factors that can affect the success of a baiting program due to their potential to impact on bait toxicity and palatability. There was no rainfall in the two weeks leading up to the baiting event, and minimal (<1 mm) precipitation on the days following the baiting (Figure 11). The maximum relative humidity was high (over 80%) at the time of bait delivery but quickly dropped below 70% for the duration of the bait period.

At the time of the rescheduled bait delivery (21 and 22 July) there was little if any surface water on the Marsh, resulting in the total area of the treatment cell - 998 km² being baited (Figure 12).

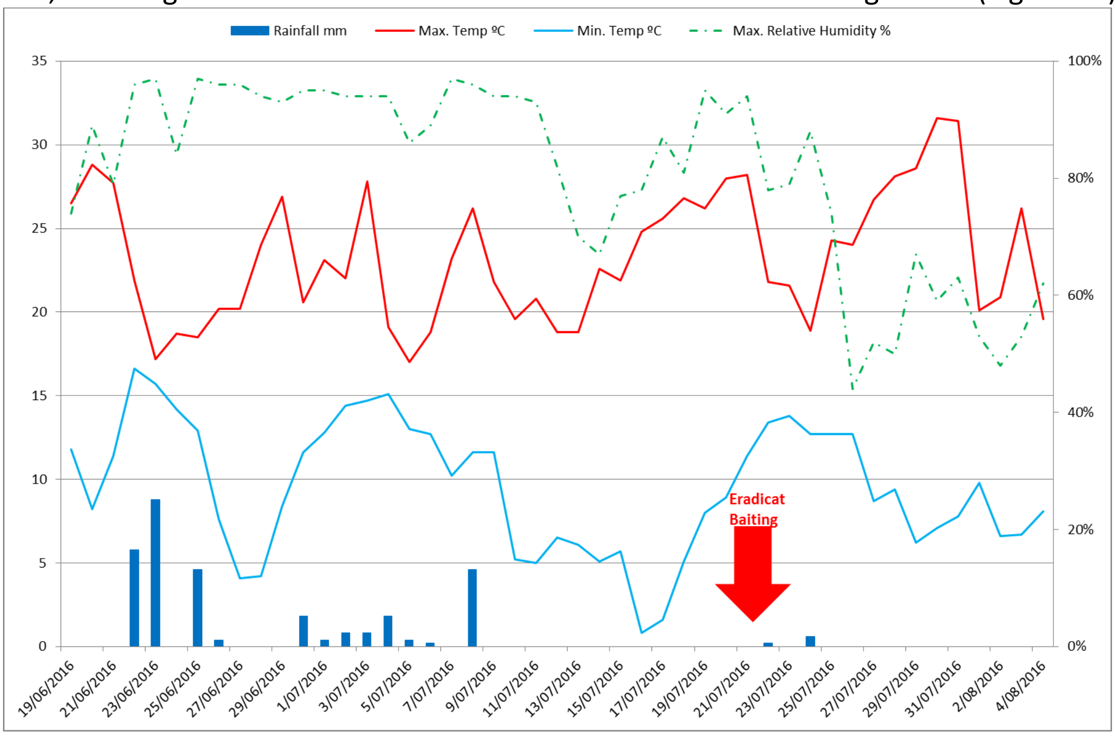


Figure 11. Excerpt of climatic data from the portable weather station that was positioned in the middle of the treatment cell, 17 May – 28 August 2016.

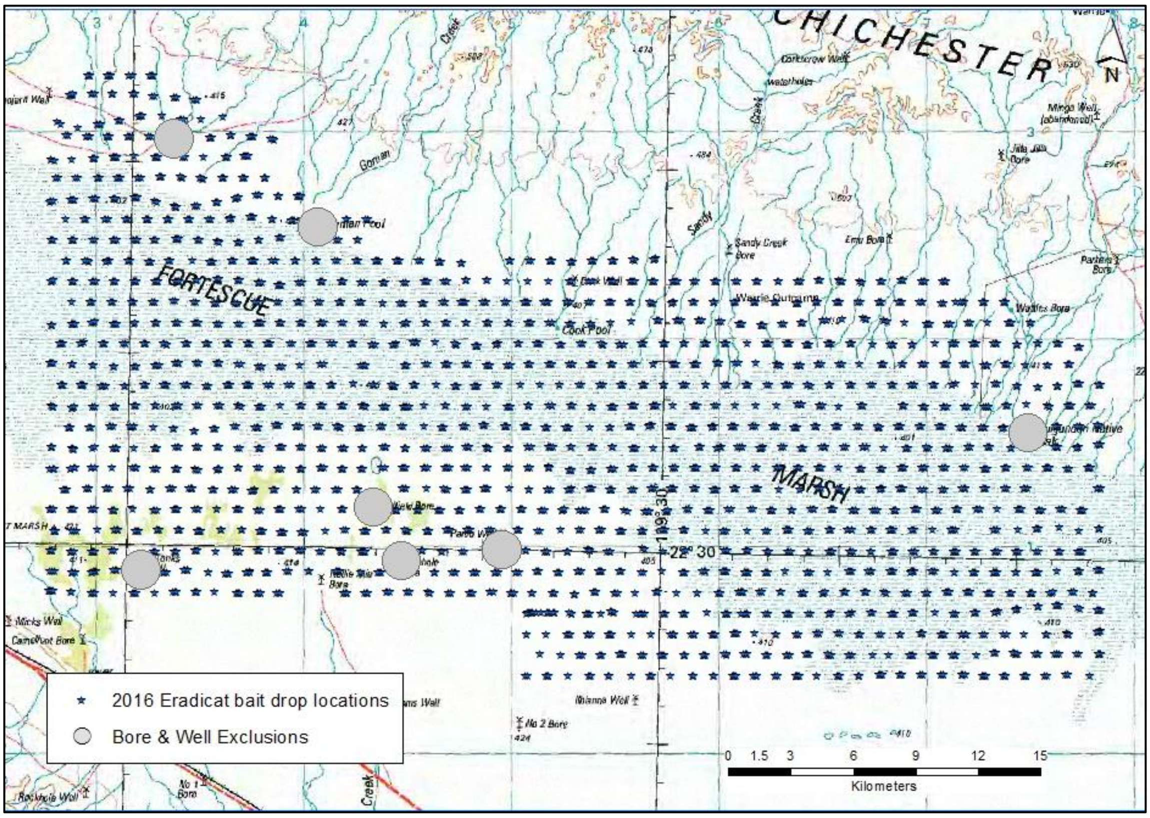


Figure 12. Distribution of baits on 21 and 22 July. Bait exclusion areas are shown as grey (bore buffer areas).

3.2 Feral Cats

3.2.1 Trapping and Radio-collaring

In 2016, 19 feral cats (eight males and eleven females) were captured over 483 trap-nights with a capture success rate of 3.93 % (Figure 13). Seventeen of the 19 feral cats were fitted with radio-collars. One sub-adult female FMGf15 was too small to be collared. The adult male, FMGm14 was found deceased in the trap after a small pack of wild dogs (*Canis lupus familiaris*) were moved away from the trap site. It is suspected that this individual had likely been stressed by the dogs causing its death.

In 2016, bodyweight (mean ± SE) of the males was 3,773 ± 301 g and the females were 2,778 ± 94 g (Table 3). Half the captures occurred on the south-west of the Marsh, four were captured on the north Marsh, after which the traps in this area were closed. Three cats were trapped in the south-east and a further three cats were trapped on the Marsh proper (Figure 13). The distribution of traps in 2016 (and subsequent captures) was a deliberate attempt to add to the previous years' data, increasing the area of the Marsh and diversity of habitats used for analysis of feral cat habitat preferences.

Table 3. Capture records for feral cat on Fortescue Marsh, 12 - 19 May, 2016.

Identifier	Trap №	Capture Date	Sex	Weight (g)	Coat Colour	Age	VHF Freq.
FMGm01	SL03	13/05/2016	♂	5310	Tabby	Adult	151.504
FMGm02	SL06	13/05/2016	♂	3370	Tabby	Adult	151.362
FMGf03	SL19	13/05/2016	♀	2260	Tabby	Adult	151.160
FMGm04	NW24	14/05/2016	♂	2980	Tabby	Adult	151.140
FMGf05	NW30	14/05/2016	♀	3190	Tabby	Adult	151.442
FMGf06	NW04	14/05/2016	♀	2800	Tabby	Adult	151.343
FMGm07	SL21	14/05/2016	♂	3680	Tabby	Adult	151.303
FMGm08	SL40	14/05/2016	♂	2370	Tabby	Sub-adult	151.263
FMGf09	SE02	14/05/2016	♀	2800	Tabby	Adult	151.462
FMGf10	NW15	15/05/2016	♀	2770	Tabby	Adult	151.241
FMGm11	SL21	15/05/2016	♂	3500	Tabby	Adult	151.482
FMGf12	SL22	15/05/2016	♀	2600	Tabby	Adult	151.221
FMGf13	SL27	15/05/2016	♀	2825	Tabby	Adult	151.122
FMGm14	SL32	15/05/2016	♂	3250	Black	Adult	n/a
FMGf15	SL19	16/05/2016	♀	910	Black	Sub-adult	n/a
FMGf16	SL23	16/05/2016	♀	2890	Tabby	Adult	151.182
FMGm17	SE13	16/05/2016	♂	4320	Tabby	Adult	151.421
FMGf18	SL05	17/05/2016	♀	2430	Black	Adult	150.460
FMGf19	SE09	19/05/2016	♀	3210	Tabby	Adult	151.322

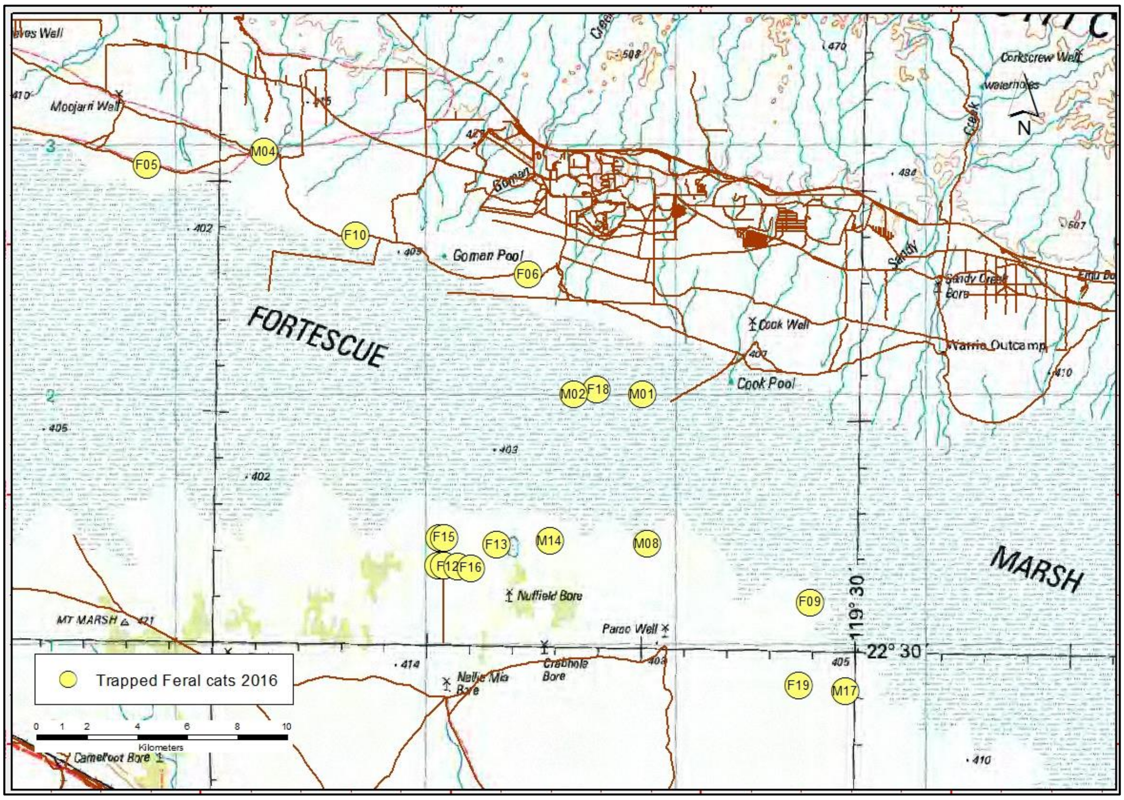


Figure 13. Location of the feral cat captures for 2016.

Non-target captures were minimal with only three captures - two wild dogs (*Canis lupus familiaris*) and a Brown Songlark (*Cincloramphus cruralis*). The dogs were euthanised at site of capture as per the agreement made with the adjoining pastoralists for the duration of this project. The songlark was found dead in the trap and appeared to have had an instantaneous death due to a snapped neck.

Between 2012 and 2016 there have been a total of 65 feral cat captures on the Marsh (Appendix 6.2), of which 60 were collared. The annual mean weights have remained relatively steady over time (Figure 14).

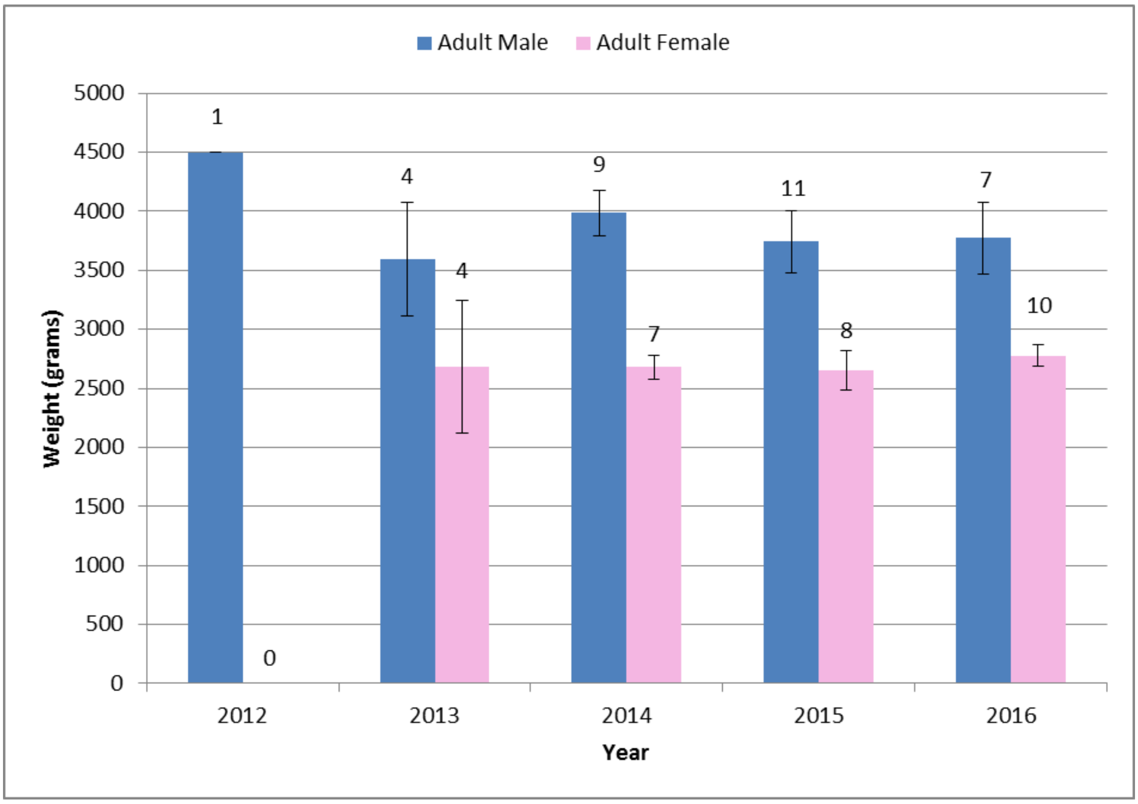


Figure 14. Annual mean adult feral cat weight, 2012 – 2016

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

The timing of the helicopter flights for the recovery of the 2016 collars was not ideal after the long delay in baiting. With limited options for conducting the flight, this delay encroached on the scheduled flights resulting in the first flight being whilst the baits were still active (26 July) and the rescheduled second flight for the end of August also had to be postponed due to unforeseen Fortescue administration issues. The second flight was quite late in the season (30 September) which resulted in reduced low temperature flying time which hinders the ability to detect live feral cats as they take cover in the heat.

Despite the issues with flight timings, twelve collars were recovered during the 2016 program plus a collar from 2015. Nine collared cats died as a result of baiting (82%), with all of these animals stationary within three hours of passing through a bait drop location, and five dying within the hour. Of the 17 cats collared, twelve were accounted for during the post-bait searches but one individual had died prematurely, four weeks after being captured.

Distances moved post-bait uptake ranged from 30 – 370 m. FMGf06 survived the first four days after baiting but as she was unable to be located again after this time, as such no conclusions can be made of her outcome. For those four days, her home range data suggests that she spent less than 40% of her time within the treatment cell (Figure 15).

The average daily distances travelled by collared cats was consistent within sexes with females averaging 3.9 km/day (range: 2.8 – 5.7) and the males 4.2 km/day (range: 3.5 – 6.2) (Table 4).

Table 4. Feral cat radio-collar activity and recovery details, May – August 2016.

Identifier	Duration of filtered data	Total № fixes	Ave distance per day (m) ±sd	MCP95 (ha)	Cat Outcome
FMGm01	no data	n/a	n/a	n/a	MIA since capture
FMGm02	17 May - 24 July	1581	3948 ±993	3103	**Died from bait**
FMGf03	14 May - 26 July	1653	3528 ±823	104	**Died from bait**
FMGm04	15 May - 22 July	1577	6232 ±1708	1980	**Died from bait**
FMGf05	15 May - 30 August	2431	3811 ±1362	567	Alive 30 August
FMGf06	15 May - 26 July	1665	5654 ±1351	665	MIA since 26 July
FMGm07	15 May - 26 July	1656	3470 ±657	148	**Died from bait**
FMGm08	15 May - 22 July	1549	3735 ±1012	500	**Died from bait**
FMGf09	15 May - 26 July	1657	2989 ±1019	471	Alive 30 Sept
FMGf10	16 May - 12 June	622	4117 ±1247	181	Died prior to baiting
FMGm11	16 May - 23 July	1557	3731 ±721	149	**Died from bait**
FMGf12	16 May - 24 July	1571	4036 ±801	185	**Died from bait**
FMGf13	no data	n/a	n/a	n/a	MIA since capture
FMGm14	not collared	n/a	n/a	n/a	Deceased; died in trap
FMGf15	not collared	n/a	n/a	n/a	Released; too small to collar
FMGf16	17 May - 25 July	1571	3948 ±993	242	**Died from bait**
FMGm17	no data	n/a	n/a	n/a	MIA since capture
FMGf18	no data	n/a	n/a	n/a	MIA since capture
FMGf19	20 May - 23 July	1476	2780 ±905	582	**Died from bait**

All thirteen collars with recovered data have collected sufficient GPS fixes (>504 or three weeks) to be analysed to establish home range size. Minimum convex polygons were run for 95% of GPS fixes (Table 4). The cluster of five cats near Nuffield Bore in the south (Figure 15) show a high level of overlap with FMGf12 being almost entirely encompassed by the two adjoining feral cat home ranges. The average (±SE) of the home ranges for males was 1,176.4 ha (±589) and females was 374.6 ha (±78).

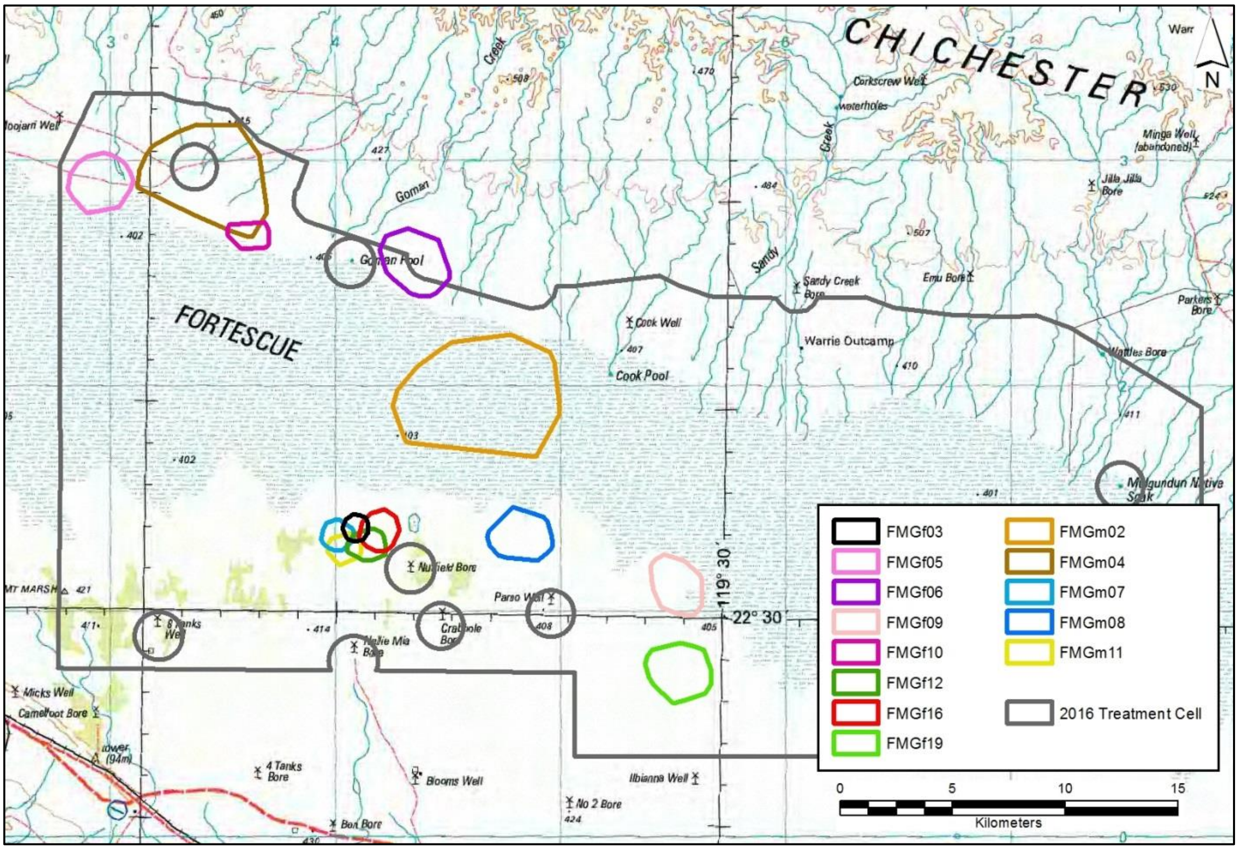


Figure 15. Feral cat home range as defined by 95% Minimum Convex Polygons showing the area of use by the collared feral cats.

Whilst searching for the 2016 collars, collar 15FMGm13 was also detected and collected showing that this cat has died as a result of baiting the in the year it was trapped.

Analysis of temporal movements of collared cats in 2016 was conducted for thirteen individuals. All but one individual showed the typical bimodal peak activity at dawn and dusk. FMGm08 showed a preference of peaks offset to the average male activity with a peak in the afternoon (16:00 h) and a second peak mid-morning (08:00 h). Both sexes had average activity levels similar to those of 2013 (Figure 16).

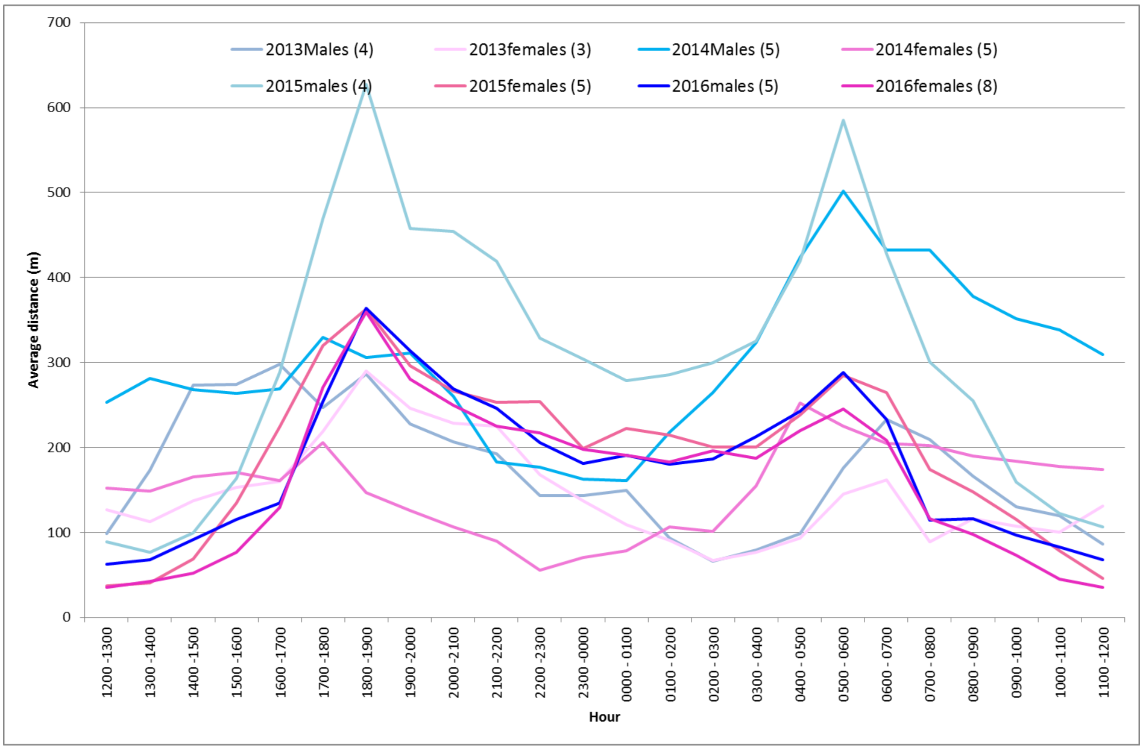


Figure 16. Average temporal movement pattern of male and female collared feral cats per survey year at Fortescue Marsh, 2013 – 2016

The distribution of cat collar data collected over the life of the project are the same for the north and the south of the Marsh (18 each) with the capture and recovery of collars in the middle of the Marsh proving to be more challenging (Figure 17). Of the seven captured and collared in the middle, three have been recovered.

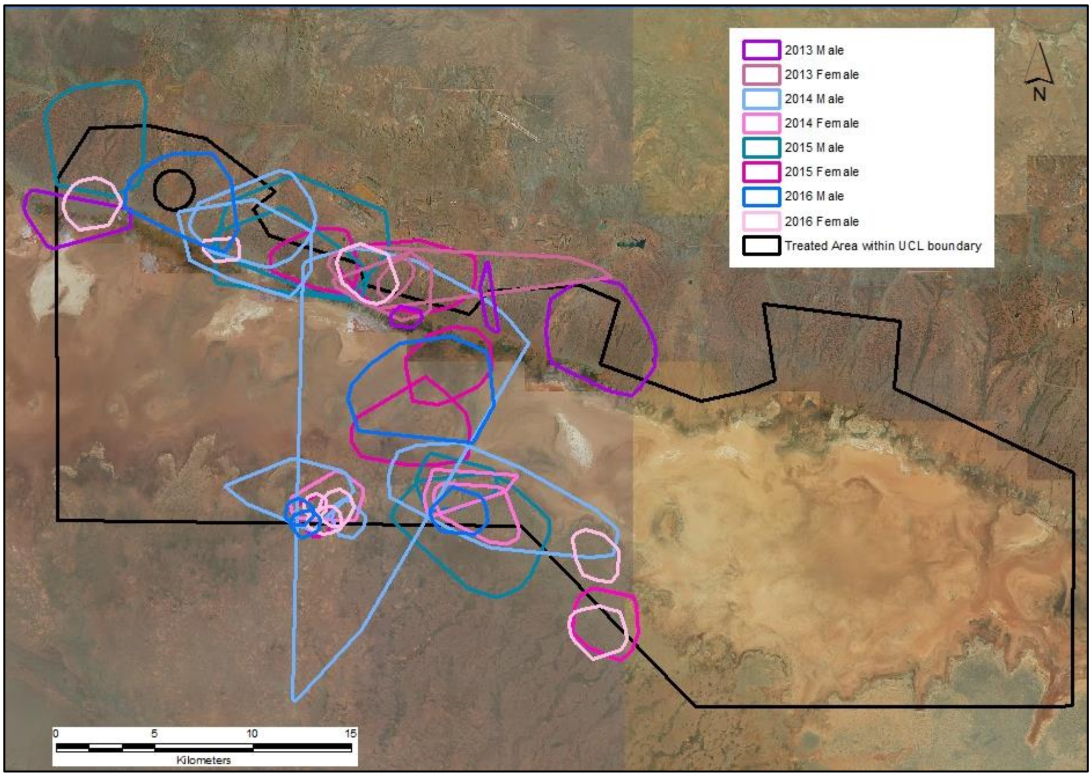


Figure 17. Distribution of feral cat home ranges 2013 – 2016 (n=40)

3.2.3 Site Occupancy

The camera surveys were conducted from 22 May to 30 August in 2016. The 64 treatment and 30 control cell cameras were operational for approximately three weeks, before they were decommissioned prior to baiting. With the unexpected bait delay these were non-operational for nearly seven weeks before being reactivated two weeks after baiting. The cameras and lures were reinstated for another three weeks for the post-bait monitoring in August.

A total of 3,507 camera trap-nights (Table 5) was conducted, resulting in feral cats being recorded on 45 out of 94 cameras sites (Figure 18).

Table 5. Camera trap-nights for survey areas, 2016.

	Pre-bait	Post-bait
Control (n=30)	780	630
Treatment (n=64)	1151	946

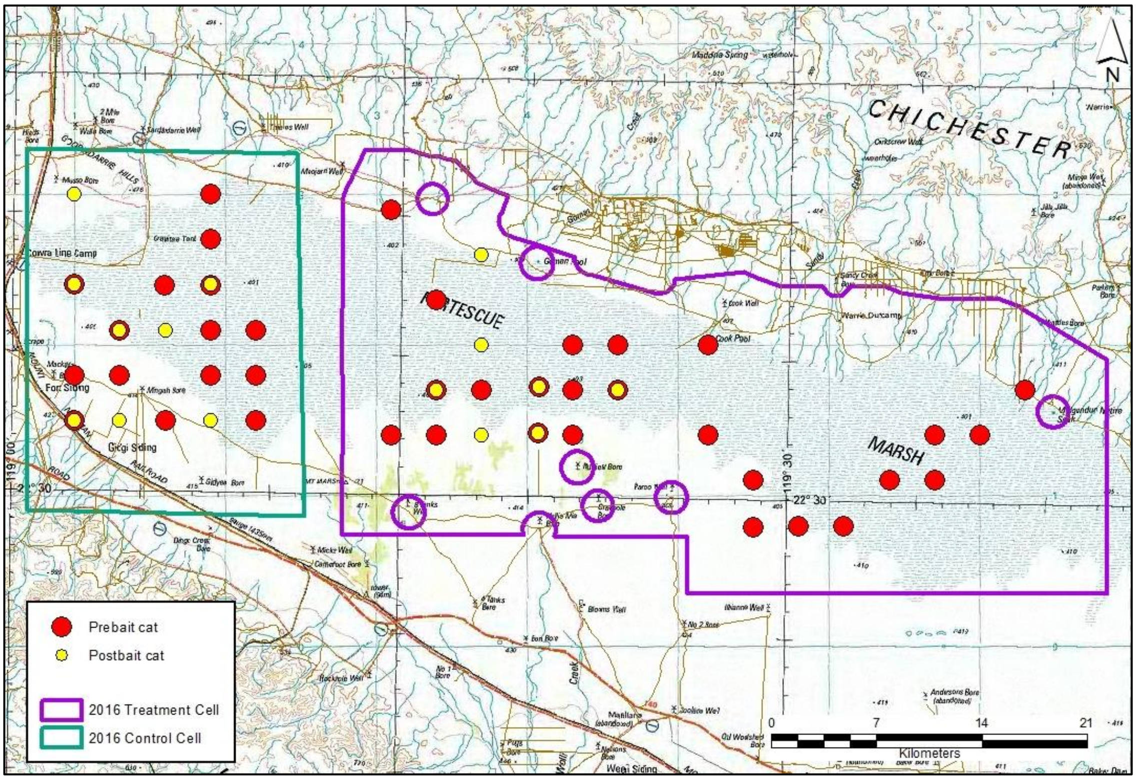
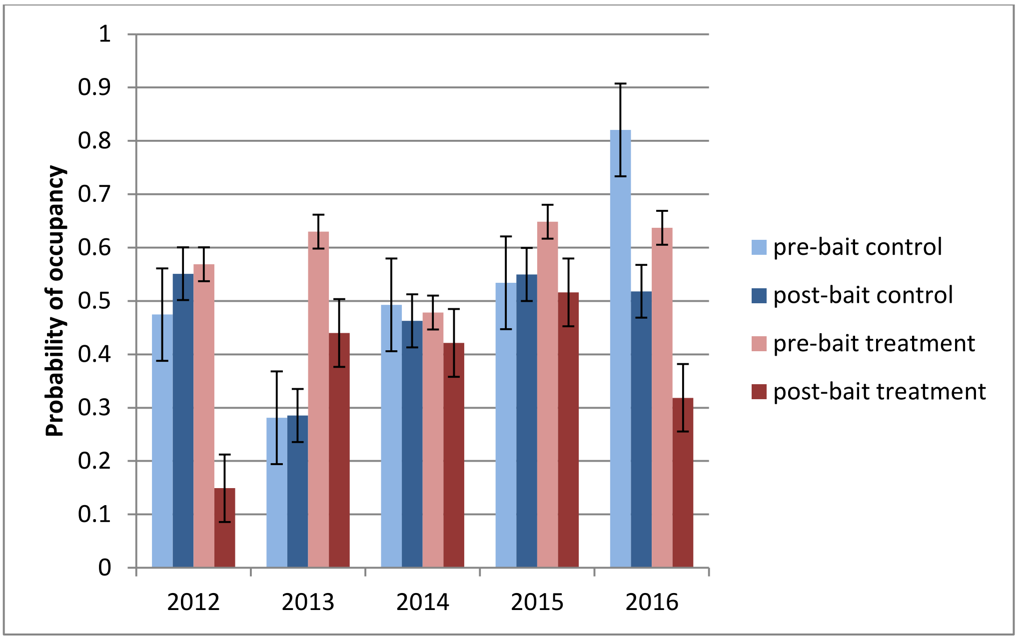


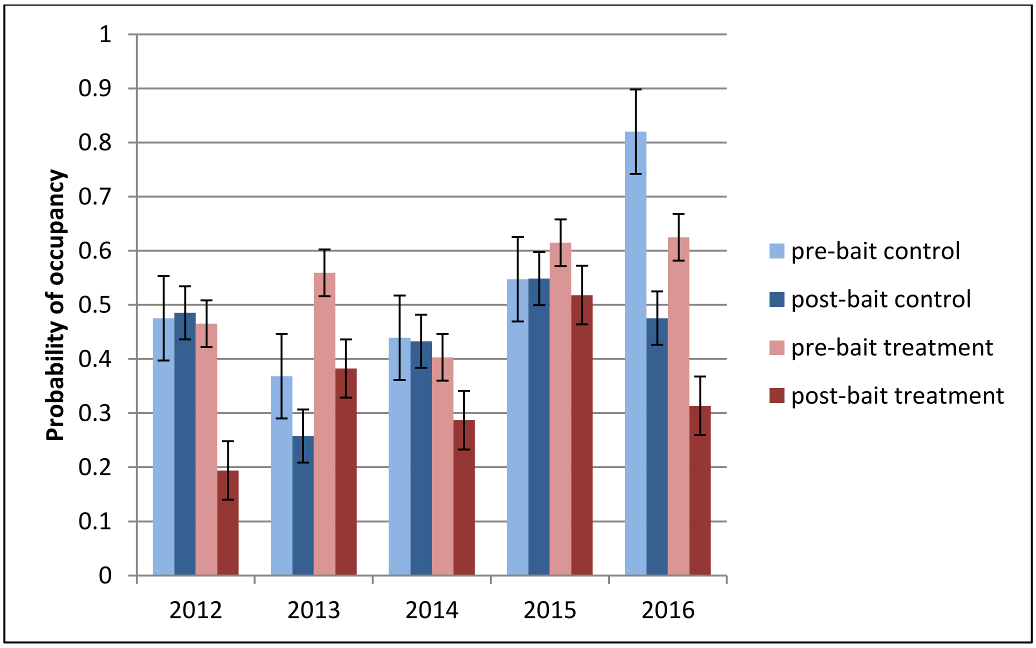
Figure 18. Location of feral cats recorded at camera-traps for both pre- and post-bait surveys for the control and treatment cells in 2016.

In 2016, both models (random effects and spatial component) showed a significant decrease pre- and post-baiting in occupancy on the control grid (t-test, p>0.01). However, both models also showed a greater order of magnitude in the decrease post-baiting for the treatment (t-test, p<0.01) (Appendix 6.1 and Figure 19a & 19b)

Camera data from 2012–2016 were used to calculate site occupancy pre- and post-baiting with random effects and spatial models, and all years are summarised in Comer *et al.* (in prep.).



a) modelled random effects



b) modelled spatial component

Figure 19. Site occupancy (mean ±SE) pre- and post-baiting in control and treatment cells for 2012-2016 with random effects (a) and spatial component (b).

3.2.4 Genetics

The allele rarefaction curve (Figure 20) shows that the sample size for Fortescue Marsh (FM) (n = 65) was sufficient to capture most of the available genetic diversity in this population, since the curve approaches an asymptote by 130 genes (double the number of samples). However, the curve for the Fortescue Camp (FC) population does not approach an asymptote and therefore a larger sample size than 14 would be required before the genetic diversity of this population can be substantively captured.

Figure 20 also shows the lower allelic diversity for FC with just 4.64 mean alleles per locus observed compared to 6.18 for FM. In addition, the FC exhibits significant departure from HWE, indicating low level inbreeding (FIS = 0.0889, $p < 0.05$), although this was not statistically significant once a Bonferroni correction for multiple testing was applied. No significant inbreeding was noted for the FM population. Estimates of FIS across the three temporal cohorts showed an overall increase in inbreeding from -0.0258 in 2012–14 to 0.0034 in 2016, peaking in 2015 with 0.08367. However, none of these values were significant at the 95% level. Allelic diversity also declined across these cohorts with mean allelic richness (calculated by rarefaction removing bias caused by differing sample sizes) reducing from 5.69 for 2012-14 to 5.27 in 2016.

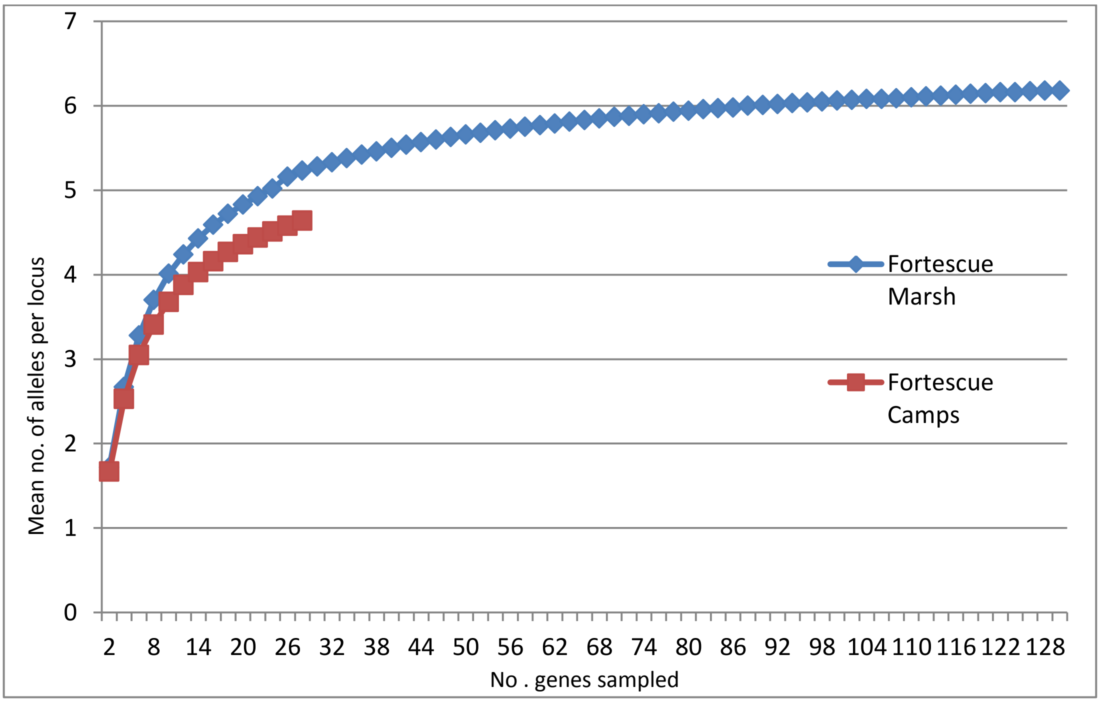


Figure 20. Allele rarefaction curve for samples of Fortescue Marsh and Fortescue Camps populations indicating the proportion of the available diversity has been sampled for the given set of markers.

An estimate for Nm of 3.28 migrants per generation was calculated between the two populations but values for FST showed no significant differentiation. Furthermore, modelling with STRUCTURE showed no evidence of geographic population structure. A Neighbour-Joining phylogenetic tree was produced incorporating all individuals from both populations to infer relatedness (Appendix 6.4). Individuals from the FC population were assigned to branches throughout the dataset, although a cluster of five individuals from the vicinity of Karntama Village (Christmas Creek) were grouped together on the same branch.

Figure 21 shows the estimates for effective population size for the three cohorts within the FM sample set. Both methods (LD and MCo) show an overall decline in Ne from a large estimate in 2012-14 to a comparatively small result for 2016, with an associated reduction in the confidence interval estimates.

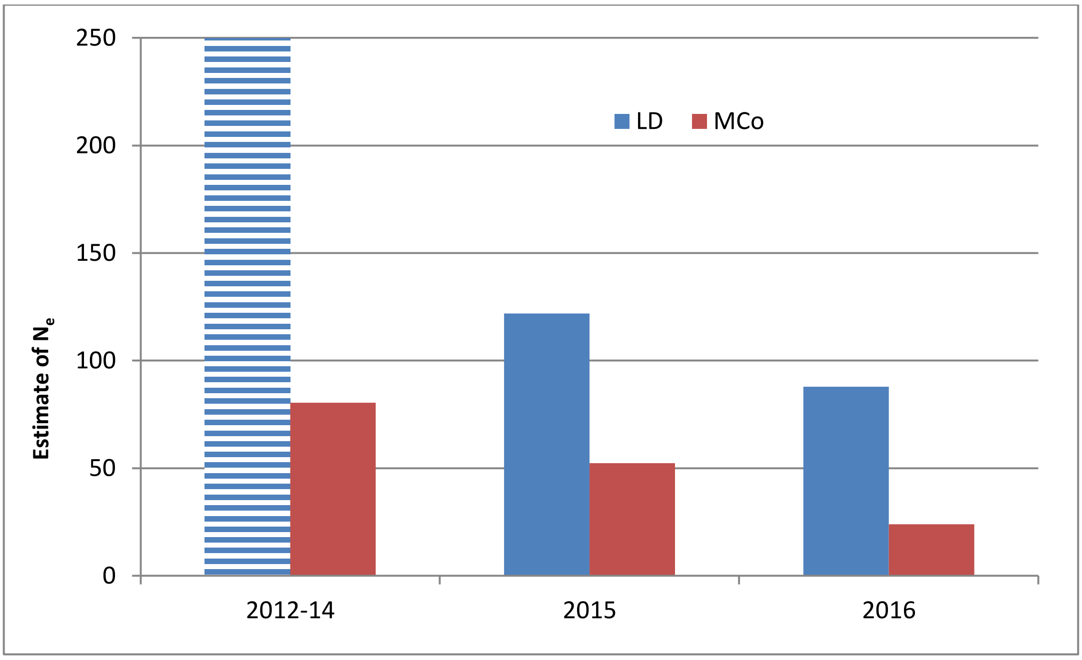


Figure 21. Estimates of Effective Population Size (N_e) for FM population using Linkage Disequilibrium (LD) and Molecular Coancestry (MCo) models (using NeEstimator, Do *et al*., 2014). Hatched bar indicates estimate $N_e = \infty$ (infinity) NB. 95% confidence intervals not shown.

3.2.5 Diet

Analysis of stomach content was conducted for six cats and one fox. The fox which was trapped and euthanised in 2014 presented no material other than less than 1 g of plant material. Attempts were made to recover stomachs from baited cats but as is the nature of toxin ingestion these cats had emptied the contents of their stomachs prior to death.

In the small sample size, contents identified shows a preference for mice, both native and introduced however as opportunistic hunters there is a broad selection with mammals, birds, reptiles, invertebrates and plants all on the menu (Table 6).

Table 6. Analysis of stomach contents from trapped cats that were either euthanised at capture or on collar retrieval.

Identifier	Wet weight (g)	№ of samples	Contents identified
13FMG5	n/a	n/a	*Mus musculus*, unidentified bird feathers, 3 x reptile claws & body parts, bird leg, cat hair
14FMGf11	24	6	*Dasyurid sp., Pseudomys sp.*, insect, plant material, unknown crustaecan, unknown rodent
14FMGf12	n/a	2	*Pseudomys desertor, Equus sp.*
15FMGf04	66	3	*Mus musculus, Dasyurid sp*., Brown Songlark, Australasian Pipit
15FMGf19	n/a	13	6 x *P.desertor*, 3 x *Mus musculus, P.hermannburgensis, Oryctolagus cuniculus, Notomys sp.*, unknown rodent
16FMGm14	20	3	*P.desertor*, Grasshopper, plant material

Predator scats were also analysed for what animal may have deposited the scats as well as any prey found in the material.

Table 7. Analysis of predator scats collected opportunistically along quad tracks and around the Marsh.

Sample Identifier	Date	Easting	Northing	Scat species	Contents Identified
FMG01	18/05/2014	731550	7529318	WT eagle	feathers only
FMG02	12/06/2014	751961	7520030	Dog	*Macropus robustus*, bird
FMG03	16/05/2016	757983	7506830	Cat	*Dasykaluta rosamondae*, rodent, beetle
FMG04	19/05/2016	756567	7508193	Cat	*Tiliqua multifasciata*, seed
FMG05	20/05/2016	758967	7511660	Cat	*Pseudomys hermannburgensis*, 2x *P.desertor*, *Sminthopsis macroura*, unknown dragon, beetle
FMG06	20/05/2016	758967	7511660	Cat	*P.desertor*, *Sminthopsis macroura*, dragon
FMG07	16/06/2016	740446	7518913	Fox	2 x *P.hermannburgensis*, bird, skink, grasshopper, beetle
FMG08	16/06/2016	747242	7523729	Cat	*Oryctolagus cuniculus*
FMG09	18/06/2016	722604	7530806	Cat	*Macropus robustus*
FMG10	4/08/2016	741097	7517050	Fox	*P.desertor, Niniguai timealeyi*, bird, grasshopper, beetle
FMG11	5/08/2016	758823	7508053	Fox	2x *P.hermannburgensis*, 2x *P.desertor, Dasykaluta rosamondae*, grasshopper
FMG12	8/08/2016	710000	7530000	Fox	*P.hermannburgensis, P.desertor,* dragon
FMG13	4/09/2016	740794	7519253	Fox	2x *P.desertor, P.hermannburgensis*, grasshopper

3.3 Non-target Species

3.3.1 Birds

Although 18 ARUs were deployed, one unit failed to record, another only recorded for two mornings and two units stopped recording after one week. It appeared that there had been a technical issue with the D-cell batteries in these units, which had dislodged from the battery slot, most likely due to a collision by wildlife. Additionally, cattle interfered with three units and although these continued to record, the external microphones were damaged, reducing or ceasing the recording capacity of the unit. In total, 1,464 hours of recordings was made during the survey period.

All recordings were analysed using SoundID using the Threshold of Distance at 1.75 degrees. The results of SoundID analysis from 2016 were compared to a re-analysis of the previous years, ensuring all data were analysed consistently (Table 8). The number of days on which either species was recorded was divided by the total number of days that were recorded, to provide an index of abundance in that year.

Table 8. Results of ARU analysis for White-winged and Variegated Fairy-wren calls, using SoundID to automatically recognise calls, between 2013 and 2016.

Year	№ ARUs	Total days	White-winged Fairy-wren	Variegated Fairy-wren	Total Calls	% positive days
2013	16	185	36	1	37	17%
2014	17*	217.5	9	0	9	7%
2015	14	138	0	0	0	0%
2016	17*	244	0	0	0	0%

* Number of units that made recordings was less than originally deployed.

Ninety-one bird species were recorded during the five-year project, including two species not previously recorded before 2016: Southern Whiteface (*Aphelocephala leucopsis*) and Little Woodswallow (*Artamus minor*) (see Appendix 6.6).

Nine of the camera sites where ARUs were located recorded feral cats during 2016.

3.3.2 Bilby and Mulgara

In 2016, five sites consisting of five cameras each covered approximately 10 ha. A total of 2,384 camera-nights were surveyed with neither Mulgara nor Bilby being detected. These cameras detected a suite of species, with a percentage capture success rate shown for pre- and post-bait presented in Table 9.

Table 9. Capture success rates for all species captured by non-lured Bilby/Mulgara targeted monitoring cameras, 2016

Common Name	*Scientific Name*	Site One		Site Two		Site Three		Site Four		Site Five	
		Pre-bait	Post-bait	Pre-bait	Post-bait	Pre-bait	Post-bait	Pre-bait	Post-bait	Pre-bait	Post-bait
Feral cat	*Felis catus*	1.2	0	1.3	0.6	1.9	0.6	7.1	4.6	8.2	0
Desert Mouse	*Pseudomys desertor*	0	0	0	0	1.0	3.4	0.3	0	0	0
European Rabbit	*Oryctolagus cuniculus*	0	0.5	0	0	0.3	0	0	0	0	0
Little Red Kaluta	*Dasykaluta rosamondae*	14.6	3.8	2.2	1.7	2.9	3.4	3.9	4.6	0	0.7
Nankeen Kestrel	*Falco cenchroides*	0	0	0	0	0	0	0.3	0	0	0
Red Kangaroo	*Macropus rufus*	0.9	0.5	0	0	0.6	0	0	0	0	0.7
Short-beaked Echidna	*Tachyglossus aculeatus*	0.3	0	0	0	0.6	7.4	1.3	0.6	0	0
small mammal	*small mammal*	1.8	1.1	1.6	29.7	10.0	19.4	3.2	13.1	4.3	9.9
Spinifex Hopping Mouse	*Notomys alexis*	0.3	0	0.6	0	2.3	1.1	0	0	3.1	4.2
Stripe-faced Dunnart	*Sminthopsis macroura*	0	0.5	0	0	0	0	0	0	0	0
Notomys sp.	*Notomys sp.*	0.3	0	0	0	28.4	16.0	0.3	2.3	15.6	21.8
Pseudomys sp.	*Pseudomys sp.*	29.0	9.2	21.3	13.1	6.5	12.0	11.6	0.6	0	0
Pygmy Desert Monitor	*Varanus eremius*	0	0	0	0	0	0	0	0	0.4	0
Yellow-spotted Monitor	*Varanus panoptes*	0	0	0	0	0.6	0	0.3	0.6	0	0
Unknown		2.1	0	0.3	0	1.6	0.6	0.3	0.6	0.4	0.7
Unknown reptile		0	0	0.3	0	0	0	0	0	0	0
Unknown varanid		0	0	0	0	0.3	0	0	0	0	0

Each site had a significant decline in feral cat captures post-bait and Kaluta captures fluctuated from one site to another pre- and post-bait suggesting no impact to these carnivores from baiting.

3.3.3 Incidental records

In 2016, at least four wild dogs were sighted at the trap site where a cat had died. Two dogs were also trapped as described in section 3.2.1 No further recent dog evidence was detected in the treatment cell after 15 June. There has been a continual presence of wild dogs and to a lesser extent foxes throughout the duration of the project (Appendix 6.5).

In addition to the species captured in the Bilby/Mulgara targeted cameras, the 'cat' cameras also captured wild horses (*Equus cabullus*). A complete list of all species detected is presented in Appendix 6.7.

A significant find was that of a carcass of a Ghost bat (Macroderma gigas) which was found dead, caught up in a barbed wire fence near Minga Bore (50H N 7517484 E 714246) in May.

Plate 4 & 5. The EPBC listed Ghost bat specimen found in the control area on the 21st of May, 2016. **Photo: L. Clausen/DPAW**

4 Discussion

Survey conditions for 2016 were favourable for access with another dry summer followed by intermittent autumn and winter showers. The wet season preceding the annual surveys has been variable over the five years with 2013 and 2016 being dry years and the majority of 2015 rainfall occurring late, in autumn. Although this study was limited to five years, the annual rainfall has shown to be a significant factor in the success of the baiting, with dry conditions prior to baiting proving to have a greater success in feral cat knockdown. This result is likely due to dry conditions creating scarcity of feral cat prey, driving cats to feed on *Eradicat*® baits.

In 2016 the trapping program progressed smoothly with a capture success rate of 3.93%. Given it was the final year of collaring, targeted trapping was conducted focussing on a small sample for the north of the Marsh (closing traps after four days) and more effort in the centre and south-east where there has been less collar recovery success.

Seventeen cats were collared out of the 19 captured, similar numbers to 2015. Of these, 12 collars were recovered with one dying prior to bait delivery giving a total sample of 11. Nine of these 11 were shown to have died from baiting, giving an 82% baiting efficacy rate. A carcass was also found near the northern marsh road that appeared to have been of similar condition to dead collared cats however, given its proximity to the track it has not been included in the bait death numbers. A thirteenth cat was detected on the first tracking flight (four days post-bait) as alive but was unable to be detected again after ground tracking in August and a second flight at the end of September. Given the baits were still active when this cat was last detected its post-bait status had to be listed as unknown. One Sirtrack collar was deployed on a female in the centre of the Marsh. This collar was unable to be detected at any stage and was deemed to have malfunctioned due to the experienced unreliability of these collars on other projects.

The mean home range for both males and females in 2016 was significantly lower than previous years with at least 50% decrease from 2015. For the males, this in part could be attributed to the fact that there were no large (> 4,000 g) male collars recovered. Mean hourly movements remained similar despite the reduced home range and temporal patterns were similar to those of 2013 – the other dry year in this study. The movement fluctuations in this project are indicating the annual cohort is becoming more site restricted suggesting a naivety of its surrounds.

Occupancy modelling using the remote camera data has again provided a robust method to support the efficacy of baiting programs over the large treatment area. The analysis of camera data using occupancy models, with both spatial and random effects modelled, again found the effect of baiting on decreasing probability of site occupancy to be highly significant. Application of the same Bayesian models to the 2012–2016 data also supports the value and repeatability of the occupancy modelling using infra-red cameras for determining the efficacy of baiting on the Fortescue Marsh (Comer *et al*. in prep.).

The significant decrease in probability of occupancy for the control cell in both models in 2016 may have been the result of localised pulses in resource availability, for example patchy rainfall may have driven an increase in activity in the western end of the study area Figure 10 shows a georeferenced overlay of the location of the survey area as being on the edge of two rainfall units that range between 50 – 100 mm and 100 – 200 mm. The installed weather stationed suggested that the treatment cell received approximately 61 mm between 1 June and 4 August, supporting that the treatment cell fitted into the lesser rainfall unit. However, as the Control was situated closer to the boundary of the mapped units it is highly probable that isolated showers could have been substantially greater than in the treatment cell causing the anomaly in the pre-bait Control occupancy.

Genetic analysis of the feral cats sampled from in and around Fortescue Marsh demonstrated that, while the population on the Marsh (FM) has relatively high genetic diversity, cats around areas of mining infrastructure have relatively low genetic diversity and potentially significant levels of inbreeding. However, while the sample size for the FM population was predicted to be adequate to sample most of the available genetic diversity, the sample size for Fortescue Camps (FC) (n = 14) was too small to ensure that all diversity was captured. Incorporating more samples from these areas would be valuable to provide a more accurate assessment of the genetics of this population. Nevertheless, from these data it seems probable that the FC population is less genetic diverse and is experiencing a low level of inbreeding. The generational migration rate was moderate and there was no significant evidence of differentiation between populations, implying that the low levels of gene flow are sufficient to prevent isolation of the FC population.

While no geographic population structure was predicted for these populations, some clustering of genotypes was observed using a phylogenetic tree (see Appendix 6.4), particularly for five animals captured around Christmas Creek. This suggests a high degree of relatedness between these animals, which may validate the predictions of inbreeding in this population. However, other most other branches from the FC population did not cluster together, suggesting a different origin for these individuals.

Finally, estimates of Ne for the FM population show a clear negative trend across three temporal cohorts (2012-14, 2015 and 2016) for both methods used in this analysis. This reveals that the number of reproductive individuals is predicted to have decreased over the period that the Marsh has been baited by as much as 70%. The Linkage Disequilibrium model indicated an infinite population for the 2012-14 cohort and therefore this result should regarded with caution. However, the Molecular Coancestry method produced more reliable results, which support the overall trend observed for both methods. Furthermore, these data correlate with results for allelic diversity and inbreeding, with mean allelic richness declining and FIS increasing over the period that the Marsh was baited. Based on these results, it appears that the baiting program has a measurable impact on genetic diversity and the number of reproductive individuals in Fortescue Marsh.

Diet analysis did not reveal any EPBC listed species or any previously unknown species from the Pilbara. As there were too few samples (n=6), no conclusions can be drawn on temporal diet changes or prey preference. The scat analysis was from six cats, five foxes, one dog and one bird of prey. None of the samples collected in 2016 were from dogs, despite the prominence of dog sign in the first few days traversing the Marsh when trapping. Both the fox and the cat scats presented a bias of murids.

Predator presence in 2016 as suggested by camera detection, the predator scat analysis, and trapping/sightings (dogs) was relatively high. The prey species identified supports the findings from the stomach analysis and the predator scat identifications for foxes support the increase in camera detections of foxes (Appendix 6.5).

In an attempt to provide a comparable dataset of the ARU data between all years (2013–2016), analysis was only undertaken for two species Variegated Fairy-wren and White-winged Fairy-wren (VFW and WWFW) using identical parameters across all recordings from all years. Of the species listed as potential indicators of feral cat density, these species are the most frequently encountered in the field and easily detected using the automated recognition software package SoundID. It was hoped that this method would provide an index that could indicate patterns of abundance for both species. Previously, different methods of analysis were employed (e.g. manual analysis in 2013; different ToDs in 2014 and 2015) and this was the first time a standard method was used.

Results of the analysis of ARU recordings show a marked decrease in the number of records of fairy-wrens (particularly WWFW) from 17% of days deployed in 2013, 7% in 2014 to 0% in 2015 and 2016. However, this decline is not supported by anecdotal observations, as White-winged Fairy-wrens continued to be as common and widespread in 2016 as they were in 2013. Furthermore, such a drastic reduction in abundance of this species seems unlikely in response to any potential influence, including feral cats.

Re-analysing the 2016 ARU data found that WWFW calls could be detected by SoundID but only with a ToD of 2.5 degrees, cf. 1.75 in the initial analysis. Furthermore, analyses in 2015 detected WWFW on 50% of units (Clausen *et al*. 2015), whereas analysis using the standardised method produced no positive records.

This suggests that there may be an issue with the hardware (e.g. degradation of microphones or ARUs, due to exposure to the elements) that has reduced recording fidelity over time. This could explain why units recorded more positives early in their life and steadily reduced in efficacy. If this is the case, this could have important implications for any long-term monitoring that employs the use of ARUs for extended periods.

This work shows that ARUs may have the potential to become useful tools for monitoring bird populations in the future and work with the Western Ground Parrot (Pezoporus flaviventris) on the South Coast of Western Australia has demonstrated the value of using them for this work (Tiller *et al*. in prep.). However, the Fortescue study flags a number of potential confounding issues and there is clearly need for refinement of both the software and hardware components before this method can be used reliably to accurately detect fluctuations in the abundance of individual species.

Incidental records of birds in 2016 produced a total of 91 species, which is lowest recorded in the whole five-year study period. A possible reason for this low diversity is the low summer rainfall, which led to relatively dry conditions in and around the Marsh. As a result, waterbirds and other nomadic species were in relatively low numbers in the study period in 2016.

Monitoring for the EPBC listed species Mulgara and Bilby was again conducted in 2016 with camera traps. The lack of detection of either of these species suggests that if these are present within the study area then they are at very low densities. Eight mammal taxa were identified on these camera as compared with nine for the cat targeted cameras, indicating that although not lured with any bait the effort for detection was sufficient for determining what is present on the marsh.

The Ghost bat record is a significant find with the nearest known records being in the Hamersley Ranges (Armstrong 2000). The carcass was found caught up in a barbed wire fence where it presumably was tangled and ultimately died. It is likely this bat and potentially others use the Marsh area to feed with the camera work over the last five years recording potential prey species (eg birds such as quails, small mammals and reptiles).

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6 Appendices

6.1 Probability of occupancy ± SD (n) modelled with random effects and spatial component

		Control		Treatment	
Model	**Year**	**Pre-bait (n)**	**Post-bait(n)**	**Pre-bait (n)**	**Post-bait(n)**
Random	2012	0.4747±0.1527 (29)	0.5511±0.2286 (29)	0.5687±0.6250 (49)	0.1491±0.1324 (49)
Random	2013	0.2813±0.1900 (31)	0.2845±0.1640 (31)	0.6298±.0190 (29)	0.4399±0.2335 (29)
Random	2014	0.4927±0.2042 (30)	0.4628±0.1891 (30)	0.4785±0.1283 (56)	0.4215±0.1642 (56)
Random	2015	0.5340±0.0949 (24)	0.5497±0.1031 (24)	0.6487±0.0736 (44)	0.516±0.0.0812 (44)
Random	**2016**	**0.8206±0.1212** (30)	**0.5182±0.1789** (30)	**0.6374±0.1565** (64)	**0.3186±0.1765** (64)
Spatial	2012	0.4853±0.1106 (29)	0.4852±0.0839 (29)	0.4649±0.1446 (49)	0.194±0.1696 (49)
Spatial	2013	0.3684±0.2383 (31)	0.2577±0.1670 (31)	0.5593±0.1836 (29)	0.3824±0.2030 (29)
Spatial	2014	0.4393±0.1958 (30)	0.4325±0.1898 (30)	0.4031±0.0831 (56)	0.287±0.0560 (56)
Spatial	2015	0.5472±0.1028 (24)	0.5487±0.108 (24)	0.6147±0.0708 (44)	0.5181±0.0820 (44)
Spatial	**2016**	**0.8198±0.1184** (30)	**0.4755±0.1646** (30)	**0.6246±0.1398** (64)	**0.3134±0.1777** (64)

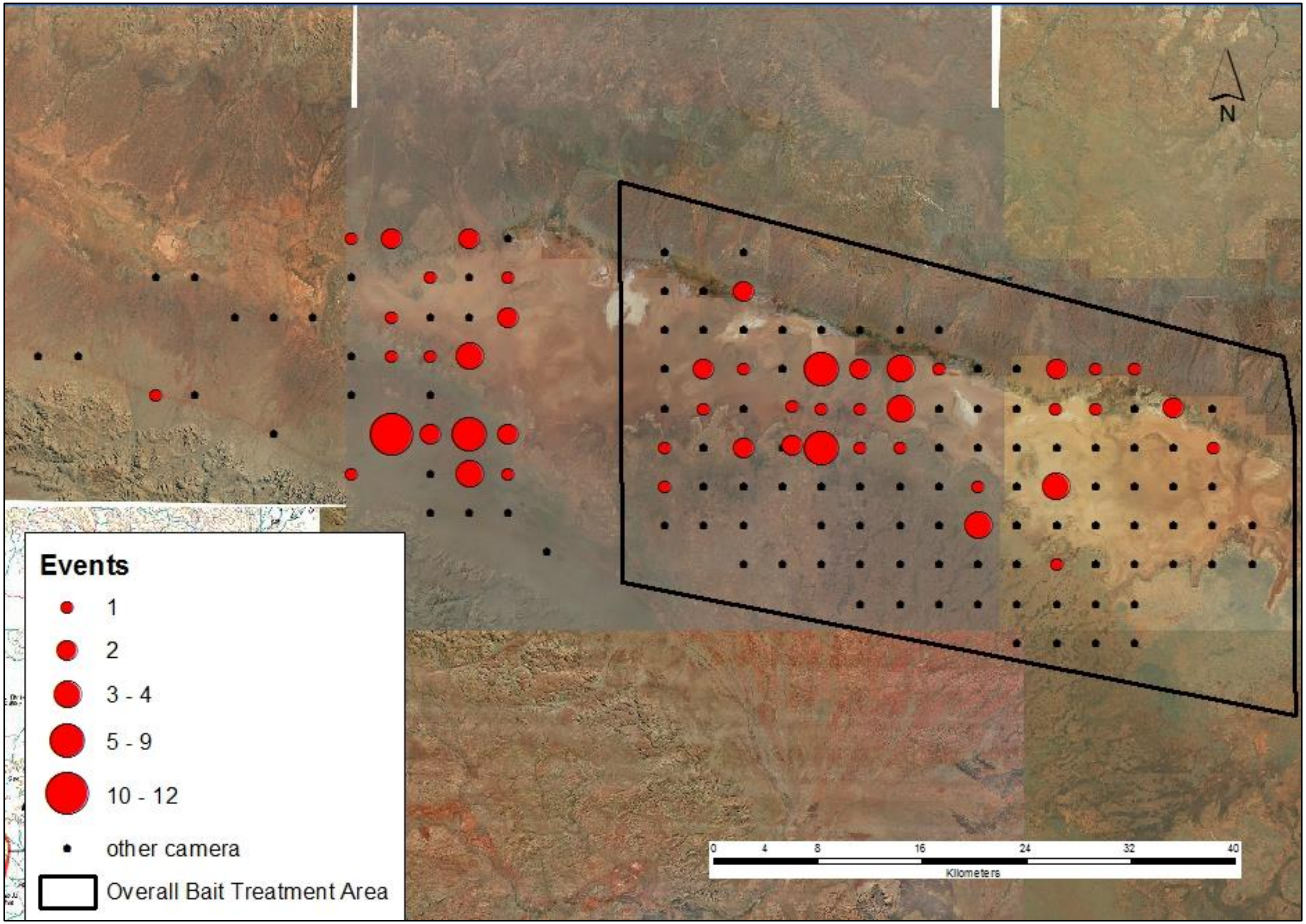
6.2 Feral cat captures 2012 - 2016 (Marsh =65, other = 15)

Identifier	Trap No	Capture Date	Latitude	Longitude	VHF Freq	Sex	Weight (g)	Age	Comments
12FMG01	T3	11/07/12	-22.5075	119.357	150.08	M	4500	A	
13FMG01	T24	24/05/13	-22.3753	119.4182	151.76	F	1950	A	
13FMG02	T17	24/05/13	-22.3895	119.453	149.56	M	5250	A	
13FMG03	T62	25/05/13	-22.3739	119.3803	148.90	F	1750	A	
13FMG04	T34	26/05/13	-22.3653	119.3703	150.92	F	2125	A	
13FMG05	T23	27/05/13	-22.3756	119.4243	151.32	M	4000	A	
13FMG06	T66	27/05/13	-22.3732	119.3625	151.86	F	3250	A	
13FMG07	T28	28/05/13	-22.3744	119.3927	151.90	M	2170	A	
13FMG08	T60	28/05/13	-22.3279	119.2216	148.94	M	3000	A	
13FMG09	T52	29/05/13	-22.3295	119.2743	150.06	M	3550	A	
13CF02	Con2	22/08/13	-22.3695	119.6506		F	2100	A	Christmas Ck
13CM01	Con3	22/08/13	-22.3693	119.6504		M	4900	A	Christmas Ck
13KF01	K11	22/08/13	-22.3748	119.674		F	4600	A	Christmas Ck
13KF02	K25	23/08/13	-22.3387	119.6726		F	3250	A	Christmas Ck
13CF03	Con9	25/08/13	-22.3697	119.6508		F	3375	A	Christmas Ck
13CM04	Water tanks	26/08/13	-22.3212	119.4011		M	2500	A	Cloudbreak
14F05	KV5	22/02/14	-22.3383	119.6736		F		A	KV Kitchen. Mike Seitz
14F06	KV2	22/02/14	-22.34	119.6772		F		J	KV Y-Block. Mike Seitz.
14M19	cat3	23/03/14	-22.3382	119.6735		M			Mike Seitz (Christmas Ck)
14M20	CCY1	20/04/14	-22.3971	119.7371		M			Mike Seitz (Christmas Ck)
14FMGm01	NW16	9/05/14	-22.3523	119.2968	150.18	M	3600	A	
14FMGm02	NW28	10/05/14	-22.3264	119.248	150.38	M	3600	A	
14FMGf03	SW05	10/05/14	-22.4608	119.4015	150.02	F	1900	A	
14FMGm04	NW30	11/05/14	-22.3278	119.2219	150.04	M	3900	A	
14FMGm05	SE10	11/05/14	-22.4857	119.4801	150.30	M	3750	A	
14FMGf06	SW20	12/05/14	-22.4713	119.3436	150.58	F	2900	A	
14FMGf07	SE20	12/05/14	-22.5141	119.4962	150.70	F	2750	A	
14FMGf08	NW13	12/05/14	-22.3541	119.3165		F	1500	A	
14FMGm09	NW01	13/05/14	-22.3641	119.3836	150.24	M	3500	A	
14FMGm10	SW15	14/05/14	-22.4645	119.3545	150.52	M	4650	A	
14FMGf11	SW19	14/05/14	-22.471	119.3395	150.48	F	2800	A	

Identifier	Trap No	Capture Date	Latitude	Longitude	VHF Freq	Sex	Weight (g)	Age	Comments
14FMGf12	SW24	14/05/14	-22.4724	119.3622	150.16	F	2300	A	
14FMGm13	NW09	14/05/14	-22.3646	119.3384	150.28	M	4500	A	
14FMGm14	NW13	14/05/14	-22.3541	119.3165	150.10	M	3400	A	
14FMGf15	SW01	15/05/14	-22.4618	119.4183	150.08	F	2650	A	
14FMGm16	SE12	15/05/14	-22.4946	119.4772	150.36	M	5000	A	
14M22		14/06/14	-22.3382	119.6735		M	4500	A	Mike Seitz (Christmas Ck)
14F15		15/06/14	0	0		F		A	Matt Adams (Cloudbreak)
14M23		15/06/14	0	0		M		A	Matt Adams (Cloudbreak)
14F16		28/07/14	-22.468	119.3557					Found dead, nil PCR result
14F15		23/08/14	0	0					Antony Taggart (Cloudbreak)
15FMGm01	W04	14/05/15	-22.3652	119.3701	151.67	M	2290	A	
15FMGm02	W10	15/05/15	-22.3624	119.3346	151.61	M	3260	A	
15FMGf03	S01	15/05/15	-22.3965	119.4179	151.57	F	2920	A	
15FMGf04	S08	15/05/15	-22.4317	119.4186	151.13	F	2270	A	
15FMGm05	SW09	16/05/15	-22.4627	119.3851	151.65	M	5270	A	
15FMGf06	M05	16/05/15	-22.3749	119.4054	151.69	F	3150	A	
15FMGm07	W20	16/05/15	-22.3411	119.2778	151.29	M	4720	A	
15FMGm08	W25	16/05/15	-22.3221	119.2649	151.43	M	3970	A	
15FMGf09	M03	17/05/15	-22.3743	119.391		F	1860	A	
15FMGf10	E06	18/05/15	-22.3894	119.4417		F	1520	A	
15FMGm11	W15	18/05/15	-22.3529	119.3128	151.35	M	2760	A	
15FMGf12	SL23	18/05/15	-22.4711	119.3395	151.27	F	2850	A	
15FMGm13	SL28	18/05/15	-22.473	119.3712	151.15	M	3740	A	
15FMGm14	W20	19/05/15	-22.3411	119.2778	151.33	M	3240	A	
15FMGm15	SL42	20/05/15	-22.4792	119.4737	151.41	M	4900	A	
15FMGm16	SL20	20/05/15	-22.439	119.3394	151.19	M	3820	A	
15FMGm17	SW08	20/05/15	-22.4622	119.391	151.47	M	1871	SA	
15FMGf18	M07	21/05/15	-22.3739	119.3819	151.17	F	2720	A	
15FMGf19	W09	21/05/15	-22.3653	119.341	151.45	F	2780	A	
15FMGm20	S01	22/05/15	-22.3965	119.4179	151.25	M	3210	A	
16FMGm01	SL03	13/05/16	-22.408	119.4156	151.50	M	5310	A	

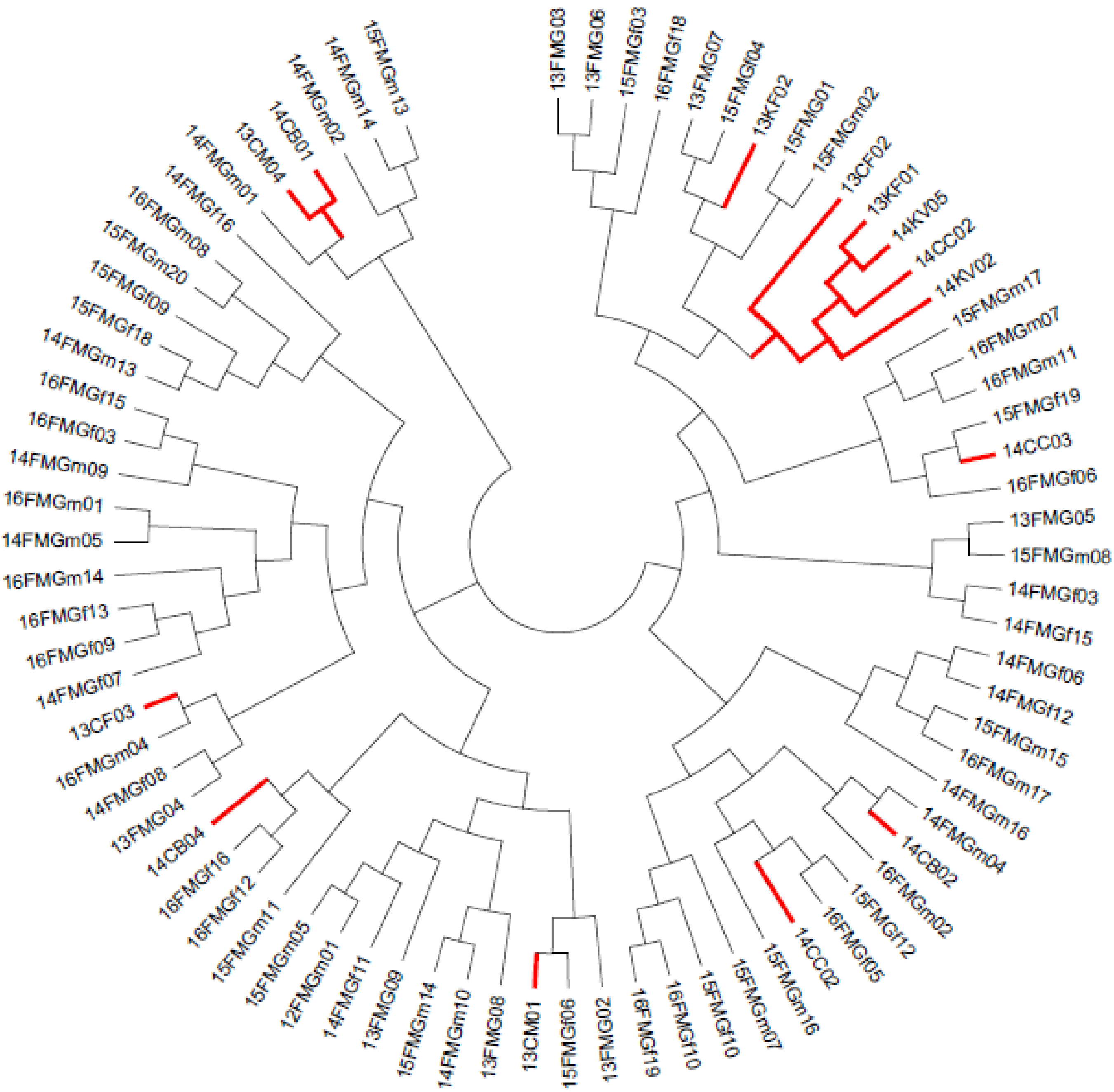
16FMGm02	SL06	13/05/16	-22.4084	119.389	151.36	M	3370	A	
Identifier	Trap No	Capture Date	Latitude	Longitude	VHF Freq	Sex	Weight (g)	Age	Comments
16FMGf03	SL19	13/05/16	-22.4608	119.3394	151.16	F	2260	A	
16FMGm04	NW24	14/05/16	-22.3224	119.2671	151.14	M	2980	A	
16FMGf05	NW30	14/05/16	-22.3279	119.2219	151.44	F	3190	A	
16FMGf06	NW04	14/05/16	-22.3652	119.3703	151.34	F	2800	A	
16FMGm07	SL21	14/05/16	-22.4711	119.3395	151.30	M	3680	A	
16FMGm08	SL40	14/05/16	-22.4618	119.4183	151.26	M	2370	SA	
16FMGf09	SE02	14/05/16	-22.4821	119.482	151.46	F	2800	A	
16FMGf10	NW15	15/05/16	-22.3521	119.3031	151.24	F	2770	A	
16FMGm11	SL21	15/05/16	-22.4711	119.3395	151.48	M	3500	A	
16FMGf12	SL22	15/05/16	-22.4713	119.3446	151.22	F	2600	A	
16FMGf13	SL27	15/05/16	-22.4632	119.3599	151.12	F	2825	A	
16FMGm14	SL32	15/05/16	-22.4613	119.3807		M	3250	A	
16FMGf15	SL19	16/05/16	-22.4608	119.3394		F	910	SA	
16FMGf16	SL23	16/05/16	-22.4717	119.3499	151.18	F	2890	A	
16FMGm17	SE13	16/05/16	-22.5141	119.4962	151.42	M	4320	A	
16FMGf18	SL05	17/05/16	-22.4066	119.3978	150.46	F	2430	A	
16FMGf19	SE09	19/05/16	-22.5123	119.4782	151.32	F	3210	A	

6.3 Feral cat camera captures post-bait 2012 - 2016

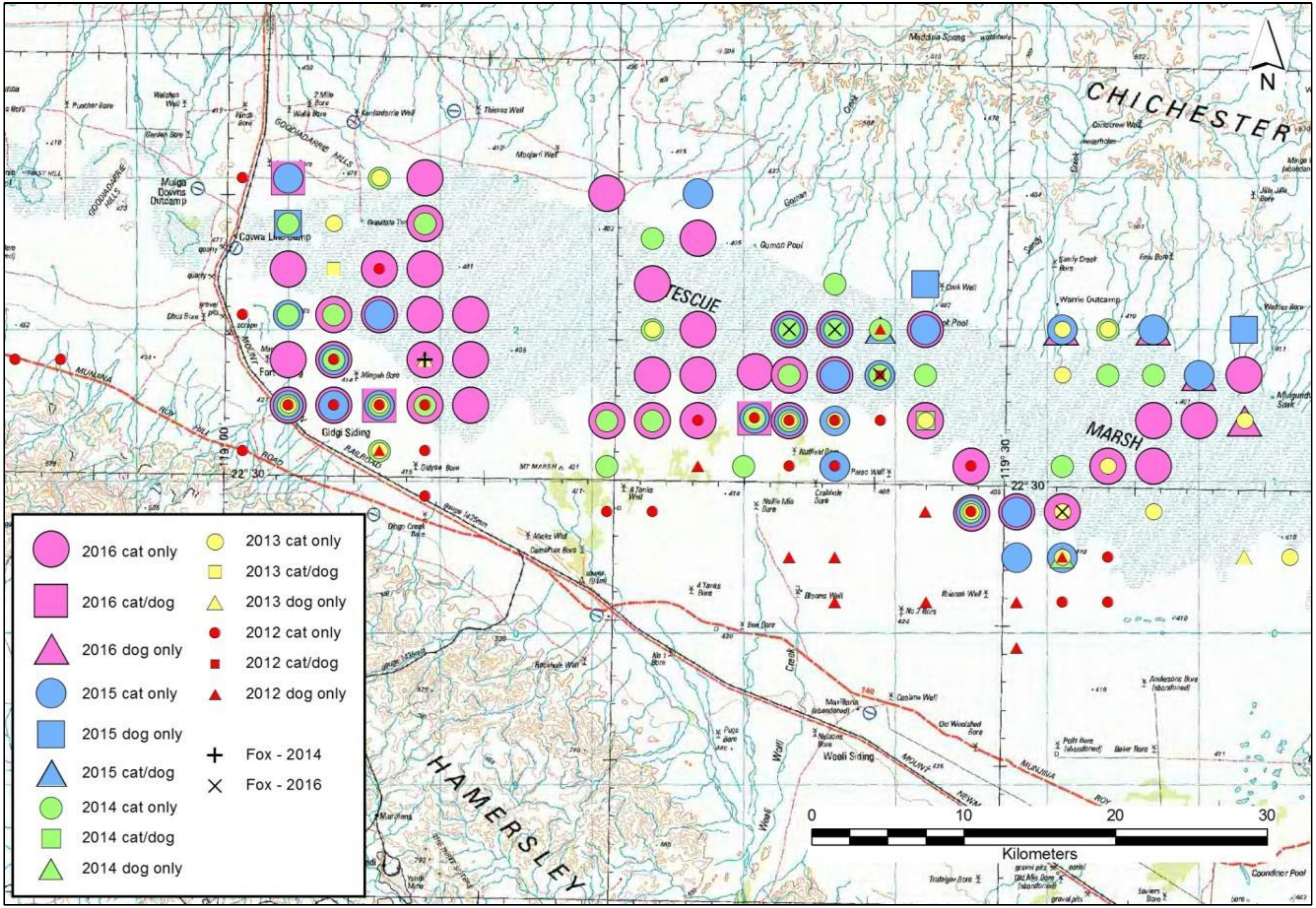


6.4 Phylogenetic (Neighbour-Joining) Tree

All individuals analysed in this study and the relatedness between Fortescue Marsh (FM) and Fortescue Camp (FC) populations. Branches highlighted red, indicate individuals assigned to FC population.



6.5 Spatial and temporal distribution of feral predators captured on cameras 2012 - 2016



6.6 Birds recorded on Fortescue Marsh 2012 - 2016

Species	Scientific Name	DPaW Schedule	2012	2013	2014	2015	2016
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*		Y	Y	Y	Y	Y
Inland Thornbill	*Acanthiza apicalis*			B			
Slaty-backed Thornbill	*Acanthiza robustirostris*		Y	Y	B	Y	B
Chestnut-rumped Thornbill	*Acanthiza uropygialis*			B	B	B	B
Collared Sparrowhawk	*Accipiter cirrocephalus*		B	B	B	B	B
Brown Goshawk	*Accipiter fasciatus*		Y	Y	B	B	B
Australian Owlet-nightjar	*Aegotheles cristatus*			C	B		
Striated Grasswren	*Amytornis striatus*	P4			A		
Grey Teal	*Anas gracilis*		A	B	B	B	B
Pacific Black Duck	*Anas superciliosa*		A			B	
Australian Darter	*Anhinga novaehollandiae*		A	B			
Australasian Pipit	*Anthus novaeseelandiae*		Y	Y	Y	Y	Y
Southern Whiteface	*Aphelocephala leucopsis*						B
Wedge-tailed Eagle	*Aquila audax*		B	Y	Y	B	B
Eastern Great Egret	*Ardea modesta*	5	C		B	B	
White-necked Heron	*Ardea pacifica*		A	B	B	B	B
Australian Bustard	*Ardeotis australis*		Y	Y	Y	Y	Y
Black-faced Woodswallow	*Artamus cinereus*		Y	Y	Y	Y	Y
Little Woodswallow	*Artamus minor*						C
Masked Woodswallow	*Artamus personatus*		Y	Y	B	Y	Y
Australian Ringneck	*Barnardius zonarius*		B	B	Y	Y	Y
Little Corella	*Cacatua sanguinea*		Y	B	B	Y	A
Pallid Cuckoo	*Cacomantis pallidus*			A	Y	Y	B
Red-necked Stint	*Calidris ruficollis*	5	C		B		
Pied Honeyeater	*Certhionyx variegatus*		B	B		Y	C
Horsfield's Bronze-cuckoo	*Chalcites basalis*			B		B	C
Black-eared Cuckoo	*Chalcites osculans*					B	
Inland Dotterel	*Charadrius australis*		Y			C	B
Red-capped Plover	*Charadrius ruficapillus*		C			B	B
Oriental Plover	*Charadrius veredus*	5	B				
Whiskered Tern	*Chlidonias hybrida*				B		
Brown Songlark	*Cincloramphus cruralis*		Y	Y	Y	Y	B
Rufous Songlark	*Cincloramphus mathewsi*		Y	B	B	Y	Y
Chestnut-breasted Quail-thrush	*Cinclosoma castaneothorax*			B	B	B	Y
Swamp Harrier	*Circus approximans*		?B		B		
Spotted Harrier	*Circus assimilis*		Y	Y	Y	Y	B
Grey Honeyeater	*Conopophila whitei*		?B	?B			
Ground Cuckoo-shrike	*Coracina maxima*		C		A		
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*		Y	B	Y	Y	Y

Species	Scientific Name	DPaW Schedule	2012	2013	2014	2015	2016
Little Crow	*Corvus bennetti*		B	B			
Torresian Crow	*Corvus orru*		Y	Y	B	Y	Y
Stubble Quail	*Coturnix pectoralis*		B		B		B
Brown Quail	*Coturnix ypsilophora*		B	B	B	C	B
Pied Butcherbird	*Cracticus nigrogularis*		Y	Y	B	Y	Y
Grey Butcherbird	*Cracticus torquatus*			B	B	Y	B
Black Swan	*Cygnus atratrus*				B	B	
Blue-winged Kookaburra	*Dacelo leachii*		A		A	B	
Plumed Whistling-duck	*Dendrocygna eytoni*		A	B		B	B
Mistletoebird	*Dicaeum hirundinaceum*			B			
Emu	*Dromaius novahollandiae*		B	B	B		B
White-faced Heron	*Egretta novaehollandiae*		C	B	B	B	
Black-shouldered Kite	*Elanus axillaris*		C	B	Y	B	B
Black-fronted Dotterel	*Elseyornis melanops*		C	B	B	B	B
Painted Finch	*Emblema pictum*				A		B
Galah	*Eolophus roseicapillus*		Y	Y	Y	Y	Y
Orange Chat	*Epthianura aurifrons*		C	B	B	Y	Y
Crimson Chat	*Epthianura tricolor*		Y	Y	Y	Y	Y
Spinifexbird	*Eremiornis carteri*		Y	Y	B	B	B
Red-kneed Dotterel	*Erythrogonys cinctus*			B			
Spotted Nightjar	*Eurostopodus argus*		A		B	B	A
Brown Falcon	*Falco berigora*		Y	Y	Y	Y	B
Nankeen Kestrel	*Falco cenchroides*		Y	Y	Y	Y	Y
Grey Falcon	*Falco hypoleucos*	VU			B	B	A
Australian Hobby	*Falco longipennis*		Y	B	B	B	
Peregrine Falcon	*Falco peregrinus*				B	B	B
Black Falcon	*Falco subniger*		C	B	A		
Buff-banded Rail	*Gallirallus philippensis*				B		
Gull-billed Tern	*Gelochelidon nilotica*	5			B	B	
Diamond Dove	*Geopelia cuneata*		Y	Y	Y	Y	B
Peaceful Dove	*Geopelia striata*		A				B
Spinifex Pigeon	*Geophaps plumifera*			B	A	A	A
Western Gerygone	*Gerygone fusca*			B	Y		
Magpie-Lark	*Grallina cyanoleuca*		Y	Y	A	Y	Y
Australian Magpie	*Gymnorhina tibicen*		B		A		B
White-bellied Sea-eagle	*Haliaeetus leucogaster*		A		B	B	B
Whistling Kite	*Haliastur sphenurus*		Y	Y	Y	B	Y
Black-breasted Buzzard	*Hamirostra melanosternon*		B	Y	B		B
Little Eagle	*Hieraaetus morphnoides*		B		B	C	B
Black-winged Stilt	*Himantopus himantopus*		A		B		B

Species	Scientific Name	DPaW Schedule	2012	2013	2014	2015	2016
Welcome Swallow	*Hirundo neoxena*					B	
Caspian Tern	*Hydroprogne caspia*	5			B	B	
White-winged Triller	*Lalage sueurii*		Y	B	B	B	Y
Grey-headed Honeyeater	*Lichenostomus keartlandi*		A	B	A		A
White-plumed Honeyeater	*Lichenostomus penicillatus*		B	Y	Y	Y	B
Singing Honeyeater	*Lichenostomus virescens*		Y	Y	Y	Y	Y
Brown Honeyeater	*Lichmera indistincta*		B	Y	B	Y	B
Square-tailed Kite	*Lophoictinia isura*					B	B
Pink-eared Duck	*Malacorhynchus membranaceus*			B			
Variegated Fairy-wren	*Malurus lamberti*		Y	Y	B	B	B
White-winged Fairy-wren	*Malurus leucopterus*		Y	Y	Y	Y	Y
Yellow-throated Miner	*Manorina flavigula*		Y	Y	Y	Y	Y
Hooded Robin	*Melanodryas cucullata*		B	B	B	B	B
Black-chinned Honeyeater	*Melithreptus gularis*			B			
Budgerigar	*Melopsittacus undulatus*		Y	Y	Y	Y	B
Rainbow Bee-eater	*Merops ornatus*	5	B	Y	B	Y	Y
Black Kite	*Milvus migrans*		B	B	B	B	A
Horsfield's Bushlark	*Mirafra javanica*		Y	Y	Y	Y	Y
Elegant Parrot	*Neophema elegans*			B	B		
Bourke's Parrot	*Neopsephotus bourkii*		B	Y	Y	B	B
Southern Boobook	*Ninox novaeseelandiae*		A				
Cockatiel	*Nymphicus hollandicus*		Y	B	Y	Y	Y
Crested Pigeon	*Ocyphaps lophotes*		Y	Y	Y	Y	Y
Crested Bellbird	*Oreoica gutturalis*		Y	Y	Y	Y	Y
Rufous Whistler	*Pachycephala rufiventris*		Y	B	Y	Y	Y
Red-browed Pardalote	*Pardalotus rubricatus*		B	B	A	Y	B
Australian Pelican	*Pelecanus conspicillatus*		A		B	B	
Fairy Martin	*Petrochelidon ariel*		C			Y	B
Tree Martin	*Petrochelidon nigricans*			B		B	B
Red-capped Robin	*Petroica goodenovii*		Y	B		B	C
Great Cormorant	*Phalacrocorax carbo*				B		
Little Black Cormorant	*Phalacrocorax sulcirostris*		A		B	B	
Common Bronzewing	*Phaps chalcoptera*		Y	B	Y	B	B
Flock Bronzewing	*Phaps histrionicus*					C	
Yellow-billed Spoonbill	*Platalea flavipes*		A		B		
Royal Spoonbill	*Platalea regia*		A		B		
Tawny Frogmouth	*Podargus strigoides*		B				
White-browed Babbler	*Pomatostomus superciliosus*		C	B	Y		B
Grey-crowned Babbler	*Pomatostomus temporalis*		Y	B	B	B	B
Western Bowerbird	*Ptilonorhynchus guttatus*		B	B		B	B

Species	Scientific Name	DPaW Schedule	2012	2013	2014	2015	2016
White-fronted Honeyeater	*Purnella albifrons*			C			
Redthroat	*Pyrrholaemus brunneus*		B	B		B	
Willie Wagtail	*Rhipidura leucophrys*		Y	Y	Y	Y	Y
Weebill	*Smicrornis brevirostris*		Y	Y	A		B
Australian Pratincole	*Stiltia isabella*		B	B	B	B	
Black Honeyeater	*Sugomel niger*		B	B	B	Y	C
Australasian Grebe	*Tachybaptus novaehollandiae*			A	A	A	
Australian Shelduck	*Tadorna tadornoides*		A	B	B	Y	B
Zebra Finch	*Taeniopygia guttata*		Y	Y	Y	Y	Y
Australian White Ibis	*Threskiornis molucca*				B		
Straw-necked Ibis	*Threskiornis spinicollis*		Y	B	B	Y	B
Red-backed Kingfisher	*Todiramphus pyrrhopygius*		Y	B	Y	Y	Y
Sacred Kingfisher	*Todiramphus sanctus*		A				
Black-tailed Native-hen	*Tribonyx ventralis*			B			
Little Button-quail	*Turnix velox*		Y	Y	Y	B	Y
Eastern Barn Owl	*Tyto javanica*			B		B	B
Banded Lapwing	*Vanellus tricolor*					B	
		Totals	99	94	102	96	91

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)

6.7 Vertebrate species list from all camera data 2012 – 2016

Common Name	Scientific Name	2012	2013	2014	2015	2016
agamid sp.		✓	✓	□	✓	✓
Australasian Pipit	*Anthus novaeseelandiae*	✓	✓	✓	✓	✓
Australian Bustard	*Ardeotis australis*	✓	✓	✓	✓	✓
Australian Magpie	*Gymnorhina tibicen*	✓	□	□	□	✓
Australian Owlet-nightjar	*Aegotheles cristatus*	□	✓	□	□	□
Australian Ringneck	*Barnardius zonarius*	□	□	□	□	✓
Black Honeyeater	*Sugomel niger*	□	□	□	✓	□
Black-faced Woodswallow	*Artamus cinereus*	✓	✓	✓	✓	✓
Bourke's Parrot	*Neopsephotus bourkii*	✓	□	□	□	□
Brown Falcon	*Falco berigora*	✓	□	□	□	□
Brown Goshawk	*Accipiter fasciatus*	✓	✓	□	□	□
Brown Quail	*Coturnix ypsilophora*	✓	✓	✓	□	✓
Brown Songlark	*Cincloramphus cruralis*	✓	✓	✓	✓	✓
Budgerigar	*Melopsittacus undulatus*	✓	□	□	□	□
Buff-banded Rail	*Gallirallus philippensis*	□	□	✓	□	□
Cattle	*Bos taurus*	✓	✓	✓	✓	✓
Central Military Dragon	*Ctenophorus isolepis*	□	□	✓	□	□
Centralian Blue-tongue	*Tiliqua multifasciata*	□	□	□	✓	✓
Chestnut-breasted Quail-thrush	*Cinclosoma castaneothorax*	□	□	□	✓	✓
Cockatiel	*Nymphicus hollandicus*	✓	□	□	□	□
Collared Sparrowhawk	*Accipiter cirrocephalus*	✓	□	✓	□	□
Common Bronzewing	*Phaps chalcoptera*	✓	✓	✓	✓	✓
Crested Bellbird	*Oreoica gutturalis*	✓	□	✓	✓	✓
Crested Pigeon	*Ocyphaps lophotes*	✓	□	✓	✓	✓
Crimson Chat	*Epthianura tricolor*	✓	✓	✓	✓	□
Desert Mouse	*Pseudomys desertor*	□	□	✓	✓	✓
Diamond Dove	*Geopelia cuneata*	✓	✓	□	✓	✓
Dog/Dingo	*Canis lupus familiaris*	✓	✓	✓	✓	✓
Donkey	*Equus asinus*	✓	□	□	✓	□
dunnart	*Sminthopsis sp.*	□	□	✓	✓	□
Emu	*Dromaius novaehollaniae*	□	✓	✓	✓	✓
European Rabbit	*Oryctolagus cuniculus*	✓	✓	✓	✓	✓
Feral Cat	*Felis catus*	✓	✓	✓	✓	✓
Galah	*Eolophus roseicapilla*	✓	✓	✓	✓	✓
Greater Bilby	*Macrotis lagotis*	✓	□	□	□	□
Grey Butcherbird	*Cracticus torquatus*	□	□	✓	✓	✓
Ground Cuckoo-shrike	*Coracina maxima*	✓	□	□	□	□
harrier sp.	*Circus sp.*	✓	□	□	□	□
Hooded Robin	*Melanodryas cucullata*	✓	□	□	□	□
Horse	*Equus caballus*	□	□	□	□	✓
Horsfield's Bronze-cuckoo	*Chrysococcyx basalis*	□	□	□	✓	□

Common Name	Scientific Name	2012	2013	2014	2015	2016
Horsfield's Bushlark	*Mirafra javanica*	✓	☐	☐	✓	✓
Inland Dotterel	*Charadrius australis*	✓	☐	☐	☐	☐
Little Button-quail	*Turnix velox*	✓	✓	✓	☐	✓
Little Corella	*Cacatua sanguinea*	☐	☐	☐	✓	☐
Little Eagle	*Hieraaetus morphnoides*	☐	☐	☐	✓	☐
Little Red Kaluta	*Dasykaluta rosamondae*	☐	✓	✓	✓	✓
Magpie-lark	*Grallina cyanoleuca*	☐	☐	✓	✓	☐
mulgara	*Dasycercus sp.*	☐	☐	☐	✓	☐
Nankeen Kestrel	*Falco cenchroides*	✓	✓	✓	✓	✓
Ningaui sp.	*Ningaui sp.*	☐	☐	☐	✓	☐
Notomys sp.	*Notomys sp.*	☐	☐	☐	✓	✓
One-humped Camel	*Camelus dromadarius*	☐	✓	☐	✓	☐
Orange Chat	*Epthianura aurifrons*	☐	☐	✓	✓	☐
Pallid Cuckoo	*Cuculus pallidus*	☐	☐	☐	✓	☐
Perentie	*Varanus giganteus*	☐	☐	☐	✓	☐
Pied Butcherbird	*Cracticus nigrogularis*	☐	☐	✓	✓	✓
Pied Honeyeater	*Certhionyx variegatus*	☐	☐	☐	✓	☐
Pseudomys sp.	*Pseudomys sp.*	☐	☐	☐	✓	✓
Pygmy Desert Monitor	*Varanus eremius*	☐	☐	✓	☐	✓
Red Fox	*Vulpes vulpes*	☐	☐	✓	☐	✓
Red Kangaroo	*Macropus rufus*	✓	✓	✓	✓	✓
Red-capped Robin	*Petroica goodenovii*	✓	☐	☐	☐	☐
Rufous Songlark	*Cincloramphus mathewsi*	✓	☐	☐	☐	☐
Rufous Whistler	*Pachycephala rufiventris*	☐	☐	☐	✓	☐
Short-beaked Echidna	*Tachyglossus aculeatus*	✓	☐	✓	✓	✓
Singing Honeyeater	*Lichenostomus virescens*	✓	✓	☐	✓	✓
small mammal	*small mammal*	✓	✓	✓	✓	✓
Southern Boobook	*Ninox novaeseelandiae*	✓	☐	☐	☐	☐
Spinifex Hopping-mouse	*Notomys alexis*	✓	✓	✓	✓	☐
Spinifexbird	*Eremiornis carteri*	☐	☐	☐	✓	✓
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*	☐	☐	☐	✓	✓
Spotted Harrier	*Circus assimilis*	☐	☐	✓	☐	✓
Spotted Nightjar	*Eurostopodus argus*	☐	☐	✓	✓	☐
Straw-necked Ibis	*Threskiornis spinicollis*	☐	☐	✓	✓	☐
Stripe-faced Dunnart	*Sminthopsis macroura*	☐	✓	✓	✓	✓
Stubble Quail	*Coturnix pectoralis*	✓	☐	✓	☐	☐
Tawny Frogmouth	*Podargus strigoides*	✓	☐	☐	☐	☐
Torresian Crow	*Corvus orru*	✓	✓	✓	✓	✓
varanid sp.		☐	☐	☐	✓	✓
Variegated Fairy-wren	*Malurus lamberti*	☐	☐	✓	✓	✓
Wedge-tailed Eagle	*Aquila audax*	✓	☐	✓	☐	✓
Western Bowerbird	*Ptilonorhynchus guttatus*	✓	✓	☐	✓	☐
Whistling Kite	*Haliastur sphenurus*	✓	☐	✓	☐	☐

Common Name	Scientific Name	2012	2013	2014	2015	2016
White-browed Babbler	*Pomatostomus superciliosus*	✓	□	□	□	✓
White-faced Heron	*Egretta novaehollandiae*	□	□	✓	□	□
White-necked Heron	*Ardea pacifica*	□	□	✓	□	□
White-winged Fairy-wren	*Malurus leucopterus*	□	✓	✓	✓	✓
Willie Wagtail	*Rhipidura leucophrys*	✓	✓	✓	✓	✓
Yellow-spotted Monitor	*Varanus panoptes*	✓	✓	✓	✓	✓
Yellow-throated Miner	*Manorina flavigula*	✓	□	□	✓	✓
Zebra Finch	*Taeniopygia guttata*	✓	✓	✓	✓	✓