Invasive Animals Cooperative Research Centre

"Together, create and apply solutions"

Final report for Invasive Animals Cooperative Research Centre Project 10.U.01:

Introduced predator control and sustained fauna recovery in SW WA - is there a mesopredator release effect? Sub-project 3 'Woylie decline in Dryandra Woodland: Mesopredator release?'

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Department of Environment and Conservation
Our environment, our future

Executive Summary

The trap success of woylies declined in Dryandra Woodland between 1995 and 2005 despite continuation of the previously successful fox baiting regime. In an attempt to identify the cause of this decline the effectiveness of the fox baiting regime was investigated.

The identity of individual foxes was obtained through analysis of DNA collected from predators' saliva from collars of predated woylies (see below), from fox scats and carcasses collected throughout the study areas, and from hair samples collected at monitoring sites. Most foxes in Dryandra Woodland and Tutanning Nature Reserve (90 and 95% respectively) were only monitored once indicating the baiting regime of monthly delivery of 3mg baits delivered at the rate of 5 baits km^{-2} was effective. However two individual foxes in Tutanning Nature Reserve survived for 3 and 8 months respectively and in Dryandra Woodland three foxes each survived 3, 5 and 8 months revealing some foxes were not controlled by the standard baiting regime.

The foxes which did not succumb to baiting may not have encountered a bait, may not have ingested a bait even if they had found one, or may not have been killed by an ingested bait if the bait's 1080 content was insufficient.

The rate of bait ingestion by foxes was examined by studying fox behaviour at bait stations via the use of remote cameras. Thirteen per cent of baits were examined by foxes and of these 50% were removed. The foxes not removing baits may have consumed baits at a later time when they were sufficiently motivated.

A sample of three foxes were fed toxic baits to determine if fox baits contained sufficient 1080 to be lethal. All three foxes died within six hours of the bait being ingested.

A high level of non-target uptake of fox baits was observed. At least 50% of fox baits were removed within 72 hours by brush tailed possums *(Trichosurus vulpecula)*, birds (Currawongs and Ravens) and woylies. Too few baits may be available under the standard fox baiting regime to control all foxes present.

The intensity of the fox baiting regime was increased to 50 baits km^{-2} in the northern half of Dryandra Woodland to determine if fox control could be improved and thus whether the survival of woylies could be enhanced. Initial results indicated greater survival of woylies under the increased baiting regime but this was not sustained. It appeared cat predation increased when fox control was intensified and this nullified any advantages gained by improving fox control.

In a further attempt to determine the reasons for the woylie decline a sample of approximately 20 radio-collared woylies was maintained in both

Dryandra Woodland and Tutanning Nature reserve for the duration of the 4-year project. 146 woylies were radio-collared and these were monitored for five days per week. Ninety-eight woylies died and the cause of their deaths was determined. The identity of any predators was obtained by collecting samples of saliva from the dead woylies' radio-collars. These samples were analysed by collaborating IACRC colleagues at UWA. Initially the identity of the predator was revealed using a three way test to differentiate between fox, feral cat and chuditch DNA. Once the species of predator was identified the individual predator's genotype was obtained. The predominated cause of death (60%) of woylies was feral cat predation, especially by male cats. Fox predation accounted for a further 18% of woylie deaths whereas predation by raptors and pythons was negligible.

From these results a mesopredator release of feral cats is indicated. This conclusion was further supported by the observation that more cat activity occurred in areas where foxes were controlled than in unbaited areas.

The results of this work are of use to landholders and conservation estate managers because they reveal cat predation is now a major factor limiting the recovery of native fauna in WA. It is now imperative that an operational cat control methodology be developed and tested with the utmost urgency. The optimum timing, frequency and intensity of cat baiting and the usefulness of other control techniques need to be quantified. Once this methodology has been devised and found to be of acceptable risk to non-target species, it should be employed in conjunction with intensified fox baiting as soon as possible to effect a reduction in predator abundances and to reduce predation upon woylies and other fauna.

1. Background

Introduction/project justification

The abundance of woylies (Bettongia penicillata) has declined in Dryandra Woodland. The reasons for this decline remain unclear because the fox baiting regime which initially resulted in enhanced woylie survival has been maintained.

The effectiveness of the fox baiting regime was investigated to determine if foxes were being adequately controlled. The activity of foxes and cats was recorded at sand-plots which were monitored quarterly for three consecutive nights both before and after a fox baiting event. One hundred and twenty nine sand-plots were positioned in Dryandra Woodland, seventy five plots in Tutanning Nature Reserve and 33 in each of two unbaited blocks; Quinns block and Highbury block.

The actual number of foxes and cats present in these four sites was quantified by collecting hair samples at every second sand plot and analysing these using DNA analysis techniques to identify individuals. Hair samples were obtained by enticing animals to pass between three semi-vertical sticks, each with double sided tape adhered to it. Results of this research were used to determine whether individual, 'resident' foxes were surviving more than one baiting event or whether all foxes were being killed at each monthly baiting. The presence of individual foxes in all sites was also monitored by obtaining DNA genotypes from fox scats which were collected on a regular basis and from fox carcases found opportunistically.

Fox bait uptake trials revealed non-target species especially brush tailed possums and birds were removing baits before foxes were able to access them. The intensity of fox baiting was increased in the northern half of Dryandra Woodland to 50 baits km-2 (from the standard baiting regime of 5 baits km-2). The effectiveness of this increased baiting intensity was monitored by determining the number of foxes present in the northern half of Dryandra Woodland before and after each quarterly baiting event. The survival of woylies was also compared within the intensively baited area at Dryandra Woodland with that of Tutanning Nature Reserve where the 'standard' fox baiting regime was maintained. Each year woylies are monitored in Dryandra Woodland and Tutanning Nature Reserve as part of DEC's Western Shield fauna monitoring project. There are 50 trap locations in Tutanning Nature Reserve and 75 in Dryandra Woodland. These are monitored for three consecutive nights, once per year.

One of the main areas of research was whether predation upon woylies by other predators (mesopredator release) occurred when foxes were controlled. Specifically the predatory roles of pythons, raptors and feral cats were examined. The change in feral cat abundance (mesopredator release) that may have resulted from the control of foxes was quantified by comparing the relative activities of these two species in baited and unbaited areas.

The level of predation upon woylies by native predators such as wedge tailed eagles and carpet pythons was investigated to determine if these

species increase their predatory impact in areas where foxes are controlled.

The factors responsible for the deaths of woylies were identified by monitoring the fate of radio-collared individuals. A sample of approximately 20 radio-collared woylies was maintained in Dryandra Woodland and Tutanning Nature Reserve for the duration of the project. The status (alive or dead) of each individual was monitored five days per week. When a mortality event occurred the carcass of the individual was collected; its general condition was examined, evidence of disease was sought and any signs of predation recorded. A swab was collected from the radio-collar and the identity of the predator which may have left a saliva sample was obtained using DNA analysis. This latter work was undertaken in collaboration with IACRC colleagues from the University of Western Australia.

Project objectives

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 (the baiting regime in the northern half of Dryandra Woodland was increased to 50 baits per square kilometre and each bait has a 1080 loading of 4.5mg)
3) to investigate if increased predation upon woylies by other introduced or native predators occurs when foxes are sufficiently controlled

Hypothesis under test: woylie survival is a function of a suite of factors including fox, cat, python and raptor predation

Project participants

DEC

Project Leader	N. Marlow.
Team Members	B. Macmahon, J. Lawson (both IA CRC funded), N. Thomas and A. Williams

Other Collaborators

Project Leader	O. Berry (IA CRC funded post doc, University of Western Australia).

IA CRC operational target to be addressed

1. A benefit of $29 million p.a. by reducing impacts of foxes by 10%.
6. Reduced impacts of feral cats over 5 M hectares.

Specific objectives

Goal:

1.1 New knowledge on fox and wild dog biology, ecology, impact, management, and the ecological interactions of control methods

Outputs:

1.1.3 Management-scale (end-user) assessment of new wild dog and fox strategies commenced at demonstration sites in different states with different stakeholders
1.1.5 Ecological experiments and large scale demonstration project completed

Goal:
1.2 Fox and wild dog management packages that include new and existing toxins, application strategies and end-user training

Outputs:
Nil outputs listed

Goal:
6.1 New knowledge on feral cat ecology and ecological interactions of control methods

Outputs:
6.1.1 Field effectiveness of feral cat baits for reducing the impact of predation on threatened wildlife measured.

Success criteria

Milestone description		Objective		Success criteria
No.	Milestone/ Objective	Start Date	Due Date*	Outcome/Output
1	Set up sand-plots	Jan 2006	May 2006	Monitoring of fox/ cat abundance
2	Initial woylie monitoring	March 2006	May 2006	Sites for woylie trapping grids identified
3	Sand plot monitoring initiated	May 2006	June 2006	Relative abundance of foxes and feral cats in baited and unbaited sites examined
4	Fox abundance estimated in baited and unbaited sites (DMBs)	June 2006	Dec 2006 Revised to Jun 08 due to higher than expected non-target bait uptake	Effectiveness of dried meat baits for fox control determined
5	Woylie survival monitoring	June 2006	June 2007 Revised to Jun 08 due to difficulties identifying cause of woylie deaths	Factors affecting woylie survival (including mesopredators, if any) identified
6	Fox abundance estimated in baited and unbaited sites (Probaits)	Dec 2006	Dec 2007 Revised to Jun 08 due to higher than expected non-target bait uptake	Effectiveness of Probaits for fox control determined
7	Predator dietary analysis	June 2006	Dec 2007 Revised to Jun 08	Diets of foxes, cats and wedge tailed eagles quantified
8	Fox and cat trapping (if non-target issues are overcome)	Aug 2006	Dec 2007 Revised to Jun 08	Presence of resident foxes and cats (if any) confirmed. Habitat partitioning by foxes and cats (in any) identified
9	Fox and cat abundance	Dec 2007	June 2008	Effectiveness of Probaits and

	estimated in baited and unbaited sites (Probaits and Eradicat)			Eradicat baits determined
10	Bait effectiveness testing	August 2006	Jun 2008	Bait longevity and 1080 content quantified
11	Complete summer pre and post baiting sand plotting	Feb 2009	Progress report at 30 April 2009	Continue determination of effectiveness of 50 baits per km
12	Undertake summer fox hair collection (where possible)	Feb 2009		Identification of individual foxes
13	Undertake annual woylie trapping	March / April 2009		Estimate of population size
14	Complete autumn pre and post baiting sand plotting	May 2009	Progress report at 1 June 2009	Continue determination of effectiveness of 50 baits per km
15	Undertake autumn fox hair collection (where possible)	May 2009		Identification of individual foxes
16	Complete winter pre and post baiting sand plotting	Commence August 2009	1 Dec 2009	Continue determination of effectiveness of 50 baits per km
17	Undertake winter fox hair collection (where possible)	Commence August 2009	1 Dec 2009	Identification of individual foxes
18	Commence and complete winter scat collection	Commence June/July 2009	1 Dec 2009	Continued assessment of fox dietary intake
19	Complete spring (and final) pre and post baiting sand plotting	Commence Oct 2009	1 Dec 2009	Continue determination of effectiveness of 50 baits per km
20	Undertake spring (and final) fox hair collection (where possible)	Commence Oct 2009	1 Dec 2009	Identification of individual foxes
21	Commence and complete spring (and final) scat collection	Commence Nov 2009	1 Dec 2009	Continued assessment of fox dietary intake
22	Continue monitoring survival of radio-collared woylies	Commenced 2007	1 Dec 2009	Continued assessment and determination of causes of woylie mortality
23	Continue collecting wedge-tailed eagle dietary items	Opportunistic-when birds at nests	1 Dec 2009	Continued assessment of eagle dietary intake
24	Completion of final report		1 Dec 2009	Final report now complete

2. Project key findings and best practices

Key findings and achievements

1) to determine if the current fox baiting regime is effective in reducing fox predation upon woylies

The current fox baiting regime at Dryandra Woodland and Tutanning Nature Reserve results in the deaths of many foxes, though not all are killed.

Molecular techniques were used to identify the survival of individual foxes. Genotypes were obtained from fox hair, carcass and scat samples collected during the study. Approximately 90-95% of foxes were only monitored once in the baited areas indicating the monthly fox baiting regime was effective in removing reinvading foxes. The standard fox baiting regime is still largely effective. The small number of foxes which survived at least one fox baiting event were either not encountering, not ingesting, or were not being killed by baits. Because no monitoring of foxes was undertaken in any of these sites before the commencement of this study it is unclear whether any change in the effectiveness of the baiting regime had occurred.

A study to investigate the 1080 content of fox baits was undertaken. Baits with known, hand injected aliquots of 1080 were placed in the field and then collected at specified times for up to three months. These trials were repeated each season. The baits were to be analysed to determine if their 1080 content decreased with time and/ or season and thus whether they remained toxic to foxes. Baseline samples of baits were sent to two different institutions to assess the institutions' capability to accurately quantify the amount of 1080 present. Neither institution was able to do this with any accuracy due to the difficulties involved in extracting 1080 from a meat based, salami-style product. Consequently no formal analysis of the baits collected from the field was undertaken. Subsequently three captive foxes were fed standard 1080 baits and all died within four hours of ingesting the bait thus indicating the baits contain sufficient toxin to be lethal.

An experiment was undertaken to discover the fate of the baits laid for fox control in Dryandra Woodland and Tutanning Nature Reserve. Remote cameras were employed to identify the species responsible for removing the bait and brush-tailed possums and birds were observed to be the predominate species responsible. Most baits were removed within 72 hours and this reduced the number of baits available for fox control.

A further test of the effectiveness of the standard fox baiting regime was undertaken by examining the proportion of radio-collared woylies predated by foxes. A sample of approximately 20 radio-collared woylies was maintained throughout the study. When a dead woylie was located in the field its carcass was collected and its radio-collar swabbed to in an attempt to obtain DNA from the saliva of any predator involved in its death. The saliva sample was then analysed using DNA methodologies and the species (fox, cat, chuditch) responsible for the woylie's death identified. In total 146 woylies were radio-collared and of these 98 were known to have died. Of these 18% were killed by foxes. Of the other woylie deaths 60% were attributed to cat predation. Predation upon woylies by raptors, pythons and chuditch was negligible.

2) if the current fox baiting regime is inadequate, to improve it so that fox predation on woylies is minimised

In order to increase the effectiveness of the fox baiting regime the intensity of bait delivery was increased in the northern half of Dryandra Woodland to 50 baits km-2 commencing November 2008. Annual trapping of woylies revealed the number of woylies known to be alive and to survive appeared to increase (to 30) in Dryandra Woodland in March 2009 whereas it stayed stable in Tutanning Nature Reserve where the baiting regime was unaltered. This suggested the increased fox baiting regime was effective in reducing woylie mortality. Unfortunately subsequent monitoring of the survival of woylies revealed that this rate of survival was not sustained. It appeared an increase in cat predation as a consequence of the increased control of foxes negated any benefit of the improved fox control.

3) to investigate if increased predation upon woylies by other introduced or native predators occurs when foxes are sufficiently controlled

Another extremely important result to be obtained from monitoring the fate of radio-collared woylies was whether any mesopredator release of feral cats, pythons or raptors occurred in the presence of fox control. In both Dryandra Woodland and Tutanning Nature Reserve the predominate predator of woylies was the feral cat, which indicates a mesopredator release of feral cats occurred. Conversely the incidence of predation upon woylies by pythons and raptors was low indicating that mesopredator release of these two species did not occur.

Further evidence of a mesopredator release of feral cats in the presence of fox control was obtained by examining the activity of cat tracks on sandplots in fox baited and unbaited sites. Cat activity on sandplots increased relatively in the two sites where fox baiting was undertaken in comparison with where no fox baiting was implemented.

Despite the standard baiting regime resulting in approximately 18% of radio-collared woylies being predated by foxes, an analysis of the diet of foxes did not reveal a high level of consumption of woylies. Foxes were predominately ingesting *Mus domesticus*. Only one fox scat was found to contain any woylie remains.

An analysis of the diet of wedge tailed eagles also revealed that woylies were not an important dietary item for this species. 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 by eagles, macropods, rabbits *Oryctolagus cuniculus* (15.7%) and brush-tailed possums *Trichosurus vulpecula* (10.5%) were the most important prey species.

Best practices

The increased intensity fox baiting regime (50 baits^{-2}) was field tested for its effectiveness in small reserves. Despite an initial increase in woylie survival this was not sustained, probably due to a resultant increase in cat predation. Until an operational cat control methodology for the south west of WA has been developed the standard monthly fox baiting regime (5 baits km^{-2}) should be maintained. When effective cat control can be implemented this should be combined with increased intensity fox baiting so that both introduced predators are controlled, the mesopredator release of feral cats is ameliorated, and fauna recovery can occur once more.

Conclusions

Although the standard fox baiting regime does not kill all foxes it still controls 90-95% of foxes present. Increasing the intensity of fox baiting may have an initial beneficial outcome but this is not sustained in the longer term, probably due to a consequent increase in cat predation.

The main factor responsible for the deaths of woylies in Dryandra Woodland and Tutanning Nature Reserve is predation by feral cats. Approximately 60% of radio-collared woylies were killed by cats. This result indicates a mesopredator release of feral cats occurred in the presence of fox control. Further evidence of a mesopredator release of

feral cats was indicated by an increased rate of activity by feral cats on sandplots in areas where foxes have been removed. Lower rates of cat activity were observed in sites where no fox baiting was undertaken.

No mesopredator release of pythons or raptors was observed. The small amount of woylie remains in fox scats or eagle prey debris precluded any more sophisticated modelling of the seasonal ingestion of woylies by either of these native predators.

3. Project performance

Success in achieving project objectives

Goal	Completed? Y/N	Comments (if 'no')
1.1 New knowledge on fox and wild dog biology, ecology, impact, management, and the ecological interactions of control methods	Y	
1.2 Fox and wild dog management packages that include new and existing toxins, application strategies and end-user training	Y	
6.1 New knowledge on feral cat ecology and ecological interactions of control methods	Y	

Output	Completed? Y/N	Comments (if 'no')
1.1.3 Management-scale (end-user) assessment of new wild dog and fox strategies commenced at demonstration sites in different states with different stakeholders.	Y	Initial assessment of the effectiveness of the increased intensity (50 baits km^{-2}) fox baiting regime revealed increased woylie survival. This trial was extended until March 2011 to assess whether this increased effectiveness is maintained
1.1.5 Ecological experiments and large scale demonstration project completed.	Y	
1.2 Nil outputs listed	Y	
6.1.1 Field effectiveness of feral cat baits for reducing the impact of predation on threatened wildlife measured.	N	Although the need for a cat bait was highlighted by the results of this sub project, no operational cat bait suitable to be used in the SW of WA became available and so no cat control could be undertaken

Success in achieving project milestones

Milestone	Completed? Y/N	Comments (if 'no')

Set up sandplots	Y	
Initial woylie monitoring	Y	
Sand plot monitoring initiated	Y	
Fox abundance estimated in baited and unbaited sites (DMBs)	Y	
Woylie survival monitoring	Y	
Fox abundance estimated in baited and unbaited sites (Probaits)	Y	
Predator dietary analysis	Y	
Fox and cat trapping (if non-target issues are overcome)	N	Foxes and cats were too wary to be caught and so this aspect of the study was abandoned
Fox and cat abundance estimated in baited and unbaited sites (Probaits and Eradicat)	N	Eradicat baits did not become available for use in Dryandra and Tutanning during this study. This was a major setback for this project because it meant that the effectiveness of cat control in the conservation of woylies could not be evaluated
Bait effectiveness testing	N	No institution was able to accurately quantify the 1080 content of the salami- style meat fox baits
Complete summer pre and post baiting sand plotting	Y	
Undertake summer fox hair collection (where possible)	Y	
Undertake annual woylie trapping	Y	
Complete autumn pre and post baiting sand plotting	Y	
Undertake autumn fox hair collection (where possible)	Y	
Complete winter pre and post baiting sand plotting	Y	
Undertake winter fox hair collection (where possible)	Y	
Commence and complete winter scat collection	Y	
Complete spring (and final) pre and post baiting sand plotting	Y	
Undertake spring (and final) fox hair collection (where possible)	Y	
Commence and complete spring (and final) scat collection	Y	
Continue monitoring survival of radio-collared woylies	Y	
Continue collecting wedge-tailed eagle dietary items	Y	
Complete final report	Y	

Project outputs

ISI peer reviewed journals:

Non-ISI peer reviewed journals:

Asher J, Marlow N, Brazell R (2007). **Taking the bait**. **Landscope** 22(4), pp. 39–41

Research-related books:

Research-related book chapters:

De Tores PJ, Marlow N (2012). The relative merits of predator-exclusion fencing and repeated fox baiting for protection of native fauna: five case studies from Western Australia. In **Fencing for Conservation: Restriction of Evolutionary Potential or a Riposte to Threatening Processes?** (eds MJ Somers, MW Hayward). Springer, New York. pp. 21–42

Full written conference papers published in refereed proceedings:

Reports and technical documents:

Schedule (timeline) performance

Milestone	Agreement due date	Actual delivery date
Set up sandplots	May 2006	May 2006
Initial woylie monitoring	May 2006	May 2006
Sand plot monitoring initiated	June 2006	June 2006
Fox abundance estimated in baited and unbaited sites (DMBs)	Dec 2006 Revised to Jun 08 due to higher than expected non-target bait uptake	Dec 2008
Woylie survival monitoring	June 2007 Revised to Jun 08 due to difficulties identifying cause of woylie deaths	Dec 2008
Fox abundance estimated in baited and unbaited sites (Probaits)	Dec 2007 Revised to Jun 08 due to higher than expected non-target bait uptake	Dec 2008
Predator dietary analysis	Dec 2007 Revised to Jun 08	Dec 2008
Fox and cat trapping (if non-target issues are overcome)	Dec 2007 Revised to Jun 08	Not achieved due to the wary nature of the foxes and cats in heavily baited areas
Fox and cat abundance estimated in baited and unbaited sites (Probaits and Eradicat)	June 2008	Not achieved due to the non-availability of Eradicat baits
Bait effectiveness testing	Jun 2008	Not achieved due to inability to obtain accurate assessment of 1080 content of baits
Complete summer pre and post baiting sand plotting	Progress report at 30 April 2009	14 Oct 2009
Undertake summer fox hair collection (where possible)	Progress report at 30 April 2009	14 Oct 2009
Undertake annual woylie trapping	Progress report at 1 June 2009	12 June 2009
Complete autumn pre and post baiting sand plotting	Progress report at 1 June 2009	12 June 2009
Undertake autumn fox hair collection (where possible)	Progress report at 1 June 2009	14 Oct 2009
Complete winter pre and post baiting sand plotting	1 Dec 2009	29 June 2010
Undertake winter fox hair collection (where possible)	1 Dec 2009	29 June 2010
Commence and complete winter scat collection	1 Dec 2009	29 June 2010
Complete spring (and final) pre and post baiting sand plotting	1 Dec 2009	29 June 2010
Undertake spring (and final) fox hair collection (where possible)	1 Dec 2009	29 June 2010
Commence and complete spring (and final) scat collection	1 Dec 2009	29 June 2010
Continue monitoring survival of radio-collared woylies	1 Dec 2009	29 June 2010
Continue collecting wedge-tailed eagle dietary items	1 Dec 2009	29 June 2010
Completion of final report	December 2009	Final report now completed

Quality

APVMA authority was obtained for the increased intensity baiting experiment.

All work was done with approval of DEC's Animal Ethics Committee and under appropriate scientific licences.

Budget

This has been provided

4. Project closure

Issues

See below

Assets

No major assets were purchased during this project other than an isoflourane anaesthetic machine.

Post project tasks

There are still papers/ reports to be finalised from this project and these include:

de Tores and Marlow, An overview of 1080 baiting programs for control of the introduced red fox, *Vulpes vulpes*, in Western Australia, an investigation of the potential for mesopredator release, and recommendations for future management and research, *Biol Conservation*

Marlow, Berry, Matt Williams, de Tores, Wayne, Clarke, Andy Williams, Thomas, McMahon and Lawson, Modelling predation characteristics to identify predators - validation through molecular techniques, *Biol Conservation*

Marlow, Macmahon, Thomas, A. Williams, Lawson, Modelling survival of woylies (Bettongia penicillata) in Dryandra Woodland and Tutanning Nature Reserve, *Biol Conservation*

Marlow, Thomas, Macmahon, A. Williams, Lawson, Fox baiting effectiveness in two Wheatbelt reserves, *Journal of Wildlife Management*

Marlow, Macmahon, A. Williams, Lawson, Thomas, Modelling the diet of foxes in relation to woylie survival in Dryandra Woodland and Tutanning Nature Reserve, *Wildlife Research (progress of this manuscript has been hampered by the lack of woylie remains found in fox scats)*

*Marlow, Thomas, Macmahon, A. Williams, Lawson,*Population dynamics and viability of woylies (Bettongia penicillata) in Dryandra Woodland and Tutanning Nature Reserve, *Journal of Wildlife Management*

Marlow, A. Williams, Macmahon, Cherriman, Wedge tailed eagle diet in Dryandra Woodland and Tutanning Nature Reserve, *Wildlife Research (progress of this manuscript has been hampered by the lack of woylie remains found in eagle nests)*

Marlow, Thomas, Macmahon, A. Williams, Lawson, What woylie decline'?, *Landscope*

A. Williams, Marlow, Cherriman, Wedge tailed eagles in Dryandra and Tutanning, *Landscope*

Thomas, Marlow, Macmahon, Fox bait uptake at Dryandra and Tutanning, *Landscope*

5. Project issues

Risks

The predicted amber level risk of an operational cat bait not becoming available by August 2007 (or at all during the life of this project) was unfortunately realised. This lack of a cat bait seriously impeded the progress of the project and resulted in a very important aspect of the work (i.e. implementation of cat baiting to determine its effectiveness in protecting woylies from predation) not proceeding. It was frustrating to have identified a very high level of cat predation upon woylies and yet not be able to undertake any meaningful cat control to alleviate this situation.

Limitations and difficulties

We had difficulty obtaining reliable assays of the concentration of 1080 in our meat based fox baits. This is a widely recognised difficulty but before we could further address this issue all bait samples were destroyed when a freezer malfunctioned.

Lessons learned

Our milestone reporting dates were revised during the project and this provided more realistic reporting times.

Project shortcomings

Although fox (and cat) trapping were undertaken in Dryandra Woodland in an attempt to fit GPS radio-collars, our incredibly concerted efforts were not rewarded in a single capture of a fox or feral cat. This limited our ability to monitor the specific movements of foxes within the reserve and their potential to be killed by baits. The foxes were incredibly wary of our trapping activities and did not approach our sets.

6. Adoption of project outcomes

Extension activities

A fact sheet on woylie decline and fox control was produced for public and landholder meetings.

Media opportunities

Communications:

- Seminars/ presentations
  - Society for Conservation Biology conference, Tennessee, August 2008
  - Highbury public meeting,
  - Cuballing public meeting,
  - Barna Mia public meeting,
  - Dryandra landholders public meeting (2)
  - Fauna program review
  - Wheat belt managers review
- Radio interview
  - ABC Albany 2008

  - ABC Albany June 2009
- Newspaper
  - Narrogin Observer

Current adoption of project outcomes

None- although the extreme need for a feral cat bait was identified, because no operational cat bait is available for use then no current adoption of the project outcomes (i.e. the identification of extremely high levels of predation upon woylies by feral cats) is possible.

Future potential for adoption of project outcomes

The increased intensity fox baiting strategy and its potential for implementation are discussed above.

7. Project impact on management

Current impact on management

The standard fox baiting regime was observed to be largely effective in controlling foxes and its use will be continued. The increased intensity fox baiting regime did not result in sustained improvements in woylie survival and so was not implemented.

Future impact on management

The identification of feral cat predation as the most important factor affecting the survival of woylies will need to be addressed urgently. Managers will need to focus on providing the impetus to ensure an operational cat control methodology, suitable for use in the SW where there are numerous non-target species, is developed as soon as possible.

8. Conclusions

1) The current standard fox baiting regime at Dryandra and Tutanning kills 90-95% of foxes. A small number of foxes was observed to survive at least one fox baiting event. Non-target uptake of fox baits was high and some foxes ignored baits. However if a fox finds and ingests a bait there is sufficient toxin present to result in that animal's death.

2) An increased intensity fox baiting regime produced an initial increase in woylie survival but this was not sustained. An increase in cat predation on woylies probably resulted as a consequence of the increased fox baiting intensity.

3) Cat predation upon woylies was the main factor responsible for the deaths of radio-collared woylies. Mesopredator release of feral cats in the presence of fox control is indicated and this was further supported by an observed increase in cat activity in areas where foxes are controlled. No mesopredator release of pythons or raptors was observed.

9. Recommendations

Further research / future directions

The standard fox baiting regime needs to be maintained until effective cat control methods can be implemented.

It is recommended that the development of an operational cat control methodology, suitable for use in the SW WA in the presence of numerous non-target species, be given the highest priority by DEC managers. As soon as such a methodology is available for use it needs to be employed in Dryandra Woodland and Tutanning Nature Reserve (and other sites) to relieve the predation pressure currently being experienced by populations of woylies therein.