Warru Recovery Plan

Recovery of *Petrogale lateralis* MacDonnell Ranges race in South Australia | 2010–2020

An initiative of the Federal government, Department of Environment and Natural Resources, Alinytjara Wilurara Natural Resources Management Board, Anangu Pitjantjatjara Yankunytjatjara, Conservation Ark and Ecological Horizons.

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Government of South Australia

Anangu Pitjantjatjara Yankunytjatjara

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Minister's foreword

Warru have contracted dramatically in range and abundance over the past 80 years and are now considered one of South Australia's most endangered mammal species. The Warru Recovery Plan outlines the opportunity to fulfill the vision of the Warru Recovery Team (WRT) and its stakeholders of reversing this decline and restoring warru to their former range where their Tjukurpa (dreaming) can continue to develop.

The Warru Recovery Plan sets out a range of actions and measurable targets which aim not only to increase the distribution and abundance of warru across South Australia, but to produce positive landscape environmental change across the Anangu Pitjantjatjara Yankunytjatjara Lands.

Central to the Warru Recovery Plan are two important themes:

a. Warru conservation will continue to provide training and employment opportunities for Anangu, as well as strong connections to historical and contemporary Tjukurpa.

b. The management, research and initiatives described in the Warru Recovery Plan will produce positive landscape environmental change across the APY Lands.

We strongly believe that adoption and implementation of the Warru Recovery Plan will not only lead to the recovery of Warru, but also to many positive environmental and social outcomes in one of Australia's most spectacular and remote landscapes.

Hon Paul Caica MP
Minister for Sustainability, Environment and Conservation
Minister for Aboriginal Affairs and Reconciliation

"Warru has been here for a long time, before us, and they should be in our lands because they are Traditional Owners too. Alice Springs are responsible for their warru, we are responsible for ours. We want to see them back in all places where they used to be. And not just warru, we should bring back ninu, mala, tjuwalpi and wayuta too. All of them."

Frank Young
Aṉangu Pitjantjatjara Yankunytjatjara Lands

"When I was young, I always see my brothers killing warru, rock-wallabies. And we always eating, good meat. We don't want to eat them anymore because we looking after now, today. We're working for rock-wallaby, looking after. Some fox might come and eat him, that's why we're looking after."

Dora Haggie
Aṉangu Pitjantjatjara Yankunytjatjara Lands

"After devoting more than 25 years to rock-wallaby marsupial conservation I urge you to press on the best you can to try and give these wonderful creatures a future. Bear in mind, that science moves on relentlessly, and that some day the biological control of exotic predators will be a reality, and all of those empty rock piles will come alive again."

Jack Kinnear
Rock-wallaby conservation biologist

Note: *Although every care has been taken, users of the Warru Recovery Plan should be aware that it may contain images or content relating to deceased persons.*

Contents

2. Executive Summary

Warru (*Petrogale lateralis* MacDonnell Ranges race) have contracted dramatically in range and abundance over the past 80 years. As a result of this ongoing decline they are considered one of South Australia's most endangered mammal species. The following Warru Recovery Plan outlines the key obstacles and opportunities to fulfill the vision of the Warru Recovery Team and its stakeholders of reversing this decline and restoring warru to their former range where their Tjukurpa can continue to develop.

The Warru Recovery Plan provides a compendium of historical and contemporary data on warru, drawing on recent summaries (Cooke 2006; Pearson 2010) and contemporary data (Read 2010; Ruykys 2011; Ruykys *et al.* 2011; Ward *et al.* 2011a; Ward *et al.* 2011b), to set out a clear set of objectives and actions for the multi-stakeholder Warru Recovery Team. The overarching 40-year objective of the Warru Recovery Team is to downgrade the status of Warru in South Australia from endangered to vulnerable.

Central to the objectives and actions of the Warru Recovery Plan are two important themes:

a. Warru conservation is currently and will in the future play a critical role in providing training and employment opportunities for Aṉangu, as well as strong connections to historical and contemporary Tjukurpa.

b. The management, research and cross-jurisdictional initiatives described and costed in the Warru Recovery Plan are intended to facilitate tangible positive environmental change at a landscape scale across the Aṉangu Pitjantjatjara Yankunytjatjara (APY) Lands.

The Warru Recovery Plan has been prepared as a benchmark document to guide initial management, research and investment decisions for the development of the Warru Recovery Project. This will ensure that conservation priorities are addressed, wise investment decisions are made and delivery success is assessed. In addition, the Warru Recovery Plan should form the basis for ongoing revisions and reporting which are the hallmarks of a dynamic adaptive management program.

The Warru Recovery Team strongly believes that adoption and implementation of the Warru Recovery Plan will not only lead to the recovery of this iconic species, but to many lasting and positive landscape-scale environmental and social outcomes in one of Australia's most spectacular and remote regions.

A summary of the primary objectives and actions of the Warru Recovery Plan and associated costs is provided below.

2.1 Long-term objectives of the Warru Recovery Project (0–40 years)

1. Warru down-listed from endangered to vulnerable in South Australia (*NPW Act 1972*).
2. Warru Recovery Plan meets multi-level objectives of the APY community.
3. Warru Recovery Plan leads to long-term landscape conservation outcomes.

2.2 Short-term objectives of the Warru Recovery Project (0–10 years)

1. Maintain genetic diversity and increase the distribution and abundance of warru in South Australia.
2. Anangu have ownership of key WRT decisions and on-ground actions, and have access to employment opportunities and educational outcomes arising from the Warru Recovery Project.
3. The Warru Recovery Project is jointly managed and administered strategically towards achieving long-term objectives.

2.3 Primary Actions of Warru Recovery Project (0–10 years)

Actions – Objective 1

- Implement appropriate threat abatement and monitoring and refine with added knowledge.
- Maintain current warru monitoring regime at known warru colonies in the Eastern Musgrave and Tomkinson Ranges.
- Maintain a captive warru population with genetic representation from known *in-situ* colonies.
- Encourage and support specific dedicated research and development projects on warru conservation ecology.
- Supplement existing colonies only where appropriate.
- Conduct reintroduction of warru into the APY Lands within its former range.
- Support and encourage surveys of warru in adjacent ranges in Western Australia and the Northern Territory.
- Engage pastoral industry to adopt warru as a potential icon species for conservation on pastoral leases within the Davenport Ranges.

Actions – Objective 2

- Conduct regular WRT Meetings.
- Employ an iterative decision-making process for the WRT between Piranpa and Ananngu members.
- Ensure at least two Traditional Owners who can speak for each warru metapopulation are involved in the Warru Recovery Team.
- Ensure all on-ground works have an appropriate level of Ananngu employment.
- Translate and communicate aspirations of the Warru Recovery Plan into Pitjantjatjara and Yankunytjatjara (supported by the Mobile Language Group project, University of Adelaide).
- Hold community meetings to discuss the objectives and actions of the Warru Recovery Plan with as many relevant communities of the APY Lands as feasible.
- Develop an agreed media protocol for the WRT.

Actions – Objective 3

- Update WRT Terms of Reference (2007).
- Produce WRT annual report.
- Maintain the "Warru Wiki" (web based document centre) as a key information source with access to reports, Warru Recovery Plan, etc.
- Produce an intellectual property agreement between WRT members.
- Develop a stand-alone funding strategy based on the Warru Recovery Plan.
- Finalise Memorandum of Understandings between stakeholders.
- Adopt Warru Recovery Plan, communicate with outside stakeholders and ensure it is in line with National Recovery Plan (Pearson 2010).

2.4 Warru Recovery Project budget 2010–2015

Note: *indicative only and not committed. All figures x $1000*

Objective	2010/11	2011/12	2012/13	2013/14	2014/15	Total	Committed	Required
1	550	615	673	633	793	3264	425	2839
2	402	425	402	390	402	2021	1499	522
3	33	6	28	6	28	101	12	89
Total	**985**	**1046**	**1103**	**1029**	**1223**	**5386**	**1936**	**3450**

3. Acknowledgements

This plan has benefited greatly from the wisdom and involvement of many Aṉangu and Piṟanpa including:

- Abraham Paddy
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- Veronica Penhall
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- Wendy Foster
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The following organisations have demonstrated commitment to ensuring warru remain in the APY Lands:

- Alinytjara Wilu̱rara NRM Board
- Aṉangu Pitjantjatjara Yankunytjatjara (APY) and APY Land Management
- Conservation Ark
- Ecological Horizons Pty Ltd
- Department of Environment and Natural Resources (formerly Department for Environment and Heritage)
- Department of Sustainability, Environment, Water, Population and Communities (in particular Working on Country)
- Indigenous Land Corporation
- Kalka Community
- Nature Foundation
- Pipalyatjara Community
- Pukatja Community
- WWF

4. Reference material

4.1 Abbreviations

APY	Anangu Pitjantjatjara Yankunytjatjara
APYLM	Anangu Pitjantjatjara Yankunytjatjara Land Management
AWNRM	Alinytjara Wilurara NRM Board
CA	Conservation Ark – Royal Zoological Society of South Australia
DEH	Department for Environment and Heritage
DENR	Department of Environment and Natural Resources
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities
EH	Ecological Horizons Pty Ltd
EPBC	Environment Protection and Biodiversity Conservation
IPA	Indigenous Protected Area
NPWS	National Parks and Wildlife (SA)
NES	National Environmental Significance
NRM	Natural Resource Management
TEK	Traditional Ecological Knowledge
WRP	Warru Recovery Plan
WRT	Warru Recovery Team (South Australia)

4.2 Pitjantjatjara and Yankunytjatjara language used

Aṉangu People of the Aṉangu Pitjantjatjara Yankunytjatjara Lands

Kanyaḻa Euro *Macropus robustus*

Kapi Water

Mala Rufous hare-wallaby *Lagorchestes hirsutus* (central mainland form)

Malu Red Kangaroo *Macropus rufus*

Minyma A mature woman, usually with several children

Ninu Bilby *Macrotis lagotis*

Piṟanpa Caucasian

Tjilpi Older man, elder

Tjukurpa There is no one English meaning for this word. It encompasses Aṉangu law, stories, beliefs.

Tjuwalpi Stick-nest rat *Leporillus apicalis*

Warru Black-footed rock-wallaby *Petrogale lateralis* MacDonnell Ranges Race

Wati Initiated man

Wayuta Brush-tailed possum *Trichosurus vulpecula*

Note: *Although the term for black-footed rock wallaby is referenced as "waru" by Goddard (1996), the Warru Recovery Team was instructed by Traditional Owners in 2007 to use the term "Warru" to distinguish it from waṟu (fire). Elsewhere, the words above are the general word that is used by both Pitjantjatjara and Yankunytjatjara people and referenced from Goddard (1996).*

Introduction

5.1 Scope of Warru Recovery Plan

The core objective of the South Australian Warru Recovery Plan is to downgrade the conservation status of warru in South Australia from endangered to vulnerable within 40 years, thereby maximising the likelihood of conserving functioning, *in situ* and genetically distinct populations.

This plan links with the Recovery Plan for Five Species of Rock-wallabies (Pearson 2010), thereby setting the agenda for the South Australian Warru Recovery Team (WRT), Aṉangu Pitjantjatjara Yankunytjatjara Land Management (APYLM), State and the *Commonwealth Environment Protection and Biodiversity Conservation Act* (EPBC 1999) compliance-related Commonwealth decisions on the management of the species.

The Warru Recovery Plan also aims to embrace and promote several key values of the Warru Recovery Project which are integral to achieving its core objectives, including:

- Tjukurpa and cultural values of warru.
- Stewardship role of Aṉangu for warru recovery.
- Training and employment benefits for Aṉangu.
- Proficient functioning of a multi-stakeholder Warru Recovery Team.

The scope is sufficiently broad to provide direction into research priorities, future monitoring and reintroductions potentially beyond their historical distribution should climate change shift the optimal range of warru.

The Warru Recovery Plan recognises the potential for warru recovery to facilitate landscape-scale positive environmental change in the APY Lands, including other species and ecosystems affected by processes such as fire and predation by introduced carnivores.

In addition to the Recovery Plan for Five Species of Rock-wallabies (Pearson 2010), relevant information for this plan is also accessible in specific recovery plans, including *Petrogale persephone* (Nolan and Johnson 2001), *Petrogale penicillata* (draft dated August 2005, NSW Department of Environment and Conservation), the Warrumbungles population of *Petrogale penicillata* (NPWS 2002) and for *P. l. lateralis* (Hall and Kinnear 1991).

5.2 Species information and general requirements

5.2.1 Taxonomy and species description

The black-footed rock-wallaby (*Petrogale lateralis*) was described by Gould (1842) from specimens collected in south-western Western Australia. Subsequent genetic work has confirmed that several disjunct *P. lateralis* populations represent unique subspecies and genetic races (Pearson 2010).

In the central ranges region of arid Australia, the black-footed rock-wallaby (*Petrogale lateralis* MacDonnell Ranges race), or "warru" as it is known by Aṉangu, was identified as a separate race by Briscoe *et al.* (1982), but it is generally considered an undescribed subspecies (Eldridge 1997).

Warru are a relatively small rock-wallaby. Adult males weigh 4.1–5.0 kg and females 3.1–3.8 kg (Eldridge and Close 1995;

Eldridge and Pearson 2008). They are considerably smaller than other southern rock-wallaby species where the average weight of both sexes exceeds 6kg (e.g. yellow-footed rock-wallabies *Petrogale xanthopus* and brush-tailed rock-wallabies *Petrogale penicillata*).

Warru are dark grizzled brown on the dorsal surface with grey shoulders and are distinguished by a shorter coat than the populations of *P. l. lateralis* in south-west Western Australia (Pearson 2010). Their pelage lightens to a predominantly sandy-brown colour in summer. A dorsal stripe of dark brown to black runs from between the ears to below the shoulders (Figure 1). A white side-stripe bordered with a wider dark brown stripe extends from the axillary area to the thighs. The chest is paler and the belly is buff (Eldridge and Pearson 2008a). Warru have a grey head with a white cheek-stripe, while the ears are dark brown with a paler smoky brown base. The tail is dark grey, becoming browner distally with a black terminal brush which tends to be less distinct than that of *P. l. lateralis* (Eldridge and Pearson 2008a).

5.2.2 Conservation status

Petrogale lateralis (MacDonnell Ranges race) are classified as vulnerable under the national EPBC Act (1999). Due to a known population size of fewer than 250 mature animals, in South Australia warru are considered endangered (Criteria D) under the *SA National Parks and Wildlife Act (1972)*, *Schedule 7*. These listings are based on IUCN criteria (Appendix 1). The severe contraction in historic geographic range within South Australia (Ward *et al* 2011a), including the documented extinction from the Davenport Ranges (Figure 2) and Wamitjara (Figure 3) within the past three generations, suggest that warru would also classify for endangered status under the decline in range (Criteria B1).

The species is considered vulnerable under the *WA Wildlife Conservation Act (1950)*, but despite a paucity of monitoring data and population trend analyses, is not listed by the *Territory Parks and Wildlife Conservation Act (2000)*.

The target of this Warru Recovery Plan is to shift the conservation status of warru from endangered to vulnerable under the *SA NPWS Act (1972)* by 2050. See Long-term objectives (9.3) and Appendix 1 for details.

Figure 1. *Warru Petrogale lateralis MacDonnell Ranges race.*

5.2.3 Legislative obligations

5.2.3.1 International obligations

Warru are recognised with all Australian fauna under the Convention on Biological Diversity (www.cbd.int/countries/profile.shtml?country=au#nbsap) of which Australia is a signatory (Commonwealth of Commonwealth of Australia 2001). Australia has endorsed the United Nations Declaration on the Rights of Indigenous Peoples, however, this is not a legally binding instrument under international law. Warru are not listed in Appendices 1–3 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Following their extinction from Uluru Kata Tjuta National Park, Warru no longer occur in World Heritage Areas.

5.2.3.2 Environment Protection and Biodiversity Conservation (EPBC) Act 1999

The overarching legislation affecting matters of warru recovery is the *EPBC Act (1999)*, the Australian Government's principal environmental legislation protecting matters of National Environmental Significance (NES). Matters of NES include listed threatened species, including warru.

The *EPBC Act* requires the approval of any actions which may have a significant impact on a matter of NES. Guidelines on what constitutes a significant impact can be found at: http://www.environment.gov.au/epbc/publications/nes-guidelines.html.

The following threats, as listed in the *EPBC Act*, should be considered having the potential of having 'significant impact' on Warru:

- feral predators (Section 6.1)
- exotic weeds (Section 6.2)
- inappropriate fire regimes (Section 6.3)
- domestic and feral herbivores (Section 6.4)
- pastoralism (Section 6.5)
- changes to water availability (Section 6.6)
- disturbance by hunting or recreation (Section 6.10)
- resource exploration and mining (Section 6.11).

5.2.3.3 South Australia Natural Resource Management Act (2004)

Key parts of Section 7 of the *SA NRM Act (2004*) which pertain to warru recovery include:

1. The objects of this act include to assist in the achievement of ecologically sustainable development in the State by establishing an integrated scheme to promote the use and management of natural resources in a manner that:
    a. recognises and protects the intrinsic values of natural resources.
    b. seeks to protect biological diversity and, insofar as is reasonably practicable, to support and encourage the restoration or rehabilitation of ecological systems and processes that have been lost or degraded.
    c. provides for the prevention or control of impacts caused by pest species of animals and plants that may have an adverse effect on the environment, primary production or the community.
    d. promotes educational initiatives and provides support mechanisms to increase the capacity of people to be involved in the management of natural resources.
2. The following principles should be taken into account in connection with achieving ecologically sustainable development for the purposes of this Act:
    a. decision-making processes should effectively integrate both long-term and short-term economic, environmental, social and equity considerations.
    b. if there are threats of serious or irreversible damage to natural resources, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation.
    c. a consideration should be the conservation of biological diversity and ecological integrity.
    d. consideration should be given to Aboriginal heritage, and to the interests of the traditional owners of any land or other natural resources.

5.2.3.4 Anangu Pitjantjatjara Yankunytjatjara Land Rights Act

The Act states in Division 2

6–Powers and functions of Anangu Pitjantjatjara Yankunytjatjara

1. The functions of Anangu Pitjantjatjara Yankunytjatjara are as follows:
   a. to ascertain the wishes and opinions of traditional owners in relation to the management, use and control of the lands and to seek, whewre practicable, to give effect to those wishes and opinions.
   b. to protect the interests of traditional owners in relation to the management, use and control of the lands.
   c. to negotiate with persons desiring to use, occupy or gain access to any part of the lands.
   d. to administer land vested in Anangu Pitjantjatjara Yankunytjatjara.

5.2.4 South Australian Government Strategic Priorities

5.2.4.1 South Australian Strategic Plan 2011

The marriage of social and environmental objectives ensures the Warru Recovery Plan contributes to many of the priorities of South Australia's Strategic Plan.

6.	Aboriginal Wellbeing: Improve the overall wellbeing of Aboriginal South Australians.
51.	Aboriginal Unemployment: Halve the gap between Aboriginal and non-Aboriginal employment rates by 2018.
69.	Lose no species: Lose no species as a result of human impact.
72.	Nature Conservation: Increase participation in nature conservation activities by 25% by 2015.
79.	Aboriginal healthy life expectancy: Increase the average life expectancy of Aboriginal males to 67.5 years (22%) and Aboriginal females to 72.3 years (19%) by 2020.

5.2.4.2 Department of Environment and Natural Resources Corporate Plan 2010–2014

The Warru Recovery Project plays numerous roles in ensuring a sustainable and propserous South Australia.

Implement No Species Loss: A nature conservation strategy for South Australia.

1a.	Implement *No Species Loss: A nature conservation strategy for South Australia.*
2b.	Facilitate the co-management of more protected areas and engage and support Aboriginal people and communities in the management of their traditional lands.
2c.	In partnership with Aboriginal people and communities, preserve ecological knowledge and find ways for the knowledge to be shared and understood.

5.2.4.2 No Species Loss – A Strategic Framework For Nature Conservation In South Australia

Recognition as South Australia's most endangered mammal ensures the importance of the warru recovery effort in the State Government's No Species Loss policy. The following goals and targets from No Species Loss are addressed by the Warru Recovery Plan.

Goal 1 – Conservation of South Australia's biodiversity.

Objective 1.3. – To maintain, improve and reconstruct species and ecological communities.

Target 7 Benchmarks for current status of threatened species and ecological communities are established, and management impactions for each NRM region determined, by 2010.

Target 10 Recovery Plans are implemented for 40% of South Australia's endangered and vulnerable threatened species.

Target 11 Decline in species and ecological communities is halted, by 2017.

Goal 2 – Community ownership and stewardship for biodiversity.

Objective 2.2 – To raise community capacity, stewardship and decision-making for biodiversity conservation.

Recommendation 1 – Existing partnerships to improve Indigenous participation in management of species and ecological communities at regional and local levels are developed and enhanced.

Goal 3 – Ecological knowledge that can influence decision-making.

Objective 3.1 – To identify and fill key gaps in knowledge to influence biodiversity management.

Target 23 Gaps in knowledge and priority areas for research on biodiversity and impacts on biodiversity are identified and appropriate research supported, by 2012.

Objective 3.2 – To build capacity to collect and share information to inform biodiversity management.

Target 32 Knowledge that contributes to biodiversity management is captured, retained and promoted in consultation with urban, rural and Indigenous communities, by 2011.

5.2.4.3 Alinytjara Wilurara Regional NRM Plan

"People" Asset – Five Year Outcomes

- There is an increase in communities, agencies and individuals involvement in NRM.
- NRM programs and projects demonstrate success, as shown by monitoring and evaluation.
- Technologies and innovations are improving the management of natural resources across the region.
- The 'report card' shows improving regional environmental, health, trend and caring for country (stewardship)
- Programs are guided by Traditional Ecological Knowledge (TEK) blended with research and monitoring findings.
- Changed perceptions and practices in NRM are demonstrated.

"Country" Asset – Five Year Outcomes

- There is improved knowledge around the health and trend for all landscapes and seascapes in the region.
- Populations of flora and fauna of conservation significance are secure.
- There is regular monitoring of key sites and indicators for climate change impacts.
- Culturally important or unique flora, fauna and habitats are safe and secure in at least one regional landscape or seascape.
- Ecologically sustainable practices are applied to all pastoral, mining, fishing, wild harvest and tourism activities in the region.
- There is stable or improved land condition in all landscapes.

5.2.5 Other affected interests and matters for compliance

South Australian warru now persist entirely within the freehold APY Lands, although populations recently occurred on Nilpinna and The Peake pastoral stations where potential reintroduction could occur. Potential future reintroductions to areas outside the APY Lands on pastoral stations will mean that the *Pastoral Land Management Act (1989)* will have relevance to the Warru Recovery Plan. Of particular note is:

- The potential for pastoral grazing intensity to increase
- A change in the type of stock run (in particular goats or browsing sheep breeds, which could compete with warru for forage)
- The intensity and timing of dingo controls
- Additions or renovations to waterpoints within 10km of warru colonies or potential reintroduction sites.

The *Mining Act (1971)* and *Petroleum Act (2000)* are also relevant to this plan since several of the occupied and potential reintroduction sites (particularly around Kalka and petroleum leases in the southern APY Lands and Eastern Musgrave Ranges) are prospective areas for mineral and petroleum exploration or exploitation. Mining (Section 6) may cause direct or indirect disturbances to warru and also has the potential to lure warru rangers away to more lucrative employment. However, it may also provide resources to assist with the warru recovery effort.

The predation of warru by foxes and cats has been managed by baiting for foxes using dried kangaroo meat baits injected with 1080, and more recently the Warru Recovery Team (through Biosecurity SA) holds a license to use cat specific baits (Eradicat®.) The Australian Pesticides and Veterinary Medicines Authority (APVMA) provide licenses for the use of 1080 and Eradicat®. Both Biosecurity SA and APVMA should be regularly contacted in order to keep up to date with baiting regulations. In general, baiting using 1080 poses a risk to camp and hunting dogs and requires rigorous sign-posting, careful baiting strategies and liaison with Traditional Owners.

5.3 General distribution, abundance and ecology

5.3.1 Historic distribution and abundance

At the time of European settlement, warru occupied the largest distribution of any of the *Petrogale lateralis* group (Figure 2). Warru were widespread in South Australia to the north and west of Lake Eyre South, throughout the central western region of Western Australia and the southern Northern Territory as far north as the Tanami Desert (Figure 2, Burbidge *et al.* 1988; Pearson 1992; Gibson and Cole 1993; Copley and Alexander 1997; Lundie-Jenkins and Findlay 1997; Pearson and Council 1997; Pearson and Kinnear 1997; Reid *et al.* 1997; Gibson 2000; Pearson 2010).

Early explorers and Aṉangu informants reported the species to be common. Spencer (1896) remarked that it was "to be met with probably everywhere in the hill country of the central part of Australia" and it was "plentiful in and confined to the rocky ranges". In 1904, Murray reported that rock-wallabies were present in the Cavanagh (just into the NT), Mann and Musgrave Ranges, but considered them to be scarce in the Everard Ranges. However, in contradiction of this view, Captain S. A. White stated that rock-wallabies were common in the granite rock-piles of the Everard Ranges in 1914, and particularly at Moorilyanna Well where he collected five specimens that are now in the SA Museum (White 1915). In 1961, Finlayson (1961) stated that 'in 1932–35 it (*Petrogale lateralis*) was one of the commonest mammals of the (region) with swarming populations in many of the rocky outliers of the main ranges. Today (1961), although it still persists at scattered points there, it is a comparatively rare form.'

Over the past 80 years there has been a dramatic reduction in both the distribution and abundance of warru at all but a few localities. Finlayson (1961) found rock-wallabies to be rare at some of the sites in the Northern Territory and South Australia where they had been plentiful only 25 years earlier. Aṉangu have also noted a dramatic decline in the range and abundance of warru in the APY Lands since the 1930–40s (Nesbitt and Wikilyiri 1994). Localised extinctions have occurred at all previously occupied sites outside of the APY Lands in South Australia (Figure 3). Within the APY Lands, recent surveys of old and fresh warru scats, and analyses of past and present distribution records, has confirmed a decline in extent of occurrence of 93% of their former range of 88,515km^2 in South Australia (Ward *et al.* 2011b).

Likewise, warru are now extinct across much of their former range in Western Australia (Pearson 2010). Although Gibson and Cole (1993; 1996) considered *P. lateralis* to be widespread in the Northern Territory, they reported that populations varied from common in the central and northern arid areas to rare and declining in southern arid areas. Surveys between 1975 and 1999 found that rock-wallabies had disappeared at 21 of 400 sites inspected in the Northern Territory, mostly small ranges, hills with limited habitat or at the fringes of its known distribution (Gibson 2000). Fresh warru scats were found at 30% of 53 locations on 10 cattle stations in the southern Alice Springs region, but sign was abundant at only 4% of these locations (Central Land Management Association and Threatened Species Network N.T. 2001). Local extinctions of *P. lateralis* had occurred in the central ranges region, particularly from isolated hills and minor ranges at the edges of its known distribution, including Uluru and Kata Tjuta (last record mid-1980s).

5.3.2 Current distribution and abundance

Across Australia, Pearson (2010) reports that extant warru populations have been confirmed from the Northern Territory in the Harts Range, Mt Windajong (Gibson 2000), the George Gill Range, the Petermann Ranges (1996), Bloods Range (1998), Mt Connor (2001), the Davenport Ranges (NT) and the MacDonnell Ranges from Glen Helen in the west to Loves Creek in the east (C. Pavey, pers. comm.).

In Western Australia, warru are thought to survive in isolated pockets in the Townsend Ridges, Cavenagh Range, Murray Range, Rawlinson Range and the Walter James Range. Warru were present at the Bell Rock Range during the 1990s, however a trip in 2010 by the authors with Traditional Owners from Wingellina and Pipalyatjara failed to find any sign. Warru are relatively abundant in the Calvert Range, where recent cat-baiting efforts with Eradicat® has lead to a remarkable and heartening population recovery (Kendrick et al. 2010). Warru are also present at Pungkulpirri Rockhole in the Walter James Range, where fresh scats were collected during a survey trip there in approximately 2007 (D. Pearson pers. comm.). Elsewhere in Western Australia, individuals are rarely observed and populations are apparently widely fragmented (Pearson 1992).

The main stronghold for the taxon remains the MacDonnell Ranges in the Northern Territory (Pearson 2010), stretching over several hundred kilometres with Alice Springs at its approximate centre (Lundie-Jenkins and Findlay 1997; Gibson 2000).

Only two extant metapopulations of warru are currently known in South Australia – in the Eastern Musgrave Ranges (Figure 4), and the Tomkinson Ranges (Figure 5).

5.3.3 Eastern Musgrave Range metapopulation and habitat

Recent surveys have confirmed that a warru metapopulation occupies approximately 640km^2 within the Eastern Musgrave Ranges (Figure 6), extending from approximately 16km west of Pukatja to 5km north of New Well (Ward *et al.* 2011b). This metapopulation is likely to be by far the largest in South Australia and contains at least 100 animals (Ward *et al.* 2011a). Most of the warru monitoring data to date have been derived from three colonies – New Well, Alalka and the now extinct (as of 2006) Wamitjara.

In the Eastern Musgrave Ranges, warru occupy shelter sites including fissures, overhangs and caves associated with granite cliff faces as well as complex piles of massive boulders which typically occur at the base of these cliffs. Geelen (1999) found that highest use areas of Wamitjara and New Well were on slopes of 16–40 degrees and that cliffs with ledges, caves and boulder piles were key habitat. Most of the persistent warru refuges occur at considerable elevation from the surrounding plain, where densities of predators and their primary rabbit prey are typically lower.

Vegetation on these hills typically consists of *Triodia* irritans hummocks, with a mix of *Acacia olgana*, fig *Ficus brachypoda*, native pine *Callitris glaucophylla*, spearbush *Pandorea doratoxylon*, native grasses (*Enneapogon polyphyllus, Cymbopogon ambiguus, Digitaria brownii, Aristida contorta*) and forbs (including *Ptilotus obovatus* and *Sida spp.*).

5.3.4 Tomkinson Range metapopulation and habitat

Currently, warru are known in three locations in the Tomkinson Ranges (encompassing the Tomkinson Range and the Hinckley Range). The largest of these colonies occurs in the boulder-piles, cliffs and gorges on the large hill between Kalka and Pipalyatjara and is referred to as the "Kalka colony" or Dulgunja Hill (Figure 5). Recent surveys by Warru Rangers near Kalka have found two extant colonies, one approximately 5km south of Pipalyatjara and another approximately 5km west (Ward *et al.* 2011b). The population of warru in the Tomkinson Ranges is estimated to be at least 30 animals, but probably less than 50 animals (Ward *et al.* 2011a). The extent of occurrence of Warru in the Tomkinson Ranges is currently 671km^2.

In the Tomkinson Ranges, much of the rocky habitat where warru shelter consists of piles of angular granitic or ultra-mafic boulders. These rock piles, which provide deep, narrow and convoluted crevices, form quite different shelter sites than the more massive outcrops characteristic of the Musgrave Ranges.

The rocky hills of the Tomkinson Ranges are predominantly vegetated by *Triodia* with a low overstorey of blue mallee *Eucalyptus gamophylla* and *Callitris glaucophylla*. The boulder piles which form refuge sites are very sparsely vegetated with occasional figs *Ficus brachypoda* and spearbush *Pandorea doratoxylon*, although dense grasslands and stands of plum bush *Santalum lanceolatum* are found in adjacent drainage areas.

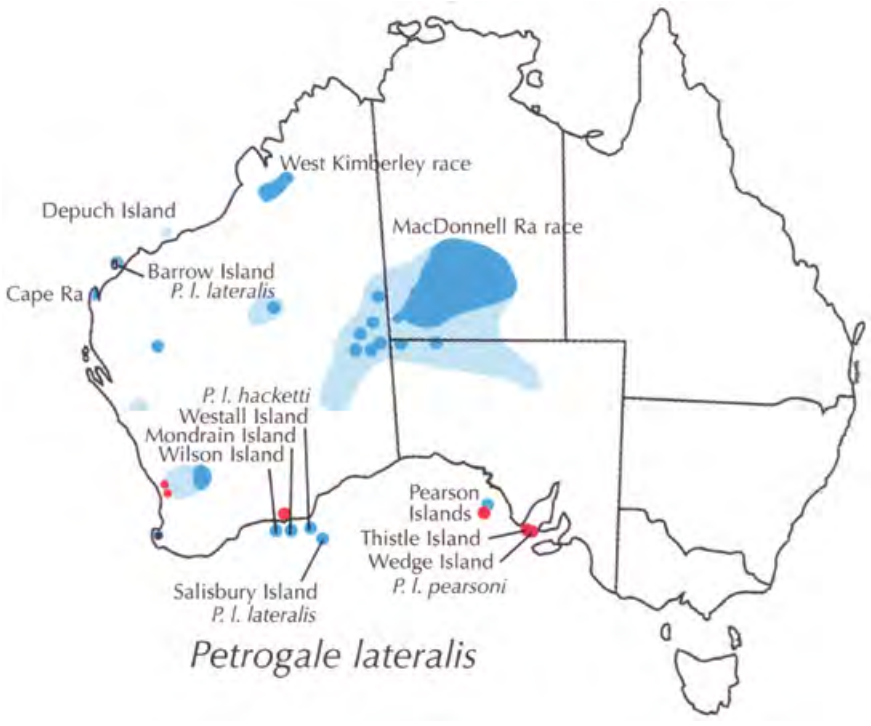

Figure 2. *National distribution of Petrogale lateralis including distribution of Warru P. lateralis MacDonnell Ranges race (taken from Van Dyck and Strahan, 2008).*

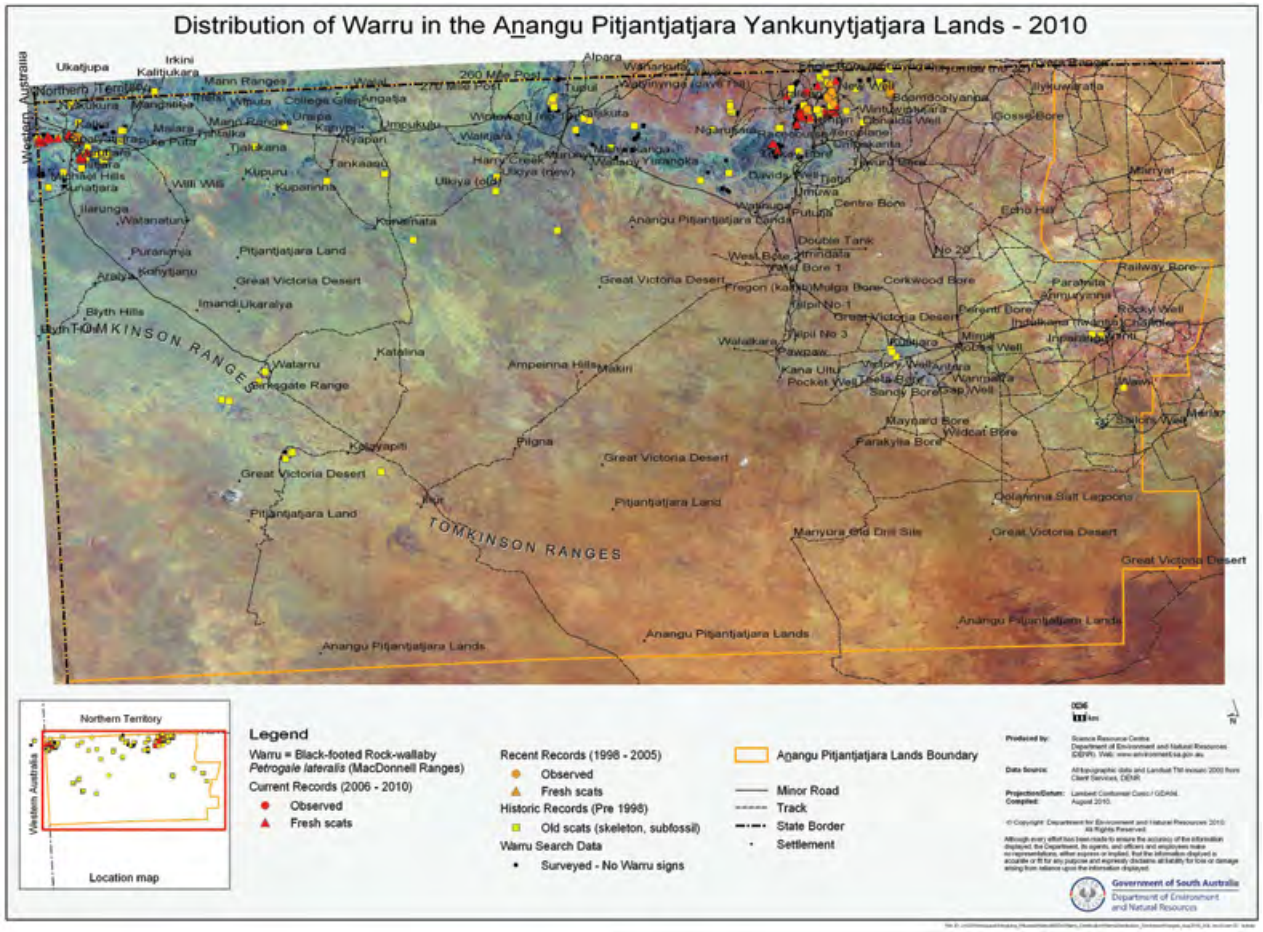

Figure 3. *Historical and current (May 2010) distribution of warru in the Anangu Pitjantjatjara Yankunytjatjara Lands, South Australia.*

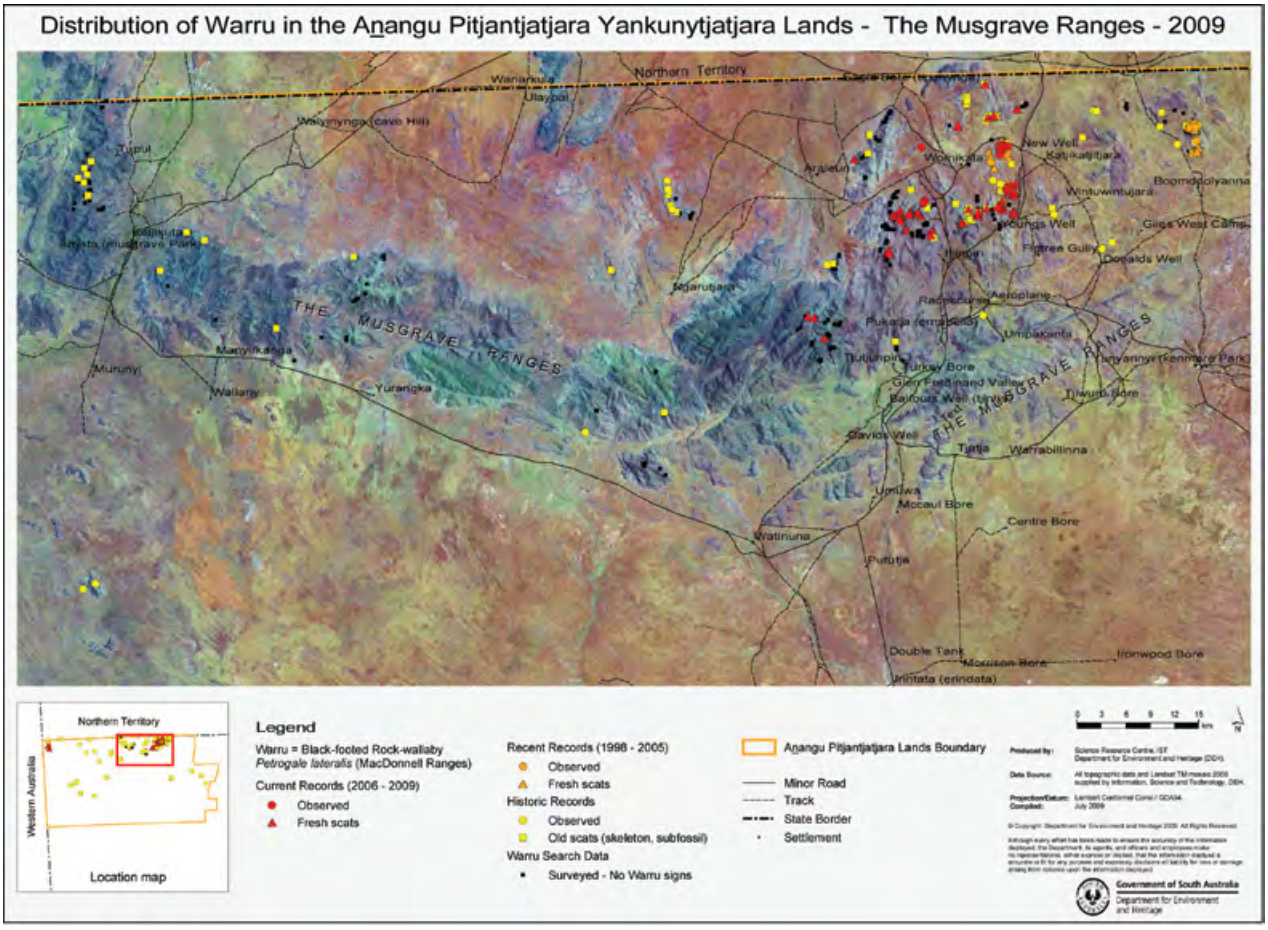

Figure 4. *Historic and current (July 2009) distribution of warru in the Musgrave Ranges, Anangu Pitjantjatjara Yankunytjatjara Lands, South Australia.*

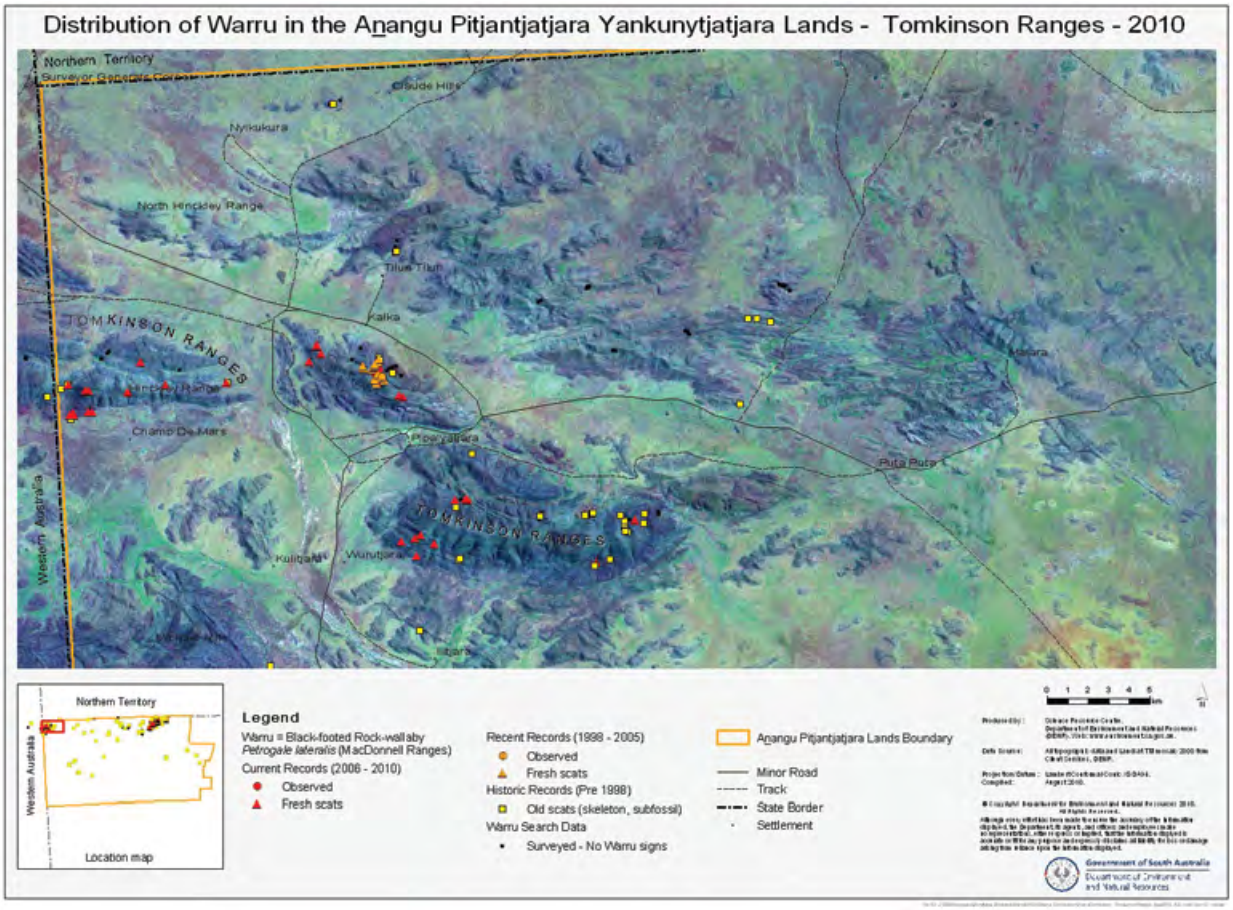

Figure 5. Historic and current (May 2010) distribution of warru in the Tomkinson Ranges, Anangu Pitjantjatjara Yankunytjatjara Lands, South Australia.

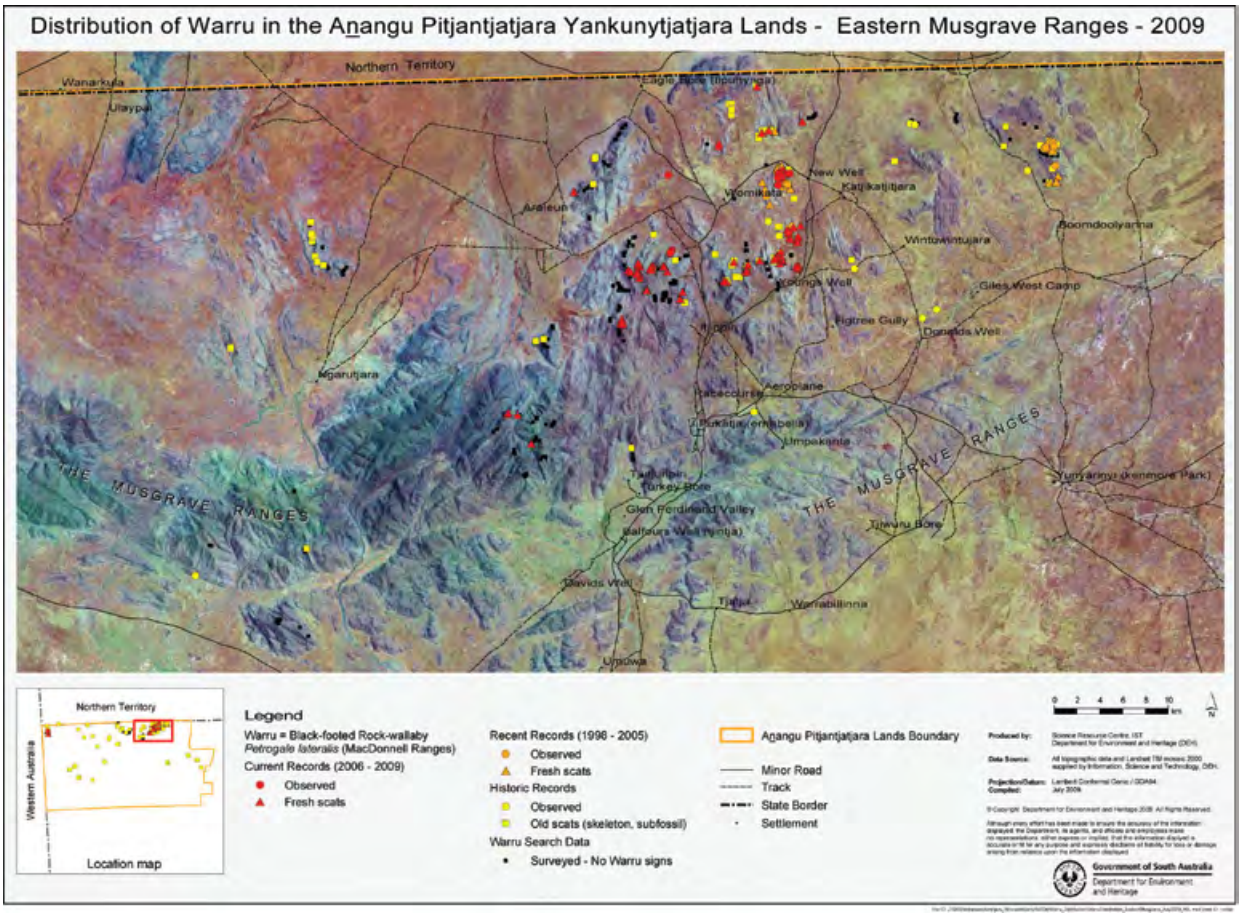

Figure 6. *Historic and current (July 2009) distribution of warru in the Eastern Musgrave Ranges, Anangu Pitjantjatjara Yankunytjatjara Lands, South Australia.*

5.3.5 Food plants

Grasses (especially *Cymbopogon ambiguus, Digitaria brownii* and *Enneapogon polyphyllus*) are a key component of warru diet from New Well and Wamitjara, and fig (*Ficus brachypoda*) fruit and leaves are often found in rock-wallaby scats (Geelen 1999).

A range of other browse (notably *Pandorea doratoxylon* and *Dodonaea viscosa*) and forb (*Rumex vesicarius* and *Rumex acetosa, Ptilotus obovatus* and *Cheilanthes lasiophylla*) species are also considerable components of the diet (Geelan and Read, pers. obs.). Fig is an important part of the diet of *P. l. lateralis* in Cape Range NP along with a variety of other perennial species, especially *dicotyledons* (Creese 2007). Capararo (1994) found that warru near Alice Springs feed mainly on grasses along with a variety of shrubs, herbs and a fern. Aangu informants also suggest that tall grasses (*Themeda* or *Cymbopogon*), *Solanum ellipticum, Boerhavia spp* (roots for moisture) and fig fruit are important dietary items for warru (Geelen 1999).

5.3.6 Den sites, movements and dispersal

Much of what we know about the habitat use and movements of warru in the APY Lands follows radio-telemetry of over 20 warru around New Well and Alalka (Read and Ward 2007), and a limited study using GPS collars (Ruykys *et al.* in prep.).

Read and Ward (2007) found that most warru dens occur in deep crevices, often between the main rock slab and fractured blocks, from which warru can be neither seen nor flushed. One female was radio-tracked on two different days to a site with no visible crevices or dens within 10m, indicating that she must have sheltered in a substantial cave system below ground. Occasionally warru occupy boulder piles, from which they are more likely to be flushed. Males are twice as likely to be observed active or flushed during the day than females. Most warru, particularly males, use different diurnal dens nearly every day with an average separation distance between den sites of 550m for males, compared with 307m for females (Read and Ward 2007). Three females exhibited very strong site fidelity by using dens within 40m throughout the six night monitoring period (Read and Ward 2007).

Warru clearly can and will move away from the immediate vicinity of their den sites, however the majority of their activity is almost exclusively restricted to rock outcrops (Read and Ward 2007).

Ruykys *et al.* (2011) found that there are numerous interesting individual records of animals making forays at least 1km away from the highest quality den-site habitat at the main face of Alalka. Using GPS collars (albeit from only one animal due to mass equipment failure), Ruykys (2011) found that a female warru had a broader home range of 57.9ha (90% kernel range), however its core home range of 9.3ha (50% range) was focused in an area of high habitat complexity that included innumerate rocky outcrops and boulder piles.

Ruykys (2011) also found that the warru's broader home range encompasses flats adjacent to the primary rocky escarpment, and the animals make larger movements of up to 1.2km, including across flat terrain. In support of this, genetic analyses of warru parentage in the APY Lands found evidence of migration from New Well to the Alalka colony (approximately 12 km, Ruykys 2011).

Therefore, despite their restriction to rocky habitats, warru can have large home ranges and be highly mobile, and this needs to be considered in future planning of conservation management, including reintroductions.

5.3.7 Metapopulation potential

The presence of multiple colonies, within relatively safe dispersal distances (1–5km), appears important for the persistence of warru in the APY Lands. In these areas a colony that has suffered decline or localised extinction through predation, fire or other causes can be repopulated by adjacent colonies. Colonies within a metapopulation, or likely distribution range, are considerably more robust than remote colonies with little or no chance of repopulation or infusion of new genetics. Kinnear *et al.* (2010) demonstrated how Western Australian wheatbelt *P. lateralis* colonies act as a metapopulation by recolonising vacant niches.

In the APY Lands the remaining areas where warru exist are no longer thought to consist of isolated colonies of New Well, Alalka and Kalka, but comprise warru metapopulations. These metapopulations are the Eastern Musgrave metapopulation and the Tomkinson Ranges metapopulation (Ward *et al.* 2011b).

5.3.8 Rainfall in warru habitat

Mean annual rainfall for Ernabella is 276mm and Pipalyatjara is 284mm, both predominantly in the summer months. William Creek (adjacent to Davenport Ranges population) receives an average of 125mm per year with a more even monthly spread.

6. Known and potential threats

6.1 Predation

6.1.1 Fox

The role of fox *Vulpes vulpes* predation in causing the decline and preventing the recovery of rock-wallabies has been demonstrated for *P. lateralis* in the WA wheatbelt (Kinnear *et al.* 1988; Kinnear *et al.* 1998; Kinnear *et al.* 2010), in coastal *P. rothschildi* populations on the Burrup Peninsula and Dampier Archipelago islands (Kinnear *et al.* 2002), for *P. penicillata* (Short and Milkovits 1990, NPWS 2002) and for *P. xanthopus* (Sharp 1999; Department for Environment and Heritage 2006).

Although causality has not been demonstrated in other studies, evidence suggests that foxes have been largely responsible for the demise or extinction of other warru populations, including Kalbarri National Park (Pearson and Kinnear 1997), Calvert Range and Cape Range (Pearson 1992) and the Davenport Ranges (SA), where warru remains were recorded from two of 13 fox scats collected immediately following the demise of the warru population (Moseby *et al.* 1998). Further evidence of the role that foxes play in limiting or threatening rock-wallaby populations is presented by the persistence of stable rock-wallaby populations in the Pilbara and central Northern Territory (Pearson 2010), and in south-west Queensland, all areas where foxes are scarce or absent.

In the APY Lands, high numbers of foxes detected through spotlighting around Wamitjara and New Well in the early 2000s (Read 2001) are thought to have contributed to the extinction or suppression of local warru colonies (Read 2006). Regular fox baiting has precipitated recoveries in rock-wallaby populations in southern areas of Australia (DEH 2006; Kinnear *et al.* 2010) and is believed to have led to an increase in abundance and reoccupation of vacant habitat in the Townsend Ridges (30km SE of Warburton, Pearson 2010).

However, inconsistencies in either baiting effort, monitoring rigour, or observed response have masked interpretation of the effectiveness of fox baiting in the APY Lands. Currently, the fox population around the New Well population is thought to be low, based on monitoring results from the Warru Recovery Team. Whether this is going to lead to a recovery of warru numbers at New Well can only be determined through many years of monitoring. Interestingly, where fox baiting has been less frequent – Alalka and some surrounding ranges – warru populations have not demonstrated any significant decline in recent years (cautionary note – this comparison is based on trapping data 2005–2009 from Alalka, as opposed to scat quadrat monitoring 2000–2009 at New Well and Wamitjara).

6.1.2 Feral cat

Confirmation of the role of feral cat (*Felis catus*) predation on warru remains unclear, largely due to the difficulties in experimentally manipulating cat numbers and acquiring stomach or scat samples for dietary analyses. Kinnear (pers. comm.) observed a feral cat standing over the body of a freshly killed juvenile *P. lateralis*, and Spencer (1991) observed feral cats eating young *Petrogale assimilis* (up to 4kg in weight as adults) in tropical Queensland and believed that feral cats had a role in limiting recruitment. Cats are also considered the primary cause of warru predation in the Kurukanti (Calvert Ranges) population in the Little Sandy Desert (Rangelands NRM WA *et al.* 2009).

In the APY Lands, cats are at times abundant in the vicinity of warru colonies (Read 2009b) and several large cats (>5.5kg) have been shot in rocky habitat occupied by warru (pers. obs.). Despite typically being more difficult to detect through track monitoring, cats have consistently been recorded more frequently than foxes at New Well from 2007–2010 (Section 7.3). Evidence from studies of other medium-sized threatened species suggest that even a small number of cats that have learned to prey on adults or young can cause the localised extinction of small or confined populations including those of rock-wallabies (Spencer 1991), mala (Gibson *et al.* 1994) and bilbies (K. Moseby pers. comm.).

Hence, it is likely that cats have played an important role in suppressing already diminished warru populations in the APY Lands. The survival monitoring carried out by the Warru Recovery Team through radio-telemetry supports this notion. Of 23 adult warru radio-tracked between August 2007 and December 2008, 21 were assumed to be alive, one had died and the fate of the final one was unknown, possibly through equipment failure (Warru Recovery Team unpublished data). This high adult survivorship would suggest that juvenile mortality is a more significant factor in driving warru decline than adult mortality, and given low dog and fox numbers it is likely that cats are responsible for predation of many of these juveniles.

There is evidence that the removal of dingoes and foxes leads to an increase in feral cat numbers through a "mesopredator release" mechanism (Corbett 1995; Finke and Denno 2004; Johnson 2006). This phenomenon has potentially serious consequences if cats, due to their ability to enter the wallabies den sites, are more efficient predators of juvenile (or adult) warru than dingoes and foxes. A complementary technique to comprehensive predator baiting, would be to maintain dingo and dog numbers to suppress cat populations and deliver fox baits in dingo-excluding devices, and/or deliver poison to cats in a controlled manner that does not expose dingoes or dogs.

Feral cats have proven difficult to control wherever their prey is abundant because they generally only scavenge under times of severe food stress and are less likely to consume baits (Denny and Dickman 2010) or be attracted to baited traps than dingoes or foxes.

Recently, however, Kendrick *et al.* (2010) found that year-round implementation of combined fox and cat baiting using Eradicat® led to a significant decrease in the number of cats and foxes and a subsequent significant recovery of Warru in the Calvert Ranges in Western Australia. This is very exciting news and a trial implementation of Eradicat® baiting is high on the action priority list for the Warru Recovery Team.

6.1.3 Native and naturalised predators

6.1.3.1 Dingo

Dingoes are the largest predator throughout the contemporary distribution of warru in South Australia, although their threat to warru remains unclear. Warru remains were recorded from 6 of 13 dingo scats analysed just after the Davenport Ranges (SA) population crashed to extinction in 1998 (Moseby *et al.* 1998) and Ngaanyatjarra Aborigines identify dingoes as important predators of rock-wallabies (Pearson 1992). However, 36 Canis scats collected and analysed from the Musgrave Ranges in 2008 demonstrated no warru predation (80% of scats were made up of *Macropus* and rabbit *Oryctolagus cuniculus* hairs, Ward, unpublished data).

Dingoes, however, are also believed to reduce the threat of foxes, either by direct predation or interference (Johnson 2006; Glen *et al.* 2007) and in some environments predation risks appear reduced when dingoes are not controlled. Likewise, the high densities of camp dogs in and around warru populations at Kalka and several Alice Springs populations may be beneficial for these warru by reducing fox or cat predation. The role of dingoes or dogs in suppressing more effective warru predators is not consistent. Despite apparent benefits in some regions, warru are continuing to decline or have become extinct in parts of the APY Lands and Western Australia (Pearson 2010) where dingoes are not controlled.

The relative threat of warru predation by dingoes versus the role that dingoes can play in cat and fox suppression are likely to be dependent upon the complexity of warru refuges (dingoes are less agile and less able to penetrate small crevices than foxes and cats), the composition and abundance of alternative prey and the necessity for warru to move outside safe refuges for feeding or dispersal. Dingoes may also play an important role in suppressing euro, goat, rabbit and other herbivores that may otherwise compete with warru for food resources. Further complicating the role of dingoes is that stable dingo packs may be more likely to defend their home ranges against competitors (mainly mesopredators). Hence, they could be more likely to suppress foxes and cats than immigrants invading an area of dingo control (Wallach *et al.* 2009), which suggests that low levels of dingo control may have a disproportionately large effect on their potential beneficial role.

Regional broad-scale dingo control (including baiting by pastoralists in NT and SA) has disrupted the ecological balance and likely contributed to increased densities of kanyala and cats in the warru habitat. Continued broad-scale baiting campaigns that affect dingoes and camp dogs are unlikely to provide a long-term sustainable environment conducive to the persistence of warru.

Management of dingo and feral predators presents one of the most challenging conundrums for warru conservation. Ideally, a method of controlling exotic predators without disrupting the pack structure of resident dingoes should be implemented.

6.1.3.2 Wedge-tailed Eagle

The wedge-tailed eagle *Aquila audax* is another native predator of rock-wallabies across Australia (Hsu 2001) and is also a renowned scavenger of carcasses. Their impact on warru is not quantified and likely to be minimal when compared to the scale of the potential impact of foxes and cats.

Between one and three wedge-tailed eagles were sighted on each of 16 of 18 visits to New Well and were particularly abundant at Wamitjara where eight eagles were counted in May 2004 (JL Read unpublished data). By contrast, a maximum of two eagles were recorded on only five of 12 visits to the Kalka warru colony. Warru bones have also been found in a wedge-tailed eagle nest at New Well (Read unpublished data), and eagles were present in significant numbers at the last known refugia of warru in the Davenport Ranges just prior to their demise (H. Ehman pers. com.).

A range of other birds of prey, large goannas and pythons may also be occasional predators, however, they are not thought to pose a threat to warru conservation.

6.2 Exotic plant invasions

6.2.1 Buffel grass

Introduced to the APY Lands as a dust suppressant around communities and as forage for pastoralism, the spread of buffel grass *Cenchrus ciliaris* remains uncontrolled, with infestations in new locations increasing in abundance (pers. obs.). Buffel grass is a fast-growing and very flammable exotic grass that has invaded warru habitat in recent decades. It can withstand long periods of drought and frequent fires (Paltridge and Latz 2010a). Through its displacement of native grasses and propensity to carry fires which can destroy key warru forage species, including fig, buffel grass poses a serious threat to the sustainability of warru habitat and biodiversity in general.

Buffel grass remains uncontrolled across the APY Lands and landscape control is probably now unattainable. Once established, buffel grass fuel loads require frequent management if threatened species locations are to be protected (Paltridge and Latz 2010a).

Buffel grass management should initially focus on minimising the impact on threatened species sites such as known warru colonies, hardening-off and reintroduction sites. Control can include a combination of burning, chemical spraying and mechanical removal (Greenfield 2007).

Reports of various control attempts given at a buffel grass workshop in Port Augusta in September 2010 indicated that chemical spraying is most effective over a large areas. Chemical spraying should occur following good rains when buffel grass is green (before mature plants flower), and spraying within 10 days of rain may be required to prevent seed set. See Greenfield (2007) for a summary of other potential chemical applications. Preliminary results in the Alinytjara Wilurara region indicate that comprehensive coverage of each individual plant is one of the most important factors in killing each individual plant.

Although buffel grass burns readily even when green, it recovers quickly after fire and the ashes make a good seed bed from which germination quickly occurs (Greenfield 2007), particularly for medium to large patches.

Manual and mechanical removal is effective in small isolated patches and may be applicable in priority areas, such as threatened species sites (Pitt 2004). However, it is labour intensive, costly and inappropriate for extensive areas.

From their work at the Uluru Kata Tjuta National Park, Puckey and Albrecht (2004) found that the most efficient means of control at sites that have a well developed buffel grass seed bank is to spray plants with herbicide, then burn the dry plant matter and surface seed bed, with a follow-up spray of any regrowth. This method is most appropriate for small patches of dense buffel grass with little or no shrub or tree cover on flat terrain (Greenfield 2007).

It is recommended that a buffel grass management plan be developed for the APY Lands, with dedicated staff members to control buffel grass at key sites across the lands, in particular important warru sites.

6.2.2 Other

Ruby dock *Acetosa vesicaria* has colonised several areas occupied by warru. Unlike buffel grass, however, it is not likely to dramatically change the environment and has been noted as a food plant of warru (pers. obs.).

Although not currently a threat in warru habitat in the APY Lands, cacti, including rope cactus and prickly pear (*Opuntia* spp.), have the potential to colonise rocky inland ranges and serious infestations could be detrimental. Growing of potentially invasive exotic plant species should be discouraged on the APY Lands and any outbreaks adjacent to warru habitat should be quickly removed.

6.3 Inappropriate fire regimes

Warru populations are partially buffered from the effects of wildfires due to their occupancy of rocky landscapes. However, uncontrolled wildfires have been suggested as a factor in the decline of some macropod species (Burbidge and McKenzie 1989; Woinarski *et al.* 2001; Pearson 2010). Evidence of a less frequent fire regime in the Musgrave Ranges includes remnant patches of mulga, mallee and *Callitris* which have been untouched by fire (pers. obs.).

Fire may cause short-term loss of feeding resources and expose rock-wallabies to increased predation, but it may also regenerate areas of unpalatable vegetation (such as old *Triodia*), stimulating palatable fire ephemerals and regenerating perennials. A fire that burnt around 80% of the area occupied by a *P. lateralis* West Kimberley race population in the Erskine Range appeared to have little impact on the abundance of rock-wallabies (Pearson 2010).

The APY Fire Management Plan (Paltridge and Latz 2010a) and Fire Management Plan for three rock-wallaby sites in the eastern APY Lands (Paltridge and Latz 2010b) should be referred to for direction on managing fire around known warru colonies. Some fire management has already been conducted, including protection burns around the lower slopes and base of New Well. Furthermore, a protection burn implemented in 2011 around the Warru Pintji was effective in stopping a wildfire from reaching the fence and the warru colony.

The authors believe there are two types of site-specific fire management strategies that should be employed at warru colonies – habitat protection burns and habitat enhancement burns. Habitat protections burns should be employed regularly to prevent large-scale wildfires completely burning out the entire warru colony. For New Well, this could involve patch-burning areas of grasslands surrounding New Well on an annual rotating basis, or in particular after heavy rains have promoted vigorous regrowth. In addition, fire could be used to manage buffel grass around New Well but only when combined with intensive chemical control (Section 6.2.1). If left to colonise much of Warru habitat, buffel grass itself has the potential to negatively alter fire regimes and lead to larger, more intense wildfires.

Habitat enhancement burns are designed to promote regrowth or 'green-pick' to enhance the availability of quality feed for warru. For example, there was evidence of warru feeding several months after a fire on the lower slopes of New Well. Habitat enhancement burns should not occur too often and extreme care is required to ensure these burns do not negatively affect the core den sites and shelter areas for warru.

It should be noted that any habitat enhancement/habitat protection patch burning should be complemented with follow-up monitoring to determine whether warru, kanyala, and predators are preferentially feeding in or avoiding that area. Options include scat count comparisons inside and outside the burn and the use of GPS collars on warru.

6.4 Domestic, feral and native herbivores

Overlaps in the diets of several sympatric herbivores with warru have been recorded (Capararo 1994; Creese 2007). Euros *Macropus robustus* (kanyala) are likely to be the major competitor in the APY Lands. Their overlapping dietary preferences, superior reach to obtain browse (Creese 2007) and release from predation where dingoes have been controlled are likely to favour kanyala over warru and account for their high population densities, especially relative to their historic low densities in the APY Lands (Finlayson 1961). There is also evidence that euros can be physically aggressive towards other *Petrogale* in order to access water.

Pearson (2009) questions whether there may be times when some control of euro numbers (either directly through removal or indirectly by turning off or fencing water sources) may improve rock-wallaby recruitment and survival, especially in small populations where predator baiting is being used to increase numbers, as well as at translocation sites. This could easily be achieved through the employment or hiring of professional or local shooters and appropriate disposal of carcasses (see sub-action 1.1.2).

In the APY Lands, donkeys *Equus asinus*, cattle *Bos taurus* and camels *Camelus dromedarius* have increased in recent years and at times exert obvious impacts on the vegetation of the plains and creeklines around warru colonies. These large ungulates also foul and drink water supplies which could also affect warru. However, the main impact of large ungulates is likely to be removing cover used by dispersing warru. Should predator control allow warru to once again forage extensively on the plains away from their rock refuges, the grazing of these large ungulates will likely limit food resources for warru, especially in dry times and in the immediate vicinity of waters.

European rabbits shelter in warrens and rock-piles around the base of rocky ranges and even on the tops of desert ranges. Presumably, they also reduce the amount of potential forage for rock-wallabies although their principal threat is likely to be by supporting higher predator populations (Read and Bowen 2001).

6.5 Pastoralism

Much of the APY Lands in the vicinity of both extinct and extant warru populations has been used, or is still in use, for pastoral production. High densities of sheep significantly reduced forage levels in the vicinity of several warru colonies in the Eastern Musgrave Ranges (D. Fraser pers. comm.), but in recent years broadscale cattle grazing has been the principal pastoral activity. Domestic stock may reduce available food resources for warru and competing herbivores on the plains surrounding warru colonies. A large herd of agisted cattle were introduced to the Wamitjara region and noticeably reduced grass cover in the early 2000s, but this was not considered a key threat for warru which had already declined and were restricted to complex den sites, most likely because of high predation pressure.

Of greater consequence to warru are likely to be the eco bi-products of pastoralism. These include burgeoning populations of donkeys and camels that have benefited from pastoral water supplies, as well as euros and cats which have benefited from dingo control by pastoral interests.

Any expansion of waterpoints or dingo control in the vicinity of warru colonies may therefore present additional challenges to warru recovery. Likewise, careful consideration of current and potential pastoral practices should be given prior to selecting locations for warru reintroductions, both within and outside the APY Lands.

6.6 Changes to water availability

Although near-permanent springs or rockholes are a feature of the habitat of many warru populations, their dependency on and use of free water remains unclear. For example, the rockholes in the Davenport Ranges were believed to be a key resource for the warru colony (Moseby *et al.* 1998). However, by comparison, a paucity of warru scats or tracks around the Maku Valley spring at the Kalka warru colony suggest they may not regularly use this potential resource, despite remote camera records of a warru using the spring (APY Land Management unpublished data).

More significantly, despite better quality rockholes persisting in areas formerly occupied by warru in the APY Lands, most of the extant warru colonies in the Eastern Musgrave Ranges do not have ready access to permanent or even remotely reliable free surface water. Therefore, any changes to the regional hydrology through extraction of water for pastoralism or mining exploration are unlikely to directly affect warru. However, further research should be undertaken if existing pastoralism or mining expand into key warru sites.

Paradoxically, with increased predator numbers limiting warru access to permanent water, ephemeral rockholes and even fresh surface water may provide an important resource for warru. Pearson Island black-footed rock-wallabies *Petrogale lateralis pearsoni* apparently compete for free surface water on rocks after rain and have been observed drinking from puddles (D. Taggart, pers. comm.). Kinnear *et al.* (2010) suggest that free water may enable *P. lateralis* to increase to 'pest' status by reducing their dependence on thermal refuges. We also do not discount the possibility that although apparently not essential for adult warru, which have been the focus of the Warru Recovery Team research and monitoring, free water may enhance recruitment rates of juvenile warru. The significance of this possibility is elaborated in the climate change and proposed management sections.

6.7 Small population size and population fragmentation

The increased likelihood of inbreeding when rock-wallaby populations are small may result in reduced genetic variability, the expression of recessive genes or suppressed reproductive rates (Eldridge *et al.* 1999; Eldridge *et al.* 2004). These negative traits are likely to become increasingly serious as populations are likely going to need to adapt to changing climates. A study of the level of inbreeding at three warru colonies (Kalka, Alalka and New Well) indicate the colonies are currently neither inbred nor outbred (Ruykys 2011).

6.8 Disease

Little is known about the parasites and diseases of rock-wallabies, although fleas, ticks and lice are found on many wild caught *P. lateralis* (Pearson 2010), as well as on ecologists who handle warru (pers. obs.). Furthermore, the potential role of disease in causing the decline of rock-wallabies is unknown but has been suggested by Woinarski *et al.* (2001).

For warru, no specific diseases have been evident in wild caught or captive bred individuals despite attendance of vets during trapping sessions. Warru have yet to be tested for toxoplasmosis, however, to which *Petrogale* are highly susceptible and can circum very quickly. Rigid hygiene practices have been employed to minimise the likelihood of transferring diseases to both the wild and captive populations of warru. Despite many hours of monitoring warru over nearly a decade, sick or dying animals have not been encountered and together with high adult survivorship suggest that disease is not a proximal factor in the decline or suppression of warru populations.

6.9 Climate change

Climate change is predicted to lead to higher temperatures, large increases in annual potential evaporation and lower annual rainfall, but a likely increase in frequency and magnitude of heavy summer rainfall events over much of the contemporary and historic range of warru (McInnes *et al.* 2003). Increased climatic variability could lead to changes in fire regimes, the types or availability of food resources and the populations of competitors and predators. Consequently, optimal warru management regimes need to incorporate monitoring and adaptive change as required.

Although difficult to assess, climate change may have already rendered marginal warru localities unsuitable for occupancy or may result in shifts in the optimal geographic range of warru. For example, if accessibility to fresh water following summer rainfall enhances warru recruitment, modest changes to the frequency or timing of summer rainfall events could lead to considerable changes in warru populations. Any fragmentation of populations and reduced genetic variability also limits the possible evolutionary response of populations and dispersal to changed habitats (Pearson 2010). These factors increase the importance of reintroducing warru to widely separated parts of their former range and also charges the Warru Recovery Team with researching and implementing appropriate dispersal mechanisms (including assisted dispersal) for warru or their genetic material.

Producing spatial habitat suitability models for warru and how this may change over time with climate change will be valuable for assessing potential future reintroduction sites outside of the APY lands.

6.10 Disturbance by hunting or recreation

New Well area was historically a favoured area for hunting warru and alerted government scientists to their presence (Copley pers. comm., Nesbitt and Wikilyiri 1994). Other isolated outcrops, including Wamitjara and several hills in the northern Tomkinson Ranges, also provided access to vehicle-based hunters. The colonies occupying higher or more remote hills (including Kalka and Alalka) have probably experienced little hunting since vehicle-based shooting became the favoured hunting technique. Warru traps, consisting of boulders and logs sealing off back entrances to favoured caves, still remain in the Watarru area and probably significantly enhanced hunting success in the past.

Hunting pressure on introduced or over-abundant animals in and around warru colonies could be beneficial, especially where cats, rabbits and kanyala are shot or killed by hunter's dogs.

Warru appear to be relatively tolerant of passive human visitation to their colonies and indeed some colonies in the Alice Springs area have likely benefited from enhanced food supplies associated with visitors.

6.11 Resource exploration and mining

An increase in pastoral and mining activities has been highlighted as a threat to country in the draft Alinytjara Wilurara NRM Plan (Alinytjara Wilurara NRM Board 2010). In recent years, there has been an increase in mining exploration activities across the APY Lands. Some of the rock outcrops within the Tomkinson Ranges have been sites of chrysoprase extraction, and the area is highly prospective for other minerals, in particular limonite, laterite nickel and cobalt deposits (http://www.anangu.com.au/minerals-resources.html).

Increased mineral exploration throughout the APY Lands could lead to ground-disturbing exploration and potentially mining activities in or adjacent to other extant or potential warru habitat. Mining, and particularly modern exploration activities, usually have a relatively confined direct footprint, however potential secondary impacts need to be considered when assessing exploration and mining applications, including:

- Invasion of exotic plants, particularly buffel grass, which are readily spread by vehicles, earthmoving equipment, clothing, footwear etc.
- Increased use by feral animals of new tracks developed by exploration activities.
- Extraction of water which may affect local spring fed rock-holes.
- Uncontrolled wildfire.
- Disturbance by humans and machinery of warru behaviour and habitat.

Another threat to land and warru management is economic drivers favouring employment in other sectors, resulting in a loss of people with high skill and ability levels (Alinytjara Wilurara NRM Board 2010). Conversely, companies and their royalties could provide valuable finances and logistic support for natural resource management generally, and specifically for warru conservation activities.

Any proposed mining or exploration activities within the vicinity of existing or potential warru habitat needs to be carefully considered, managed and monitored to minimise primary and secondary impacts to warru and to ensure that net impacts to warru and their environments are beneficial.

7. Warru research and management

7.1 Warru distribution surveys

7.1.1 Davenport Ranges

In 1989, a geographically isolated population of around 50 warru was located in the Davenport Ranges on the western side of Lake Eyre (Eldridge *et al.* 1994). The colony was estimated at approximately 30 animals by both Mark Eldridge in 1992 and Peter Alexander in 1993 and 12 warru were seen by Ralph Coulthard in March 1997. However, extensive searches throughout 1998 failed to locate any sightings or fresh scats in the Davenport Ranges (Moseby *et al.* 1998) and it is believed that prey-switching by foxes and dingoes following the decline in rabbit populations through the arrival of rabbit calicivirus disease (RCD) caused their local extinction (Moseby *et al.* 1998). In addition, the numbers of foxes and dingoes was also probably elevated at the same time due to a substantial donkey eradication program.

7.1.2 APY Lands, 1966–2006

The following summary of Warru surveys in the past 40 years is in part an edited extraction from Robinson *et al.* (2003). For distribution prior to 1966, see Section 5.3.1.

Peter Aitken (unpublished journal and museum collections) did not record the species during either of his collecting trips to the region in December 1966 and February 1968. And, in 1967, Philpott and Smyth recorded rock-wallabies at only one location, Alkara, 145km SW of Mt Woodroffe.

During an ecological survey of the APY Lands commencing in 1985, local Aboriginal people were asked about the whereabouts of rock-wallabies, and there was some searching of suitable habitat and the collection of sub-fossil material. In September 1985, Copley *et al.* (1989) observed rock-wallabies at only one site – a large cave with boulders all around it, near Wamikata, just north of Ernabella. From locating fresh scats, Copley *et al.* (1989) also reported a few scattered extant populations during this survey; including Wamitjara (Sentinel Hill) in the Musgrave Ranges, one site in the Everard Range and two sites in the Mann Ranges. However, Aboriginal informants indicated that warru were once found in a number of areas in the north-western region of the state, including the Everard, Indulkana, Birksgate, Musgrave and Tomkinson Ranges, the Deering Hills and Sentinel Hill (Copley and Alexander 1997).

Because no rock-wallabies were located at standard survey sites during the biological survey, a more targeted survey for the species was undertaken by Brad Nesbitt and Ginger Wikilyiri (1994). They visited 14 sites in the north-eastern part of the APY Lands in 1994 where traditional owners believed rock-wallabies were still extant. This resulted in wallabies being found at two sites, near New Well and at Sentinel Hill/Wamitjara. Old faecal pellets were found in caves at many of the sites, supporting the earlier accounts of the species' former widespread distribution and also supporting the claims of their more recent serious decline. Exemplifying this, was the lack of any recent sign of wallabies at the Wamikata site where they were seen in 1985. Genetic examination of some ear tissue taken from a rock-wallaby trapped at Sentinel Hill in 1997 indicated these animals belong to *Petrogale lateralis* MacDonnell Ranges race (Eldridge, pers. comm., in litt.).

In 1999, warru were only known from a fraction of the New Well and Wamitjara outcrops (Geelen 1999), however, the known extent of both these colonies was subsequently increased to much of both outcrops (Read 2001). The New Well population was subsequently revealed to be part of a metapopulation of small colonies found on a number of outcrops stretching approximately 5km north and 15km south of New Well (Read 2008). However, there were no further sightings of rock-wallabies at Wamitjara after May 2002, and no fresh scats were recorded after October 2005, suggesting this population declined to extinction by 2006 (Read 2006).

Since 1999, APY Land Management, Ecological Horizons and SA Department of Environment and Natural Resources have been conducting further surveys. In the Tomkinson Ranges, a population was located at Dulgunja Hill near the community of Kalka (Read 2001). Local people identified three other sites near Kalka and one near Watarru where they believed rock-wallabies were extant, but only Dulgunja Hill had fresh signs in a confined area of habitat (Read 2001). Another small colony was located approximately 5km south of Kalka at Nyimu Valley, providing hope that other colonies will be recorded in nearby hills south and east of Pipalyatjara (Read 2009a). Searches in the Mimili, Walalkara and Indulkana regions recorded old warru scats but no evidence of extant populations.

In October 2005, an extant population was found by Jason van Weenen approximately 12km south west of New Well at a site called Alalka. Subsequently, Alalka has become a significant trap monitoring site and source of pouch young for captive breeding purposes, and seems to be a stronghold within the larger Eastern Musgrave metapopulation (Ward *et al.* 2011a).

7.1.3 APY Lands, 2006–2010

More recently, there has been considerable effort in surveying areas of the former range of warru for extant populations, in order to clarify the distribution and status of the species and to inform management. In particular, the Warru Recovery team has focused on inaccessible areas, as well as areas adjacent to current populations previously not surveyed. A recent protocol for warru surveys developed by John Read is provided in Ward *et al.* (Ward *et al.* 2010a).

Between August 2008 and June 2010, the Warru Recovery Team conducted helicopter- and ground-based searches at over 500 sites in the Musgrave Ranges (Ward *et al.* 2011b). Numerous new sites containing signs of extant and historical warru habitation were identified during the searches (Figure 6). Of particular note in the Musgrave Ranges (as identified by the presence of fresh scats), were a number of small extant populations in the various hills approximately 5km north of New Well, and at least two small colonies approximately 15km due West of Ernabella.

However, the surveys have highlighted the massive range contraction of warru across the entire Musgrave Ranges. The current known extent of occurrence (EO) and area of occupancy (AO) – based on a range of 2km from scat locations – is 427km^2 and 247km^2 respectively, representing a known decline of 3306 km^2 in EO and 393 km^2 in AO from their historic distribution.

In the Tomkinson Ranges, a number of new locations where Warru currently live were identified, when previously they were thought to only occur on Dulgunja Hill between Kalka and Pipalyatjara. This includes what seems like a much wider distribution of warru over Dulgunja Hill, important dens sites south of Pipalyatjara, and the discovery of small colonies to the west of Pipalyatjara and Kalka along the Hinckley Range to the Western Australian border. In addition, further evidence of historic colonies were found in the ranges approximately 18km east of Kalka. It is not possible with the data available to determine whether the increase in known contemporary range recorded during the 2008 and 2010 surveys indicates a real increase in the distribution of warru or is a consequence of inadequate search effort in the past, however, the latter is more likely.

Furthermore, in the Tomkinson Ranges surveys in 2010, a scat which was believed to be less than five years old, was found approximately 20km south of Pipalyatjara, suggesting that range contractions are still continuing (Ward *et al.* 2011a; Ward *et al.* 2011b). The current known EO and AO of warru in the Tomkinson Ranges is 158km^2 and 143km^2 respectively, representing a known decline of 513km^2 in EO and 82km^2 AO from their historic distribution.

The current surveys have also significantly refined the recovery team's knowledge of the range contraction of warru across the entire APY Lands and South Australia by enabling comparison of the historical range (based on historical localities and old warru records) and the current extant distribution. Currently, the EO of warru in South Australia is 6,400km^2 and occurs entirely in the APY Lands, representing a decrease of 82,115km^2 (Ward et al. 2011b). A summary of the EO and AO of warru across different ranges in the APY Lands is provided in Figure 7 and Table 1 (next page).

Table 1. *Summary of the historic and current known Extent of Occurrence and Area of Occupancy of warru (Petrogale lateralis MacDonnell Ranges race) in South Australia, including the different geographical zones of the Anangu Pitjantjatjara Yankunytjatjara (APY). All figures are km² and from Ward et al (2011b).*

	Geographic region	Historic and potential range	Known current	% Decline
Extent of occurrence	South Australia	88515	6400	93
	APY Lands	52657	6400	88
	Musgrave Ranges	3733	427	89
	Tomkinson Ranges	671	158	76
	Everard Ranges	27	0	100
	Indulkana Ranges	224	0	100
	Mann Ranges	1799	0	100
	Central Isolated Granites	2012	0	100
	South-west Isolated Granites	1018	0	100
Area of occupancy	South Australia	1257	390	69
	APY Lands	1235	390	68
	Musgrave Ranges	640	247	61
	Tomkinson Ranges	225	143	36
	Everard Ranges	27	0	100
	Indulkana Ranges	50	0	100
	Mann Ranges	76	0	100
	Central Isolated Granites	80	0	100
	South-west Isolated Granites	89	0	100

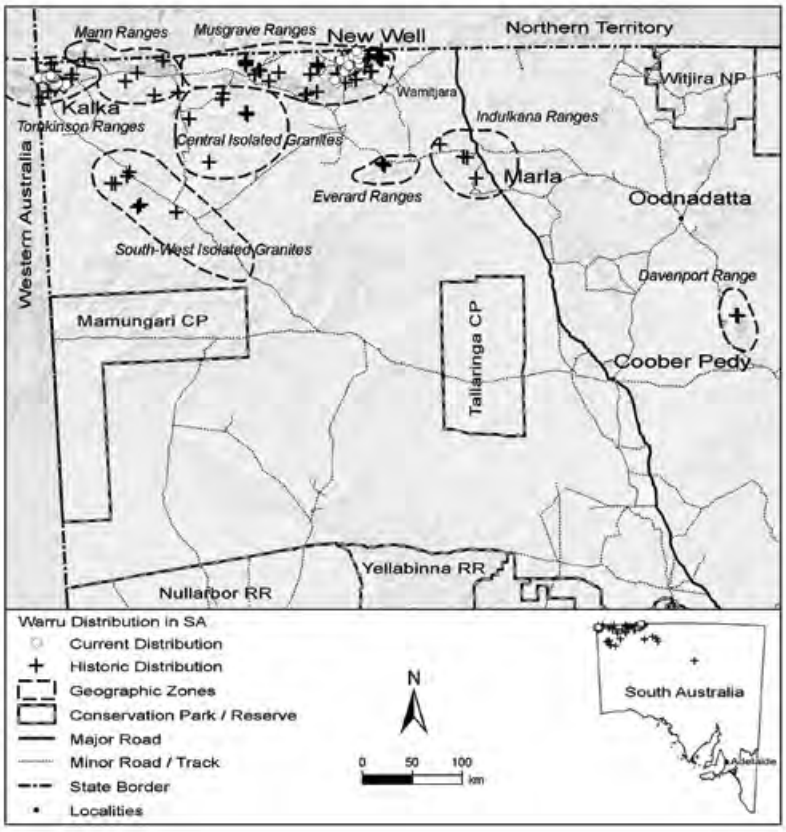

Figure 7. Historic and current distribution of warru in South Australia, including the Anangu Pitjantjatjara Yankunytjatjara Lands (Ward et al. 2011b).

7.2 Warru monitoring

7.2.1 Scat quadrats

Because of the elusive nature of warru, counting the number of scats built up over time is a useful surrogate for measuring their presence and relative activity levels in specific locations. The technique is currently being used in the Warru Recovery Project and has been used extensively in other *Petrogale* studies (e.g. Telfer *et al.* 2006).

In 1998, Geelen (1999) installed 26 scat quadrats of one-metre radius within prime warru habitat at New Well and eight quadrats at Wamitjara. Scats were removed from these quadrats and the subsequent accumulation of scats were counted to provide a baseline density for both colonies. These quadrats formed the basis of ongoing monitoring, firstly by APY Land Management in July 2000 and subsequently by John Read of Ecological Horizons approximately twice a year from 2001–2010 for APY Land Management and the Warru Recovery Team. Not all of the original scat quadrats at Wamitjara could be located and the remainder were augmented when warru were located in other parts of the outcrop. Scat quadrats were also installed at Kalka in 2001 and north New Well in 2007.

The results of the scat counts (Figure 8) support qualitative observations of scat densities in other regions in revealing a general downward trend of warru density at all sites since monitoring commenced (Read and Ward 2011).

7.2.2 Spotlighting

Whenever scat quadrats were monitored, spotlight counts were also conducted along both sides of an 11.7km perimeter road transect at New Well and a 13.3km perimeter road at Wamitjara. These data show comparable declining trends that mirror scat counts (Figure 8), although the value of spotlighting is reduced at low densities due to the relatively low detectability of warru by this method. Spotlighting was not feasible at other colonies due to the remoteness of the warru habitat from access tracks.

7.2.3 Trapping

Trapping at New Well and Alalka was first carried out by APY Land Management and the DENR in October 2005, and has since continued on an annual basis (though two trapping sessions in 2007 were conducted to facilitate translocations Section 7.4). Trapping is currently conducted by a larger collaboration of the Warru Recovery Team including APYLM, DENR and Conservation Ark, and between 2007 and 2010 this group monitored the warru population dynamics, as well as overseeing the removal and translocation of pouch young for cross-fostering (Section 7.4).

A summary of the trap nights and capture rates is provided in Tables 2–4. 'Soft' cage traps (Sheffield Wire Products Pty Ltd, Western Australia) with a wire frame supporting a thick shade cloth bag were used. For each trapping session, traps were 'free fed' for at least two and preferably three days prior to the trapping session starting, with bait (peanut butter, oat mix and apples) placed inside the trap with the door of the trap wired open.

Results and analyses of trapping at Alalka (Table 2), Kalka (Table 3) and New Well (Table 4) are also summarised in Ward *et al.* (2011a). Key results include:

- POPAN modeling indicates that population sizes were 23 at New Well, 24 at Alalka and 14 at Kalka.
- Confirmation of recent survey results (Ward *et al.* 2011b) that warru are endangered in South Australia.
- Signs for potential recovery of the race, including high average reproductive rates (>90% of reproductively active females with pouch young in the Musgrave Ranges), even sex ratios and relatively high adult survivorship (>75%).
- Juvenile survival is significantly lower than that of adults (51%). Given fox numbers are known to be low at these sites, this is likely due to predation by feral cats *Felis catus*.
- Juvenile survival is also positively correlated with winter rainfall, possibly indicating that access to water is important during the drier winter months of the APY Lands.
- Intensive management of remaining warru colonies should initially focus on cat control and consider the importance of access to free water during winter, as well as addressing landscape scale threats such as wildfire and the spread of exotic plants.

Combined with survival data from radio-tracking (Table 5), this indicates that recruitment failure, rather than adult mortality, is probably the key driver of population declines observed in the past decade.

7.2.4 Radio-telemetry and survival

During the trapping 32 warru had VHF radio-collars fitted for survival monitoring. The collars provide an alternate pulse frequency signal when the unit does not move for a considerable period of time, indicating animal mortality. Survival monitoring by the Warru Recovery Team, carried out by APY Land Management and Warru Rangers, has demonstrated high adult survivorship over at least 18 months (Table 5).

The radio-tracking for survival has proven to be a very useful technique in engaging Aṉangu in the scientific monitoring of the population and should be continued where possible. However because of the low mortality it could be scaled back to a monthly monitoring regime.

Figure 8. *Scat quadrat and spotlight monitoring at Wamitjara (showing recent extinction), New Well, Kalka and New Well North. "Kuna" = scats.*

Table 2. *Summary of warru trapping, between 2005 and 2010 at Alalka, APY Lands (Ward et al. 2011a).*

Parameter	2005	2006	2007	2008	2009	2010	Total
Trapping parameters							
Total no. trap nights	20	20	60	54	54	36	244
Population information							
All animals							
Total no. caught#	3	5	16	14	18	16	72
Sex ratio	0.67	0.8	0.69	0.5	0.55	0.44	0.57
% females breeding	100	100	89	100	87.5	100	96.1 (mean)
New animals							
Number	3	5	12	7	8	9	44
Sex ratio	0.67	0.8	0.67	0.43	0.5	0.33	0.55
No. juveniles	1	1	2	3	4	1	12
No. sub-adults	0	0	5	1	0	5	11
No. adults	2	4	5	3	4	3	21
Population estimates							
Known to be living animals*	3	5	16	16	23	16	NA
POPAN model	5.2	10.9	28.2	24.6	30.5	31.0	23.6
Capture rates							
Capture rate (new animals/trap night)	0.15	0.25	0.2	0.13	0.15	0.25	0.18
Sub-adult capture rate (no. new sub-adults/trap night)	0	0	0.08	0.02	0	0.14	0.05
Juvenile capture rate (no. new juveniles/trap night)	0.05	0.05	0.03	0.06	0.07	0.03	0.05
Retrap rate (previous session retraps/trap night)	0	0	0.07	0.13	0.19	0.19	0.11

#Does not include same session retraps or pouch young.
**Known to be alive – sum of new animals, previous session retraps and animals that went 'missing' in one year but were recaptured in future trapping sessions.*

Table 3. *Summary of warru trapping, between 2005 and 2010 at Kalka, APY Lands. Trapping did not occur at Kalka 2006–2007 (Ward et al. 2011a).*

Parameter	2005	2008	2009	2010	Total
Trapping parameters					
Total no. trap nights	20	72	78	78	248
Population information					
All animals					
Total no. caught#	3	13	9	13	38
Sex ratio	0.67	0.38	0.67	0.38	0.47
% females breeding	50	50	100	100	75 (mean)
New animals					
Number	3	11	5	6	24
Sex ratio	0.67	0.36	0.8	0.17	0.46
No. juveniles	0	1	1	2	4
No. sub-adults	0	2	2	3	7
No. adults	3	8	2	1	13
Population estimates					
Known to be living animals*	3	13	11	15	NA
POPAN model	2.3	13.2	14.2	16.9	13.7
Capture rates					
Capture rate (new animals/trap night)	0.15	0.15	0.06	0.08	0.15
Juvenile capture rate (no. new juveniles/trap night)	0	0.01	0.01	0.03	0.02
Sub-adult capture rate (no. new sub-adults/trap night)	0	0.03	0.03	0.04	0.03
Retrap rate (previous session retraps/trap night)	0	0.03	0.05	0.09	0.05

#Does not include same session retraps or pouch young.
**Known to be alive – sum of new animals, previous session retraps and animals that went 'missing' in one year but were recaptured in future trapping sessions.*

Table 4. *Summary of warru trapping, between 2005 and 2010 at New Well, APY Lands (Ward et al. 2011a).*

Parameter	2005	2006	2007	2008	2009	2010	Total
Trapping parameters							
Total no. trap nights	44	44	229	120	120	80	637
Population information							
All animals							
Total no. caught#	12	10	20	16	21	23	102
Sex ratio	0.5	0.5	0.45	0.44	0.57	0.56	0.51
% females breeding	83	100	89	100	100	82	92.3 (mean)
New animals							
Number	12	8	9	5	7	10	51
Sex ratio	0.5	0.62	0.44	0.2	0.71	0.6	0.53
No. juveniles	0	0	1	4	3	4	12
No. sub-adults	0	0	0	0	2	4	6
No. adults	12	8	8	1	2	2	33
Population estimates							
Known to be living animals*	12	14	20	18	22	24	N/A
POPAN model	12.9	25.4	22.4	21.2	22.3	26.7	22.9
Capture rates							
Capture rate (new animals/trap night)	0.27	0.18	0.04	0.04	0.06	0.13	0.08
Juvenile capture rate (no. new juveniles/trap night)	0	0	0.004	0.033	0.025	0.05	0.019
Sub-adult capture rate (no. new sub-adults/trap night)	0	0	0	0	0.017	0.05	0.009
Retrap rate (previous session retraps/trap night)	0	0.045	0.048	0.092	0.117	0.16	0.082

#Does not include same session retraps or pouch young.
**Known to be alive – sum of new animals, previous session retraps and animals that went 'missing' in one year but were recaptured in future trapping sessions.*

Table 5. *Status summary of animals on which VHF and GPS trackers have been placed between 2007 and 2009 as at July 2009. Weight is the weight of the animals when most recent tracker placed on animal. G1–G10 indicated GPS collar IDs in June 2008 (Ward et al. 2010a).*

Site	Animal ID	Sex	Weight	Date caught		Collar on animal?			Collar working	Current Frequency
				First	Last	Aug 07	Jun 08	Jul 09		
Alalka	197279	M	5.25	8/05/2007	6/06/2008	No	Yes (G9)	Yes	No	GPS 9
	199284	M	4.475	6/06/2008	27/07/2009	No	Yes	No	–	150.8009
	199337	F	2.925	12/05/2007	7/06/2008	No	Yes	Yes	?	151.5543
	201402	F	1.82	3/6/2008	23/7/2009	No	Yes (G8)	No	–	–
	204108	M	3.30	3/06/2008	22/7/2009	No	Yes	Yes	?	151.3558
	521565	M	5.00	17/08/2007	27/07/2009	No	Yes (G6)	No	No	–
	523592	F	3.275	2/08/2006	7/06/2008	No	Yes	Yes	Yes	151.3450
	528757	F	3.2	20/10/2005	26/07/2009	No	Yes (G7)	No	–	–
	529970	F	3.775	17/08/2007	23/07/2009	No	No	Yes	Yes	150.9541
	657116	F	3.55	17/08/2007	26/07/2009	No	Yes (G10)	No	No	–
Kalka	191516	M	4.75	3/06/2008	3/06/2008	No	Yes	Yes	Yes	151.4152
	191798	F	2.90	3/06/2008	7/06/2008	No	Yes	Yes	No	–
	192689	F	3.00	2/06/2008	25/07/2009	No	Yes	Yes	Yes	151.3052
	192921	F	3.30	23/07/2009	23/07/2009	No	No	Yes	Yes	151.8431
	193646	F	2.90	22/07/2009	22/07/2009	No	No	Yes	Yes	151.2309
	196575	M	3.50	3/06/2008	27/07/2009	No	No	Yes	Yes	151.8355
	524946	M	4.05	27/11/2005	27/07/2009	No	Yes	Yes	Yes	151.2160
	526169	F	3.25	27/11/2005	24/07/2009	No	Yes	Yes	Yes	150.9885
New Well	191484	F	3.50	7/05/2007	22/07/2009	Yes	Yes	Yes	Yes	151.8847
	193300	F	3.60	7/05/2007	22/07/2009	Yes	Yes(G4)	No	–	–
	202109	M	6.00	8/05/2007	27/07/2009	Yes	Yes (G1)	Yes	Yes	150.8105
	203708	F	4.40	10/05/2007	25/07/2009	Yes	Yes	Yes	Yes	151.1867
	491419	M	4.80	19/10/2005	16/08/2007	Yes	Yes	Yes	No	151.6760
	520981	M	4.70	1/08/2006	27/07/2009	Yes	Yes	Yes	Yes	151.0277
	522051	M	5.25	22/10/2005	27/07/2009	Yes	Yes	No	Yes	151.6760
	522903	F	3.825	3/08/2006	26/07/2009	Yes	Yes	Yes	Yes	150.8265
	523261	M	5.55	21/10/2005	25/07/2009	Yes	Yes	Yes	Yes	151.0184
	523604	M	4.86	19/10/2005	24/07/2009	Yes	Yes (G3)	No	No	–
	523752	F	3.00	21/10/2005	25/07/2009	Yes	Yes	Yes	Yes	150.7966
	525781	F	3.275	1/08/2006	14/08/2007	Yes	Yes	Yes	No	151.5943
	527850	F	3.75	1/08/2006	6/06/2008	Yes	Yes (G2)	Yes	No	GPS 2
	528396	M	5.325	2/08/2006	23/07/2009	Yes	Yes (G5)	No	–	–

7.3 Threat abatement and predator monitoring

7.3.1 Ground-based baiting

Fox baiting using dried kangaroo meat baits impregnated with 1080 poison commenced around perimeter tracks at New Well and Wamitjara in 1996 (Geelen 1999). This poisoning became more regular, approximately every 2–3 months, from August 2000 (Table 6). Approximately 500 baits were laid per session at New Well and 400 per session at Wamitjara. Due to concerns about not baiting foxes residing in the warru habitat and biasing baiting of dingoes (which typically use roads) rather than cats, baits were principally laid by hand in crevices and caves deemed to be accessible to foxes and cats but not dingoes from 2001 to 2007.

Fox baiting then reverted to 34 marked bait stations around the perimeter of New Well in 2008 and has continued on an approximately monthly basis around New Well. Baiting was discontinued at Wamitjara in 2007 due to the extinction of warru and at Kalka in 2007 due to fears of baiting dogs from the communities that may also deter foxes and cats.

7.3.2 Aerial baiting

Aerial baiting was instigated around the Eastern Musgrave Ranges warru metapopulation in July 2004. This involved the use of a helicopter and distribution of approximately 7000 baits through a dispenser or simply thrown out of the window. Due to concerns regarding baiting of hunting dogs, baits were only dropped directly on hills and no baiting zones were designated along roads, around communities and homelands (Figure 9). Since February 2007, aerial baiting has not extended to Wamitjara and bait use has declined to 4000.

Since 2000, sightings of dingoes, foxes and cats have been recorded during all monitoring visits to the warru colonies, with quantitative 'count' data derived from the spotlight counts and opportunistic data added to the 'total' category. Fox detectability was initially high but has remained very low since 2002 at both New Well and Wamitjara and cats have consistently been the most abundant predator recorded (Figure 10). During these monitoring trips a total of two foxes and 17 cats have been shot at New Well and eight foxes and 11 cats shot at Wamitjara (Figure 2). Track based surveys by Warru Rangers from 2008–2010 support this evidence of greater numbers of cats than foxes at New Well (Figure 11). These data suggest that fox control has been largely effective but unlike in the well researched Goldfields populations of *P. lateralis* (Kinnear *et al.* 2010), these fox reductions have not been followed by a dramatic increase in warru numbers in the APY Lands. Factors other than fox predation alone are evidently also responsible for suppressing and threatening warru in South Australia.

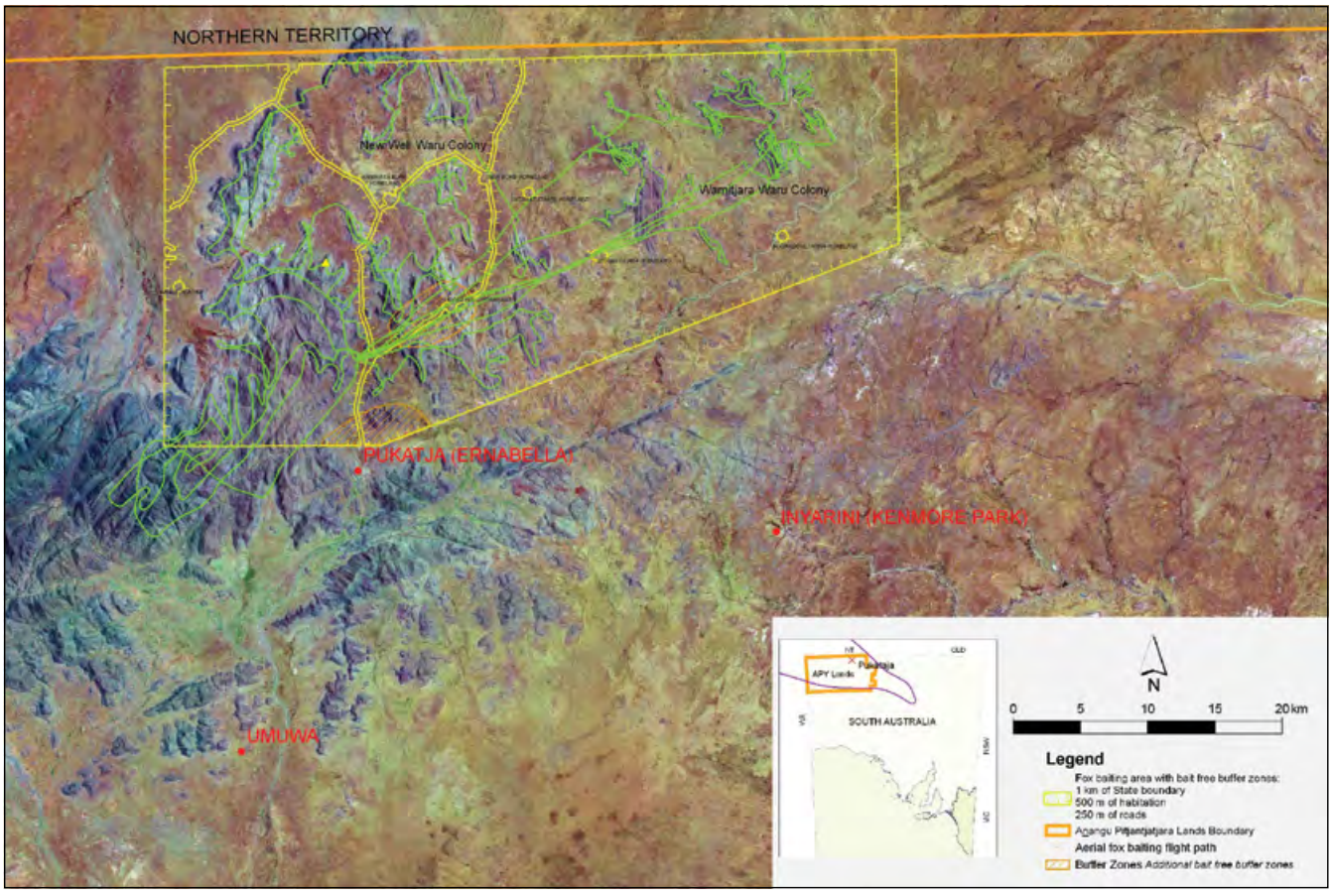

Figure 9. *Aerial baiting zone and most recently documented aerial baiting run in the APY Lands Baiting Management Zone.*

7.3.3 Monitoring and control of potentially competing herbivores

Kanyala scats are counted within the warru scat quadrats and, along with spotlight counts at New Well, provide an indication of population trends (Figure 12). Despite evidence of high densities of kanyala at New Well in particular, no coordinated control of kanyala has occurred.

Rabbits are counted in spotlight transects at New Well and in recent years have not reached densities where they are likely to compete with warru for food resources, although they may support populations of warru predators. The low occupancy rate of established warrens suggests that Rabbit Calicivirus Disease (RCD) has had, and still maintains, considerable control over rabbit populations adjacent to warru colonies. Although not currently perceived to be a major threat, an explosion in rabbit numbers and their associated predators could pose a serious threat to warru colonies. Proactive control and vigilance are therefore advisable.

There has historically been a reluctance to control donkeys, horses and camels throughout much of the APY Lands and the abundance and impact of these species appear to be increasing as a result. A potential breakthrough in the management of large feral ungulates occurred in October 2009 when Anangu members of the Warru Recovery Team suggested that donkeys, camels and horses should be removed due to their impacts upon the vegetation and, in turn, their threat to warru.

Table 6. *Fox baiting episodes in the APY Lands. Esc = escarpment baiting where baits were laid directly on the rocky hill slopes (grey cells). Grnd = ground-based baiting where baits were buried as per DENR 1080 standards (green cells). Aerial = aerial baiting (blue cells). All baiting has been conducted by APYLM under a SA Department for Environment and Heritage license.*

Year	Month	New Well			Alalka			Wamitjara			Kalka		
		Esc	Grnd	Aerial	Esc	Grnd	Aerial	Esc	Grnd	Aerial	Esc	Grnd	Aerial
1998	Aug							1					
2000	Aug	1						1					
	Sep												
	Oct	1						1					
	Nov												
	Dec												
2001	Jan												
	Feb	1						1					
	Mar												
	Apr												
	May												
	Jun	1						1					
	Jul												
	Aug												
	Sep	1						1					
	Oct												
	Nov												
	Dec	1						1			1		
2002	Jan												
	Feb	1						1			1		
	Mar												
	Apr												
	May	1						1			1		
	Jun												
	Jul	1						1			1		
	Aug												
	Sep	1						1			1		
	Oct												
	Nov	1						1			1		
	Dec												

Table 6. *Fox baiting episodes in the APY Lands. Esc = escarpment baiting where baits were laid directly on the rocky hill slopes (grey cells). Grnd = ground-based baiting where baits were buried as per DENR 1080 standards (green cells). Aerial = aerial baiting (blue cells). All baiting has been conducted by APYLM under a SA Department for Environment and Heritage license.*

Year	Month	New Well			Alalka			Wamitjara			Kalka		
		Esc	Grnd	Aerial	Esc	Grnd	Aerial	Esc	Grnd	Aerial	Esc	Grnd	Aerial
2003	Jan	1						1					
	Feb												
	Mar										1		
	Apr												
	May	1						1					
	Jun												
	Jul	1						1			1		
	Aug												
	Sep	1						1			1		
	Oct												
	Nov										1		
	Dec												
2004	Jan												
	Feb										1		
	Mar	1						1			1		
	Apr												
	May												
	Jun												
	Jul			1			1			1			
	Aug												
	Sep												
	Oct	1						1			1		
	Nov	1						1					
	Dec										1		
2005	Jan												
	Feb			1			1			1	1		
	Mar												
	Apr												
	May	1						1			1		
	Jun												
	Jul	1						1			1		
	Aug												
	Sep												
	Oct	1						1			1		
	Nov												
	Dec												
2006	Jan												
	Feb												
	Mar												
	Apr												
	May	1						1			1		
	Jun	1						1			1		
	Jul	1						1					
	Aug												
	Sep	1						1			1		
	Oct												
	Nov												
	Dec			1			1						

Table 6. *Fox baiting episodes in the APY Lands. Esc = escarpment baiting where baits were laid directly on the rocky hill slopes (grey cells). Grnd = ground-based baiting where baits were buried as per DENR 1080 standards (green cells). Aerial = aerial baiting (blue cells). All baiting has been conducted by APYLM under a SA Department for Environment and Heritage license.*

Year	Month	New Well			Alalka			Wamitjara			Kalka		
		Esc	Grnd	Aerial	Esc	Grnd	Aerial	Esc	Grnd	Aerial	Esc	Grnd	Aerial
2007	Jan												
	Feb	1						1			1		
	Mar		1										
	Apr			1			1						
	May		1										
	Jun		1								1		
	Jul		1										
	Aug		1										
	Sep		1										
	Oct		1										
	Nov		1										
	Dec		1										
2008	Jan		1	1			1						
	Feb		1										
	Mar		1										
	Apr		1										
	May		1										
	Jun		1	1			1						
	Jul		1										
	Aug		1										
	Sep		1	1			1						
	Oct		1										
	Nov		1										
	Dec		1										
2009	Jan		1										
	Feb		1										
	Mar		1	1			1						
	Apr		1										
	May		1										
	Jun		1	1			1						
	Jul		1										
	Aug		1										
	Sep		1										
	Oct		1										
	Nov		1										
	Dec		1										
2010	Jan		1										
	Feb		1										
	Mar		1										
	Apr		1										
	May		1										
	Jun		1	1			1						

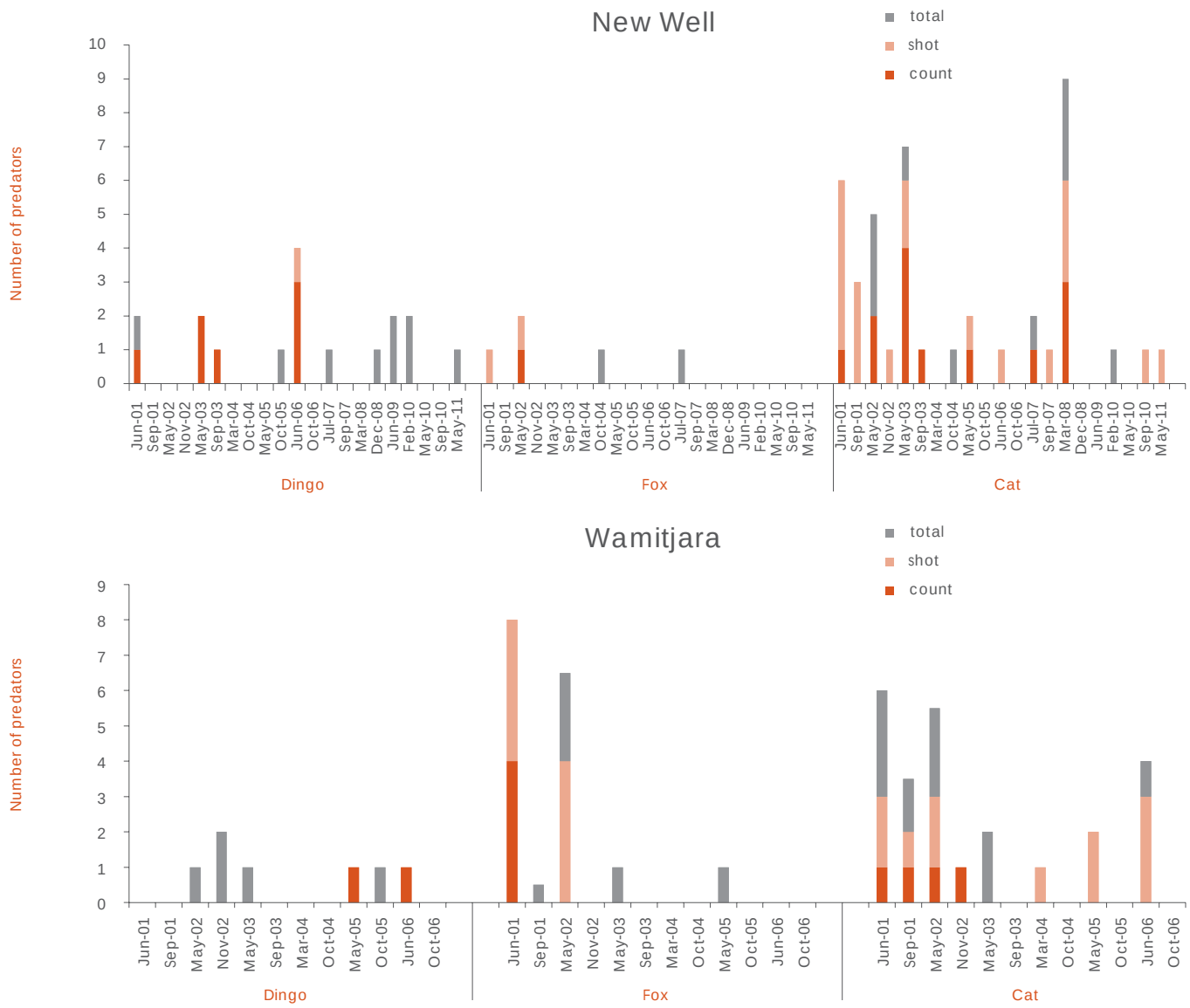

Figure 10. *Spotlighting at New Well and Wamitjara. Number of predators recorded on a single standardised vehicle-based spotlight circumnavigation of the New Well and Wamitjara outcrops (Anangu Pitjantjatjara Yankunytjatjara Lands, South Australia), from 2001–2011 (black-bars). Additional animals that were shot (red bar) or sighted opportunistically (white bar) constitute the total count for each session (Read and Ward 2011).*

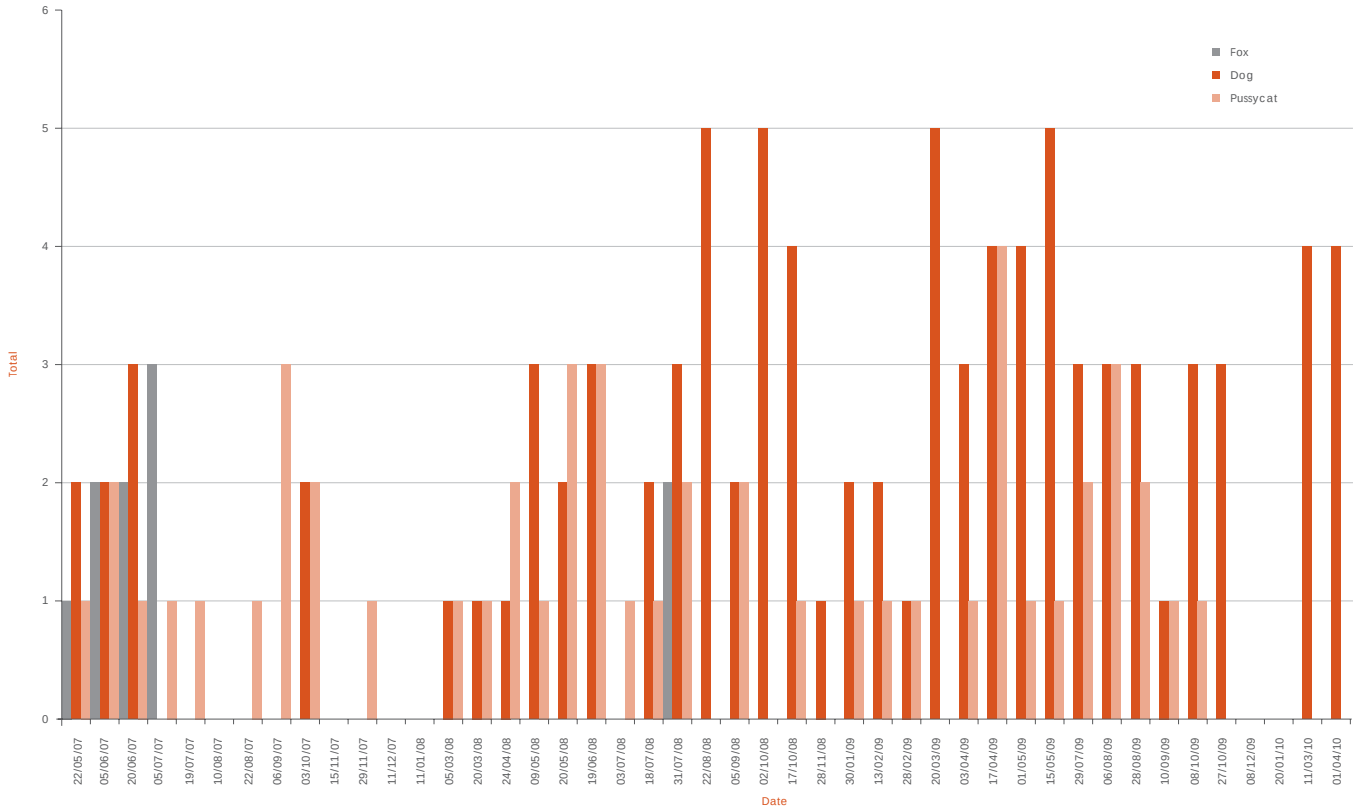

Figure 11. *Tracking at New Well. Total number of times track of cats, foxes and dogs have been recorded in all monitoring transects (six transects) around New Well in APY Lands between May 2007 and April 2010.*

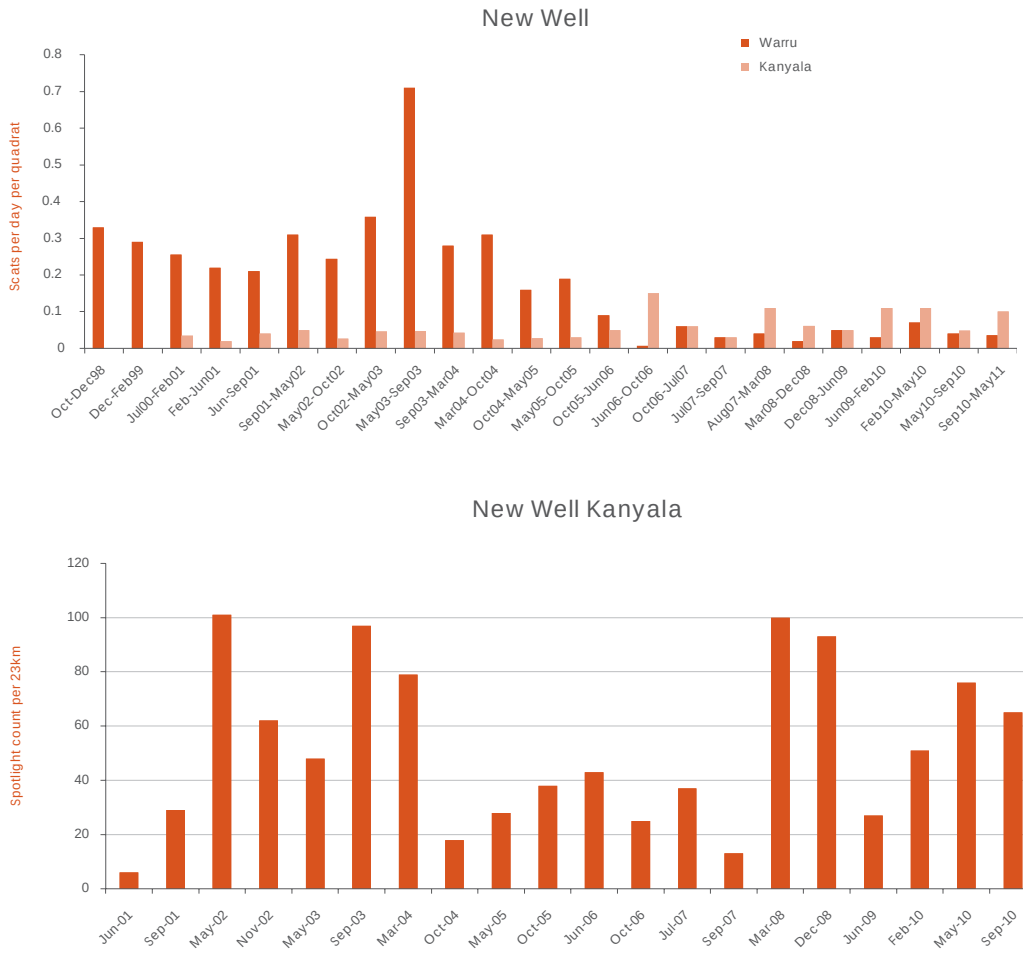

Figure 12. *Scat quadrats counts. Top: Scat quadrat counts for warru Petrogale lateralis MacDonnell Ranges and kanyala/euro Macropus robustus at New Well, Anangu Pitjantjatjara Yankunytjatjara Lands, between 1998 and May 2011. Bottom: Spotlight counts of kanyala at New Well between 2001 and 2011.*

7.4 Captive breeding

The alarming decline of monitored warru populations and recent extinction of the Davenport Ranges (SA) and Wamitjara populations prompted the emergency establishment of a captive warru population to safeguard against the extinction of remaining populations.

After the approval by APY of a warru translocation proposal (Ward and Clarke 2007), the Warru Recovery Team, with expert involvement of David Taggart from Conservation Ark, used trapping sessions in 2007, 2008 and 2009 to remove warru pouch young of suitable size and translocate them by plane to Monarto Zoo. There they were cross-fostered to yellow-footed rock-wallabies *P. xanthopus* – a technique developed and honed for the brush-tailed rock-wallaby and mainland tammar recovery programs (Taggart *et al.* 2002; Jones *et al.* 2004; Taggart *et al.* 2005; Taggart *et al.* 2010).

Cross-fostering minimises the impact of establishing a captive breeding population on small *in situ* warru populations. Instead of bringing adult animals into captivity, small pouch young are taken from wild warru mothers. This frees up the mother to have another pouch young in approximately four weeks so that wild recruitment is not affected in the long-term. A total of 22 pouch young were successfully brought into captivity using this method from New Well (10), Alalka (7) and Kalka (5). The genetic analyses by Ruykys (2011) led the Warru Recovery Team to treat the warru pouch young sourced from Alalka and New Well as one larger metapopulation and allow breeding between these two sets of animals. Four of these females had bred by 2010 as part of a trial to determine the breeding age of the animals, providing stimulus for the Warru Recovery Team to begin developing facilities for housing extra animals and trial releases.

Cross fostering can also be used as part of the management of the captive population if the need arises to increase the reproductive rate of the population. The results of the breeding trial though suggests that the warru breed from 15 months of age which is quite early compared to other rock-wallaby species.

The status of the captive population as of October 2011 is provided in Table 7.

Maintenance of two genetically diverse captive warru colonies provides long-term insurance against extinction of both known SA metapopulations and a basis for breeding programs for both reintroductions and supplementation. By maintaining separate genetic lines, captive bred animals may be used for supplementation, or establishing separate reintroductions, or else combined at the time of reintroduction. Cross-fostering can also be a useful tool in a 'floating' fostered population, whereby either wild or captive-bred pouch young are raised to independence by surrogate mothers before being acclimatised to local conditions and then released to the wild when they are less vulnerable.

7.5 Warru reintroduction

The Warru Recovery Team considers reintroductions of warru into the APY Lands a key method by which their conservation status can downgraded from endangered to vulnerable under the *SA NPWS Act (1972)*. Also, it is a primary desire of Aṉangu members of the WRT to see offspring of warru taken for captive breeding to be returned as soon as possible to the APY Lands, for conservation and for a positive development of the contemporary Tjukurpa that has been developed around the Warru Recovery Project. This view is expressed often by Aṉangu members of the WRT, and has been recorded at several of the larger WRT meetings.

The Warru Recovery Team is firm in its commitment that reintroductions should always complement and never override landscape management and recovery of extant *in-situ* populations.

Because of the challenging, remote and expensive nature of conservation management in the APY Lands, the Warru Recovery Team acknowledges that eventual reintroductions of warru into the APY Lands will aim for minimal management for the greatest landscape conservation outcome. Currently, the Warru Recovery Team is aiming for a combination of 'soft' and 'hard' release reintroductions. Animals will be acclimatised to local conditions in a predator free environment (the soft component), and then reintroduced into an unoccupied site (the hard component).

Prior to this release, however, numerous steps are required including:

1. Communication of the objectives of the Warru Recovery Plan across the APY Lands (through University of Adelaide Mobile Language Centre and other means).
2. Acclimatisation of warru prior to reintroduction in a "soft-release" predator-free exclosure on the APY Lands (Warru Fence or Warru Pintji).
3. Selection of reintroduction sites.
4. Thorough research, understanding and appropriate management of predator dynamics and other threatening processes at potential reintroduction sites.
5. New resources and capacity (over and above what is already in place) to implement reintroductions, associated management and monitoring to test the success of the reintroduction process.
6. Thorough support from the APY Executive and APY communities.

In the ensuing sections, reintroductions are primarily referred to in the context of the Eastern Musgrave metapopulation, which is genetically distinct from that of the Tomkinson Ranges.

The Tomkinson Ranges warru population require a separate reintroduction plan that should benefit from the lessons learned through initial reintroduction of Musgrave Range animals. This is part of the longer-term Warru Recovery Project (0–40 years).

7.5.1 The Warru Pintji – acclimatisation of warru prior to reintroduction

In order to maximise the potential success of reintroductions, the Warru Recovery Team believes that warru need a chance to safely acclimatise and adapt to local food sources, conditions, aerial predators and terrain without the immediate pressure of terrestrial predators (dogs, foxes and cats) and reduced competition from herbivores.

Therefore, the Warru Recovery Team has built a 100ha predator-proof and exotic herbivore-proof Warru "Pintji" (Pitjantjatjara word for fence) for hardening-off captive-bred warru in the APY Lands prior to wild reintroduction.

The process for choosing the location for the Warru Pintji is summarised in detail in Ward *et al.* (2010b) and involves the following major steps:

- Desktop selection of more than 20 sites across the Eastern Musgrave Ranges.
- Suggestions of additional sites by Anangu members of the WRT who selected 10 of these sites that were culturally and potentially biologically suitable for the hardening-off facility.
- Site visits by scientists and Anangu members of the WRT, and application of a scoring system using site selection criteria to judge different potential sites to determine which are the most appropriate logistically, culturally and ecologically for the Warru Pintji (Ward *et al.* 2010b).

After applying this process, it was decided to build the Warru Pintji around a site named Alkinya, approximately 14km east of Young's Well (Figure 13). The approximate layout for the Warru Pintji (Figure 14), the cross-section of the fence design (Figure 15), the built fence (Figure 16) and an aerial image of the completed Pintji (Figure 17) are provided below. The site contains one large and one small granite outcrop (Ward *et al.* 2010b) and was chosen for the following reasons:

- Initial approval from Traditional Owners and pastoral lessee Donald Fraser was granted.
- Warru were present historically but became locally extinct at least 10 years ago
- Fencing of the site was achievable.
- The site is large enough, contains a high number of potential den sites and sufficient food plants to potentially support at least 50 warru (Ward *et al.* 2010b).
- Management of warru is achievable, with the outcrops not being more than approximately 30m in height.
- A smaller outcrop within the 100ha area has been fenced separately to allow for some micro-management of any captive population (Figure 14). This provides opportunities for close monitoring of particular individuals for veterinary or research purposes or to hold re-trapped warru from the main Pintji in the event of a predator incursion.
- Alkinya is within the zone around *in situ* Musgrave Ranges warru colonies that are already managed and monitored for some warru predators.

7.5.2 Free-breeding of warru in the Warru Pintji

Five warru (three males and two females) were released into the Warru Pintji in March 2011 (Table 7). It is hoped that free breeding will occur, increasing the number of warru available for supplementation and reintroduction, while relieving some of the immediate and long-term resource pressures (space, staffing, financial) on captive breeding facilities.

Having free-breeding animals within the Warru Pintji means the animals have to cope with less environmental change when reintroduced as they will be already used to the environmental conditions (bar ground-based predators), making the change to life in the wild less demanding.

7.5.3 Supplementation

There may come a stage where the number of warru inside the Warru Pintji area is unsustainable. It is possible that warru bred inside the Warru Pintji will be used for trial releases into existing warru metapopulations, i.e. small-scale supplementations within an area with an established monitoring and management capacity.

Reasons for supplementation include:

- Conducting small-scale trial reintroductions to learn of warru behaviour once released into a natural environment. This should only occur in an area already in a predator management zone (e.g. into one of the adjacent outcrops next to the Warru Pintji).
- Emergency supplementation of an existing *in-situ* colony if its numbers fall below a critical level.
- Supplementing particular genetic lineages.
- Releasing capacity pressure in the Warru Pintji.

Supplementation is a step which will provide the Warru Recovery Team with many lessons for future reintroductions elsewhere on the APY Lands.

7.5.3.1 Critical Level for New Well supplementation

The Warru Recovery Team proposes that the critical level to trigger emergency trial supplementation of warru from the Warru Pintji into New Well will be:

- Less than six successful recruits in any two-year period (either retrapped second-year or old first-year animals).
- Predicted adult population of less than 15 animals or eight females.

This will ensure that not only are new recruits coming into the population, but that they are surviving their first two years by which time they will be sexually mature animals. The minimum threshold of 15 animals is considered less than 10% of the carrying capacity and historical colony size at New Well.

Supplementation triggers for other colonies will be determined through the ongoing future review of the Warru Recovery Plan.

7.5.4 Selection of reintroduction sites

Warru conservation would benefit from reintroductions into sites within and beyond the APY Lands where warru have recently become extinct (Figure 3). The role of the WRT is to prioritise reintroduction regions based on geographic spread, logistics and capacity. A Davenport Ranges reintroduction could follow successful APY reintroductions and would provide increased insurance against climate change and stochastic events in the APY lands (e.g. catastrophic wildfire).

The selection for a reintroduction site should follow the process used for Warru Pintji (Ward *et al.* 2010b) and any lessons learnt from the holding of warru within the Pintji. This has been adopted to fit potential reintroduction sites and is summarised in Appendix 2.

7.6 Summary of management, recovery and reintroduction priorities

Below is a broad summary of the order of priority of the major recovery processes for warru in the APY Lands.

1. Recovery and management of in-situ populations (Eastern Musgrave Ranges and Tomkinson Ranges).
2. Maintenance of captive breeding populations (Monarto and Warru Pintji) and subsequent reintroductions of these warru into the prepared reintroduction site.
3. Supplementation of existing populations should population numbers fall below trigger point (Section 7.5.3).

7.7 Key knowledge gaps around warru recovery

Following is a list of key questions and knowledge gaps associated with recovery and reintroduction of warru into the APY Lands.

- What is the optimum method of determining and managing predation rates within sustainable limits at extant colonies and potential reintroduction sites?
- Can rabbit control be used as an effective proxy or complementary tool to direct predator control?
- What are the optimum methods to monitor and control cat predation at extant sites, including the use of Eradicat®?
- How important is water for warru, particularly during drought and for juvenile animals?
- How do warru use areas which have been burnt?
- Do dingoes and community dogs suppress fox and cat numbers at Kalka and Pipalyatjara?
- Will release from competition with euros allow some population recovery at New Well?
- Is warru food limited and can food supplementation promote recruitment?
- Can supplementary feeding lead to Warru population recovery?
- What are the genetic implications of a lack of changes in dispersal?
- What are the minimum number and optimal demographics of warru required to establish a successful reintroduction population?
- What is the carrying capacity for warru in the Warru Pintji?
- What is the role of disease in Warru recovery and decline, in particular toxoplasmosis?
- What happens to juveniles out of pouch and at dispersal?
- What makes a very good reintroduction site?

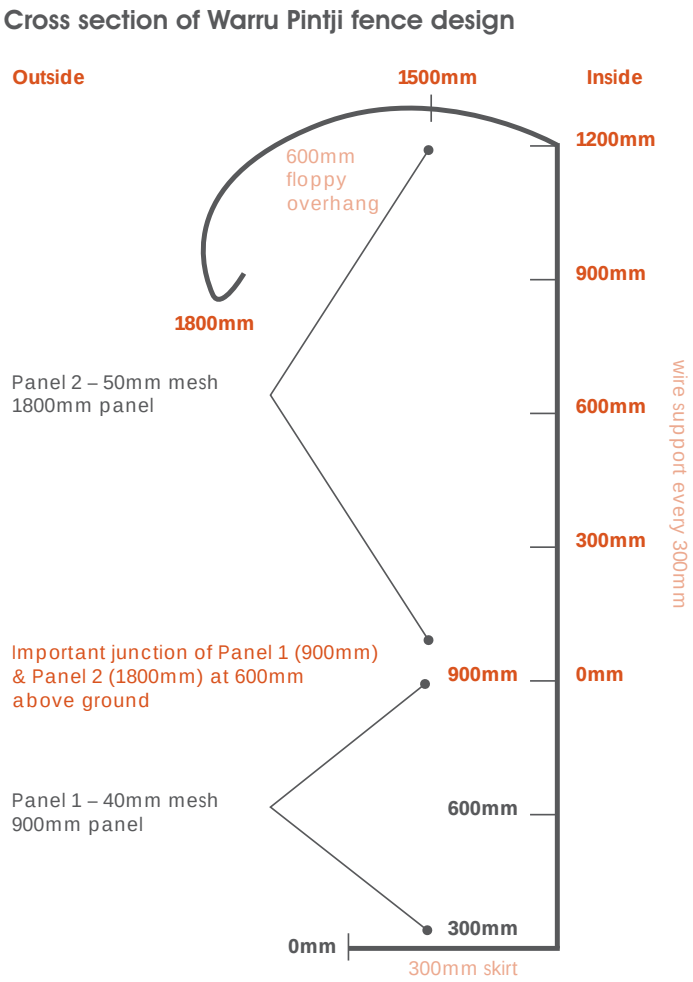

Figure 15. *Cross-section of Warru Pintji design. Main fenceline consists of two panels joined together. Total height of the fence is 1800mm (Diagram © Jasmina Muhic).*

Figure 16. *Completed Warru Pintji, Donald's Well, Anangu Pitjantjatjara Yankunytjatjara Lands (February 2011).*

Table 7a. *Status of captive warru population at Monarto Zoo at December 2009. All warru were initially transferred from the Anangu Pitjantjatjara Yankunytjatjara Lands, except where the source is listed as Monarto Zoo in which instance the animals were captive born.*

Name	Gender	Source site	Source date	Weight at capture	Rearing	Current weight	Estimated D.O.B	Bred	Notes
Widu	M	New Well	9/5/07	815g	Mother-reared	3.3kg	24/10/06	Yes	Extremely flighty.
Kurparu	M	New Well	12/5/07	56g	Cross-foster	4.1kg	26/2/07	No	Nasty, attacks keepers.
Snowy	M	Alalka	12/8/07	35.7g	Cross-foster	3.8kg	8/6/07	No	Timid and curious. *(NB died due to complications arising from an ingested fur ball in April 2010).*
Maureen	F	New Well	12/8/07	34.3g	Cross-foster	3.2kg	13/6/07	No	Extremely tame.
Doreen	F	New Well	12/8/07	5.5g	Cross-foster	2.7kg	18/7/07	No	Not tame.
Sandy	F	New Well	12/8/07	11.5g	Cross-foster	3.3kg	9/7/07	No	Fairly tame.
Nemo	M	Alalka	12/8/07	9g	Cross-foster	3.1kg	10/7/07	No	Timid and curious.
Tiltin	F	Alalka	12/8/07	12.9g	Cross-foster	3.2kg	8/7/07	Yes	Fairly tame. Good breeder, 1 young at foot +ve pouch young.
Puti	M	Alalka	3/6/08		Cross-foster	2.8kg	9/5/08	No	Fairly tame
Kaku	F	Alalka	5/6/08	814g	Hand-reared	2.7kg	16/12/07	Yes	Extremely flighty. +ve pouch young.
Nyi Nyi	M	Alalka	15/8/07	5g	Cross-foster	4kg	21/7/07	No	Fairly tame.
Ninu	F	Kalka	2/6/08	19g	Cross-foster	2.1kg	15/4/08	No	Extremely flighty.
Langki	M	Kalka		38g	Cross-foster	2.2kg	5/3/08	No	Timid and curious.
Arnguli	F	Kalka	23/7/09	2g	Cross-foster		10/7/09	No	Still in pouch.
Zoe	F	Kalka	23/7/09	86.5g	Cross-foster	1.1kg	24/4/09	No	Extremely flighty.
Ngankali	M	Kalka	6/6/08	900g	Mother-reared	2.1kg	1/12/07	No	Extremely flighty.

Figure 13. *Approved warru hardening-off site for Warru Pintji (Alkinya, HOS-21B) and surrounding archipelago. Also outlined is a cattle fence already in place*

Figure 14. *Selected Warru Pintji site. See outline of potential fence-line.*

Table 7b. *Status of captive warru population at the Warru Pintji (APY Lands) at October 2011. All warru were initially transferred from the Anangu Pitjantjatjara Yankunytjatjara Lands to Monarto Zoo, except where the source is listed as Monarto Zoo in which instance the animals were captive born. All these animals have been reintroduced into the Warru Pintji in 2011.*

Ula	M	New Well	7/5/07	250g	Hand-reared	4.6kg	29/12/06	No	Reintroduced to Warru Pintji 25 July 2011.
Minnie	F	New Well	8/5/07	14g	Cross-foster	3.4kg	28/3/07	Yes	Had a young 12 September 2009. Parents Puti and Minnie. Reintroduced to Warru Pintji 25 July 2011.
Mingkiri	M	New Well	8/5/07	30g	Cross-foster	3.5kg	19/3/07	No	Extremely Flighty. Reintroduced to Warru Pintji 25 July 2011.
Aliyan	F	Alalka	17/8/07	367g	Hand-reared	2.6 kg	31/3/07	No	Extremely flighty. Reintroduced to Warru Pintji 25 July 2011.
Kalinya	F	New Well	2/6/08	482g	Hand-reared	3.6kg	27/1/08	Yes	Extremely Flighty. Parent, with Puti, of Tjalpu Tjalpu. Reintroduced to Warru Pintji 25 July 2011.
Kupinya	M	New Well	2/6/08	171g	Hand-reared	4.0kg	26/2/08	No	Nasty. Reintroduced to Warru Pintji 25 July 25 2011. Found deceased 17 October 2011.
Ltatura	M	Monarto	First seen 22/5/09		Cross-foster	3.1kg	17/5/09	No	Parents - Widu and Kalinya Extremely flighty. Reintroduced to Warru Pintji 29 March 2011. Found deceased 29 July 2011.
Itunpa	M	Monarto	First seen 29/4/09		Cross-foster	3.2kg	24/4/09	No	Parents - Widu and Tiltin Extremely flighty. Reintroduced to Warru Pintji 29 March 2011.
Tjalpu Tjalpu	F	Monarto	In pouch	–	Captive born	2.3kg	20/7/09	No	Parents - Puti and Kalinya. Reintroduced to Warru Pintji 29 March 2011 with pouch young.
Ngangala	F	Monarto	In pouch	–	Captive born	2.1kg	12/9/09	No	Parents - Puti and Minnie. Reintroduced to Warru Pintji 29 March 2011. Has pouch young 10 June 2011.
Marura	M	Monarto	In pouch	–	Captive born	3.3kg	1/12/09	No	Parents - Widu and Tiltin. Reintroduced to Warru Pintji 29 March 2011.

Figure 17. *Aerial photo of the Warru Pintji and internal enclosure, Donald's Well, Anangu Pitjantjatjara Yankunytjatjara Lands (February 2011).*

8. Warru Recovery Team

The local extinction of warru at Wamitjara, and the dramatic decline in warru scat and spotlighting counts around New Well (Read 2006) led to the formation of the Warru Recovery Team, which first met in March 2007 in Adelaide. This involved Traditional Owners, scientists and land managers from DENR, Ecological Horizons, Conservation Ark, APY Land Management and communities of APY discussing potential recovery actions, knowledge gaps and the desires of Anangu.

A terms of reference was developed for the Warru Recovery Team in 2007 and this requires updating as soon as possible. The roles and responsibilities of team members is provided in Appendix 3.

8.1 Key internal threats and blocks and resolutions

8.1.1 Issues on country

8.1.1.1 Potential issues

- Disagreement on ownership, cultural significance or access to sites.
- Disagreement on appropriate access to consultation, training or employment opportunities.

8.1.1.2 Potential strategies

- APY Land Management has the overarching role of coordinating and resolving land ownership and access issues on behalf of the WRT.
- Other members of the WRT to meet with key interested Traditional Owners, Anangu and families in the APY Lands, by conducting community consultation about the Warru Recovery Project across the APY Lands in consultation with and support from APY.
- Cultural and heritage clearance reports, endorsed by APY Executive, are obtained by APYLM for work involving new access, including survey areas, sites for hardening-off facilities and reintroductions.
- Ensure key Anangu contacts for WRT are documented and consulted widely in the team.
- Ensure objectives and actions of the WRT are understood amongst other government agencies working in the APY Lands.

8.1.2 Communication issues between external agencies

8.1.2.1 Potential issues

- Disagreement between direction of project between external agencies.
- External agencies unable to gain access to APY Lands.
- External agencies do not consult appropriately with APY and do not fulfill the requirements of their permits.
- Overlap in skills base between agency staff causing conflict.
- Conflict over intellectual property, employment opportunities or management input into WRT.
- Discrepancies between relative contributions of stakeholders both within the WRT and presented via the media.
- Media releases without prior knowledge of other WRT members.

8.1.2.2 Potential strategies

- Multilateral involvement and endorsement of the Warru Recovery Plan.
- Development of a communications strategy for the WRT.
- Regular revision of WRT terms of reference.
- External agencies consult appropriately with APY and fulfill the requirements of their permits.
- Representation from multiple state and federal government agencies on the WRT to ensure open and fair processes.
- A clear representation of capacity and commitment to the Warru Recovery Project, endorsed and signed by higher levels of individual agencies.
- Development of memorandum of understandings involving WRT and individual agencies to better determine and clarify roles, responsibilities and relationships.
- Develop an agreement on knowledge gaps, research priorities and potential university supervisors.
- Develop a policy for the WRT on intellectual property.
- WRT to develop a series of approved photographs for publicity, available through secure internet site.

8.1.3 Funding of Warru Recovery Project and stakeholders

There has been significant funding of the Warru Recovery Project from state, federal and philanthropic bodies since 2006. Table 8 outlines the amount of funding delivered for the Warru Recovery Project since 2006 across different warru recovery actions.

While these expenses have been integral to the warru recovery effort and have been carefully justified and managed, it is unlikely that such a level of funding will be available in the long term. However, in order to maintain momentum in the recovery effort and meet objectives of breeding, raising, returning and managing captive-bred warru to several regions within the State it is likely that at least this level of expenditure will be required for the next decade or more.

8.1.3.1 Potential issues

- Inability to attract funds for on-grounds and captive components of the Warru Recovery Project.
- Lower priority warru recovery actions are more attractive to funding bodies than higher priority actions (e.g. ex-situ compared to in-situ conservation).
- Discontinuation of positions integral to the WRT activities.

8.1.3.2 Potential Strategies

- Development of a funding strategy for the WRT and plan.
- Plan to attract greater Commonwealth investment.
- Plan to attract greater philanthropic investment.
- Establish an endowment fund for longer-term funding.
- Establish long-term sponsorship arrangement to cover core costs.
- Fundraising for specific research or management projects independent from the core WRT budget.
- Strategically and regularly promote the Warru Recovery Plan across various levels of government.
- Cross-agency support for all positions.
- Develop more cost-effective methods for key activities within the Warru Recovery Plan, including less intensive management of captive warru.

Table 8. *Summary of approximate costs involved in the Warru Recovery Project 2006 – 2010.*

Year	Delivery	Funding	Stream	Staffing	Detail	Cost ($)
06–07	DENR	AWNRM/DENR	WRT, monitoring and coordination	2 x regional ecologists	WRT coordination, grant administration, on-grounds monitoring	100,000
	DENR	DENR	WRT, Scientific Monitoring	Threatened species ecologist, threatened fauna ecologist, wildlife management officer	Recovery team and field work contributions	10,000
	DENR	DENR	WRT		WRT Meeting administration. Meetings, conference calls	2500
	DENR	AWNRM /DENR	Captive breeding	Warru translocations, plane charter	Warru Translocations – Plane Charter	15,166
	DENR	AWNRM /DENR	Captive breeding		Warru Translocations – Trapping trip	10,000
	Conservation Ark	Commonwealth	Captive breeding		Warru translocations – plane charter. Establishment of temporary holding pens	92,000
	Conservation Ark	Conservation Ark	Captive breeding	Warru keepers, vet staff	Captive warru care	75,000
	Uni. of Ad.	Uni. of Ad	Research	1 x PhD research student	Warru ecology research	6000
	APY	ILC	On-grounds monitoring and management	1 x threatened species officer, running costs	On-grounds monitoring, management	50,000
					Total 2006–2007	**310,666**
07–08	DENR	AWNRM/DENR	WRT, monitoring and coordination	2 x regional ecologists	WRT coordination, grant administration, on-grounds monitoring	100,000
	DENR	DENR	Warru Recovery Team		WRT Meeting administration. Meetings, conference calls	2500
	DENR	DENR	WRT, scientific monitoring	Threatened species ecologist, threatened fauna ecologist, wildlife management officer	Recovery team and field work contributions	10,000
	DENR	AWNRM/DENR	Captive breeding		Warru Translocations. Plane charter x 2	59,374
	DENR	AWNRM/DENR	Captive breeding		Warru translocations. Trapping trips x 2	20,000
	DENR	AWNRM/DENR	Research		Radio-tracking	6648
	Conservation Ark	Conservation Ark	Captive breeding	Warru keepers, vet staff	Captive warru care and facilities	80,000
	Uni. of Ad.	Uni. of Ad	Research	1 x PhD research student	Warru ecology research	20,000
	Uni. of Ad.	Philanthropy	Research		Project Costs	39,306
	APY	ILC	On-grounds monitoring and management	1 x threatened species officer	On-grounds monitoring & management	100,000
					Total 2007–2008	**337,828**

Table 8. *Summary of approximate costs involved in the Warru Recovery Project 2006 – 2010.*

Year	Delivery	Funding	Stream	Staffing	Detail	Cost ($)
08–09	DENR	DENR	WRT, monitoring and coordination	2 x regional ecologists	WRT coordination, grant administration, on-grounds monitoring	80,000
	DENR	DENR	Research		Genetic research – contribution to PhD	1400
	DENR	DENR	WRT		WRT meeting administration. Meetings, conference calls	2500
	DENR	State NRM	On-grounds monitoring and management	Warru rangers	Warru surveys Eastern Musgrave Ranges	33,593
	DENR	DENR	On-grounds monitoring and management	Warru rangers	Warru surveys Musgrave Ranges	78,000
	DENR	DENR	WRT, monitoring and coordination	Threatened species ecologist, threatened fauna ecologist	Recovery team and field work contributions	10,000
	Conservation Ark	DENR	Captive breeding		New warru dedicated facilities	60,000
	Conservation Ark	Nature Foundation	Captive breeding		New warru dedicated facilities	10,000
	Conservation Ark	Conservation Ark	Captive breeding	Warru keepers, vet staff	Captive warru care	85,000
	Uni. of Ad.	Uni. of Ad	Research	PhD research student	Warru ecology research	21,000
	Uni. of Ad.	Philanthropy	Research		Project costs	22,800
	APY	AWNRM	On-grounds monitoring and management	Warru Recovery Project (Jan–Dec 08) 1 x Warru recovery officer (Jan 08 – Dec 09) Warru rangers	On-going warru monitoring	100,000
	APY	AWNRM	On-grounds monitoring and management	Feral carnivore control project (Jan – Dec 08) Warru rangers	Baiting, predator monitoring	50,000
	APY	WOC	On-grounds monitoring and management	Warru Recovery Project (July–Dec 09) 1 x Warru recovery officer 8 x Warru rangers, operating	Warru monitoring	322,819
	APY	ILC	On-grounds monitoring and management	1 x threatened species officer and operating (Jan – Dec 08)	Warru monitoring	100,000
					Total 2008–2009	**977,112**

Table 8. *Summary of approximate costs involved in the Warru Recovery Project 2006 – 2010.*

Year	Delivery	Funding	Stream	Staffing	Detail	Cost ($)
	DENR	DENR	WRT, monitoring and coordination	1 x regional ecologist	WRT coordination, grant administration, on-grounds monitoring	40,000
	DENR	DENR	WRT		Meetings, conference calls	2500
	DENR	DENR	WRT	1 x consultant	WRT sitting fees	3600
	DENR	DENR/WCF	On-grounds monitoring and management		Warru trapping	10,000
	DENR	DENR	Captive breeding		Warru translocation, plane charter	8000
	AWNRM and APY	State NRM	Reintroduction	Warru Pintji Project. 1 x Warru reintroduction officer. 4 x fence rangers.	Establishment of warru fence/hardening-off site, monitoring.	205,000
	Zoo and DENR	State NRM	On-grounds monitoring and management		Warru surveys – Tomkinson Ranges	50,000
09–10	Uni. of Ad.	Uni. of Ad	Research	PhD research student	Warru ecology research	22,000
	Uni. of Ad.	Philanthropy	Research		Warru ecology research	14,580
	Conservation Ark	Philanthropy	Captive breeding		Captive breeding facilities	30,000
	Conservation Ark	Conservation Ark	Captive breeding	Warru keepers, vet staff	Captive warru care	90,000
	APY	WOC	On-grounds monitoring and management including baiting	Warru Recovery Project. 1 x Warru recovery officer. 8 x Warru rangers, operating.	On-grounds monitoring and management	60,4812
	AWNRM	AWNRM	Reintroduction	1 x threatened species officer	Coordination of Warru Pintji project, contribution to WRT	35,000
	Conservation Ark	AWNRM	Captive management		Captive breeding facilities	20,000
	APY	ILC	On-grounds monitoring and management	1 x threatened species officer and operating	Warru monitoring	50,000
					Total 2009–2010	**1,185,492**
					Total 2006–2010	**2,961,098**
					Total/year	**740,274**
					Total/28 warru in captivity	**105,753**

8.1.4 Loss of continuity, corporate knowledge and intellectual property

8.1.4.1 Potential issues

- The risks of high turnover of WRT members resulting in a loss of consistency in management and monitoring, the need to frequently develop new relationships between individuals and organisations and that lessons learned and skills developed will be lost.
- Aṉangu and Warru rangers in the APY Lands are highly mobile and not always present.
- Average tenure of staff in associated organisations is relatively short-term (e.g. approximately three years).
- Tenure of staff in associated organisations is subject to change due to availability of funding and changes to bureaucratic frameworks resulting in loss of consistency in management and monitoring.

8.1.4.2 Potential Strategies

- Warru Recovery Plan and subsequent updates and WRT annual reports will provide a key reference for new WRT members.
- Maintain 'Warru Wiki' for documentation, storage and availability of reports, funding applications, procedures, and WRT meeting minutes. This will also assist in minimising the threats associated with loss of intellectual property.
- Development of intellectual property agreement between WRT members.
- Each agency taking responsibility to select and coach suitable replacement personnel in a timely manner.
- Secure funding for key positions (e.g. Warru recovery officer, Warru reintroduction officer, WRT chair).

8.1.5 Culture, language and consultation

Differences in culture and language along with differences in agendas and expectations complicate the functioning of multi-stakeholder teams. Management of these issues is integral to the functioning of the Warru Recovery Team and the recovery of warru. Development of these relationships is an ongoing objective, particularly with the high turnover of WRT members

8.1.5.1 Potential issues

- Differences in culture and language causes miscommunication and different objectives between Aṉangu and other WRT members.
- Aboriginal business or exodus of Aṉangu staff for funerals, festivals etc disrupts work schedules.

8.1.5.2 Potential strategies

- Agencies represented in the WRT select and tutor team members who are culturally and gender sensitive, willing to learn the languages and appreciate the cultures of the other team members.
- Wherever possible, engage interpreters at meetings involving Aṉangu and Piṟanpa to translate and interpret various viewpoints to ensure the contribution and ownership of all stakeholders in the WRT plans and outcomes.
- Support involvement of the Mobile Language Centre (University of Adelaide) as much as possible in promoting the work and objectives of the WRT and Warru Recovery Plan.
- WRT members promote the involvement of other intra-agency staff in cultural awareness training.
- WRT members promote the involvement of other intra-agency staff in WRT actions to support succession training.
- Piṟanpa and Aṉangu members of WRT recognise flexible milestones in funding arrangements to plan for contingencies associated with cultural, climatic or mechanical disruptions to work plans.
- Aṉangu, APYLM and all delivery agents recognise that disruptions to agreed workplans of external agencies can be costly and potentially detrimental to both the Warru recovery effort and possibly the welfare of any animals being intensively managed.
- Respectful working relationships between WRT stakeholders with high degrees of personal communication should assist in finding workable and culturally acceptable solutions to access challenges.

8.1.6 Land access

8.1.6.1 Potential issues

- Heavy rainfall or fire closing roads present logistical challenges which can thwart field work plans in remote regions.
- Anangu business.
- Staff not able to access lands in a timely manner.

8.1.6.2 Potential strategies

- Recognise flexible milestones in funding arrangements to plan for contingencies associated with climatic or mechanical disruptions to work plans.
- Ensure staff involved with the project have appropriate clearances to work on the lands.
- Plan early and communicate regularly prior to visits.

9. Recovery information

9.1 Program implementation

This Warru Recovery Plan will run from 2010 until 2020 and will be managed by the South Australian Warru Recovery Team.

9.2 Program evaluation

The SA Warru Recovery Team will be responsible for annual assessments of progress towards recovery through the production of annual reports by Warru recovery participants addressing key actions. This recovery plan will be reviewed when deemed appropriate by the Warru Recovery Team.

9.3 Long-term objectives

The long-term objectives (0–40 years) of the Warru Recovery Project are:

1. Warru down-listed from endangered to vulnerable in South Australia (*NPW Act 1972*), meaning:
    - Key threatening processes are understood and managed and the survival of extant wild populations is significantly improved.
    - More than two metapopulations exist within the APY Lands and at least one is established outside the APY Lands.
    - A captive breeding program is no longer required.
    - Populations can withstand sustainable and regulated hunting if necessary.
2. Warru Recovery Plan meets multi-level objectives of the APY community.
3. Warru Recovery Plan leads to long-term landscape conservation outcomes.

9.4 Short-term objectives (0–10 years)

1. Maintain genetic diversity and increase the distribution and abundance of warru in South Australia.
2. Anangu have ownership of key WRT decisions and on-ground actions, and access to employment opportunities and educational outcomes arising from the Warru Recovery Project.
3. The Warru Recovery Project is jointly managed and administered strategically towards achieving long-term objectives.

9.5 Objective 1: Maintain genetic diversity and increase the distribution and abundance of warru in South Australia.

9.5.1 Performance criteria

1. Scat densities at long-term quadrats at monitored sites have increased significantly above:
   a. New Well – 0.24 scats per quadrat per day (May–Oct 2002 levels, Read 2010).
   b. Kalka – 0.03 scats per quadrat per day (May–Oct 2002 levels, Read 2010).
2. Trapping rates of new animals at long-term trapping sites have increased significantly from those reported in 2010 (Ward *et al.* 2011a), to a level to sustain a population as determined by population viability analysis.
3. Representation of wild colony genetics is maintained in the wild population (at least maintaining genetic variability of in-situ samples from 2007–2009).
4. Increase in the number of occupied den sites in previously searched and unoccupied sites by:
   a. At least five in the Musgrave Ranges.
   b. At least two in the Tomkinson Ranges.

9.5.2 Actions

Detailed timelines and costs for all actions and costs are provided in Table 9. Extra detail for all actions and sub-actions is provided in Appendix 4.

Action 1.1 – Implement appropriate threat abatement and monitoring and refine with added knowledge:

1.1.1 Maintain predator monitoring and management around existing colonies.

1.1.2 Implement and monitor a trial of Eradicat® baits in Eastern Musgrave Ranges between by July 2011.

1.1.3 Develop and implement plan for control of large feral herbivores and over-abundant native herbivores in core areas of warru range and APY Lands by July 2013.

1.1.4 Control rabbits and rabbit warrens within a 1km buffer of the hills on which known warru colonies occur.

1.1.5 Implement APY Lands Fire Management Plan (Paltridge and Latz 2010a) with respect to warru habitat by July 2013.

1.1.6 Encourage and support production and implementation of APY Lands Buffel Grass Management Strategy and promote state and national biological control initiatives.

Action 1.2 – Maintain current warru monitoring regime at known warru colonies in the Eastern Musgrave and Tomkinson Ranges:

1.2.1 Scat quadrat counts (biannual).

1.2.2 Warru trapping program (annual).

1.2.3 Adult survivorship monitoring of radio-collared adults (at least monthly whilst collars remain operational).

1.2.4 Warru distribution surveys (once every five years) to determine any range expansion or contraction or major dispersal events.

Action 1.3 – Maintain a captive warru population with genetic representation from known in-situ colonies:

1.3.1 Maintain existing captive animals and breed captive animals for colony maintenance.

1.3.2 Undertake routine or opportunistic assessment of genetic diversity in wild and captive populations.

Action 1.4 – Encourage and support specific dedicated research and development projects on warru conservation ecology:

1.4.1 Conduct population viability analysis for remaining metapopulations based on trapping results and survival analysis.

1.4.2 Define inherent natural predator dynamics and warru population dynamics in a landscape where warru populations are apparently stable and robust.

1.4.3 Determine optimum techniques for predator management (especially cats) to minimise warru predation.

1.4.4 Determine influence of supplementary feeding, supplementary water and patch burning on recruitment.

1.4.5 Define inherent natural warru population dynamics with respect to climate.

1.4.6 Determine effect of interactions between human settlements and warru populations.

1.4.7 Determine fate of young warru through recruitment and dispersal studies

1.4.8 Examine the prevalence of toxoplasmosis and other diseases in extant warru populations.

Action 1.5 – Supplement existing colonies where appropriate:

1.5.1 Define supplementation thresholds for current extant colonies.

1.5.2 Conduct supplementation if population thresholds are met, and suitable animals are available.

Action 1.6 – Conduct reintroduction of warru into the APY Lands within former range:

1.6.1 Establish and maintain genetically diverse captive breeding population of warru at Monarto with appropriate facilities.

1.6.2 Establish and maintain a predator-proof facility (the Warru Pintji) in the APY Lands with no incursions affecting warru and conduct trial hardening-off and free-breeding.

1.6.3 Rank potential reintroduction sites and test site selection criteria by July 2012 (Ward *et al.* 2010b).

1.6.4 Implement research project to determine predatory threats and competition thresholds viable to conduct reintroductions.

1.6.5 Increase range of threat abatement, as directed by Actions 1.4.2 and 1.4.3 to maximise chances of successful reintroduction.

1.6.6 Undertake cross-fostering program for warru once reintroduction sites are identified, prepared and appropriately managed.

1.6.7 Conduct hard reintroduction of warru into the APY Lands once actions 1.6.1 to 1.6.6 have been undertaken.

1.6.8 Investigate need for Warru Pintji in the Tomkinson Ranges.

Action 1.7 – Support and encourage surveys of warru in adjacent ranges in Western Australia and the Northern Territory.

Action 1.8 – Engage pastoral industry to adopt warru as a potential icon species for conservation on pastoral leases within former range (i.e. Davenport Ranges).

9.6 Objective 2: Anangu have ownership of key WRT decisions, on-ground actions, employment opportunities, educational outcomes and cultural values of warru recovery.

9.6.1 Performance criteria

1. Continued involvement and support from Anangu WRT members.
2. Retained access for warru surveys, monitoring and management in new and existing locations.
3. Gainfully employed Anangu staff and training opportunities retained at least at 2010–2011 levels.
4. Anangu staff obtain training through appropriate accredited training organisation. Career strategies developed to account for improved capacity of Anangu staff.

9.6.2 Actions

Action 2.1 – Conduct regular WRT meetings.

2.1.1 Conduct regular WRT meetings with land management, technical and scientific staff.

2.1.2 Conduct annual WRT meetings with Anangu and Piranpa representatives with a translator present.

Action 2.2 – Employ an iterative decision-making process for the WRT between Piranpa and Anangu members of the WRT.

Action 2.3 – Ensure at least two Traditional Owners who can speak for each warru metapopulation (e.g. Musgrave, Tomkinson and potentially Everard Ranges) are involved in the WRT.

Action 2.4 – Ensure all on-grounds works have an appropriate level of Anangu employment.

Action 2.5 – Translate and communicate aspirations of the Warru Recovery Plan into Pitjantjatjara and Yankunytjatjara (support Mobile Language Group project, University of Adelaide).

Action 2.6 – Hold community meetings across the APY Lands to discuss the objectives and actions of the Warru Recovery Plan with as many relevant communities of the APY Lands as feasible.

Action 2.7 – Develop an agreed media protocol for the WRT:

2.7.1 Determine appropriate future media opportunities which need to be pursued.

2.7.2 Develop an agreement on types of media opportunities which require pre-approval.

2.7.3 Develop a memorandum of understanding around process and use of images.

2.7.4 Define a process for acknowledgement of funding bodies.

9.7 Objective 3: The Warru Recovery Project is jointly managed and administered strategically towards long-term objectives.

9.7.1 Performance criteria

1. Warru Recovery Project meets objectives outlined in Warru Recovery Plan and continues to be funded.
2. Relationships between WRT members or stakeholders remain strong and effective and do not affect implementation of Warru Recovery Plan.

9.7.2 Actions

Action 3.1 – Update WRT Terms of Reference (2007).

Action 3.2 – Produce WRT annual report.

Action 3.3 – Maintain the Warru Wiki as a key information source with access to reports, Warru Recovery Plan, etc.

Action 3.4 – Produce an intellectual property agreement between WRT members.

Action 3.5 – Develop a stand-alone funding strategy based on the Warru Recovery Plan.

Action 3.6 – Finalise memorandum of understandings between stakeholders.

Action 3.7 – Warru Recovery Plan is adopted and embraced by outside stakeholders and is in line with National Recovery Plan (Pearson 2010).

Table 9. *Summary of Warru Recovery Plan actions, including priorities, delivery time, responsible agencies and indicative annual budget.*

Objectives	Action	Description	Sub-action	Description	Priority	Delivery time	2010–11	2011–12	2012–13	2013–14	2014–15	Agency	Total	Comm.	Req.
1. Maintain the genetic diversity and increase the distribution and abundance of warru in South Australia.	1.1	Implement appropriate threat abatement and monitoring and refine with added knowledge	1.1.1	Maintain predator management monitoring around existing colonies	H	Og	33	33	33	33	33	APYLM	165	0	165
			1.1.2	Conduct an ongoing trial of Eradicat® baits in Eastern Musgrave Ranges by July 2011	H	1	25	25	25	25	25	APYLM	125	0	125
			1.1.3	Develop and implement plan for control of large feral and superabundant native herbivores in core areas of warru range by July 2013	H	2	8	8	8	8	8	WRT/ APYLM	40	0	40
			1.1.4	Control rabbits and rabbit warrens within a 1km buffer of the hills on which known warru colonies occur	H	Og	20	20	20	20	20	APYLM	100	16	84
			1.1.5	Implement APY Lands Fire Management Plan (Paltridge and Latz 2010) with respect to warru habitat by July 2013	H	Og	4	4	4	4	4	APYLM	20	16	4
			1.1.6	Encourage and support production and implementation of APY Lands Buffel Grass Management Strategy and promote state and national control initiatives	H	1	40	40	40	40	40	WRT/ APY/ AWRM/ DENR	200	0	200
	1.2	Maintain current warru monitoring regime at known warru colonies in the Eastern Musgrave and Tomkinson Ranges	1.2.1	Conduct scat quadrat counts	H	Og	12	12	12	12	12	APYLM and EH	60	48	12
			1.2.2.	Conduct warru trapping program	H	Og	17	15	15	15	15	DENR, APYLM Zoos SA	77	17	60
			1.2.3	Conduct adult survivorship monitoring	M		50	15	15	15	15	APYLM	110	95	15
			1.2.4	Conduct warru distribution surveys	M	Og			50		50	DENR, APYLM	100	0	100

Priority: H = High, M = Medium, L = Low. To be used when prioritising actions with same delivery times. Delivery Times: Og = ongoing and necessary. 1 = 1–5 years, 2 = > 5 years. Comm. = funding already committed. Req. = funding required.
* = where costs are incorporated/committed in other actions. All figures x $1000.

Table 9. *Summary of Warru Recovery Plan actions, including priorities, delivery time, responsible agencies and indicative annual budget.*

Objectives	Action	Description	Sub -action	Description	Priority	Delivery time	2010–11	2011–12	2012–13	2013–14	2014–15	Agency	Total	Comm.	Req.
1. Maintain the genetic diversity and increase the distribution and abundance of warru in South Australia.	1.3	Maintain captive warru populations with genetic representation from known in-situ colonies and suitable facilities at Monarto	1.3.1	Maintain existing captive animals and breed captive animals for colony maintenance	H	Ag	*	*	*	*	*	CA			
			1.3.2	Undertake routine or opportunistic assessment of genetic diversity in wild and captive populations				10		10		CA	20	0	20
	1.4	Encourage and support specific dedicated research and development projects on warru conservation ecology	1.4.1	Conduct population viability analysis for remaining metapopulations based on trapping results and survival analysis	H	1	10					DENR	10	0	10
			1.4.2	Define inherent natural predator dynamics and warru population dynamics in a landscape where warru populations are apparently stable and robust	H	1		50	50	50		Uni. of Ad.	150	0	150
			1.4.3	Determine optimum techniques for predator management (especially cats) to minimise warru predation	H	1		25	25	25		WRT/EH	75	75	
			1.4.4	Determine influence of supplementary feeding, supplementary water and patch burning on recruitment	H	2	20	20	20	20	20	EH/APYLM	100	0	100
			1.4.5	Define inherent natural warru population dynamics with respect to climate	L	2			10	10		Uni. of Ad.	20	0	20
			1.4.6	Determine effect of interactions between human settlements and warru populations.	L	2		5	5	5	5	WRT	20	0	20

Priority: H = High, M = Medium, L = Low. To be used when prioritising actions with same delivery times. Delivery Times: Og = ongoing and necessary. 1 = 1–5 years, 2 = > 5 years. Comm. = funding already committed. Req. = funding required.
* = where costs are incorporated/committed in other actions. All figures x $1000.

Table 9. *Summary of Warru Recovery Plan actions, including priorities, delivery time, responsible agencies and indicative annual budget.*

Objectives	Action	Description	Sub -action	Description	Priority	Delivery time	2010–11	2011–12	2012–13	2013–14	2014–15	Agency	Total	Comm.	Req.
1. Maintain the genetic diversity and increase the distribution and abundance of warru in South Australia.	1.4	Encourage and support specific dedicated research and development projects on warru conservation ecology	1.4.7	Determine fate of young warru through recruitment/ dispersal studies	L	2			20	20	20	WRT/Uni. of Ad.	60	0	60
			1.4.8	Examine the prevalence of toxoplasmosis and other diseases in extant warru populations	L	2			10			Zoos SA	10	0	10
	1.5	Supplement existing colonies only where appropriate	1.5.1	Define supplementation thresholds for current extant colonies	H	1	1	1	1	1	1	WRT	5	5	0
			1.5.2	Conduct supplementation if population thresholds are met	M	2			5	5	5	APY/ Zoos SA	15	0	15
	1.6	Conduct reintroduction of warru into the APY Lands within former range	1.6.1	Establish and maintain genetically diverse captive breeding population of warru	H	1	150	90	95	100	105	Zoos SA	540	0	540
			1.6.2	Establish and maintain a predator-proof facility (the Warru Pintji) in the APY lands with no incursions affecting warru and conduct trial hardening-off and free-breeding.	H	1	150	150	100	100	100	WRT/ APY	600	200	400
			1.6.3	Rank potential reintroduction sites and test site selection criteria (Ward *et al.* 2010b)	H	1	10	10				WRT	20	20	0
			1.6.4	Implement research project to define thresholds of threats (predation) considered viable to conduct reintroductions.	H	Og			50	50	50	WRT/ Uni. of Ad.	150	0	150
			1.6.5	Increase range of threat abatement, as directed by Actions 1.4.2 and 1.4.3 to maximise chances of success of reintroduction (if needed according to research).	H	2		80	60	60	60	APY	260	0	260

Priority: H = High, M = Medium, L = Low. To be used when prioritising actions with same delivery times. Delivery Times: Og = ongoing and necessary. 1 = 1–5 years, 2 = > 5 years. Comm. = funding already committed. Req. = funding required.
* = where costs are incorporated/committed in other actions. All figures x $1000.

Table 9. *Summary of Warru Recovery Plan actions, including priorities, delivery time, responsible agencies and indicative annual budget.*

Objectives	Action	Description	Sub -action	Description	Priority	Delivery time	2010–11	2011–12	2012–13	2013–14	2014–15	Agency	Total	Comm.	Req.
1. Maintain the genetic diversity and increase the distribution and abundance of warru in South Australia.	1.6	Conduct reintroduction of warru into the APY Lands within former range	1.6.6	Undertake cross-fostering program for warru once reintroduction sites are identified, prepared and appropriately managed.											
			1.6.7	Conduct hard reintroduction of warru into the APY Lands once actions 1.6.1 to 1.6.6 have been undertaken.	H	2					200	WRT	200	0	200
			1.6.8	Investigate need for Warru Pintji in the Tomkinson Ranges	M	1	5					WRT/APY	5	5	0
	1.7	Support and encourage surveys of warru in adjacent ranges in Western Australia and the Northern Territory		Contact key agencies in WA and NT and assist with joint grant application in conjunction with SA searches	M	Og		2		2		DENR/WRT	4	0	4
	1.8	Engage pastoral industry as potential icon species for conservation on pastoral leases within former range (i.e. Davenport Ranges).		Use results of 2.1.4 to determine potential for success of Davenport Range reintroduction, see cooperation from pastoral lessees and establish threat monitoring program	M	2				3	5	DENR/WRT	8	8	0
2. Anangu have ownership of key WRT decisions, on-ground actions, employment opportunities and educational outcomes.	2.1	Conduct regular WRT meetings	2.1.1	Conduct regular WRT meetings with land management, technical and scientific staff			5	5	5	5	5	DENR	25	5	20
			2.1.2	Conduct annual WRT meetings with Anangu and Piranpa representatives and with a translator present.	H	Og	30	30	30	30	30	DENR/ WRT/ APYLM	150	97	53
	2.2	Employ an iterative decision-making process for the WRT between Piranpa and Anangu members of the WRT.			H	Og	na	na	na	na	na	WRT	0	0	

Priority: H = High, M = Medium, L = Low. To be used when prioritising actions with same delivery times. Delivery Times: Og = ongoing and necessary. 1 = 1–5 years, 2 = > 5 years. Comm. = funding already committed. Req. = funding required.
* = where costs are incorporated/committed in other actions. All figures x $1000.

Table 9. *Summary of Warru Recovery Plan actions, including priorities, delivery time, responsible agencies and indicative annual budget.*

Objectives	Action	Description	Sub-action	Description	Priority	Delivery time	2010–11	2011–12	2012–13	2013–14	2014–15	Agency	Total	Comm.	Req.
2. Anangu have ownership of key WRT decisions, on-ground actions, employment opportunities and educational outcomes.	2.3	Ensure all on-grounds works have an appropriate level of Anangu employment			H	1	320	355	355	355	355	APY/WRT	1740	1385	355
	2.4	Ensure there are at least two Traditional Owners who can speak for each warru metapopulation involved in the Warru Recover Team			H	Og	*	*	*	*	*	WRT			
	2.5	Translate Warru Recovery Plan		Communicate aspirations of the WRP into Pitjantjatjara and Yankunytjatjara (support Mobile Language Group project, University of Adelaide).	M	Og	20	20				Uni. of Ad. (Mobile Language Centre)	40	0	40
	2.6	Hold community meetings with relevant communities in the APY Lands to discuss the objectives and actions of the Warru Recovery Plan			H	2	15	15				WRT	30	0	30
	2.7	Develop an agreed media protocol for the WRT	2.7.1	Determine appropriate future media opportunities which need to be pursued	H	2	5		5		5	WRT	15	5	10
			2.7.2	Develop an agreement on types of media opportunities which require pre-approval	H	2	1		1		1	WRT	3	1	2
			2.7.3	Develop a memorandum of understanding around process and use of images	H	2	5		5		5	WRT	15	5	10
			2.7.4	Define a proper process for acknowledgement of funding bodies	H	2	1		1		1	WRT	3	1	2

Priority: H = High, M = Medium, L = Low. To be used when prioritising actions with same delivery times. Delivery Times: Og = ongoing and necessary. 1 = 1–5 years, 2 = > 5 years. Comm. = funding already committed. Req. = funding required.
* = where costs are incorporated/committed in other actions. All figures x $1000.

Table 9. *Summary of Warru Recovery Plan actions, including priorities, delivery time, responsible agencies and indicative annual budget.*

Objectives	Action	Description	Sub -action	Description	Priority	Delivery time	2010–11	2011–12	2012–13	2013–14	2014–15	Agency	Total	Comm.	Req.
3. The Warru Recovery Project is jointly managed and administered strategically towards long-term objectives	3.1	Update WRT Terms of Reference (2007)			H	1	2		2		2	DENR/WRT	6	2	4
	3.2	Produce WRT annual report.		Key stakeholders meeting to establish key performance indicators, endorsed by Warru Recovery Team.	H	Og	5	5	5	5	5	DENR/WRT	25	5	20
	3.3	Maintain Warru Wiki			H	Og	1	1	1	1	1	Zoos SA / WRT	5		5
	3.4	Produce intellectual property agreement between WRT members			H	2	10				5	WRT/ Consultant	20	0	20
	3.5	Develop a stand-alone funding strategy based on the Warru Recovery Plan.			H	1	5				5	DENR/WRT	15	0	15
	3.6	Finalise memorandum of understandings between stakeholders.			H	1	5				5	WRT	15	0	15
	3.7	Warru Recovery Plan is adopted and embraced by outside stakeholders and is in line with National Recovery Plan (Pearson 2010)			H	2	5				5	DENR/WRT	15	5	10

Priority: H = High, M = Medium, L = Low. To be used when prioritising actions with same delivery times. Delivery Times: Og = ongoing and necessary. 1 = 1–5 years, 2 = > 5 years. Comm. = funding already committed. Req. = funding required.
* = where costs are incorporated/committed in other actions. All figures x $1000.

Total cost for 5 years	Funding committed	Funding required
$5,391 K	**$1,941 K**	**$3,450 K**

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11. Appendices

11.1 Appendix 1 – IUCN Criteria

The South Australian National Parks and Wildlife Act Schedule 7 uses IUCN criteria to rate threatened species at the critically endangered, endangered and vulnerable level. These are given below.

11.1.1.1 Critically endangered/endangered/vulnerable

A taxon is critically endangered/endangered/vulnerable when the best available evidence indicates that it meets any of the following criteria (A to E), and it is therefore considered to be facing some risk of extinction in the wild:

A. Reduction in population size based on any of the following:

1. An observed, estimated, inferred or suspected population size reduction of 90%/70%/50% over the last 10 years or three generations, whichever is the longer, where the causes of the reduction are clearly reversible and understood and ceased, based on (and specifying) any of the following:
   a. direct observation
   b. an index of abundance appropriate to the taxon
   c. a decline in area of occupancy, extent of occurrence and/or quality of habitat
   d. actual or potential levels of exploitation
   e. the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites.
2. An observed, estimated, inferred or suspected population size reduction of 80%/50%/30% over the last 10 years or three generations, whichever is the longer, where the reduction or its causes may not have ceased or may not be understood or may not be reversible, based on (and specifying) any of (a) to (e) under A1.
3. A population size reduction of 80%/50%/30%, projected or suspected to be met within the next 10 years or three generations, whichever is the longer (up to a maximum of 100 years), based on (and specifying) any of (b) to (e) under A1.
4. An observed, estimated, inferred, projected or suspected population size reduction of 80%/50%/30% over any 10 year or three generation period, whichever is longer (up to a maximum of 100 years in the future), where the time period must include both the past and the future, and where the reduction or its causes may not have ceased OR may not be understood OR may not be reversible, based on (and specifying) any of (a) to (e) under A1.

B. Geographic range in the form of either B1 (extent of occurrence) or B2 (area of occupancy) or both:

1. Extent of occurrence estimated to be less than 100/5000/20000km^2, and estimates indicating at least two of a–c:
   a. Severely fragmented or known to exist at only a single/five/10 locations.
   b. Continuing decline, observed, inferred or projected, in any of the following:
      i. extent of occurrence
      ii. area of occupancy

iii. area, extent and/or quality of habitat

iv. number of locations or subpopulations

v. number of mature individuals.

c. Extreme fluctuations in any of the following:

i) extent of occurrence

ii) area of occupancy

iii) number of locations or subpopulations

iv) number of mature individuals.

2. Area of occupancy estimated to be less than 10/500/2000km^2, and estimates indicating at least two of a–c:

a. Severely fragmented or known to exist at only a single/five/10 locations.

b. Continuing decline, observed, inferred or projected, in any of the following:

i) extent of occurrence

ii) area of occupancy

iii) area, extent and/or quality of habitat

iv) number of locations or subpopulations

v) number of mature individuals.

c. Extreme fluctuations in any of the following:

i) extent of occurrence

ii) area of occupancy

iii) number of locations or subpopulations

iv) number of mature individuals.

C. Population size estimated to number fewer than 250/2500/10000 mature individuals and either:

1. An estimated continuing decline of at least 25%/20%/10% within three/five/10 years or one/two/three generations, whichever is longer, (up to a maximum of 100 years in the future) or

2. A continuing decline, observed, projected, or inferred, in numbers of mature individuals and at least one of the following (a–b):

a. Population structure in the form of one of the following:

i. no subpopulation estimated to contain more than 50/250/1000 mature individuals, or

ii. at least 90%/95%/all of mature individuals in one subpopulation.

b Extreme fluctuations in number of mature individuals.

D. Population size estimated to number fewer than 50/250/1000 mature individuals.

E. Quantitative analysis showing the probability of extinction in the wild is at least 50% within 10 years or three generations/20% within 20 years or five generations/10% within 100 years, (whichever is the longer, up to a maximum of 100 years).

11.1.1.2 National IUCN Listing

Listed as near-threatened nationally because, although it has a large extent of occurrence, its distribution is very patchy, few (if any) populations are considered secure, the total population is not much greater than 10,000 mature individuals, and it is probably decreasing overall, thus making the species close to qualifying for vulnerable under criterion C.

All three subspecies and both races of black-footed rock-wallaby are listed as threatened under Australian law. The species occurs in a number of protected areas. The separate subspecies and races are managed separately. Some of the island populations should be sampled genetically – not all have been sampled and there is evidence of inbreeding with some locations. Regular monitoring of populations should be conducted in a coordinated fashion. Predator control measures (primarily fox baiting) need to be maintained and expanded within key areas for the species, as well as monitoring of fox populations. Fire management and habitat restoration should be implemented where feasible.

11.2 Appendix 2 – Reintroduction site selection criteria

Adopted from Ward *et al.* (2010b) to fit a potential reintroduction site.

ID	Criteria	Criteria level	Essential?	Score
A	Accessible to Aṉangu workers	Reasonable distance to a potential warru ranger team	Yes	4
		Likely to detract some warru rangers from working there		2
		Ranger team(s)/Aṉangu unwilling or able to work at site		Exclude
B	Aṉangu clearance	Site cleared by Traditional Owners and APY Executive and anthropological clearance	Yes	Permit
		Site NOT cleared by Traditional Owners and APY Executive and anthropological clearance		Exclude
C	Warru presence/absence	Warru currently resident	Yes	Exclude
		Warru present in last 10 years.		5
		Warru present in last 50 years.		2
		Warru never present		1
D	How many individuals could be sustained at the site?	0–15	Yes	1
		15–30		3
		30–60		5
		60+		5
E	Dispersal/connectivity between colony sites (ability to start metapopulation)	Continuous rock faces to medium/large dispersal sites	Yes	6
		Continuous rock faces to small dispersal sites		5
		Some connectivity to rock faces to medium/large dispersal sites		4
		Some connectivity of rock face to small dispersal sites		3
		No connecting rock faces/outcrops but medium/large habitat within 500m		2
		No connecting rock faces/outcrops but small within 500m		Exclude
F	Food plants available	Abundant/very common	Yes	Exclude
		Isolated site		10
		Common		6
		Uncommon		3
		Rare/absent		Exclude
G	Size of area with suitable habitat (in particular shelter sites)	> 50 ha or more	Yes	4
		0 – 50 ha		2
		None		Exclude
H	Number of ideal shelter sites per ha. Ideal = labyrinth/ crevice, fits 1–2 people, low – medium exposure, in/ adjacent to other areas of high complexity.	20 or more	Yes	10
		0 – 20		5
		None		Exclude
I	Management of predation	The site greater than 4km from a community (Yes/No)	Yes	2
		A continuous track network within 10km is or can be established (Yes/No)		2
		An on site baiting ring can be established (Yes/No)		2
		A multiple layer of feral predator defence be established (Yes/No)		2
		Is baiting currently occurring within 1km of the site (Yes/ No)		2
J	Bait take	No/low	Yes	10
		Medium		5
		Consistently high		Exclude

ID	Criteria	Criteria level	Essential?	Score
K	Fire risk	High Buffel grass/spinifex fuel loads in the flats		0
		Potentially high buffel grass/spinifex fuel loads following rain in the flats		1
		Low buffel/spinifex fuel loads in the flats		2
		No buffel or spinifex in the flats		3
L	Fire control	Tracks network around site	Yes	2
		Tracks passing site		1
		No tracks accessing site		0
M	Competition from rabbits	No/low rabbit densities at site and controllable	Yes	5
		Rabbits in medium – high density and difficult to manage		0
N	Competition from other macropods	Low or no threat due to low densities or absence	Yes	5
		Medium threat due to medium densities		2
		High threat due to high densities		1
O	Ability to manage the site safely (available communications, vehicle access, terrain at sites, travel time etc.)	Good communications (Yes/No)	Yes	4
		Vehicle access (Yes/No)		4
		Travel time < 1 hour		4
		Travel time 1–2 hours		1
		Travel time > 2 hours		0
P	Human usage	Low human use, managed easily	Yes	5
		Existing moderate level of usage		3
		High usage, difficult to manage		Exclude
		Major human use area		Exclude
Q	Accessibility	Not far off a well maintained road so that impacts associated with increased activity are minimised.	Yes	4
		Access road likely to get boggy or degraded in the wet or prone to erosion with increased use.		0
R	Potential to form large, complex metapopulation	> 10 potential and/or historical) refuge areas within 10km and well connected by rugged terrain	Yes	15
		5–9 potential &and/or historical) refuge areas within 5km and well connected by rugged terrain		10
		1–4 other potential and/or historical) refuge areas within 5km		4
		No other potential refuge areas within 5km		Exclude

11.3 Appendix 3 – Roles and responsibilities of Warru Recovery Team members.

11.3.1 APYLM

- The APY Land Management Unit (APYLM) was established in 1990 to assist Pitjantjatjara and Yankunytjatjara people to realise their aspirations for the management of their land. The APYLM also supports the social and economic objectives of Aṉangu Pitjantjatjara Yankunytjatjara. This includes identifying and creating opportunities for employment in natural resource management and enabling the sustainable use of the natural resources for economic development – in both the traditional and contemporary sense.
- As primary landholder and primary applicant of the take permit (when removing animals for captive breeding purposes) Aṉangu Pitjantjatjara Yankunytjatjara have legal possession of warru. Royal Zoological Society of South Australia (RZSSA) as a secondary applicant has responsibility for the primary care of warru. See section 11.1 in Ward and Clark (2007) for more details.
- APY would play a similar role of primary owner of reintroduced warru offspring and future reintroduction proposals.
- APY holds a DENR scientific research permit for 'biological survey of the APY Lands' which is primarily for warru trapping and a research and teaching license which covers the warru trapping. DENR has organised the animal ethics permits to date. APYLM will maintain the permits for the WRT but DENR assistance will be required to maintain the animal ethics, licenses and permits
- APY administers the permits for access to the APY Lands, and all land-based projects and activities need APY executive approval which has a number of stipulations including APY involvement and Aṉangu employment. APY has responsibilities for consultation with Traditional Owners on all land based activities; this can not be delegated.
- APY sources funds for the on-ground management of warru and employment of APY and Aṉangu staff involved with warru management and affiliated IPAs.

11.3.2 DENR

- Establishing and fostering strong working relationships between key stakeholders in the WRT and the warru recovery process.
- Facilitating, hosting and attending WRT meetings.
- Sourcing funding, where and as appropriate, for the Warru Recovery Project to achieve goals and objectives of the Warru Recovery Plan.
- Promoting achievements of WRT within DENR and State Government.
- Providing ecological, technical and logistical support to the WRT to meet the conservation objectives of the Warru Recovery Project.
- Liaising with, and representing, other DENR interests including Science Resource Centre (survey, research permits and animal ethics), nature conservation programs and regional conservation delivery.
- Liaising with other DENR projects with potential interest with Warru Recovery Project.
- Promoting, initiating and driving research projects which apply to warru recovery.
- Providing corporate knowledge of the workings of the WRT and familiarity with rock-wallaby monitoring and management issues.
- Providing link and feedback to Alinytjara Wilu̱rara NRM Board.

11.3.3 Conservation Ark

RZSSA, as a secondary applicant of the take permit for warru translocations, has responsibility for the primary care of captive warru through its integrated science and conservation arm, Conservation Ark – see section 11.1 in Ward and Clark (2007). Responsibilities include:

- Managing the captive population of warru at Monarto Zoo.
- Managing the warru stud book and pairings of animals for breeding.
- Overseeing and managing the field and captive components of the cross-fostering program.
- Veterinary care of the captive population and pre-release health checks and disease risk analysis.
- Providing health checks and post mortems of wild-caught animals where appropriate.
- Sourcing funding to support captive breeding, reintroduction and monitoring components of the Warru Recovery Project where opportunities arise.
- Providing support for field work through staff participation, provision of equipment or technical support.
- Involvement in warru-related research, e.g. supervision of a PhD student.
- Promoting the joint recovery efforts of the WRT through a variety of media.
- Supporting the skill development of Anangu through provision of training where opportunities arise.
- Supporting and developing links between recovery team members and partners to ensure the smooth running of the program.
- Providing updates to the recovery team about the above activities.

11.3.4 Ecological Horizons/independent researchers

- Providing independent expert ecological advice and opinion to the WRT and its individual stakeholders regarding ecology, monitoring and management of macropods and pest animal management.
- Providing expert ecological field services when requested.
- Providing continuity with warru monitoring which is important when other stakeholders typically have shorter tenures.
- Providing corporate knowledge of the workings of the WRT and familiarity with rock-wallaby monitoring and management issues.

11.3.5 Universities

- Providing research support to address knowledge gaps highlighted by the WRT.

11.3.6 DSEWPC

- Reviewing national status rating for *P. lateralis* MacDonnell Ranges race.
- Determining any potential significant impacts of development on warru.
- Providing links to national initiatives and funding opportunities of relevance to the WRT, e.g. Working on Country Program.

11.3.7 All Warru Recovery Team members

- Upholding WRT terms of reference.
- Producing an annual report for the rest of the WRT reporting on agreed annual objectives.
- Attending recovery team meetings and completing actions arising from meetings.

11.4 Appendix 4 – Detailed recovery actions

Action/ sub-action	Details
1.1.1	**Maintain predator monitoring and management around existing colonies** • Fortnightly ground-based baiting around New Well. • Quarterly aerial baiting in baiting management zone encompassing New Well, Alalka, Wamitjara and hills in Warru Pintji.
1.1.2	**Conduct an ongoing trial of Eradicat® baits in Eastern Musgrave Ranges by July 2011** • Eradicat® license has already been approved. • Use Eradicat® in place of 1080 baits in both regular aerial and ground-based baiting. • Ensure cameras are set up to determine what is taking the baits. • If initially ineffective, cat baits could particularly be used during dry times when alternate prey for cats is unavailable.
1.1.3	**Develop and implement a plan for control of large feral herbivores and over-abundant native herbivores in core areas of warru range and APY Lands by July 2013** • Employ a "roo shooter" for two days per year to remove superabundant Kanyula from New Well area where they compete with warru for space and food resources by July 2012. • Remove donkeys from New Well and Warru Pintji area and truck them out of APY Lands once a year. Option to use holding yards at New Well, Young's Well or Donald's Well by July 2013.
1.1.4	**Control rabbits and rabbit warrens within a 1km buffer of the hills on which known warru colonies occur** • Designed to reduce prey numbers for dogs, foxes and cats. • Four days per year already marked in APY's Working on Country Project. • Warrens could be ripped in the flats around the Tomkinson Ranges.
1.1.5	**Implement APY Fire Management Plan (Paltridge and Latz 2010a) with respect to warru habitat by July 2013** • One habitat protection and one habitat enhancement burn in the Musgrave and Tomkinson ranges each year. • Develop smaller scale specific fire management plan for New Well, Donald's Well and Alalka area. • Adjust according to Warru specific fire plan being written by Desert Wildlife Services.
1.1.6	**Encourage and support production and implementation of APY Lands Buffel Grass Management Strategy** • Ensure management plan has a site specific focus, in particular minimising impact of buffel spread on New Well, Kalka, Alalka and Warru Pintji site. • Discuss the possibilities of the formation of a "Buffel Blitz team".
1.2.1	**Conduct scat quadrat counts** • Biannual counts at New Well, New Well North and Kalka. • Plan with APY Land Management so that scat counts are conducted by Warru rangers from 2011–2012 onwards.
1.2.2	**Conduct warru trapping program** • Annual trapping essential for good population data. • Joint trips with Warru Rangers, APYLM, DENR and Conservation Ark. • Trapping simultaneously at Kalka, New Well and Alalka (and possibly Warru Pintji). • Aim to have Warru Rangers conduct free-feeding independently by 2012. • Minimum of one animal hand raiser/zoo keeper per site and one ecologist with experience in handling warru and setting traps appropriately. • General anesthesia only required if animals do have pouch young removed for captive breeding purposes, or samples being collected for health and disease reasons. Radio-collars can be placed without anesthesia.
1.2.3	**Conduct adult survivorship monitoring** • Monthly monitoring by Warru rangers at New Well and Kalka. • Radio-telemetry on animals at New Well with radio-collars which emit a mortality signal. • Increase to radiotracking inside and outside Warru Pintji (possibly assisted with tower at Donald's Well).

Action/ sub-action	Details
1.2.4	**Conduct warru distribution surveys** • Periodic surveys when funding and timing opportunities exist. • Using helicopters, drop searchers on hills and mountain ranges to search for warru scats. • Minimum five days searching using search method in Ward *et al.* (2011b). • Priority new areas to search using helicopter based surveys: 1. Mann Ranges. 2. Everard Ranges. 3. Indulkana Range/Eastern APY Lands. 4. Isolated granite outcrops south-western APY Lands. • Areas should only be targeted again at least five years post initial survey and include: a) fringes of previous range to determine range contractions or expansions. b) key den sites to determine ongoing occupation. • Expansion/contraction of Warru metapopulations could then be described in terms of distribution (area) and persistence (% of key den sites still occupied). • Anthropological clearance required. • Recommend using Commercial Helicopters Pty Ltd – used in 2008, 2009 and 2010 – because of their mobile fuelling unit. • Shorter, cheaper surveys can be conducted via ground-based visitation to targeted outcrops pending Traditional Owner approval.
1.3.1	**Maintain existing captive animals and breed captive animals for colony maintenance** • Best captive facilities and experience for *P. lateralis* captive management now at Monarto Zoo. • Continue complete separation of Kalka and Musgrave animals. • Maintain up-to-date and accurate stud management books. • Ensure cross-section of animals which are chosen to "free breed" in Warru Pintji are genetically diverse. • Maintain sufficient genetic analysis of animals free-bred in Warru Pintji to ensure the population to potentially release is genetically diverse.
1.3.2	**Undertake routine or opportunistic assessment of genetic diversity in wild and captive populations** • Ensure genetic diversity does not fall below thresholds for strategic supplementation of wild or captive populations.
1.4.1	**Conduct population viability analysis for remaining metapopulations based on trapping results and survival analysis** • Determine thresholds for trapping rates to measure population change.
1.4.2	**Define inherent natural predator dynamics and warru population dynamics in a landscape where warru populations apparently stable and robust** • To determine targets of predator dynamics for potential warru reintroduction areas. • Recommend a dedicated research project which may need to be conducted in areas of the Northern Territory where *P. lateralis* populations are flourishing.
1.4.3	**Determine optimum techniques for predator management (especially cats) to minimise warru predation** • Conduct Eradicat® trial (Sub-action 1.1.6) • Conduct trials of other cat-specific control techniques (e.g. Scentinal or Cat Pipes)
1.4.4	**Determine influence of supplementary feeding, supplementary water and patch-burning on recruitment** • Conduct experimental trials in areas where baseline recruitment and population levels are already established. • Conduct patch burns/habitat enhancement burns and determine relative use of these areas through GPS telemetry and scat quadrats/counts. • Monitor changes in recruitment through scat counts and trapping.
1.4.5	**Define inherent natural warru population dynamics with respect to climate** • To determine potential changes in warru population dynamics relative to climate change

Action/ sub-action	Details
1.4.5	**Determine effect of interactions between human settlements and warru populations** • Compare relative predator abundances in similar habits proximal and distal to settlements. • Conduct telemetry (GPS) of predators close to settlements to determine influence of interactions.
1.4.7	**Determine the fate of young warru through recruitment/dispersal studies**
1.4.8	**Examine the prevalence of toxoplasmosis and other diseases in extant Warru populations**
1.5.1	**Define supplementation thresholds for current extant colonies** • Analyse current trapping data for each extant colony to determine suitable thresholds. – E.g. for New Well, 2009–2010 – less than six successful recruits in any two-year period (either retrapped second-year or old first-year animals), and/or – Predicted adult population of less than 15 animals or eight females.
1.5.2	**Conduct supplementation if population thresholds are met** • Analyse trapping data following trapping trips to determine if supplementation thresholds for current extant colonies have been met. • Release minimum number and optimum sex/genetics to satisfy threshold.
1.6.1	**Establish and maintain genetically diverse captive breeding population of warru** • See Action 1.3.1
1.6.2	**Establish a predator-proof facility in the APY Lands with incursions affecting warru and conduct hardening-off and free-breeding of warru** • Establish 100ha facility in Musgrave Ranges proximal to in-situ populations (Ward *et al.* 2010b). • Warru Pintji/Fence built as part of SA State NRM Grant Program, administered by Alinytjara Wilurara NRM Board and delivered by APY and overseen by WRT.
1.6.3	**Rank potential reintroduction sites and test site selection criteria (Ward et al. 2010b)** • First-round desktop assessment of potential reintroduction sites by scientists to rank regions in light of potential climate change, land use management and potential metapopulation connectivity. • Determine whether Anangu are supportive of potential reintroduction sites. • Test site selection criteria and seek Anangu approval and anthropological clearance. • Commence threat monitoring at priority sites to fine-tune selection process and provide measures of future threat abatement success.
1.6.4	**Implement research project to determine predatory threats and competition thresholds viable to conduct reintroductions** • See sub-action 1.4.3
1.6.5	**Increase range of threat abatement (as directed by 1.6.4 and 1.4.3) to maximise changes of success of reintroductions** • This should not occur in a potential reintroduction area before: a) baseline measurements are obtained of predator dynamics in reintroduction area b) predator dynamics in an area where warru are flourishing are understood c) Predation thresholds for a successful reintroduction are understood.
1.6.6	**Undertake cross-fostering program for warru once reintroduction sites are identified and prepared and appropriate managed** • Depends on preparedness of free-breeding warru for hard-reintroduction.
1.6.7	**Conduct hard reintroduction of warru into the APY lands** • This should not occur before predation levels are understood and at a point where reintroductions are likely to be successful. • 1.6.1–1.6.6 need to have been completed before reintroductions.
1.6.8	**Investigate need for Warru Pintji in Tomkinson Ranges** • Determine whether management of in-situ population is leading to recovery. • Consult with community and other agencies involved in the region (e.g. IPA).

Action/ sub-action	Details
1.7	**Support and encourage surveys of warru in WA and NT** • Contact key agencies in WA and NT and assist with joint grant application in conjunction with SA searches. • Follow methods of Ward *et al.* (2011b). • WA – Nyaanyatjarra Land Management involvement required. • NT – survey parts of Mann Ranges which extend into NT.
1.8	**Engage pastoral industry as potential icon species for conservation on pastoral leases within former range (i.e. Davenport Ranges)** • Use results of 2.1.4 to determine potential for success of Davenport Range reintroduction, seek cooperation from pastoral lessees and establish threat monitoring program. • Send a letter to appropriate pastoralists highlighting the collaboration and successes of the Warru Recovery Team, and the role that pastoralists' country could play in the conservation of the species. • If support from pastoralists obtained, commence a research project on predator dynamics in the Davenport Ranges. • This work should not take away any potential resources from conservation of in-situ APY population nor expansion of range in the APY Lands.
2.1.1	**Conduct a trial of Eradicat® baits in Eastern Musgrave Ranges metapopulation** • Eradicat® license has already been approved. • Use Eradicat® in place of 1080 baits in both regular aerial and ground-based baiting. • Ensure cameras are set up so that it can be determined what is taking the baits. • If initially ineffective, cat baits could particularly be used during dry times when alternate prey for cats is unavailable.
2.1.1	**Conduct regular WRT meetings with land management, technical and scientific staff** • Minimum once per quarter to ensure Warru Recovery Plan objectives and actions are being met.
2.1.2	**Conduct annual WRT meetings with Anangu and Piranpa representatives with a translator present** • Full meeting with all Anangu involved in implementing Warru Recovery Plan held annually, over at least two days, including a field trip. • Aim is to ensure Warru Recovery Plan objectives and actions are being met. • Interpreter must be present. • Held at a variety of locations. (e.g. 2007 Adelaide, 2008 Umuwa APY Lands, 2009 Roxby Downs). Potential other locations include Monarto/Adelaide Zoo, Uluru, Kalka/Pipalyatjara. • Funds to be sought for this.
2.2	**Employ an iterative decision-making process for the WRT between Piranpa and Anangu members of WRT**
2.3	**Ensure at least two Traditional Owners who can speak for each warru metapopulation (e.g. Musgrave, Tomkinson and potentially Everard Ranges) are involved in the WRT**
2.4	**Ensure all on-grounds works have an appropriate level of Anangu employment. Current levels of employment are a good benchmark** • 1 x FTE Warru recovery officer. • 8 x PTE Working on Country Warru rangers. • 1 x FTE Warru reintroduction officer. • 2 x PTE Warru reintroduction rangers. • Warru Pintji fence rangers as required.
2.5	**Translate Warru Recovery Plan** • Communicate aspiration of the WRP into Pitjantjatjara and Yankunytjatjara • Support Mobile Language Group, University of Adelaide.

Action/ sub-action	Details
2.6	**Hold meetings with relevant communities in the APY Lands to discuss the objectives and actions of the WRP**
2.7.1	**Determine appropriate future media opportunities which need to be pursued**
2.7.2	**Develop an agreement on types of media opportunities which require pre-approval**
2.7.3	**Develop a MOU around use of images**
2.7.4	**Define a proper process for acknowledgement of funding bodies**
3.1	**Update WRT terms of reference (2007)**
3.2	**Produce WRT annual report** • WRT partners reporting against agreed key performance indicators endorsed by WRT. • Key information made accessible by all partners and key stakeholders.
3.3	**Maintain "Warru Wiki" as a key information source with access to reports, Warru Recovery Plan, etc**
3.4	**Produce an intellectual property agreement between WRT members**
3.5	**Develop stand-alone funding strategy based on the Warru Recovery Plan**
3.6	**Finalise MOUs between stakeholders** • Includes MOU around Warru Pintji Project
3.7	**Warru Recovery Plan adopted and embraced by outside stakeholders and is in line with National Recovery Plan (Pearson 2010)**

For further information please contact:

Department of Environment and Natural Resources Phone Information Line (08) 8204 1910,
or see SA White Pages for your local Department of Environment and Natural Resources office.
Online information available at: www.environment.sa.gov.au

The Warru Recovery Plan was prepared by Dr John Read and Dr Matthew Ward from planning conducted by the Warru Recovery Team in September 2009, including staff and students from the Department of Environment and Natural Resources, Anangu Pitjantjatjara Yankunytjatjara Land Management, Ecological Horizons Pty Ltd, Conservation Ark, University of Adelaide and Vicki-Jo Russell.

This recovery plan sets out the actions necessary to stop the decline of, and support the recovery of, the listed threatened species or ecological community.

The plan has been developed with the involvement and cooperation of a broad range of stakeholders, but individual stakeholders have not necessarily committed to undertaking specific actions. The attainment of objectives and the provision of funds may be subject to budgetary and other constraints affecting the parties involved. Proposed actions may be subject to modification over the life of the plan due to changes in knowledge.

This plan should be cited as follows: Read, J. and Ward, M.J. (2011). Warru Recovery Plan: Recovery of *Petrogale lateralis* MacDonnell Ranges race in South Australia, 2010–2020. Department of Environment and Natural Resources.

Copies of the plan are available at:
www.environment.sa.gov.au/biodiversity/threatened-species/threatened-fauna.html

Cover image: Warru Recovery Team Logo by Amanyi Haggie, Traditional Owner, Pukatja, Anangu Pitjantjatjara Yankunytjatjara Lands. This depicts warru, the puli (hills) and kulpi (caves) in which warru live, and Anangu and piranpa scientists working together.

Images: M Ward (DENR) pages 1, 4, 7, 8, 21, 28, 50, 59, 71, 75; J Muhic (APY LM) pages 10, 28, 51; B Dutch pages 11, 31; APYLM page 2; R West page 58.

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