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Diagnosing recent woylie declines in south-western Australia: Situation assessment, research approach and disease investigations

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Abstract

The woylie (*Bettongia penicillata ogilbyi*) made a strong recovery since the 1970's in response to fox control and subsequent reintroductions. However, since 2001 rapid and substantial declines of woylies have occurred, especially in the largest and most important populations such as the remnant 'natural' populations and the largest, previously most successful reintroduced populations. These extensive declines have so far resulted in the loss of as much as 95% from some populations in a matter of a few years. There are now few moderate density populations remaining in south-western Australia.

Collaborative and integrated research is underway to investigate the cause(s) of the woylie declines. A notoriously difficult endeavour, the scientific approach to diagnose the declines is briefly outlined. A meta-analysis of available woylie data from the last 30 years will provide an insight into the temporal, spatial and demographic changes in woylie populations. An intensive population comparison study, involving populations at various stages of decline, examines in detail woylies (demographics, survival and mortality) as well as the primary putative causes that can be broadly classified as predation, resources, disease and direct human interference. Details of the approach to the disease investigations are provided.

Situation Assessment

Woylie population change

The woylie (*Bettongia penicillata ogilbyi*) had a distribution across much of Australia prior to settlement by Europeans (Figure 1). By the 1960's the woylie was reduced to three isolated remnant populations in south-western Australia (Upper Warren [principally Perup], Tutanning and Dryandra) (Figure 2). Fox control and woylie reintroductions began in the 1970's. Since 1996, these activities have been expanded and strategically managed as part of the 'Western Shield' conservation program (Orell 2004). These efforts resulted in a dramatic recovery that culminated in the woylie being the first Australian mammal to have its conservation status downgraded as a result of it being delisted from Commonwealth and State conservation lists (Endangered / Threatened) in 1998 (Start et al. 1998).

Since 2001, however, woylie populations throughout southwestern Australia have undergone rapid and substantial declines. For example, trapping data from long-term monitoring and research has indicated that the woylie population at Dryandra declined by about 90% between 2001 and 2005. The Upper Warren population(s) underwent a median and mean decline of 95% between 2002 and early 2007. The woylie population at Batalling (a 1982 reintroduction site east of Collie; Figure 2) declined by at least 70% between 2003 and 2006. Evidence from multiple sources including live trapping, sand pad surveys, woylie nest and digging densities and spotlight surveys all concur and demonstrate that these declines are real (Wayne 2006). A concurrent woylie decline has also been observed in South Australia (Venus Bay Peninsula); while South Australian island populations appear to have remained relatively stable (pers comm. J. VanWeenan).

In general, the largest and most substantial woylie populations have undergone substantial declines while the very small and/or low density, often isolated populations appear to be less affected. Overall, an estimated 70-80% decline in woylie numbers has occurred in Australia over five years. These declines are still continuing and there is little evidence of signs of a recovery (Freegard 2007). While introduced predators (fox and cat) and habitat loss were among the principal factors thought responsible for historical declines, the cause(s) of these current declines is unknown.

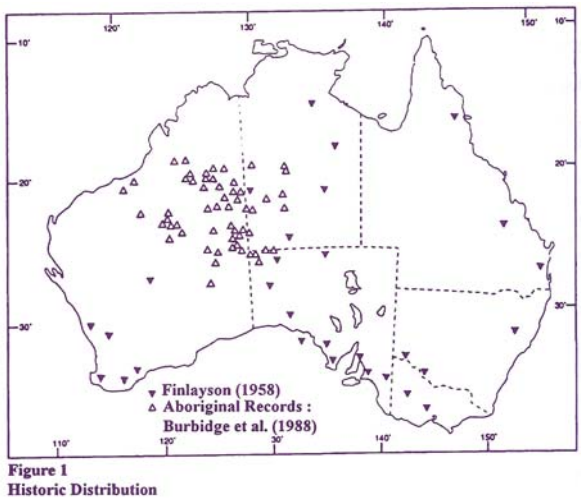

Figure 1. Historic distribution of woylies (*Bettongia penicillata*). Source: Start et al. (1995)

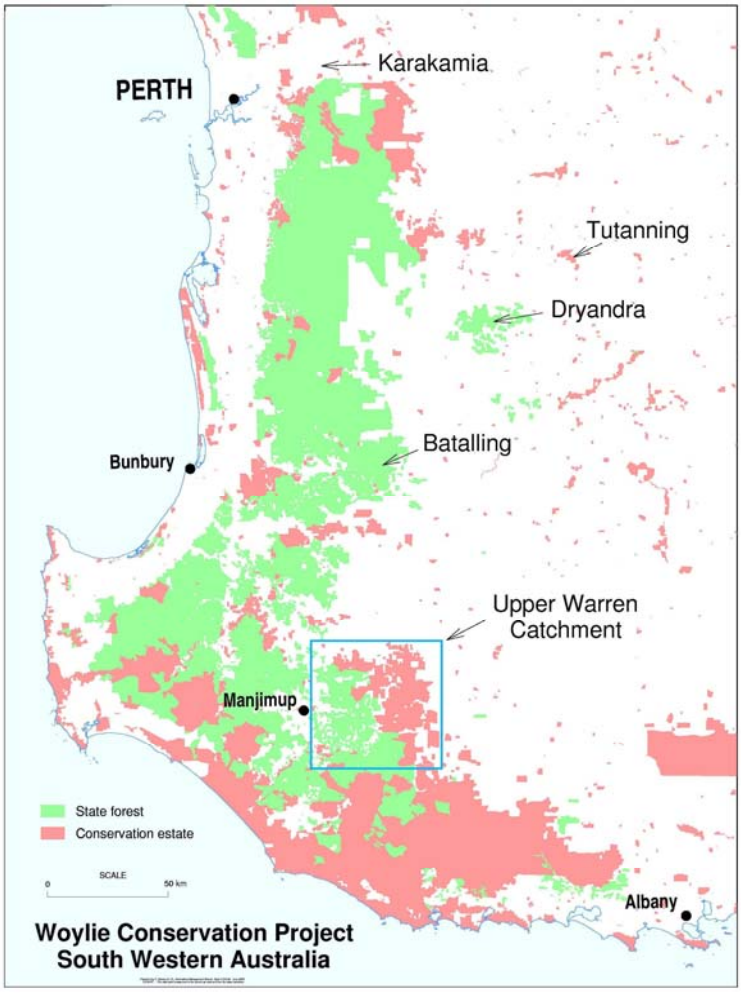

Figure 2. The location of important woylie populations in southwestern Australia.

Diagnosing woylie declines: the Research Approach

The Department of Environment and Conservation (DEC) has established a comprehensive and collaborative effort to diagnose the recent woylie declines.

The principal aims of the woylie conservation research project (WCRP) are;

a) Determine the causal factors responsible for the recent woylie declines in south-western Australia;

b) Identify the management required to ameliorate these declines; and,

c) Develop mammal monitoring protocols that will better inform factors associated with future changes in population abundances.

Determining the cause(s) of population or species decline is notoriously difficult (e.g. Caughley 1994; Caughley and Gunn 1996; Peery et al. 2004). Common challenges identified in the literature include;

i) Overcoming the complexity due to the likelihood of multiple factors being involved either simultaneously or sequentially.
ii) The need to separate independent effects to avoid the confounding between factors.
iii) Discriminating between causes, effects, and associations (coincidental or otherwise).
iv) Detecting reduced survival or productivity caused by environmental contaminants or disease is rarely straightforward.
v) The influence of habitat upon the decline of a species is particularly difficult to diagnose and that a safer preliminary hypothesis would conjecture that a species ends up, not in the habitat most favourable to it, but in the habitat least favourable to the agent of decline.
vi) The need to reduce some causal agents, such as habitat modification, down to the individual processes and specific effects (e.g. resource elements such as food and shelter).
vii) Avoiding the seduction of the obvious and the easy to measure. Not all agents are so conspicuous, which in no way lessens their importance.

Scientific rigour is, therefore, critical to the success of endeavours to identify the cause(s) of a species' decline. Based on the 'declining population paradigm' and related scientific approaches (e.g. Caughley 1994; Caughley and Gunn 1996; Peery et al. 2004) the diagnosis framework used to investigate the recent woylie declines is;

1) Confirm that the population has declined.
2) Determine the spatial, temporal and demographic characteristics of the observed decline.
3) Understand the species' ecology.
4) Identify all potential causes.
5) Use circumstantial evidence to help shortlist the potential causes.
6) Seek direct evidence – test putative causes.

7) Given the evidence, determine the most appropriate conservation and management responses within an active adaptive management framework.

The WCRP uses a hypothetico-deductive approach (as recommended by Caughley 1994) involving parallel lines of enquiry addressing the numerous possible agents of decline, most of which can be broadly classified into four major groups;

1. Resources – including food depletion and consequences of climate change, fire management, etc.
2. Predation – including native and introduced species, and effectiveness of current control measures.
3. Disease – including known and novel agents (viral, haemaparasites, endoparasites, ectoparasites, bacterial diseases, nutrition and toxicology).
4. Direct human interference – e.g. negative consequences of trapping (over-harvesting for translocations, disrupted breeding success, reduced condition, injuries, increased stress and susceptibility to other mortality factors).

The research has a specific focus on the Upper Warren region to concentrate existing resources in the one area where declines have been current. Such a focus is expected to improve the chances of success and eliminate the potential confounding of differences in the factors being potentially at play elsewhere. Nonetheless, information from other woylie populations has been incorporated through collaborations with other research and monitoring wherever appropriate and possible.

The project has three major components that together, address the above diagnosis framework.

1) Meta-analysis of existing data sets to;

a. Confirm that the declines are real

b. Quantify the spatial, temporal and demographic characteristics of the woylie decline, which in turn will,

c. Provide circumstantial evidence that will aid in the identification of the possible causes of decline.

2) Broad-scale monitoring of the Upper Warren region – an enhancement and co-ordination of existing monitoring and research activities – that provides;

a. six-monthly information up-dates on population change and associated characteristics at the regional scale and,

b. a regional-scale means of collecting data on woylies and putative agents of decline to complement the finer-scaled population comparison study.

3) Population comparison study is a detailed investigation of woylies and the possible agents of decline. This principally involves six sites that support populations at different stages of decline;

- Declined populations now at low densities: Boyicup and Winnejup (Upper Warren Region)
- The last remaining moderate-density woylie populations in the Upper Warren region: Keninup, Warrup and Balban
- High-density and stable population - Karakamia Wildlife Sanctuary (50 km east of Perth), a fenced (i.e. closed) population

The five main lines of enquiry to be investigated at the population comparison study sites are;

a. Woylie density and demographics
b. Woylie survival and mortality
c. Predators
d. Resources
e. Disease

Investigating the possible roles of disease

The disease agents potentially responsible for marsupial population declines (either in isolation or in concert with other factors) are extensive and can be broadly grouped as;

i) bacterial disease
ii) haemaparasites
iii) endoparasites
iv) ectoparasites
v) viral
vi) toxic
vii) nutritional

The Woylie Disease Reference Council (WDRC) was established to address the complexities and numerous specialist expertises required to comprehensively address the issues of wildlife disease in relation to the woylie declines. The principal roles of the WDRC are to provide expert advice and direction on disease research priorities and to co-ordinate the collaborative working relationships across institutions and between specialists that is essential to optimise the efficiency and quality of the woylie disease enquiries. The membership of the WDRC was designed to provide adequate representation of expertise across all major types of diseases and disease research relevant to south-western Australian native wildlife in general, and the woylie in particular.

The membership of the Woylie Disease Reference council includes;

MURDOCH UNIVERSITY

Prof Andrew Thompson - Parasitology **(WDRC Chair)**
A/Prof Stan Fenwick – Microbiology and Public Health
A/Prof Phil Clark – Clinical Pathology (Haematology)
Dr Phil Nicholls –Pathology
Dr Graeme Knowles – Pathology **(WDRC Pathology Co-ordinator)**

A/Prof Alan Lymbery – Parasitology and Ecology
Dr Andy Smith – Parasitology and Ecology (ectoparasites)
Dr Peter Adams – Parasitology and Microbiology
Dr Trevor Ellis – Virologist
A/Prof Ian Robertson – Epidemiologist

PhD Students
Nevi Parameswaran – Toxoplasmosis in wildlife
Unaiza Parkar – Endoparasites in wildlife
Yazid Abdad – Ectoparasites and Rickettsia in wildlife
Dr Lisa Hulme-Moir –Clinical pathology
Dr Halina Burmej –Ectoparasites in wildlife
Dr Carlo Pacioni –Conservation genetics

PERTH ZOO VETERINARY DEPARTMENT

Dr Paul Eden – Wildlife Clinician **(WDRC Clinical Medicine Co-ordinator)**
Dr Cree Monaghan – Wildlife Clinician and Nutritionalist

DEPARTMENT OF ENVIRONEMENT AND CONSERVATION

Dr Adrian Wayne – Fauna Ecology Research Scientist **(Woylie Conservation Research Project Chief Scientist and Co-ordinator, Disease sampling field co-ordinator)**
Keith Morris – Principal Research Scientist and Fauna Conservation Program Leader
Marnie Swinburn – Fauna Conservation Officer **(Disease sampling data co-ordinator and liaison).**

The objectives of the woylie disease enquiries directed by the WDRC are:

1) Identify parasites and other micro-organisms and evaluate their potential role in woylie declines.
2) Examine indirect evidence (e.g. demographic changes) that may help to determine whether a disease in general or a specific disease may be responsible for recent woylie declines.
3) Assess the prevalence and potential for specific high-risk disease agents to be a causal factor in the decline of woylies.

Information on diseases and their pathogenicity in native mammals in south-western Australia is limited and the opportunities to identify the cause(s) while the woylie declines are underway have by default been diminishing. Therefore, routine health checks and extensive sampling for disease agents have been conducted as part of the field research conducted by DEC (i.e. Upper Warren monitoring and Population Comparison Study). Routine samples include;

- blood for haematology, toxoplasmosis and reference serum
- faeces for endoparasites, salmonella and diet (i.e. food resources research)

- ectoparasites
- ear tissue for genetics

Woylies with clinical symptoms that may be encountered during the field-based research activities have been sent to the Perth Zoo Veterinary Department for medical examination (co-ordinated by Dr Paul Eden). Similarly, fresh carcasses that are encountered as part of the research are sent to Murdoch University Pathology Unit for necropsy (co-ordinated by Dr Graeme Knowles). As with all aspects of the disease research, specific protocols have been established to direct and standardise information and sampling collection and management.

Research Progress

The *investigative phase* of the project began when DEC researchers were first alerted to be the problem in October 2005. The preliminary field work and analyses instructed the subsequent formalized scientific investigations, which were conducted between June 2006 and July 2007. The management and analysis of samples and data is currently underway. An assessment of the collated evidence to date will be used to inform the *experimental phase*, which will scientifically test the short-listed putative agents of recent woylie declines to provide direct evidence of their role(s). The experiments will be designed within an active adaptive management framework wherever possible.

The analyses of disease screening samples are also still underway. Table 1 provides a summary of the samples collected and analysed between October 2005 and June 2007 inclusive. During the same period there have also been six cases of sick or injured animals that have undergone medical examination at the Perth Zoo and 28 necropsies performed at Murdoch University Pathology. Subsequent papers in the proceedings of the Wildlife Disease Symposium (13 July 2007) provide further detail on some of the preliminary findings from the woylie disease investigations.

Table 1. Summary of the number of woylie samples collected for routine disease screening between October 2005 and June 2007.

The figures in brackets indicate the number of samples that have been analysed.

* Ectoparsite samples that have been screened for *Ricketsia*

	Haematology	Toxoplasma	Ectoparasites	Endoparasites	Salmonella
Upper Warren	350 (286)	89 (296)	595 (11*)	542 (69)	141 (141)
Karakamia	35 (34)	81 (81)	149	60 (60)	27
Batalling	26 (23)	26 (26)	25	19	-
Tutanning	5 (4)	8 (8)	6	4	-
Dryandra	8 (4)	12 (12)	5	1	-
South Aust.	121 (99)	130 (0)	96	140	-
TOTAL	**545 (450)**	**646 (423)**	**876 (11*)**	**733 (129)**	**141 (141)**

Acknowledgements

The success of our efforts to diagnose the woylie declines is critically dependant on the collaborations and commitment of a great many people. Over 80 people are involved in this project in some ongoing manner, most of which are involved through collaborative relationships. We would like to acknowledge each their contributions.

Field staff that have been responsible for the collection and management of the samples and data, principally include Colin Ward, Marika Maxwell, Christos Vellios, Bruce Ward, Ian Wilson, Julia Northin, Brian Whittred, David Butcher, Zoe Clark, and Graeme Liddelow among many other DEC staff. We also thank over 100 volunteers contributing over 3000 hours. Australian Wildlife Conservancy staff and volunteers at Karakamia under the general direction and management of Alison Dugand, Jo Williams and Trish Gardiner. Other field collaborators include Fiona Kirkpatrick, Christine Gilbert, Nicky Marlow, Neil Thomas, Andy Williams, Jeff Richardson and South Australian DEH staff under the liaison and co-ordination of Jason VanWeenan.

Additional data management and support has been provided by David McKenzie, Peter Orell, Sheryn Prior and Christine Freegard. Paul Davies produced Figure 2.

The Woylie Conservation Steering Group has provided general support and assistance where needed. The Woylie Disease Reference Council members have been fundamental and essential to the development of our understanding of woylie diseases. Pathologists, specialist technical and laboratory staff and the collaborating PhD students at Murdoch University and the staff at the Perth Zoo Veterinary Department have also been critically important in the analysis of the animals and disease samples that have been collected.

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