Fortescue Marsh Feral Cat Baiting Program

(Christmas Creek Water Management Scheme)

Year 1

Annual Report

November 2012

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1 Introduction

The Australian arid zone has experienced a high rate of native mammal decline following European settlement. Since the 1920s, approximately 33% of all mammals and about 90% of medium-sized mammals (35 – 5,500 g adult bodyweight range) have either suffered dramatic range contractions or are extinct (Burbidge & McKenzie 1989). Many of these species are now restricted to several offshore islands and others, due to small population sizes and restricted geographic ranges, are vulnerable to total extinction. A number of causes have been proposed to explain this decline. These causes include changed fire regimes, competition from introduced herbivores, disease, extreme variability in weather and site fertility and predation by introduced predators, specifically the feral cat (*Felis catus*) and fox (*Vulpes vulpes*) (see Abbott 2002; Burbidge & McKenzie 1989; Dickman 1996a, b; EA. 1999; Johnson *et al*. 1989; Morton 1990). Predation by feral cats has also been demonstrated to threaten the continued survival of many other native species persisting at low population densities (e.g. Risbey *et al*. 2000; Smith & Quin 1996) and has been identified as one of the major obstacles to the reconstruction of faunal communities as it has prevented the successful re-introduction of a number of species to parts of their former range (Christensen & Burrows 1995; Dickman 1996b; EA. 1999; Gibson *et al*. 1995). The suppression of introduced predators is therefore a critical component of successful reintroduction, recovery or maintenance of populations of small to medium-sized native fauna (Christensen & Burrows 1995; Fischer & Lindenmayer 2000; McKenzie *et al*. 2007).

Effective control of feral cats is recognised as one of the most important fauna conservation issues in Australia today and as a result, a national Threat Abatement Plan (TAP) for Predation by Feral Cats (EA 1999; DEWHA 2008a) has been developed. The objective of the TAP is to protect affected native species and ecological communities, and to prevent further species and ecological communities from becoming threatened. The impact of feral cats in the Pilbara is discussed in McKenzie *et al*. (2009), and addressing this threat will have a significant impact on maintaining populations of native species in this important area. Further more for waterbirds cat control in Fortescue Marsh is highly desirable, given this site is proposed for nomination as a Ramsar site at the next opportunity and it is also designated as a Wetland of National Importance (see Directory of Important Wetlands in Australia [Environment Australia 2001])

Baiting is recognized as the most effective method for controlling feral cats on mainland Australia (Algar & Burrows 2004; Algar *et al*. 2007; DEWHA 2008a; EA 1999; Short *et al*. 1997), when there is limited risk posed to non-target species. The feral cat bait (*Eradicat*®) (see detailed description in Algar & Burrows 2004; Algar *et al*. 2007) has proven to be an effective tool in reducing feral cat numbers. Most baiting campaigns have shown that baiting for feral cats can consistently achieve highly effective control, especially in semi-arid and arid areas. When the results of broad-scale baiting have been less successful, it can generally be attributable to unfavourable weather conditions at the time of baiting or an abundance of prey.

The Fortescue Marsh baiting program will maximise the benefits of the control of feral cats while minimising the risk to migratory and EPBC Act listed threatened species.

1.1 Adaptive management process

The present study was designed within the Active Adaptive Management (AAM) paradigm (McCarthy & Possingham 2007; Walters & Holling 1990). AAM is a form of management that treats management actions as 'quasi experiments' with a cycle involving at least seven steps (Burrows 2005):

1. Problem assessment: identification of a specific and high priority issue requiring a management response to deliver conservation and land management outcomes. In this case, the issue is that introduced predators, especially cats, are impacting negatively on populations of threatened animals, and Fortescue is required by the Commonwealth to address this issue in their sphere of operations near their mining operations on the margin of the Fortescue Marsh, which is an area of high conservation significance.
2. Potential solutions: exploration of alternative hypotheses and management actions. It is hypothesised that feral cats are the major threat to populations of threatened animals in this area, and that reduction of the cat population will result in population recovery in threatened prey species.
3. Project design: a detailed management action plan, including a monitoring program, that will guide what actions are to be taken, when, where, how, and by whom, budget and other resource needs. For the current project, these arrangements are described by Algar *et al*. (2011) and the present document.
4. Project implementation: the plan is resourced and actioned. The plan is being resourced primarily by Fortescue, and is being actioned by DEC,
5. Monitoring: appropriate parameters are monitored/measured to determine how effective actions have been in meeting management objectives and to test the hypothesised relationships. Populations of introduced predators and likely prey species are being monitored as described in Algar *et al*. (2011) and the present document.
6. Project evaluation: comparison of the actual outcomes based on monitoring program, and interpreting reasons that may underlie any differences. Evaluation will be based on methods currently being developed for this project, including the use of standard statistical procedures and occupancy modelling.
7. Adjustment: management policies, practices and objectives are adjusted (if necessary) to reflect new understanding gained by monitoring and evaluation, and changes to budget and resource constraints. The project will contribute to the understanding of population dynamics in predator-prey systems in arid environments, and it is envisaged that management actions will be evaluated in this context, and altered or adjusted as necessary.

Active adaptive management acknowledges and confronts uncertainty and the need for long-term commitments to monitoring. Management decisions are treated as provisional experiments subject to verification or amendment. In contrast to traditional approaches to management, in which changes are generally based simply on the trialling of alternative approaches, the key feature of AAM is that changes are based on increased understanding based on hypothesis testing.

2 Methods

The Fortescue Marsh is an extensive intermittent wetland situated at 22^0 26'.44" S, 119^0 26'.38" E.. 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 1,000 km^2 when in flood (DEWHA 2008b) (see Figure 1).

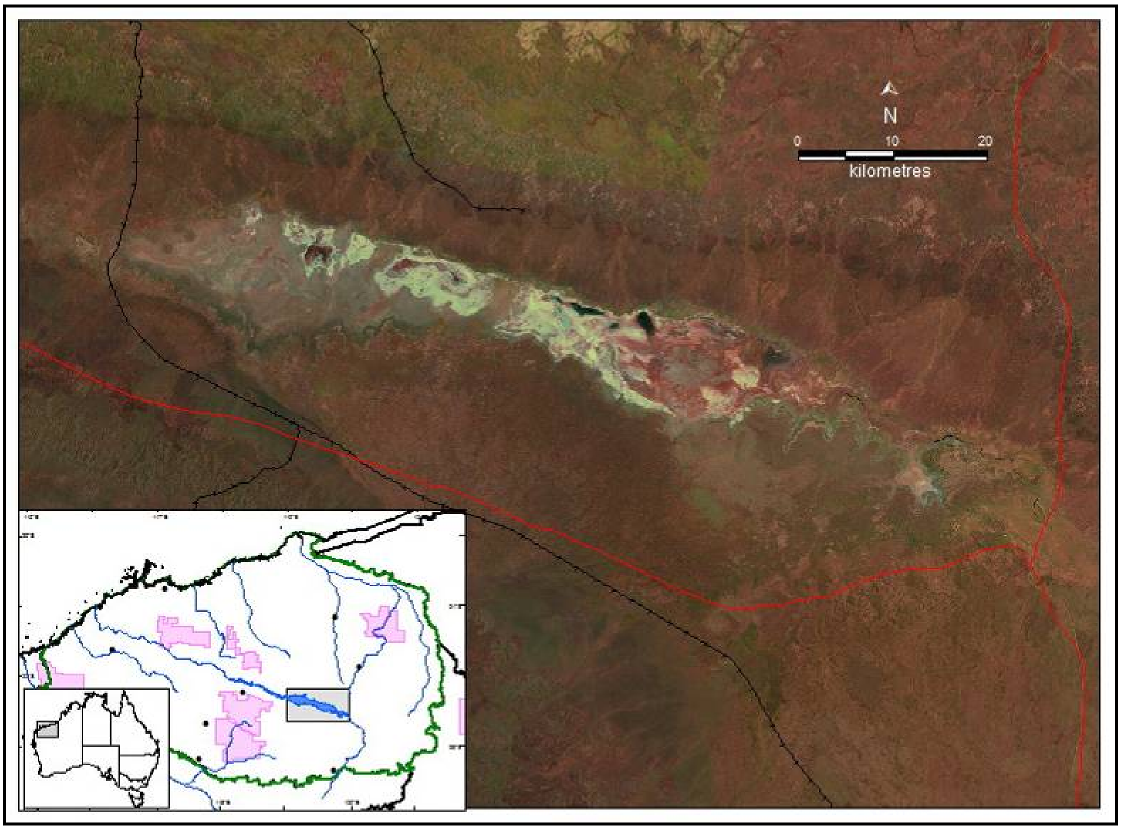

Figure 1 Location and regional setting of the Fortescue Marsh.

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

Botanical surveys conducted for Fortescue's Cloud Break Iron Ore Project Public Environmental Review included fringing vegetation of the Marsh. Five distinct vegetation communities were identified (Mattiske Consulting Services 2005, cited in Fortescue 2009) and include:

- low woodland to low open forest of *Acacia aneura*, *A. citrinoviridis*, *A. pruinocarpa* over *A. tetragonophylla* and *Psydrax latifolia* over *Chrysopogon fallax*, *Stemodia viscosa*, *Blumea tenella*, *Themeda triandra* and species of *Triodia* and *Aristida*. This vegetation community occurs within the creek and drainage lines leading into the Marsh;
- hummock grassland of *Triodia angusta* with patches of *A. victoriae*, *A. aneura*, *A. xiphophylla* over *Atriplex codonocarpa*, *Eremophila cuneifolia* and mixed chenopods;
- low halophytic shrubland of *Tecticornia auriculata* and *T. indica* with associated chenopods including *Maireana* species and *A. flabelliformis* with *Muehlenbeckia florulenta* with patches of *A. victoriae* and *A. sclerosperma*. This vegetation community adjoins the low woodland to low open forest of *A. aneura*;
- low halophytic shrubland of *T. auriculata*, *T. indica*, *T. halocnemoides* with patches of *Frankenia* species. This is the predominant vegetation community along the fringes of the Marsh and
- hummock grassland of *T. angusta* with patches of *A. victoriae* over *A. codonocarpa* and mixed chenopods and Poaceae species.

2.1 Study areas

2.1.1 Treatment area / bait cell

The treatment site was located at the eastern side of the study area, where the Marsh is at its widest (Figures 2 and 3). This was chosen to reduce the effect of reinvasion of predators after baiting. The bait cell incorporated land from the Marillana, Roy Hill, Mulga Downs and Hillside Pastoral Leases (Table 1, Figure 2). Outside of the marsh and the immediate surrounding spinifex habitat, the area within the bait cell on Marillana Station and the southern section of Roy Hill Station is currently used as active pastoral land. There appears to be little use of the actual marsh for grazing, although some signs of cattle (*Bos taurus*) presence exist. In 2015, it has been agreed that the majority Fortescue Marsh be incorporated into DEC managed land through the relinquishment of blocks of pastoral lease (see DEC reserve boundary Figure 3).

Due to the variable annual water levels of the marsh, the total area of the bait cell encompassed a total of 1,240 km^2, of which a maximum of 1,000 km^2 are to be baited annually over the five year program. Higher than average water levels during 2012 reduced the area baited to a maximum of 858 km^2.

At the request of the station managers, a buffer zone of 1 km was provided around all bores and wells within the bait cell. This buffer zone included the exclusion of baits and all monitoring activity.

Table 1. Location and size of bait cell within each pastoral lease and the boundary of DEC managed land at the Fortescue Marsh

Pastoral lease / DEC managed land	Bait cell (km^2)	% Pastoral lease / DEC managed land in bait cell	Area baited 2012 (km^2)	% Pastoral lease / DEC managed land baited in 2012
Marillana	671.5	18.8	557.6	16.5
Roy Hill	194.9	4.9	103.6	2.6
Hillside	242.7	6.0	83.1	2.1
Mulga Downs	131.2	3.7	81.7	2.3
DEC managed land in 2015	838.9	46.6	456.6	25.4

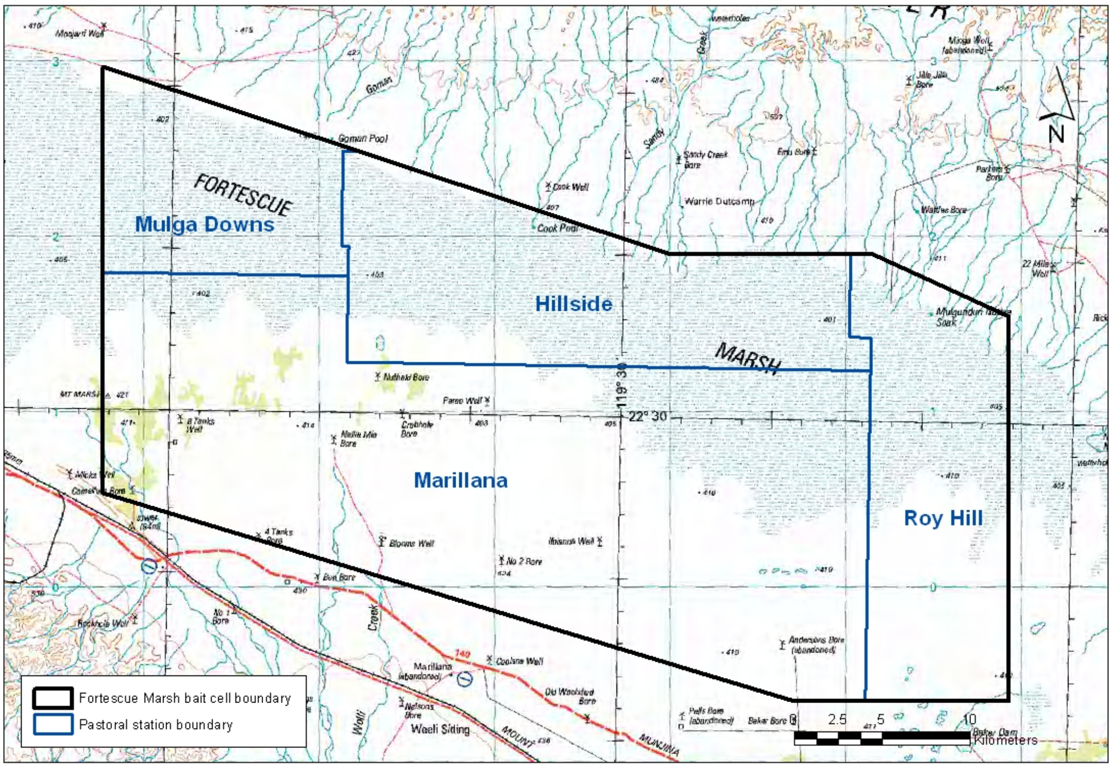

Figure 2 Location of pastoral leases within entire bait cell at the Fortescue Marsh

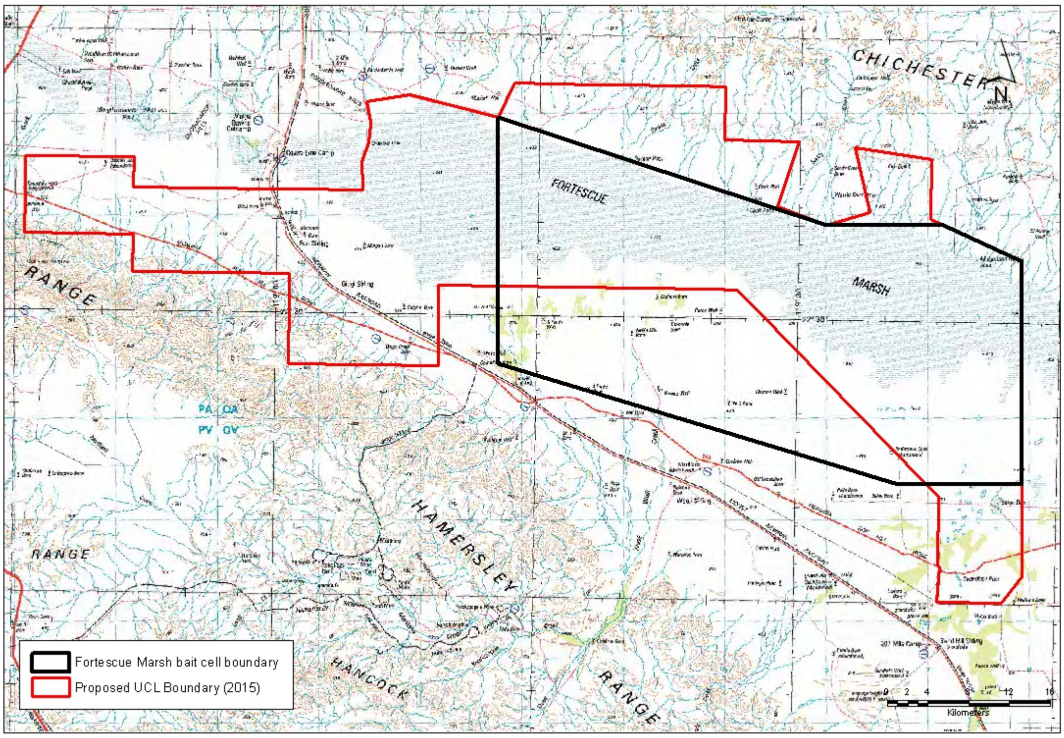

Figure 3: Location of bait cell and boundary of land to be relinquished from pastoral leases in 2015 at the Fortescue Marsh

2.1.2 Control area

The control site was located at the western end of Fortescue Marsh, encompassing an area of 843.8 km^2 (Figure 4). This site was chosen due to its proximity to that within the treatment/baited site. However, vegetation in the in control cell is significantly different from treatment cell, in particular on the western side of BHPBIO railway, which has more mulga woodlands than samphire shrublands. In addition, the control site contains considerably more infrastructure and mining activity than the treatment area.

To ensure independence between the treatment and control sites, a buffer zone of at least 5 km was used to separate monitoring at the control site from the bait cell. The buffer zone should be at least one average feral cat home range estimated to be approximately 5 km in all directions (D. Algar unpub. data).

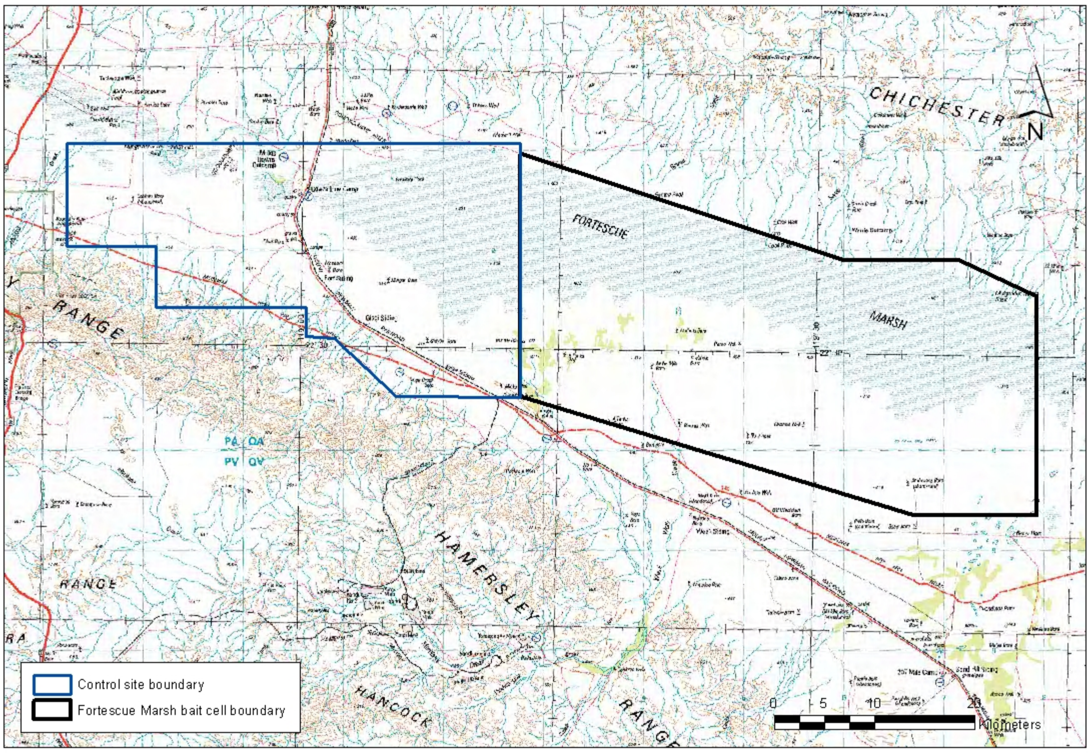

Figure 4 Location of treatment and control site boundaries at the Fortescue Marsh

2.2 Baits

The feral cat baits (*Eradicat*®) used in the Fortescue Marsh baiting program are manufactured at DEC'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 4.5 mg of sodium monofluoroacetate (compound 1080) per bait. Prior to bait application, feral cat baits are thawed and placed in direct sunlight on-site. This process, termed 'sweating', causes the oils and lipid-soluble digest material to exude from the surface of the 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 by cats by limiting the physical presence of ants on and around the bait medium.

2.3 Baiting

Baiting operations were conducted under an 'Experimental Permit' (Permit No. PER12732) issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA) and governed by the 'Code of Practice on the Use and Management of 1080' (Health Department, Western Australia) and associated '1080 Baiting Risk Assessment'.

The timing of baiting was conducted in mid-late winter to maximise the uptake of baits by feral cats, minimise the rate of non-target species bait uptake, and allow for sufficient pre-bait monitoring to be established. Earlier research in the arid and semi-arid zones has indicated that the effectiveness of baiting programs for feral cats is maximized by distributing baits during the cool, dry winter periods (Algar & Burrows, 2004). At this time the abundance and activity of all prey types, in particular predator-vulnerable young mammals and reptiles, is at its lowest, and bait degradation due to rainfall, ants and hot, dry weather, is significantly reduced.

The baiting program was conducted from a dedicated baiting aircraft under DEC's Western Shield Program Aerial Baiting Contract which deployed baits along previously designated baiting flightlines. The baiting aircraft flew at a nominal speed of 150 knots at 500 feet AGL (Above Ground Level). A GPS point was recorded on the flight plan each time bait left the aircraft. A baiting intensity of 50 baits km^{-2} was conducted for effective and cost efficient control (Algar & Burrows 2004). The 'bombardier' released a bag of 50 baits into each 1 km map grid, along flight transects 1 km apart, to achieve the application rate of 50 baits km^{-2}. The ground spread of 50 baits is approximately 250 x 50 m (D. Algar unpub. data). Accredited DEC staff were responsible for transportation, on-site preparation and baiting operations.

The 2012 bait cell was designed according to the water boundary mapped from an orthophoto taken in late April 2012 (Figure 5) with 1 km exclusion zones around bores and wells at the request of the pastoralists. In future, the water boundary could be mapped by helicopter several weeks prior to baiting or the pilot/bombardier could be instructed to bait by sight according to the water boundary at the time of baiting.

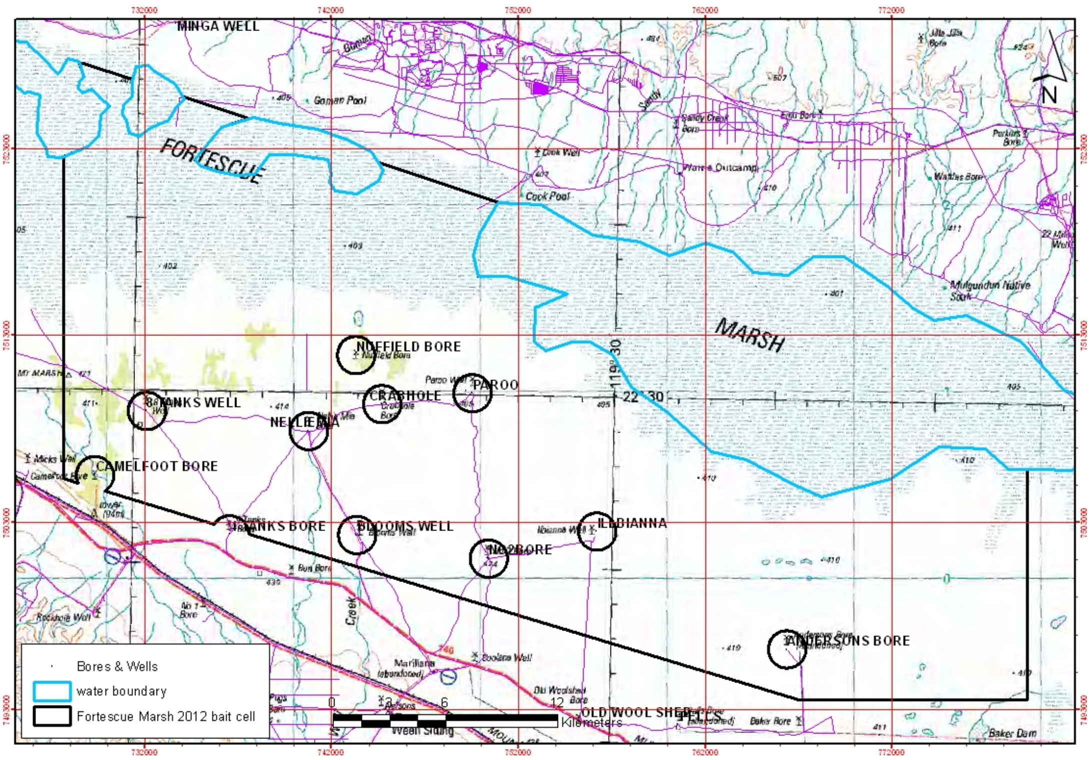

Figure 5. Boundary of the 2012 *Eradicat* bait cell, with exclusion zones at the Fortescue Marsh

2.4 Feral cat monitoring

Feral cat, wild dog/dingo hybrids (*Canis familiaris*) and foxes are all known to be present in the Marsh but evidence of feral cat and wild dog only was observed. Both these species will readily consume feral cat baits and it has previously been demonstrated that feral cat baiting programs will impact these other introduced predators (Algar *et al*. in review). Other introduced predators were also surveyed using the methodology for monitoring feral cats, and results will be collated and analysed in future years.

Two independent methods for monitoring baiting efficacy were proposed (Algar *et al*. 2011) and implemented: 1) trapping and radio-collaring of feral cats prior to the baiting program; 2) surveys of cat activity at camera-trap stations to derive indices of abundance/activity/occupancy. Differences in the indices obtained pre- and post-baiting are used as a measure of baiting efficacy.

2.4.1 Feral cat trapping and GPS radio-collaring

A short trapping program (135 trap-nights) was conducted within the bait cell prior to the baiting program (see Figure 6 for trap locations). The location of traps incorporated a range of habitat types including mulga woodland, spinifex grassland and samphire/marsh habitat. The trapping technique involved the use of padded leg-hold Victor 'Soft Catch'® traps No. 3 (Woodstream Corp., Lititz, Pa.; U.S.A.) with a mixture of cat faeces/urine and an audio lure

(Feline Audio Phonic) as the attractant. In the mulga woodland, within active pastoral land, trap sets were parallel to the track along the verge at 0.5 km intervals. Trap sets in spinifex and samphire/marsh habitat were located off-track. 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. A total of 27 traps was commissioned on 6 July to target feral cats to enable GPS radio-collars to be fitted. All traps were decommissioned on 11 July.

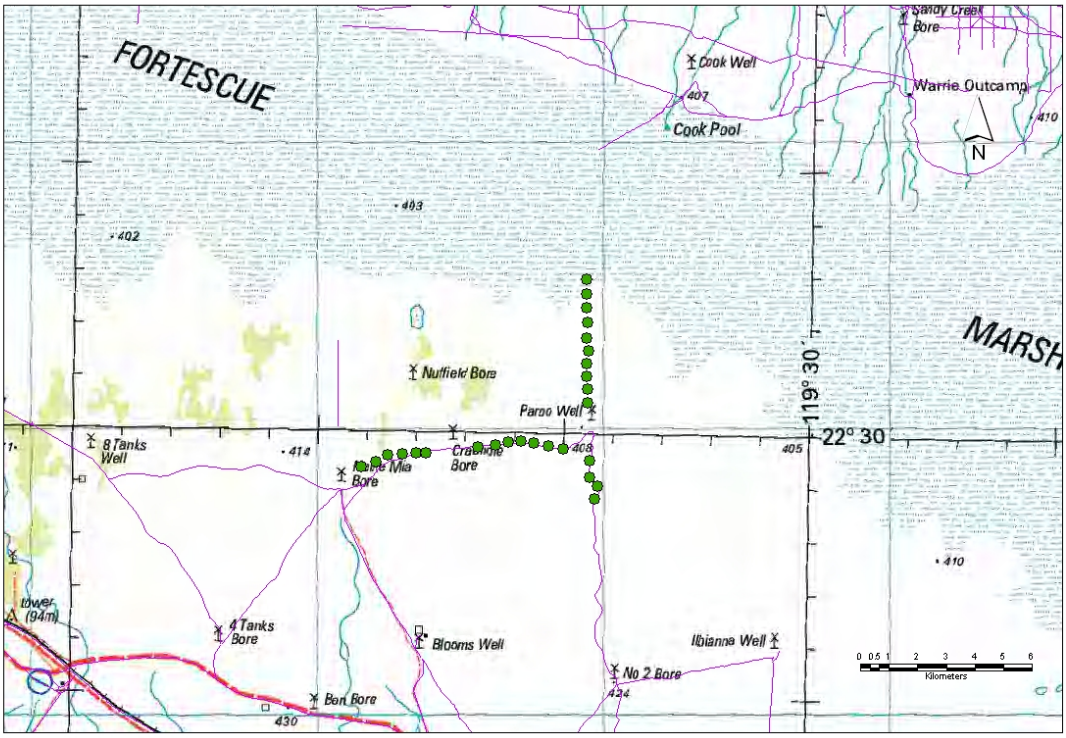

Figure 6. Feral cat trap locations at the Fortescue Marsh

2.4.2 Feral cat camera trap surveys

During 5-16 July, a total of 30 and 49 cameras were established in the control and treatment cells, respectively (see Figures 7 and 8). Lures consisted of a vial with a mesh lid containing dampened cotton wool covered with a scent lure (Catastrophic, Outfoxed Victoria) which was attached to a wooden stake approximately 30 cm from the ground. White turkey feathers were attached to the outside of the vial to provide a visual lure. Cameras were set horizontally, also approximately 30 cm from the ground.

All monitoring activity within the study area ceased from 16 July to reduce the effect of human disturbance on the movements of introduced predators during a minimum two-week period prior to baiting. Presence/absence data for feral cats and dogs was collected during this period. Lures were removed during 31 July – 13 August to provide a two-week period with lures absent from camera sites. These were reinstated during 31 August – 5 September to commence the two-week period of post-bait monitoring at these sites. Cameras and lures were removed from the field during 11 - 15 September.

An occupancy model using detection histories at sites was used to generate a probability of occupancy of a site rather than just presence/absence. These probabilities are based on four assumptions as detailed in MacKenzie *et al.* (2006): population closure, no un-modeled heterogeneity in occupancy, no un-modeled heterogeneity in detection, and detection histories at each site are independent. In the first year of operation we have focussed on developing an appropriate methodology for trialling the application of these robust techniques to camera trapping data.

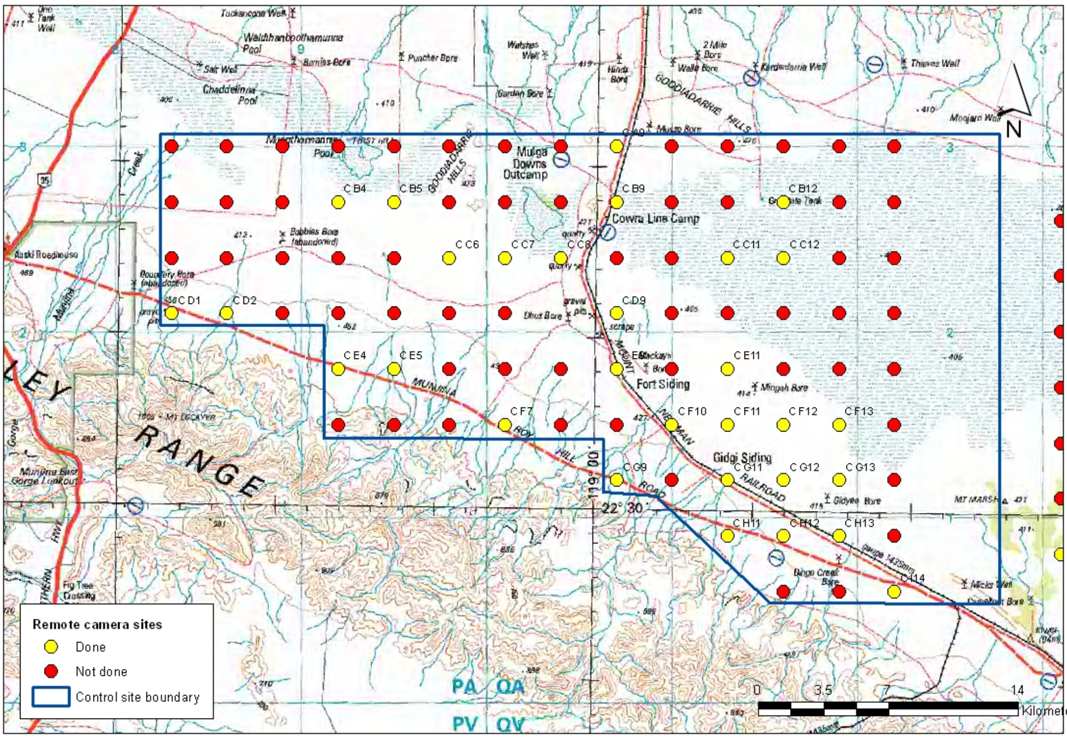

Figure 7. Control cell camera locations for 2012 at the Fortescue Marsh

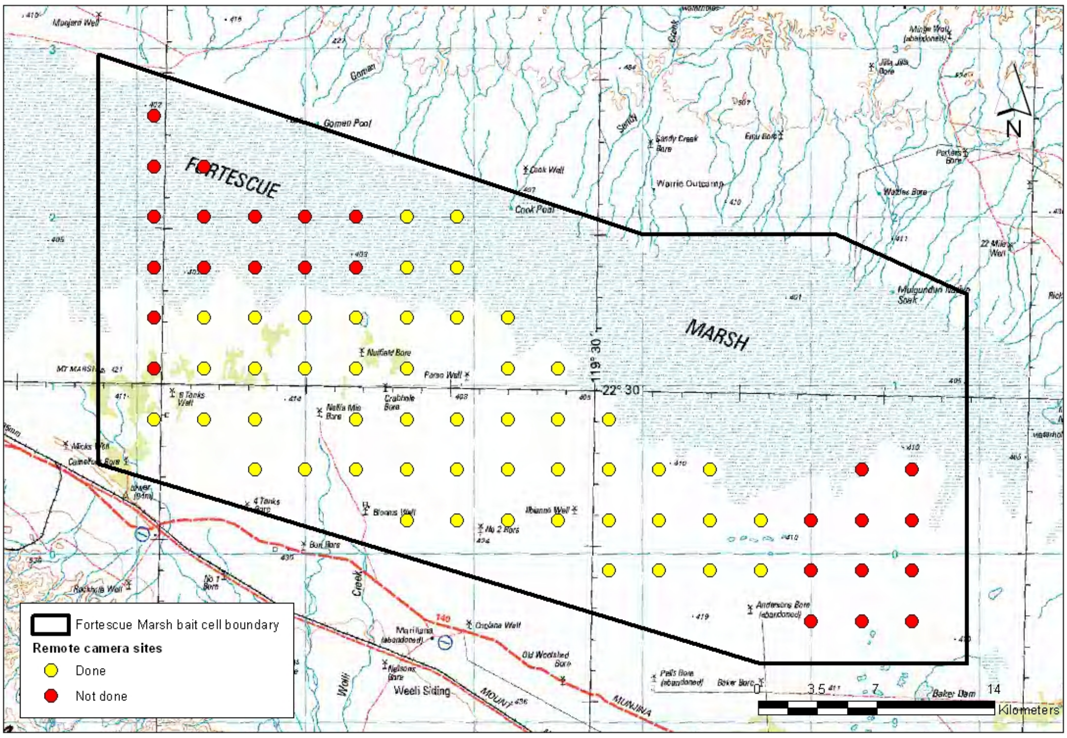

Figure 8. Baited cell camera locations for 2012 at the Fortescue Marsh

2.5 Non-target species

2.5.1 Non-target species baiting risk and mammal surveys

A trapping transect comprising 50 Elliott traps and 50 Sheffield traps placed at 100 m intervals was located along the track at either side of the Paroo Well on the Marillana Station (see Figure 9). Traps were baited with a peanut butter, oats and sardine mixture. All traps were commissioned on 5 September and decommissioned on the 9 September.

The non-toxic biomarker dye Rhodamine B (RhB) was incorporated into the *Eradicat*® baits. This is a systemic marker and is effective as an indicator of bait ingestion to determine whether native species had consumed baits. This biomarker was injected into the bait medium at the time of their production and, once consumed, the dye enters the animal's bloodstream and is incorporated into growing tissue, hairs and vibrissae (Fisher 1998). Presence of RhB is detected by fluorescent staining, usually as bands, with detection in most species requiring the use of a fluorescence microscope. It is generally considered the preferred method for detecting bait uptake by mammals (Claridge *et al.* 2006; Fenner *et al.* 2009; Fisher 1998; Körtner *et al*. 2003; Körtner 2007).

The presence of native mammal species was also identified using the remote cameras.

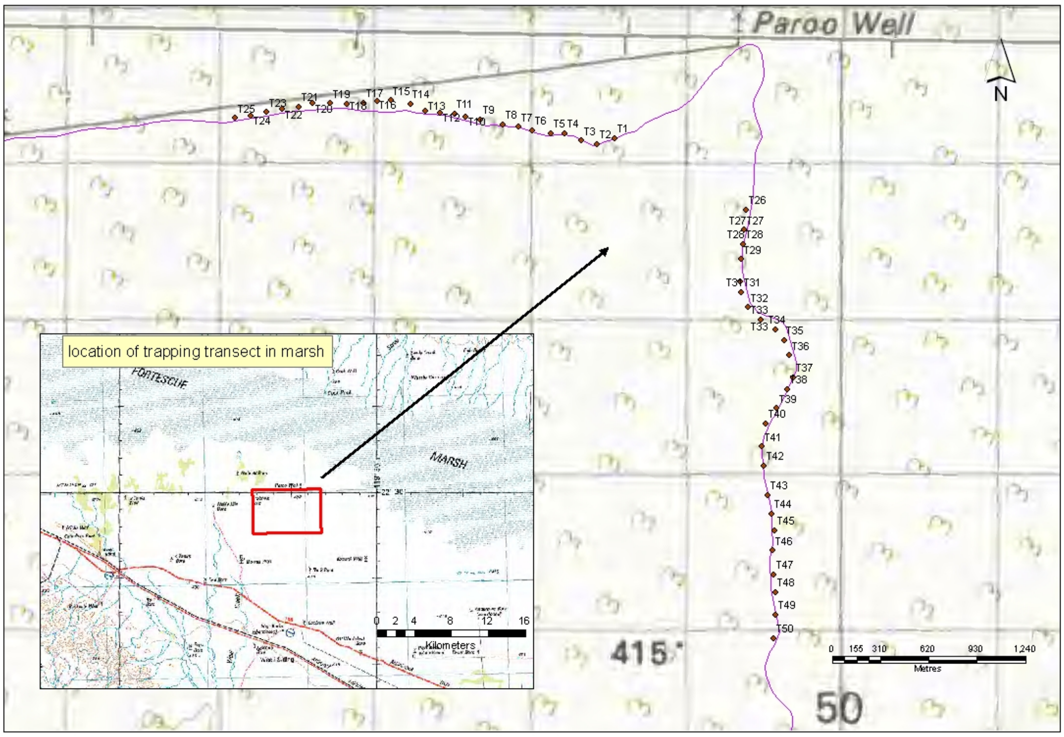

Figure 9. Non-target trapping transect at the Fortescue Marsh

2.5.2 Bird surveys

Bird surveys consisted of opportunistic observations throughout the study period within and immediately adjacent to the study area. Birds were also surveyed by the remote cameras placed within the control and treatment sites. The first procedure provided data on species presence while the second provided data that can be used in reporting rate calculations (ie Relative Activity Index) or, potentially, in occupancy modelling.

2.5.3 Northern Quoll habitat assessment

Habitat critical to the survival of the Northern Quoll (*Dasyurus hallucatus*) occurs in two broad forms (Hill and Ward 2010):

1. rocky habitats such as ranges, escarpments, mesas, gorges, breakaway, boulder fields, major drainage lines or treed creek lines;
2. offshore islands where the northern quoll is known to exist.

Additionally, structurally diverse woodland or forest areas containing large diameter trees, termite mounds or hollow logs for denning purposes may be important for this species (DSEWPAC, 2012).

Foraging or dispersal habitat is recognised to be any land comprising predominantly native vegetation in the immediate area (within 2 km) of denning/shelter habitat, quoll records or land comprising predominantly native vegetation that is connected to denning/shelter habitat within the species range.

A habitat assessment of the area including and immediately surrounding the study area was conducted during 5 – 16 July and 31 July – 13 August to determine the extent of critical habitat, including foraging or dispersal habitat.

3 Results

3.1 Baiting

The production of *Eradicat*® baits was completed in May 2012 at the DEC Harvey bait factory and consisted of 50,000 toxic baits for the Fortescue Marsh baiting program. All baits contained the Rhodamine B biomarker to facilitate the non-target species bait uptake trials. Bait sweating racks were established at the Munjina airstrip during March 2012.

Forty-three thousand *Eradicat*® baits were sweated on the morning of 2 August 2012. Before delivering baits to the bait cell, the plane conducted five non-toxic bait drops over the Munjina airstrip to determine the scatter pattern of baits at different flight speeds (within 120-150 knot range). This determined the spread of baits to be approximately 150 x 50 m. Three bait flights were conducted during 2 August and the final flight on the morning of 3 August (Figure 10). There was no rain experienced in the east Pilbara during this period or for the following two weeks.

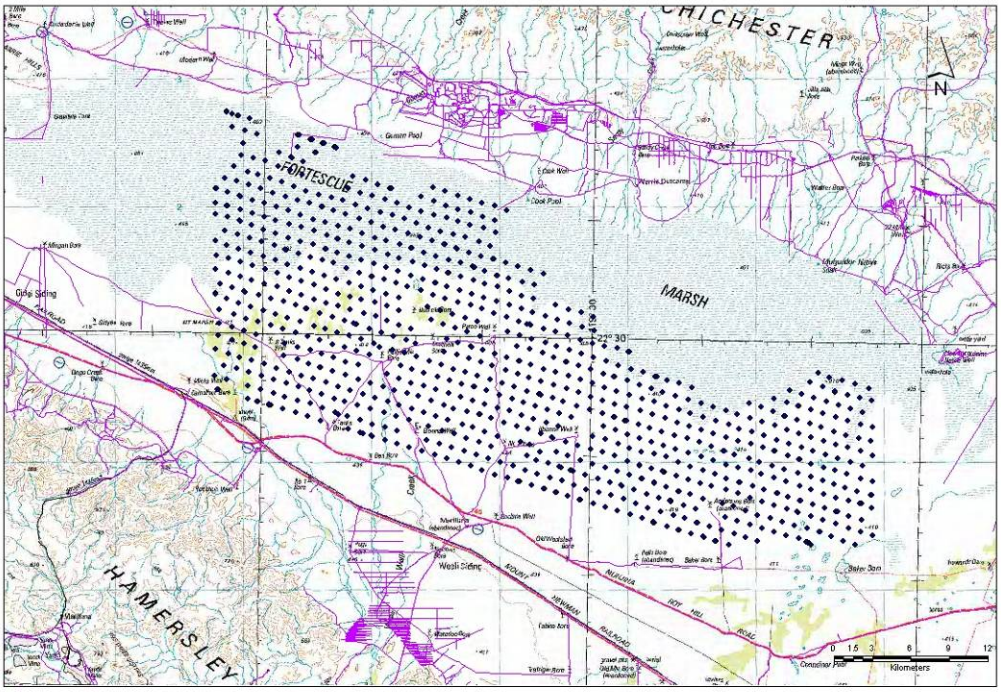

Figure 10. Location of bait drops in Fortescue Marsh.

3.2 Feral cat monitoring

3.2.1 Feral cat trapping and GPS radio-collaring

During the trapping program only one feral cat was captured, with no other sign or tracks observed along the trapping transect during this period. This cat was sedated before being fitted with a GPS data-logger (Telemetry Solutions, US) containing a mortality signal and programmed to drop-off on 28 August 2012.

3.2.2 Feral cat camera trap surveys

At total of 2,767 camera traps nights was recorded. Cats were detected at nine of 30 cameras in the control area and 11 of 49 cameras in the treatment area. Cattle were recorded at none of the 30 cameras in the control area, although the habitat at some sites was obviously impacted by cattle grazing, and at 14 of the 49 cameras in the treatment area. The location of feral cats recorded during remote camera monitoring displayed a negative relationship with the location of cattle; that is, feral cats were less likely to be recorded where cattle were also present (see Figure 11).

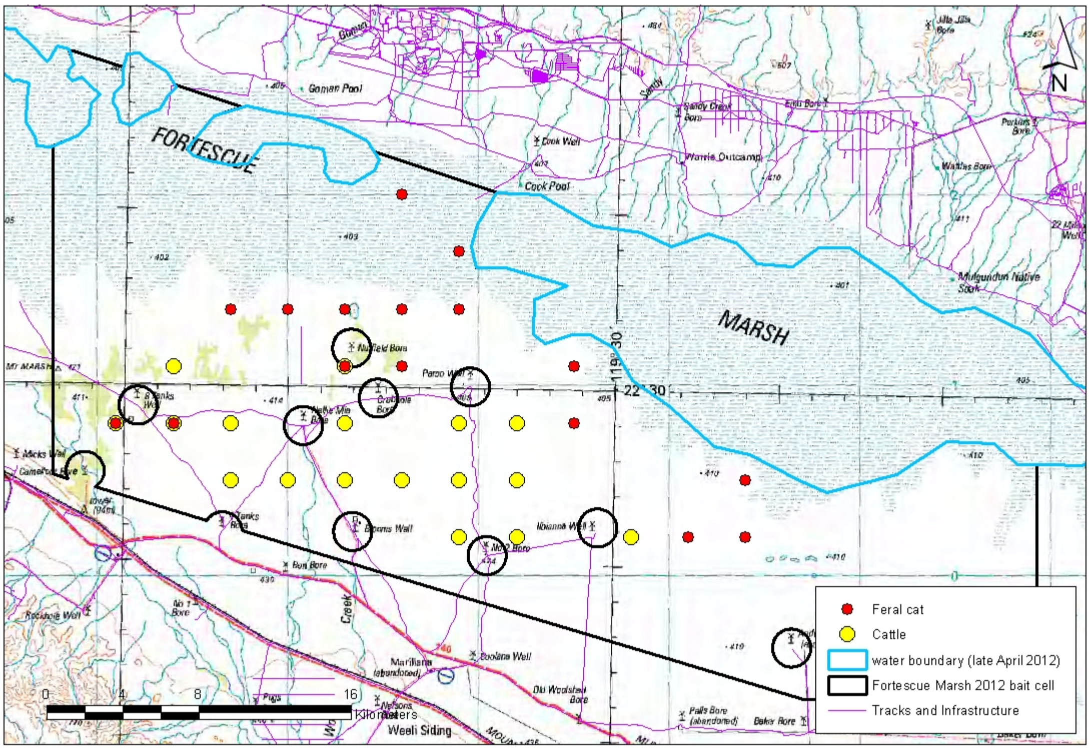

Figure 11. Location of positive records for feral cats and cattle in baited cell during all remote camera surveys.

Without the inclusion of habitat covariates, there is a highly significant decline in the occupancy of the baited area by cats post-baiting (Table 2). This result suggests that baiting had a major impact on the cat population however, this outcome should be treated with some caution. Given the large standard errors, this may also be, in part, due to the reduced sample size resulting from the removal of blank cells from the data set. Work is currently being undertaken on adjusting the model to allow for missing data. At present where data are missing the data for that entire day is unusable, e.g. if camera A is set on day 1 but camera B is set on day 2. This is particularly important in the post-baiting data from the current year where there is a very short period when the cameras are active and cat numbers are lower following baiting (Table 3). Due to the number of cameras set and the distances involved not all cameras can be set (or retrieved) on the same day, therefore there will be days at the start and finish of each session when the dataset is incomplete. Investigation is being conducted to enable the occupancy models to utilise data from days when not all cameras were operational.

Table 2. Probability of occupancy (±SE (95%CI)) with no habitat covariates

	Pre-bait	Post-bait
Control	0.0079±0.0045 (0.0025-0.0242)	0.0234±0.0116 (0.0088-0.0601)
Treatment	0.0564±0.0252 (0.0231-0.1312)	0.0075±0.0053 (0.0019-0.0296)

Table 3. Number of days cameras were active pre- and post-baiting, with the number of days where there was a complete dataset.

	Pre-baiting	Post-baiting
Total days active	34	15
Days with complete dataset	17	8

The inclusion of environmental variables into the models did not improve the fit of the model (Table 4). Again this is likely due to the removal of blank cells from the initial data set resulting in the loss of data for those days.

Table 4. Testing of model fit using environmental variables (dist-disturbance, canopy-canopy cover, ground-ground cover). Model fit is measured using AIC where lowest AIC value represents the best model fit.

Model	AIC	Delta AIC	AIC wgt	Model likelihood
psi(.),p(.)	205.62	0.00	0.3049	1.0000
psi(ground),p(.)	206.47	0.85	0.1993	0.6538
psi(dist),p(.)	207.33	1.71	0.1297	0.4253
psi(canopy),p(.)	207.36	1.74	0.1277	0.4190
psi(ground,canopy),p(.)	208.30	2.68	0.0798	0.2618
psi(ground,dist),p(.)	208.46	2.84	0.0737	0.2417
psi(dist,canopy),p(.)	209.03	3.41	0.0554	0.1818
psi(all covar),p(.)	210.30	4.68	0.0294	0.0963

No spatial analysis of the data has been undertaken at this stage. One of the assumptions of occupancy modelling is the independence of sites (MacKenzie *et al*. 2006). In order to achieve independence of sites either each site needs to be far enough away from adjoining sites such that an individual animal will not appear on more than one camera. Alternatively, the spatial autocorrelation can be modelled, this will allow sites to be closer together, which will be essential for smaller study sites where it will not be possible to have large distances between sites. The next stage of analysis will be to develop spatial autocorrelation models for the data.

3.3 Non-target native species bait uptake and mammal surveys

There were no mammals captured during the survey period, despite traps being run for a total of 400 trap-nights. This is likely due to the grazing pressure within the active pastoral lease where the transect was located and the associated lack of ground-cover and understorey in this area. Pit trapping would have increased captures of small mammals, but is outside the scope of this project. Surveys with the remote cameras identified Spinifex Hopping-Mouse (*Notomys alexis*),) Stripe-faced Dunnarts (*S. macroura*), Kaluta (*Dasykaluta rosamondae*) and Bilby (*Macrotis lagotis*). It was not possible to identify what was thought to be a second *Sminthopsis* to species level. There were no Northern Quolls identified from camera surveys. Native species identified during remote camera surveys are presented in Table 5.

Table 5. Native mammal species identified during remote camera surveys

Species	% cameras in treatment cell with species present	% cameras in control area with species present
Kangaroo (*Macropus* sp.? rufus)	42.9	20.7
Spinifex Hopping-mouse (*Notomys alexis*)	6.1	3.4
Bilby (*Macrotis lagotis*)	0.0	3.4
Kaluta (*Dasykaluta rosamondae*)	0.0	3.4
Pseudomys sp. & other Rodentia	24.5	10.3
Dunnart (*Sminthopsis* spp.)	4.1	0.0
Echidna (*Tachyglossus aculeatus*)	2.0	3.4
Other Dasyurid	2.0	3.4
Unknown	6.1	0.0

3.4 Bird surveys

A list of bird species identified throughout the study area is provided in Table 6. In total, 98 species were identified, including 42 species identified during remote camera surveys. This includes the Inland Dotterel (*Charadrius australis*) which was not recorded during surveys by

Table 6. Bird species identified within and immediately adjacent to the study areas at the Fortescue Marsh.

Species	Scientific Name	DEC Schedule	Camera	4/7/12 - 15/7/12	7/8/12 - 12/8/12	31/8/12 - 15/9/12
Emu	*Dromaius novaehollandiae*			B	B	B
Stubble Quail	*Coturnix pectoralis*		Y			
Brown Quail	*Coturnix ypsilophora*		Y		B	
Plumed Whistling-duck	*Dendrocygna eytoni*	*		A		
Australian Shelduck	*Tadorna tadornoides*	*			A	
Grey Teal	*Anas gracilis*	*				A
Pacific Black Duck	*Anas superciliosa*	*			A	
Common Bronzewing	*Phaps chalcoptera*		Y	A	A	Y
Crested Pigeon	*Ocyphaps lophotes*		Y	Y	Y	Y
Diamond Dove	*Geopelia cuneata*		Y	Y	Y	Y
Peaceful Dove	*Geopelia striata*				A	
Tawny Frogmouth	*Podargus strigoides*		Y		B	
Spotted Nightjar	*Eurostopodus argus*			A		
Australian Darter	*Anhinga novaehollandiae*				A	
Little Black Cormorant	*Phalacrocorax sulcirostris*				A	
Australian Pelican	*Pelecanus conspicillatus*				A	
White-necked Heron	*Ardea pacifica*				A	
Eastern Great Egret	*Ardea modesta*	3*			C	
White-faced Heron	*Egretta novaehollandiae*				C	
Straw-necked Ibis	*Threskiornis spinicollis*				C	B
Royal Spoonbill	*Platalea regia*				A	A
Yellow-billed Spoonbill	*Platalea flavipes*				A	
Black-shouldered Kite	*Elanus axillaris*	*		B	C	C
Black-breasted Buzzard	*Hamirostra melanosternon*	*			B	
White-bellied Sea-eagle	*Haliaeetus leucogaster*	3*				A
Whistling Kite	*Haliastur sphenurus*	*	Y	Y	Y	Y
Black Kite	*Milvus migrans*	*		A	B	A
Brown Goshawk	*Accipiter fasciatus*	*	Y	B	Y	B
Collared Sparrowhawk	*Accipiter cirrocephalus*	*	Y		A	B
Spotted Harrier	*Circus assimilis*	*	Y	Y	Y	Y
Wedge-tailed Eagle	*Aquila audax*	*	Y	B	A	B
Little Eagle	*Hieraaetus morphnoides*	*		B	A	B
Nankeen Kestrel	*Falco cenchroides*	*	Y	Y	Y	Y
Brown Falcon	*Falco berigora*	*	Y	Y	Y	Y
Australian Hobby	*Falco longipennis*	*		B	C	A
Black Falcon	*Falco subniger*	*		A	C	A
Australian Bustard	*Ardeotis australis*		Y	Y	Y	Y
Black-winged Stilt	*Himantopus himantopus*	*			A	
Red-capped Plover	*Charadrius ruficapillus*	*			C	
Oriental Plover	*Charadrius veredus*	3*				B
Inland Dotterel	*Charadrius australis*	*	Y	C	Y	
Black-fronted Dotterel	*Elseyornis melanops*	*		C	A	A
Red-necked Stint	*Calidris ruficollis*	3*			C	
Little Button-quail	*Turnix velox*		Y	Y	Y	Y
Australian Pratincole	*Stiltia isabella*				B	
Galah	*Eolophus roseicapillus*		Y	Y	Y	Y
Little Corella	*Cacatua sanguinea*			B	B	Y
Cockatiel	*Nymphicus hollandicus*		Y	Y	Y	Y
Australian Ringneck	*Barnardius zonarius*				B	
Budgerigar	*Melopsittacus undulatus*		Y	Y	Y	Y
Bourke's Parrot	*Neopsephotus bourkii*		Y			

Species	Scientific Name	DEC Schedule	Camera	4/7/12 - 15/7/12	7/8/12 - 12/8/12	31/8/12 - 15/9/12
Southern Boobook	*Ninox novaeseelandiae*		Y			A
Blue-winged Kookaburra	*Dacelo leachii*				A	
Red-backed Kingfisher	*Todiramphus pyrrhopygius*			Y	B	A
Sacred Kingfisher	*Todiramphus sanctus*				A	
Rainbow Bee-eater	*Merops ornatus*	3*		B	A	B
Western Bowerbird	*Ptilonorhynchus guttatus*		Y			
White-winged Fairy-wren	*Malurus leucopterus*		Y	Y	Y	Y
Variegated Fairy-wren	*Malurus lamberti*			C	Y	Y
Redthroat	*Pyrrholaemus brunneus*				B	
Weebill	*Smicrornis brevirostris*			B	C	
Slaty-backed Thornbill	*Acanthiza robustirostris*			Y	Y	Y
Red-browed Pardalote	*Pardalotus rubricatus*			B	B	A
Pied Honeyeater	*Certhionyx variegatus*			?B		
Singing Honeyeater	*Lichenostomus virescens*		Y	Y	Y	Y
Grey-headed Honeyeater	*Lichenostomus keartlandi*					A
White-plumed Honeyeater	*Lichenostomus penicillatus*			B	B	A
Yellow-throated Miner	*Manorina flavigula*		Y	B	Y	Y
Spiny-cheeked Honeyeater	*Acanthagenys rufogularis*			Y	Y	Y
Grey Honeyeater	*Conopophila whitei*			?B		
Crimson Chat	*Epthianura tricolor*		Y	Y	Y	Y
Orange Chat	*Epthianura aurifrons*				C	
Black Honeyeater	*Sugomel niger*			B	B	
Brown Honeyeater	*Lichmera indistincta*			B	B	B
Grey-crowned Babbler	*Pomatostomus temporalis*				A	Y
White-browed Babbler	*Pomatostomus superciliosus*		Y	C	C	
Ground Cuckoo-shrike	*Coracina maxima*		Y		C	
Black-faced Cuckoo-shrike	*Coracina novaehollandiae*			Y	Y	Y
White-winged Triller	*Lalage sueurii*			Y	Y	Y
Rufous Whistler	*Pachycephala rufiventris*			Y	Y	Y
Crested Bellbird	*Oreoica gutturalis*		Y	Y	Y	Y
Masked Woodswallow	*Artamus personatus*				B	Y
Black-faced Woodswallow	*Artamus cinereus*		Y	Y	Y	Y
Pied Butcherbird	*Cracticus nigrogularis*		Y	Y	Y	Y
Australian Magpie	*Gymnorhina tibicen*		Y	B	B	A
Willie Wagtail	*Rhipidura leucophrys*		Y	Y	Y	Y
Little Crow	*Corvus bennetti*		?	B	B	A
Torresian Crow	*Corvus orru*		Y	Y	Y	Y
Magpie-Lark	*Grallina cyanoleuca*		Y	B	B	Y
Red-capped Robin	*Petroica goodenovii*		Y	B	Y	B
Hooded Robin	*Melanodryas cucullata*		Y	B		
Horsfield's Bushlark	*Mirafra javanica*		Y	Y	Y	Y
Rufous Songlark	*Cincloramphus mathewsi*		Y	Y	Y	B
Brown Songlark	*Cincloramphus cruralis*		Y		Y	Y
Spinifexbird	*Eremiornis carteri*			B	Y	B
Fairy Martin	*Hirundo ariel*				A	C
Zebra Finch	*Taeniopygia guttata*		Y	Y	Y	Y
Australasian Pipit	*Anthus novaeseelandiae*		Y	Y	Y	Y

A = recorded immediately adjacent to study areas
B = recorded in Baited Cell
C = recorded in Control Area
Y = recorded in both the Bait Cell and Control Area
? = unconfirmed sighting
3 = included under Schedule 3 of WA Wildlife Act (1950) (Migratory birds protected under an international agreement) (updated February 2012)
* = included EPBC Migratory Species List (JAMBA/CAMBA/Bonn Convention)

Bamford Consulting in April and May 2005 for the Cloudbreak fauna survey (Davis *et al*. 2005); nor is it recorded on the Birds Australia Atlas database for this area. Furthermore, two additional species (Oriental Plover (*Charadrius veredus*) and Red-necked Stint (*Calidris ruficollis*)) were observed in the study area, but were not on the list of species cited as likely to occur in the area by Algar *et al*. (2011) or Johnstone *et al*. (in press). These two species are significant in that they are listed under the EPBC Migratory Species List (EPBC Act, 2001) and are also listed as Schedule 3 under the WA Wildlife Act (1950).

3.5 Northern Quoll habitat assessment

There was no site within 5 km of either the control or treatment site that contained habitat considered suitable for the Northern Quoll. The study sites are both primarily flat marshland and contain no major watercourses. The closest land that may contain suitable habitat is approximately 5 km north of the study area.

4 Discussion

4.1 Baiting

Due to the late commencement of fieldwork (caused by the late acquisition of funds), baiting was conducted at what was considered the limit of suitable climatic conditions. By early August, signs of increased reptile activity were observed which may have reduced bait consumption by feral cats with the increased prey resource. In addition, the increasing temperatures at this time of year could potentially reduce the palatability of baits by “drying out” the soft-meat bait. In future, targeted feral cat baiting in the Pilbara should be conducted no later than early July each year.

The pattern of bait ‘scatter’, trialled at the Munjina airstrip prior to the bait drop, did not replicate the desired 250 x 50 m. The actual bait “scatter” was closer to 150 x 50 m. Further trials have been planned on the south coast in late 2012 to determine methods of improving the pattern of scatter.

4.2 Feral cat collaring

Unfortunately the one cat that was collared could not be relocated during the final study period and hence the collar has not yet been retrieved. Efforts to retrieve this data will continue at a later date.

4.3 Feral cat monitoring

Feral cat activity appeared to be negatively affected by the presence of cattle. This is most likely due to habitat alteration caused by cattle grazing reducing the abundance of small mammals, one of the primary prey items for feral cats. It is therefore proposed that the design of the bait cell be changed for subsequent years of the trial to incorporate more of the current control area that is not subject to the same level of grazing pressures.

Results from camera trapping and occupancy models showed a highly significant decline in feral cat activity post-baiting in the treatment cell, which suggests that cat baiting was successful. In addition these results provide an important benchmark for future baiting programs in the Fortescue Marsh. However, the methods used to determine activity levels and provide evidence of effectiveness of baiting regimes are still being developed and refined. As such, in this first report the analysis should be considered as preliminary only, refinements to the technique and inclusion of covariates will provide more robust analysis and interpretation of camera data. As a greater emphasis on trapping and radio-collaring of cats will be achievable in future investigations it will also be possible to incorporate detailed information on detection probabilities and mortality rates to provide a more rigorous analysis and further confirmation of baiting impact.

4.4 Non-target species monitoring

The grazing pressure caused by the presence of cattle on the active pastoral leases appears to severely limit the presence of small native mammals in these areas, determined by the lack of mammals captured during targeted surveys and data collected from the remote cameras in these areas. As a consequence of limiting a major food resource for feral cats, the presence of these introduced predators also appears to be limited in these areas. Outside the areas that are currently utilised for pastoral activities, feral cat abundance appears greater, coinciding with an increase in the activity of small mammals as determined by the remote cameras.

During the survey periods, other feral animals were observed within the control and treatment sites. Horses (*Equus caballus*), donkeys (*Equus asinus*) and dogs were all observed and evidence of recent camel (*Camelus dromedaries*) activity was recorded. Any future surveys for native mammals should be conducted only in areas where the presence of cattle is limited.

Remote camera surveys allowed passive data-collection for non-targets and a range of native mammal species were recorded (Table 5). The sole record of Bilby came from a remote camera site in the control area, in a mulga habitat that was regenerating after having cattle excluded from it in recent years. No other evidence of Bilby activity was noted in this area but this is likely due to no targeted survey effort for this species.

4.5 Bird surveys

Forty-two of the 98 species recorded in and immediately adjacent to the study area in June-Sept 2012 were recorded from remote cameras. Of these, three bird species were recorded solely from remote cameras (Table 6) and were not recorded by opportunistic observations, highlighting the utility of these cameras in recording bird species diversity in the study area. Species not recorded on remote cameras can be grouped in two broad categories: largely arboreal (e.g. honeyeaters) or aerial (e.g. Fairy Martin (*Hirundo ariel*)) and waterbirds (cormorants; herons; waterfowl; waders). Exceptions to the first category are raptors (Accipitriformes; Falconiformes) and owls (Strigiformes), with more than half the total species recorded being captured on remote cameras (Table 6). However, this may be due to the use of white turkey feathers as part of the lure for introduced mammal predators (see 2.4.2), which may have acted as an attractant to predatory bird species as well.

4.6 Northern quoll habitat assessment

Further habitat assessment (outside the scope of this project) is required to determine the suitability of habitat in these areas for the presence of Northern Quoll.

5 Recommendations/Limitations

The primary limitation on the ability to conduct the required monitoring for this program was caused by the late acquisition of funds, with the first purchase order not received until the 4 April 2012. This resulted in delays to both purchasing of equipment and the ability to provide staff to plan and prepare for the field program. As a result, the timing of baiting was pushed back to the limit of what was considered acceptable to allow for some pre-bait monitoring to be conducted. In future, funds for this project will be required by the end of February, as per the agreed schedule of payment, to ensure that all resources are available to commence monitoring at a more appropriate time.

The delivery of baits should be conducted no later than the last week June/first week of July each year. This will ensure that the baits are not affected as much by increasing temperatures and a decrease in native animal activity will result in a reduced risk of bait uptake and leave more baits available for the target species. Also, post-bait monitoring should be completed by mid-August to minimise the potential fire risk caused by quad bike activity through the spinifex and mulga habitats.

Habitat within the control area does not provide a suitable comparison to that contained within the bait cell due to differences in grazing pressures, vegetation communities, surface hydrology, water quality and mining activities. Differences in the rates of camera detection of feral cats throughout different vegetation types appears to be determined by quality of habitat, caused by the presence/absence of cattle, rather than the vegetation itself. As a result, comparisons between control and treatment areas may be flawed.

Baiting should be confined to areas outside active pastoral land. Heavy grazing by cattle appears to have restricted the abundance of small native mammals which are the primary food source for feral cats. By increasing the focus on feral cat collaring and the number of cameras distributed throughout this area, the need for a control area is reduced. We would propose changing the boundary of the treatment area and remove the control area from this trial.

Figure 12 displays a potential treatment cell for subsequent trials. This proposed new treatment cell encompasses 112,110 ha of which a maximum of 100,000 ha would be baited annually. Inundated areas within the treatment cell would not be baited, but the extent of this area excluded from baiting would change on an annual basis. The proposed new bait cell would encompass a greater area of quality habitat for native species and exclude a greater proportion that is currently subject to heavy cattle grazing.

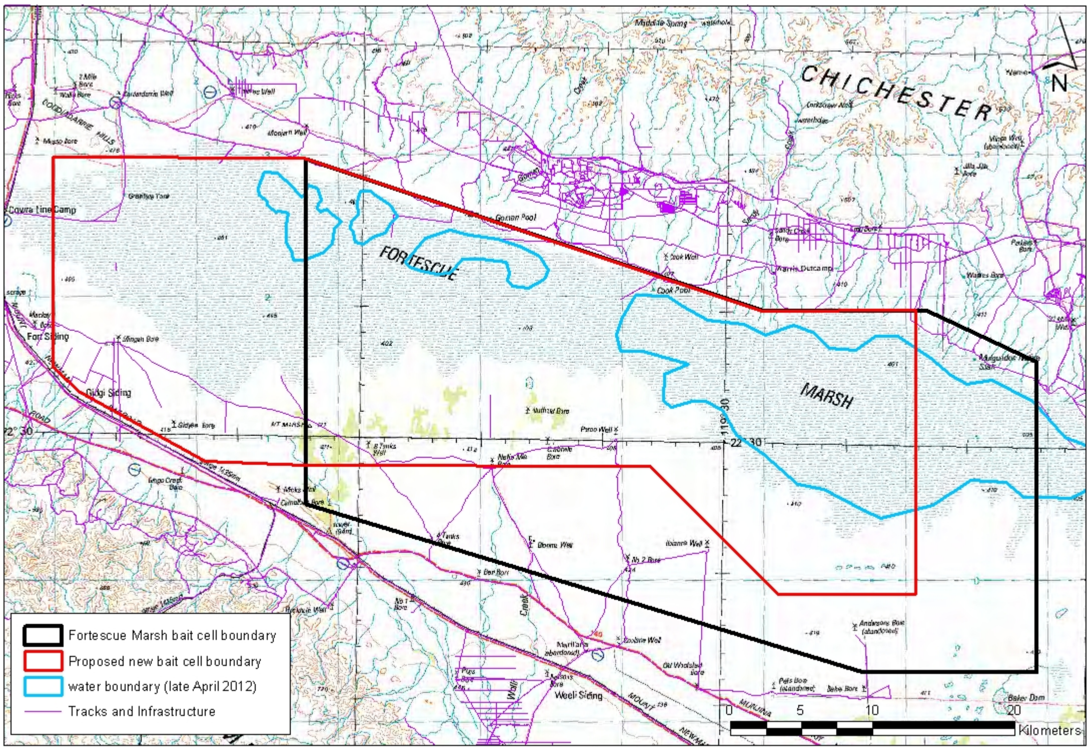

Figure 12. Location of proposed new treatment cell boundary in Fortescue Marsh in comparison with the current bait cell.

6 Budget

A financial statement on expenditure for 2012 will available in late January 2013 if required, as some costs and outstanding invoices have not yet been processed.

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8 References

Abbott I (2002) Origin and spread of the cat, *Felis catus*, on mainland Australia, with a discussion of the magnitude of its early impact on native fauna. *Wildlife Research.* **29**, 51-74.

Algar D, Robertson H. & Rummery C. (2011) *Proposed Management Plan for Baiting Feral Cats on the Fortescue Marsh*. Report prepared for Fortescue Metals Group Ltd. Department of Environment and Conservation.

Algar D & Burrows ND (2004) A review of Western Shield: feral cat control research. *Conservation Science Western Australia* **5(**2), 131-163.

Algar D, Angus GJ, Williams MR, *et al*. (2007) Influence of bait type, weather and prey abundance on bait uptake by feral cats (*Felis catus*) on Peron Peninsula, Western Australia. *Conservation Science Western Australia* **6**(1), 109-149.

Algar D, Richards J, Hamilton, N, *et al*. (in review) Controlling introduced predators in the rangelands. *Wildlife Research*.

Burbidge AA & McKenzie NL (1989) Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. *Biological Conservation* **50**, 143-198.

Burrows ND (2005). *Active adaptive management: enhancing the integration of science and management to improve delivery of conservation and land management outcomes : a discussion paper*. Department of Conservation and Land Management, Kensington, WA.

Christensen PES & Burrows ND (1995) Project Desert Dreaming: the reintroduction of mammals to the Gibson Desert. In *Reintroduction Biology of Australian and New Zealand Fauna* (ed M Serena), pp. 199-208. Surrey Beatty and Sons, Chipping Norton.

Claridge AW, Murray AJ, Dawson, J *et al.* (2006) The propensity of spotted-tailed quolls (*Dasyurus maculatus*) to encounter and consume non-toxic meat baits in a simulated canid-control program. *Wildlife Research*, **33**(**2**), 85-91.

Davis RA, Wilcox J, Metcalf BM, Bamford MJ (2005) Fauna survey of proposed Iron Ore Mine, Cloudbreak. Report prepared for Fortescue Metals Group by MJ & AR Bamford.

DEWHA (Department of the Environment, Heritage, Water and the Arts) (2008a) Threat Abatement Plan for Predation by Feral Cats, DEWHA, Canberra.

DEWHA (Department of the Environment, Heritage, Water and the Arts) (2008b) Australian Heritage Database. *Fortescue Marshes, Roy Hill, WA, Australia*. Department of the Environment, Heritage, Water and the Arts. Australian Federal Government.

DSEWPAC (Department of Sustainability, Environment, Water, Population and Communities) (2012) *Dasyurus hallucatus* in Species Profile and Threats Database, Department of Sustainability, Environment, Water, Population and Communities, Canberra. Available from: http://www.environment.gov.au/sprat. Accessed 13th November 2012.

Dickman CR (1996a) Impact of exotic generalist predators on the native fauna of Australia. *Wildlife Biology* **2**, 185-195.

Dickman CR (1996b) *Overview of the Impact of Feral Cats on Australian Native Fauna*. Report to Australian Nature Conservation Agency.

EA (1999) Threat Abatement Plan for predation by feral cats. Environment Australia, Biodiversity Group, Canberra, Australia.

Environment Australia (2001) A Directory of Important Wetlands in Australia, Third Edition. Environment Australia, Canberra.

Fenner S, Körtner, G & Vernes, K (2009) Aerial baiting with 1080 to control wild dogs does not affect the populations of two common small mammal species. *Wildlife Research*, **36**(6) 528-532.

Fischer J & Lindenmayer DB (2000) An assessment of the published results of animal relocations. *Biological Conservation* **96**(**1**), 1-11.

Fisher P (1998) Rhodamine B as a marker for the assessmentof non-toxic bait uptake by animals. Report No.4, Vertebrate Pest Research Department, Department of Natural Resources and Environment, Victoria.

Fortescue (2009) *Fortescue Marshes Management Plan*. Fortescue Metals Group Limited.

Gibson DF, Johnson KA, Langford DG, *et al*. (1995) The Rufous Hare-wallaby *Lagorchestes hirsutus*: a history of experimental reintroduction in the Tanami Desert, Northern Territory. In *Reintroduction Biology of Australian and New Zealand Fauna* (ed M Serena), pp 171-176. Surrey Beatty and Sons, Chipping Norton.

Hill BM & Ward SJ (2010) National Recovery Plan for the Northern Quoll *Dasyurus hallucatus*. Department of Natural Resources, Environment, The Arts and Sport, Darwin.

Johnson KA, Burbidge AA & McKenzie NL (1989) Australian Macropodoidea: status, causes of decline and future research and management. In *Kangaroos, Wallabies and Rat Kangaroos* (eds G Grigg, P Jarman, I Hume) Surrey Beatty, Sydney.

Johnstone, R.E., Burbidge, A.H., and Darnell, J.C. (in press) Birds of the Pilbara region, Western Australia: distribution, status and historical changes. *Records of the Western Australian Museum*, **Supplement 78**.

Körtner G, Gresser, S & Harden, B (2003) Does fox baiting threaten the spotted-tailed quoll, *Dasyurus maculatus*? *Wildlife Research*, **30**(**2**), 111-118.

Körtner G (2007) 1080 aerial baiting for the control of wild dogs and its impact on spotted-tailed quoll (*Dasyurus maculatus*) populations in eastern Australia. *Wildlife Research*, **34**(**1**), 48-53.

MacKenzie, DI, Nichols, JD, Royle, JA, Pollock, KH, Bailey, LL and Hines JE (2006) Occupancy estimation and modelling: Inferring patterns and dynamics of species occurrence. Elsevier, New York.

Mattiske Consulting Services (2005) Flora and vegetation on the Cloud Break and White Knight Leases. Report for the Fortescue Metals Group.

McCarthy MA & Possingham HP (2007) Active adaptive management for conservation. *Conservation Biology* **21**, 956-963.

McKenzie NL, Burbidge AA, Baynes A, *et al*. (2007) Analysis of the factors implicated in the recent decline of Australia's mammal fauna. *Journal of Biogeography* **34**, 597-611.

McKenzie, N.L., van Leeuwen, S., and Pinder, A.M. (2009) Introduction to the Pilbara Biodiversity Survey, 2002 - 2007. *Records of the Western Australian Museum* **Supplement No. 78**, 3-89.

Morton SR (1990) The impact of European settlement on the vertebrate animals of arid Australia: a conceptual model. *Proceedings of the Ecological Society of Australia* **16**, 201-213.

Risbey DA, Calver M, Short J, *et al*. (2000) The impact of cats and foxes on the small vertebrate fauna of Heirisson Prong, Western Australia. II. A field experiment. *Wildlife Research* **27**, 223-235.

Short J, Turner B, Risbey DA, *et al*. (1997) Control of feral cats for nature conservation. II. Population reduction by poisoning. *Wildlife Research* **24**, 703-714.

Smith AP & Quin DG (1996) Patterns and causes of extinction and decline in Australian conilurine rodents. *Biological Conservation* **77**, 243-267.

Walters CJ & Holling CS (1990) Large-scale management experiments and learning by doing. *Ecology* **71**, 2060-2068.