Invasive Animals Cooperative Research Centre
Uptake of Products and Strategies Program:
Project:10.U.1 Western Australian Demonstration Site

Subproject 2:
Introduced predator control and sustained fauna recovery in south-west Western Australia.
The importance of fox, cat and native predator interactions to sustained fauna recovery in the northern jarrah forest – is there a mesopredator release effect?

Progress Report at 30 June 2008

Paul de Tores, Duncan Sutherland, Al Glen, Rob Hill, Lenny Bloomfield, Sean Garretson, Lauren Strümpher, Deb Feeniks, Helen Darby, Sheree Mammone, Jennyffer Cruz and Gillian Bryant

Not for citation without discussion with the authors

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1 The project team, collaborators and volunteers

The personnel involved in the project are listed in Table 1(current project team) Table 2 (personnel previously involved as members of the project team), Table 3 (collaborators) and Table 4 (volunteers).

Table 1: The current project team for the northern jarrah forest predator interaction and sustained fauna recovery research project.

Personnel **(bolding indicates current team member)**	**Affiliation** **(reflects employer and funding source)**	**Title / Role**	**Commitment (as a fraction of 1.0 FTE)**	**Period of involvement**
Paul de Tores	DEC	DEC Science Division Research Scientist project leader	0.85	1 Jan 2006 to 30 June 2008
Duncan Sutherland	IA CRC / DEC	DEC Science Division Post doctoral Research Scientist. Varanid research	1.0	July 2006 to 30 June 2008
Al Glen	IA CRC / DEC	DEC Science Division Post doctoral Research Scientist. Chuditch research	1.0	August 2006 to 30 June 2008
Rob Hill	IA CRC / DEC (0.67 / 0.33) (0.50 / 0.25)	DEC Science Division Technical Officer	0.85 0.75	June 07 to 31 Mar 08 From 01 April to 30 June 2008
Lenny Bloomfield	IA CRC / DEC (0.67 / 0.33) (0.50 / 0.25)	DEC Science Division Technical Officer	0.85 0.75	August 07 to 31 Mar 08 From 01 April to 30 June 2008
Sean Garretson	Chicago Botanic Garden (International Exchange Program) IA CRC / DEC (0.67 / 0.33) (0.50 / 0.25)	DEC Science Division Technical Officer	1.0 0.85 0.75	June to September 2007 01 Nov 07 to 31 Mar 08 From 01 April to 30 June 2008
Lauren Strümpher	IA CRC / DEC (0.50 / 0.25)	DEC Science Division Technical Officer	0.75	10 Mar 2008 to 30 June 2008
Jessica Read-Brain	DEC	Project Officer, External Communications		Casual - 10 hrs May-June 2008
Deb Feeniks	DEC	DEC Science Division Technical Officer		Casual – 95 hours 14 Apr – 30 June 2008
Sheree Mammone	DEC	DEC Science Division Technical Officer		Casual – 19 hours 14 April – 30 June 2008
Helen Darby	DEC	DEC Science Division Technical Officer		Casual – 11 hours 14 April – 30 June 2008
Gillian Bryant	DEC / Murdoch	PhD Student python research	0.5	2006 to 30 June 2008
Jennyffer Cruz	DEC / UQ	PhD Student brushtail possum research	1	Oct 2007 to 30 June 2008
John Asher	DEC	Principal Coordinator - Invasive Species. DEC, EMB	0.025	1 Jan 2006 to 30 June 2008
Nisha Powell / Rob Brazell / Peter Orell (western shield coordinator)	DEC	Western Shield co-ordinator. DEC, Environmental Management Branch (EMB)	0.025	1 Jan 2006 to 30 June 2008
DEC Dwellingup District wages staff	DEC / IA CRC	DEC, Dwellingup District wages staff – casual technical support		1 Jan 2006 to 30 June 2008

Table 2: Personnel formerly involved in the northern jarrah forest predator interaction and sustained fauna recovery research project

Personnel **(bolding indicates current team member)**	**Affiliation** **(reflects employer and funding source)**	**Title / Role**	**Commitment to the northern jarrah forest project (as a fraction of 1.0 FTE)**	**Period of involvement**
Anna Nowicki	DEC	DEC Science Division Technical Officer	0.5	29 Nov to 2 Mar 2008
DEC Dwellingup District wages staff	DEC / IA CRC	DEC, Dwellingup District wages staff – casual technical support		1 Jan 2006 to present
Judy Turner	DEC / IA CRC	DEC, Dwellingup District wages staff – casual technical support		June to Oct 2007
Tom Robinson	DEC / IA CRC	DEC, Dwellingup District wages staff – casual technical support		29 Oct to Dec 2007
Helen Darby	DEC / IA CRC	DEC, Science Division – casual technical support		Oct to Dec 2007
Storm Hancock	DEC / IA CRC	DEC, Science Division – casual technical support		Oct to Dec 2007
Anthea Dempster-East	DEC (Dwellingup District)	DEC, Dwellingup District staff, training and part time technical support	1.0	November 2007
Jennifer Jackson	IA CRC / DEC	DEC Science Division Technical Officer	0.8	January 2006 to June 2007
Wesley Manson	IA CRC / DEC	DEC Science Division Technical Officer	0.8	April 2006 to April 2007
Judy Dunlop	IA CRC / DEC	DEC Science Division Technical Officer	0.8	June 2006 to June 2007

Table 3: Collaborators in the northern jarrah forest predator interaction and sustained fauna recovery research project

Collaborator	Affiliation	Nature of collaboration
Oliver Berry	IA CRC / UWA	Genetic analysis of fox hair, scat samples and predator bite marks
Steve Sarre	University of Canberra	Genetic analysis of cat hair and scat samples
Kristen Warren	Murdoch	Veterinary expertise with implant surgery, wildlife health screening PhD co-supervisor – Gillian Bryant
Trish Fleming	Murdoch	PhD co-supervisor – Gillian Bryant
Ian Robertson	Murdoch	PhD co-supervisor – Gillian Bryant
Paul Eden	Murdoch / Perth Zoo	Veterinary expertise with implant surgery
Brian Green	University of Canberra	Varanid ecology expertise, providing genetic markers
Peggy Rismiller and Mr Mike McKelvey	Pelican Lagoon Research Centre, Kangaroo Island	Varanid ecology and implant surgery expertise
Michael Kearney	University of Melbourne	Mechanistic modelling of varanid, fox and cat interactions
Warren Porter	University of Wisconsin	Mechanistic modelling of varanid, fox and cat interactions
Greg Kerr	EcoLogical Associates	Reptile ectoparasite expertise
Michael Bull	Flinders University	Reptile ectoparasite expertise
Peter Spencer	Murdoch University	Varanid and possum genetics
Luke Leung	University of Queensland	PhD co-supervisor – Jennyffer Cruz
Judy Clarke	PhD candidate – Murdoch / DEC	Veterinary expertise with wildlife health screening.
Helen McCutcheon	PhD candidate – Murdoch / ARC / DEC	Veterinary expertise with wildlife health screening.
Rebecca Vaughan	Murdoch University / Perth Zoo	Veterinary expertise with implant surgery
Maria Cardoso	University of New South Wales	Chuditch population genetics
Peter Grey	Sigma Delta Technologies	Research and development of GPS micro-loggers specific for chuditch and varanids

Table 4: Volunteers in the northern jarrah forest predator interaction and sustained fauna recovery research project

Volunteer	Period of Involvement
Johnny Fogarty	6 May to 6 June 2008
Robin Scott	6 to 10 May 2008
Wayne Greer	2 and 28 May 2008
Jessica Read-Brain	11 days during May and June 2008
Susanne Orchard	28 April to 3 May 2008
Jessica Bell	28 April to 3 May 2008
Graham Zemunik	6 to 11 April 2008
Michael Collier	6 to 11 April 2008
Michael Williams	13 to 18 April 2008
Frank Williams	13 to 18 April 2008
Alice Risely	13 to 18 April 2008
Ching-Min Lee (Jimmy)	13 to 18 April 2008
Yu-Ping Huang (Apple)	13 to 18 April 2008
Tammy Hanson	10 to 15 February 2008
Ron Lockley	10 to 15 February 2008
Geoff Monk	10 to 11 February 2008
Heather Nicholson	10 to 29 February 2008
Chris Hedger	20 to 22 February 2008
Jessica Binder	20 to 21 February 2008
Lauren Strumpher	17 to 22 February 2008
Amy Llewellyn	17 to 22 February 2008
Jennifer Lam	24 to 29 February 2008
Teresa Beasley	24 to 29 February 2008
Catherine Riffard	24 to 29 February 2008
Jordan Hampton	4 to 7 and 10 to 29 February 2008
Elizabeth Lowe	25 to 30 November 2007 and 24 to 29 February 2008
Peter Dawson Bark	29 November 2007
Brian Hume	25 to 30 November 2007
Annaleise Bryant	25 to 30 November 2007
Dawn Fleming	11 to 16 November 2007
Peter Johnston	11 to 16 November 2007
Frank Marshall	11 to 16 November 2007
Albert Chandler	4 to 9 November 2007
Patricia Chandler Suzanne Rosier	4 to 9 November 2007 1 Jan 2006 to present

2 Overview and background

As part of its *Western Shield* fauna conservation and recovery program (Bailey, 1996; Burbidge *et al.*, 1996), the Department of Environment and Conservation (DEC) implements fox control over nearly 4 million hectares of Western Australia. Although fox control has been highly beneficial for many native animals, the recovery of some species has not been sustained. For example, the woylie, *Bettongia penicillata*, showed a detectable increase in abundance, as inferred from trap capture success, immediately post commencement of 1080 baiting, however, recent findings suggest it has subsequently declined in abundance (de Tores and Start, 2008).

Various hypotheses have been proposed to explain the recent faunal declines, none are universally accepted and combinations of causes are likely to occur. A likely hypothesis to contributing to these declines is that removal of foxes has led to mesopredator release of introduced and/or native predators such as feral cats, goannas, chuditch and pythons. Mesopredator release may be acting in conjunction with other causal factors. Mounting evidence shows mesopredator release can have profound effects on biodiversity (Crooks and Soulé, 1999). In the northern jarrah forest, complex networks of interactions are likely to exist between native and introduced predators. Changes in the abundance of any predator species can be expected to influence the abundance of other predators, with likely cascading effects on biodiversity (trophic cascades). For example, following fox control in the northern jarrah forest, increased predation by chuditch and feral cats limited the translocation success of western ringtail possums (de Tores *et al.*, 2005a). In a similar example in New South Wales, fox control caused the sand goanna to become the dominant predator (Olsson *et al.*, 2005). In turn, increased predation by goannas altered the abundance and diversity of prey species.

These examples support the hypothesis that there are cascading effects on shared prey species from reducing one or more predators. Such “cascades” are difficult to predict, making it important to take a whole-of-community approach. In the case of the current project, a focus on foxes and cats alone has the potential to overlook the effects of native predators, making results difficult to interpret.

The project therefore seeks to investigate the numeric and behavioural responses to fox density reduction shown by the suite of native and introduced predators. The project will also investigate the relationship between predator and prey communities, measuring prey availability, the extent of dietary overlap and the dietary response by these predators in the presence and absence of fox control. The behavioural responses to fox control will also be assessed for a predation sensitive, key native prey species, the western brushtail possum.

The northern jarrah forest mesopredator release research project commenced in January 2006, as part of a larger Western Australian Department of Environment and Conservation (DEC) and Invasive Animals Cooperative Research Centre (IA CRC) project. The larger project constitutes the DEC / IA CRC Western Australian Demonstration Site and is comprised of four subprojects (Figure 1):

Subproject 1:	Sustained introduced predator control in the rangelands
Subproject 2:	The importance of fox, cat and native predator interactions to sustained fauna recovery in the northern jarrah forest – is there a mesopredator release effect?
Subproject 3:	Woylie decline in Dryandra Woodland: Mesopredator Release?
Subproject 4:	Factors affecting fauna recovery in the wheatbelt – Lake Magenta and Dunn Rock

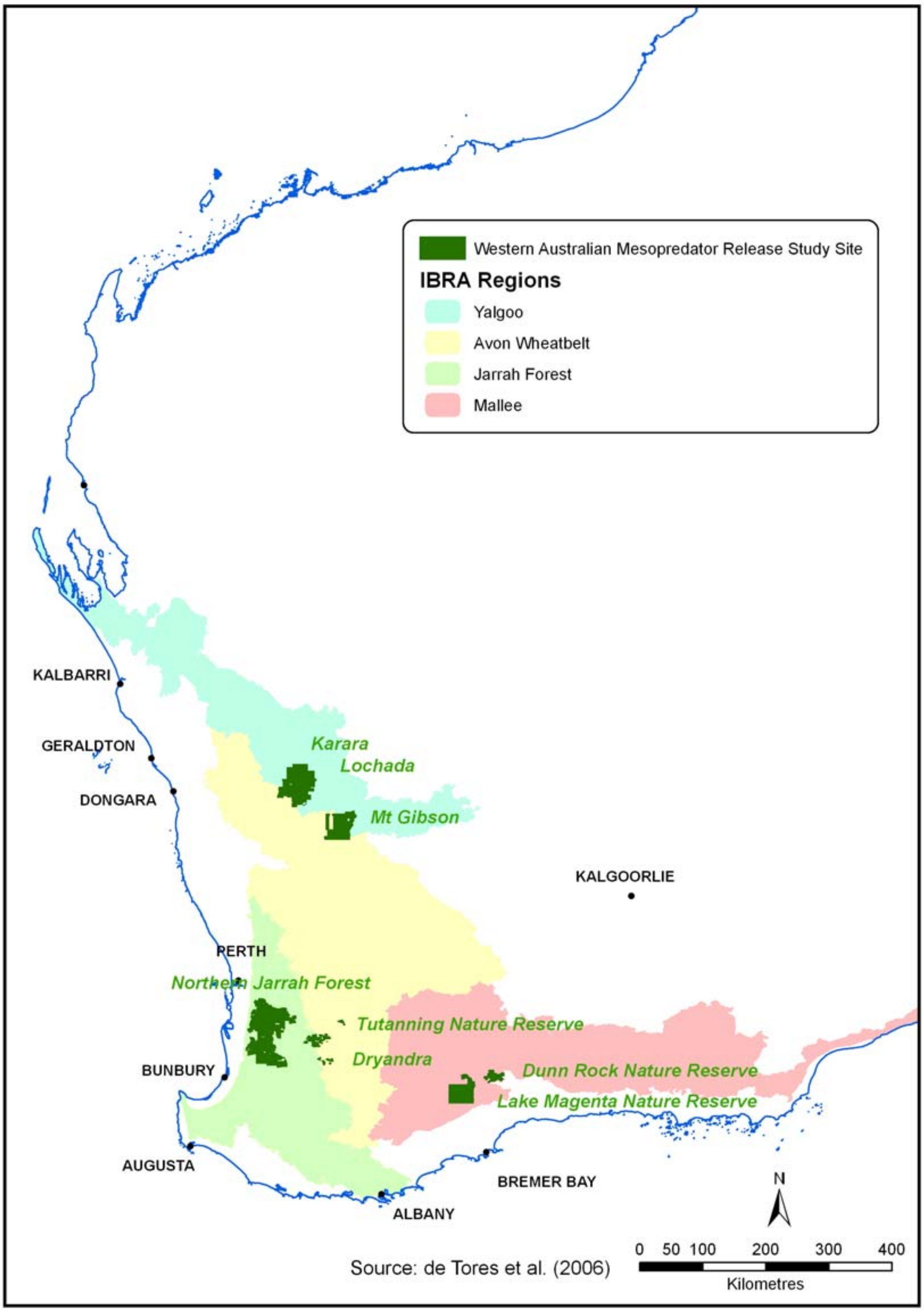

Figure 1: The four research sites (sub projects) constituting the DEC / IA CRC Western Australian Demonstration Site.

Rangelands: Mt Gibson, Karara and Lochada;
Northern Jarrah Forest;
Dryandra / Tutanning; and
Lake Magenta / Dunn Rock

Source: de Tores *et al*. (2006)

3 The northern jarrah forest predator interaction project

The northern jarrah forest subproject is supported by DEC, the IA CRC, the DEC / Alcoa Forest Enhancement program (DECAFE), Worsley Alumina, Murdoch University and the University of Queensland (UQ).

Initial funding was provided by DEC for the period 1 January 2006 to 31 December 2009. This funding was provided on the basis of the proposals submitted by de Tores *et al*. (2004) and de Tores *et al*. (2005b). Funding approval incorporated the recommendation to seek supplementary funds from other agencies including the IA CRC, the Commonwealth (through the NRM program), other stakeholders and universities.

The funding proposals presented evidence of mesopredator release from sites where translocated populations of the western ringtail possum, *Pseudocheirus occidentalis*, had been intensively monitored in the presence of fox control. Monitoring data gave strong support for the presence of a mesopredator release response by feral cats, *Felis catus*, and the south-west carpet python, *Morelia spilota imbricata*. In the presence of fox control, predation by feral cats and the south-west carpet python accounted for seven and nine predation events of radio collared western ringtail possums respectively, from a sample size of 26. There was only one mortality event attributed to fox predation over the same period (de Tores *et al.*, 2005a; de Tores *et al.*, 2005c). At the unbaited control site there were only two deaths attributed to predation, one by a raptor and one by a fox (de Tores *et al.*, 2005a; de Tores *et al.*, 2005c).

Similar, but less conclusive results were obtained from the large scale fox control study (*Operation Foxglove*) conducted in the northern jarrah forest from 1994 to 2000. Survivorship of translocated populations of the woylie, or brush-tailed bettong, *Bettongia penicillata*, showed some evidence of an increase in the number of cat predation events in treatments with an increased frequency of fox baiting (de Tores, 1999; de Tores *et al.*, in prep-a). However, survivorship analysis of translocated populations of the woylie and subsequent recruits to the population gave most support (Δ QAICc < 2) (Burnham and Anderson, 2002) to models which incorporated a covariate for winter (de Tores *et al.*, in prep-a). The analysis indicated survivorship was lower for animals released in winter (de Tores *et al.*, in prep-a) The preferred model (where survivorship was a function of the baited treatment and a covariate for winter) indicated the probability of survivorship in the 6 baitings per year treatment was 15% higher than in the treatment with the operational standard baiting regime of 4 baitings per year (de Tores *et al.*, in prep-a). The effect of winter has been hypothesised as indicating:

(i) fox baits may less effective in winter (the higher winter rainfall may increase leaching of 1080); and/or

(ii) alternative prey availability may be reduced in winter, therefore foxes are more likely to prey upon woylies; and/or

(iii) the arid adapted woylie is not well suited physiologically to the more mesic northern jarrah forest (de Tores *et al.*, in prep-a).

In recognition of the results from the woylie survivorship study, the current northern jarrah forest study (Figure 2) has implemented a baiting frequency of 6 baitings per year. Aerial baiting occurs in March, June, July, September, October and December. The temporal component of the baiting regime, with more baitings over the winter period, is also in recognition of the findings from (de Tores *et al.*, in prep-a).

Other supporting evidence for a mesopredator release response, albeit equivocal, includes:

- the lack of sustained recovery at sites where fox control has been implemented, for example the lack of recovery by quokkas, *Setonix brachyurus*, within the northern jarrah forest (Hayward *et al.*, 2003);
- the decline of the woylie over much of its range; and
- the lack of demonstrated success for several species at fauna translocation sites.

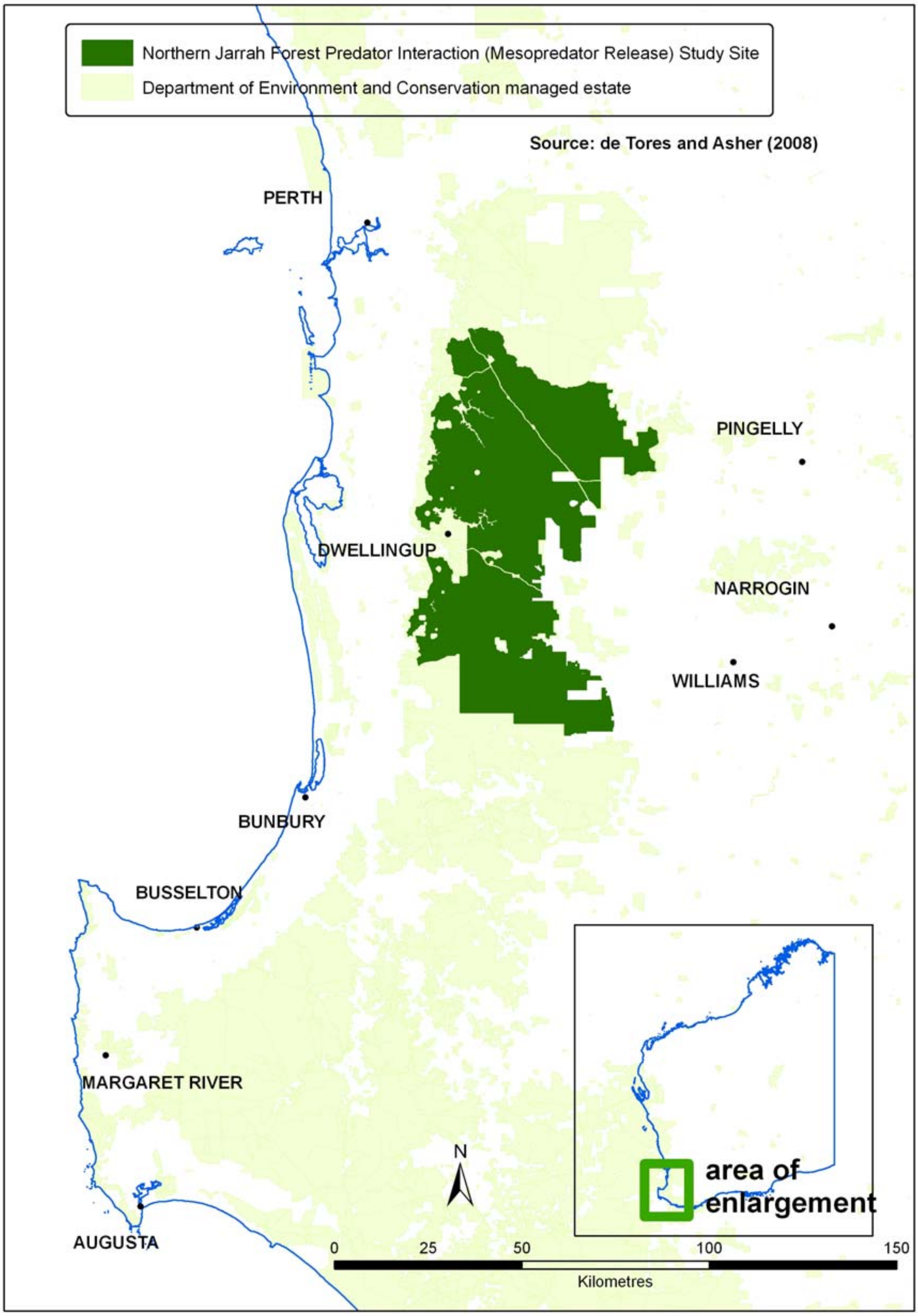

Figure 2 Location of the northern jarrah forest mesopredator release study area
Source: de Tores and Asher (2008)

4 Objectives and hypotheses

The project has adopted a multi species landscape approach to determine:

- whether fox baiting in the northern jarrah forest is effective in terms of reducing fox density; and
- if a reduction in fox density leads to an increase in the abundance of the suite of native and introduced predators (mesopredator release), and if so, what are the biodiversity implications from this.

The leading hypothesis is that effective long term 1080 baiting for fox control at the landscape scale has led to the desired reduction in fox density and has also led to a mesopredator release response by feral cats.

However, there is no *a priori* reason to expect a mesopredator release response by cats will occur in all cases where fox density reduction is achieved (de Tores and Marlow, in prep). It is further hypothesised a mesopredator release response by cats generally, if it occurs, will not be a simple linear function of the level of fox density reduction achieved, but will be a function of the level of fox density reduction achieved in combination with the density of any higher trophic level predators (for example dingoes), the environmental productivity of the site, the size of the area subject to fox density reduction, the configuration of this area (perimeter to area ratio), the continuity of the fox baiting and the availability of the prey resource (de Tores and Marlow, in prep). The availability of the prey resource may in turn be influenced by the gross productivity of the site and by the diversity of the suite of introduced and native predators (which in turn are hypothesised to show a mesopredator release response to effective fox control) (de Tores and Marlow, in prep).

Equally confounding, cats may respond to fox density reduction as a result of a release from interference competition (including intraguild predation), a release from exploitative competition, or both (de Tores and Marlow, in prep).

A suite of predictions (Table 5) has been formulated for cat survivorship, density, diet, habitat use, and temporal activity under the different potential outcomes from fox control for the scenario of cats responding to release from interference competition and responding to release from exploitative competition. A testable hypothesis has been formulated for each scenario (Table 6). However, as the outcomes are not mutually exclusive in terms of a response to interference or exploitative competition, it may not always be possible to determine if the outcome is a response to release from interference competition, from exploitative competition or both. From a management perspective, it is of no relevance, as in all cases it is a response to the same fox management regime and leads to the same outcomes in terms of implications for biodiversity conservation (de Tores and Marlow, in prep).

From a management perspective, the importance appears to be determining whether fox control has led to an increase in cat abundance. However, this may also be irrelevant, as it is the biodiversity implications (*i.e.* the flow on effects) from this increase in the number of cats present, not the absolute number *per se* (de Tores and Marlow, in prep).

If cats do show a mesopredator release response to fox control in the northern jarrah forest, this response may mask and/or prevent a response by other (native) predators, resulting in no net conservation benefit. A suite of predictions (Table 7) has also been formulated under the different hypotheses examined for different outcomes in terms of fox and cat response to 1080 baiting.

Table 5: Predicted outcomes for cat survivorship, density, diet, use of the landscape and temporal activity under the scenario whereby:
1. Cats are released from interference competition; and
2. Cats are released from exploitative competition.

↑ = increase. ↓ = decrease. ↔ = no change
(adapted from de Tores and Marlow, in prep)

Scenario	Parameter	Predicted outcome for cat density/behaviour for each given outcome for fox density		
		fox density ↓	fox density ↑	fox density ↔
1. Cats released from interference competition	Cat survivorship	↑	↔ or ↓	↔
	Cat density	↑	↔ or ↓	↔
	Cat diet	↔ or ↑	↔ or ↓	↔
	Cat use of the landscape	↑	↓ or ↔	↔
	Cat temporal activity	↑	↓ or ↔	↔
2. Cats released from exploitative competition	Cat survivorship	↑	↔ or ↓	↔
	Cat density	↑	↔ or ↓	↔
	Cat diet	↑	↔ or ↓	↔
	Cat use of the landscape	↔ or ↑ or ↓	↔ or ↓ or ↑	↔
	Cat temporal activity	↔ or ↑ or ↓	↔ or ↓ or ↑	↔

Table 6: Hypotheses, the parameters measured to test each hypothesis, how these parameters are measured and the type of mesopredator release response (release from interference competition or release from exploitative competition) which predicts these outcomes.
(adapted from de Tores and Marlow, in prep)

Hypothesis	**Parameters measured (predicted outcome)**	**Methodology for measuring this parameter.**	**Type of mesopredator release response consistent with the predicted outcome.**
In the presence of effective fox control, survivorship of cats in the northern jarrah forest will increase.	Density of foxes (fox density will be lower in treatment sites baited for fox control than in the unbaited control site)	Sandplotting to determine fox presence and derive density estimates. Use of molecular studies to determine the number of individual foxes present – e.g. genotyping from routinely collected scats and hair. Satellite and GPS telemetry to determine if foxes are being "turned over" by successive baiting events.	Interference competition and/or exploitative competition
	Survivorship of cats (survivorship will be higher in treatment sites baited for fox control)	Radio telemetry. Subject to sample size, survivorship will be determined through the known fate model from Program MARK (White, 2001)	
In the presence of effective fox control, density of cats in the northern jarrah forest will increase.	Density of foxes (fox density will be lower in treatment sites baited for fox control than in the unbaited control site)	Sandplotting to determine fox presence and derive density estimates. Use of molecular studies do determine the number of individual foxes present – e.g. genotyping f from scats and hair. Satellite and GPS telemetry to determine if foxes are being "turned over" by successive baiting events	Interference competition and/or exploitative competition
	Density of cats (cat density will be higher in treatment sites baited for fox control)	Sandplotting to determine cat presence and derive density estimates. Use of molecular studies do determine the number of individual cats present – e.g. genotyping from collected scats and hair	

Table 6 (…cont.): Hypotheses, the parameters measured to test each hypothesis, how these parameters are measured and the type of mesopredator release response (release from interference competition or release from exploitative competition) which predicts these outcomes. (adapted from de Tores and Marlow, in prep)

Hypothesis	**Parameters measured (predicted outcome)**	**Methodology for measuring this parameter.**	**Type of mesopredator release response consistent with the predicted outcome.**
In the presence of effective fox control, the dietary intake of cats in the northern jarrah forest will change to include dietary items from which cats were previously excluded.	Density of foxes (fox density will be lower in treatment sites baited for fox control than in the unbaited control site)	Sandplotting to determine fox presence and derive density estimates. Use of molecular studies to determine the number of individual foxes present – e.g. genotyping from routinely collected scats and hair. Satellite and GPS telemetry to determine if foxes are being "turned over" by successive baiting events.	Primarily exploitative competition. However, release from interference competition may also result in cats foraging more widely and/or over a greater and/or different period of time daily.
	Prey availability (The suite of prey available will be determined and the density of each prey species or density of the guild of similar prey species will be derived. This availability will reflect the biophysical resources present)	Surveys to determine the suite of potential prey items available and estimates of density for each prey species or guild of similar prey species. Trapping webs will be used to ensure estimates of density can be derived for sparse data.	
	Dietary intake of foxes (dietary items consumed by foxes will be proportionally represented relative to availability at unbaited and baited treatment sites)	Dietary analyses of collected fox scats	
	Dietary intake of cats (dietary items consumed by foxes will be less well represented in the diet of cats at sites unbaited for fox control, and proportionally represented relative to availability at fox baited treatment sites)	Dietary analyses of collected cat scats	

Table 6 (…cont.): Hypotheses, the parameters measured to test each hypothesis, how these parameters are measured and the type of mesopredator release response (release from interference competition or release from exploitative competition) which predicts these outcomes.
(adapted from de Tores and Marlow, in prep)

Hypothesis	**Parameters measured (predicted outcome)**	**Methodology for measuring this parameter.**	**Type of mesopredator release response consistent with the predicted outcome.**
In the presence of effective fox control, spatial use of the northern jarrah forest landscape by cats will change. A greater range of major vegetation structural types and/or a greater proportion of open vegetation structural types will be used.	Density of foxes (fox density will be lower in treatment sites baited for fox control than in the unbaited control)	Sandplotting to determine fox presence and derive density estimates. Use of molecular studies to determine the number of individual foxes present – e.g. genotyping from routinely collected scats and hair. Satellite and GPS telemetry to determine if foxes are being "turned over" by successive baiting events.	Primarily interference competition. However, release from exploitative competition may also result in cats changing their spatial pattern of use of the landscape to forage more widely. Conversely, by releasing cats from exploitative competition by reducing competition for the prey resource, cats may forage less widely as the food resource becomes more readily available.
	Habitat use / use of the landscape by foxes (the structural vegetation types used by foxes will be identified and will be comparable, in terms of proportion of home range and availability, between the unbaited control site and baited treatment sites)	Satellite telemetry, aerial photograph interpretation to delineate major vegetation structural units and home range analysis (Kenward *et al.*, 2003)	
	Habitat use / use of the landscape by cats (structural vegetation types which cats are not using, or appear to show avoidance of, in the unbaited control site will be used / used more, in terms of proportion of home range and availability, by cats in the treatment sites baited for fox control)	Satellite telemetry, aerial photograph interpretation to delineate major vegetation structural units and home range analysis (Kenward *et al.*, 2003)	

Table 6 (…cont.): Hypotheses, the parameters measured to test each hypothesis, how these parameters are measured and the type of mesopredator release response (release from interference competition or release from exploitative competition) which predicts these outcomes.
(adapted from de Tores and Marlow, in prep)

Hypothesis	**Parameters measured** **(predicted outcome)**	**Methodology for measuring this parameter.**	**Type of mesopredator release response consistent with the predicted outcome.**
In the presence of effective fox control, temporal use of the northern jarrah forest landscape by cats will change.	Density of foxes (fox density will be lower in treatment sites baited for fox control than in the unbaited control)	Sandplotting to determine fox presence and derive density estimates. Use of molecular studies to determine the number of individual foxes present – e.g. genotyping from routinely collected scats and hair. Satellite and GPS telemetry to determine if foxes are being "turned over" by successive baiting events.	Primarily interference competition. However release from exploitative competition may also result in cats changing their temporal pattern of use of the landscape to forage over a greater period of time. Conversely, by releasing cats from exploitative competition by reducing competition for the prey resource, cats may need to spend less time foraging as the food resource becomes more readily available.
	Temporal use of the landscape by foxes (the temporal use of the landscape by foxes will be identified and will be comparable between the unbaited control site and baited treatment sites)	Satellite telemetry and temporal use of home range (Kenward *et al.*, 2003)	
	Temporal use of the landscape by cats (temporal use of the landscape by cats will change – time periods where foxes are most active within the unbaited control will correspond to periods of less activity by cats. This pattern will not be evident, or will be less evident, in treatment sites baited for fox control)		

Table 7: Prediction table relating expected observations for hypotheses under the alternative outcomes of introduced predator management.

↑ = increase. ↓ = decrease. ↔ = no change

		Effect of baiting treatment on abundance of introduced predators			
Hypothesis	Parameter	Foxes ↓ Cats ↔	Foxes ↓ Cats ↑	Foxes ↓Cats ↓	Foxes ↔ Cats ↔ (or no mesopredator release)
Removal of introduced predators releases mesopredator from interference competition	Mesopredator survival	↑	↑ / ↔ / ↓	↑↑	↔
	Mesopredator density	↑	↑ / ↔ / ↓	↑↑	↔
	Mesopredator fecundity	↑	↑ / ↔ / ↓	↑↑	↔
	Mesopredator diet	↔	↔	↔	↔
	Mesopredator habitat use	Mesopredators avoid direct encounters with introduced predators	Mesopredators avoid direct encounters with introduced predators	Mesopredators avoid direct encounters with introduced predators	Mesopredators avoid direct encounters with introduced predators
	Mesopredator temporal activity	↑ diel, seasonal and thermal	↑ / ↔ / ↓	↑ diel, seasonal and thermal	↔
	Ambush posturing	↑	↑ / ↔ / ↓	↑↑	↔
Removal of introduced predators releases mesopredator from exploitation competition	Mesopredator survival	↑	↑ / ↔ / ↓	↑↑	↔
	Mesopredator density	↑	↑ / ↔ / ↓	↑↑	↔
	Mesopredator fecundity	↑	↑ / ↔ / ↓	↑↑	↔
	Mesopredator diet	Mesopredators in baited areas consume more prey normally favoured by foxes	Mesopredators in baited areas consume more prey normally favoured by foxes and less prey normally favoured by cats	Mesopredators in baited areas consume more prey normally favoured by foxes and cats	Mesopredator diet does not differ between baited and unbaited areas
	Mesopredator habitat use	↔	↔	↔	↔
	Mesopredator temporal activity	↑ diel, seasonal and thermal	↑ / ↔ / ↓	↑ diel, seasonal and thermal	↔
	Ambush posturing	↔	↔	↔	↔
Baiting releases vulnerable prey from predation	Prey survival	↑	↑ / ↔ / ↓	↑↑	↔
	Prey density	↑	↑ / ↔ / ↓	↑↑	↔
	Prey habitat use	Prey use more open habitat	↔ / prey use more open habitat	Prey use more open habitat	↔
	Den swapping	↓	↑ / ↔ / ↓	↓↓	↔
	Distance to refuge	↑	↑ / ↔ / ↓	↑↑	↔
Mesopredator release intensifies predation	Mesopredator density	↑	↑	↑	↔
	Prey survival	↓	↓	↓	↔
	Prey density	↓	↓	↓	↔
	Den swapping	↑	↑	↑	↔
	Distance to refuge	↓	↓	↓	↔

5 Methodology

5.1 *The baiting treatments – spatial and temporal design*

Three treatment zones have been established to compare the impact of introduced predator management within the northern jarrah forest. The treatments are a northern and southern zone, each baited with DEC's 1080 sausage meat bait, Probait, at a frequency of 6 times per year at a baiting intensity of 5 baits/km^2. The northern baited zone is 172,109 ha and the southern baited zone is 120,690 ha. There is an unbaited control of 63,061 ha. (Figure 3). Each aerial baiting event is accompanied by hand baiting (vehicle based delivery of baits) at the perimeter of the baited treatments.

The project has two temporal phases. The first phase is the period January 2006 to December 2008, where emphasis is on determining whether a mesopredator release response has resulted from long term fox control. This response is being assessed for a suite of predators, specifically, the feral cat, chuditch, two species of varanid and the south-west carpet python. The response by the suite of resident prey species is also being monitored to assess if there is evidence of trophic cascades resulting from long term fox control and the biodiversity implications of these cascades, if they exist.

The second phase is scheduled for the period January to December 2009. Subject to determining if the feral cat has shown a mesopredator release response, and the outcome of trials to assess the suitability and non-target risks of DEC's feral cat bait (Eradicat), phase two will implement an integrated introduced predator baiting program in the northern baited zone. The integrated baiting program will target foxes and cats through use of Eradicat with the toxin para-aminopropiophenone (PAPP). The impact of the integrated fox and cat baiting program will then be monitored to assess the response by the above suite of predators.

In the event the feral cat has shown a mesopredator release response and DEC's Eradicat is considered unsuitable for use in the northern jarrah forest (possibly as a result of non-target issues and/or an insufficient knock-down of feral cats), a fallback position has been prepared whereby the existing fox baiting within the northern zone will halt. The fallback position is proposed to assess whether an increase in cat abundance in the presence of fox control outweighs the conservation benefits from fox control. The fallback position is subject to DEC's Animal Ethics Committee approval and agreement from all stakeholders.

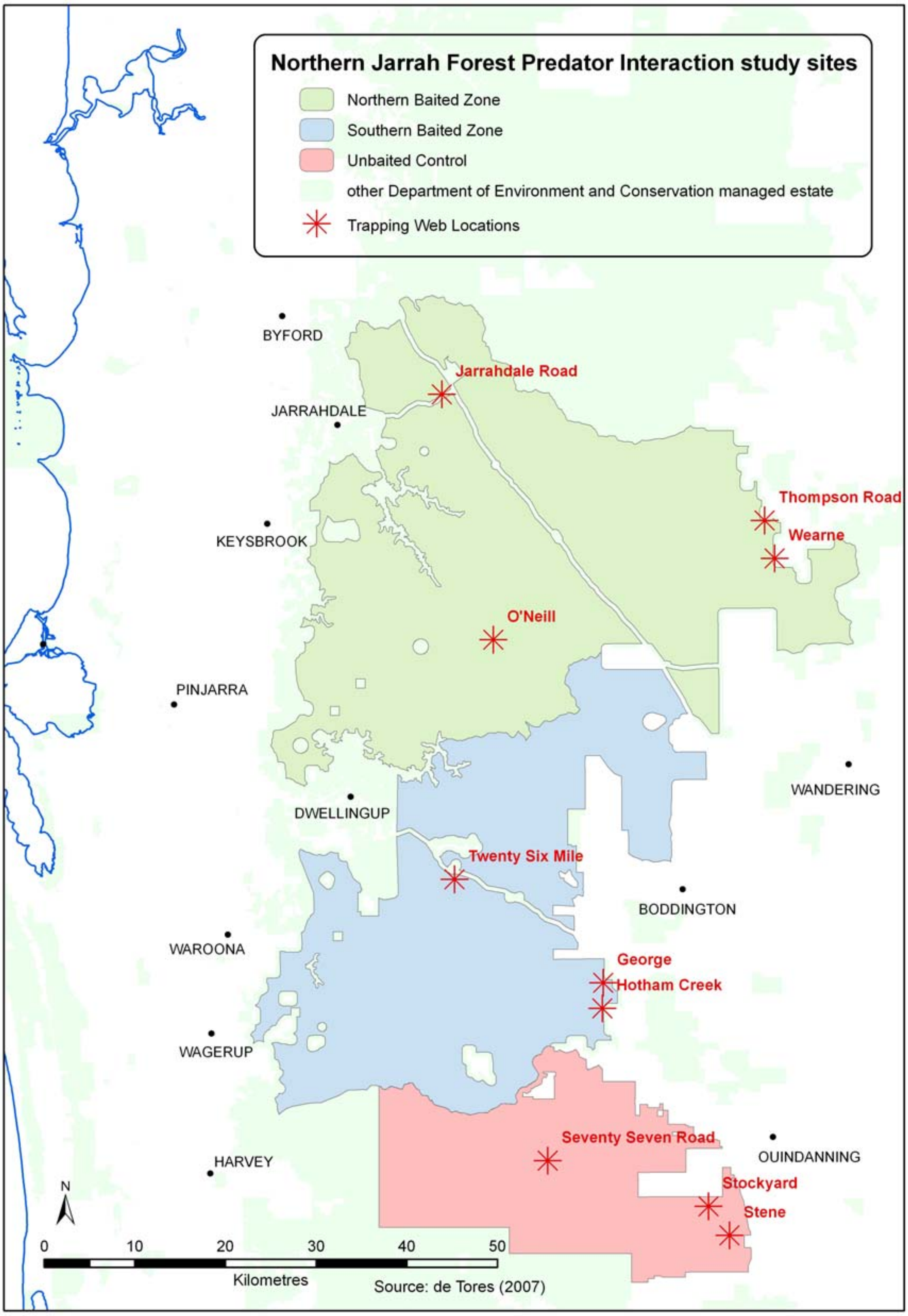

Figure 3: The baited treatment areas, unbaited control and trapping web locations within the northern jarrah forest mesopredator release study area

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

There are now sufficient data (for example Burrows and Liddelow, 1998; Burrows *et al.*, 2003; de Tores *et al.*, 2005a; de Tores *et al.*, 2005c) to suggest there is a need to quantify the effects from feral cats in Western Australia and to implement cat control measures. Preliminary work identifying the uptake of Eradicat sausage bait by non target native fauna (mainly mammals) has been undertaken. Recently the feral cat bait has been modified to include a plastic pellet that will ultimately contain the toxin used - 1080 or PAPP. This pellet is also designed to increase target specificity as other animals are known to eject "pellet like" foreign objects such as ball bearings before swallowing the sausage bait. A trial using non-toxic Eradicat baits with a plastic pellet containing the biomarker Rhodamine B is proposed to assess the non target uptake of Eradicat. The testing is also assessing this new methodology (the Eradicat bait containing an encapsulated toxin) as an alternative for delivery of existing and alternative toxins.

Rhodamine B is a systemic dye used to identify animals which have ingested the medium containing the dye (Fisher, 1998; Fisher *et al.*, 1999). The dye enters the bloodstream and is then incorporated into growing tissue. Rhodamine B has been used as a systemic dye to assess uptake (of various media, usually a bait) in several mammalian species. The dye rapidly accumulates in vibrissae (whiskers) of mammals. At approximately three weeks post consumption of the marker (dye), the whiskers are removed and the accumulated dye can be detected (Fisher, 1998). Examination of whiskers of non-target animals will therefore determine if these non-target species are at risk of consuming toxic baits, irrespective of the toxin, provided ultimate delivery is via a capsule contained within the Eradicat bait.

As reptiles do not possess hairs, this method is unsuitable for the varanids within the northern jarrah forest considered potentially at risk from the PAPP toxin. Assessment of bait uptake by varanids will involve: (1) a small captive trial involving monitor lizards to determine a sampling technique that reliably detects Rhodamine B in lizards that have consumed a capsule containing the marker; and (2) to then use this technique for monitor lizards captured in the field.

Specific sites for the trial conducted by the northern jarrah forest research team are the George and Hotham Creek trapping webs (Figure 3) and/or coastal translocation release site(s) for the western ringtail possum (Leschenault Peninsula Conservation Park and Yalgorup National Park). The sites will ensure a range of non-target species are exposed to the non-toxic bait. Trials are scheduled for Spring 2008 to Spring/Summer 2008/2009. If there are no non-target species at risk, or there is an acceptable risk to non-target species, toxic baits will be deployed at a local scale at coastal sites and at a landscape scale in the northern baited zone of the northern jarrah forest in 2009.

5.3 *Indices of Activity and estimates of density - sandplots*

5.3.1 *Fox and cat indices and density estimates*

Indices of fox and, to a lesser extent, cat activity have been widely used to infer levels of abundance. These indices are derived from monitoring the activity of each species, as determined by the presence of spoor on passive sandplots (Allen *et al.*, 1996; Engeman, 2005). The technique is accepted in the scientific literature, however, as there is no *a priori* rationale to assume activity is related to density/abundance, the reliance on an index of activity to infer abundance or density requires validation. Estimates of fox density derived from monitoring fox activity at 1m x 1m active sandplots, *i.e.* sandplots where a lure or reward is provided, has been validated in the northern jarrah forest, (de Tores *et al.*, in prep-b). However, the technique (the Foxglove Estimate of Density technique, or FED) was considered less sensitive to detection of cat presence (de Tores *et al.*, in prep-b).

Initial sandplot trials in the current northern jarrah forest project in 2006-2007 supported the assertion (de Tores *et al.*, in prep-b) that 1m x 1m active sandplots are less effective in detection of cat presence than they are at detecting fox presence. Trials have subsequently assessed combinations of active and passive plots and different types of active plots, including active 1m X 1m plots, as used in the FED technique, and plots which span the width of the road. A description of the sandplots methodologies trialled is given in Table 8.

Table 8: The history of sandplot establishment, trials and monitoring to assess techniques and derive indices to fox and cat activity and/or estimates of fox density within the northern jarrah forest fox/cat interaction study.

Session number	**Sandplotting session**	**Description**	**Sandplotting Network and Treatment**						
			Northern Baited Zone			**Southern Baited Zone**		**Unbaited control**	
			Jarrahdale Road	**Wearne / Thompson Road**	**O'Neill**	**26 Mile Road**	**George / Hotham Creek**	**77 Road**	**Stene / Stockyard**
0	Preliminary trials 2006 - 2007	Active sandplots (lure provided) 1m x 1m, set at roadside.							
1	Pre September 2007 baiting	25 passive plots 1m wide, across the width of road monitored for 6 consecutive days 25 active plots (lure provided) 1m x 1m monitored for 6 consecutive days Days 1-6 for active sandplot monitoring corresponded with days 1-6 of passive sandplot monitoring	not established	completed	completed	completed	completed	not established	completed
2	Post September 2007 baiting	25 passive plots 1m wide, across width of road monitored for 6 consecutive days 25 active plots (lure provided) 1m x 1m monitored for 6 consecutive days Days 1-6 for active sandplot monitoring corresponded with days 1-6 of passive sandplot monitoring	not established	completed	completed	completed	completed	completed	completed
3	Pre December 2007 baiting	25 passive plots 1m wide, across the width of the road, monitored for 9 consecutive days.. 25 active plots (lure provided) 1m x 1m, monitored for 6 consecutive days Days 1-6 for monitoring of active plots corresponded with days 4-9 of passive plots, *i.e.* passive plots were monitored for three days prior to setting active plots (see text).	completed	completed	completed	completed	completed	completed	completed
4	Post December 2007 baiting	December 2007 scheduled aerial delivery of all Western Shield and research baiting programs did not proceed. No sandplotting session.							
5	Pre March 2008 baiting	25 passive plots 1m wide, across the width of road at all networks. All were monitored for 6 consecutive days. At Stene / Stockyard, six of the 25 plots trialled use of hair collection devices. Each hair collection device provided a lure and each is therefore considered to bean active plot. Each of these six plots offered two hair collection devices (one at each end of the plot) - The "Sticky Wicket" and the "Poly Pipe". All were monitored for 6 consecutive days.	completed	completed	completed	completed	completed	completed	completed

Table 8 (cont. …): History of sandplot establishment, trials and monitoring to assess techniques and derive indices to fox and cat activity and/or estimates of fox density within the northern jarrah forest, fox/cat interaction study.

Session number	**Sandplotting session**	**Description**	**Sandplotting Network and Treatment**						
			Northern Baited Zone			**Southern Baited Zone**		**Unbaited control**	
			Jarrahdale Road	**Wearne / Thompson Road**	**O'Neill**	**26 Mile Road**	**George / Hotham Creek**	**77 Road**	**Stene / Stockyard**
6	Pre June 2008 baiting	25 passive plots 1m wide, across the width of road at all networks. At each network, 13 plots were passive and 12 were active. Each Active plot had two hair collecting devices, one at each end – the "Sticky Wicket" and "Poly Pipe". Each "Poly Pipe" device provided a lure (rabbit meat) and each "Sticky Wicket" provided a FAP and an olfactory lure (Pongo). All were monitored for 6 consecutive days.	completed	completed	completed	completed	completed	completed	completed

The methodology adopted and to be held constant until the end of the study for the northern jarrah forest program is as described for the sandplotting session pre the March 2008 baiting (sandplotting Session 5) and has adapted use of the FED technique to incorporate larger passive sandplots, more sensitive to detection of cat presence. Seven sandplot networks have been established within the study area. Each network utilises the existing roading system and each network has 25 sandplots, all within a nominal area no greater than 25 km^2. The exact area required to capture all 25 sandplots within each sandplot network is determined by calculating the minimum convex polygon (MCP) which encompasses all sandplots (Ranges6 software) (Kenward *et al.*, 2003). A 500m buffer (ESRI, 1999-2004) is added to the Ranges determined MCP to estimate the final area capturing all 25 sandplots within each grid/web network (de Tores *et al.*, in prep-b). The area covered by each sandplot network is shown in Table 9.

Each sandplot is approximately 1m wide and spans the width of the road, with each individual sandplot no closer than 500m from its nearest neighbouring sandplot. A combination of alternating active and passive sandplots is used, with 12 active and 13 passive plots within each network. Active plots have a lure/reward placed at each end of the sandplot. The reward is incorporated into hair collection devices – the “Sticky Wicket” device (Algar, 2008) and the “Poly Pipe” device – both based on use of double sided tape to collect hair which is retained for subsequent molecular analyses. There is one “Sticky Wicket” and one “Poly Pipe” device at opposite ends of each active sandplot, see Algar (2008) for description of the “Sticky Wicket” and Section 6.4 of this report for description of the “Poly Pipe”. An auditory lure, a Felid Attracting Phonic (FAP), and an olfactory lure, “pongo” (pureed cat faeces) is placed near each Sticky Wicket hair collecting device.

Fox and cat activity is monitored by detection of spoor and other evidence of presence at each sandplot for 6 consecutive days. Data are analysed in two ways:

(i) ***through use of the Allen / Engeman Index of Activity (Engeman, 2005):*** a cumulative mean is derived for the number of plots which show evidence of fox and cat activity – indices of activity are derived separately for foxes and cats for each sandplot network; and

(ii) ***through use of a modified version of the FED technique:*** evidence of fox or cat spoor is interpreted as indicating presence of one individual fox or cat. Where neighbouring sandplots show evidence of fox or cat activity, this is interpreted as indicating the presence of the same fox or cat at those plots. A break in continuity, with two or more sandplots showing no activity, followed by sandplots with activity, is interpreted as indicating the presence of a different individual fox or cat. Interpreting continuity, or lack of continuity, also relies on the history of activity of preceding days. The cumulative mean number of foxes and cats is estimated daily. Fox and cat density is then estimated for each sandplot network by dividing the cumulative mean number of foxes at day 6 by the area derived from the MCP, inclusive of the 500m buffer (de Tores *et al.*, in prep-b).

Results from molecular analyses (genotyping from hair and scats) will be used to test the validity and assumptions of each method (see Section 5.4).

The sandplot networks have been established within each treatment to assess fox and cat activity at locations where trapping webs (below) have been established. Spatial arrangement is such to ensure independence of each sandplot network.

Monitoring at each sandplot network is carried out four times per year, with monitoring immediately prior to aerial delivery of 1080 baits. Each network of sandplots is also monitored once annually (*i.e.* a fifth time annually), post 1080 baiting, to derive an annual “before-and-after-baiting” index of activity and estimate of density.

Table 9: Sandplot networks established to derive indices of activity and estimates of density for foxes and cats within the northern jarrah forest fox/cat interaction study.

Treatment	**Sandplot network**	**Area (Km^2)**
Northern Baited Zone	Jarrahdale Road	16.53
	O'Neill	16.53
	Wearne / Thompson Road	20.30
Southern Baited Zone	26 Mile Road	16.83
	George / Hotham Creek	22.97
Unbaited Control	Stene / Stockyard	20.86
	77 Road	25.32

5.3.2 Indices of activity for varanids and chuditch

The extent of activity on monitored sandplots is also used to derive an index of activity for varanids and chuditch. There is no mechanism for differentiation between activity by *Varanus gouldii* and *V. rosenbergi* and there has been no validation of indices of activity on sandplots to infer density or abundance estimates for varanids or chuditch. However, the technique can be compared to trapping data for both groups and the value of sandplotting to derive density/abundance estimates can be assessed. Subject to the outcomes from these analyses, the technique may provide an alternative, non invasive technique to trapping.

Sandplotting to derive estimates of chuditch abundance/density would enable these estimates to be derived when chuditch are unable to be trapped, *i.e.* when females are lactating and prior to young being able to independently thermo regulate.

5.4 Molecular analyses

5.4.1 Epithelial scrapings from predator scats

Predator scats are collected routinely five times per year, coinciding with sandplot monitoring, and opportunistically when trapping for foxes and cats. Epithelial scrapings are taken from each predator scat collected and stored in Di Methyl Sulphoxide (DMSO) in a saturated salt solution. The rest of the scat is retained (stored frozen) for subsequent dietary analysis. DNA recovered from scrapings is used to identify the predator responsible for leaving the scat. DNA recovered from epithelial scrapings is also used to genotype foxes and cats – identifying individuals.

5.4.2 Hair traps

A suite of collection devices have been trialled for collection of fox and cat hair. DNA recovered from hair is used to identify individual foxes and cats.

5.5 Fox and cat dietary analysis

All collected scats identified as fox or cat scats are stored for dietary analysis. Identification of dietary items within each scat is outsourced. Data are then used to assess fox and cat dietary overlap, seasonal patterns in diet and, in conjunction with trapping data to assess prey availability, patterns in prey selection/preference.

5.6 Fox and cat use of the landscape – trapping and satellite telemetry

Fox and cat trapping occurs immediately post each of the four major sandplot monitoring sessions. Areas where foxes and cats have been detected on sandplots are targeted for trapping. Trapping uses Victor Softcatch (size 1.5) padded leg-hold traps and large wire cage traps (quokka traps). Standard morphometric data are collected for both species and tissue samples are collected for inclusion in the IA CRC fox and cat genetic studies.

All trapped foxes and cats are anaesthetised (Isoflurane gas anaesthesia) when morphometric data and tissue samples are collected. Attempts are made to collect faecal material when animals are under anaesthesia. Collected scats are used to supplement the dietary studies.

A small subset of trapped foxes from the baited treatment(s) is radio-collared with a GPS collar to assess the spatial and temporal pattern of movement at a local scale. The remaining trapped foxes and all trapped cats are radio-collared with Sirtrack satellite (Argos) collars incorporating contact/proximity circuitry. Satellite radio-telemetry monitoring is assessing home range, home range overlap and broadscale use of the landscape. Monitoring will also assess turnover of each species and therefore determine the effectiveness of Probait and Eradicat. Satellite transmitters have been duty cycled to collect diurnal and nocturnal location records. Home range analysis is through use of the software Ranges 6 (Kenward *et al.*, 2003). The sample size will be determined by capture success.

5.7 Native predators

5.7.1 Chuditch density estimates, survivorship and habitat use

The population dynamics of chuditch are being investigated via a capture-mark-recapture study. Chuditch are being trapped within an area of 10-15 km^2 using an extended trapping web (**Error! Reference source not found.**) at seven sites across the three baiting treatments. The extended trapping webs consist of wire cage traps set at intervals of 200 m near the sides of bush tracks, and baited with chicken wings. Trapping is conducted seasonally across five consecutive days. This trapping procedure is also effective for goannas, thus delivering data for both postdoctoral projects. Densities and survival rates of chuditch are being compared between the baited and unbaited treatments. Chuditch density is being estimated from spatially explicit capture data using simulation and inverse prediction in Program DENSITY (Efford, 2007).

Movements and habitat use are being studied using GPS collars, as well as spool-and-line tracking. Detailed data on home range and microhabitat use will be compared between different baiting treatments. Using satellite-collar data from foxes and cats, patterns of avoidance between chuditch and introduced predators will be investigated.

Diet is being studied by analysis of scats collected from trapped animals and targeted searches along roads. Chuditch diet, and dietary overlap with cats and foxes, will be compared between the baited and unbaited treatments. Scats will be sent to a specialist for analysis.

5.7.2 Varanid density estimates, survivorship and habitat use

To monitor the response of varanids to predator control, a total of seven sites have been selected across treatment zones which coincide with that of chuditch. At each site varanids are being captured by trapping in the extended trapping web (Figure 4) as well as opportunistic capturing with a rod-and-noose device. Densities and survival rates are being compared between baited and unbaited treatments. Analysis of trapping data will be conducted using Program DENSITY (Efford, 2007) if sufficient recaptures are recorded within trips, otherwise adjusted trap success (Caughley, 1977) will be used.

Captured individuals are identified to species, morphometric measurements are taken, weighed, marked with a PIT tag and external mark, a tissue sample is taken for genetic analysis, and ectoparasites are recorded. The sex of individual varanids is to be confirmed with genetics. The population genetic structure and potential stress/health level of varanids within each site is being compared using this information.

Collected genetic samples will be analysed using microsatellite markers to identify individuals. Extraction, optimisation and analysis is to be conducted in collaboration with Dr Peter Spencer at Murdoch University. An honours project is being developed for 2009 to carry this out.

The diet of varanids is being studied by collecting scats from live captured individuals and by collecting stomach contents from either road-killed varanids or flushed from some live-captured individuals. The diet of each species and the overlap in diet between varanids and introduced predators will be compared between the baited and unbaited treatments.

Temporal activity at the baited and unbaited sites is being compared using trap timers fitted to half of all traps to indicate the time the animal was trapped. The distribution of activity times for each trapped species at each site is being compared. Additional trap timers are being developed.

Fine and broad scale habitat use are being monitored by conventional radiotelemetry and custom developed GPS loggers across the zones to compare home range size, intra- and inter-species overlap, population survival, activity and thermal behaviour. Furthermore, some individuals are fitted with a spool-and-line device to measure differences in microhabitat use between sites.

The theoretical likelihood for, and extent of, exploitation and interference competition between the two varanid species, introduced foxes and feral cats is being estimated using a modelling approach. Data on morphology, physiology, field thermal activity and environmental conditions are used to model the energy requirements (both environmental and dietary) as well as predict the spatial and temporal activity potential of each species. The extent and nature of niche overlap between species can then be compared. Data is being derived from this study as well as other published studies.

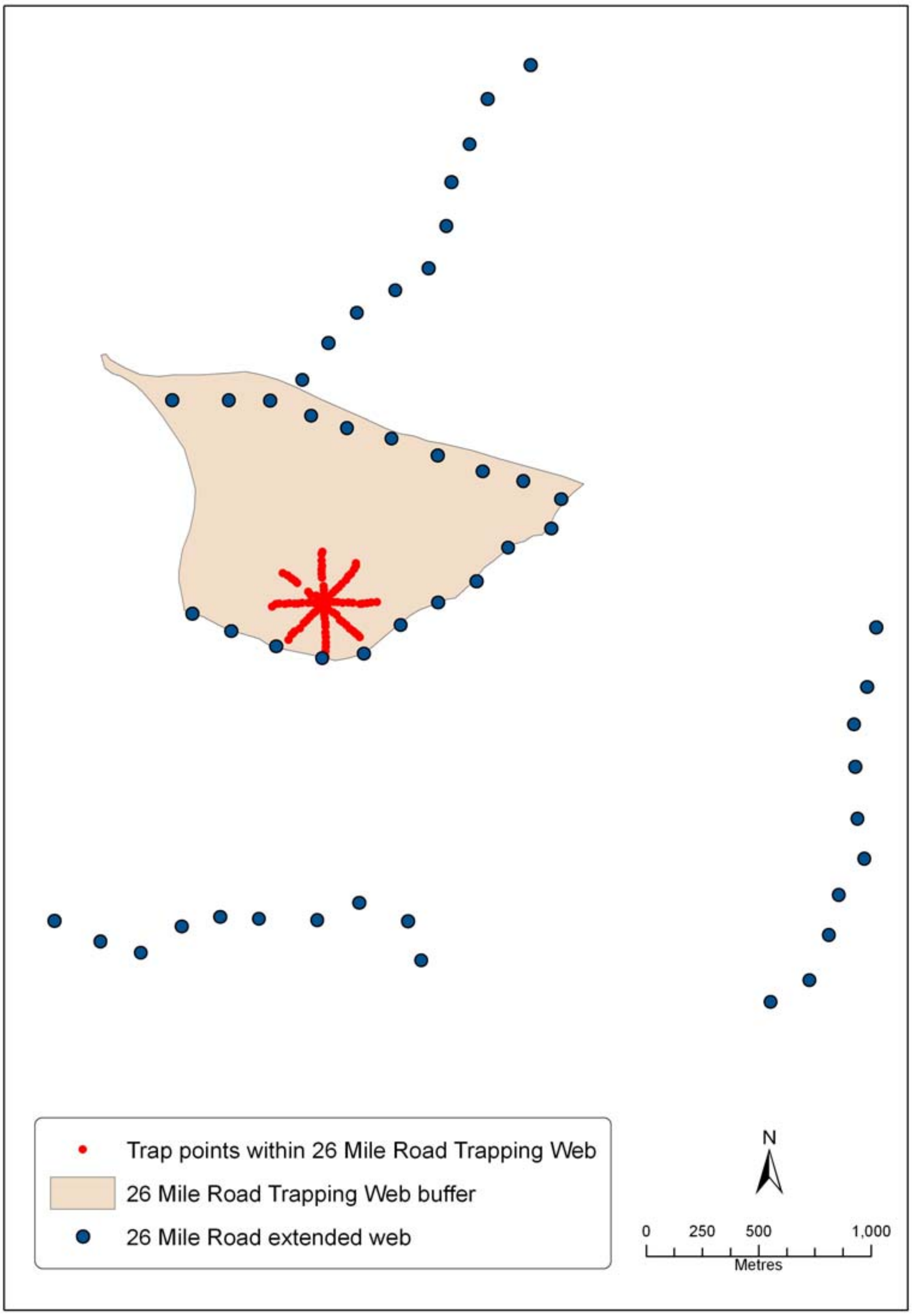

Figure 4 Trapping web layout at 26 Mile Road web, showing the inner trapping web, buffer zone and outer trapping area.

The inner web (red) is used for assessing abundance and density of small ground dwelling mammals and reptiles through program MARK and/or DISTANCE, the trapping web buffer (see text) and the outer web trap points (blue) used for assessing abundance and density of species with larger home range, i.e. chuditch, both species of varanid and the western brushtail possum.

5.7.3 Python survivorship, behaviour, habitat use and health

Background and hypotheses

The response of the south-west carpet python, *Morelia spilota imbricata*, to long term fox control is being undertaken in collaboration with an existing research project which is assessing the importance of python predation to translocation outcomes for the western ringtail possum, *Pseudocheirus occidentalis*. The western ringtail possum translocation sites are at coastal locations at Leschenault Peninsula Conservation Park and Yalgorup National Park, approximately 90km and 60km respectively, east of the northern jarrah forest. The DEC and IA CRC research in the northern jarrah forest provided the opportunity for collaboration with the existing python research program to determine whether pythons demonstrate a mesopredator release response to long term baiting in the jarrah forest, and specifically, the opportunity to determine whether pythons have responded in the same manner at small coastal reserves baited for fox control and within the large baited area of the northern jarrah forest. The collaboration also brought veterinary expertise from Murdoch University staff to the northern jarrah forest project.

Morelia spilota imbricata is an elusive, crepuscular, ambush predator. Pythons can not be lured to a site, and therefore, conventional survey methods to assess abundance and density, or derive indices to density are not applicable. Indirect measurements of python population health will be used to detect evidence of a mesopredator release response.

The indirect measurements include behaviour, diet, body weight index, survivorship, and reproductive success/activity. Hypotheses being tested are:

- in the presence of fox control, python behaviour will change as a result of reduced interference competition. Pythons will spend more time in ambush position (prey striking position) and there will be an increase in exposed basking locations;
- in the presence of fox control, a wider range of prey species will be available for pythons; and
- in the presence of fox control, survivorship and hatching success will be increased.

Capture of pythons, implanting of radio-telemetry transmitters and radio-telemetry monitoring

Capture of pythons to establish the monitored sample has been through opportunistic capture and through detection of predation events of radio-collared prey species (*i.e.* radio collared western ringtail possums found to be preyed upon by pythons). Captured pythons are surgically implanted with a temperature sensitive transmitter (the pulse rate of the transmitters varies and is determined by the body temperature of the python). Implanting is as per the DEC standard operating procedures which have been progressively refined as a result of the current python research. All implanted pythons are held at the Dwellingup Research Centre in purpose built enclosures. Pythons are held for up to two weeks post implantation. Release is at the point of capture. Radio-telemetry monitoring is conducted on a weekly basis.

Home range is derived using the Harmonic Mean estimation (Dixon and Chapman, 1980) in Ranges 6 software (Kenward *et al.*, 2003). Home range overlap is also calculated in Ranges 6 (Kenward *et al.*, 2003).

Dietary analysis is through periodic collection of faecal material purged from radio-tagged individuals. Dietary items are compared with prey availability from the web trapping data (see below) and the extent of dietary overlap with cats and foxes will be determined.

5.8 Availability of prey species – trapping webs

The availability of prey species is assessed through seasonal capture-mark-release trapping for five consecutive days at each of ten trapping webs established within the study area (Figure 3). Trapping webs have been established to enable analysis of sparse data (Buckland *et al.*, 2005; Lukacs *et al.*, 2005). Each web is approximately 18ha. Each of the ten trapping webs is comprised of 96 wire cage (Sheffield) traps, 96 Elliott traps and 48 pitfall traps. Trap spacing is at 20m, except for the first interval which is 10m (Lukacs *et al.*, 2005) (Figure 5).

Each of the ten trapping webs was established within a buffer zone, quarantined from the operational activities of harvesting and burning (Figure 3). However, the extended webs used for trapping chuditch, varanids and brushtail possums includes areas outside the buffer zone (Figure 4).

The method for analysis of data from the inner trapping webs will be determined by capture rates, with preference given to use of the robust design model from Program MARK (White, 2001). In the absence of sufficient captures, and/or failure to meet relevant Goodness of Fit tests, analysis will be through use of DISTANCE Sampling (Buckland *et al.*, 2005; Thomas *et al.*, 2005), which enables analysis of sparse data. Analysis of trapping web data from the western ringtail possum translocation release sites at Leschenault Peninsula Conservation Park and Yalgorup National Park (Nowicki, 2007) indicated the number of days of continuous trapping may be reduced to four and still meet the assumptions required for analysis in DISTANCE, specifically the assumption that the probability of capture at the centre of the web is 1. This is yet to be assessed in the northern jarrah forest.

5.9 Habitat assessment of trapping webs

Each trapping web will be assessed to quantify the extent vegetation structural heterogeneity and other site specific habitat variables. These data will also be used in modeling to identify the variables which best explain patterns of distribution and abundance for each species and/or suites of species trapped at each of the webs. Modeling will be through the “General Linear Modeling” approach (Hardin and Hilbe, 2007) and the Akaike Information Criterion (AIC) (Burnham and Anderson, 2002) to determine the model, from a set of *a priori* candidate models, which best describes the data.

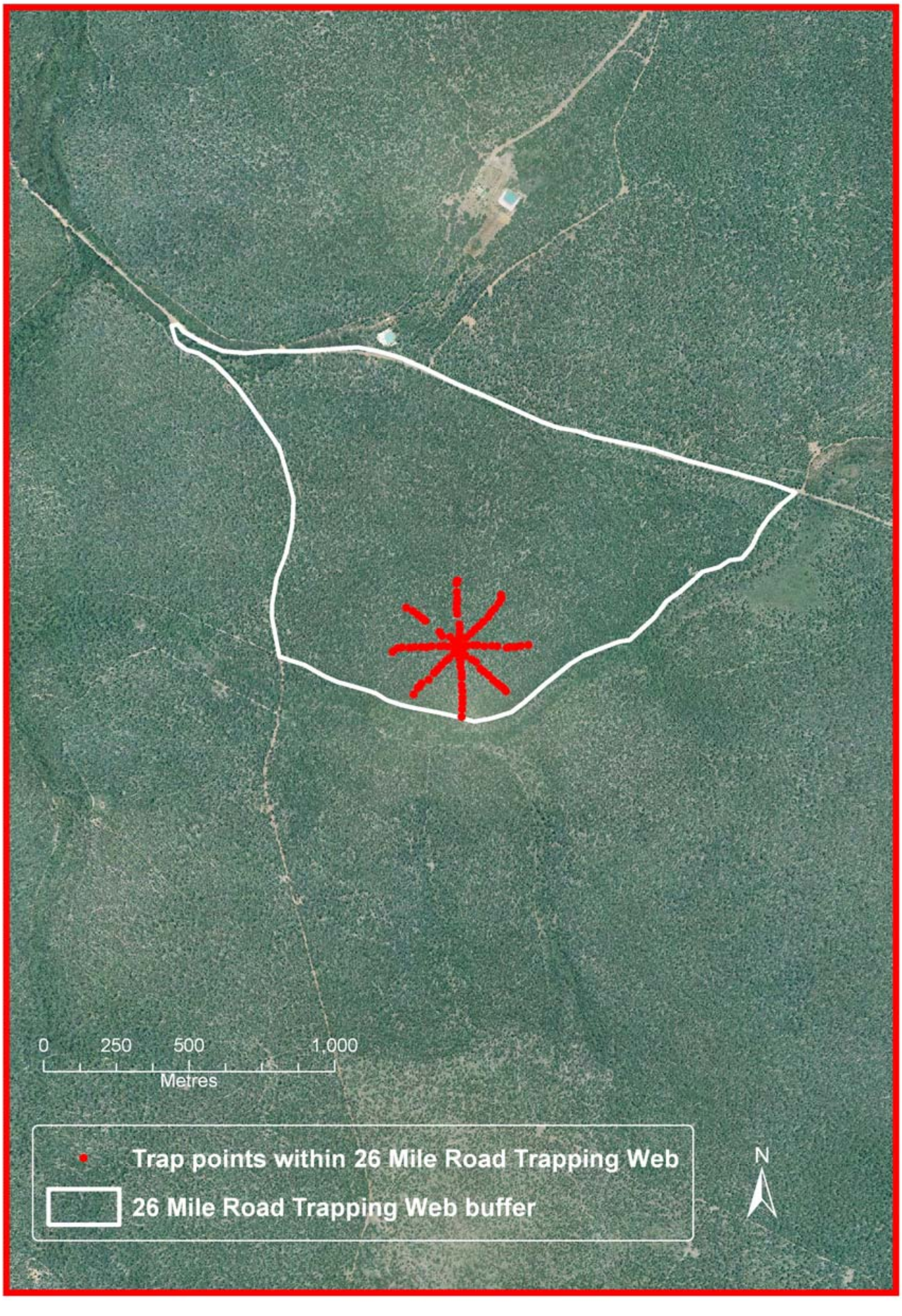

Figure 5: Orthophotograph showing the location of 26 Mile Road Trapping Web configuration and the buffer zone established to quarantine the web from operational activities (harvesting and burning) for the duration of the study.

There are 10 trapping webs used to assess prey availability within the northern jarrah forest predator interaction research.

5.10 Brushtail possum density estimates, survivorship, diet, behaviour, habitat use and health

5.10.1 Diet

Little of the diet of the western brushtail possum is known. The only two diet studies of the western brushtail possum (How and Hillcox, 2000; Sampson, 1971) have only looked at diet composition in terms of foliage and so, the breadth of the diet is still unknown. In terms of foliage, the western brushtail possum is known to consume high proportions of *Agonis flexuosa* (45.4-83.8 % found in scats) and *Eucalyptus rudis* (0.8-50.8 %) as well as moderate amounts of *Pinus radiata* (0.2-17.4 %) when available (How and Hillcox, 2000). However, it is likely that the western brushtail possum has a similar diet to the common brushtail possum. The main aims of this section are:

- to determine the main diet groups that comprise the diet of the western brushtail possum in the northern jarrah forest,
- to determine whether there are any site or seasonal differences in their diet

Possum diet is determined from scat samples collected from three sites (Jarrahdale Rd, Stene, George) during seasonal trapping. Scats are analysed using a combination of microhistological techniques adapted from Martin et al. (Martin *et al.*, 2007) and Gibson (Gibson, 2001). One pellet is selected from a dropping (group of pellets collected from the same animal on the same occasion) and soaked in water overnight in a Petri dish to soften it. The pellet is then teased apart and suspended evenly by adding a small amount of water and examined underneath a dissecting microscope to separate invertebrate material from the rest for analysis. Another pellet is sieved using an Endecotts wet sieve shaker. Each sample is then subjected to chemical digestion and transferred to a slide following Martin et al.(2007). Stratified, randomly selected straight transects are scanned on each slide on a compound microscope at 100 x magnification, until 100 fragments are encountered. Fragments are grouped into one of the following food groups:

- fruit
- seed
- flower
- tree species (identified to one of the following species using a reference collection: *Eucalyptus marginata, Eucalyptus wandoo, Corymbia callophylla, Bansia grandis, Sheoak*).
- other plants (shrubs and ground plants) using reference slides prepared by Martin et al. (ref?)
- fungi
- invertebrates

Results are expressed as percentage of food group fragments within each fraction and then combined across fractions by multiplying each percentage of food group by the proportion that each fraction contributes to the overall sample.

5.10.2 Effect of resource availability and predation on density of western brushtail possum populations

Brushtail possums have declined in the NJF since the introduction of fox control (J. Cruz unpublished data). The effects of resource availability (den and food) and predation (explanatory variables) on possum abundance (response variable) is investigated using an information theoretic, multiple model testing approach (Burnham and Anderson, 2002) available in program MARK. Candidate linear models to be tested include various combinations of explanatory variables as follows.

- possum abundance = βint + βden availability + βfood availability + βpredator abundance + error
- possum abundance = βint + βfood availability + βpredator abundance + error
- possum abundance = βint + βden availability + βfood availability + error
- possum abundance = βint + βden availability + βpredator abundance + error
- possum abundance = βint + βfood availability + error

- possum abundance = βint + βpredator abundance + error
- possum abundance = βint + βden availability + error

where β is a coefficient term, error is the uncertainty of the model and βint is the intercept term.

Non-linear models are not included because of the small power to detect non-linearity with small data sets (ref?).The best model is selected using the adjusted AICc which is more suitable when dealing with small sample sizes (Burnham and Anderson, 2002).

Trapping

Survival and abundance of possum populations is being investigated through a capture-mark-release study. Ten sites are trapped for 5 nights using 96 cage traps as described above for the web trapping to assess prey availability. Three of these sites also have 50 additional cages in a design that uses the extended webs from the chuditch and goanna projects (Figure 3). In the extended webs, "possum" cages, baited with universal bait, are placed on the opposite side of the road to the predator (goanna and chuditch) cages. Trapping is to continue seasonally until the end of 2009 so that survival estimates can be compared yearly and across seasons. Possum density is estimated from spatially explicit capture data using simulation and inverse prediction in Program DENSITY (Efford, 2007).

Food availability

Food availability is determined from 7 sites in the northern jarrah forest. Each site is roughly 16 km^2 and comprises an array of logging and fire histories as well as vegetation types (eg. jarrah/marri, jarrah/wandoo). Availability of various food groups is determined as follows:

- ***Invertebrate Pitfall trapping (passive)*****:** Pitfall trapping is a useful method for capturing spiders, harvestmen, millipedes, centipedes and other myriapods, ants, cockroaches, earwigs, adult beetles and beetle and fly larvae. (Ausdeen, 1996). 48 pitfall traps are used per site. They are placed at the first 6 points of each transect line of the inner trapping web. Pitfall traps consist of a PVC tube dug 60cm into the ground. Inside a container is placed with a funnel over its mouth. Pitfall traps used are designed to capture small mammals, reptiles and amphibians and are being used to determine prey availability (see section 5.8). Invertebrates are a bi-catch of these pitfall traps. Invertebrates are collected from pitfall traps for five days every season and placed in a jar containing 70% alcohol for preservation and are identified to order. The number of invertebrates is summed up across pitfall traps to obtain an index of invertebrate abundance per site.
- ***Tree abundance:*** Basal areas of each tree species are calculated by measuring the DBH (diameter at breast height) of all trees with DBH > 2cm along 6 transects of 2 m by 100 m dimensions. The starting point of each transect is selected following a stratified sampling design. The 6 stratums per site consist of: road trap points 1-10, 11-20, 21-30, 31-40, 41-50 and the 6th stratum is the inner web trapping points. A trap point within each stratum is randomly selected as the starting point of a transect and the transect's direction is a randomly chosen compass bearing. This design ensures that sampling isn't concentrated to particular areas of the site due to chance. The total basal area is summed up across transects and then converted to a measurement per hectare for each site.
- ***Ground cover:*** Estimates of ground plant cover (<0.5 m tall) and shrub cover (> 0.5 m, < 2 m) are obtained using the line intercept method Canfield (1941) at the 6 transects used to estimate tree abundance. The line intercept methodology was chosen because of its strong theoretical background (Lucas & Seber 1977). The line intercept method consists of measuring the length of a line that is intercepted by each plant form (shrubs and ground plants). This length is then divided by the total length of the line to obtain estimates of the proportion of area covered by each plant form. The line is one side of the transect (100 m). It is measured by progressively moving a 10m tape placed along the length of the transect (details of stratified sampling design above). The length of the tape that is touched by either shrubs or ground plants along each 1 m of the tape is estimated and summed along the 100 m and divided by the total length of the line (100 m) to obtain estimates of plant cover for each transect. The estimates are averaged between transects and converted to per hectare estimates for each site.

Den availability

Measurements of DOB (diameter over bark), species and canopy senescence (following scale used by Whitford 2002) will be recorded for *Eucalyptus marginata, Eucalyptus wandoo* and *Corymbia calophilla* species along the 6, 2m wide by 100m long transects used for tree abundance estimates. Measurements collected are used to estimate the number of hollows available to brushtail possums from the following equation derived from Whitford and Williams (2002):

$$\boldsymbol{P_H = \exp(-4.827 + (0.019 \times DOB) - (1.286 \times SP) + (1.651 \times SENES34) + (2.398 \times SENES5) + (2.457 \times SENES6) + (2.177 \times SENES789))}$$

Where P_H= number of hollows in a tree, DOB= diameter over bark, SP = species, SENES = the corresponding crown senescence classes (1 to 9).

The P_H values are calculated for all measured trees of either *Eucalyptus marginata¸ Eucalyptus wandoo* and *Corymbia calophylla* with a diameter >50cm, since no possums have been found in trees of smaller diameters through radio-tracking (J. Cruz, unpublished data). The P_H values within each transect are summed by site and then converted to a measure per hectare.

Predation

Fox and cat activity indices (see section 5.3) will be used as a measure of predation pressure at each site. estimated from the trapping data using an Information Theoretic approach available in program MARK (White and Burnham, 1999). Survival estimates are being compared across the three sites with remaining possum populations and these are being related to different predator assemblages at these sites.

Survival at Jarrahdale Rd, George, Stene of radio-collared individuals is also being monitored weekly (except during trapping). Mortality events encountered from radio-tracking are being evaluated using the principles of wildlife forensics which consider the mortality events as forensic investigation sites where evidence is collected (including DNA) to help determine cause of death. Up to 5 possums will be monitored at each site at a particular time. Radio-collared animals will be monitored until the end of 2009.

5.10.3 Effects of resource availability and predation on western brushtail possum population parameters

This section looks at the mechanisms by which resource availability limit possum densities through their effects on various population parameters. Food availability and predation limit population density through their effects on population parameters including body condition, survival and reproductive output. Furthermore, food availability can also alter the sex-ratio of pouch young. As explained by Johnson et al. (2001) and proposed by Clark (1978) the local-resource-competition hypothesis predicts that species with sex differences in natal philopatry (resident vs. dispersing sex), should vary the sex ratio of offspring produced in response to resource availability so that, under low resource availability sex ratios should be biased towards the dispersing sex. In mammals, daughters usually show natal philopatry, while sons disperse (Cockburn 1990; Johnson et al. 2001). Various studies have shown mammalian sex ratios of young to be male-biased, consistent with local resource competition between mothers and daughters (refs?). Common brushtail possums also seem to follow this trend. Johnson et al. (2001 – ref?) found that the offspring ratio of common brushtail possums was strongly correlated with the availability of dens, with low den availability resulting in a male-biased offspring. Males are the dispersing sex (refs?} and therefore, a male-biased offspring is thought to be a response of brushtail possums to low resource availability.

Population parameters are measured seasonally from 3 sites and a 4th site will be incorporated soon. Predation risk and food availability are also be measured at each site (see section 5.9.2). Hypotheses tested are based on a series of either additive or alternative predictions on how different predation risk/ food availability scenarios will ultimately affect possum density through their effects on population parameters (Table 10).

Table 10: Prediction table outlining hypotheses explored and how they can be differentiated based on expected differences in measured parameters.

Note that some hypotheses can't be distinguished under some scenarios. # : no effect of predation is expected on body condition or reproductive output if possums continue to forage despite high predation risk. If they recognize predators as a threat and decrease their foraging, high predation risk is expected to result in lower body condition and reproductive output. -: negative effect, . : no effect, =: offspring sex ratio close to parity, ♂-biased: offspring biased towards the male sex ratio.

Predictions	Body condition	Survival	Reproductive output	Density	Offspring sex ratio
1. Possums are limited by food availability	-	.	-	-, .	=, ♂-biased
2. Possums are limited by high predation risk	(. , -)[#]	-	(. , -)[#]	-	=
3. Possums are limited by den availability	.	.	.	.	♂-biased
4. Possums are limited by food and den availability	-	.	-	-	♂-biased
5. Possums are limited by food and high predation risk	-	-	-	-	=, ♂-biased
6. Possums are limited by dens and high predation risk	(. , -)[#]	-	(. , -)[#]	-	♂-biased
7. Possums are limited by dens, food and high predation risk	-	-	-	-	♂-biased

5.10.4 *Disease*

All radio-collared possums are being health-screened prior to fitting of radio-collars to determine if there is an indication of reduced fitness from disease. Health-screening involves the testing of blood samples to obtain baselines of general biochemistry and haematology as well as testing for the presence of toxoplasmosis. Faeces and urine samples are tested for the high presence of possible pathogens including leucocytes, campylobacteria and yeast.

5.10.5 *Behavioural responses to predation*

Russel and Banks (2005) suggested that introduced predators may have been so successful at eradicating native prey species due to the inability of prey species to recognise introduced predators as a threat. Pickett *et al*. (2005) however, found brushtail possums in NSW to be more wary of food stations scented with fox urine at unbaited sites compared to fox-baited sites, suggesting that possums may be able to adapt their behaviour with changes in the abundance of predators at their sites. It is unknown whether the WA subspecies of brushtail possums could also have learnt to recognize introduced predators and be able to adapt their behaviour in order to maximize their fitness. In fact, little is known about their anti-predation behaviours in general.

Possible anti-predation behaviours of possums are being explored at the three sites were they remain. The main questions explored include:

- Do home-ranges differ with different predator assemblages?
- Do they swap dens more often if predator pressure is higher?
- Do they alter their use of microhabitat (eg. open vs dense, ground vs, arboreal) depending on what predators are present?

This will be assessed through the use of spool-and-line tracking. To date, eleven animals across the 3 sites have been tracked using either 500m or 1000m cotton spools. Variables recorded every 10m include:

- % ground cover (per 1m^2) around spool points;
- Distance to nearest escape tree; and

- If possum travelled above ground, tree species, height, diameter, incline and number. of contact trees are recorded. Contact trees are surrounding trees where a possum could escape to or from if chased by a predator.

6 Progress to date

6.1 The baiting treatments – spatial and temporal design

At the cessation of Operation Foxglove in 2000, the baiting program within the northern jarrah forest reverted to a frequency of four baitings year and perimeter hand baiting ceased. Baiting recommenced at six baitings per year in 2006 with the commencement of the current northern jarrah forest mesopredator release / predator interaction project.

The aerial baiting cells (the units for the aerial baiting program) which encompass the northern jarrah forest study area are the Perth Hills Cell and the Lane Poole Cell. These cells are scheduled for baiting four times per year (March, June, September and December) as part of the standard operational program. An additional cell, the Perth Hills / Lane Poole Cell, encompassing part of each of the Perth Hills Cell and the Lane Poole Cell, and all of the study area, is baited in July and October, thus giving 6 baitings per year to the baited treatment sites within the study area.

At the completion of the July 2007 aerial baiting, the baited treatments had received their requisite number of baitings (six) in the preceding year (see Appendix 1). Since December 2006, bait delivery has approximated scheduled delivery, with the exception of December 2007 and the subsequent March 2008 baiting, where major logistical problems were encountered. These problems may have been rectified (Rob Brazell, pers comm. to PdeT)

The scheduled vehicle based delivery of baits was also held back at these two occasions to ensure vehicle delivery coincided with aerial delivery.

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

Trials for the cat bait were scheduled for April 2008, but have been delayed as a result of unsuitability of the capsules containing the biomarker. This trial is now scheduled for the Spring 2008 or Summer 2008/2009 trapping session. The Animal Ethics application has been approved for this trial, and includes approval for the captive trial of varanid uptake of Rhodamine B. Results from the trial will be of direct relevance to potential non-target risks from use of 1080, PAPP and alternative toxins in the DEC Eradicat bait.

6.3 Indices of activity and estimates of density - Sandplots

6.3.1 Fox and cat indices of activity and estimates of density

Estimates of fox and cat density and indices of fox and cat activity have been derived for sandplotting sessions 3, 5 and 6 – the sessions with greatest consistency of technique (see Table 8). The mean estimate of fox and cat density for sandplotting sessions 3, 5 and 6 for all sites (Figure 6) indicates cat density is higher than fox density at all but one site (George / Hotham Creek). When averaged within treatments, the estimate of cat density is higher than fox density in the baited treatment and the unbaited control (Figure 7).

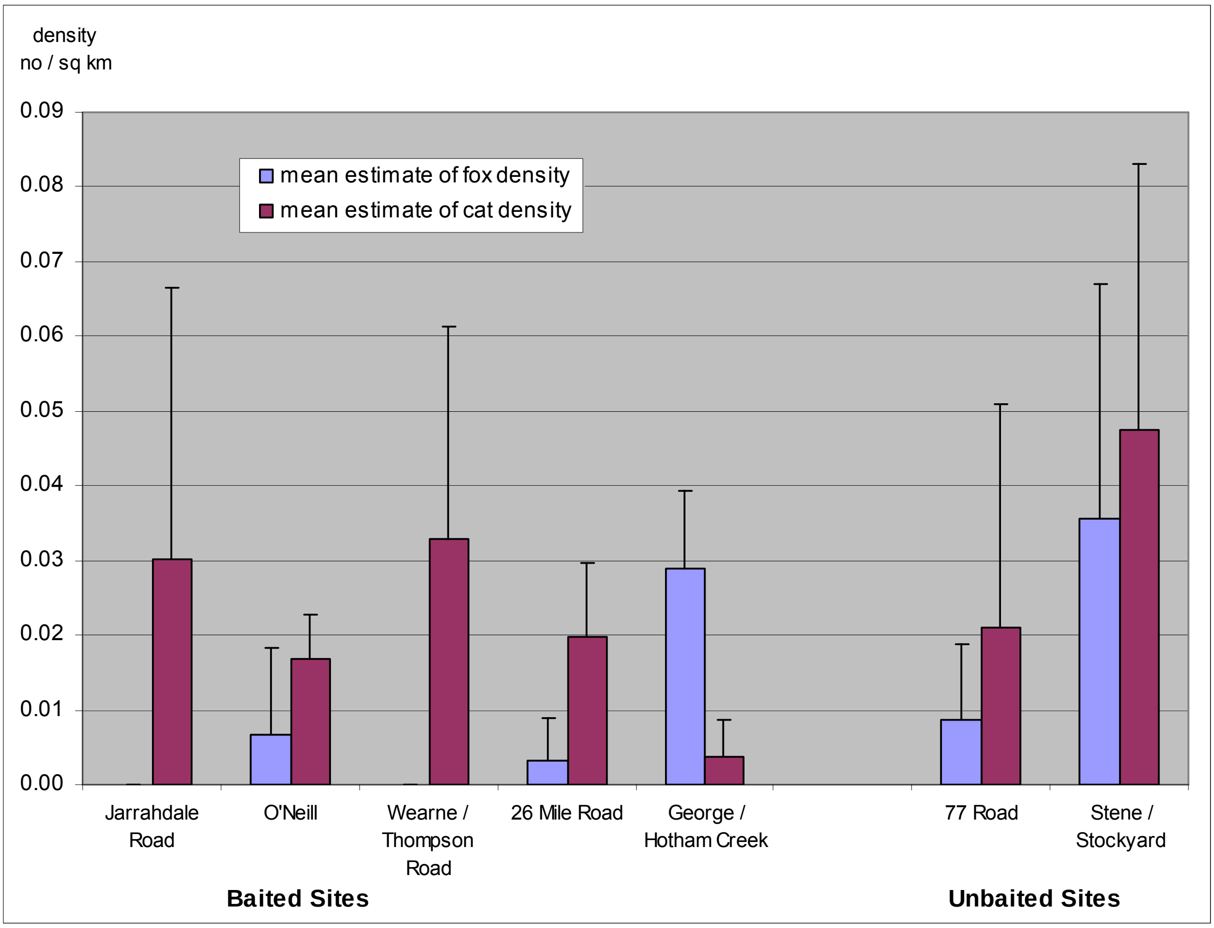

Figure 6: Mean estimates of fox and cat density at each site for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

Estimates are derived from a modification of the Foxglove Estimate of Density technique (FED) (de Tores *et al.*, in prep-b)

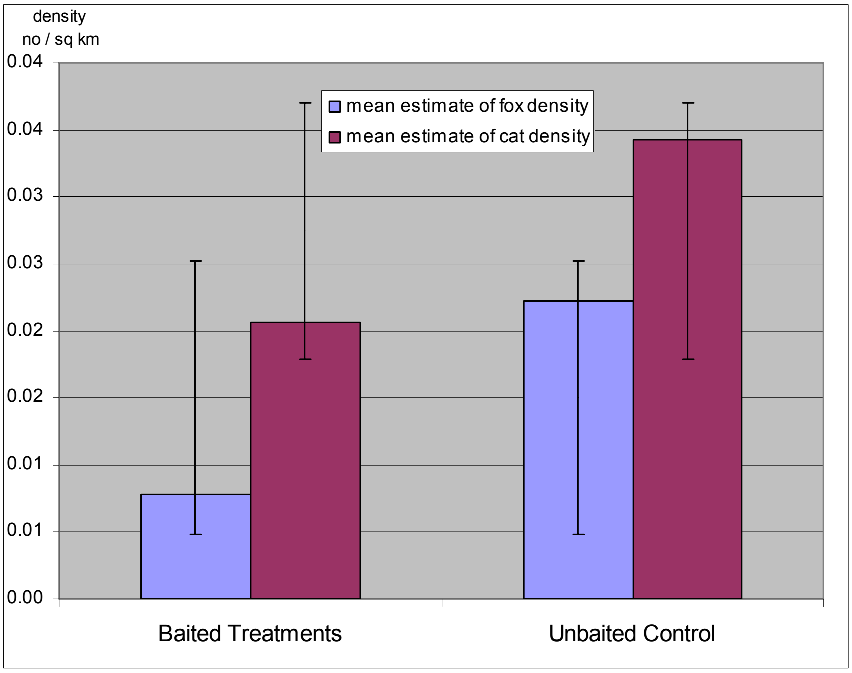

Figure 7: Mean estimates of fox and cat density within treatments for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

Estimates are derived from a modification of the Foxglove Estimate of Density technique (FED) (de Tores *et al.*, in prep-b)

The mean indices of fox and cat activity for sandplotting sessions 3, 5 and 6 for all sites (Figure 8) indicated cat activity was higher than fox density at all but two sites (Stene / Stockyard as well as George / Hotham Creek). When averaged within treatments, the indices of cat activity were higher than the indices of fox activity in the baited treatment and the unbaited control (Figure 9).

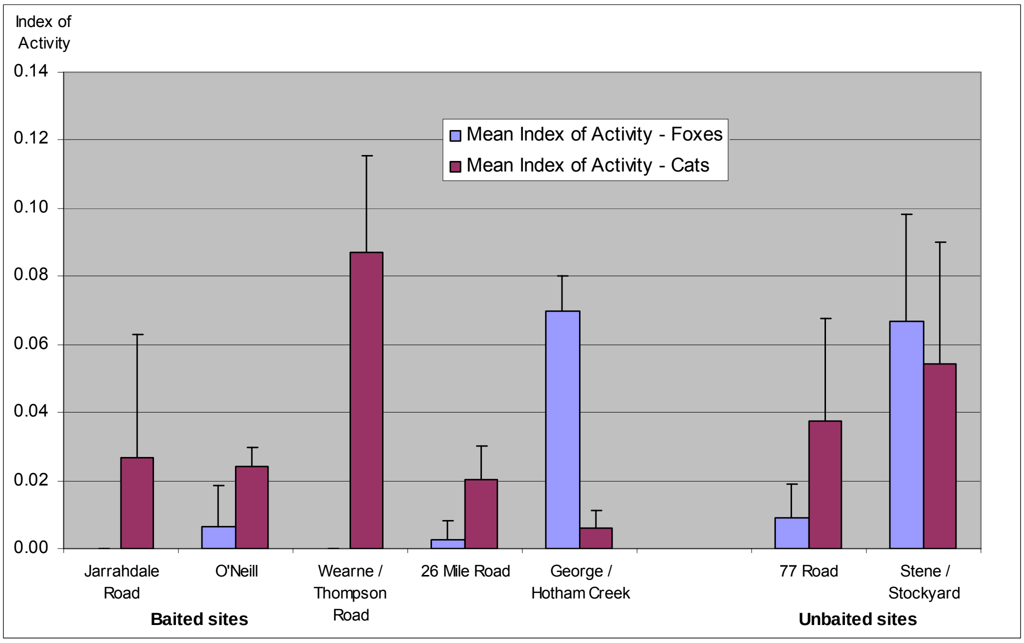

Figure 8: Mean indices of fox and cat activity at each site for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

Indices are derived from use of the Allen / Engeman Index of Activity (Engeman, 2005)

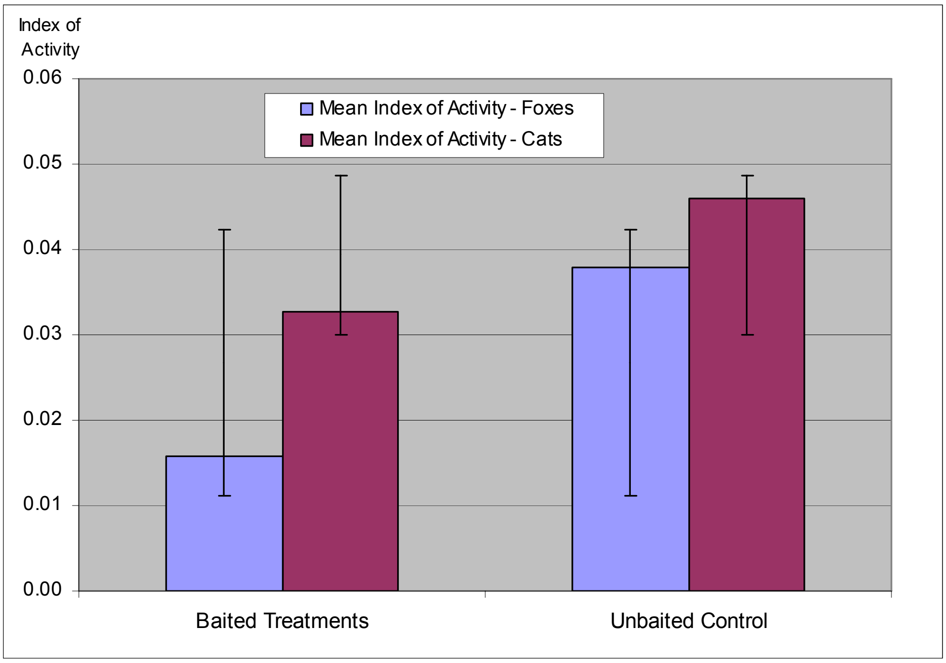

Figure 9: Mean indices of fox and cat activity within treatments for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

Indices are derived from use of the Allen / Engeman Index of Activity (Engeman, 2005)

The Index of Activity and the FED do not rank the sites in the same order (Figure 10 and Figure 11). These differences are more pronounced where deriving estimates/indices for cats (Figure 11). However, when averaged within each treatment, both techniques show a higher estimate of density/index of activity in the unbaited control for both species (Figure 12 and Figure 13).

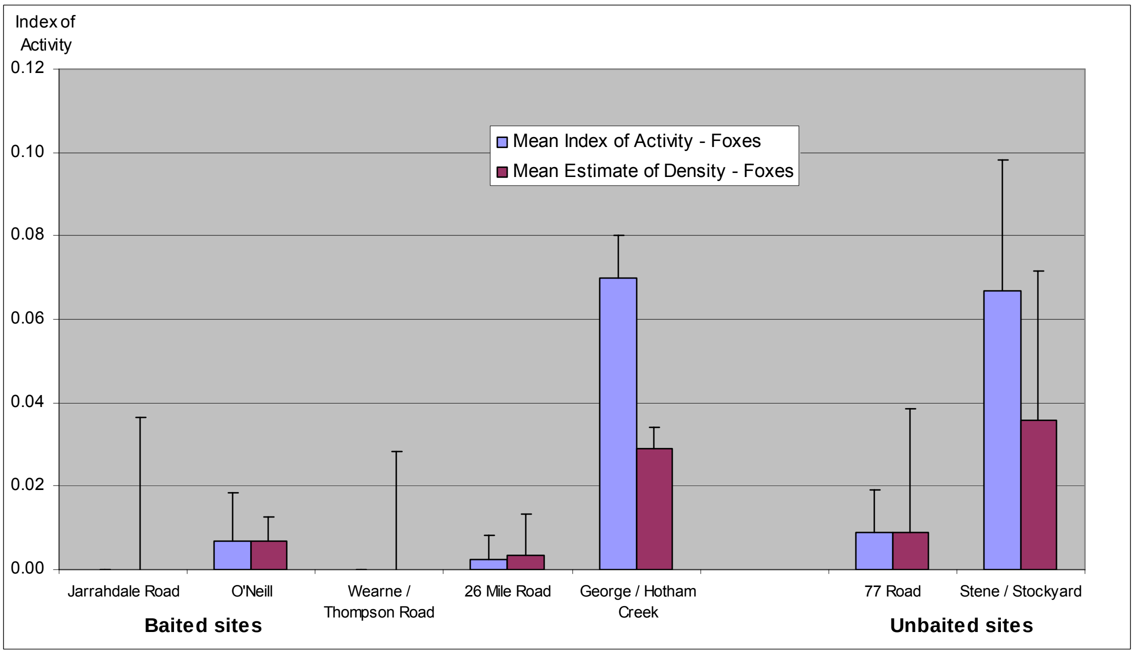

Figure 10: Mean indices of fox activity and mean estimate of fox density at each site for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

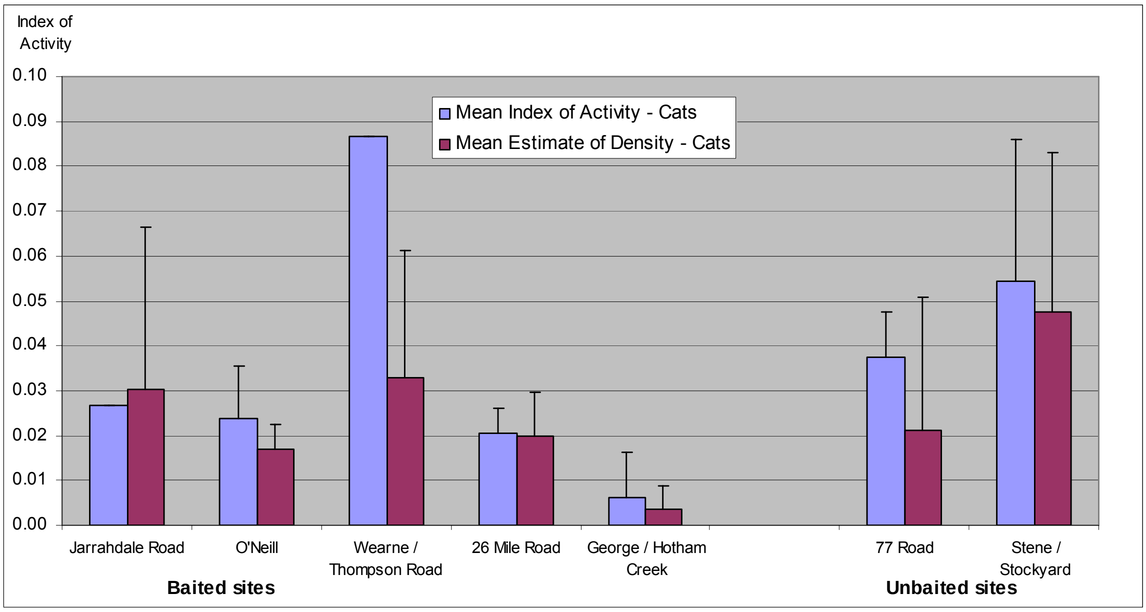

Figure 11: Mean indices of cat activity and mean estimate of cat density at each site for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

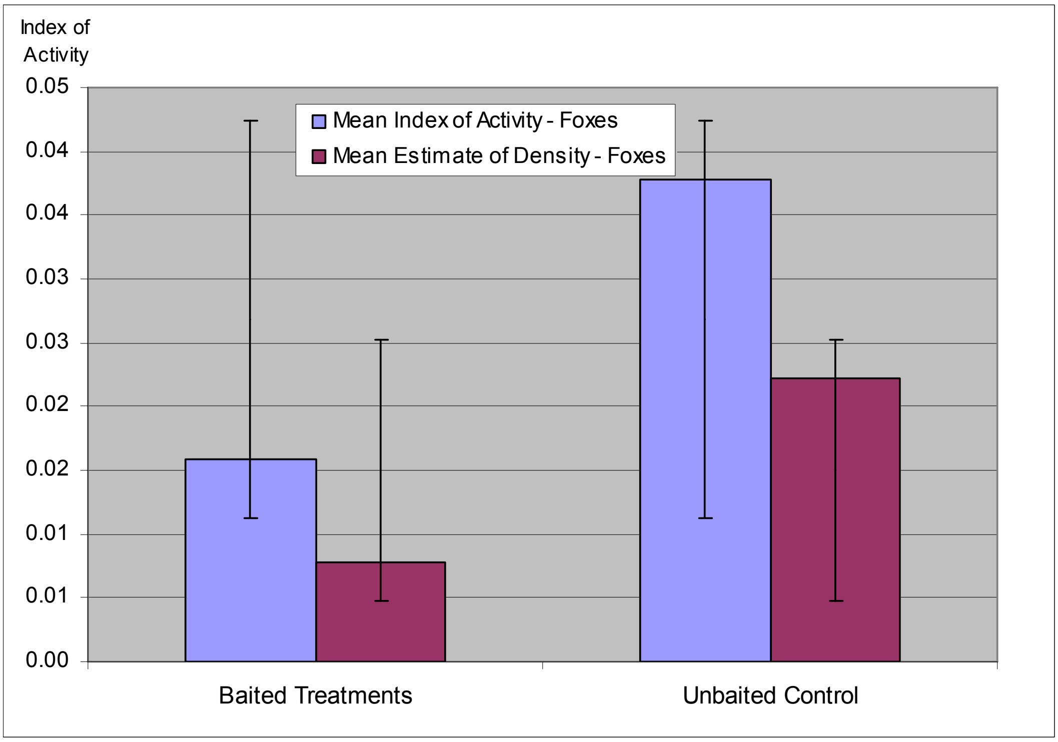

Figure 12: Mean index of activity and mean estimate of density for foxes within treatments for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

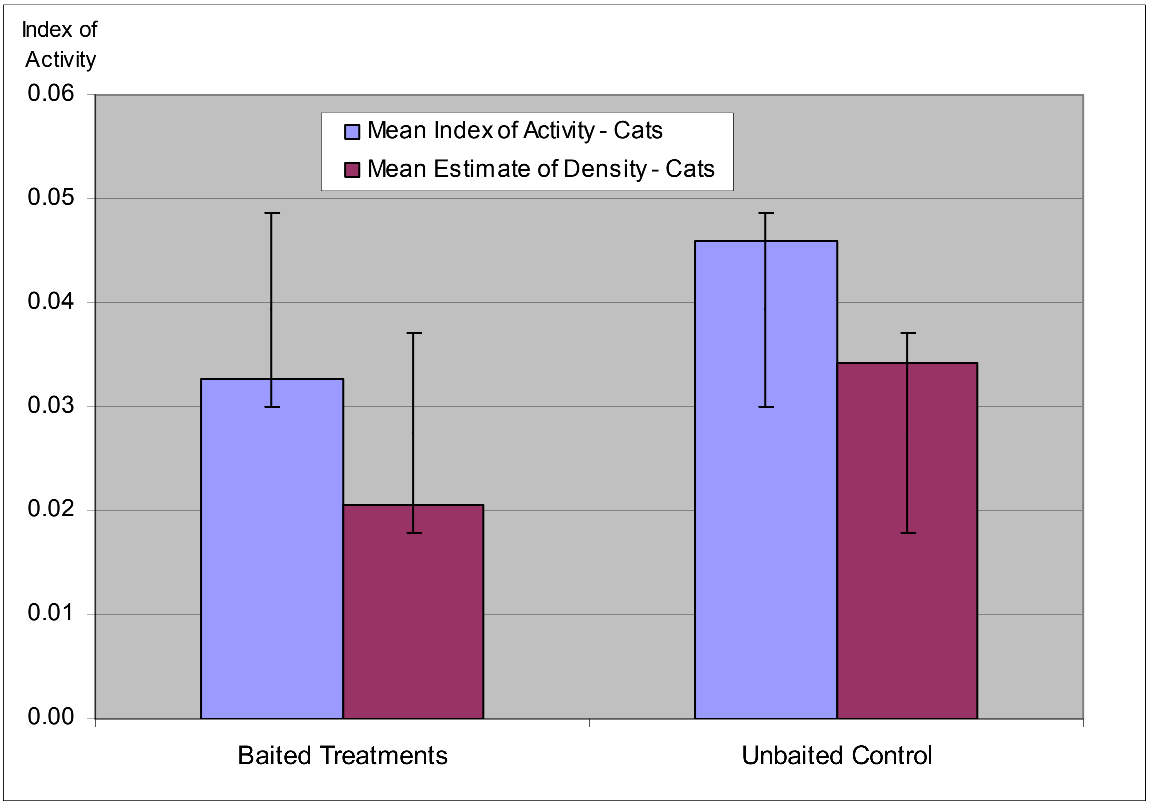

Figure 13: Mean index of activity and mean estimate of density for cats within treatments for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

Although not showing definitive evidence of a mesopredator release response by cats, the data indicate relatively high levels of cat density / high indices of cat activity (Figure 7 and Figure 9). The ratio of cat density to fox density and the ratio of indices of cat activity to fox activity (Table 11) are consistently higher within the baited treatments and are consistent with a mesopredator release response by cats.

Table 11: Ratio of cat mean index of activity to fox mean index of activity and mean estimate of cat density to mean estimate of fox density at fox baited treatments and the unbaited control within the northern jarrah forest.

	Baited Treatments	Unbaited Control
Ratio of cat mean index of activity to fox mean index of activity	2.07	1.22
Ratio of cat mean estimate of density to fox mean estimate of density	2.65	1.54

6.3.2 *Indices of activity for varanids and chuditch*

Indices of activity for varanids (Figure 14) show the highest level of varanid activity, for both varanid species combined, at the George / Hotham Road and the O'Neill sandplotting networks, consistent with the trapping data for these species (Figure 20, see section 6.7.2, below). Similarly, the index of activity for both varanid species combined is higher in the baited treatment (Figure 15) than the unbaited control and is consistent with the varanid trapping data (Figure 21, see section 6.7.2, below).

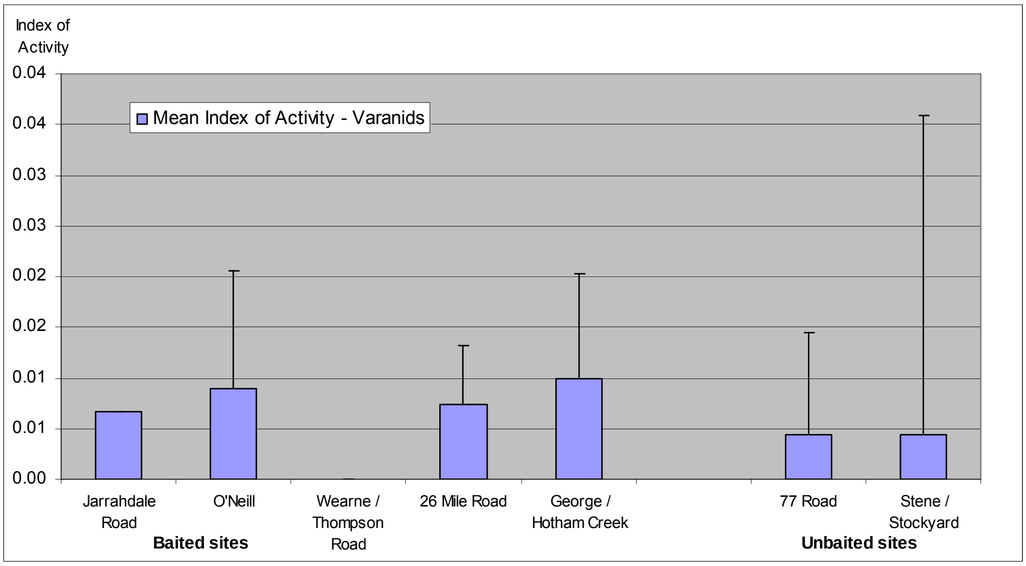

Figure 14: Mean indices of activity for two varanid species, *Varanus gouldii* and *V. rosenbergi* at each sandplotting network for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

Indices are derived from use of the Allen / Engeman Index of Activity (Engeman, 2005)

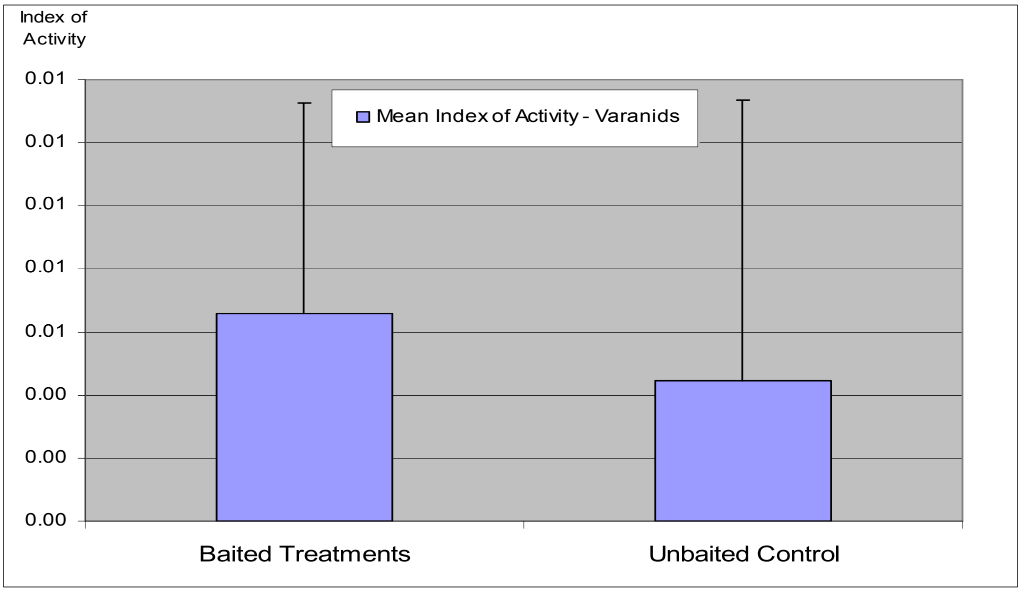

Figure 15: Mean indices of activity for two varanid species, Varanus gouldii and V. rosenbergi within the baited treatments and the unbaited control for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

Indices are derived from use of the Allen / Engeman Index of Activity (Engeman, 2005)

Indices of activity for chuditch (Figure 16) indicates chuditch abundance within the northern jarrah forest is patchy, consistent with trapping data (see section 6.7.1, below). The highest level of activity is at the George / Hotham Road, Wearne / Thompson Road and 26 Mile Road sandplotting networks. The index of activity for is higher in the baited treatment (Figure 17) than the unbaited control and is consistent with the chuditch trapping data (Figure 19, see section 6.7.1, below).

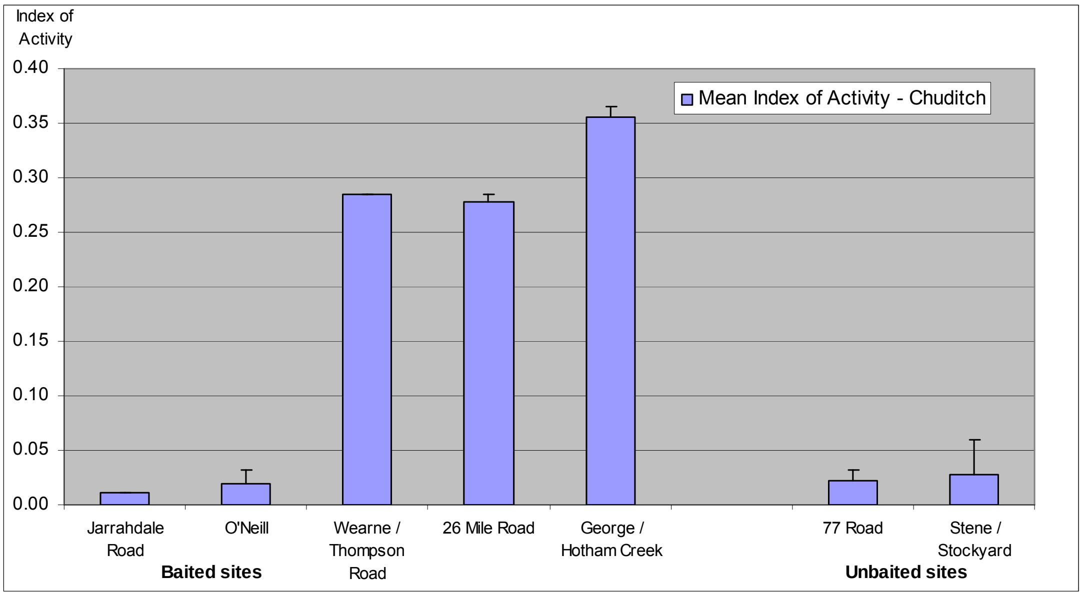

Figure 16: Mean indices of activity for chuditch at each sandplotting network for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

Indices are derived from use of the Allen / Engeman Index of Activity (Engeman, 2005)

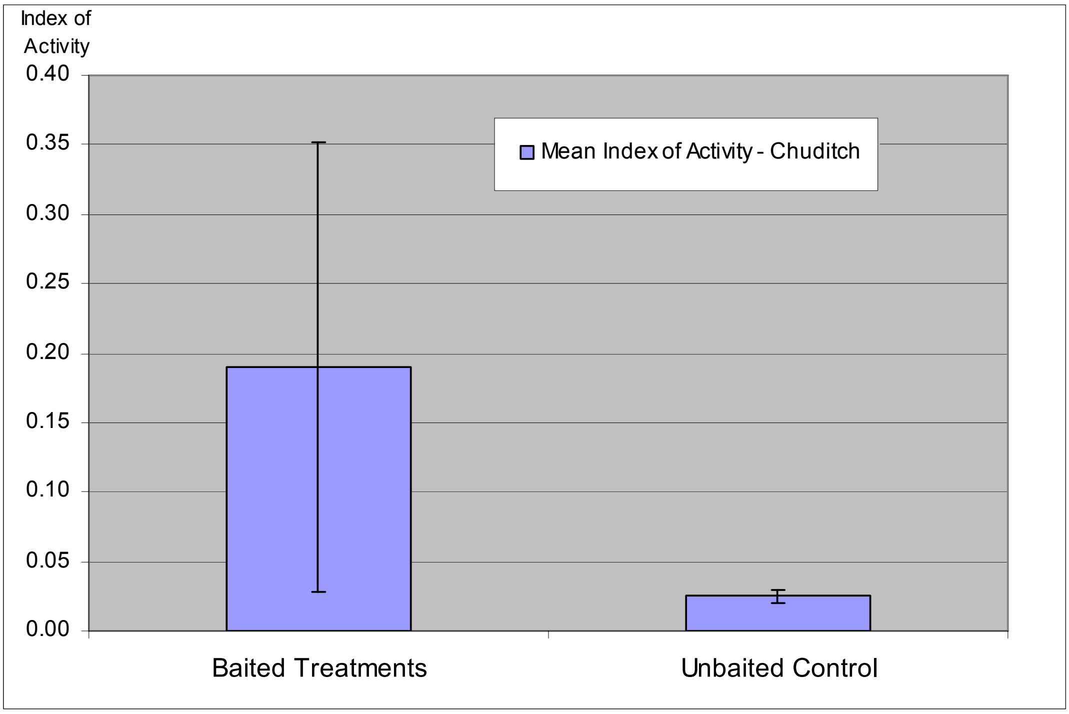

Figure 17: mean indices of activity of chuditch within the baited treatments and the unbaited control for sandplotting sessions 3, 5 and 6 (see Table 8) within the northern jarrah forest.

Indices are derived from use of the Allen / Engeman Index of Activity (Engeman, 2005)

6.4 Molecular analyses

6.4.1 Epithelial scrapings from predator scats

There has been a high correlation between techniques (*i.e.* ID allocated by the collector on the basis of scat physical morphology and ID from DNA recovered from the scat scrapings) for identification of the predator species responsible for leaving scats. Sufficient DNA has also been recovered for genotyping from fox scats, however, recovery of DNA from scats has been less successful than recovery from hair samples.

6.4.2 Hair traps

Considerable effort has been invested in development and trial of devices for collection of fox and cat hair. The major goal was to develop a single device able to collect hair from both species for subsequent DNA analysis and genotyping. Captive animal trials have assessed the effectiveness of rubbing posts (several variations of posts with double sided tape and / or glue), barbed wire and a variation of the hair tunnel used for collection of Stoat hair (Byrom and Gleeson, (2006? undated)). All devices have been shown to collect hair; however, the reliability of collection is highly variable.

Captive trials have shown the “Poly Pipe” device to be the most reliable. The device (

Figure 18) is a variation of the hair tunnel used for Stoats. The captive animal trials of the “Poly Pipe” showed five from five inspections of the device by a captive fox resulted in collection of hair. Similarly, five from five inspections of the “Poly Pipe” by a captive cat resulted in collection of hair. Molecular analysis has shown sufficient DNA can be recovered for fox genotyping. Results are still pending for the cat hair.

Trials of the “Poly Pipe” carried out in January 2008 demonstrated hair could be collected in the field. Field deployment of six “Poly Pipe” and six “Sticky Wicket” devices (Algar, 2008) (

Figure 18) commenced as part of the March 2008 sandplotting session. Hair was collected from the “Poly Pipe” device on two occasions over the six day monitoring period and on one occasion from the “Sticky Wicket” device over the same period. Review of data from hair collected by the Poly Pipe and Sticky Wicket during sandplotting session 6 (see Table 8) indicated the Poly Pipe was more successful than the Sticky Wicket, with 74 and 29 hair samples collected from each device respectively from 492 trap nights over a six day period. The results have been submitted for presentation of a paper at AWMS, December 2008.

6.5 Fox and cat dietary analysis

A total of 141 fox, cat and chuditch scats have been collected from roads during sand plot monitoring. A subset of 89 of these was suitable for epithelial scrapings. Pending results of the ID of the predator responsible for leaving the scat, all fox and cat scats will be analysed to assess diet in relation to prey availability. The extent of dietary overlap between foxes, cats, chuditch, varanids and pythons will also be assessed.

6.6 Fox and cat use of the landscape – trapping and satellite telemetry

Trapping has commenced at two sites post the March 2008 sandplotting session and is currently in progress.

Two cats, one male, one female, were caught in 2007 as non-target captures during the possum trapping. Both were from the unbaited control and both have been fitted with satellite collars. Data have been successfully acquired for approximately 40 Class 3 location records (i.e. records considered to be within 100m of the true location). No analysis has been carried out to date for these data.

The contact/proximity circuitry component of the fox/cat collars has been unreliable. All collars have been returned to the manufacturer to:

- replace existing firmware;

- resolve issues with inconsistency in the distance over which a “contact” or “proximity” event is logged; and
- replace the data logger software and resolve the issue whereby records of contacts are logged for “ghost” collars which are not present / not activated / don’t exist.

All issues appear to have been resolved and fox/cat trapping is scheduled to resume immediately after completion of sandplot session 7 (the session immediately prior to the September 2008 aerial baiting).

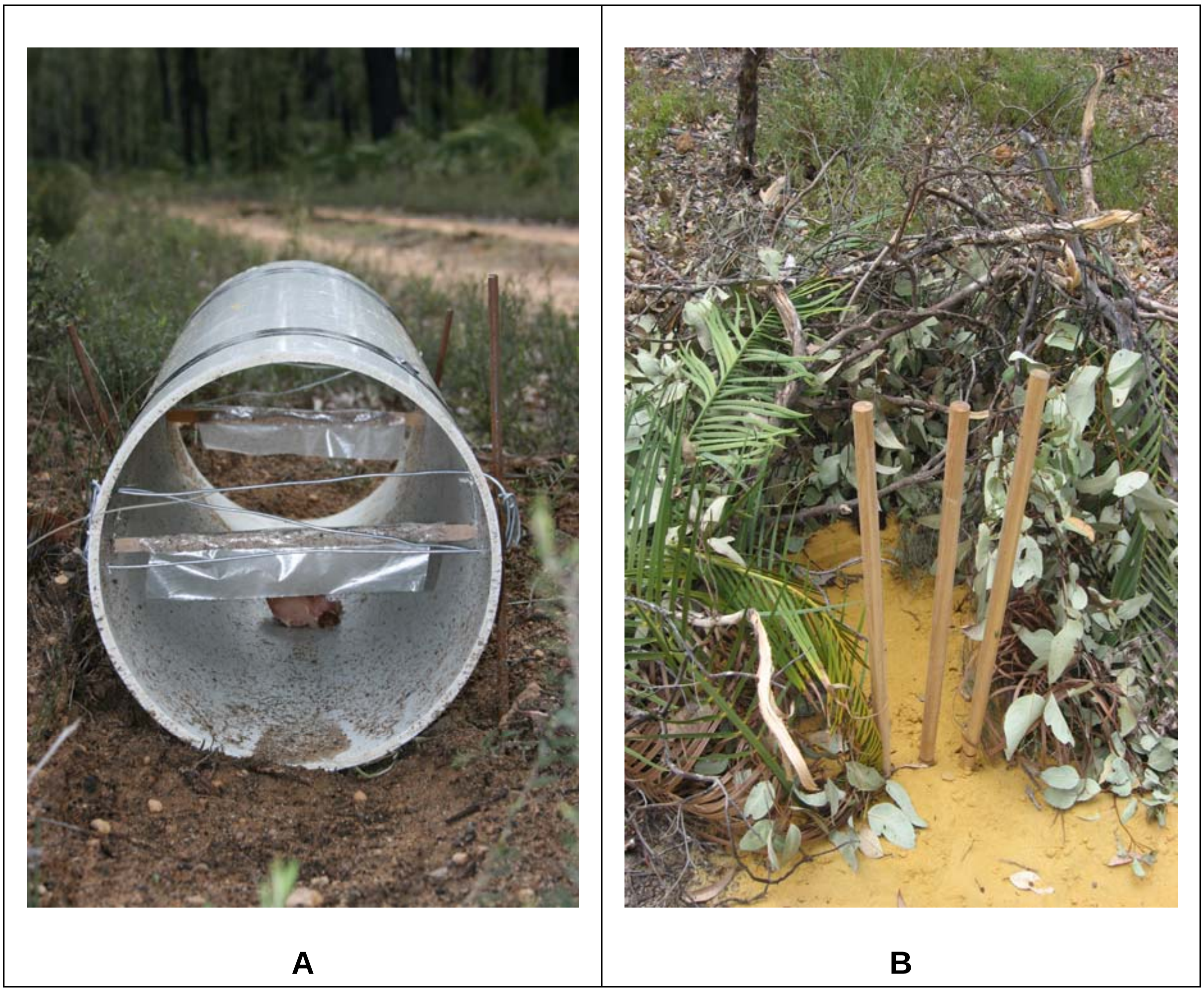

Figure 18: hair collection devices trialled for collection of fox and cat hair:

A: The “Poly Pipe” device successfully used for collection of hair from foxes and cats in the northern jarrah forest captive trial and shown to successfully collect hair from field sites

B: The “Sticky Wicket” device (Algar, 2008), also shown to successfully collect hair from field sites

6.7 Native predators

6.7.1 Chuditch density estimates, survivorship and habitat use

Mark-recapture study

A trapping pilot study was conducted in order to determine an effective protocol (bait type, trap layout etc.) for trapping both chuditch and goannas. Analysis of data from these trials indicates that the trap configuration being used is appropriate to satisfy the assumptions of Program DENSITY. The area being trapped is large relative to the movements of individual animals, and traps are spaced such that individual animals are captured in several different traps during a trapping session. In order to test for repeatability of results, sampling was conducted at the same site in consecutive weeks, yielding density estimates for chuditch of 0.31 km^{-2} and 0.23 km^{-2} respectively. This indicates that the methods being used are capable of producing reliable density estimates.

Following these pilot studies, trapping for chuditch and goannas has been conducted at 8 sites (5 baited, 3 unbaited). Based on these results, site selection is now complete. Seven sites have continued to be trapped on a seasonal basis.

Trapping has so far yielded 416 captures of 148 individual chuditch. Average density is higher in the baited zone (Figure 1), but chuditch distribution is patchy. Apparent survival of chuditch is also markedly higher in the baited area than in the unbaited zone. This suggests that mortality rates are higher in the unbaited area, possibly indicating that it is a sink for animals dispersing from the baited zone.

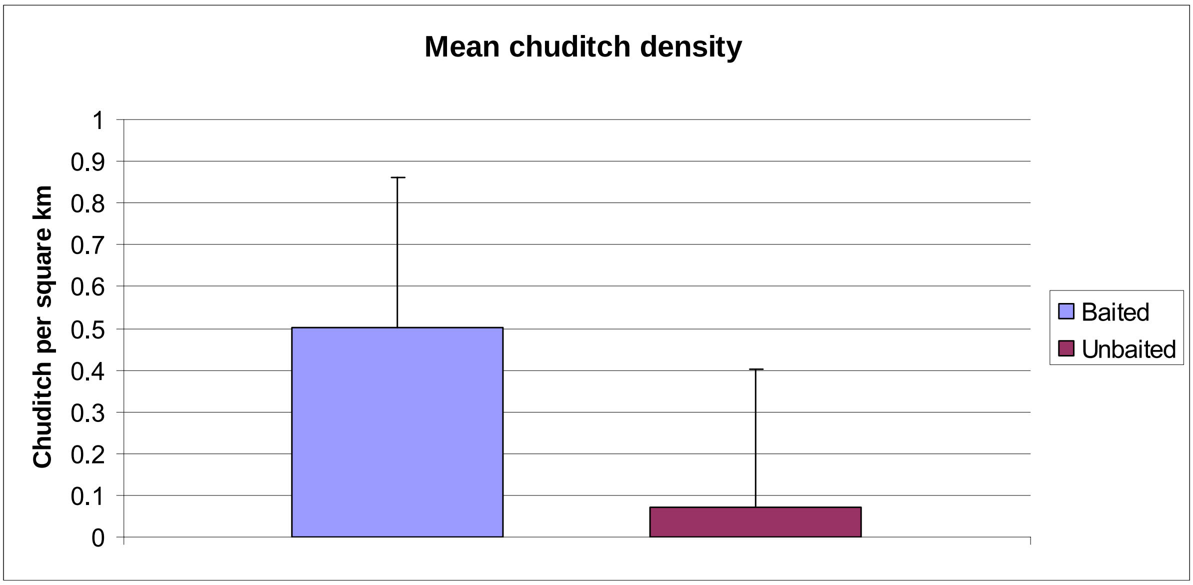

Figure 19: Mean (+ SD) density estimates of chuditch at 5 baited and 3 unbaited sites trapped between Summer 2007 and Autumn 2008.

In addition to data obtained from trapping, a freshly killed juvenile chuditch was recovered from one study site. The carcass had puncture wounds to the neck, consistent with a killing bite from a larger predator. Swabs of the wound sites were taken and sent to the University of Western Australia for genetic analysis. The results indicated that the chuditch had been killed by a feral cat, constituting the first concrete evidence of interspecific killing between these two species. To confirm this result, the carcass was subjected to a post-mortem examination, and the bite wounds compared to reference skulls of a fox, cat and chuditch. Examination of the carcass revealed no other injuries or signs of ill health, confirming that the chuditch had been killed by a predator. The size and spacing of the puncture wounds were consistent with the dentition of a cat, but not with that of a chuditch or fox. Two large puncture wounds on the throat closely matched the upper canines of the cat reference skull, and two smaller wounds corresponded with the left and right first premolars. By articulating the mandible of the cat skull, we simultaneously aligned the lower canines and premolars with wounds of corresponding size on the back of the neck. In conjunction with the genetic results, this provides conclusive evidence that the predator responsible was a cat. A short note has been prepared for imminent submission to a journal (Glen, A. S., Berry, O., Sutherland, D. R., Garretson, S., Robinson, T. and de Tores, P. J. (in prep). Forensic DNA confirms competitive killing of a chuditch (*Dasyurus geoffroii*) by a feral cat (*Felis catus*). To be submitted to *Wildlife Research*).

Home ranges and habitat use

A pilot study was conducted to confirm the suitability of a spool-and-line tracking technique for studying microhabitat use of chuditch. Tracking was conducted for three chuditch over a cumulative distance of 920 m, and showed some arboreal activity, as well as use of hollow logs and burrows. A novel method for assessing microhabitat cover was also developed in the process, and a technical note is currently in preparation. This will be submitted to the *Journal of Zoology (London)* in the near future. A novel spool-and-line device has also been developed, and this is described in a short note recently accepted for publication in *Australian Mammalogy.* Spool-and-line tracking was resumed during the February round of trapping, and will continue during subsequent seasons. Eleven chuditch have so far been tracked. In consultation with a DEC biometrician, we have also developed a new methodology for sampling microhabitat availability in spool-and-line tracking studies. This will provide greater rigour than previous studies using this technique.

In order to investigate home ranges and movements, GPS collars were fitted to chuditch. This replaced the previously-planned approach, which was to use contact telemetry. Because of the need to track chuditch at several, widely-separated sites, too few data could be collected using contact telemetry collars before the batteries would fail. Travel costs and time required for this approach were also prohibitive.

As an alternative to radio-tracking, custom-made GPS collars were developed for chuditch in conjunction with Sigma Delta Technologies. GPS collars have a number of advantages over conventional radio telemetry. Much larger volumes of data can be collected with greater accuracy. There is also less ongoing expense because of the reduced need for vehicles and staff. The batteries can be recharged by the user so that the collars can be re-deployed many times.

Following development of a prototype, ten GPS collars were completed in mid-January. The collars were field-tested for deployment in the February round of seasonal trapping. Five collars were deployed at a site in the northern baited zone (Wearne). Five collars were also intended to be deployed at an unbaited site (Stene). However, all but one of the chuditch captured at Stene in February were sub-adult animals, which were too small to be collared. During the subsequent round of trapping in Autumn 2008, two of the six collared individuals were recaptured. One had lost its collar. The collar of the second animal was still attached, but the apparatus (GPS unit and VHF transmitter) had broken off. This suggests that the collars may not have been sturdy enough for deployment on chuditch. The VHF transmitters on all the deployed collars were due to activate at the end of June. A thorough search was conducted from an aircraft in an attempt locate these transmitters. However, no signal was detected, suggesting that all six collars have failed. The four collars that were not deployed will be returned to the maker for either modifications or a refund.

Because GPS tracking has been unsuccessful, an alternative approach will now be adopted to test the hypothesis that chuditch alter their behaviour in response to different densities of introduced predators. Giving up density (GUD) experiments will now be used to determine whether chuditch in areas of high fox density show greater vigilance in response to fox odour than chuditch in areas with low fox density. In combination with data on microhabitat choice from the spool-and-line tracking, this will provide a powerful approach to detect differences in the movement and foraging behaviour of chuditch in response to fox control.

Diet

Scats are being collected from trapped animals, targeted searches, and opportunistically. Over 230 scats have so far been collected from trapped animals. These were sent to a specialist for analysis in June, and the results are expected in July. Because these scats come from known individuals, they will be used to compare diets of chuditch according to sex and size class. Over 100 scats have also been collected on roads and sand plots. These samples will be pooled with the scats from known animals to compare diets between different baiting treatments. Scat collection continues, and scats of known age will also be used for seasonal comparisons.

6.7.2 Varanid density estimates, survivorship and habitat use

Mark-recapture study

No published method exists for systematically capturing varanids; therefore a trial was conducted to determine the feasibility and most effective method for capturing varanids. Cage traps, tube traps, funnel traps and rod-and-noose capture of varanids on vehicle tracks were trialled. Wire cage traps baited with rotten chicken (n = 16) and opportunistic captures with a rod-and-noose device (n = 3) captured more varanids than tube traps (n = 1) and funnel traps (n = 0).

Trapping and opportunistic capture of varanids has been conducted at seven sites. Another three sites have also been trapped for varanids during the course of the study but will not be trapped on a regular basis as prey species availability is not being assessed at these sites. There have been a total of 151 captures of 131 individuals throughout the study to date, plus another 22 collected carcasses. 150 genetic samples have been collected. The number of individuals captured at each site is shown in Figure 20 and the mean number captured and the standard error at baited and unbaited sites is shown in Figure 21. The relative abundance of varanids at each of the seven seasonally monitored sites is also being estimated by recording the frequency of tracks observed in active and passive sand plots.

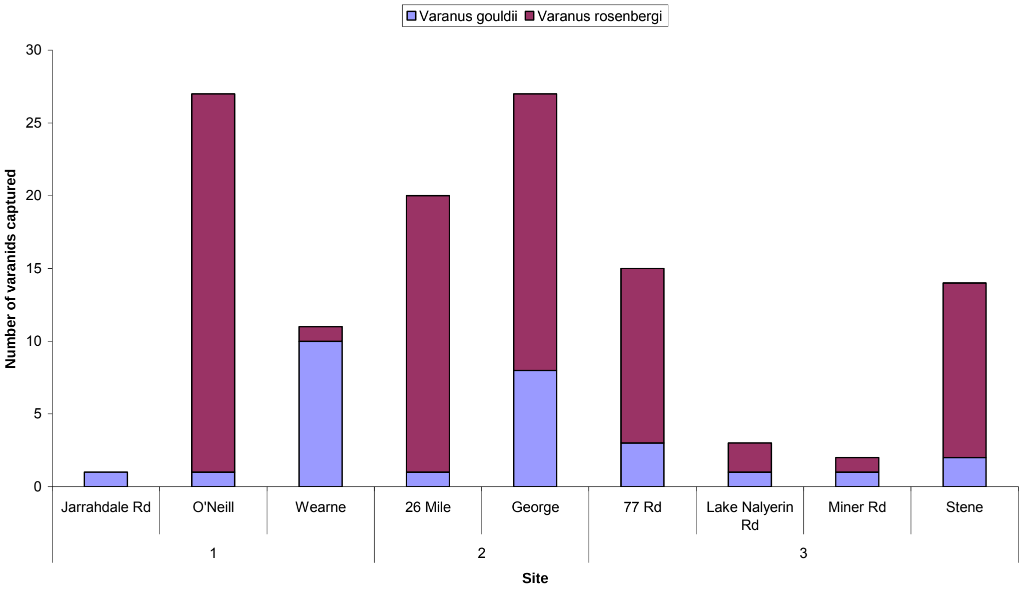

Figure 20: Number of captures of varanid lizards at seven sites.
Zones 1 and 2 are baited for foxes, zone 3 is unbaited.

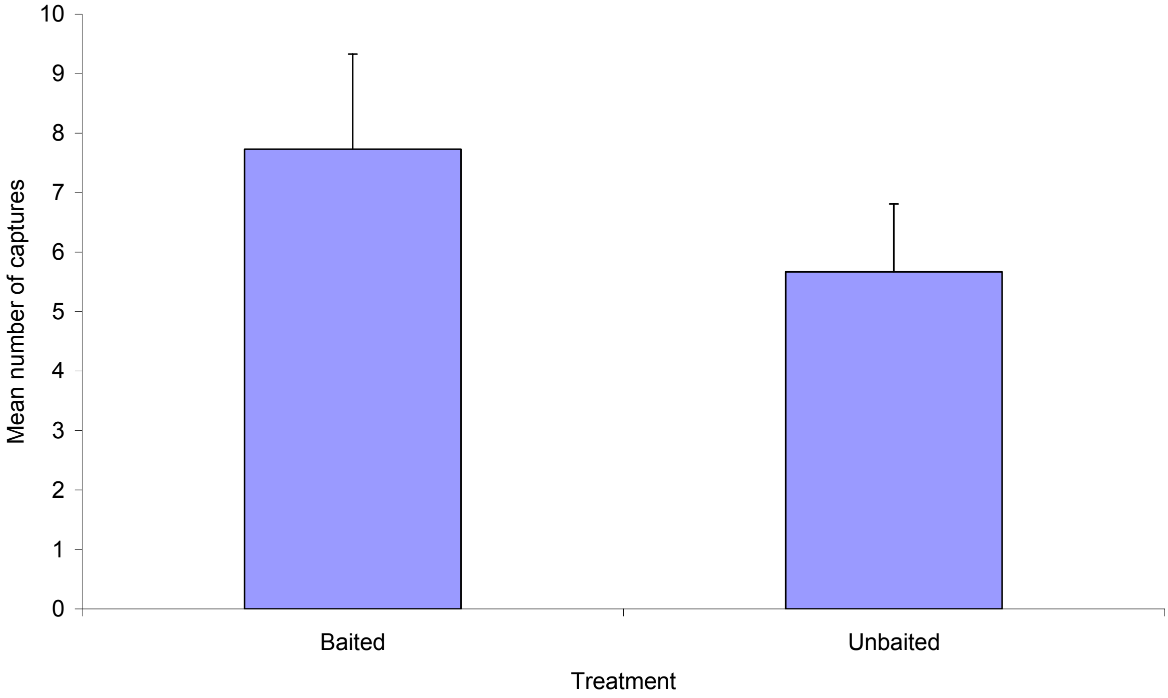

Figure 21: Mean number of varanids captured at baited and unbaited sites.
N = 11 baited sites trapped for 5 consecutive days; N = 6 unbaited sites trapped for 5 consecutive days.

Home range and habitat use

A surgical technique to implant radio transmitters has been developed for this project that is an improvement on previously used techniques for varanids or similarly sized reptiles (Ferrell *et al.*, 2005; Reinert and Cundall, 1982; Reinert, 1992; Sweet, 1999). This technique was developed, tested and implemented in the field after visiting Kangaroo Island in January 2007 to observe the procedure used by Dr Peggy Rismiller and after discussion with Dr Sam Sweet and Dr Rebecca Vaughan to modify the procedure. Since March 2007, 10 animals have had a radio-transmitter and two iButton temperature dataloggers surgically implanted subcutaneously rather than into the body cavity, and animals have had blood tests to detect signs of infection or sustained tissue damage as a result of the new technique. Animals have been monitored on about a weekly basis. No animals have shown signs of injury from either blood tests or field observation, and no implanted animals have died during the course of the study. These transmitters last for 12 or 18 months and have been deployed at two sites in the southern baited zone. The radio-transmitters are also temperature sensitive permitting the range of temperatures at which varanids are active to be determined. Records from active animals have ranged from 27.9°C to 42.6°C (average 36.0°C) with basking animals down to 17.3°C (n = 181).

Preliminary results of home range size from radio tracking are depicted in Figure 22 and Figure 23 and actual estimates are presented in Table 12.

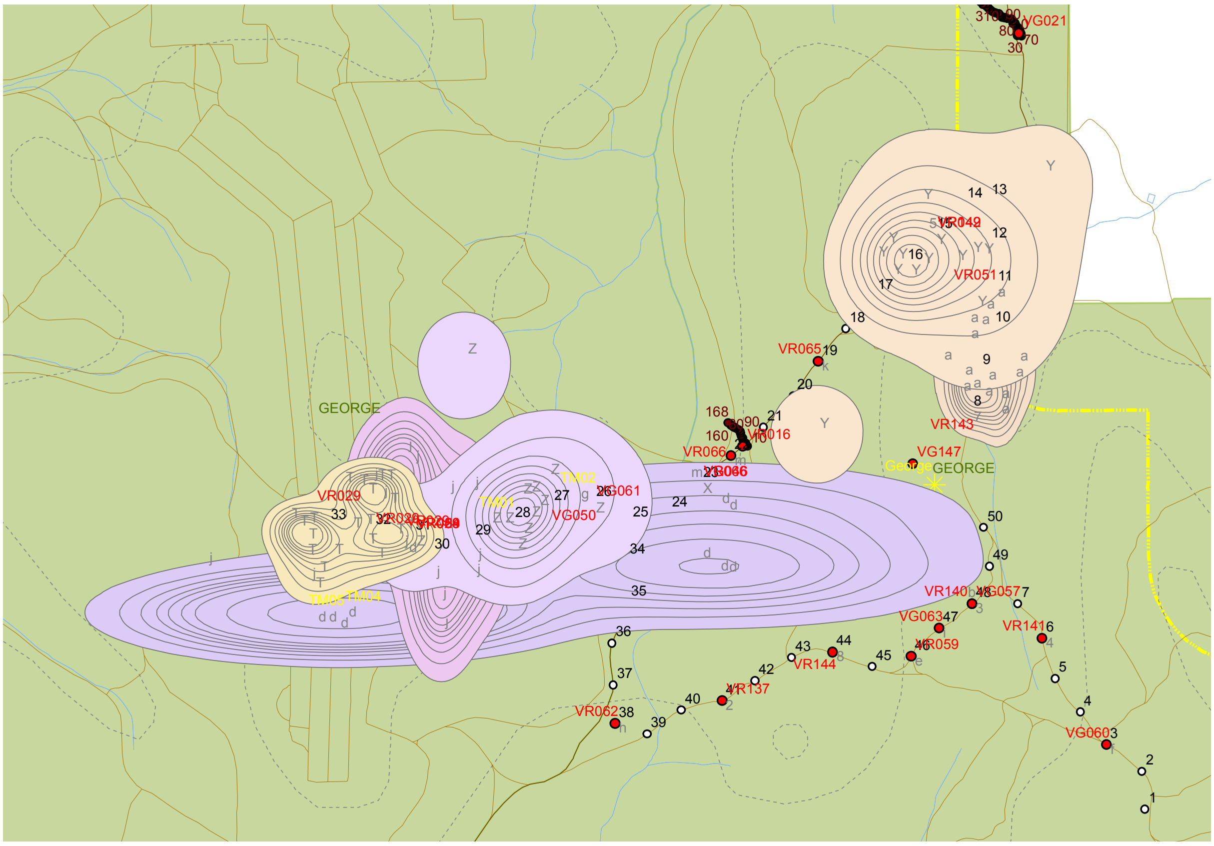

Figure 22: Kernel home range outlines for varanids at George site.

Individual animals are differentiated by colour.

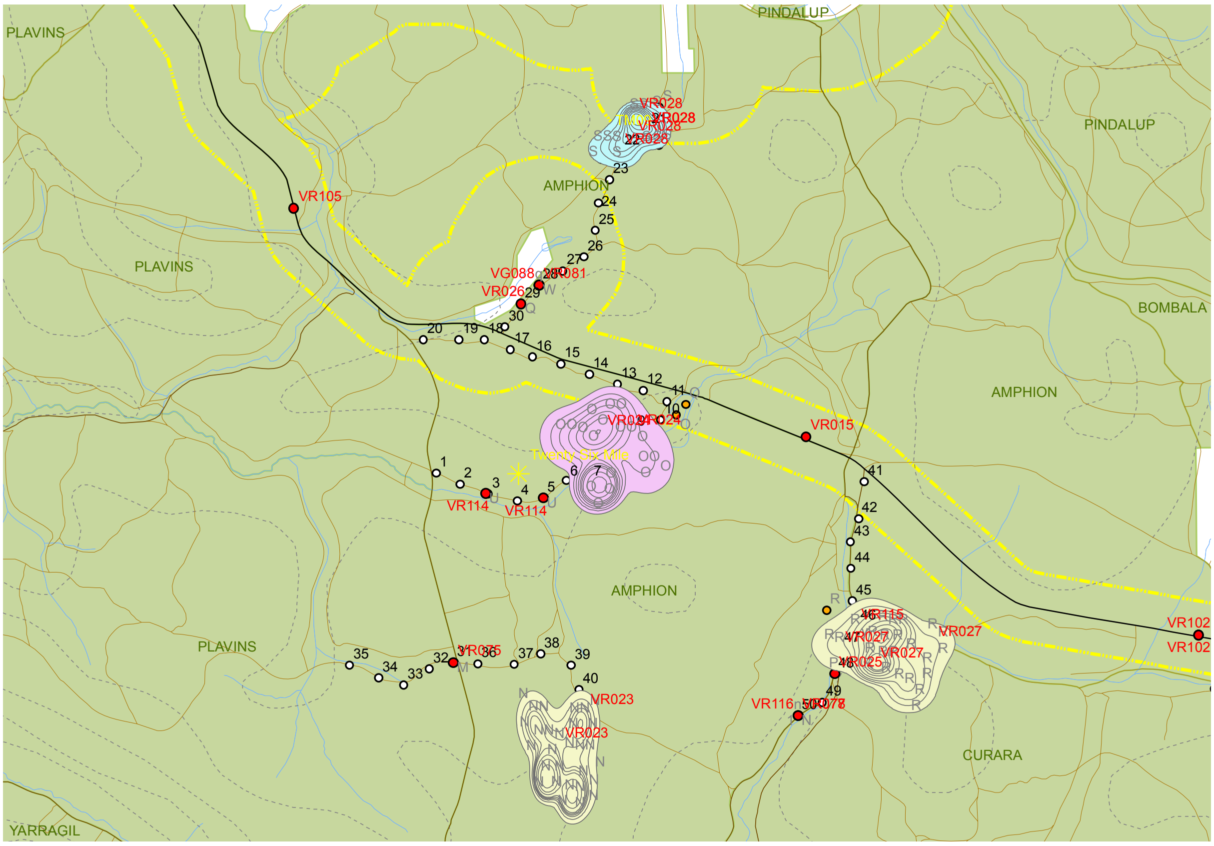

Figure 23: Kernel home range outlines for varanids at 26 Mile site. Individual animals are differentiated by colour.

Table 12: Preliminary kernel home range estimates for 10 varanids in the northern jarrah forest.

ID Code	Sex	Site	Number of fixes	Kernel home range (ha)
VR023	Female	26 Mile	46	41.8
VR024	Male	26 Mile	46	61.9
VR027	Male	26 Mile	36	52.6
VR028	Female	26 Mile	28	21.5
VR029	Female	George	18	40.7
VR049	Male	George	15	139
VR051	Female	George	15	30.9
VR058	Female	George	11	271
VR064	Male	George	14	70
VG050	Male	George	14	103

In addition to conventional radiotelemetry, GPS loggers have been developed in conjunction with Sigma-Delta Technologies specifically for varanid lizards. Ten loggers have been deployed at a northern baited site and an unbaited control site in February 2008 and were due to be recovered in April 2008. The loggers were not recovered but attempts will be made to recover them in spring 2008.

The GPS loggers are also fitted with a light sensor and thermocouple. The light sensor will trigger the GPS to take a fix first thing in the morning so that the overnight burrow is identified then a further 5 fixes are taken at 2 hourly intervals that day. Body temperature and light readings are also recorded at 15 minute intervals throughout the day. On a set date towards the end of the active season for varanids a VHF telemetry module will begin so that loggers can be located and retrieved. GPS loggers were chosen as they offer several distinct advantages over conventional telemetry: they do not require monitoring hence vastly reducing travel and staff costs; the loggers have a rechargeable battery hence can be re-deployed rapidly and the cost of replacing the battery; promise to provide high quality data (6 fixes per day as well as temperature data at 15 minute intervals) that could not be achieved with conventional telemetry.

Microhabitat use is being assessed using spool-and-line devices. An improved methodology for rapid and objective assessment of microhabitat density relevant to studies of predation risk has been developed and a technical note is in preparation. The technique has been implemented for 18 varanids thus far (Figure 24). In addition to structural density, the substrate, height from ground level, log use, and foraging behaviour are recorded at 10 m intervals. Spools are 500 m or 1000 m long.

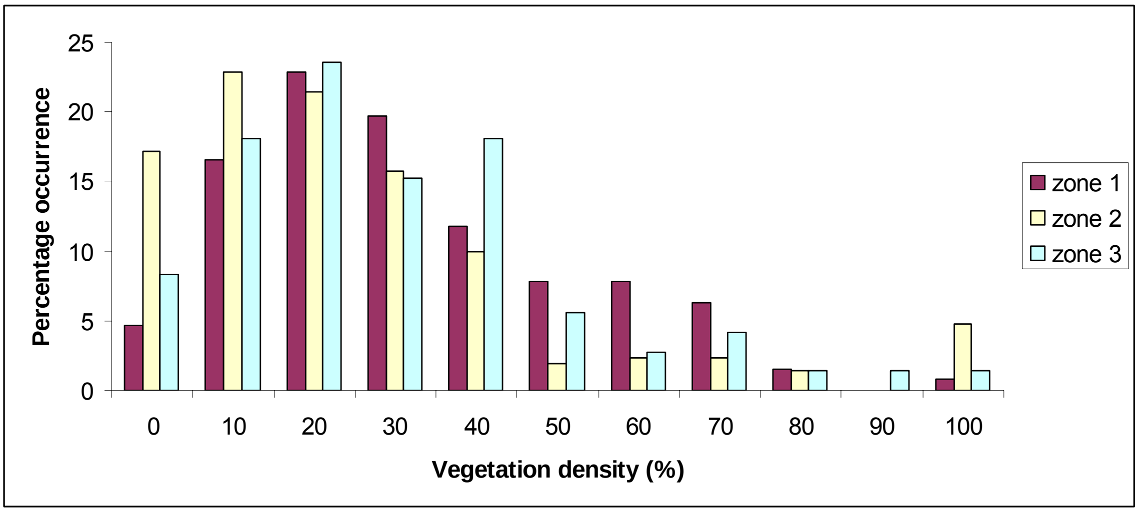

Figure 24: Microhabitat use as measured by percentage vegetation density of varanid lizards in the three treatment zones.

The vegetation density available to the animals is not presented.

To complement the microhabitat use study, the perceived predation risk of the two varanids lizard species is to be investigated with a giving up density (GUD) experiment. A difference in behavioural response by varanids to fox odours in areas of high fox density compared to areas of low fox density will indicate whether varanids perceive foxes as a threat and can respond accordingly.

Temporal activity

The temporal pattern of activity of animals being trapped in this study is being determined by conventional telemetry, the GPS loggers and trap timers. Trap timers have indicated peak periods of activity for those species with sufficient captures (Figure 25). The potential exists for temporal shifts in activity associated with a perceived risk of predation or interference competition by any of the species recorded and may be detected with sufficient records.

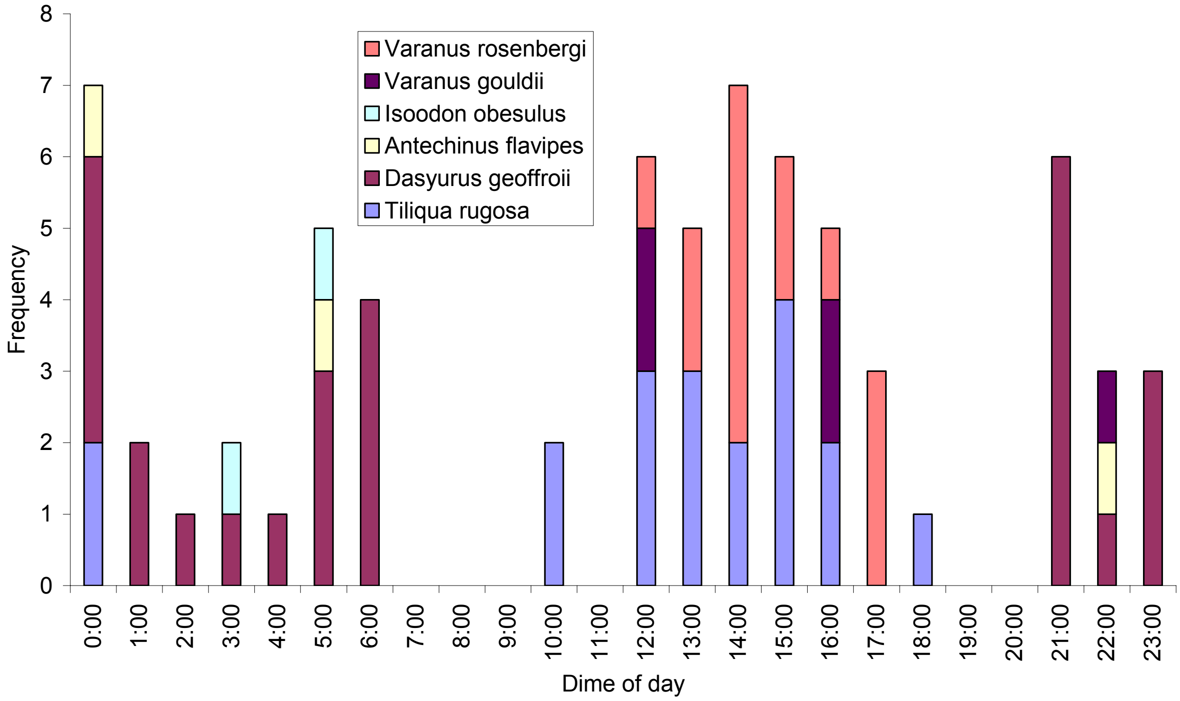

Figure 25: The time of day that trapped animals of six species have been captured in the northern jarrah forest as determined by trap timers (n = 85).

Diet

For dietary analysis and comparison with the diets of foxes and cats in each treatment zone, 45 scats and 22 sets of stomach contents have been collected from varanids. Because captured animals do not regularly provide scats for collection, stomach flushing of some live-captured individuals has commenced (N =2). Samples collected to June 2008 have been sent for analysis with results expected in August.

6.7.3 Python survivorship, behaviour, habitat use and health

Sample size

A total of 45 pythons have been implanted with radio transmitters. Nine pythons are from the northern jarrah forest (all from the southern baited zone), with seven currently still being monitored. Twenty four pythons are from the coastal sites (19 from the baited site at Leschenault Peninsula Conservation Park and five from the unbaited control site at Martin's Tank, within Yalgorup National Park). No successful captures of pythons have occurred in the unbaited zone of the jarrah forest. Therefore, with this lack of pythons, no analyses of jarrah forest pythons in relation to Mesopredator release can be made and it is unreasonable to compare coastal pythons with jarrah forest pythons for reasons owing to pythons residing in very different habitat types.

Of the 45 implanted pythons, 12 have expelled transmitters. The phenomenon of radio transmitter expulsion has been reported previously for pythons (Pearson and Shine, 2002).

Radio telemetry

Pythons are declining all over the world, mainly from human activities. It is possible that these processes may increase the threat of predation by foxes and cats, which may be adding to python decline. There are three threatened python species in Western Australia including the south west carpet python (*Morelia spilota imbricata*).

Although this species of python can measure up to 2.4m in body length and weigh up to 6kg in mass, they are incredibly cryptic animals. This species of python is active during the day or night, where it will use a combination of chemosensory olfaction and rostral and labial pits that extend its range of vision into the infrared spectrum to detect, strike, prey and then kill by constriction and suffocation. Foxes and pythons have a clear overlap in mammalian prey, however, pythons consume a greater proportion of other reptiles compared with foxes (Glen, 2005{Pearson, 2002 #50). When foxes are removed from the ecosystem, python's diet may change in the percentage of animal types they consume. Pythons may also alter their feeding frequency and hence body weight index may change accordingly.

As mentioned previously, conventional methods to assess population can not be employed with this species. Therefore, to assess the response of pythons to fox control, indirect methodologies have been used to monitor the population. Data presented is collected from 45 pythons. Over 700 diurnal and nocturnal location records have been collected. Table 13 provides summary information of the python research.

Table 13: Summary of animal numbers and study site distribution for *Morelia spilota imbricata*

Study site		**Total number**		**Number of Observations**		**Number of body weight Measurements**	
		Females	**Males**	**Females**	**Males**	**Females**	**Males**
Coastal woodland	**Unbaited** Martin's Tank	**2** **(2*, 1$)**	**1** **(1*)**	**105**	**56**	**31**	**18**
	Baited Leschenault Peninsula	**5** **(2*, 8$)**	**7** **(1*, 4$)**	**377**	**231**	**126**	**121**
Jarrah forest	**Unbaited**	**0**	**0**	**0**	**0**	**0**	**0**
	Baited	**3** **(1*)**	**4** **(3*)**	**98**	**123**	**15**	**58**

* Expelled transmitter

$ mortality

Figures

Figure 26 andFigure 27 show microhabitat selection as a percent of sightings for each month of the year. Microhabitats include tree hollows, hollow logs, burrows, tree branches, ground cover, bare ground and in-vegetation. There is a clear pattern at the baited coastal site, Leschenault Peninsula, where pythons use hollow logs and burrows over the hotter months and move into tree hollows over the winter months (Figure 26). This pattern of microhabitat use is not so defined at the un-baited coastal site (Figure 27). A variety of reasons including sample size, temperature (ambient, microhabitat, and body) and other undefined factors could be influencing this trend. Sand plotting for fox density and prey trapping data for prey density will be taken into consideration when finalising these analyses.

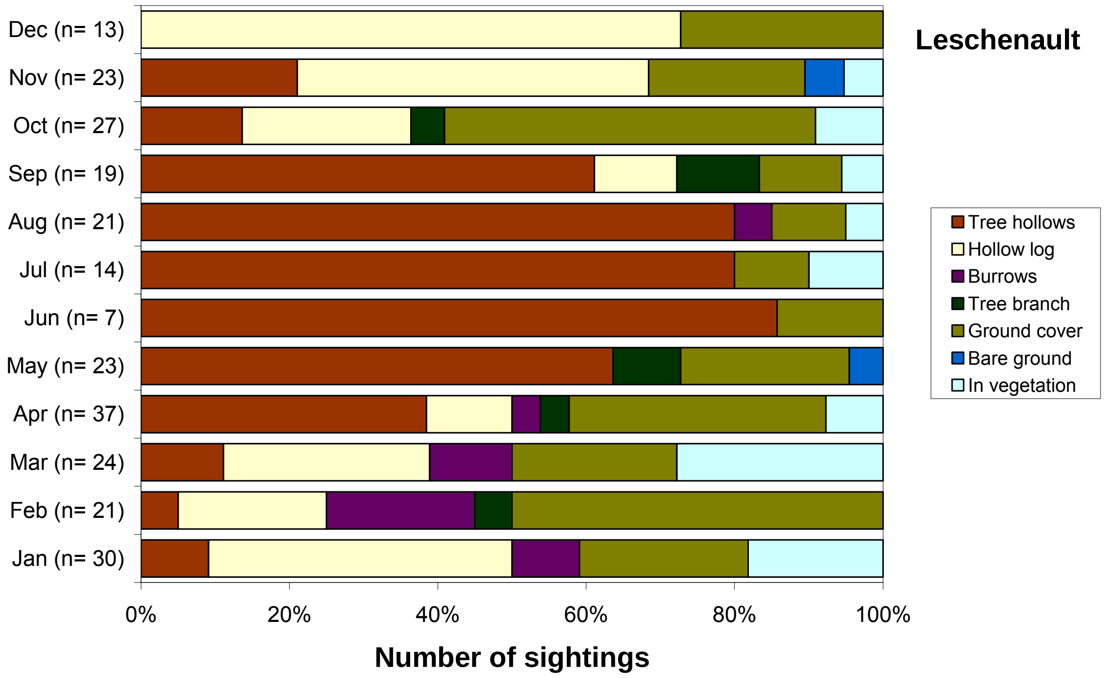

Figure 26: Python microhabitat selection as a percent of sightings each month at the baited coastal site, Leschenault.

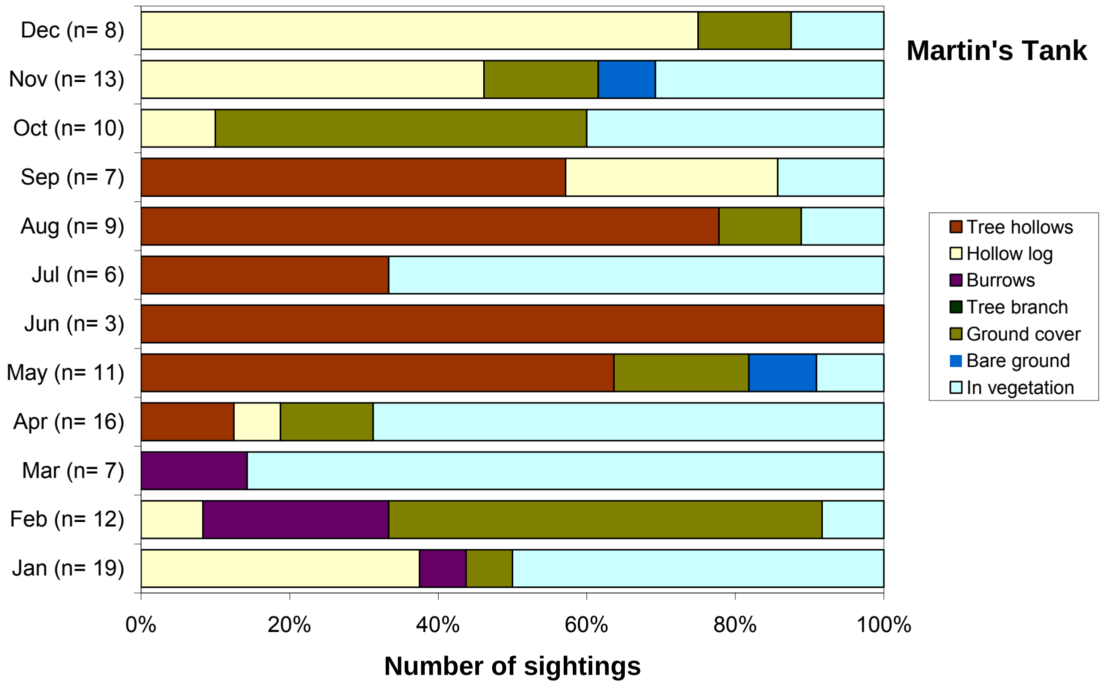

Figure 27: Python microhabitat selection as a percent of sightings each month at the unbaited coastal site, Martin’s Tank

Behavioural data including how much of the python's body it is exposing to the sun while basking at the coastal sites is presented in Figure 28. Data suggest pythons may expose less body to the sun particularly when in loose coil or coil in the unbaited site. Similarly, any number of factors may be responsible for this apparent trend. In the same way as the microhabitat selection data, fox density data will be used when finalising these analyses.

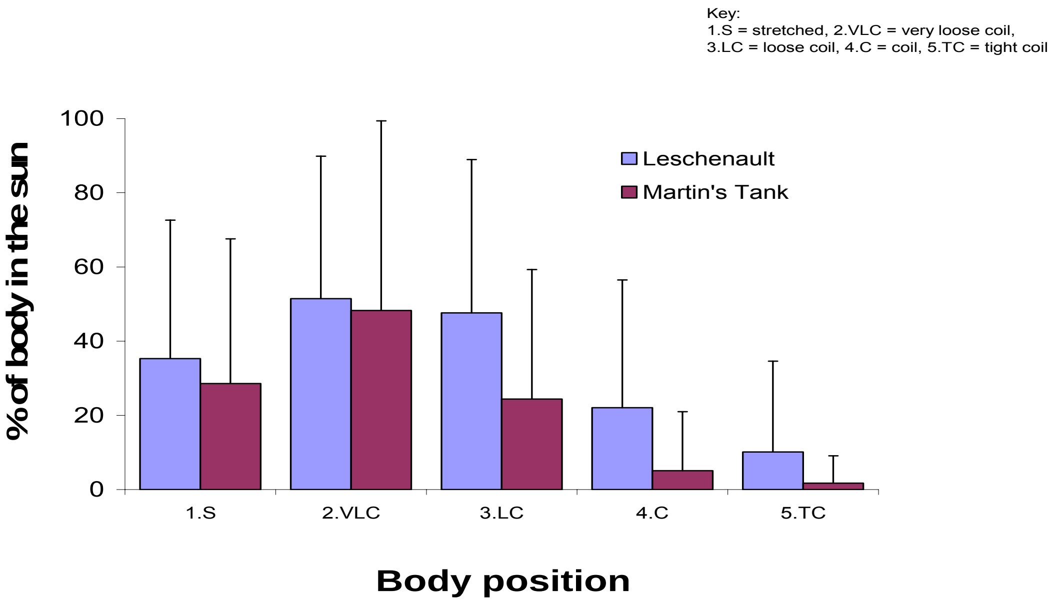

Figure 28: Percent of body pythons expose to the sun when in different body positions at the coastal study sites.

Unfortunately, capture of pythons in the unbaited jarrah forest zone of the study area were unsuccessful. Analysis for assessing Mesopredator release response in pythons is therefore limited to the coastal study sites. Considering the cryptic nature of this species, it will be necessary to combine the indirect population health and behaviour data collected over the last two-three years with fox density and prey availability data to analyse and interpret all factors of the python's ecology to determine if a Mesopredator release response occurs in this species.

6.8 Availability of prey species – trapping webs

Ten trapping webs have been established (Figure 3) and are trapped seasonally to assess prey availability. The first web trapping session was Spring 2007, after each treatment had received six baitings in the preceding year. Trapping results are highly skewed, with a patchy distribution and abundance of species between and within treatments (see previous report). Density estimates for each species will be derived at completion of five consecutive trapping sessions.

The low capture rate, *i.e.* confirmation of sparse data from trapping, has justified the commitment to trapping webs.

6.9 Habitat assessment of trapping webs

Site assessment at all trapping grids, to quantify vegetation structural heterogeneity and other site specific habitat variables, is scheduled to commence Autumn 2009.

6.10 Brushtail possum density estimates, survivorship, behaviour, habitat use and health

6.10.1 Diet

Thirty six scats were collected during the winter 2008 trapping session. The techniques of scat analysis have been refined and will commence in July 2008. Scats will be collected in the next four trapping sessions in order to look at seasonal trends.

6.10.2 Effect of resource availability and predation on density of western brushtail possum populations

One hundred and four possums have been captured from 10 sites trapped from winter 2006 until winter 2008 (Table 14). Lake Nalyerin and Miner Rd were only trapped once in search of more possum populations with negative results. George, Jarrahdale Rd and Stene were the only sites with good number of possums present. Measurements of den and food availability will commence in July 2008.

Table 14**:** Total number of female and male brushtail possums trapped up to date.

Bold cells are sites in the baited zones and non-bolded cells are sites in the unbaited zone. (-) indicates possums that are known to have died since trapping (from radio-tracking).

Site	**Possums trapped**	
	male	**female**
Jarrahdale Rd	**30**	**24(-1)**
Wearne	**1**	**0**
O'Neil	**1**	**0**
26 Mile Rd	**0**	**0**
Hotham	**3**	**0**
George	**10**	**5**
77 Rd	0	0
Miner Rd	0	0
Stene	14(-1)	13
Lake Nalyerin	-1	0

6.10.3 Effects of resource availability and predation on western brushtail possum population parameters

Measurements of body condition, survival, reproductive output, density and offspring sex ratio have been collected since winter 2006. Measurements of resource availability will commence in July 2008.

6.10.4 Disease

Results up to date don't reveal any sign of decreased fitness due to disease in those possums tested (Table 15). No significant number of pathogens was isolated and all possums tested for toxoplasmosis yielded negative results. Further analysis on haematology and biochemistry is still lacking. Baseline haematology and biochemistry data obtained for possum populations from the northern jarrah forest will be compared with coastal populations of WA through a collaboration with Helen McCutcheon (PhD student) and Judy Clarke (PhD student), who are currently health-screening brushtail possums in Busselton and Leschenault. Results are expected to be submitted for publication within the next 12 months.

Table 15: Health-screening results of radio-collared possums.

WBC = white blood cell count.

Site	Sample ID	WBC (x109/L)	Toxoplasmosis	Pathogens from urine & faeces
George Rd	Dawn	-	-	none isolated
George Rd	Peter	2	-	none isolated
George Rd	Sandy	3.8	-	none isolated
George Rd	Kynan	4.5	-	-
George Rd	Frank	1.5	-	-
George Rd	Jordan	7.4	-	-
Jarrahdale Rd	Chloe	7.0	-	none isolated
Jarrahdale Rd	Julie	4.4	Negative	none isolated
Jarrahdale Rd	Rob	2.9	Negative	none isolated
Jarrahdale Rd	Alistair	3.1	Negative	none isolated
Jarrahdale Rd	Gary	-	-	none isolated
Jarrahdale Rd	Victor	-	-	none isolated
Jarrahdale Rd	Mat	-	-	none isolated
Jarrahdale Rd	Maria	2.5	-	-
Stene	Duncan	2.6	Negative	-
Stene	Han	2.0	-	-
Stene	Ross	1.6	-	-
Stene	Judy	2.8	Negative	none isolated
Stene	Bryan	7.4	Negative	none isolated
Stene	Gillian	4.6	Negative	none isolated

6.10.5 Behavioural responses to predation

A total of 15 possums are currently radio-collared. A sub-adult male from Stene, a sub-adult male from Lake Nalyerin and an adult female from Jarrahdale have been the only mortalities up to date. The death at Stene was a fresh kill (the night before) allowing for the use of wildlife forensics to determine the cause of death. The mortality was attributed to cat predation. DNA results provided by Oliver Berry confirmed results. The mortality at Lake Nalyerin could not be attributed to a particular predator based on evidence at the scene. However, DNA results revealed that it was a cat predation. Both Lake Nalyerin and Stene are sites located in the unbaited area. No predations have been observed at the baited areas. The female at Jarrahdale was run over by a car.

Over 300 nocturnal and diurnal fixes from 20 possums have been collected so far from Jarrahdale Rd, Stene and George. However results are presented for Jarrahdale Rd and Stene only because not enough fixes have been collected at George to allow preliminary comparisons. Based on results to date, there appear to be differences in the size of home-ranges and the number of dens used between the two sites (see: Figure 29 and Table 16Table 16: Kernel homerange estimates (95% isopleth) of brushtail possums and number of dens used by individual possums at Stene (unbaited) and Jarrahdale Rd (fox-baited).

Blue cells highlight sites in the baited zones and pink cells highlight sites in the unbaited zone.). Results suggest less den-swapping and smaller home-ranges in the unbaited area compared to the baited area. However, it is still too early to say whether these differences are due to different predator pressures or related to food availability, possum density or habitat structure at the sites.

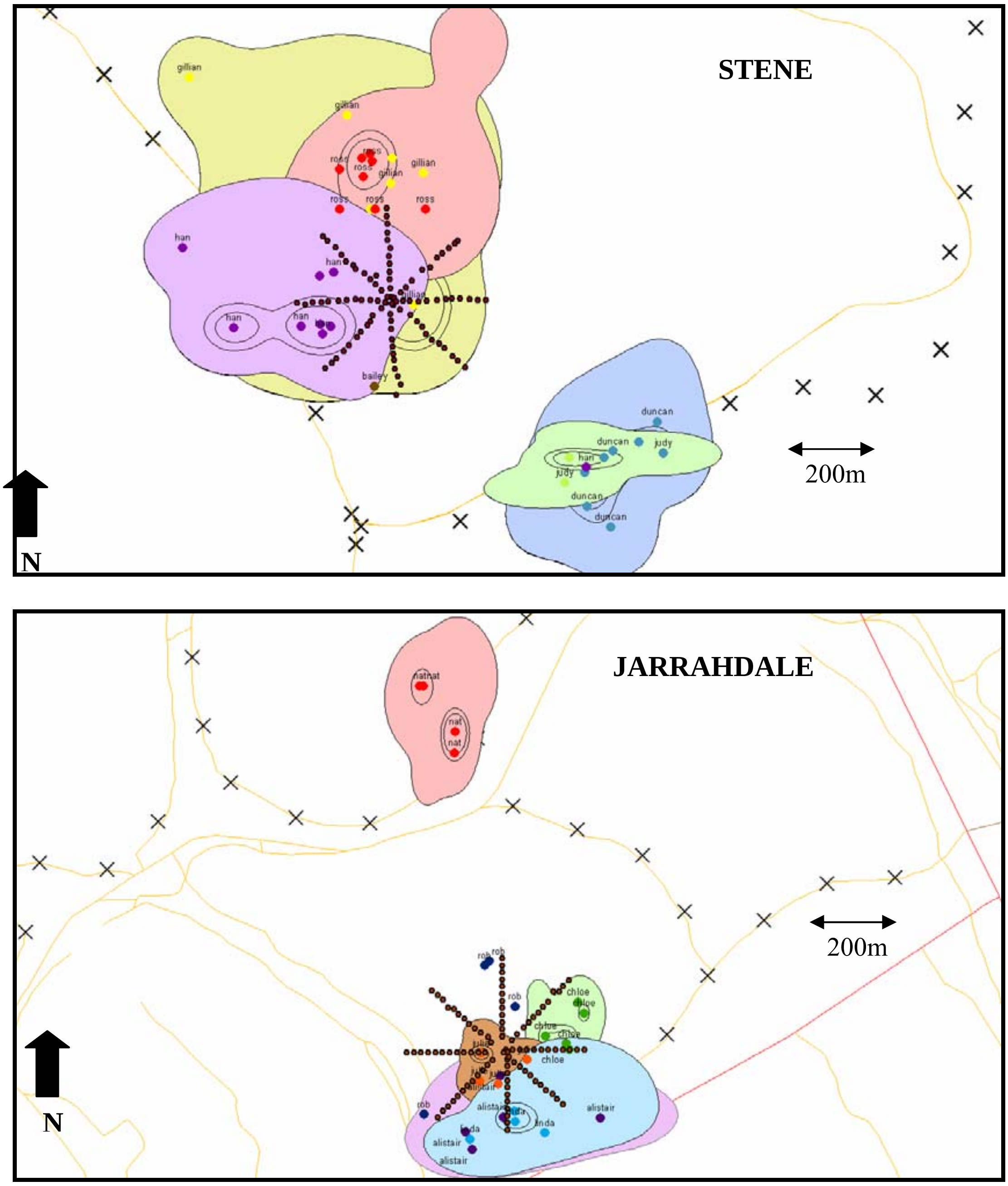

Figure 29: Kernel home range outlines (10, 50, 90 isopleths) for possums radio-collared at Stene (unbaited) and Jarrahdale Rd (baited).

Filled dots indicate den trees. Individual possums are represented by different colours. Crosses indicated road trap points.

Table 16: Kernel homerange estimates (95% isopleth) of brushtail possums and number of dens used by individual possums at Stene (unbaited) and Jarrahdale Rd (fox-baited).

Blue cells highlight sites in the baited zones and pink cells highlight sites in the unbaited zone.

Site	Animal ID (name)	Home-range (ha)	No. of fixes	No. of dens
Jarrahdale	6 (Julie)	4.65	18 (5)	4
Jarrahdale	3 (Alistair)	11.88	22 (9)	6
Jarrahdale	1 (Linda)	16.73	25 (9)	6
Jarrahdale	4 (Chloe)	6.49	20 (8)	6
Jarrahdale	2 (Nat)	11.88	20 (7)	4
Jarrahdale	5 (Rob)	-	19 (8)	4
Stene	15 (Han)	26.86	29 (9)	9
Stene	16 (Ross)	26.01	27 (9)	8
Stene	17 (Gil)	59.54	26 (9)	8
Stene	14 (Duncan)	20.01	20 (8)	9
Stene	18 (Judy)	7.50	17 (4)	5

Thirty six possums have been fitted with spools up to date from Jarrahdale Rd, Stene and George. Preliminary data analysis does not account for available habitat at each of the sites however, there appears to be no selection for greater percentage cover at any of the three sites, which all show similar trends (Figure 30). Possums also appeared to have chosen to stay close to escape trees (1-2m) while on the ground, irrespective of site (Figure 31). Comparisons with available habitat (using controls) still need to be made in order to confirm that this is actually being selected by possums rather than an artefact of habitat availability. A methodology for assessment of available habitat at a micro-scale has also been developed in association with Glen, A. and Sutherland, D. (see section 6.7.1) and assessments of available habitat will commence in October 2008.

Figure 30: Frequency of occurrence of percentage cover used by brushtail possums (taken every 10m along spools) while on the ground at three sites in the northern jarrah forest

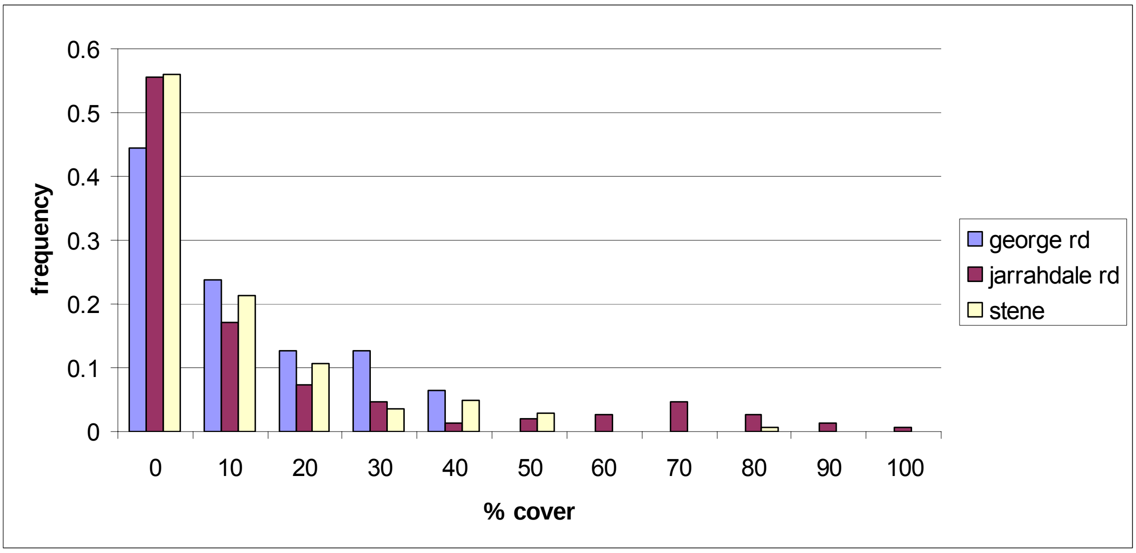

Figure 31: Frequency of occurrence of distance from nearest escape tree (taken every 10m along spools) while brushtail possums travelled or foraged on the ground at three sites in the northern jarrah forest

7 Publications and presentations

7.1 *Publications (published or in review)*

Glen, A. S. and Dickman, C. R. (2008). Niche overlap between marsupial and eutherian carnivores: does competition threaten the endangered spotted-tailed quoll? *Journal of Applied Ecology*. 45: 700-707.

Glen, A. S., Dickman, C. R., Soulé, M. E. and Mackey, B. G. (2007). Evaluating the role of the dingo as a trophic regulator in Australian ecosystems. *Austral Ecology* 32, 492-501.

Glen, A. S., Gentle, M. N. and Dickman, C. R. (2007). Non-target impacts of poison baiting for predator control in Australia. *Mammal Review* 37, 191-205.

Glen, A. S. (2007). Mesopredator release: the Australian evidence. In *Biodiversity Extinction Crisis - A Pacific Response*, p 56. Society for Conservation Biology, Sydney.

Glen, A. S. (2007). 'Hotspot' of threatened chuditch in Western Australia's jarrah forest. *Australian Wildlife* 2007 (3), 15-16.

Dickman, C. R., Glen, A. S. and Letnic, M. (in press). Reintroducing the dingo: can Australia's conservation wastelands be restored? In 'Reintroduction of top-order predators' (eds M. W. Hayward and M. J. Somers). (Blackwell Scientific Publishing.)

Glen, AS, Cardoso, M, Dickman, CR and Firestone, KB (in press). Who's your daddy? Promiscuous mating and multiple paternity in the carnivorous marsupial *Dasyurus maculatus* (Marsupialia: Dasyuridae). *Biological Journal of the Linnean Society.*

de Tores, P. and Berry, O. (2007). Will curiosity kill the cat? *Landscope* 22 (3):49-55.

Glen, A. S. (in review). Population dynamics of the spotted-tailed quoll (*Dasyurus maculatus*) in north-eastern New South Wales. Submitted to *Australian Journal of Zoology*.

Glen, A. S. and Dickman, C. R. (in review). Why are there so many spotted-tailed quolls (*Dasyurus maculatus*) in parts of north-eastern New South Wales? Submitted to *Australian Zoologist*.

Glen, A. S. and Dickman, C. R. (in review). Population viability analysis shows spotted-tailed quolls may be vulnerable to competition. Submitted to *Wildlife Research*.

Cruz, J., Leung, L. K.-P., Lisle, A., Rivera, D. F., Staples, L., Smith, M. (in press). Grain, pellet and wax block bait take by the house mouse (*Mus musculus,* Linnaeus 1758) and non-target species: implications for mouse eradications on coral cay islands in the Great Barrier Reef, Australia. *Integrative Zoology*

Sutherland, D. R., Glen, A. S. and Cruz, J. (in press). An alternative spool-and-line device for medium sized animals. *Australian Mammalogy.* **30** xxx-xxx.

7.2 *Publications (in prep)*

Sutherland, D. R., Glen, A. S. and Cruz, J. (in prep). An improved method of microhabitat assessment relevant to predation risk. To be submitted to *Journal of Zoology (London).*

Glen, A. S., de Tores, P. J., Sutherland, D. R. and Morris, K. D. (in prep). The chuditch (*Dasyurus geoffroii*) and its interactions with introduced predators: a review. To be submitted to *Wildlife Research.*

Glen, A. S., Berry, O., Sutherland, D. R., Garretson, S., Robinson, T. and de Tores, P. J. (in prep). Killing of a chuditch (*Dasyurus geoffroii*) by a feral cat (*Felis catus*): a case of competitive killing? To be submitted to *Wildlife Research.*

Sutherland D. R., Glen A. S., Green B. I. and de Tores P. J. (in prep.) Native reptilian and introduced mammalian carnivores in Australia: serious competitors or disinterested onlookers? For submission to *Austral Ecology*.

Sutherland DR and Predavec M (in prep.) Examining temporal activity patterns on a budget: a design for universal trap timers. For submission to *Journal of Wildlife Management*.

Sutherland DR, Kearney, MR and Porter WP (planned) A mechanistic investigation into exploitation competition between varanid lizards, foxes and cats. For submission to *Ecology*.

7.3 Oral presentations:

Sutherland DR (2007) Do goannas respond to introduced predator control in the northern jarrah forest? Ecological Society of Australia, Perth, WA

Sutherland DR (2007) Introduced predator management and its impact on varanid lizards. Australian Society of Herpetologists, Albany, WA, pp 54

Sutherland DR (2007) Predator interactions and conservation in the jarrah forest. Murdoch University Wildlife Association Predator Bonanza, Murdoch, WA

Sutherland DR (2007) How could mice prevent a mouse plague? A trip into self-regulation. UWA Research Seminar Series, UWA, WA

Sutherland DR (2007) What triggers a mouse plague? Dwellingup Research Seminar Series, Dwellingup.

Sutherland DR (2007) Goannas and introduced predators in the jarrah forest. University of the Third Age, Dwellingup, WA.

Bryant, G. The south-west carpet python *Morelia spilota imbricata* and its role as a mesopredator of threatened mammals. DEC, Dwellingup Research Seminar Series, Seminar No. 4. November 2006.

Glen AS (2007) Carnivore communities in Australia: challenges and opportunities for conservation. Curtin University.

Glen AS (2007) Are dingoes the top dog in Australian ecosystems? Murdoch University.

Glen AS (2007) Competing carnivores? The relationships between predator species in Australia. DEC Seminar Series.

Glen AS (2007) Chuditch and introduced predators in the northern jarrah forest. University of the 3rd Age.

Glen AS (2007) Competing carnivores? The relationships between predator species in Australia. University of Western Australia.

Glen AS (2008) Predator control and fauna recovery in the northern jarrah forest. Dwellingup Community Seminar.

7.4 Conference posters

de Tores PJ, Marlow N, Algar D, Morris KD, Glen AS, Sutherland DR, Cruz J, Bryant J (2007) Mesopredator release – a response to 1080 control of foxes in WA. What is the evidence and what are we doing? Ecological Society of Australia, Perth WA.

7.6 Media and press releases

Resurgence of research staff at the Dwellingup Research Centre. March 2007

IA CRC national research program review at Dwellingup. April 2007

Chuditch and goanna hotspot near Dwellingup. DEC Media release, 8th August 2007.

Trappings uncover chuditch hotspot. *Mandurah Mail*, 16th August 2007.

7.7 Anticipated publications

de Tores *et al*. (planned) Cascading effects of single and multi-species predator control: response of mesopredators and prey.

de Tores *et al*. (planned). An assessment of the effectiveness of 1080 baiting at the landscape scale to control foxes

de Tores *et al*. (planned) Use of satellite telemetry to monitor fox and cat movements in a forest environment

de Tores *et al*. (planned) Home range overlap of two competing introduced predators in the northern jarrah forest of south-west Western Australia

de Tores *et al*. (planned) Dietary overlap of two introduced predators, the fox and feral cat, in the northern jarrah forest of south-west Western Australia de Tores *et al.* Non-target uptake of the feral cat bait Eradicat® in mesic environments. For submission to *Wildlife Research*.

de Tores *et al*. (planned) Do density estimates derived from sandplots concur with those derived from mark-recapture?

Hill, R, Bloomfield, L, Garretson, S Nowicki, A and de Tores, P (planned) Assessment of the use of trapping webs to quantify prey availability when data are sparse

Garretson, S *et al*. (planned) Use of a tunnel device to collect hair from two trap shy introduced predators, the fox and feral cat, in a forest environment in south-west Western Australia

Sutherland DR, Kearney, MR and Porter WP (planned) How do sympatric goannas *Varanus gouldii* and *V. rosenbergi* separate their niches? For submission to *Austral Ecology*.

Sutherland DR *et al.* (planned) Response of varanids to single and multi-species predator control. For submission to *Journal of Applied Ecology*

Sutherland DR *et al.* (planned) The population structure of varanid lizards in the northern jarrah forest. For submission to *Molecular Ecology.*

Sutherland DR *et al.* (planned) Dietary overlap within sympatric diurnal reptilian predators and nocturnal mammalian predators. For submission to *Austral Ecology*.

Sutherland DR *et al.* (planned). Is there a shift in foraging behaviour of native reptilian predators under introduced predator control? For submission to *Journal of Applied Ecology*.

Sutherland DR, Vaughan RJ and de Tores PJ (planned) An improved surgical technique for implanting transmitters into varanid lizards. For submission to *Journal of Zoo and Wildlife Medicine*.

Sutherland DR and de Tores PJ (planned) On detecting the systemic marker, Rhodamine B, in a reptilian predator. For submission to *Wildlife Research*.

Sutherland DR, Green B, Rismiller PD, McKelvey MW and Spencer PBS (planned) Comparative population structuring of *Varanus rosenbergi* from eastern and Western Australia. For submission to *Molecular Ecology*.

Sutherland DR (planned) Determining gender of varanid lizards from morphology. For submission to *Herpetological Review*.

Glen AS *et al.* (planned) Comparative demography of chuditch in areas with and without fox control. For submission to *Wildlife Research.*

Glen AS *et al.* (planned) Niche overlap between chuditch, foxes and feral cats. For submission to *Austral Ecology.*

Glen AS *et al.* (planned) Population genetics of chuditch in the northern jarrah forest. For submission to *Molecular Ecology.*

Glen AS *et al.* (planned) Diet of chuditch by sex and size class. For submission to *Wildlife Research.*

Glen AS *et al.* (planned) Home ranges and microhabitat use of chuditch. For submission to *Journal of Zoology (London).*

Glen AS *et al.* (planned) Response of chuditch to single- and multi-species predator control. For submission to *Journal of Applied Ecology*.

Glen AS *et al.* (planned) Why do turds suddenly appear? ‘Scat traps’ for DNA capture-mark-recapture analysis. For submission to *Journal of Applied Ecology*.

Cruz, J., de Tores, P.J., Leung, L. (planned) Landscape factors associated with the decline of brushtail possum populations in the northern jarrah forest. For submission to *Conservation Biology*

Cruz, J., de Tores, P.J., Leung, L. (planned) Are brushtail possums in the northern jarrah forest doomed for extinction? For submission to *Biological Conservation*

McCutcheon, H., Clarke, J., Cruz, J., Warren, K and de Tores, P.J. Are brushtail possums in the northern jarrah forest healthier than possums on the south coast of WA? For submission to *Journal of Zoo and Wildlife Medicine*

Cruz, J., de Tores, P.J., Glen, A.S., Sutherland, D.R., Leung, L. (planned) Effects of predation and food availability on the home-range of western brushtail possums. For submission to *Journal of Applied Ecology*

Cruz, J., de Tores, P.J., Leung, L. (planned) Runaway brushtails! Differences in micro-habitat use by brushtail possums to avoid predation from different predator assemblages. For submission to *Austral Ecology*

Bryant G *et al*. (planned) Diet and feeding ecology of the western carpet python.

Bryant G *et al*. (planned) Microhabitat selection of the western carpet python

Bryant G *et al.* (planned) Home range and habitat use of the western carpet python

Bryant G *et al*. (planned) Thermal biology of the western carpet python

Bryant G *et al.* (planned) Haematology of the western carpet python

Bryant G *et al*. (planned) Surgical implantation and solution to prevent radio-transmitter expulsion

Bryant G *et al.* (planned) Reproduction and chemical cue receptivity in south west carpet python

Bryant G *et al*. (planned) Locomotion and energetics in a sexually dimorphic python species

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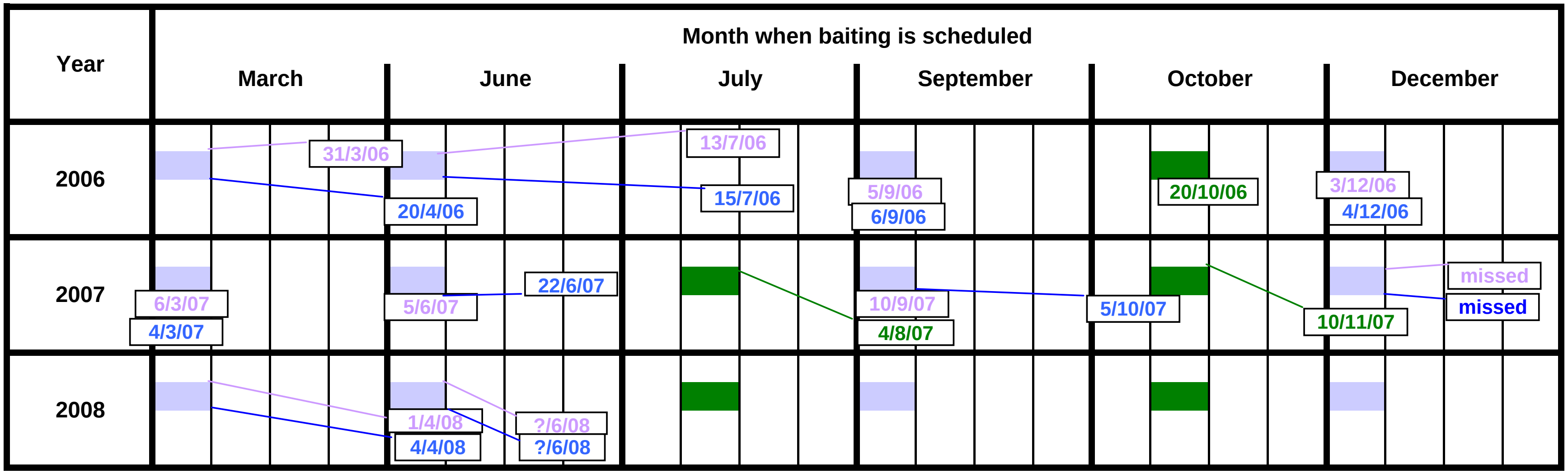
9. Appendices

Appendix 1: The aerial baiting schedule and history of aerial baiting events in the northern jarrah forest predator interaction study.

Appendix 1: The aerial baiting schedule and history of aerial baiting events in the northern jarrah forest predator interaction study.
Aerial baiting is scheduled six times per year, in March, June, July, September, October and December.



🟪 Scheduled baiting for the Perth Hills aerial baiting cell and the Lane Poole aerial baiting cell combined (both cells)
(nominal only - subject to weather conditions and logistics)
Actual date of baiting:
31/3/06 Perth Hills Cell
31/3/06 Lane Poole Cell

🟩 Scheduled baiting for the Perth Hills / Lane Poole aerial baiting cell - the additional (5th and 6th) baiting events of the northern jarrah forest predator interaction study area
(nominal only - subject to weather conditions and logistics)
Actual date of baiting:
31/3/06 Perth Hills / Lane Poole Cell