

Quokka (*Setonix brachyurus*) Recovery Plan



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Department of Environment and Conservation
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Foreword

Recovery plans are developed within the framework laid down in Department of Environment and Conservation Policy Statements Nos. 44 and 50 (CALM 1992, 1994), and the Australian Government Department for Sustainability, Environment, Water, Population and Communities (DSEWPaC's) Recovery Planning Compliance Checklist for Legislative and Process Requirements (DEWHA 2008a). Recovery plans outline the recovery actions that are required to urgently address those threatening processes most affecting the ongoing survival of threatened taxa or ecological communities, and begin the recovery process. The attainment of objectives and the provision of funds necessary to implement actions are subject to budgetary and other constraints affecting the parties involved, as well as the need to address other priorities.

This recovery plan was approved by the Department of Environment and Conservation, Western Australia. Approved recovery plans are subject to modification as dictated by new findings, changes in status of the taxon or ecological community, and the completion of recovery actions. Information in this recovery plan was accurate at January 2013.

Recovery plan preparation: This recovery plan was initially prepared by Paul de Tores and Richard Williams, formerly of DEC Science Division. The plan was reviewed and updated by Mia Podesta and Jill Pryde, DEC.

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Cover photograph: Quokka (*Setonix brachyurus*) on Rottnest Island. Photograph: Allan Burbidge (DEC).

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Abbreviations

1080	Sodium fluoroacetate
ARC	Australian Research Council
CALM	Department of Conservation and Land Management, Western Australia (changed to Department of Environment and Conservation in July 2006)
DAFWA	Department of Agriculture and Food, Western Australia
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities
DEC	Department of Environment and Conservation, Western Australia (formerly CALM)
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
FMS	Fire Management Services Branch, Regional Services Division, DEC
FPC	Forest Products Commission, Western Australia
IBRA	Interim Biogeographical Regionalisation for Australia
IUCN	International Union for Conservation of Nature
NP	National Park
NR	Nature Reserve
RFA	Regional Forest Agreement, Western Australia
RIA	The Rottnest Island Authority
SCB	Species and Communities Branch, DEC
SF	State forest
SFM	Sustainable Forest Management Division, DEC
SWALSC	South West Aboriginal Land and Sea Council
UWA	The University of Western Australia
WA	Western Australia
WWF	WWF-Australia (formerly World Wide Fund for Nature)
ZAA	Zoo and Aquarium Association (formerly the Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA))

Contents

Foreword	iii
Abbreviations	iv
Summary	vi
1. Introduction	1
1.1 Description	1
1.2 Conservation status	1
1.3 Biology and ecology.....	1
1.4 History, nomenclature and taxonomic relationships	2
1.5 Distribution	2
1.7 Population genetics	6
1.8 History of decline	6
2. Habitat critical to survival and important populations	7
3. Threatening processes	8
3.1 Foxes.....	8
3.2 Feral cats.....	8
3.3 Feral pigs.....	9
3.4 Phytophthora dieback	9
3.5 Clearing	10
3.6 Altered fire regimes.....	10
3.7 Altered hydrological regimes.....	10
3.8 Climate change.....	11
3.9 Disease	11
3.10 Disturbance from recreation.....	11
4. International obligations	12
5. Affected interests	12
6. Role and interest of Aboriginal groups	13
7. Social and economic impacts and benefits	13
8. Broader biodiversity benefits	13
9. Existing conservation measures	14
10. Management practices and policies	16
11. Guide for decision makers	17
12. Objective	17
13. Performance criteria	18
14. Recovery actions	19
15. Implementation and evaluation	22
16. References	24

Summary

Species:	<i>Setonix brachyurus</i>
Family:	Macropodidae
IBRA Regions:	Swan Coastal Plain, Jarrah Forest, Warren, Esperance Plains
DEC Regions:	Swan, South West, Warren, South Coast
DEC Districts:	Swan Coastal, Perth Hills, Wellington, Blackwood, Donnelly, Frankland, Albany

Current status of taxon:

- *Environment Protection and Biodiversity Conservation Act 1999*: Vulnerable
- *Western Australia Wildlife Conservation Act 1950*: Schedule 1, Rare or likely to become extinct: ranked as Vulnerable (using IUCN criteria).

Habitat critical to survival:

Quokkas occur in a variety of habitats, and there is a variable understanding of habitat critical to survival across its range. The quokka's habitat requirements in the northern jarrah forest have been well defined, where they require a complex mosaic of recently burnt areas and long unburnt areas (de Tores *et al.* 2004, Hayward *et al.* 2007). In the southern forest, quokkas occupy a range of forest, woodlands and wetland ecotypes and their potential habitat is more continuous. A low density of near-surface fuel, a complex vegetation structure and a varied fire-age mosaic best predict the probability of occupancy of quokka in the southern forest (Bain *et al.* in prep.(a)). In other areas the quokkas' habitat requirements are less well known.

Recovery plan objective:

This recovery plan guides the recovery of the quokka for 10 years. The overall long-term objective of the recovery program is to at least maintain their current distribution and abundance.

A change in the status of this taxon to anything less threatened than 'vulnerable' is unlikely within the next 10 years. The objectives outlined in this plan are considered to be achievable through implementation over the next 10 years, and will contribute to the achievement of the overall long-term recovery objective with a view to improving the status over a longer period.

Criteria for success:

This recovery plan will be deemed successful if, within a 10 year period, all of the following are achieved:

- the conservation status of the quokka does not meet IUCN criteria for a higher level of threat¹;
- existing populations of quokka remain extant and viable as demonstrated by quantifiable estimates of population size and trends in population size or occupancy rates over time across key monitoring areas; and

¹ Listing at a lower level of threat, or in the case of the quokka, delisting, is unlikely to be achievable within the life span of this recovery plan. However, failure to halt the contraction in the geographic range and/or the loss of additional populations may result in the quokka meeting a higher level of threat within the life of this plan.

- threats to known populations are identified and management strategies are in place to remove or ameliorate those threats.

Criteria for failure:

This recovery plan will be deemed unsuccessful if, within a 10 year period, any of the following occur:

- the conservation status meets IUCN criteria for listing at a higher level of threat;
- populations of quokka at key monitoring sites decline through anthropogenic causes;
- additional quokka populations become isolated from source populations; or
- there is a further contraction of the quokka's known geographical range.

Recovery actions:

1. Coordinate recovery actions
2. Survey and monitoring
3. Management of key populations and habitats
4. Improved understanding of threats and effectiveness of mitigation programs
5. Translocations and captive breeding if required
6. Education and communication

Recovery team:

Recovery teams provide advice and assist in coordinating actions described in recovery plans. They include representatives from organisations with a direct interest in the recovery of the species, including those involved in funding and those participating in actions that support the recovery of the species. The co-ordination and implementation of this recovery plan will be overseen by DEC with assistance from the Quokka Recovery Team.

1. Introduction

1.1 Description

The quokka is a small wallaby with thick, coarse, grey-brown fur with lighter underparts. The snout is naked and the ears are short. The short tail (25.8-31cm long) tapers and is close-haired. Body weight ranges between 2.7-4.2kg and head and body length is 400-540mm. The hind foot is 100-120mm long (Cronin 1991).

1.2 Conservation status

In 1996 the quokka was placed on the WA list of “fauna which is rare or likely to become extinct” in accordance with Section 14(2)(ba) of the *Wildlife Conservation Act 1950* (WA). Shea (1996) identified the decline in geographic range, the reduction in the number of known populations and the perceived threats from predation as justification for this listing. It is currently ranked as vulnerable by the Western Australian Threatened Species Scientific Committee using IUCN (2008) Red List categories and criteria. It is listed as vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Various authors have expressed concern at the extent of the quokka’s decline in distribution and abundance and attributed different levels of threat to its conservation status. Johnson *et al.* (1989) attempted to quantify the conservation status and causes of decline for a suite of macropod species, which included the quokka, and concluded the quokka had experienced a substantial (85 to 90 per cent) decline in its geographic range on the mainland and identified the species as warranting a high priority for conservation management. Conversely, Bradshaw (1991) concluded the quokka was not threatened on the mainland and the seasonally large Rottnest Island subpopulation negated it from qualifying as a threatened species at all.

1.3 Biology and ecology

Female quokkas are polyoestrous and capable of breeding throughout the year with a non-delayed gestation period of 27 days (Sharman 1955a). Quokkas undergo embryonic diapauses. If the first pouch young dies, the second embryo will resume development and be born 24 to 27 days later (Sharman 1955b). Young weigh about 0.4g at birth (Shield 1968). On Rottnest Island, breeding occurs only once per year and most young are born between mid February and the end of April (Shield 1965). On Bald Island, quokkas also appear to breed once per year, with most births between March and the end of April (Shield 1965). Young leave the pouch between 175 and 195 days old, and maturity is reached at about 389 days for males and 252 days for females (Sharman 1955a, 1955b, Shield and Woolley 1960). Conversely, quokkas breed throughout the year on the mainland (Hayward *et al.* 2003).

There is evidence of sexual dimorphism, as males of the species have an average head-body length of 487mm and weigh between 2.7 and 4.2kg, whereas females average 468mm and weigh between 1.6 and 3.5kg (Cronin 1991, Strahan 1998, de Tores 2008). Quokkas are believed to live for up to 14 years in captivity and are known to live more than 10 years in the wild (Nowark 1999).

The quokka is mostly nocturnal and a browsing herbivore, favouring leaves and stems (Hayward 2005). Quokkas have the ability to store fat in their tails as a mechanism to cope with seasonal

food availability (Sinclair *et al.* 1998). A dietary study of quokkas from the northern jarrah forest revealed seasonal and between-site variation in dietary intake (Hayward 2005). Localised extinctions within the northern jarrah forest have been attributed to reduced dietary diversity. These extinctions have occurred at sites which do not have the preferred recently burnt age class within the available habitat mosaic (Hayward 2005).

1.4 History, nomenclature and taxonomic relationships

The quokka was first observed in 1658, after Samuel Volckertsoon recorded them, from an island off the coast of WA, as a “wild cat resembling a civet-cat but with browner hair” (Alexander 1914). Nearly 40 years later, Willem de Vlamingh observed quokkas on the same island and described them as “a kind of rat as big as a common cat” (Alexander 1914). He subsequently named the island ‘Rottenest’, meaning rats’ nest (de Tores 2008).

The quokka is known to the Aboriginal Noongar people of south-west WA by a range of names including ‘*Ban-gup*’, ‘*Bungeup*’, ‘*Quak-a*’ (Gould 1863, Shortridge 1909), ‘*kwoka*’ and ‘*bangop*’ (Abbott 2001).

The taxonomic description was published by Jean René Constant Quoy and Joseph Paul Gaimard in 1830 (Walton 1988). The name for the genus ‘*Setonix*’ is derived from the Latin ‘*seta*’ for bristle and the Greek ‘*onyx*’ for claw. The specific name ‘*brachyurus*’ is derived from the Greek ‘*brachys*’ for short and ‘*pura*’ for tail (Strahan and Conder 2007).

The quokka is considered sufficiently different from other wallabies in the genus *Macropus*, to be placed in its own genus (Hayward *et al.* 2002, Sharman 1954) and is thought to have diverged early from the evolutionary lineage which gave rise to the browsing marsupials (Van Dyck and Strahan 2008). Its closest living relatives are thought to be rock wallabies of the genus *Petrogale* (Van Dyck and Strahan 2008).

1.5 Distribution

At the time of colonial settlement, the quokka was widespread and abundant with its distribution encompassing an area of about 41,200km² of south-west WA, inclusive of two offshore islands, Bald and Rottneest Island (de Tores *et al.* 2007). An extensive population decline occurred in the 1930s with more declines in the period from 1980 to 1992. By 1992, the quokka’s distribution on the mainland had been reduced by more than 50 per cent to an area of about 17,800km². The confirmation of quokkas at the northern extent of its geographic range, additional locations in the core of the range and their persistence at Muddy Lakes (Sinclair and Hyder 2009) has been interpreted as reflecting an increased awareness of the presence of the quokka on the mainland, rather than the recovery of the species (de Tores *et al.* 2007). Records from DEC’s Fauna Databases show that distribution from pre-1980 to current has reduced. The main areas where quokka have disappeared from include, the Cape Naturaliste Area from Yallingup in the north to Augusta in the south, east of Nannup, and from areas surrounding the City of Albany (Fig. 1).

All mainland quokkas occur within areas receiving greater than 600mm of precipitation per year and most are believed to live within areas receiving greater than 1,000mm (de Tores *et al.* 2007). The most likely reason for this is that vegetation cover and leafy green digestible vegetation are at their greatest in high rainfall areas. This relationship is also consistent with the seasonal decline of

quokkas on Rottnest Island, where loss of vegetation and reduction of available surface water can lead to starvation.

On the mainland, quokkas occur in their northern extent from immediately east and north-east of the Perth metropolitan area, continuing south, in isolated patches through the Northern Jarrah Forest IBRA Sub-region, to Collie (Fig. 1). The only known population from the Swan Coastal Plain (Perth Sub-region) is at Muddy Lakes, south of Bunbury (Fig. 1) (Sinclair and Hyder 2009), with unconfirmed reports from Thompsons Lake, and in the Yallingup area of the southern Swan Coastal Plain.

Distribution appears to be discontinuous from Collie to Nannup despite continuous forest habitat. From Nannup, quokka extend through the southern jarrah, marri and karri forests to around Denmark in the Southern Jarrah Forest and Warren IBRA Sub-regions. Distribution within the DEC Warren Region appears to be more contiguous than from within the northern jarrah forest.

The distribution extends to the south coast and east to Green Range. The quokka's occurrence at Green Range is inferred from the collection of hair samples only (de Tores *et al.* 2007). Quokkas also have sub-populations through the Stirling Range and on Bald Island.

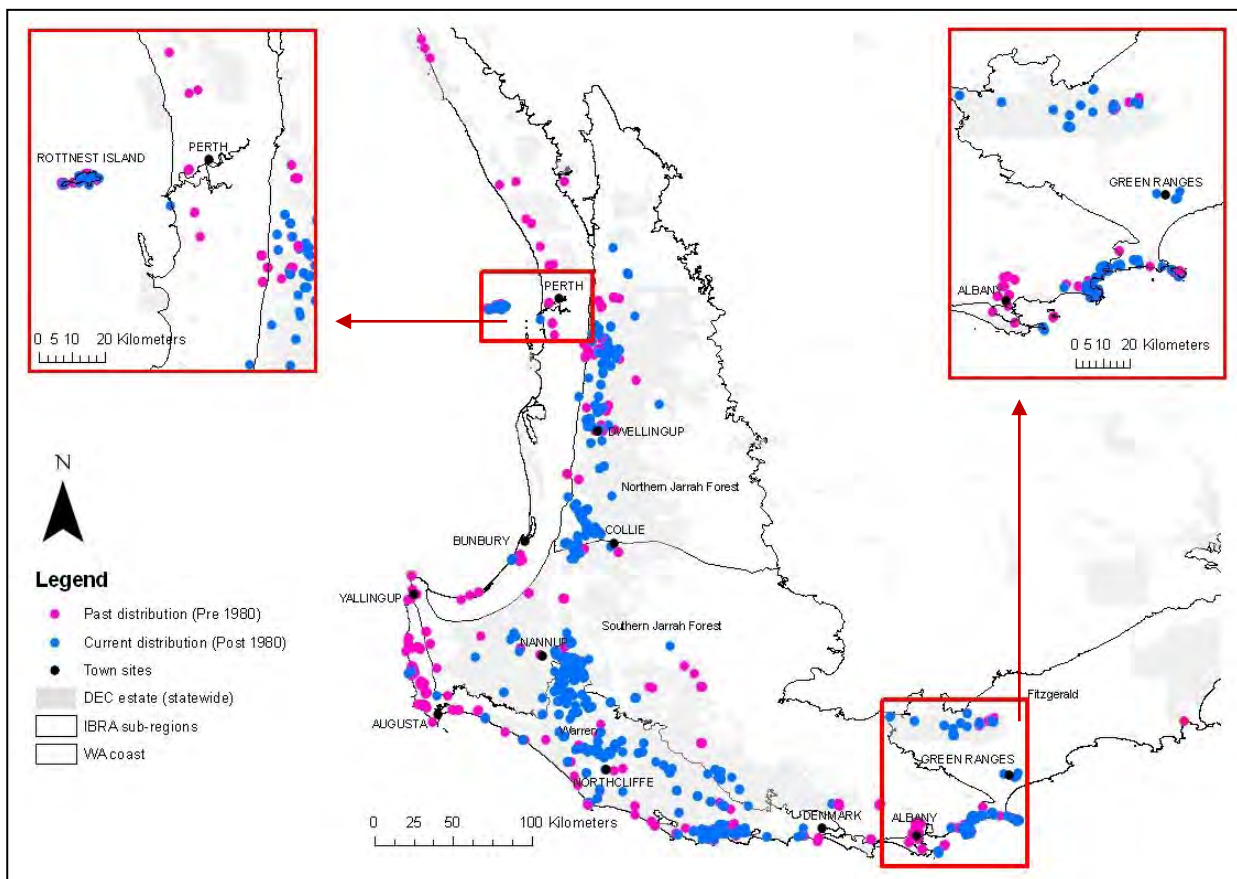


Figure 1: Past and current distribution of quokka in the south-west of WA (based on records in DEC's Fauna Databases

1.6 Population estimates

The existing known population of quokka can be grouped into seven distinct subpopulations: Rottnest Island, Bald Island, northern jarrah forest, central jarrah forest, southern forests, south coast and Stirling Range (Fig. 2). Table 1 provides an estimated size for each subpopulation. Note there are some outlying records of quokka that do not clearly fit into one of these subpopulations (e.g. the Muddy Lakes records).

Population is defined here as the total number of individuals of the taxon (IUCN 2011). A subpopulation is defined as a geographically or otherwise distinct group between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less) (IUCN 2011). A metapopulation is a number of spatially separated groups of the same species which interact at some level. They consist of several distinct groups together with areas of suitable habitat between which are currently unoccupied. Individuals from one area may act to recolonise another area where there has been local extinction.

Table 1: Estimated subpopulation sizes in 2007 (DSEWPaC 2012).

Subpopulation	Location	Locality	Estimated size	Dominant land tenure
1	Rottnest Is	Rottnest Is	8,000-12,000 individuals	Class „A’ reserve for Government Requirements
2	Northern jarrah forest	Chandler Rd	<50	SF
		Rosella Rd	<10	SF
		Kesners Swamp	<50	SF
		Wild Pig Swamp	Presence unconfirmed; presumed locally extinct	SF
		Holyoake	Presence unconfirmed; presumed locally extinct	SF
3	Central jarrah forest	Hadfield	<50	SF
		Hoffman	Presence unconfirmed; presumed locally extinct	SF
		Victor Road	<50	SF
4	Southern forest		>700	SF
5	South coast	Two Peoples Bay	>100	NR
		Mount Manypeaks	>100	NR
		Albany	No estimates available - scattered records from the Albany Region	various
		Tinkelelup NR	<50	NR
6	Stirling Range NP		>50	NP
7	Bald Is	Bald Is	600-1,000	NR

Rottnest Island population estimates

The largest extant quokka population is on Rottnest Island where the size is known to fluctuate and reported population estimates vary enormously (de Tores *et al.* 2007). The island supports a population which has temporarily high numbers of 10,000 to 12,000 individuals (Bradshaw 1991, Dickman 1992, O'Connor 1999), but seasonally falls to a much lower, unquantified population size (P. de Tores pers. comm.). The island supports highly disturbed habitats, with extensive clearing of native vegetation and limited supply of freshwater (Edward 1983). In January 1999, O'Connor (1999) estimated 46 per cent of the total population to be in the „settlement’ where water and grassed lawns are available. Rottnest Island is the only place where quokkas congregate in large numbers and feed in the open.

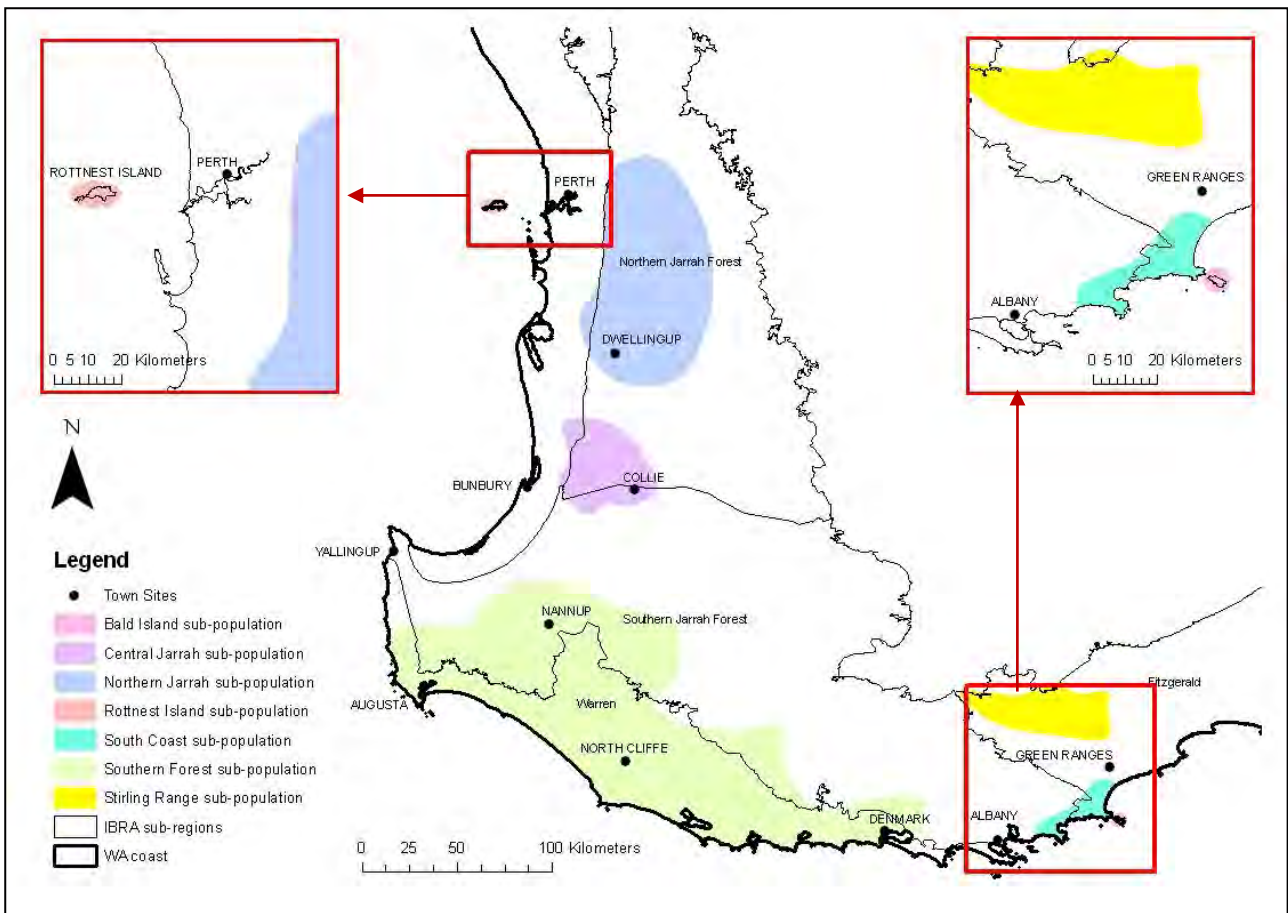


Figure 2: Sub-populations of quokka in the south-west of WA, based on records in DEC's Fauna Databases. *Note there are some outlying records of quokka that do not clearly fit into one of these sub populations (e.g. the Muddy Lakes records).

1.7 Population genetics

Genetic studies have examined the population structure from Rottnest Island and four sites in the northern jarrah forest subpopulation and found that a historic mainland metapopulation was fragmented and resulted in isolation of the Rottnest and Bald Island subpopulations about 6,000 to 8,000 years ago. Despite this, there is little evidence of morphological differences between island and mainland quokka populations, however, there is a latitudinal cline in body size (Sinclair 2001b). Genetic differences between the Rottnest Island and northern jarrah forest subpopulation have been shown through allozyme electrophoresis and mitochondrial DNA (mtDNA) studies (Sinclair 2001a).

Fragmentation of the mainland metapopulation continued, at least in the northern jarrah forest, with this fragmentation and isolation occurring before colonial settlement and possibly more than 1,000 years ago (Alacs *et al.* 2011). Studies using microsatellite and amplified fragment length polymorphisms (AFLP) markers have examined the genetic structure of the northern jarrah forest subpopulation (Alacs *et al.* 2011, Alacs 2001). Alacs *et al.* (2011) study supported the assertion made by de Tores *et al.* (2007) and Hayward *et al.* (2007) that separate, discrete areas from the northern jarrah forest formerly constituted one or more metapopulations.

Population declines and expansions occurred at Rottnest Island and habitat fragmentation has continued on the mainland causing further distancing (at least at the northern limit of the quokka's current distribution). Additionally, recent genetic comparison with the northern jarrah and southern forest subpopulations identified unique differences between these subpopulations (P. Spencer and K. Bain, pers. comm.). The southern forest subpopulation retains a much higher level of diversity, and is significantly differentiated from their northern counterparts.

The conservation implications of the genetic data suggest Rottnest and Bald Islands should not be seen as a potential source of animals for translocations to the mainland. This does not, however, negate their conservation value, which may reflect a level of adaptive difference evolved in response to their respective environmental conditions (Alacs *et al.* 2011) that is absent from those on the mainland. The genetic differences resulting from the historical separation of the northern jarrah forest quokka from those on Rottnest Island also demonstrates that these subpopulations should be managed as discrete entities, as well as distinctly from the southern mainland locations.

1.8 History of decline

Before the 1930s, quokkas were abundant on the mainland extending as far north as Perth. From the 1920s there was a range contraction southwards, a decline in the number of known locations and a decline in abundance at each location. Hunting may have contributed to this decline, with the quokka being declared vermin in 1933 (Government Gazette of WA 1933) and it was regularly hunted and poisoned at a commercial level (Prince 1984). With the compounding effect of the arrival of the fox (*Vulpes vulpes*) in WA in the 1930s (Jarman 1986), quokkas changed from being a ubiquitous animal, commonly seen grazing in pastures, to being less frequently sighted, only within or near dense vegetation (de Tores *et al.* 2007). Historical and recent range contractions suggest factors other than fox predation have contributed to the quokka's decline. The most obvious change in the environment over this time has been the loss of habitat. This loss has been mainly due to frequent high intensity fires, changes in fire regimes (see Burrows *et al.* 1995), timber harvesting and urban development. These are likely to have negatively affected the

distribution and size of quokka populations (Dickman 1996b, Kinnear *et al.* 2002, May and Norton 1996).

Although there is no unequivocal evidence for disease being a major factor in quokka decline (de Tores *et al.* 2007), Abbott (2008) cited historical accounts of those who believed there was evidence of disease in quokkas, covering a range of different inflictions before the arrival of the fox, which may have been symptomatic of the poisoning which occurred at that time. Overall the role of disease in quokka population declines is poorly known.

2. Habitat critical to survival and important populations

Habitat critical to the survival of the quokka has been well defined for the northern jarrah forest subpopulation (Hayward *et al.* 2008) and comprises *Taxandria linearifolia* swamps. Quokkas are thought to occur as, or previously occurred as, metapopulations dispersing from swamp to swamp over time as vegetation structure changes with time since fire (Hayward *et al.* 2005). Habitat critical to survival includes areas of natural vegetation where the understorey is sufficiently thick and complex to provide a predation refuge close to more open, recently burnt vegetation which is used as a food source. Habitat changes seasonally, in wetter months after wetlands become inundated the quokkas core home range shifts toward the periphery of the swamp, leaving the quokka more exposed to predation (Hayward *et al.* 2004). When this habitat is altered, and in the presence of feral predators, the carrying capacity of a site may also be reduced (Kinnear *et al.* 2002)

In the southern forest, quokkas occupy a range of forest, woodland and wetland ecotypes. The most commonly occupied sites comprise jarrah (*Eucalyptus marginata*), marri (*Corymbia calophylla*), karri (*E. diversicolor*) or tingle (*E. jacksonii* or *E. guilfoylei*) forest and riparian habitats with a sedge dominated understorey. Habitat supporting a low density of near-surface fuel, a complex vegetation structure and burn patchiness are the factors favouring quokka occupancy in the southern forest (Bain *et al.* in prep (a)). Karri regeneration areas can also be used by the quokkas as a food source in a similar way to recently burnt vegetation and then as habitat once the canopy has closed over and the undergrowth recovered (B. Barton pers. comm. 2012). Where landscape occurrence of these factors provide a greater level of habitat connectivity, quokkas are more likely to move between habitat patches creating a functioning metapopulation.

The habitat critical to survival for the south coast subpopulation includes a wider range of vegetation types (floristically and structurally) than in the northern jarrah forest, including swamps, riparian areas, incised gullies and dense coastal heath (de Tores *et al.* 2007). Specifically, in the Two Peoples Bay area habitat critical to survival is known to comprise of coastal heath and thickets (*Eucalyptus staeri*, *Allocasuarina fraseriana*, *Hakea elliptica* with *Melaleuca striatum*, *Anarthria scabrum*); swamps (*Taxandria juniperina*, *T. linearifolia*, *Melaleuca lanceolata* with *Hakea nitida*, *Beaufortia sparsa* and *Gahnia trifida*); and riparian systems (*Eucalyptus megacarpa*, *Banksia littoralis*, *Lepidosperma* spp.) (DSEWPaC 2012).

Habitat occupied at the Swan Coastal Plain site at Muddy Lakes consists of fringing wetland vegetation of dense bulrush (*Typha orientalis*)/pale rush (*Juncus pallidus*) sedgeland with other

sedges including jointed rush (*Baumea articulata*), *Typha domingensis* and coast sword-sedge (*Lepidosperma gladiatum*) (Keighery *et al.* 2002).

Specific information regarding habitat critical to survival in other subpopulations is not documented.

Information pertaining to important populations are incomplete but the Rottnest Island subpopulation likely reflects a level of adaptive difference evolved in response to the environmental conditions (Alacs *et al.* 2011) absent from mainland populations and is thus considered important. The northern jarrah and southern forests may be important with unique differences between them (P. Spencer and K. Bain pers. comm.). Given the limited population size, genetic differences and fragmentation of subpopulations, all populations should be considered important until more information is available.

3. Threatening processes

Subpopulations within the quokka's current geographic range are subjected to threats and thus at risk of becoming locally extinct. Failure to address the threatening processes listed below, may contribute to further declines in distribution and abundance.

3.1 Foxes

The arrival of the fox in the 1930s appears to be the most significant factor contributing to the historic decline in quokka numbers on the mainland (de Tores *et al.* 2007). Predation pressures by foxes have resulted in quokkas being restricted to more dense habitats which act as refuges from predation. Studies within the northern jarrah forest have found that while fox control may not lead to an increase in quokka numbers it may lead to an increased distribution (Hayward *et al.* 2003, 2007). There is substantial anecdotal evidence suggesting quokkas have increased in abundance because of fox control elsewhere within the species range (P. Collins and J. A. Friend pers. comm.). Monitoring following intensive monthly fox and cat baiting from 2005-2007 at Mount Manypeaks after the intensive fire there in the summer of 2004/2005, showed an increase in trap success for quokka (Comer *et al.* 2007). This is supported by field observations on Mount Manypeaks NR during this program (S. Comer pers. comm. 2012). Similarly, quokkas have been reported to reach seasonally high densities on Rottnest Island where foxes are absent.

There is however a lack of effective coordination of baiting programs between stakeholders and tenure over the mainland quokka's range. Some conservation reserves and SF where quokka are found occur next to private property, this allows for foxes to invade conservation reserves from unbaited freehold land.

3.2 Feral cats

Cats were common on Rottnest Island before the 1980s with no observable effect on quokka numbers. Additionally, cats have not been found to significantly limit populations of similarly sized native mammals (Dickman 1996a).

However, Dickman (1996b) suggested for species weighing between 1 and 2kg, juveniles were likely to be susceptible to cat predation, while adults may be relatively resistant. Quokkas fall within

this weight range and this is supported by observations of a small group of quokkas in the southern forest where radio-collared adults have been unaffected by feral cat predation. Females in this study have been continuously producing joeys, but none of the joeys have survived beyond the pouch (K. Bain pers. comm.). Cats are present at this site and the habitat is relatively open, making joeys particularly vulnerable to predation.

A reduction in fox density through 1080 baiting in WA may result in a corresponding increase in cat numbers through the phenomenon of mesopredator release (de Tores and Berry 2007). The available information suggests the mesopredator release of cats would not significantly affect quokka numbers where quokka populations are stable. However, it may be sufficient to push small populations into rapid decline where they are already under predation pressure and are isolated from other populations (Sinclair *et al.* 1998).

As for the fox, there is a lack of effective coordination of control programs for feral cats between stakeholders and across different land tenures.

3.3 Feral pigs

The effect of feral pigs on quokka abundance and distribution has not been quantified. However, pigs have the potential to indirectly affect quokkas through destruction of habitat. This removes food resources from the habitat and creates pathways which facilitate access for other feral animals, such as foxes (May and Norton 1996, Meek and Saunders 2000). Anecdotal reports suggest sites within south-west WA, which previously supported quokka populations, become unsuitable for quokkas after they have been disturbed by pigs (M. Dillon, G. Liddelow, B. Barton and J. Hampton pers. comm., P. de Tores pers. obs.).

In the southern forest, a study by Bain *et al.* (in prep. (a)) suggests that pig presence itself does not directly affect quokka abundance. There have been records of quokkas co-occurring in habitats with a small number of pigs. However, habitats that have been historically occupied by pigs, where vegetation and soil structure have been modified, are always unoccupied by quokkas. This suggests that pigs are having an indirect affect on abundance through modification of habitat quality (Bain *et al.* in prep. (a)).

3.4 *Phytophthora* dieback

Any fauna species which is dependent upon a complex forest structure and inhabits the forests of south-west WA is potentially threatened by *Phytophthora* dieback. *Phytophthora* dieback may be introduced in areas where quokkas occur through human activities such as forestry operations, recreational activities and mining activities, as well as non-human vectors, such as pig movement. The severity of the impact of the disease is likely to be variable depending on the location and structure of the vegetation present. Understorey species such as *Banksia* spp. and *Persoonia* spp. are highly susceptible to *Phytophthora* dieback and form an important part of the structure of jarrah forests. The loss of such forest structure has the potential to increase the risk of predation of, and result in the loss of food resources for quokka.

3.5 Clearing

The removal of vegetation from areas inhabited by quokkas and next to their habitat is likely to contribute to localised declines. With around 60 per cent of quokka records within SF or timber reserves, timber harvesting and associated infrastructure clearing may be a significant threat. Most habitat occurrences in SF are within the creek zones which are accorded “informal reserve” status during harvesting operations. Effects from clearing may be direct, that is, because of mortalities from the physical process of clearing and associated activities (such as road kill from the creation of roads and increased traffic), or indirect through the removal of habitat, or removal of components of the preferred habitat mosaic. These may force dispersal to or through unsuitable habitat. Indirect effects also include an increased predation risk by opening up pathways along which feral predators may gain access to previously impenetrable habitat.

3.6 Altered fire regimes

Fire regimes resulting in the loss of preferred habitat such as long unburnt riparian vegetation and swamps is likely to lead to the loss of quokkas from these areas. Deliberately lit fires impacting quokka habitat and/or escapes from burning operations are an ongoing and significant threat to the Muddy Lakes and other potential coastal plain occurrences. Within the northern jarrah forest, long unburnt areas and the presence of recently burnt areas have been identified as important habitat (Hayward *et al.* 2007). Opportunistic monitoring on Mount Manypeaks post-fire found high levels of activity on the ridge two years post fire. However, there is no evidence to suggest that lack of fire has a detrimental impact on quokka populations. Bald Island vegetation has not been burnt for at least 120 years, and Mount Gardner at least 60 years, yet animals are still thriving here. In the southern forest, quokkas occupy habitats with low leaf litter, complex vegetation structure and patchiness of habitat. This habitat is lost after intense, homogenising fires, or fires which result in midstorey collapse and overstorey death.

Aboriginal hunting used direct ignition of many of the swamp habitats that quokkas prefer, to flush out prey (Gardner 1957, Gould 1863). This contrasts with current low intensity prescribed burns that generally burn the swamp edges without penetrating the swamp. This leads to a reduction in swamp vegetation and does not create the mosaic of seral stages needed for quokka habitat (Hayward *et al.* 2005). The absence of fire can also affect the availability of this habitat through midstorey senescence, collapse and bio-fuel accumulation (Bain *et al.* in prep. (a)).

3.7 Altered hydrological regimes

Across much of the quokka’s range, ground and surface water abstraction, through the construction of bores and rural dams, is resulting in the significant drying of wetlands and associated habitat that quokka depend on. The demand for more harvesting of surface and ground water will increase and the *Taxandria linearifolia* swamps, as well as other wetland areas that quokkas depend on, are likely to shrink in size. Across parts of the quokka’s range, the impact of water abstraction is likely to be as severe, or go beyond the impact of climate change (CSIRO 2009). Localised changes to surface water drainage patterns through clearing, mining or forestry activities may also lead to the modification of quokka habitat. The persistence of populations (both confirmed and unconfirmed) on the Swan Coastal Plain have been influenced by both historic and contemporary urban drainage works, soil and groundwater contamination from acid sulphate soils,

chemical contamination from mosquito control activities and habitat modifications from engineering proposals leading to permanent flooding of habitat.

3.8 Climate change

In south-west WA, rainfall has been predicted to decline by up to 20 per cent from rainfall recorded between 1960 and 1990 (Hennessy *et al.* 2007). The potential effect of climate change on quokka distribution has been modelled (Gibson *et al.* 2010) and indicates a further contraction of range is likely. The predicted pattern of southern contraction in distribution is supported by the historic decline in quokka distribution, which has shown a contraction to the higher rainfall areas of south-west WA since colonial settlement (de Tores *et al.* 2007).

Drying conditions are likely to cause the contraction of swamp and riparian habitats resulting in loss of food availability and predation refuges. Changes in vegetation cover may open up areas resulting in a higher incidence of weeds, replacing native forage. A drier, hotter environment will increase the length of the bushfire season and is likely to result in larger scale and more intense fires that will bypass edaphic barriers. This may result in fire burning components of the environment that were once naturally protected from fire, for example, granite outcrops, swamps and creek lines. It may also reduce the capacity to adequately manage habitats using fire as a tool. Changes to vegetation cover, fire regimes and an increase in weeds together will increase quokka habitat disturbance, favouring the invasion of feral predators.

3.9 Disease

Disease has not been demonstrated as an important factor in the decline of the quokka, however, it has been implicated as responsible for deaths of individuals (see de Tores *et al.* 2007). Potential disease threats include salmonella infection and toxoplasmosis. Salmonella infections are believed to be common on Rottnest Island (Hart *et al.* 1986) and there have been observations of quokkas dying in large numbers from inexplicable causes before the 1940s (Waring *et al.* 1955, White 1952).

Quokkas have also previously been shown to react to a pox virus (Papadimitriou and Ashman 1972) and concern has been expressed over the vaccine for the equine influenza virus. This vaccine is based on a canary pox virus and was used extensively throughout the latter half of 2007 for protection against outbreaks of equine influenza. The vaccine has not been adequately tested and indirect infection of quokkas with the canary pox virus has been suggested (as cited in Stokes and Norman 2010).

3.10 Disturbance from recreation

Rottnest Island quokkas are exposed to high human visitation, a highly modified landscape with limited supply of fresh water (Edward 1983), frequent salmonella infections (Hart *et al.* 1986), ongoing disturbance from recreationists and associated management activities in a place actively promoted for tourism. Past and present disturbance practices have degraded the woodland community which is threatened by weeds, erosion and probably overgrazing by quokkas. There have been occasional instances of cruelty to quokkas. Despite this quokkas are abundant on Rottnest Island.

3.11 Gaps in knowledge

The quokka is one of the most studied macropods in Australia and this research has led to a wealth of understanding of macropod reproduction and physiology. However, understanding of the ecology of the quokka on the mainland has relied heavily on limited short term studies and anecdotal accounts. Comprehensive information on the ecology and biology of the quokka is lacking. Without such information, management decisions will not be based on robust data or reliable information.

There is a lack of survey and monitoring of quokka subpopulations, including changes to quokka population density and patterns of local movement, colonisation or recolonisation, localised declines and extinctions at most mainland sites. Poor management decisions and actions (or lack of actions) may be made without this supporting knowledge.

4. International obligations

This plan is fully consistent with the aims and recommendations of the Convention on Biological Diversity, ratified by Australia in June 1993, and will assist in implementing Australia's responsibilities under that Convention. The species is not listed under Appendix II in the United Nations Environment Program World Conservation Monitoring Centre (UNEP-WCMC) Convention on International Trade in Endangered Species (CITES), and this plan does not affect Australia's obligations under any other international agreements.

5. Affected interests

The quokka and its habitat occur across south-west WA on and adjacent to many different land tenures, including: NPs, NRs, conservation reserves, SF, unallocated Crown land, mining leases and freehold land used for farming and plantations. Thus there may be many interests potentially affected by this plan. In most cases, little impact upon current land use is likely because of this recovery plan. Landholders and land management agencies may be affected through statutory planning and approval processes outside this plan when seeking to alter the landscape or undertake actions that may cause any of the resulting effects to the quokka, as outlined in Section 11 Guide to Decision Makers. Where quokka occur on lands other than those managed by DEC, permission has been, or will be sought from the managers before recovery actions are undertaken on their land.

Interests potentially affected by, or involved in the implementation of this recovery plan include:

- Local communities
- Land owners and managers
- Non-government organisations
- Development and infrastructure providers
- Government departments and agencies (e.g. DEC, DSEWPaC, FPC, Department of Water)
- Local government authorities
- Traditional owners and managers (e.g. SWALSC)
- Rottnest Island Authority

6. Role and interest of Aboriginal groups

Consultation has been undertaken with South West Aboriginal Land and Sea Council (SWALSC), an aboriginal umbrella group which covers the areas considered in this plan, during the preparation of this recovery plan. DEC will continue to consult with Aboriginal communities in the regions identified in this plan and ensure consideration of their role and interests in implementation. Input and involvement will be welcome from any Aboriginal groups that have an active interest in areas that the quokka occurs, and their involvement in recovery team representation will be sought.

The Aboriginal Heritage Sites Register, maintained by the Department of Indigenous Affairs, will be used to identify significant sites near these populations. However, not all significant sites are listed on the Register, and on-going liaison will be maintained with local Aboriginal community representatives to ensure input to proposed recovery actions.

7. Social and economic impacts and benefits

The implementation of this recovery plan is not expected to have any major negative social or economic impacts. Positive economic benefits are likely to flow on from tourism, as several wildlife parks and sanctuaries in WA have captive quokkas. Rottnest Island is a class 'A' reserve and a popular tourist destination, with the quokka being one of its attractions. Recovery actions which aim to maintain and restore quokka habitat and improve the health of quokkas may have a positive economic benefit to tourism on the island through greater visitation and visitor satisfaction.

Within the forest regions, quokka occur within a variety of habitats to meet their requirements for feeding and breeding, and the sites are spread across public and private lands. Some proponents of particular land uses, for example; agriculture, forestry, mineral extraction, may be required through statutory processes to demonstrate that they will have no impact on quokkas or that any impacts can be adequately mitigated. Such requirements would be in place irrespective of this plan, and this plan will provide some clear direction for the implementation of such measures.

Control of feral predators may have a social impact if domestic pets ingest toxic baits that have been laid for the *Western Shield* fauna recovery program. However, DEC risk management strategies, including media releases warning the public of the risk that baits pose to domestic animals and signage denoting baited areas, are undertaken as a part of this program.

8. Broader biodiversity benefits

Effective conservation of the quokka will depend upon continued control of feral animals, the identification, creation and maintenance of preferred habitat, implementation of initiatives to reduce the spread of *Phytophthora* dieback and an ability to respond to the effects of climate change. In working towards these goals, other species with similar habitat requirements to the quokka are likely to benefit. Such fauna species include the noisy scrub-bird (*Atrichornis clamosus*), western whipbird (*Psophodes nigrogularis nigrogularis*), Gilbert's potoroo (*Potorous gilbertii*) and the western ringtail possum (*Pseudocheirus occidentalis*). An improved understanding of the similar

and competing habitat requirements for these species may also be achieved, particularly in relation to fire management.

The threatened ecological communities (TECs) 'Eastern Stirling Range Montane Heath and Thicket' and 'Callitris preissii (or Melaleuca lanceolata) forests and woodlands of the Swan Coastal Plain' occur within the Stirling Range NP and on Rottnest Island respectively. Recovery actions put in place for the quokka may potentially be of benefit to these TECs, if the actions are aimed at further protecting, or improving condition of the habitat. The priority 1 ecological community (PEC) 'Reedia spathacea-Empodisma gracillimum-Schoenus multiglumis dominated peat paluslopes and sandy mud floodplains of the Warren Biogeographical Region' is habitat used by the quokka and some actions to protect this habitat, in particular pig control, will benefit the quokka and the PEC.

A number of declared rare flora occur at sites where quokka are located and are thought to share similar habitat, these include *Acacia awestoniana*, *Banksia anatona*, *B. montana*, *B. squarrosa* subsp. *argillacea*, *Caladenia christineae*, *C. harringtoniae*, *C. winfieldii*, *Darwinia collina*, *Daviesia ovata*, *Grevillea rara*, *Latrobea colophona*, *Leucopogon gnaphalioides*, *Myriophyllum trifidum*, *Persoonia micrantha*, *Reedia spathacea*, *Synaphea* sp. Pinjarra, and *Xyris exilis*. These species may benefit where recovery actions improve their habitat. Many records for priority flora are also located within quokka habitat. Locations of priority flora should be sought before undertaking recovery actions in an area.

The threatened species or ecological communities listed above may be negatively impacted if recovery actions under this plan result in increases in quokka numbers that lead to overgrazing and degradation of threatened taxa and their habitat or an ecological community. A monitoring and recovery project on the DRF species *Daviesia ovata*, *Acacia awestoniana*, *Banksia anatona*, *Banksia montana*, *Leucopogon gnaphalioides*, *Darwinia collina*, *Latrobea colophona* and *Persoonia micranthera*, (the latter five of which occur within the critically endangered Eastern Stirling Range Montane Heath and Thicket TEC) has shown that these species are being impacted by grazing from herbivores including the quokka. Prescribed burning schedules should also be allied with those of any coinciding threatened taxa or ecological communities to avoid any negative impacts.

This improved understanding is only likely to be achieved if activities are co-ordinated and input from all stakeholders is sought and incorporated into research and operational activities.

9. Existing conservation measures

Several management actions and research programs have been implemented with the intent of improving management of quokka populations and known quokka habitat, and improving understanding of the ecology of the quokka. These include:

- Regular 1080 baiting for control of foxes at a range of known quokka locations.
- Implementation of new baiting programs at sites where the risks from predation are thought to have increased because of bushfire and habitat degradation or loss.
- Implementation of DEC's Quokka Fire Management Guideline No S5 which outlines burn regimes and procedures to minimise the impact of fire on quokka populations and habitat.

- Adoption of a rapid assessment technique to assess sites for signs of quokka presence; this rapid assessment has recently undergone quantification and adjustments have been made to ensure that it can be used as a reliable tool for occupancy rate analysis (Bain *et al.* in prep. (b)).
- Implementation of forest management strategies under the Forest Management Plan, achieved through a range of strategies including the creation, protection or management of:
 - The network of conservation reserves and informal reserves, including river and stream zones and old-growth forest.
 - Fauna habitat zones, these zones provide a refuge and a source of fauna to recolonise disturbed areas as they regenerate.
 - Habitat elements, including habitat trees with hollows or the potential to develop hollows for use by fauna species, habitat logs, midstorey vegetation and long-lived species in areas subject to timber harvesting.
- On a case-by-case basis DEC can put in place management strategies to further protect quokka populations from potential disturbance from harvesting operations through the approvals process for native forest timber harvesting.
- DEC support for postgraduate research including:
 - Investigating population dynamics, habitat use, dispersal and movement patterns, and fire response of quokkas in the southern forests between Manjimup and Walpole.
 - Investigating the impact of feral animals on quokka in the northern jarrah forest.
 - A collaborative research agreement between RIA, DEC and UWA. The research agreement will support a PhD program to gain an understanding of the demographic and genetic population structure of the Rottnest Island quokka. It will include quantitative estimates of population parameters for survivorship, capture probability, movement between, and spatial and temporal changes to populations.
- A management plan for Rottnest Island has been developed (RIA 2009). An initiative of the plan is to coordinate current and proposed management actions including weed and fire management, woodland restoration and quokka management. The plan outlines that a *Terrestrial Management Strategy* be developed for the island which will cover quokka and quokka habitat management in more detail.
- Federal funding for DEC's Frankland District to help in the quantification of the impact of feral pigs on EPBC listed taxa, including the quokka.
- The *South Coast Integrated Fauna Recovery Project* was established in 2009 with the objective of developing effective cat control techniques which could be used in conjunction with existing fox control, to provide integrated feral predator control for high value fauna conservation reserves in the South Coast Region.

10. Management practices and policies

Management practices (policies, strategies, plans) that have a role in the protection of the quokka include but are not limited to the following:

- WA Forest Management Plan 2004-2013 (Conservation Commission of WA 2004)
- Rottnest Island Management Plan 2009-2014 (Rottnest Island Authority 2009)
- *Western Shield* Fauna Recovery Program Draft Interim Strategic Plan 2009-2010 (DEC 2008b)
- Minimising Disease Risk in Wildlife Management 3rd Edition (Chapman *et al.* 2011)
- Policy Statement No. 3 Management of Phytophthora and disease caused by it (CALM 1998)
- Policy Statement No. 29 Translocation of threatened flora and fauna (CALM 1995)
- Policy Statement No. 33 Conservation of endangered and specially protected fauna in the wild (CALM 1991)
- Wellington NP, Westralia Conservation Park and Wellington Discovery Forest Management Plan (DEC 2008a)
- Guidelines for Protection of the Values of Informal Reserves and Fauna Habitat Zones, SFM Series, Guideline No. 4 (DEC 2009a)
- Guidelines for the Selection of Fauna Habitat Zones, SFM Series, Guideline No. 6 (DEC 2010)
- Protocol for measuring and reporting on the key performance indicators of the Forest Management Plan 2004-2013, SFM Manual No. 2 (DEC 2011)
- South Coast Regional Fire Management Plan 2009-2014 (DEC 2009b)
- Walpole Wilderness and adjacent Parks and Reserves Management Plan 2008 (DEC 2008c)
- Perup Management Plan 2012 (DEC 2012)
- Designing a Monitoring Project for Significant Native Fauna Species. Version 1.2. Prepared for Resource Condition Monitoring - Significant Native Species and Ecological Communities Project. DEC (Freegard 2009)
- South Coast Threatened Birds Recovery Plan 2009 (DEC 2009c)
- Gilbert's Potoroo Recovery Plan 2004 (Courtenay and Friend 2004)
- Threat Abatement Plan for Predation by the European Red Fox (DEWHA 2008b)
- Threat Abatement Plan for Predation by Feral Cats (DEWHA 2008c)
- DEC Quokka Fire Management Guideline No S5

11. Guide for decision makers

Under the Commonwealth EPBC Act any person proposing to undertake actions which may have a significant impact on listed threatened species (including the quokka) should refer the action to the Minister for Environment. The Minister will determine whether the action requires EPBC Act assessment and approval. As these provisions relate to proposed future actions, they can include actions which may result in increased impact from existing threats or potential threats, and actions which may result in a new threat.

Actions occurring within habitat critical to survival that result in any of the following may have a significant impact on the quokka:

- Any increase in the fragmentation of habitat.
- Any increase in numbers of feral foxes or cats.
- A reduction of the complexity or density of understorey vegetation. For example because of feral pig activity or anthropogenic changes in hydrology.
- Any introduction of *Phytophthora* dieback.
- Inappropriate fire regimes which result in fragmentation or loss of suitable habitat.
- Any increase in human activity that leads to degradation of habitat.
- Any significant increase in land clearing that leads to cumulative loss or degradation of available foraging, nesting, feeding, hibernation or migration habitat.
- Clearing of existing habitat that is to be off-set by revegetation at another location that results in a net loss in the short or long-term.
- Any action that prevents natural regeneration of habitat.
- Any modifications/reductions in the area of existing habitat through flooding and other water engineering structures within or adjacent to identified quokka habitat.
- Any reduction in environmental water availability that reduces the density and persistence of the vegetation comprising the habitat.
- Actions leading to chemical contamination of habitat associated with activation of acid sulphate soils, application of mosquito control and agricultural chemicals.

12. Objective

This recovery plan guides the recovery of the quokka for 10 years. The overall long-term objective of the recovery program is to at least maintain their current distribution and abundance.

A change in the status of this taxon to anything less threatened than „vulnerable’ is unlikely within the next 10 years. The objectives outlined in this plan are considered to be achievable through implementation over the next 10 years, and will contribute to the achievement of the overall long-term recovery objective with a view to improving the status over a longer period.

13. Performance criteria

This recovery plan will be deemed successful if, within a 10 year period, all of the following are achieved:

- the conservation status of the quokka does not meet IUCN criteria for a higher level of threat²;
- existing populations of quokka remain extant and viable as demonstrated by quantifiable estimates of population size and trends in population size or occupancy rates over time across key monitoring areas; and
- threats to known populations are identified and management strategies are in place to remove or ameliorate those threats.

This recovery plan will be deemed unsuccessful if, within a 10 year period, any of the following occur:

- the conservation status meets IUCN criteria for listing at a higher level of threat;
- populations of quokka at key monitoring sites decline through anthropogenic causes;
- additional quokka populations become isolated from source populations; or
- there is a further contraction of the quokka's known geographical range.

²

Listing at a lower level of threat, or in the case of the quokka, delisting, is unlikely to be achievable within the life span of this recovery plan. However, failure to halt the contraction in the geographic range and/or the loss of additional populations may result in the quokka meeting a higher level of threat within the life of this plan.

14. Recovery actions

14.1 Coordinate recovery actions

Tasks include:

- Quokka Recovery Team will assist DEC in coordinating recovery actions for the quokka.
- Summary of achievements and progression of recovery actions will be included in recovery team annual reports to DEC's Corporate Executive and funding bodies.

Cost: \$4,000 per year

Commencement date: on adoption of the recovery plan

Completion date: ongoing for the life of the recovery plan

14.2 Survey and monitoring

Tasks include:

- Verify unconfirmed reports of quokkas.
- Determine the conservation significance of existing and outlier quokka occurrences.
- Continue with a collaborative approach to research to develop a suitable and consistent assessment and monitoring methodology of populations across their geographic range, and different land tenures.
- Develop protocols for monitoring and reporting, particularly for detecting new quokka occurrences.
- Identify and establish key monitoring sites for routine monitoring to investigate population demographics and genetics of the quokka's geographic range.
- Establish population trends and occupancy rates, including, where suitable, through the use of remote camera techniques and radio tracking.
- Investigate the health of quokkas with disease screening programs set up on the mainland, Rottneest and Bald Islands.
- Consolidate existing records and databases and manage data to inform adaptive management.

Cost: \$400,000 year one, then \$300,000 annually thereafter

Commencement date: within six months of adoption of the recovery plan

Completion date: ongoing, subject to findings and the five year review

14.3 Improved understanding of threats and effectiveness of mitigation programs

Tasks include:

- Identify and implement the most effective predator control techniques at priority sites where predator control will have the greatest conservation outcome for quokka, and use findings to adapt existing management practices to achieve better management outcomes.

- Investigate the effects of activities associated with clearing close to quokkas, and make recommendations on acceptable activities to eliminate or mitigate any detrimental effects.
- Investigate the historical and contemporary impacts of *Phytophthora* dieback on quokka distribution and habitat and make management recommendations based on the findings.
- Conduct a hydrological assessment of the threat of groundwater drawdown or surface water modifications to the specific wetland habitats of the quokka, and use the results to identify threats and to guide landscape, catchment or local scale hydrological management.
- Commence habitat modelling studies to address climate change issues and identify the role of translocation in this process.
- Undertake genetic and demographic modelling to complement habitat modelling, and to inform climate change adaptation.

Cost: \$270,000 per year from year two for the life of the recovery plan

Commencement date: within 12 months of adoption of the recovery plan

Completion date: on-going

14.4 Management of key populations and habitats

Tasks include:

- Determine whether or not subpopulations constitute or formerly constituted one or more metapopulations, where these metapopulations occurred, and whether these metapopulations are still functional.
- Using meta-population information, determine whether each subpopulation should be managed in isolation or maximise the quality of interconnecting non-habitat to facilitate movement between subpopulations.
- Implement strategies identified in the Forest Management Plan for the maintenance of quokka habitat, and monitor success.
- Identify and implement feral pig control at priority sites where control will have the greatest conservation outcome for quokka.
- Implement the DEC Quokka Fire Management Guideline No S5, and monitor success.
- Identify areas of potential quokka habitat and apply management regimes to maintain these habitats for quokkas. Identify suitable areas of remnant vegetation that can be protected or enhanced through revegetation and hydrological management.
- Identify and implement land tenure protection (e.g. land acquisition into the conservation estate, conservation covenants etc.) of areas with suitable quokka habitat.
- Continue introduced predator control programs on DEC land, and where possible, coordinate baiting programs across different land tenures to maximise effectiveness.

Cost:

- \$330,000 per year for three years
- \$106,000 per year for year 4 and 5

Note: the cost of introduced predator control programs on DEC land is not included in this cost estimate as it is considered as ongoing management of DEC land. Additionally the cost to acquire

new areas is not included here because it will be dependent on the availability of suitable areas and market prices.

Commencement date: ongoing

Completion date: ongoing for the life of the recovery plan

14.5 Translocations and captive breeding as required

Tasks include:

- Evaluate the need for translocations and captive breeding to maintain the metapopulations.
- Undertake strict monitoring and auditing of movements of all quokkas; including orphaned, injured or rehabilitated quokkas.
- Implement any translocations of quokkas into the wild under the guidance of the DEC translocation policy (CALM 1995), with due regard of the need to maintain the genetic integrity of metapopulations, and in particular the maintenance of genetic integrity between subpopulations on the islands and the mainland.
- Restrict quokka captive breeding programs to establishments associated with ZAA, as distinct from commercial wildlife parks.

Cost: \$50,000 per year

Commencement date: as required

Completion date: on-going and subject to review

14.6 Education and communication

Tasks include:

- Maintain captive populations of quokka at participating zoos and wildlife centres as an opportunity to educate the public about quokkas and threats to quokkas.
- Provide educational interpretive information on quokkas and environmental management to encourage conservation behaviour at sites where tourism and quokkas coincide.
- Continue the quokka education and awareness programs on Rottnest Island.
- Quokka Recovery Team to organise a workshop in the fifth year to bring researchers, managers and involved members of the community together to share results and ideas, review and plan ongoing actions.

Cost: \$5,000 per year and \$20,000 in year 5

Commencement date: as required

Completion date: on-going and subject to review

15. Implementation and evaluation

Recovery teams provide advice and help coordinate actions described in recovery plans. They include representatives from organisations with direct interest in the recovery of the species, including those involved in funding, carrying out or helping to carry out actions that support the recovery of the species. The co-ordination and implementation of this recovery plan will be overseen by DEC with assistance from the Quokka Recovery Team.

This plan will run for a minimum of 10 years from the date of its adoption, or until replaced. DEC, in consultation with the recovery team, will review and evaluate the performance of this recovery plan, and in particular the performance against the success criteria. The recovery plan must be reviewed at intervals of not longer than five years or sooner if necessary, and again after 10 years. All quokka research and management actions undertaken through implementation of the actions in this recovery plan, or otherwise undertaken, will be documented and made available for the review. The recovery plan may be revised because of this review and as other information or research findings become available.

The estimated cost of fully implementing this recovery plan over the first five years is \$4,192,000 (Table 2). Note this estimated figure does not include costs associated with ongoing management of habitat by DEC, other government agencies or private landholders, associated land purchases, or the costs associated with mitigating any loss of habitat because of development that may be approved at any point over the next 10 years.

Table 2: Indicative costs and timing of recovery actions for the first five years

Recovery Action	Year 1	Year 2	Year 3	Year 4	Year 5	Total
14.1 Coordinate recovery actions	\$4,000	\$4,000	\$4,000	\$4,000	\$4,000	\$20,000
14.2 Survey and monitoring	\$400,000	\$300,000	\$300,000	\$300,000	\$300,000	\$1,600,000
14.3 Improved understanding of threats and effectiveness of mitigation programs Error! Reference source not found.		\$270,000	\$270,000	\$270,000	\$270,000	\$1,080,000
14.4 Management of key populations and habitats	\$330,000	\$330,000	\$330,000	\$106,000	\$106,000	\$1,202,000
14.5 Translocations and captive breeding as required	\$50,000	\$50,000	\$50,000	\$50,000	\$50,000	\$250,000
14.6 Education and communication	\$5,000	\$5,000	\$5,000	\$5,000	\$20,000	\$40,000
Total	\$789,000	\$959,000	\$959,000	\$735,000	\$750,000	\$4,192,000

Total of all costs over five years: \$4,192,000

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