Introduced predator control and sustained fauna recovery in south-west Western Australia

Woylie decline in Dryandra Woodland – is there a mesopredator release effect?

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1 The project team

1.1 Personnel

Personnel	Affiliation	Title/ role	Commitment	Period
N Marlow	DEC	Project leader	1.0	1/1/06- present
N. Thomas	DEC	Technical officer	1.0	1/1/06- present
A. Williams	DEC	Technical officer	1.0	1/1/06- present
B. Macmahon	DEC	Technical officer	1.0	1/8/06- present
J. Lawson	DEC	Technical officer	0.3	1/10/06- present
L. Richards	DEC	Technical officer	0.1	1/10/06- present
John Asher	DEC	EMB		1/1/06- present
Nisha Powell	DEC	EMB		1/10/07- present
Rob Brazell	DEC	EMB		1/1/06- present
Narrogin District Staff	DEC			1/1/06- present
Tony Friend	DEC			
A Wayne	DEC			
B Ward	DEC			
C Ward	DEC			
Marika Maxwell	DEC			

1.2 Collaborators

Jeff Short	Consultant	Cat predation specialist
Denice Higgins	Adelaide university	Forensic odontology
Simon Cherriman	Consultant	Wedge tailed eagles
Carlo Pacioni	Murdoch University	Woylie geneticist
Graeme Knowles	Murdoch University	Woylie post mortems
Oliver Berry	UWA	DNA specialist
Steve Sarre	Uni Canberra	Cat DNA specialist

2 Overview and background

The capture rates of woylies *(Bettongia penicillata)* increased dramatically in Dryandra Woodland after fox baiting commenced in the early 1980s (Fig. 1). Initially each fox bait contained 4.5 mg of 1080 and baits were delivered every four weeks at a rate of 5 baits per km^{-2}. Woylie trap success continued to increase until 1999 when it peaked and then started to decline despite maintained fox control regimes. It is not clear why this decline occurred.

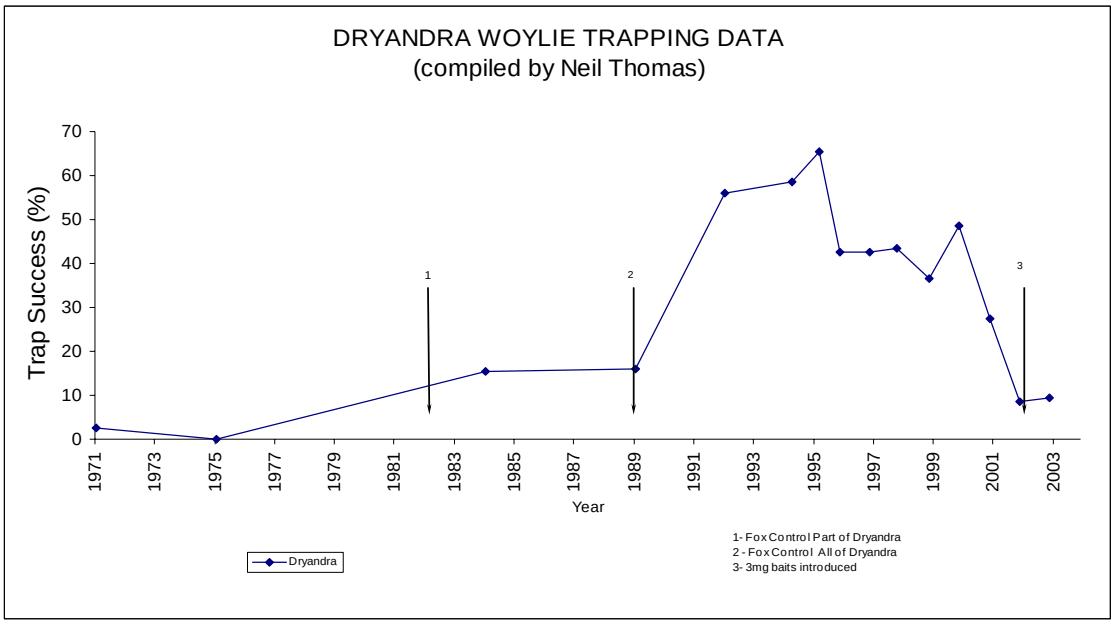


Figure 1. Woylie trap success at Dryandra Woodland

The survival of radio-collared woylies is being investigated at Dryandra Woodland and Tutanning Nature Reserve (Fig 2). Tutanning Nature Reserve has also been baited for foxes since the early 1980s though the recovery of woylies has never been as pronounced there as at Dryandra Woodland. Predation on woylies by foxes, feral cats, pythons and eagles is being quantified at both sites.

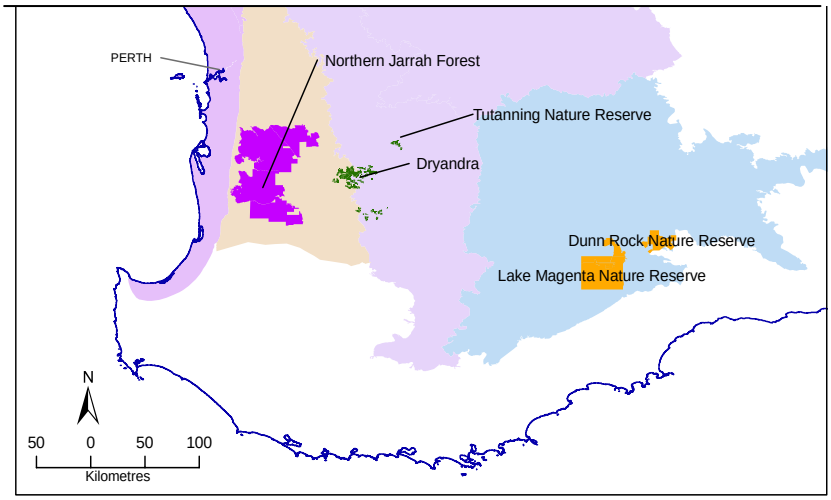


Figure 2: Map of the study area

Fox and feral cat activity at sandplots is being monitored in Dryandra Woodland, Tutanning Nature Reserve and two unbaited blocks of conservation estate (Highbury and Quinns blocks) (Figure 3). Individual foxes and cats are being identified from DNA obtained from fur samples collected on double sided tape. Sandplots are monitored each quarter, following the regular fox baiting program.

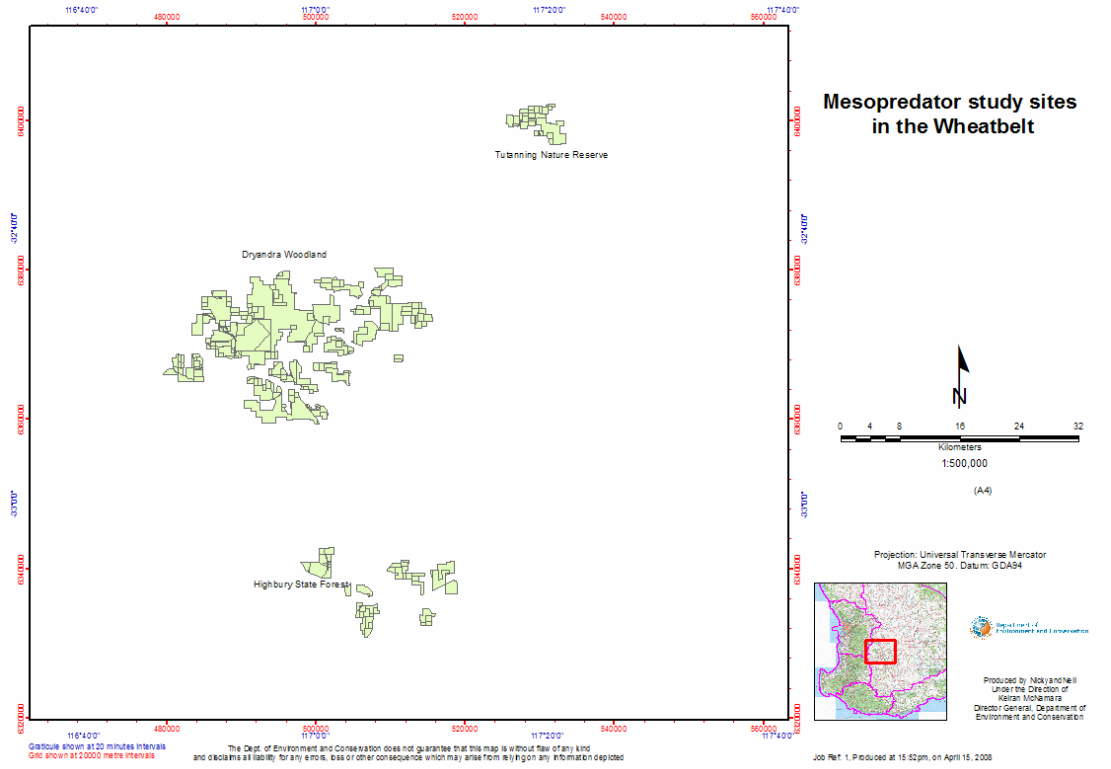


Figure 3: Map of the study sites

Trapping for foxes will be undertaken and all individuals captured will be fitted with GPS collars that are programmed to disengage at a predetermined date. The predominate timing of reinvasion and the presence of bait wary foxes (if any) will be identified.

The diet of foxes and wedge tailed eagles is being compared between baited and unbaited areas to determine if predation upon woylies is influenced by the presence of foxes.

The survival of brush tailed possums will be monitored in the two baited sites to assess whether this species continues to increase in abundance as fox control is continued or whether it too reaches a peak and then declines.

The effectiveness of the current fox-baiting regime will be investigated by analysing the uptake of baits. Remote cameras have been used to identify the species ingesting or removing baits. The 1080 content of baits and their degradation will be analysed to ensure that baits are toxic to foxes.

3 Objectives

The objectives of this project are:

1) to determine if the current fox baiting regime is effective in reducing fox predation upon woylies
2) if the current fox baiting regime is inadequate, to improve it so that fox predation on woylies is minimised
3) to investigate if increased predation upon woylies by other introduced or native predators occurs when foxes are sufficiently controlled

4 Hypotheses

1) that the current fox baiting regime is ineffective in controlling foxes
2) that woylie survival can be increased by increasing the frequency and intensity of fox baiting, if the current regime is ineffective
3) that predation on woylies by other introduced and native predators will increase when predation by foxes is decreased

5 Methodology

5.1 The baiting treatments

There are four research sites: Dryandra Woodland, Tutanning Nature Reserve and Highbury and Quinns blocks. Dryandra Woodland and Tutanning Nature Reserve are baited every four weeks with 3mg 1080 dried meat baits. The baiting rate is 5 baits per km^{-2}. Highbury and Quinns blocks are unbaited. Due to difficulties in obtaining a supply of dried meat baits, Dryandra Woodland is now baited with Probaits . The switch to the new bait type occurred in March 2008. Tutanning will continue to be baited with dried meat baits until the end of the experiment if possible.

5.2 Trials to assess non-target uptake of the cat bait, Eradicat

Before toxic cat baits can be used in Dryandra Woodland or Tutanning Nature Reserve non-target trials need to be completed. Non-toxic baits labelled with the biomarker rhodamine will be delivered at a rate of 50 baits km^{-2} (the standard cat baiting regime) to specific areas in Dryandra Woodland and Tutanning Nature Reserve. The Return to Dryandra breeding enclosures will also be baited. Cage trapping will be undertaken four weeks later. The whiskers of non-target species will be examined and the presence of rhodamine (and hence bait ingestion) determined. The species to be tested include: *Bettongia penicillata, Bettongia lesueur, Macropus lagotis, Perameles bougainville, Lagorchestes hirsutus, Macropus irma, Trichosurus vulpecula and Isoodon obesulus.*

5.3 Fox and cat activity estimates and survival

5.3.1 Sandplots

The activity of foxes and cats is being calculated using the methodology described in Allen *et al.* (1996) and Thomson *et al.* (2000). Sandplots are monitored quarterly for three consecutive nights both before and after fox baiting event. One hundred and thirty sandplots have been positioned in Dryandra Woodland, 75 in Tutanning Nature Reserve and 33 in each of the unbaited Highbury blocks.

5.3.2 Hair traps

In all sites individual foxes (and cats) will be identified where possible from DNA analysis of fur samples (Piggott and Taylor 2003). Fur samples may obtained by enticing animals to pass between three semi-vertical sticks, each with double sided tape adhered to it.

5.3.3 Telemetry

Foxes (and cats) will be trapped within the reserves using cage traps (if possible) and on adjacent farmland using #1.5 size Victor soft-catch traps (Fleming *et al.* 1998). A variety of lures will be used to entice foxes and cats into the trap site including food, visual stimuli, aural lures (felid attracting phonics (FAPs)), or scent signals such as scats or urine. Traps will be checked every 12 hours (minimum) and will be positioned carefully to avoid capture of non-target species or detection by the public.

Captured foxes will be fitted with GPS telemetry collars and data on their localities and status (alive or dead) will be recorded daily. It is anticipated that up to 10 foxes will be trapped in each baited site. The persistence of radio-collared individuals and the repeated collection of DNA from specific individuals will reveal whether resident foxes (and cats) occur within the baited areas or whether all individuals are 'turned over' after each baiting event. This will reveal whether the current fox baiting regime is effective or whether modifications are required.

5.4 Woylie survival

Woylies are trapped in Sheffield cage traps at Dryandra Woodland and Tutanning Nature Reserve. Their survival will be modelled as a function of several factors using the methodology described in Burnham and Anderson (2002). These factors include fox, cat, python and raptor predation.

The predatory impact of foxes, feral cats, pythons and raptors is monitored through the use of mortality sensing radio-collars fitted to a sample of woylies at each site. These collars are monitored five days per week and the respective mortality agent (including the predator responsible) is identified when possible. Collars are also fitted to juvenile woylies when they are captured, and the factors responsible for their mortality identified.

All brush tailed possums captured during woylie trapping sessions will be ear tagged and their survival monitored. The number of possums known to be alive at the end of each trapping session will be calculated so that population trends can be monitored.

5.5 Predator dietary analysis

Scats will also be collected from four 20 km transects in the baited sites and two 20 km transects in the unbaited sites every three months. These will be used in dietary analyses.

The diet of foxes (and cats where possible) in baited and unbaited sites is being quantified by collecting scats from 20 km transects every three months. The contents of the scats are being quantified and differences between the sites determined.

The diet of wedge-tailed eagles and their impact on native prey species is being assessed by mapping all nests in the baited and unbaited sites and collecting prey remains and regurgitated pellets at each nest site every month.

5.6 Bait uptake and longevity

5.6.1 Bait uptake

The uptake of 1080 baits is being examined by placing a single bait at each of 20-25 sandplots within Dryandra and Tutanning. The species responsible for removing the baits is being identified from tracks on the sand plot and from photographs taken with a remote camera.

5.6.2 Bait longevity

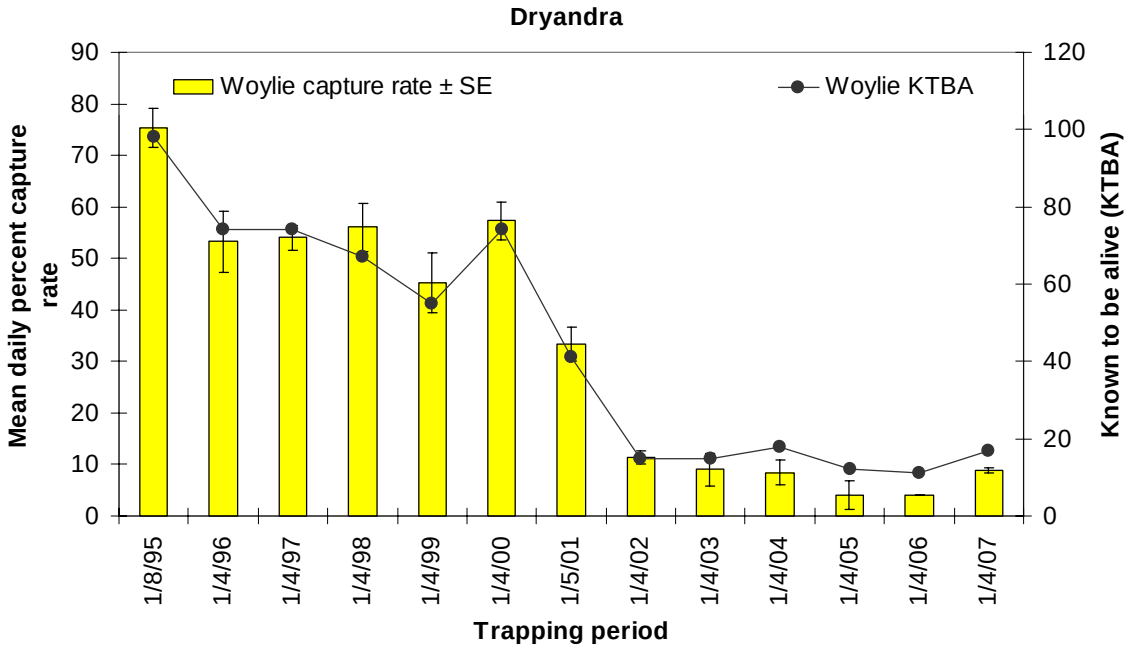
The amount of 1080 lost from fox baits between baiting events will be quantified by placing baits with a known concentration of 1080 in bait cages and monitoring 1080 loss. Four cages will be used in each site and each cage will contain 72 baits (24 of each bait type). Two baits of each type will be removed each week for 12 weeks and analysed for their 1080 content. Any loss of 1080 will be correlated with rainfall and the proportion of baits that become 'sublethal' (i.e. contain less than 1mg 1080) will be assessed. The leaching of 1080 occurs some areas may need to be rebaited if sufficient rain occurs. Also the amount of 1080 added to fox baits may need to be reassessed if many baits are becoming sublethal before they disintegrate.

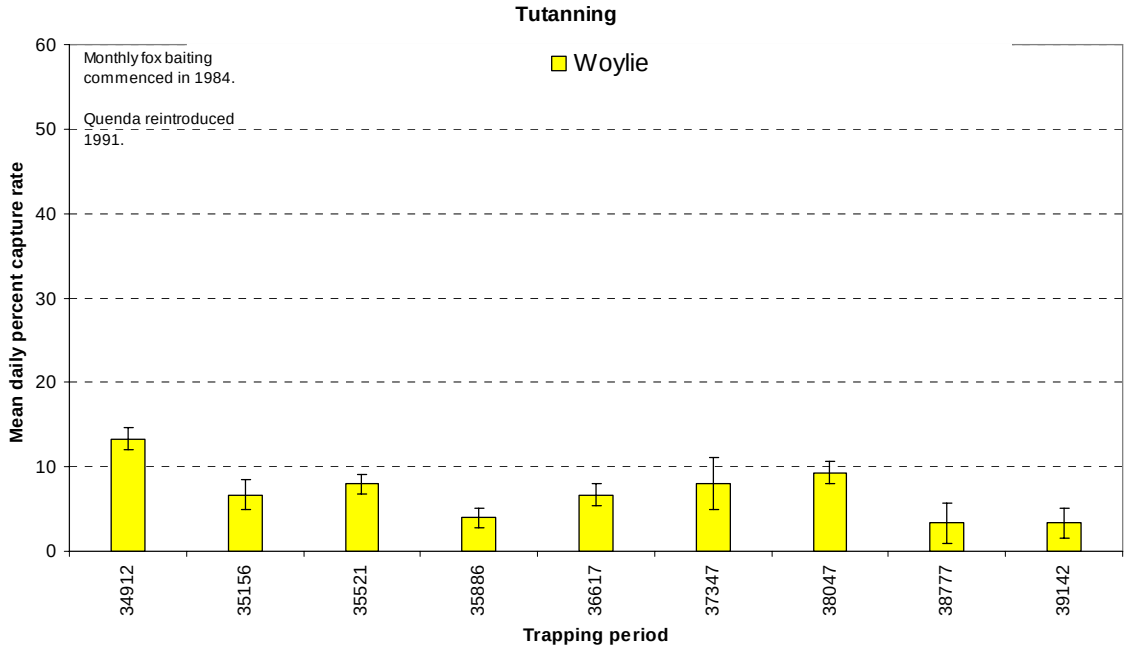
6 Progress to date

6.1 Woylie survival

Western Shield Monitoring

Woylie trap success and number of individuals known to be alive is determined each year during the Western Shield monitoring at Dryandra Woodland and Tutanning Nature Reserve. Woylie trap success has increased slightly but not significantly at Dryandra Woodland and remains unchanged at Tutanning Nature Reserve.





To date 173 woylies have been trapped. Of these, 62 in Dryandra Woodland and 57 in Tutanning Nature reserve were fitted with mortality sensing collars. Currently 42 individuals are monitored five days per week (22 in Dryandra and 20 in Tutanning). Fifty seven collared woylies have died (28 in Dryandra Woodland and 29 in Tutanning Nature Reserve).

DRYANDRA				TUTANNING			
	♀	♂	**TOTAL**	♀	♂	**TOTAL**	**GRAND TOTAL**
CURRENTLY COLLARED	**8**	**14**	**22**	**12**	**10**	**22**	**44**
DEAD	**15**	**13**	**28**	**15**	**15**	**30**	**58**
MISSING	**0**	**4**	**4**	**2**	**1**	**3**	**7**
NOT COLLARED	**19**	**36**	**55**	**9**	**3**	**12**	**67**
TOTAL COLLARED	**23**	**31**	**54**	**29**	**26**	**55**	**109**
TOTAL HANDLED	**42**	**67**	**109**	**38**	**29**	**67**	**176**

6.1.2 Attributing mortality agents

6.1.2.1 DNA analysis from collars

The radio collars removed from dead woylies were examined for the presence of predator DNA. Each collar was swabbed and the samples analysed by Olly Berry at UWA. Olly was able to obtain sufficient DNA from several collars to have the DNA sequenced. Seven samples were identified to have come from foxes. A further 14 samples proved positive for fox DNA. Sixty eight percent of these results were consistent with the conclusions of the woylie post mortem workshop (see below).

6.1.2.2 Forensic odontology

The radio collars removed from dead woylies were sent to the Forensic Odontology laboratory at Adelaide University. Researchers there used characteristic bite marks from foxes, cats and chuditch to assess the predator responsible for each woylie death. The results from this process were not conclusive. Most collars did not have sufficient tooth marks to be able to assign a predator. The death of one woylie was attributed to chuditch predation, even though chuditch are locally extinct in the study area. A collar known to have come from an animal that was still alive was included in the sample to test the rigorousness of the process. The result returned claimed the animal had been predated by a feral cat.

6.1.2.3 Post mortem workshop

A workshop was held to try to improve the accuracy of the assignment of cause of death for each woylie. Seven researchers with experience in woylie deaths were asked to provide their opinion on the cause of death of 40 woylies. The results were collated and the most likely (consistently identified) cause of death was assigned.

FOX DNA ON COLLAR	WORKSHOP (57%)	FORENSIC ODONTOLOGY
TF06	FOX	INCONCLUSIVE
TM38	FOX	INCONCLUSIVE
TM37	FOX (SECONDARY SCAVENGING)	CHUDITCH
DM06	FOX (SECONDARY SCAVENGING)	INCONCLUSIVE
TF36	FOOT CAUGHT	INCONCLUSIVE
TM32	EAGLE (SEEN FLYING AWAY)	INCONCLUSIVE
TM16	UNKNOWN	INCONCLUSIVE

N=49	DNA (7 SEQUENCED)	WORKSHOP	ODONTOLOGY
FOX	**21**	**21 (12)**	**4 (3)**
FOX/CAT			**1**
CAT		**2**	**7**
BOP		**9**	
PYTHON		**1**	
CHUDITCH			**1**
OTHER		**2**	
UNKNOWN	**8**	**4**	**17**
NOT SAMPLED	**20**	**10**	**19**

	DRYANDRA		TUTANNING		TOTAL	
	N	**%**	**N**	**%**	**N**	**%**
FOX/ PROBABLE FOX	**17**	61	**23**	77	**40**	69
FOX/ CAT	**4**	14	**1**	2	**5**	9
CAT	**1**	4	**0**		**1**	2
RAPTOR/ PROBABLE RAPTOR	**5**	17	**2**	7	**7**	12
PYTHON	**1**	4	**2**	7	**3**	5
OTHER	**0**	0	**2**	7	**2**	3
% LOSS	**44**		**43**			

6.1.2.4 Juveniles

10 sub-adult woylies have been monitored. Four have been killed by foxes, one by a fox or feral cat, and one by a wedge tailed eagle. Four individuals are still being monitored.

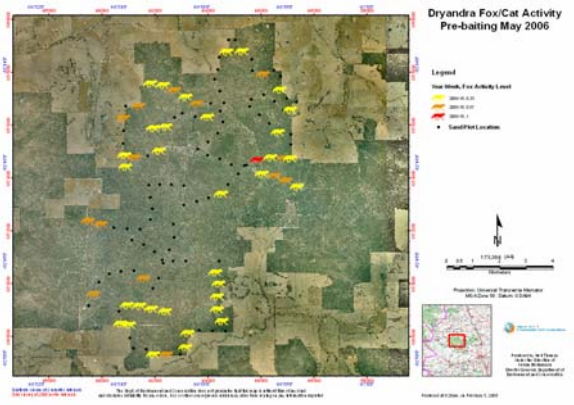
6.2 Trials to assess non-target uptake of the cat bait, Eradicat

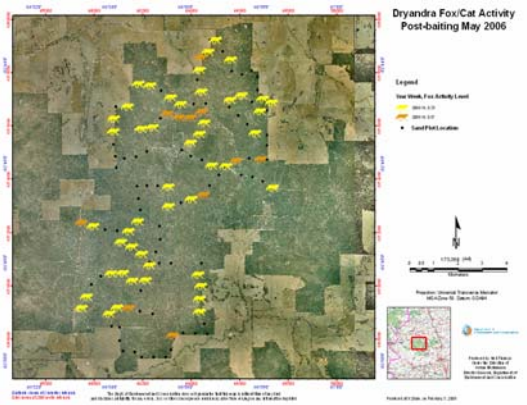
Trials to assess the non-target ingestion of Eradicat baits were postponed due to technical difficulties. The capsules including the biomarker were found to leak. This technical challenge is being addressed.

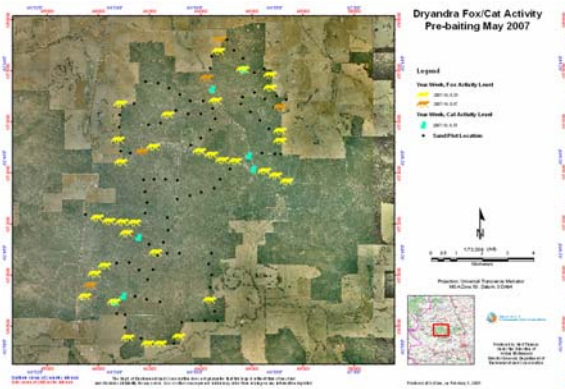
6.3 Fox and cat activity estimates and survival

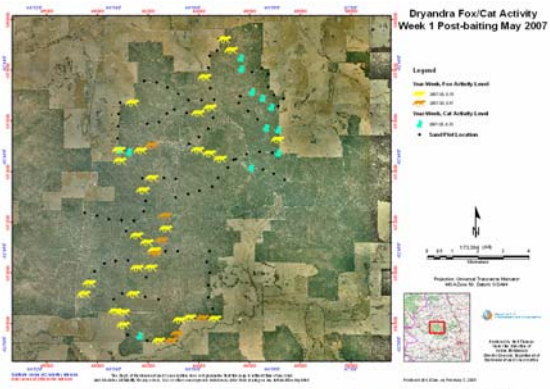
6.3.1 Sandplots

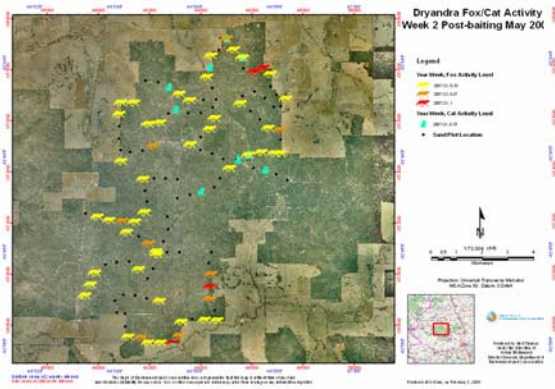
The activity of foxes and cats at sandplots in Dryandra, Tutanning and the unbaited sites of Quinns and Highbury has been monitored. These sandplots were monitored before and after fox baiting in May 2006, May 2007 (for a full rotation between baitings), October and November 2007, and May 2008. The activity of foxes varied with timing after baiting and maybe influenced by the removal of foxes by baits. The identity of individual foxes therefore needs to be obtained to determine if resident foxes reside in the sites or new foxes move in repeatedly.

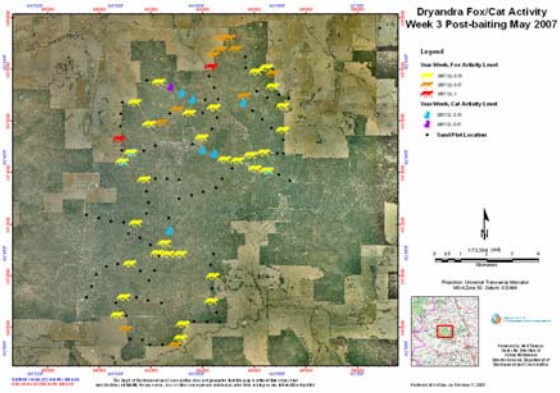


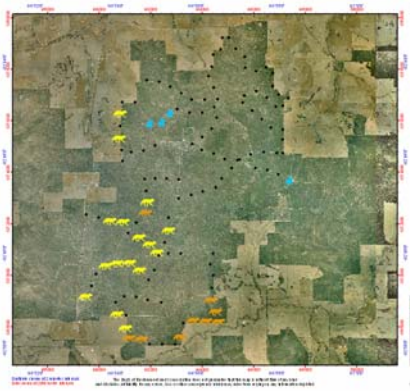











Dryandra Fox/Cat Activity
Pre-baiting October 2007
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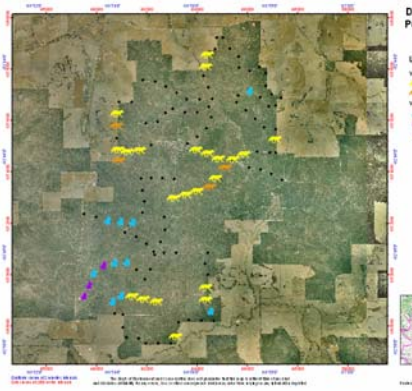
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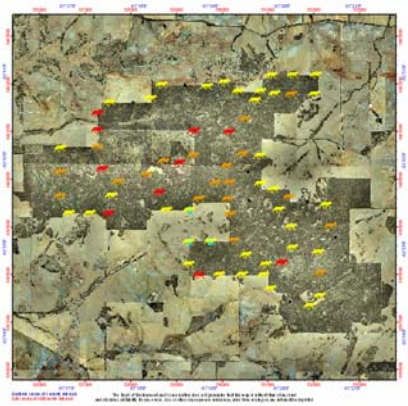
Tutanning Fox/Cat Activity
Pre-baiting May 2006
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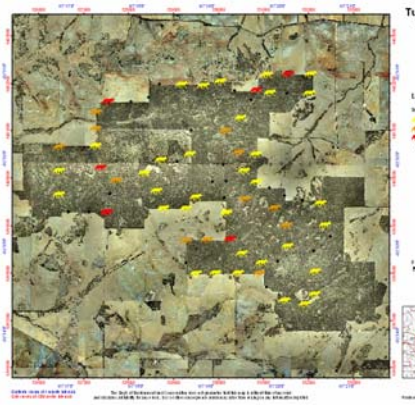
Tutanning Fox/Cat Activity
Post-baiting May 2006
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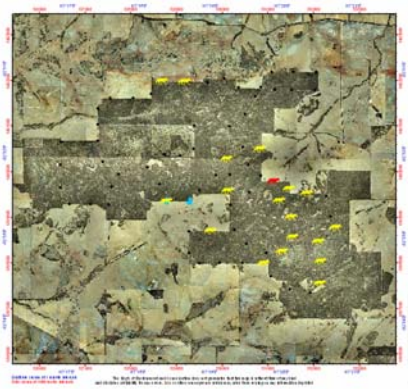
Tutanning Fox/Cat Activity
Pre-baiting October 2007
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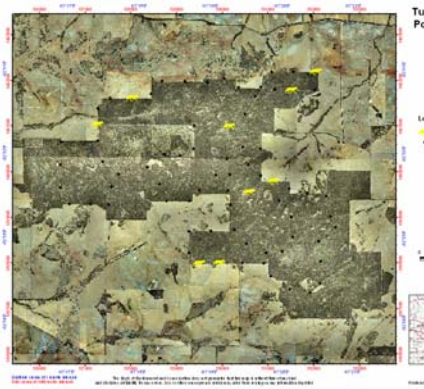
Tutanning Fox/Cat Activity
Post-baiting October 2007
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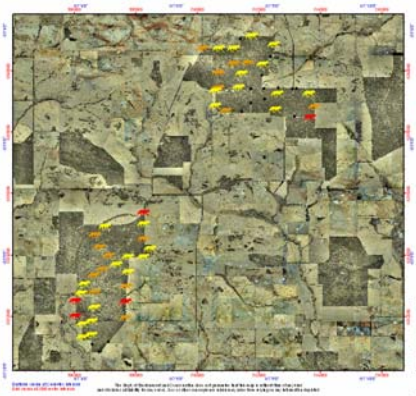
Quinns and Highbury
Fox/Cat Activity
Pre-baiting May 2006
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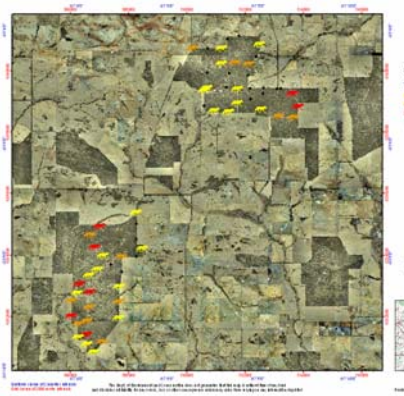
Quinns and Highbury
Fox/Cat Activity
Post-baiting May 2006
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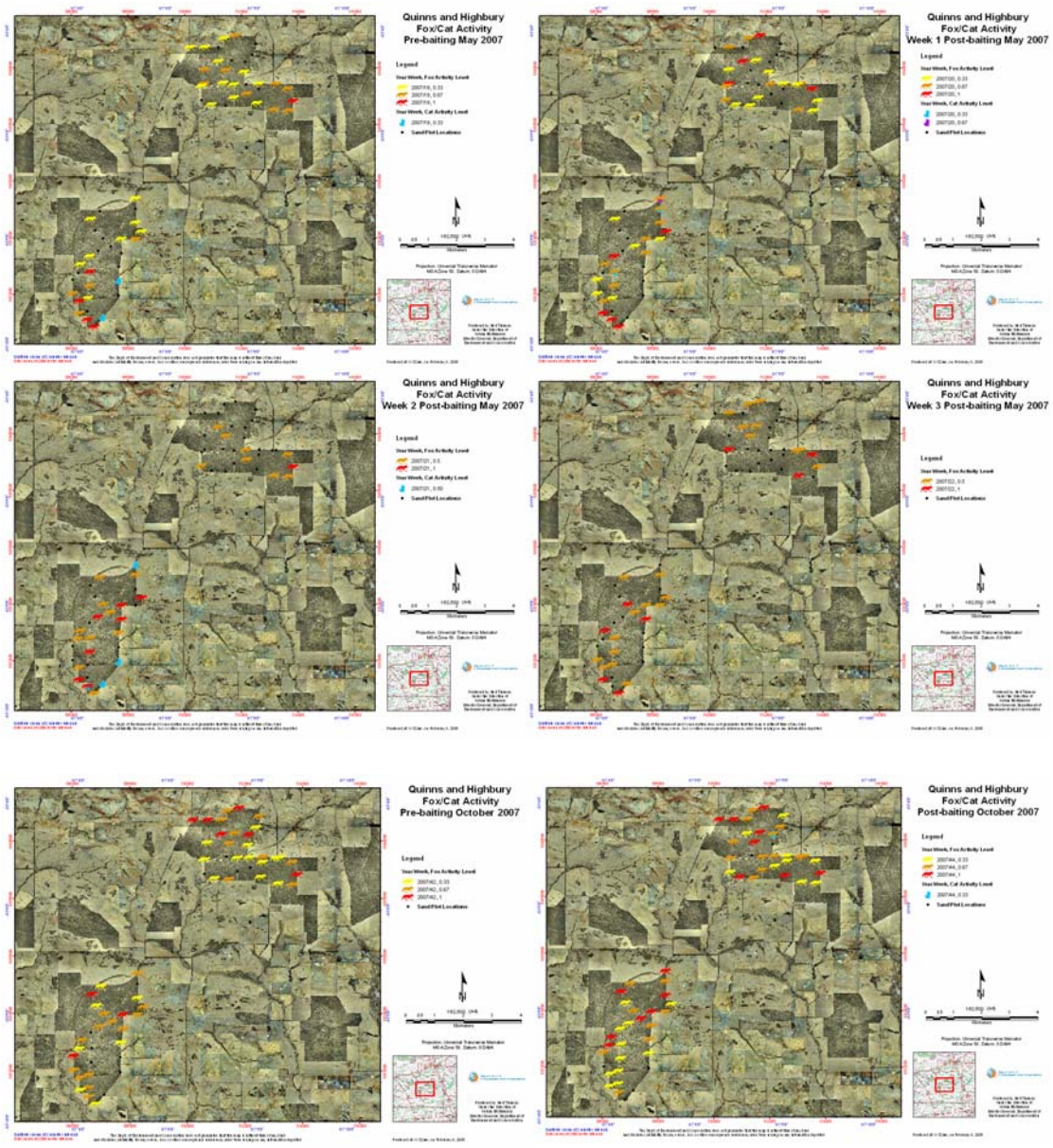
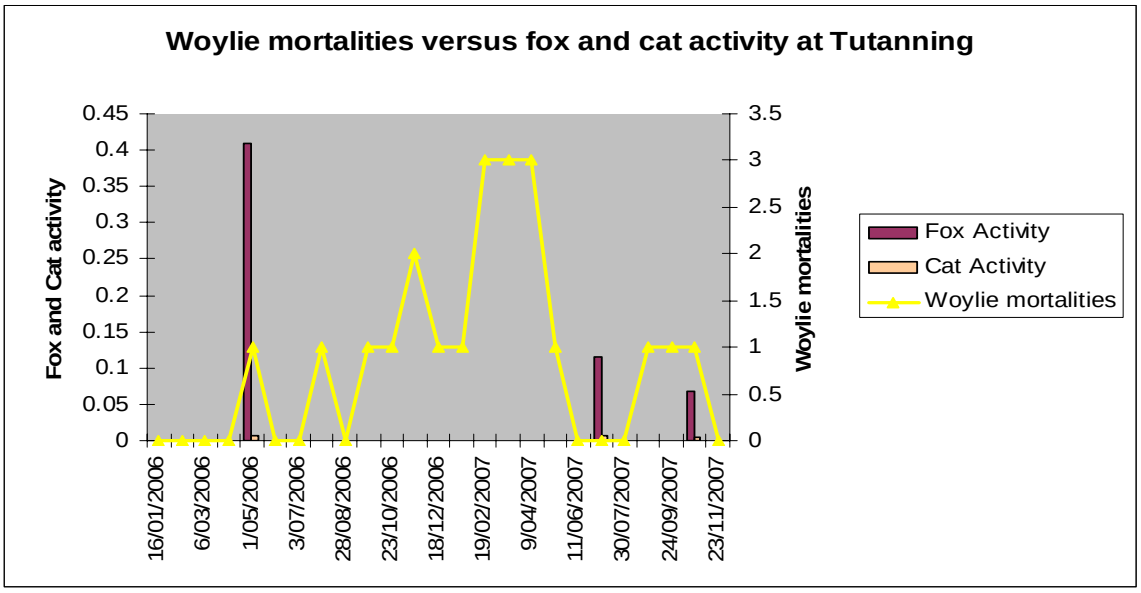
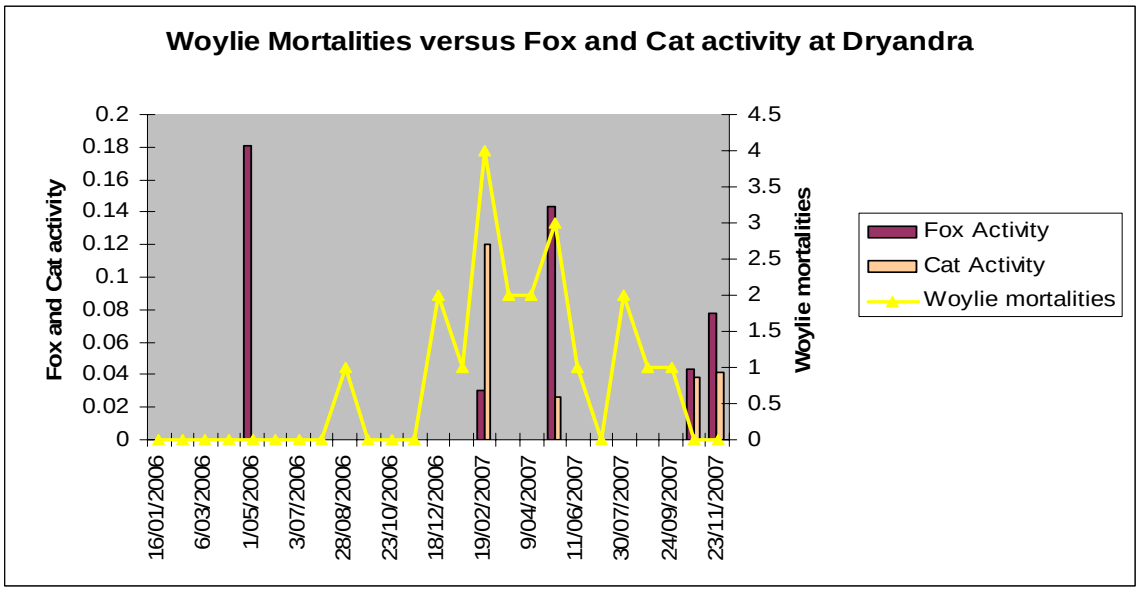
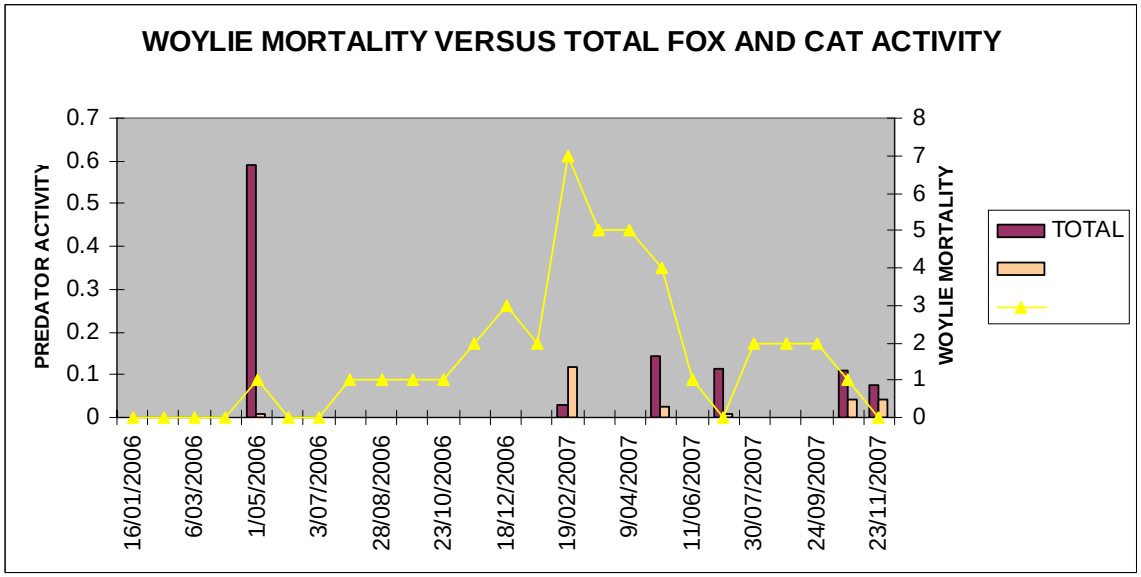


6.3.2 Woylie predation as a function of fox and cat activity







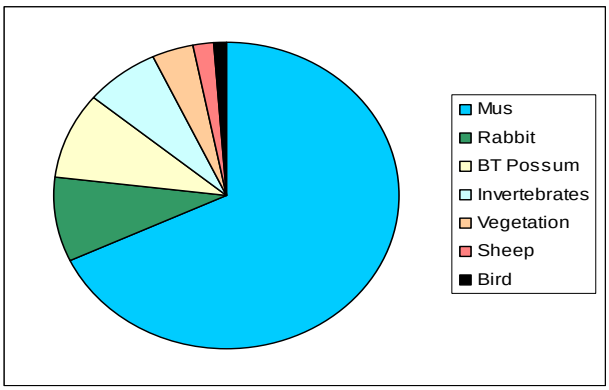
6.3.4 Hair traps

Hair traps have been placed on many of the sandplots. The hair traps are the same design as those used in the Northern Jarrah Forest. Most hair samples obtained are likely to have come from possums but analyses are underway. Initial sequencing of DNA from hair follicles from foxes showed that individuals could be identified if sufficient follicles were collected. A further 48 samples of hair have been collected and await analysis though many of these are probably from possums.

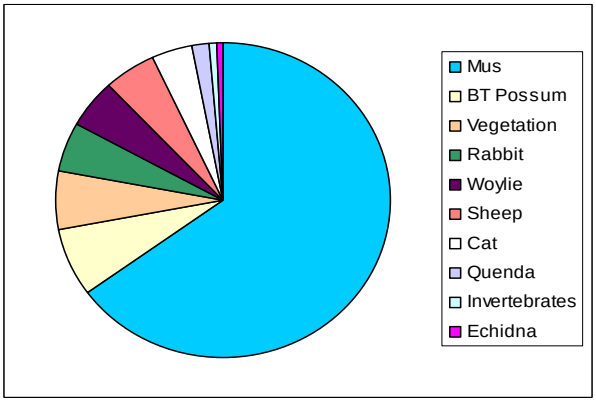
Hair ID	Species	Notes
HSP12	Fox	FOX OR POSSUM
HSP26	none	NO FOX HAIR
QSP4 (23/5)	Fox	SINGLE HAIR
QSP4 (24/5)	Fox	MULTIPLE FOX HAIRS
QSP6 (23/5)	Fox	MULTIPLE FOX HAIRS
QSP6 (25/5)	Fox	MULTIPLE FOX HAIRS
QSP12	none	WEAK AMPLIFICATION- NO FOLLICLE
QSP12 (18/5)	Fox	MULTIPLE FOX HAIRS
DSP12 (17/5)	Fox	MULTIPLE FOX HAIRS

Fox Scat Collection

The scats of foxes (and ideally cats) are collected each season from predetermined transects and sandplots. Interestingly there are very few scats collected in Dryandra and Tutanning and this has hampered dietary analyses. Twenty seven fox scats have been analysed from Dryandra Woodland and 71 from Tutanning Nature Reserve. Only one scat has revealed the presence of woylie remains. Most of the mammalian content of the fox's diet is *Trichosurus vulpecula, Mus domesticus* or *Oryctolagus cuniculus.*



Diet of foxes from Dryandra (n=27)



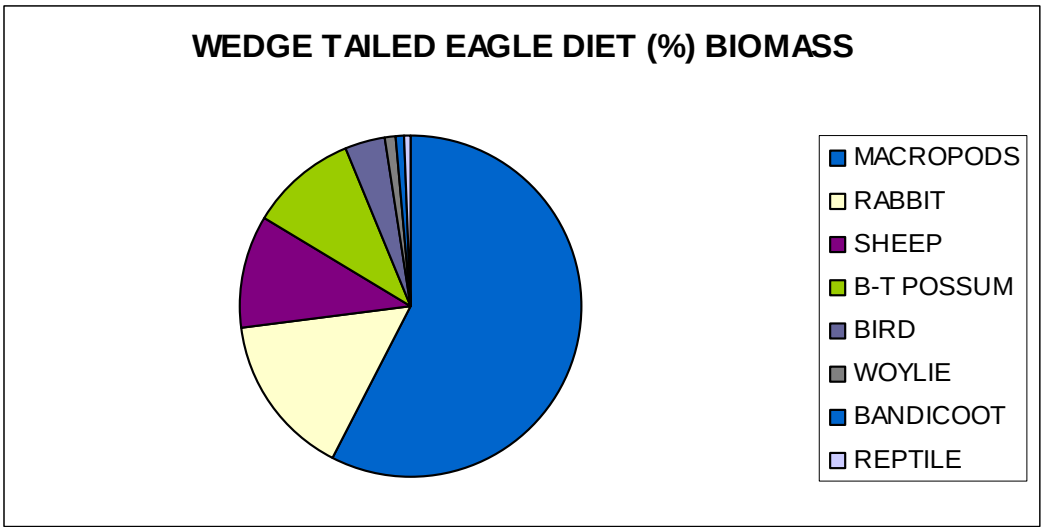
Diet of foxes at Tutanning (n=71)

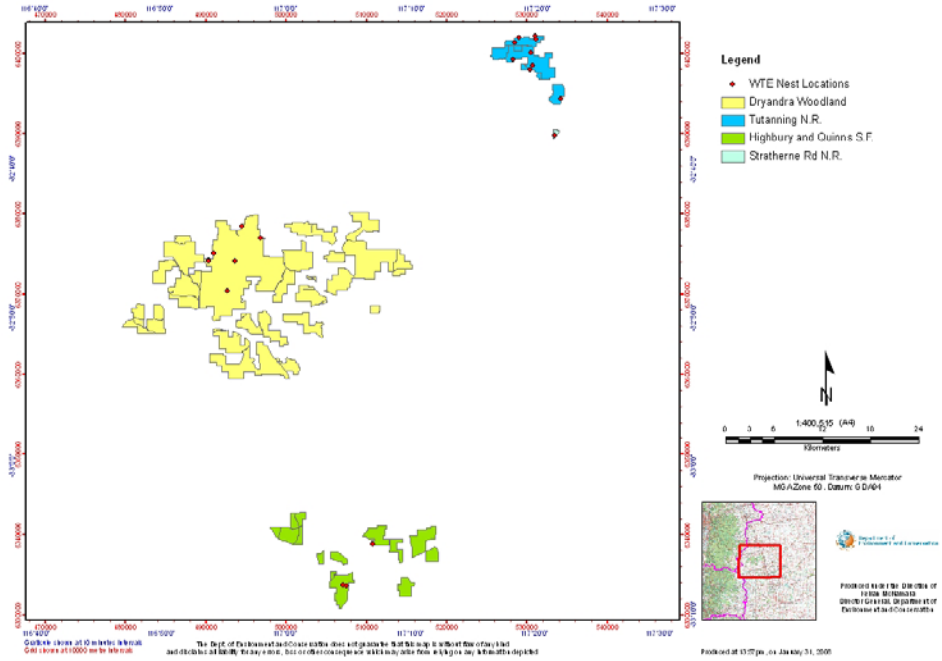
Wedge Tail Eagle Nest Identification and Dietary Analysis

Nine wedge tail eagle nests have been located in Tutanning Nature Reserve, one in Stratherne Road NR (near Tutanning Nature Reserve), six in Dryandra Woodland, two in Quinns block and one in Highbury block. The remains of prey are collected from these nests on a regular (fortnightly where possible) basis when the nests are in use. Two-hundred and one individual prey animals were identified from 615 prey remain items collected from the three DEC reserves in 2006 and 2007. These included 149 prey animals from Tutanning NR, 27 from Dryandra NR and 25 from Stratherne Road NR, and comprised 18 species of vertebrates: seven mammals, seven birds and four reptiles. Ninety regurgitated pellets were also collected from eagle nests: 55 from Tutanning, 15 from Dryandra and 20 from Stratherne Road. These are yet to be analysed and could provide some additional prey species, however they are unlikely to cause significant changes to the quantitative dataset.

Mammals were overwhelmingly the favoured prey of wedge-tailed eagles, constituting about 77% of total prey items by number and nearly 96% of the biomass of the 201 prey animals identified. Among the mammals taken, macropods (57.7% of total biomass, including tammar wallabies, 46.9%), rabbits *Oryctolagus cuniculus* (15.7%) and brush-tailed possums *Trichosurus vulpecula* (10.5%) were the most important prey species. At Tutanning in particular, tammar wallabies constituted more than half (53.7%) of the total diet biomass.

Birds were taken to a much lesser extent and contributing to a relatively minor proportion of eagle diet overall (14.5%, 3.6%). Important species of birds included ravens *Corvus coronoides* (6.0%, 1.4%) and pacific black ducks *Anas superciliosa* (2.5%, 1.2%). Reptiles were rarely taken as prey in the Narrogin region, contributing to 8.5% of total prey numbers but less than 1% of total diet biomass, with the bobtail skink *Tiliqua rugosa* (4%, 0.5%) being preferred.





Monitoring of known eagle nests is ongoing and the collection of prey remains from active ones will continue. Attempts will be made to locate more nests and to identify the number of pairs of eagles present in the reserves. This is organised to be done next winter when the birds will be breeding.

BAIT EFFECTIVENESS TESTING

Non-Target Bait Uptake

Not toxic dried meat baits were positioned at sandplots and a remote camera positioned to monitor the species removing baits.
Twenty five plots were monitored in Dryandra for four nights in February 2007.
Twenty sandplots were monitored for four nights in Tutanning in March 2007.

	DRYANDRA		***TUTANNING***	
	% baits taken	***%plots visited***	***% baits taken***	***%plots visited***
Fox	***1***	***3****	***0***	***8.75****
Cat	***0***	***11***	***0***	***6.25***
BT-Possum	***41***	***76***	***36.25***	***57.5***
Woylie	***7***	***29***	***1.25***	***10***
Quenda	***0***	***2***	***5***	***15***
Raven	***3***	***15***	***12.5***	***23.75***
Currawong	***1***	***3***	***3.75***	***3.75***
Magpie	***0***	***1***	***0***	***1.75***
Bobtail/Varanus	***2***	***3***	***0***	***0***
Unknown	***0***	***0***	***3.75***	***3.75***
Total	***55***		***62.5***	

Two of the sandplots/ baits visited by foxes had previously been visited by brush tail possums and the bait removed

***** All the baits had been removed from the sandplots before the foxes arrived***

These trials were repeated with non-toxic Probaits.

	DRYANDRA(N=60) June 2008	***TUTANNING (N=60) July 2008***
	% baits taken	***% baits taken***
Fox	***5***	***3***
Cat	***0***	***0***
BT-Possum	***20***	***10***
Woylie	***5***	***3***
Quenda	***0***	***0***
Bird	***7***	***7***
Bobtail/Varanus	***0***	***0***
Unknown	***4***	***0***
Total	***41***	***23***

Longevity Trials

Trials to determine the 1080 loss from dried meat baits, Pro-baits, Eradicat sausages and the Department of Agriculture sausage bait will commence in September 2008.