CHAPTER 1. INTRODUCTION

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Abstract

The history and recent changes in abundance and distribution of woylies is briefly summarised. The principal aim of the woylie conservation research project (WCRP) is to determine the causal factors responsible for the recent woylie declines in southwestern Australia. Using a diagnosis framework based on the 'declining population paradigm' (*sensu lato* Caughley, 1994) and a classification of possible agents of decline into resources, predators, disease and direct human interference, the WCRP focussed on determining the causes in the Upper Warren region, east of Manjimup. The WCRP has been organised into three major components; 1) Upper Warren Fauna Monitoring 2), Meta-analysis, and 3) Population Comparison Study (PCS). Effective and extensive collaborations with numerous agencies and experts have been critical to the effectiveness of this project. The nature of these collaborations, the project management framework, and project milestones are very briefly summarised. The context and purpose if this report is discussed.

1.1. Situation summary of recent woylie population declines

The woylie (*Bettongia penicillata ogilbyi*) had a distribution across much of Australia prior to settlement by Europeans (Figure 1.1). By the 1960's the woylie was reduced to three isolated remnant populations in southwestern Australia (Upper Warren [principally Perup], Tutanning and Dryandra) (Figure 1.2). 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 1996 (Start *et al.,* 1998).

Since 2001, however, woylie populations throughout southwestern Australia have undergone rapid and substantial declines. For example, capture rates from long-term monitoring and research has indicated that the woylie population at Dryandra declined by 93% between 2000 and 2006. The Upper Warren population(s) underwent a median decline of 95% between 2002 and 2007. The woylie population at Batalling (a 1982 reintroduction site east of Collie; Figure 1.2) declined by 97% between 2002 and 2007. Evidence from multiple sources including live trapping, sandpad 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 (Jason VanWeenan, pers. comm.).

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). Introduced predators (fox and cat) and habitat loss were among the principal factors thought responsible for historical declines (Burbidge and McKenzie, 1989; Start *et al.,* 1995). There also is some anecdotal evidence that disease may have caused the decline of many mammal species (including the woylie) in Western Australia in the late 1800s to early 1900s (Abbott, 2006). The cause(s) of these current declines is unknown.

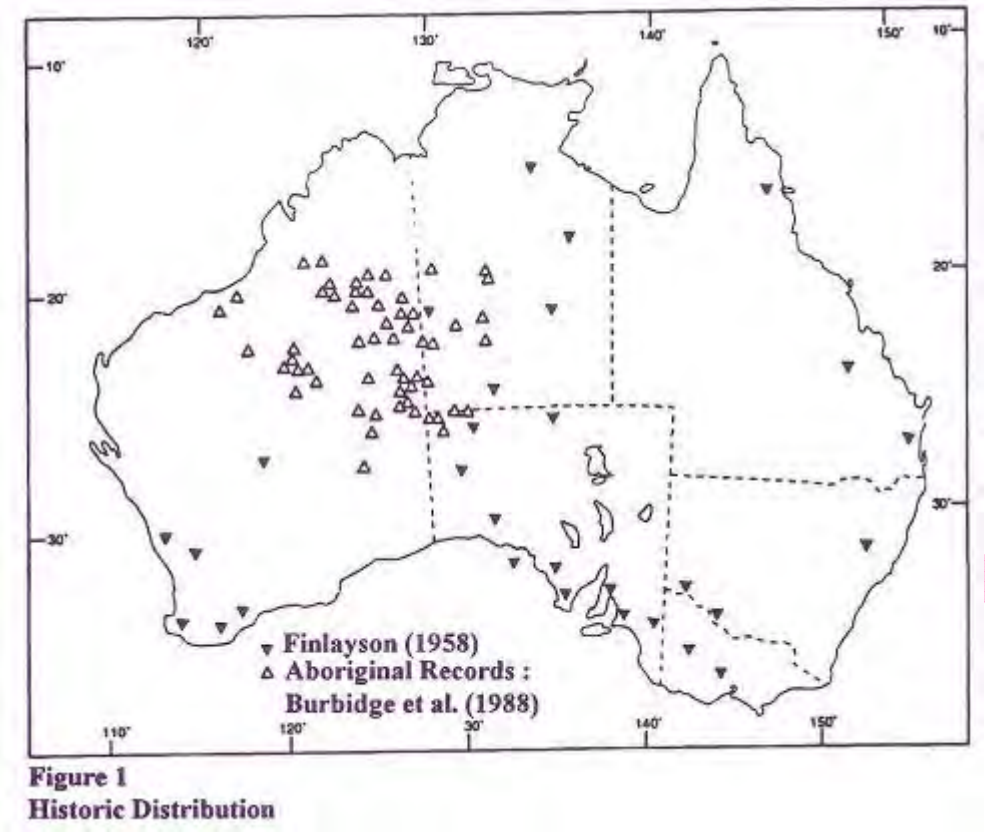

Figure 1.1. Historic distribution of woylies (*Bettongia penicillata*). Source: Start *et al.* (1995).

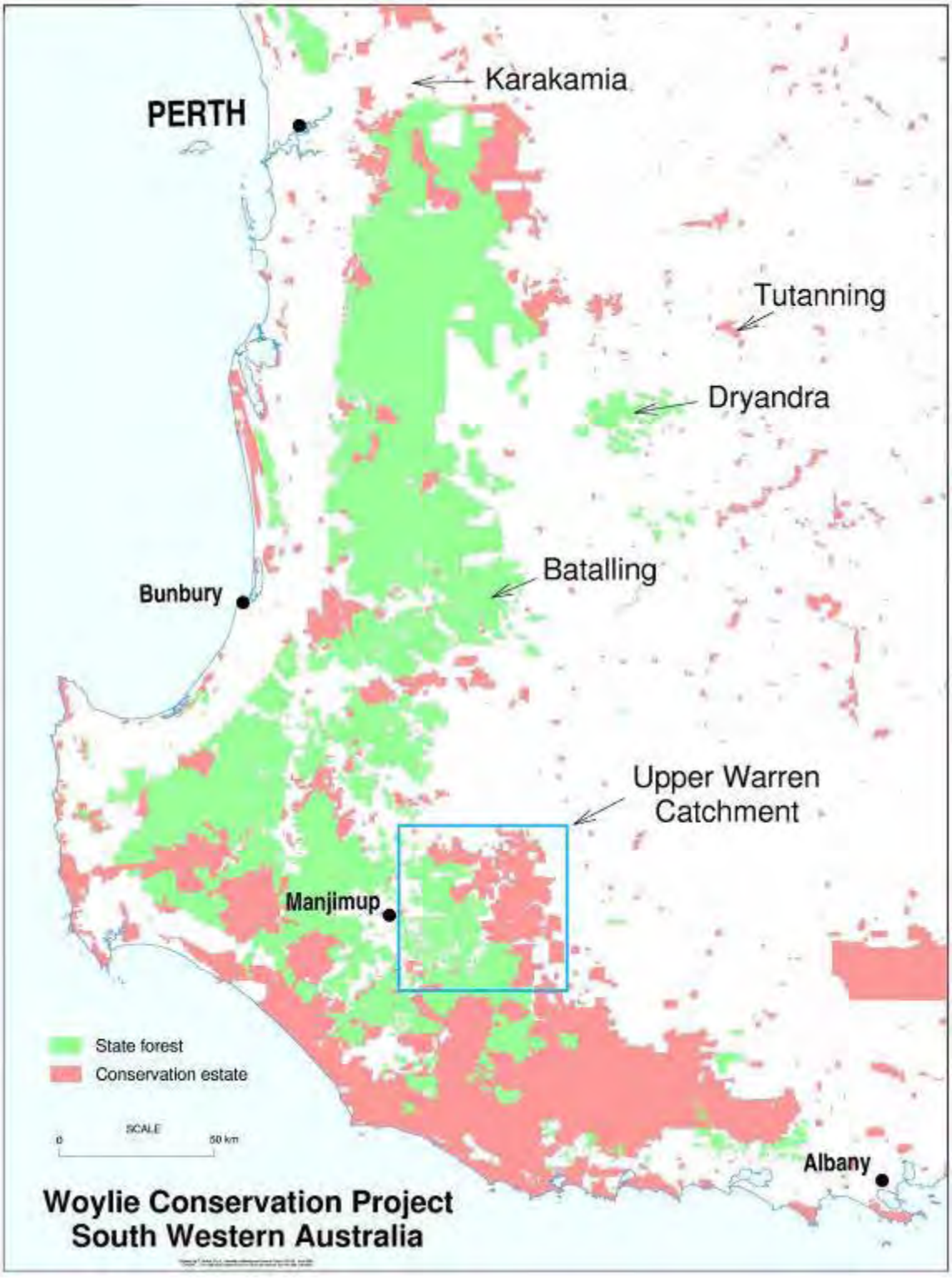

Figure 1.2. The location of important woylie populations.

1.2. The research approach to diagnosing recent woylie declines.

The Department of Environment and Conservation (DEC) has established a comprehensive and collaborative project to diagnose the cause(s) of 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 southwestern 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 are 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) Upper Warren Fauna Monitoring – an enhancement and co-ordination of existing monitoring and research activities – that provides;

- six-monthly information up-dates on population change and associated characteristics at the regional scale and,
- a regional-scale means of collecting data on woylies and putative agents of decline to complement the finer-scaled population comparison study.

2) Meta-analysis of existing data sets to;

- Confirm that the declines are real
- Quantify the spatial, temporal and demographic characteristics of the woylie decline, which in turn will,
- Provide circumstantial evidence that will aid in the identification of the possible causes of decline.

3) Population Comparison Study (PCS) 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;

- Woylie density and demographics
- Woylie survival and mortality
- Predators
- Resources
- Disease

More detail on the research approach and methodology is provided in the DEC Science Project Proposal (SPP 2007/02).

1.3. The collaborative approach to diagnosing recent woylie declines.

Collaborations with high-quality specialist expertise are considered critical to the successful diagnosis of the recent woylie declines. A large number of close collaborations are particularly necessary to adequately and comprehensively address the complexity, size and breadth of the WCRP. The success and progress of the project is fundamentally a direct result of the commitment and quality of the collaborators and their expertise. The willingness and co-operation of the individuals and institutions involved in this project (Table 1.1) have been exceptional and should be highly commended for their efforts.

Principal collaborating institutions include Department of Environment and Conservation, Murdoch University, Perth Zoo, and Australian Wildlife Conservancy. Collaborations also exist with individuals from the South Australian Government Department of Environment and Heritage, University of Western Australia, Manjimup Aeroclub, Data Analysis Australia (consultants), and University of Adelaide. Over 85 individuals are involved in some ongoing manner with the WCRP (Table 1.1). Many others have been involved on a less frequent or less regular basis. Contributions by volunteers have

also been extremely important, particularly in increasing the capacity for data and sample collection in the field. More than 123 individuals have collectively contributed more than 498 days and 3955 hours of volunteer service to the project between January 2006 and July 2007.

1.4. Project management

The management of the logistics, planning, co-ordination and communication required for this project have been extensive, particularly given the inherent complexities of the problem and research, and the number and diversity of the people involved. Figure 1.3.1 provides a summary of the WCRP management structure. The principal roles and responsibilities for the project are summarised in Table 1.2. The details of the project management are not provided here given that this report is focussed on providing an update regarding the development of results.

1.5. Research progress

Key milestones for research into the recent woylie declines include;

Oct 2005	Neil Burrows alerted to possible woylie declines. Adrian Wayne assigned to investigate and verify.
Dec 2005	Completed the survey of 12 transects throughout the Upper Warren region to substantiate and assess the extent and magnitude of woylie declines (i.e. established what became the biannual Upper Warren Fauna Monitoring program).
Feb 2006	Recent mammal declines workshop (DEC internal) convened to examine preliminary findings confirming extensive and substantial woylie declines, within the context of other native species, possible causes and developing response priorities and strategies.
Feb 2006	Establishment of the Woylie Conservation Steering Group to facilitate and assist in the co-ordination of a management and research response to recent woylie declines.
April 2006	Establishment of the Woylie Disease Reference Council to provide expert advice and research assistance into the possible role(s) of disease in recent woylie declines.
May 2006	Submission of situation report and research proposal to CALM Corporate Executive.
July 2006	Commencement of the Woylie Conservation Research Project (BCI funding secured for 2006/07).
May 2007	Completion of the database aggregation of multiple isolated datasets involving DEC fauna trapping in the Upper Warren.
August 2007	Completion of field work (excluding ongoing PhD research programs and some ongoing Upper Warren Fauna Monitoring).

Table 1.1. Summary of collaborators directly involved in the Woylie Conservation Research Project in an ongoing manner.

WCRP Component	Name	Principle WCRP Role	Affiliation
Core WCRP	Ms Marika Maxwell	Predator / Resource Co-ordinator	DEC, Science Div.
Core WCRP	Ms Julia Wayne	Upper Warren Fauna Monitoring Co-ordinator	DEC, Donnelly District
Core WCRP	Ms Sheryn Prior	Data management / Volunteer co-ordination	DEC, Science Div.
Core WCRP	Ms Wendy Sicard	Resources / Technical Support (Exchange)	U.S.A. B.L.M.
Core WCRP	Ms Marnie Swinburn	Disease Deputy Co-ordinator	DEC, Warren Region
Core WCRP	Mr Chris Vellios	Demographics / Resources Deputy Co-ordinator	DEC, Science Div.
Core WCRP	Mr Bruce Ward	Survival Deputy Co-ordinator	DEC, Science Div.
Core WCRP	Mr Colin Ward	Demographics / Survival Co-ordinator	DEC, Science Div.
Core WCRP	Dr Adrian Wayne	Project Co-ordinator / Chief Investigator / Disease Co-ordinator	DEC, Science Div.
Core WCRP	Mr Ian Wilson	District Liaison / UW Fauna Monitoring Co-Coordinator	DEC, Donnelly District
Disease (WDRC)	Mr Yazid Abdad	Parasitology and Microbiology - PhD Student	Murdoch University
Disease (WDRC)	Dr Peter Adams	Parasitology and Microbiology	Murdoch University
Disease (WDRC)	Dr Halina Burmej	Parasitology and Microbiology - PhD Student	Murdoch University
Disease (WDRC)	A/Prof Phil Clark	Haematology	Murdoch University
Disease (WDRC)	Dr Paul Eden	WDRC Clinical Co-ordinator	Perth Zoo
Disease (WDRC)	Dr Trevor Ellis	Viruses	Murdoch University
Disease (WDRC)	A/Prof Stan Fenwick	Microbiology	Murdoch University
Disease (WDRC)	Dr Lisa Hulme-Moir	Clinical Pathology - PhD student	Murdoch University
Disease (WDRC)	Dr Graeme Knowles	WDRC Pathology Co-ordinator	Murdoch University
Disease (WDRC)	A/Prof Alan Lymbery	Parasitology and Ecology	Murdoch University
Disease (WDRC)	Dr Cree Monaghan	Wildlife Clinician and Nutritionalist	Perth Zoo
Disease (WDRC)	Dr Phil Nicholls	Pathology	Murdoch University
Disease (WDRC)	Dr Carlo Pacioni	Genetics and Epidemiology - PhD Student	Murdoch University
Disease (WDRC)	Dr Nevi Parameswaran	*Toxoplasma* - PhD Student	Murdoch University
Disease (WDRC)	Ms Unaiza Parkar	Enteroparasites - PhD Student	Murdoch University

Disease (WDRC)	Dr Andrea Reiss	Wildlife Clinician	Perth Zoo
Disease (WDRC)	A/Prof Ian Robertson	Epidemiology	Murdoch University
Disease (WDRC)	Dr Andy Smith	Parasitology and Ecology (ectoparasites)	Murdoch University
Disease (WDRC)	Prof Andrew Thompson	Principal Murdoch liaison / WDRC co-ordinator	Murdoch University
Disease Support	Mr Gary Allen	Clinical Pathology (Haematology)	Murdoch University
Disease Support	Ms Susana Averis	Haemaparasites	Murdoch University
Disease Support	Ms Ailleen Elliott	Enteroparasites	Murdoch University
Disease Support	Mr Russ Hobbs	Enteroparasites	Murdoch University
Disease Support	Dr Sandy McLachlan	Pathology	Murdoch University
Disease Support	Dr Karen Payne	Wildlife Clinician	Perth Zoo
Disease Support	Dr Shane Raidal	Pathology	Murdoch University
Disease Support	Ms Judy Robertson	Clinical Pathology (Haematology)	Murdoch University
Disease Support	Dr Peter Spencer	C. Pacioni PhD Supervisor	Murdoch University
Disease Support	Dr Kris Warren	C. Pacioni PhD Supervisor	Murdoch University
External Programs	Dr Dave Algar	Mesopredator Project - Mt Gibson	DEC, Science Div.
External Programs	Mr David Armstrong	South Australian Woylie Populations	DEH, SA
External Programs	Mr Paul de Tores	Mesopredator Project - Northern Jarrah Forest	DEC, Science Div.
External Programs	Ms Christina Gilbert	Wellington District - Batalling	DEC, Wellington District
External Programs	Ms Fiona Kirkpatrick	Wellington District - Batalling	DEC, Wellington District
External Programs	Dr Nicki Marlow	Mesopredator Project - Dryandra/Tutanning	DEC, Science Div.
External Programs	Mr Jeff Richardson	Wheatbelt	DEC, Wheatbelt Region
External Programs	Mr Neil Thomas	Mesopredator Project - Dryandra/Tutanning	DEC, Science Div.
External Programs	Mr Jason van Weenen	South Australian Liaison	DEH, SA
External Programs	Mr Andy Williams	Mesopredator Project - Dryandra/Tutanning	DEC, Science Div.
Field Operative	Mr Dave Butcher	Animal Handler	DEC, Donnelly District
Field Operative	Ms Zoe Clarke	Animal Handler	DEC, Donnelly District
Field Operative	Mr Peter Davis	Aerial radio-telemetry Pilot	Manjimup Aeroclub
Field Operative	Mr Jamie Flett	Aerial radio-telemetry	DEC, Science Div.
Field Operative	Mr Wayne Fox	Animal Handler	DEC, Donnelly District
Field Operative	Mr Graeme Liddelow	Predator Deputy Co-ordinator	DEC, Science Div.
Field Operative	Mr Peter McGinty	Aerial radio-telemetry Pilot	Manjimup Aeroclub

Field Operative	Mr Brian Whittred	Animal Handler	DEC, Donnelly District
Forensics	Dr Oliver Berry	DNA forensics (predators)	University of WA
Forensics	Dr Ian Dadour	Forensics	University of WA
Forensics	Ms Denice Higgins	Forensic Odontology	University of Adelaide
Forensics	Mr Chris O'Brien	Forensics	University of WA
Meta-analysis	Dr John Henstridge	Statistical analysis consultancy	Data Analysis Australia
Meta-analysis	Mr David McKenzie	Database consultancy	Private Consultant
Meta-analysis	Ms Anna Munday	Statistical analysis consultancy	Data Analysis Australia
Meta-analysis	Mr Matthew Williams	Biometrical advice and support	DEC, Science Div.
Meta-analysis	Ms Christine Freegard	Woylie conservation status review, *Western Shield*	DEC, Nature Cons.
Miscellaneous	Ms Leslie Harrison	Principal Wildlife Carer	Volunteer
PCS	Ms Alison Dugand	Karakamia	AWC
PCS	Ms Trish Gardner	Karakamia	AWC
PCS	Dr Jacqui Richards	AWC Liaison	AWC
PCS	Ms Jo Williams	Karakamia Co-ordinator	AWC
Project Management	Ms Robyn Bowles	Administrative Support	DEC, Science Div.
Project Management	Ms Lauren Daubney	Data entry	DEC, Donnelly District
Project Management	Ms Janine East	Volunteer Co-ordinator	DEC, Donnelly District
Project Management	Mr Keith Morris	WDRC, WSORC, FCPL, WCSG, Mesopredator Project	DEC, Science Div.
Project Management	Ms Katie Schoch	Media liaison	DEC, Corporate Affairs
Resources	Dr Neil Bougher	Mycology	DEC, Science Div.
Resources	Dr Kate Bryant	K. Rodda PhD Supervisor	Murdoch University
Resources	Dr Mike Calver	K. Rodda PhD Supervisor	Murdoch University
Resources	Ms Julie Fielder	Mycology	DEC, Science Div.
Resources	Dr Richard Robinson	Mycology	DEC, Science Div.
Resources	Ms Kerry Rodda	Diet and food availability - PhD Student	Murdoch University
Resources	Dr Barbara Wilson	K. Rodda PhD Supervisor	Murdoch University
WCSG	Mr Brad Barton	WCSG Chair	DEC, Warren Region
WCSG	Mr John Gillard	Donnelly District Manager	DEC, Donnelly District
WCSG	Mr Nigel Higgs	Media Liaison	DEC, Corporate Affairs
WCSG	Mr Peter Orell	Database development, *Western Shield*, Meta-analysis, WSORC	DEC, Nature Cons.

WCRP = Woylie Conservation Research Project

WDRC = Woylie Disease Reference Council

WCSG = Woylie Conservation Steering Group

AWC = Australian Wildlife Conservancy

USA BLM = USA Bureau of Land Management

Note: This summary list may not be comprehensive. The inadvertent omission of principal collaborators is an unintentional oversight for which sincere apologies are given in advance.

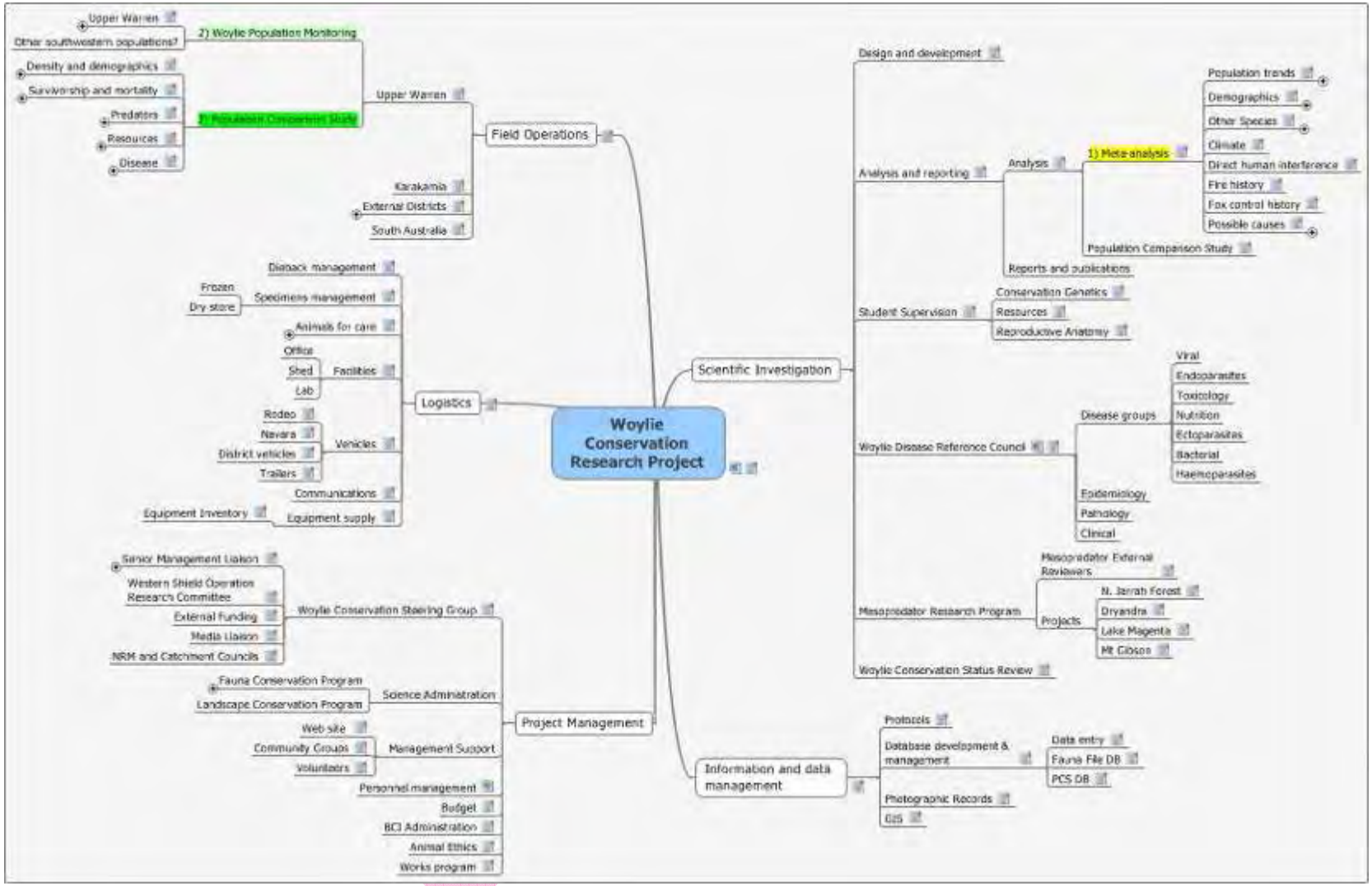

Figure 1.3. Summary of the Woylie Conservation Research Project management structure and components

Table 1.2. Summary of principal Woylie Conservation Research Project roles and responsibilities.

WCRP Component	Operations Leader	Deputy
Project Manager/Chief Investigator	Adrian Wayne	Keith Morris / Lachlan McCaw
1) Upper Warren Fauna Monitoring	Ian Wilson	Julia Wayne
2) Meta-analysis	Adrian Wayne	Matthew Williams
3) Population Comparison Study		
a) Demographics	Colin Ward	Chris Vellios
b) Survival and Mortality	Colin Ward	Bruce Ward
c) Predators	Marika Maxwell	Brian Whittred
d) Resources	Kerry Rodda / Marika Maxwell	Adrian Wayne
e) Disease	Adrian Wayne	Marnie Swinburn
WDRC Chair	Andrew Thompson	Adrian Wayne
WDRC Clinical Co-ordination	Paul Eden	
WDRC Pathology Co-ordination	Graeme Knowles	
Woylie Conservation Steering Group	Brad Barton	Adrian Wayne
Donnelly District Liaison	Ian Wilson	
Karakamia Liaison	Jo Williams	
South Australia Liaison	Jason van Weenen	
External Programs Liaison	Marnie Swinburn	
Field Logistics	Chris Vellios	
Information and Data Management	Marika Maxwell	Peter Orell / Sheryn Prior

1.6. Report outline

The purpose of this report is to collate the results from progress achieved to date across the many components of the WCRP. As such, this report provides an opportunity to examine the accumulating evidence that will assist in the diagnosis of recent woylie declines. On all accounts the results presented here are preliminary. The intent is to provide a timely update on progress that will enable some anticipation as to where the evidence may be leading the diagnosis of woylie declines, which may allow the initiation of planning and preparation of subsequent responses to the current woylie situation. It is premature to draw definitive conclusions on the basis of information provided here given that much of what is reported is descriptive and awaits more rigorous statistical and scientific testing. Nonetheless, this report will inform all those involved in the project, interested managers and DEC Corporate Executive of most of the initial findings. It will also help guide the refinement of analyses of existing datasets and begin the formulation of response plans beyond the current investigative phase.

The structure of the report reflects the structure of the project. The authors of each section generally include many of the principal individuals directly involved in that component of the project. Most of the sections and their content can be regarded as precursors to planned publications in the peer-reviewed literature.

1.7. References

Abbott, I. 2006. Mammalian faunal collapse in Western Australia, 1875-1925: the hypothesised role of epizootic disease and a conceptual model of its origin, introduction, transmission, and spread. Australian Zoologist **33**:530-561.

Burbidge, A. A., and N. L. McKenzie. 1989. Patterns in the modern decline of Western Australia's vertebrate fauna: causes and conservation implications. Biological Conservation **50**:143-198.

Caughley, G. 1994. Directions in Conservation Biology. Journal of Animal Ecology **63**:215-244.

Caughley, G. C., and A. Gunn 1996. Conservation Biology in Theory and Practice. Blackwell Science, Cambridge.

Freegard, C. 2007. Nomination of a Western Australian species for listing as threatened, change of status or delisting: woylie. Report. Department of Environment and Conservation, Kensington.

Orell, P. 2004. Fauna monitoring and staff training: Western Shield review - February 2003. Conservation Science Western Australia 5:51-95.

Peery, M. Z., S. R. Beissinger, S. H. Newman, E. B. Burkett, and T. D. Williams. 2004. Applying the declining population paradigm: Diagnosing causes of poor reproduction in the marbled murrelet. Conservation Biology **18**:1088-1098.

Start, A. N., A. A. Burbidge, and D. Armstrong. 1995. Woylie recovery plan. Wildlife Management Program No.16. Western Australian Department of Conservation and Land Management and South Australian Department of Environment and Natural Resources, Perth.

Start, A. N., A. A. Burbidge, and D. Armstrong. 1998. A review of the conservation status of the woylie (Bettongia penicillata ogilbyi (Marsupialia: Pootoroidae) using IUCN criteria. CALMScience **2(4)**:277-289.

Wayne, A. F. 2006. Interim assessment of the evidence for a recent decline in woylie abundance in south-western Australia. Pages 1-28. CALM, Perth, Western Australia.