

Western Ringtail Possum (*Pseudocheirus occidentalis*) Recovery Plan



Wildlife Management Program No. 58
Western Australia Department of Parks and Wildlife
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Department of
Parks and Wildlife



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Foreword

Recovery plans are developed within the framework laid down in Department of Parks and Wildlife Policy Statements Nos. 44 and 50 (CALM 1992, 1994), and the Australian Government Department of the Environment's Recovery Planning Compliance Checklist for Legislative and Process Requirements (DEWHA 2008). Recovery plans outline the recovery actions that are needed to urgently address those threatening processes most affecting the ongoing survival of threatened taxa or ecological communities, and begin the recovery process. Recovery plans are a partnership between the Department of the Environment and the Department of Parks and Wildlife. The Department of Parks and Wildlife acknowledges the role of the *Environment Protection and Biodiversity Conservation Act 1999* and the Department of the Environment in guiding the implementation of this recovery plan. 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 Parks and Wildlife, 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 as of February 2014.

Recovery plan preparation: This recovery plan was prepared by Kim Williams, Adrian Wayne (Department of Parks and Wildlife) and Jeff Richardson (formerly Department of Environment and Conservation).

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Abbreviations

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
DEC	Department of Environment and Conservation, Western Australia (formerly CALM; changed to Department of Parks and Wildlife July 2013))
DER	Department of Environment regulation, Western Australia (formerly part of DEC)
DFES	Department of Fire and Emergency Services, Western Australia
DOP	Department of Planning, Western Australia
DoTE	Commonwealth Department of the Environment, formerly Department of Sustainability, Environment, Water, Population and Communities
DPaW	Department of Parks and Wildlife, Western Australia (formerly DEC)
DSEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities, now Department of the Environment
EPA	Environmental Protection Authority, Western Australia
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i>
FPC	Forest Products Commission, Western Australia
FMP	WA Forest Management Plan 2004-2013
IBRA	Interim Biogeographical Regionalisation for Australia
IUCN	International Union for Conservation of Nature
LGA	Local government authorities
NP	National Park
NR	Nature Reserve
NRM	Natural resource management groups
RFA	Regional Forest Agreement, Western Australia
SCB	Species and Communities Branch, DPaW
SF	State forest
SWALSC	South West Aboriginal Land and Sea Council
WA	Western Australia
WAPC	Western Australian Planning Commission

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Summary

Species:	<i>Pseudocheirus occidentalis</i>
Family:	Pseudocheiridae
IBRA Regions:	Swan Coastal Plain, Northern Jarrah Forest, Southern Jarrah Forest, Warren, Esperance Plains
DPaW Regions:	Swan, South West, Warren, South Coast
DPaW Districts:	Swan Coastal, Perth Hills, Wellington, Blackwood, Donnelly, Frankland, Albany

Current conservation status:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act): Vulnerable.
- WA *Wildlife Conservation Act 1950* (WC Act): Schedule 1, rare or likely to become extinct: ranked as Vulnerable (using IUCN criteria).

Habitat critical to survival:

Ideal habitat comprises of long unburnt mature remnants of peppermint (*Agonis flexuosa*) woodlands with high canopy continuity and high foliage nutrients (high in nitrogen and low toxin levels); other habitats comprises of jarrah (*Eucalyptus marginata*)/marri (*Corymbia calophylla*) forests and woodlands with adequate hollows, coastal heath, myrtaceous heaths and shrublands, Bullich (*Eucalyptus megacarpa*) dominated riparian zones and karri forests.

Threatening Processes

The threatening processes operating on the western ringtail possum are complex, interactive and are often population-specific. The main threatening processes addressed in this plan are:

- Habitat loss and fragmentation
- Predation
- Climate change
- Timber harvesting
- Fire
- Competition for tree hollows
- Habitat tree decline
- Un-regulated relocation of orphaned, injured and rehabilitated western ringtail possums
- Disease
- Gaps in knowledge.

Recovery goals and objectives

The long term goals of the recovery program for the western ringtail possum are:

- to improve the population status, leading to future removal of the western ringtail possum from the threatened species list of the EPBC Act and the WC Act; and

- to ensure that threatening processes do not impact on the ongoing viability of the western ringtail population.

This recovery plan guides the recovery of the western ringtail possum for the next 10 years. The 10 year goal is:

- to slow the decline in population size, extent and area of occupancy through managing major threatening processes affecting the subpopulations and their habitats, and allowing the persistence of the species in each of the identified key management zones: Swan Coastal Plain, southern forests and south coast.

It is acknowledged that over the period of this plan populations fringing key management zones are likely to decline due to a range of threatening processes. A change in the conservation status of this taxon to a more threatened category is likely within the life of this plan, before the reversal of the impacts of threatening processes can take effect.

Criteria for success:

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

- habitat critical for survival of the western ringtail possum is retained and effectively managed for the conservation of western ringtail possums;
- an evidence-based approach is applied to conserve and manage western ringtail possums; and
- there is increased recognition of the status of the western ringtail possum and support towards its conservation.

Criteria for failure:

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

- there is substantial loss of habitat and/or increasing threatening processes that result in a further contraction of the population size, extent or area of occupancy; or
- an evidence-based management approach cannot be applied to all populations.

The specific recovery objectives for the next 10 years are, in a general order of priority*:

- To protect and effectively manage habitat critical for survival to maintain viable populations of western ringtail possums.
- To mitigate threatening processes constraining the recovery of western ringtail possums.
- To achieve an evidence-based management approach for western ringtail possums.
- To manage displaced, orphaned, injured and rehabilitated western ringtail possums for the best conservation outcome for the species.
- To raise awareness of the status of western ringtail possums and gain support and behaviour change to improve mitigation of threatening processes.

*Note that priorities vary across the distribution of the species dependant on the type and immediacy of local threatening processes, and the level of knowledge and understanding of populations and associated threats. Thus the order of priority of the objectives may not clearly represent the priorities for each management zone. To address this objectives and associated recovery actions are assigned a priority ranking for each of the three key management zones.

1. Introduction

The western ringtail possum (*Pseudocheirus occidentalis*, Thomas 1888) is a folivorous (leaf eating herbivore) arboreal marsupial endemic to south-western Australia. Since colonial settlement they have undergone a substantial range contraction, up to 90 per cent of the predicted original range (Jones 2004). As early as 1907 they were “apparently disappearing from many places” (Shortridge 1909) and from surveys in 1985 and 1986 they were considered to have “declined alarmingly” (How *et al.* 1987). Declines in abundance and habitat continue across the range of this species (Jones *et al.* 1994a, Wayne *et al.* 2012).

1.1 Description

The western ringtail possum is a small (0.8 to 1.3kg) arboreal marsupial characterised by a slender prehensile tail (up to 40cm long) with a white tip (Wayne *et al.* 2005a, Jones 1995). It is usually dark brown (though sometimes dark grey) above, with cream or grey fur on the belly, chest and throat. The species was described from a specimen collected at King George Sound, Albany on the south coast of WA in 1876 (Stacey and Hay 2007). The western ringtail possum is readily distinguished from the common brushtail possum (*Trichosurus vulpecula*) by its smaller size, shorter (usually darker) fur, smaller rounded ears and absence of a brush tail. No other large possums occur in the south-west of WA (Burbidge and de Tores 1998).

Abbott (2001) collated some names that the local Aboriginal group (the Noongars) used for the species, and recommended five of these: ngwayir ('n-waar-ear'), womp, woder, ngoor and ngoolangit.

1.2 Conservation status

The western ringtail possum has been listed as specially protected fauna that is rare or likely to become extinct under the WA *Wildlife Conservation Act 1950* (WC Act) since 1983, and is ranked as Vulnerable in WA under DPaW policy using IUCN criteria. It is listed nationally as Vulnerable under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and as threatened (Vulnerable category) in the IUCN Red List (IUCN 2012). Current opportunistic population monitoring trends suggest that a change in the status of this taxon to a higher level of threat is likely within the life of this plan.

1.3 Distribution

The historical and contemporary distribution of the western ringtail possum has been categorised by de Tores (2000) as:

- An inferred pre-historic range (derived from all known records including sub-fossil records): extending from Geraldton on the west coast of WA, to the Hampton Tableland on the south coast about 200 kilometres west of the WA/SA border.
- An inferred original distribution at the time of colonial settlement: extending from just north of Perth, down to just east of Albany including Pingelly and Borden.
- A known distribution (from 1990-2013): patchy occurrence along the south coast (from east of Albany to west of Walpole), the west coast (from Bunbury to Augusta), and inland populations in the lower Collie River Valley, at Harvey and at Perup NR and surrounding forest blocks near Manjimup (Fig. 1).

Total population size of the species is unknown but has been estimated to be less than 8,000 mature individuals in the wild, with a decreasing trend (Woinarski *et al.* in prep.). The area of occupancy is calculated to be less than 800km², using 1990-2013 data from DPaw fauna databases and 2km by 2km grids. It is however likely that this over-estimates the area of occupancy due to declines since 1990.

There have been translocations of mostly displaced or rehabilitated western ringtail possums to numerous locations since 1991. Translocation sites approved by DPAW include Leschenault Peninsula Conservation Park, Yalgorup NP, Lane Poole Reserve and Keats State Forest Block at Dwellingup, Locke NR at Busselton, Karakamia Sanctuary (predator-free wildlife sanctuary privately owned and managed by Australian Wildlife Conservancy), Gelorup bushland south of Bunbury and Perup Sanctuary (predator-free enclosure within Perup Tone NR) east of Manjimup (Fig. 1). They have persisted at only a few of these sites including Karakamia Sanctuary, Perup Sanctuary and Yalgorup NP.

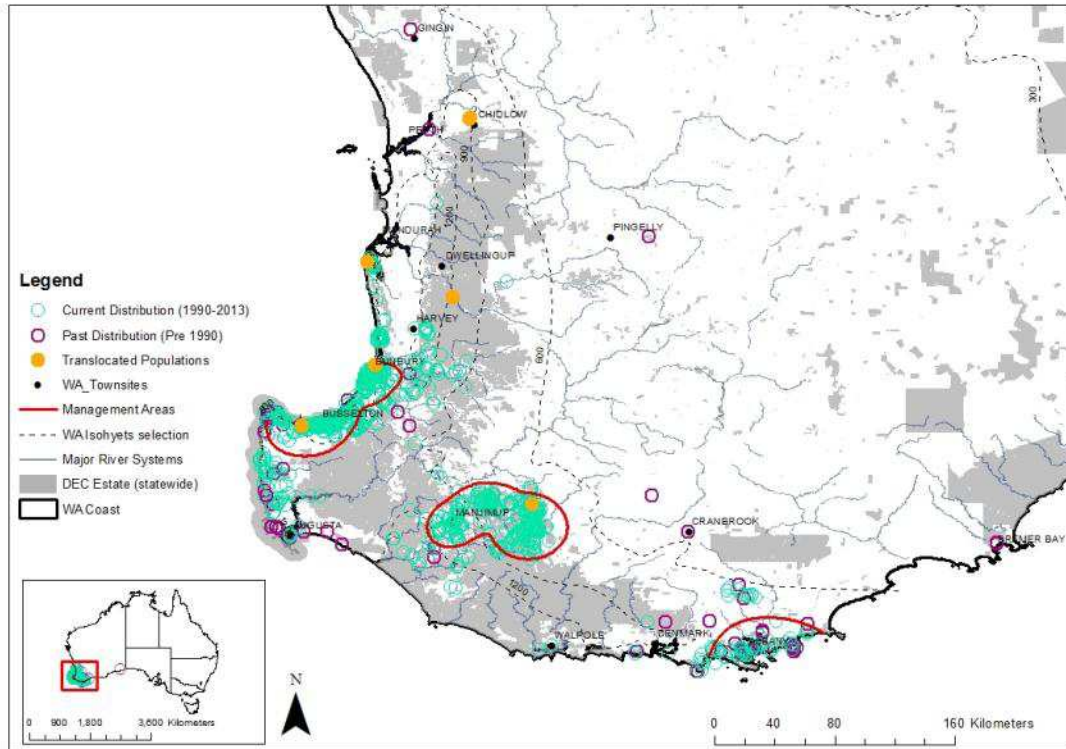


Figure 1: Current (1990-2013) distribution of western ringtail possum in the south-west of WA (based on records in DPaW's Fauna Databases). Three of the key management zones are highlighted (red lines).

Three of the key management zones are highlighted in Figure 1. These are areas known to, or previously known to support large numbers of western ringtail possums. There may be other key management zones defined during the life of the plan after more comprehensive survey, monitoring and mapping is undertaken. The three identified currently are:

1. Swan Coastal Plain zone: the peppermint woodlands and peppermint/tuart forests on the southern extremity of the Swan Coastal Plain, principally around Busselton.
2. Southern Forest zone: Jarrah forests near Manjimup where peppermint is generally absent (Jones 2004, Wayne *et al.* 2005a, 2005c, 2006).
3. South Coast zone: a diverse range of vegetation types between Denmark and Mount Manypeaks, but principally in near-coastal limestone heath, jarrah marri thicket woodland and forest, riparian, peppermint woodland and karri forest vegetation.

1.4 Abundance

Numerous surveys have confirmed that western ringtail possums are not evenly distributed across the habitats sampled (e.g. Jones *et al.* 1994b, Jones and Hillcox 1995, Jones *et al.* 2004, Wayne 2005, Wayne *et al.* 2006, Jones and Francesconi 2007). The variation in relative abundance across a survey area reveals some of the complex habitat parameters that influence habitat quality which in turn limits densities. However, knowledge of absolute abundance is limited because of a lack of comparable population estimates and survey methods across the range of the western ringtail possum (Inions 1985, Jones *et al.* 1994b, de Tores 2000, de Tores *et al.* 2004). Techniques used to census western ringtail possums commonly include spotlighting, drey searches and scat counts (Wayne *et al.* 2005a). However, variations in survey techniques have hindered comparisons of estimates of abundance between studies, areas and over time.

The highest densities of the western ringtail possum occur in the Swan Coastal Plain and south coast key management zones (Fig. 1) (Jones *et al.* 1994a, Jones 2004). Although population densities are typically not as great in the southern forests, their relative extent was substantially greater than coastal habitats and provides suitable, although suboptimal, habitat that has the potential to support overall larger populations.

The number of western ringtail possums in the southern forests is not known but is considered to have been in the tens or hundreds of thousands (A. Wayne pers. comm. 2013), and thus is thought to be the largest population prior to 2002. A severe decline of >95% (probably >99%) between 1998 and 2009 has occurred. Although the spatial extent of the declines is not well understood it is clear that there has been a steady decline at all monitoring sites (Wayne *et al.* 2012). Subsequent surveys (spotlighting, scats and camera trapping) have confirmed that western ringtail possums were still present in 2013 in a number of sites but numbers were extremely low (J. Wayne and A. Wayne pers. comm. 2013).

The Ludlow-Busselton area has long been known as the last substantial stronghold for western ringtail possums left on the Swan Coastal Plain. This Swan Coastal Plain western ringtail possum population

has been contracting since the early 1990s, mostly attributed to habitat loss and fragmentation from urban development and mining (Woinarski *et al.* in prep.). The effect of the southwest's drying climate on the peppermint stands and canopy in this area is also considered a contributing factor of the decline (Jones and Francesconi 2007). Most of the populations within the Busselton area that have had sufficient monitoring to detect a decline over the last 5-12 years have shown declines of 20-80 per cent (Woinarski *et al.* in prep.). From existing survey data, the population in the Bunbury to Dunsborough region is possibly between 2,000 and 5,000 animals (Wilson 2009; B. Jones and G. Harewood pers. comm. 2013).

While there is no quantitative data on densities and trends in the south coast populations, there is little evidence to suggest that they have declined, despite major wildfires at Two Peoples Bay NR and Mt Manypeaks NR between 2001 and 2005 (S. Comer pers. comm. 2014). Animals are frequently seen in the Albany urban and peri-urban areas, and strongholds for the species include Two Peoples Bay NR and Mt Manypeaks NR/Waychinicup NP, and adjoining Crown reserves (Gilfillan 2008).

1.5 Biology and ecology

In some coastal populations, western ringtail possums breed year round with breeding peaks in April to July and September to November (Jones *et al.* 1994b). The breeding season in inland jarrah forest near Manjimup is more discrete with most births in May and June and the remainder in October and November (Wayne *et al.* 2005c). Females can breed at less than 12 months of age and, although rare, can breed continuously, raising two subsequent young in a year (Ellis and Jones 1992). Litter size is usually one, although rare occurrences of litter sizes of two or three have been recorded in some populations (Jones *et al.* 1994b, de Tores 2000, Wayne *et al.* 2005c). The western ringtail possum has a gestation period of about two to four weeks and a pouch life of about three months. Young are weaned at six to eight months and disperse at eight to 12 months (How 1978, Ellis and Jones 1992, Jones *et al.* 1994b, Wayne *et al.* 2005b, Wayne *et al.* 2005c).

Reproductive output is apparently related to habitat quality. Areas of habitat with low foliage nitrogen content tend to have lower numbers of births. Peppermint woodlands have higher foliage nitrogen content relative to jarrah forest habitats, which may be why lower numbers of births are observed in the jarrah forest (Jones *et al.* 1994b, Wayne *et al.* 2005c). Habitat quality may also influence sex ratios. A ratio of one-to-one may be indicative of a stable population, while a female bias can occur in an expanding population in high quality habitat, and a male bias in declining or marginal habitat (Jones *et al.* 1994b).

Diet is almost exclusively comprised of the dominant or co-dominant upper and mid-storey myrtaceous plants: peppermint, marri and jarrah (Jones *et al.* 1994b). In urban areas the western ringtail possum may also feed on introduced garden species (Burbidge and de Tores 1998, Williams and Barton 2012). Western ringtail possums prefer young leaves, which have lower lignin content, often higher nitrogen levels and are more digestible (Ellis and Jones 1992). They are coprophagic, ingesting their initial faecal matter containing finer material derived from the caecum during the day.

This helps to increase nutrient absorption from their nutrient-poor food source (Hume *et al.* 1984, Hume and Sakaguchi 1993).

Little is known of the longevity, or population age structure, of wild western ringtail possums. The oldest recorded age for western ringtail possums in the jarrah forest is four years (Wayne *et al.* 2000) and six years at Leschenault Peninsula Conservation Park on the coast north of Bunbury (de Tores 2008). Vocalisations are rare, except when particularly stressed when there may be the occasional alarm call (short, bird-like call with a variable but high pitch) (Wayne *et al.* 2006).

The home range of the western ringtail possum is considered small – on average less than five hectares (Jones 2001). Home ranges in the jarrah forest average 2.7ha (Wayne *et al.* 2000). Home ranges in peppermint dominated habitat are generally less than two hectares and average 0.4ha and 0.3ha for females and males respectively (Jones *et al.* 1994b). Densities as high as 20 possums per hectare have been determined in some remnants of the Busselton peppermint stands compared to about four adults per hectare in the jarrah forest (Jones 2004). There is evidence of territoriality within western ringtail possums (Ellis and Jones 1992). Most young establish home ranges next to the natal range, but in high density groups, young disperse across at least several home ranges (Harewood 2005).

Diurnal resting sites (hereafter called refuges) include dreys, platforms, tree hollows, hollow logs, balga (*Xanthorrhoea* spp.) skirts, under sedges, forest debris and disused rabbit warrens (Jones *et al.* 1994b, Wayne *et al.* 2000, Wayne 2005). Dreys range from rough platforms to more elaborate roughly spherical arboreal nests constructed from vegetation, and are generally built where hollows are absent (de Tores *et al.* 1998). In suburban situations the species may also rest in roof spaces and other dark cavities. Western ringtail possums generally use between two and seven refuges in their home range, but can use an average of 20 or more refuges over a year (Jones *et al.* 1994b, Ninnox 1999a, Wayne *et al.* 2000).

Tree hollows are important across the range of the western ringtail possum. Hollow abundance has been positively correlated with possum abundance in peppermint/tuart (*Eucalyptus gomphocephala*) associations (Jones and Hillcox 1995) and generally constitutes more than 70 per cent of the refuges used by western ringtail possums in the jarrah forest (Wayne *et al.* 2000, Wayne 2005). Western ringtail possum nests are also found in balga of an old age and height, generally where the balga supports a fallen tree or is easy to access from the canopy (Driscoll 2000). Deep hollows and balga skirts may be particularly important for populations in the drier areas of the western ringtail possum's distribution to help reduce thermal stress (Jones *et al.* 1994a, Driscoll 2000, Wayne *et al.* 2005b).

Western ringtail possums are known to be susceptible to heat stress and can easily overheat at temperatures of 35°C (Yin 2006). Western ringtail possums have been observed to use evaporative cooling in hot weather by applying saliva to the forelimbs or panting (Jones *et al.* 1994b). Jones *et al.* (1994b) observed that in areas where dreys were used, western ringtail possums went to the ground over several hot days. Western ringtail possums are the smallest of the specialist marsupial folivores

indicating that they live close to the ecological and physiological limits of viability (B. Jones pers. comm. 2002).

A lack of phylogeographic structuring from western ringtail possum mitochondrial DNA analysis suggests that, historically, populations were interconnected as one large population. This is consistent with the original distribution at the time of colonial settlement (Wilson 2009). Population subdivision and microsatellite genetic differentiation has been a result of more recent patterns of population separation, exacerbated by habitat clearing and fragmentation occurring over the last ~180 years — when colonial settlers started to utilise the forests in south-western Australia (Ward *et al.* 2001). Wilson's (2009) microsatellite DNA analysis revealed three discrete populations existing as little as 30km apart. Populations in the southern forests showed slightly higher genetic variation than populations within the Swan Coastal Plain at Busselton and Gelorup (Wilson 2009).

2. Habitat critical to survival

Populations on the Swan Coastal Plain (Fig. 1) are associated with stands of myrtaceous trees (usually peppermint trees) growing near swamps, water courses or floodplains, and at topographic low points which provide cooler often more fertile conditions (Jones 2001, de Tores *et al.* 2004). Studies have shown that locations of extant populations are related to the quality of habitat, principally high canopy continuity and high nutrient foliage, but also the number and type of refuges available (Jones *et al.* 1994b, Jones *et al.* 2004, Wayne *et al.* 2006).

Populations in the southern forests, near Manjimup (Fig. 1) occur mainly in jarrah or marri dominated forests extending to wandoo (*Eucalyptus wandoo*) forests to the north-east of Manjimup. They also occur in karri (*Eucalyptus diversicolor*) forest from Northcliffe to west of Manjimup (Fig. 1, DEC 2012c). In the jarrah/marri forests around Manjimup the highest relative abundance occurs in areas with limited anthropogenic disturbance (unlogged or lightly logged, and a low intensity and low frequency fire history), that are intensively fox-baited and have low indices of fragmentation (Wayne *et al.* 2005a, Wayne *et al.* 2006).

On the South Coast, near Albany (Fig. 1) the western ringtail possum is found in coastal heath, jarrah/marri woodland and forest, peppermint woodlands, myrtaceous heaths and shrublands, Bullich (*Eucalyptus megacarpa*) dominated riparian zones and karri forest. In the vegetation associations mapped in the Albany urban area by Sandiford and Barrett (2010), most ringtail records were from coastal limestone heath vegetation unit 5b. Little is known of the relative abundance of the western ringtail possum within and between vegetation types, including the vegetation types where they have been recorded in the broader Denmark to Mt Manypeaks area.

The western ringtail possum is also found within plantations of pine (*Pinus* spp.) and blue-gum (*Eucalyptus globulus*) typically within remnant vegetation associated with drainage lines and

watercourses through plantations. Dreys have been constructed within these species (K. Williams pers. obs.). Dreys and animals have also been sighted in exotic tree plantations, particularly along edges next to native forest, around Manjimup (A. Wayne pers. comm. 2013). It is suspected that these plantations may provide shelter but depending on the species, are unlikely to be a food source (K. Williams pers. comm. 2013).

High western ringtail possum population densities have been recorded in urban settings, particularly where mature peppermint trees have been retained which have large, dense and overlapping canopies (Harewood 2008). This habitat type appears to provide a variety of browse items, artificial watering which buffers vegetation against the impacts of a drying climate, alternative habitat connections (fences, powerlines) and alternative shelter/roosts in buildings. It is possible that western ringtail possums have benefited from this development and adapted to the urban setting (Shedley and Williams 2013).

3. Threatening processes

The threatening processes operating on the western ringtail possum are complex, interactive and are often population specific. For instance, habitat loss and fragmentation from urban development and mining are considered the most important and immediate threatening processes in coastal and near-coastal populations. By comparison, western ringtail possum populations in extensive, publicly-owned (DPaW-managed) jarrah forests are considered to be at more risk from introduced predators, climate change, timber harvesting and fire. Some of the patchiness of contemporary populations is also accounted for by habitat quality - namely continuity of canopy, availability of suitable diurnal refuges, and foliage nutrient value and leaf toxins. Given their more fertile and productive nature, high quality western ringtail possum habitat has disproportionately received greater levels of anthropogenic disturbance than elsewhere (Wayne *et al.* 2006).

The relatively short life span and annual fecundity rate of one young per mature female means the ramifications of survivorship are great for this species. To maintain population size a female needs a minimum of two successful reproductive seasons and 100 per cent offspring survival to maturity. Anything that negates this may threaten the viability of the population (Wayne *et al.* 2006).

3.1 Habitat loss and fragmentation

The loss and fragmentation of native vegetation cover is identified as one of the principle factors threatening western ringtail populations. This is due to their high dependence on midstorey and overstorey vegetation for food, shelter and protection from predators. The long-term viability of populations is further compromised by the size of, and connectivity between, habitat remnants.

The selective nature of land clearing for agriculture of the most fertile, productive and mesic land is likely to have removed much of the higher quality western ringtail possum habitat (Wayne *et al.* 2006). Those riparian valleys which were not cleared for cultivation were dammed and flooded (B. Jones pers. comm. 2002). Furthermore, fragmentation by agriculture, timber plantations and frequent and diverse urban development has been associated with reduced western ringtail possum abundance and/or increased densities in the remaining remnants (de Tores *et al.* 2004, Wayne *et al.* 2006). Some of these remnant patches are considered to be overpopulated and overgrazed by possums (B. Jones pers. comm. 2002). Dispersing to and from these remnants increases exposure to cat, dog and fox predation. Habitat patches within the urban areas are surrounded by roads, which cause direct habitat loss, road kills and facilitate feral predator movement (May and Norton 1996). Western ringtail possum can be electrocuted when using power lines as connection corridors in fragmented urban landscapes.

3.2 Predation

The European fox (*Vulpes vulpes*) and cats (*Felis catus*) are known to be major predators of the western ringtail possum, which is confounded by the predator naivety they display (Jones *et al.* 1994b, de Tores *et al.* 1998, Wayne *et al.* 2000, Jones *et al.* 2004, Wayne *et al.* 2005c). These predators have been implicated in the disappearance of natural and translocated populations of the western ringtail possum and they are likely to be responsible for the lack of translocation success (Wayne *et al.* 2000, Grimm and de Tores 2009, Clarke 2011).

Susceptibility to predation is increased in western ringtail possums when the species needs to come to the ground. This may be due to a lack of continuity in canopy cover (Jones *et al.* 2004) or because of natural and/or anthropogenic changes such as logging and fire in jarrah/marri forests (Wayne *et al.* 2000, Wayne *et al.* 2005a, Wayne *et al.* 2006). In hot weather western ringtail possums may come to the ground to find respite from the heat and this may also make the species more susceptible to fox and cat predation (Yin 2006).

Fox baiting is intended to reduce fox numbers, but it is thought it may also lead to an increase in numbers of, and/or predation by, other predators, such as cats, chuditch (*Dasyurus geoffroii*), wedge-tailed eagles (*Aquila audax*) and south-western carpet python (*Morelia spilota imbricata*) (Risbey *et al.* 2000, Wayne *et al.* 2005c, Clarke 2011, Williams and Barton 2012).

In urban environments predation or injury by domestic dogs can be frequent (de Tores *et al.* 1998). High levels of dog ownership within the City of Busselton create dog densities at four to eight times greater per hectare than the average fox density in the south-west forests (K. Williams pers. comm. 2006).

3.3 Climate change

Western ringtail possums are among the species most likely to be impacted by predicted climate change in the south-west because they have very specific habitat requirements, have a poor ability to migrate and have lost large areas of habitat. In addition they are sensitive to drought-induced stress. Over the past 30 years there has been an approximate 20 per cent decline in rainfall in the south-west of WA, with more reductions in rainfall and increased temperatures predicted due to global climate change (Timbal 2004). These changes could result in further contraction of the species to the most fertile and mesic remnants of their extant range (Wayne 2005, Jones and Francesconi 2007).

Sensitivity to heat and drought-induced stress may result in the loss of canopy density and condition of food trees and subsequently lead to an impact on western ringtail possum populations. Drought stress in riparian vegetation and deaths of western ringtail possums have been observed at several localised sites in the lower Swan Coastal Plain (B. Jones and K. William pers. obs. 2007). Elevation in atmospheric carbon dioxide (CO₂) is known to lead to reduced nitrogen concentrations in foliage, increased fibre content of leaves and higher levels of toxic secondary metabolites (Lawler *et al.* 1997, Coley 1998, Kanowski 2001). It is therefore likely that population densities of herbivorous arboreal marsupials in many forests will decline over future decades (Hume 1999).

There is little known about the predicted effects of climate change on frost incidence and severity in south-western WA. Frosts have already been observed to cause extensive foliage damage and localised deaths of potential feed trees (A. Wayne and K. Williams pers. obs. 2006). If frosts do increase in frequency and intensity due to a drying climate this may result in localised population reductions or localised extinctions.

Climate change is also implicated in increased activity of some pathogens and insects affecting habitat trees on which western ringtail possum depend (refer below under section 3.7 'Habitat tree decline').

3.4 Timber harvesting

In the jarrah/marri forests in the Manjimup area, abundances of western ringtail possums in timber harvested areas are lower compared to areas unlogged or last logged in the 1960s (when logging practices were less intense) (Wayne *et al.* 2006). There is a significant increase in mortality during and immediately after harvesting disturbance. In a study by Wayne *et al.* (2000) up to 17.6 per cent of animals in an area logged died directly from the felling of their refuge sites during harvesting. Studies by Wayne *et al.* (2001) show that in the years following logging activities the local population subsequently collapsed, with spotlight sightings declining by more than 80 per cent (Jones 2004), and have remained almost undetectable along the three 10 kilometre spotlight transects since 2000 (Wayne *et al.* 2000, Wayne *et al.* 2005a, Wayne *et al.* 2012).

The use of balga (*Xanthorrhoea* spp.) as a shelter may be reduced in areas logged due to a reduction in shade from the upper strata (which may cause the microclimate (context) to be hotter/drier), the

removal of balga through physical disturbance during logging and the removal of skirts in post logging fires (Driscoll 2000). However, studies suggest it takes less time for a balga to be of a suitable age for western ringtail possum habitat than it does to form a hollow in a eucalypt (Driscoll 2000).

Timber harvesting also substantially increases western ringtail possum vulnerability to predation, especially from foxes and cats, because of the reduction in canopy continuity, the loss of refuges (such as hollow bearing trees and balga), and the creation of access routes for predators within the forest. As a consequence, the average life expectancy of individuals within a study area during the harvesting process was 40 per cent less than individuals within adjacent unlogged forest (Wayne *et al.* 2000).

Given the expected average life span of four to five years for western ringtail possums in undisturbed jarrah forest and sexual maturity at about one year of age, the reduction in survivorship from timber harvesting is expected to at least halve the reproductive output of females. The ability of the population to recover from timber harvesting is therefore substantially reduced, at least in the immediate term (Wayne *et al.* 2000, Wayne *et al.* 2001). Changes to forest harvesting and management practices have been instigated to assist in mitigating such impacts (e.g. Conservation Commission of Western Australia 2013).

3.5 Fire

In jarrah forests western ringtail possum abundance is related to fire intensity and history. Abundance is higher in areas where fire intensity has been low or in areas not burnt for more than 20 years (Wayne 2006). Wayne *et al.* (2005a) and Wayne (2006) identified four putative effects of fire on the western ringtail possum: reduced availability of food resources, loss of refuge (shelter) sites, reduced canopy continuity and/or death of individuals either directly or indirectly (for example increased vulnerability to predation). Western ringtail possums sheltering in flammable sites (in dreys, under balga skirts, or among ground sedges) risk being asphyxiated by smoke or directly burnt (B. Jones pers. comm. 2002).

Other habitat types such as heaths and peppermint-over-heaths on the south coast are prone to fire. These vegetation communities can carry hot fires leaving little available post-fire habitat for the western ringtail possum (S. Comer pers. comm. 2013).

Coastal peppermint forests in the Bunbury/Busselton region are rarely affected by fire (Jones *et al.* 1994a). However, regrowth after small patch fires may be important for local population recovery in the long-term (Jones *et al.* 2004). The swift growth of the population at Locke NR during the late 1980s was apparently linked to the fire regrowth mosaic following a patch burning program. Appropriate patch burning may evolve into an important management tool for offsetting the effects of contemporary habitat destruction events (for example logging, urbanisation) (Jones *et al.* 2004). There are considerable anecdotal reports of western ringtail possums favouring epicormic eucalypt flushes.

3.6 Competition for tree hollows

Western ringtail possum survivorship has been shown to be negatively associated with high numbers of the sympatric common brushtail possum (*Trichosurus vulpecula*) (Clarke 2011). Brushtail possums are larger, more mobile, more aggressive and have been frequently observed evicting western ringtail possums from hollows (How and Hillcox 2000, Wayne 2005, Wayne *et al.* 2006). The common brushtail possum is thus a potential competitor with the western ringtail possum for habitat resources. The extent to which this occurs is largely unresolved, though the high dependence of both species on tree-hollows implies that there may be competition where tree hollows are limited (Wayne 2005).

There is a clear pattern for ascendancy of brushtail possums over western ringtail possums in the changing environment of the south-west (Jones 2004). The accumulated impacts of tree removal, patch clearing and burning of remnants has forced a contraction of the distribution of possum species in the south-west and has increased competition with brushtail possums for the shrinking resource and stands of good possum habitat (B. Jones pers. comm. 2002, Grimm and de Tores 2009).

A number of other threatening processes may exacerbate the competition pressures between western ringtail and common brushtail possums. There are concerns that an increase in fox control in areas where western ringtail and common brushtail possums occur together may give brushtail possums a greater advantage (due to their greater amount of time spent on the ground) leading to increased competition pressure on western ringtail possums (Wayne *et al.* 2006). In Harvey, where western ringtail possum habitat is confined to riparian peppermints, B. Jones (pers. comm.) noted an increase in brushtail possum density (and a concomitant decrease in western ringtail possum numbers) after abutting vegetation had been burnt. Harvesting of plantations that contain or abut western ringtail possums may reduce habitat area and/or displace common brushtail possums into western ringtail possum habitat leading to competition (Grimm and de Tores 2009).

Competition may not apply ubiquitously across the distribution of the western ringtail possum. Evidence of sympatric existence can be found at Perup NR where there has been sustained fox baiting since 1977. Relatively dense populations of both possum species have persisted, and have apparently switched numerical dominance several times over this period (P. Christensen, N. Burrows and G. Liddelow pers. comm.).

Other indigenous and introduced species may also compete with western ringtail possums for tree hollows. The European honeybee (*Apis mellifera*) competes significantly for tree hollows with the common brushtail possum (Wood and Wallis 1997) and hence probably western ringtail possums. Some hollow nesting birds including the introduced rainbow lorikeet (*Trichoglossus haematodus*) and the expanding little corella (*Cacatua sanguinea*) are also potential competitors with western ringtail possums for hollows.

3.7 Habitat tree decline

As western ringtail possums are obligate folivores, they are at threat from habitat tree decline, which reduces the quality of their habitat and food sources. The main pathogens and insects that cause habitat tree decline for western ringtail possums are described below.

Phytophthora dieback caused by the root-rot water mould *Phytophthora cinnamomi* can cause extensive changes in the structure and floristic composition in susceptible vegetation communities (Environment Australia 2001, Garkaklis *et al.* 2004). The extant range of the western ringtail possum coincides with the distribution of *Phytophthora* dieback in jarrah forests and heaths.

The known canker pathogen *Neofusicoccum australe* has been found to be causing severe dieback symptoms of peppermint trees. *Neofusicoccum australe* is a common fungal endophyte, which is capable of causing disease in a stressed host plant. The factors causing this stress are not yet known, however, climate change is seen as the driving force in the apparent range expansion of this normally minor disease (Dakin *et al.* 2010). An unknown canker pathogen (possibly *Neofusicoccum australe*) is having a significant impact on *Allocasuarina* spp. at Mount Gardner (S. Comer pers. comm. 2013). Western ringtail possum dreys are often observed in *Allocasuarina* spp. along the south coast.

In Western Australia, Armillaria root disease is caused by the endemic pathogen, *Armillaria luteobubalina*. The pathogen colonises sapwood and spreads from tree to tree below ground via root contacts. It is widespread in south-west native forests, woodlands and coastal heathlands. *Armillaria* can cause juvenile tree mortality, root mortality resulting in reduced growth rate, and an increased probability of windthrow in mature trees leading to gap formation in stands (Robinson 2012). *Armillaria* is causing tree decline on the south coast, damaging several species including *Hakea* spp. and *Allocasuarina* spp. (S. Comer pers. comm. 2013).

Myrtle rust (*Puccinia psidii* s.l.) is part of a group of fungi that infects the Myrtaceae family of plants. First detected in New South Wales in 2010, it has already spread to Queensland and Victoria. It has not yet reached WA, but this is probable. The potential for it to impact on WA bushland and western ringtail possum habitat is high, with peppermint being one of the most severely damaged species. Myrtle rust produces masses of powdery bright yellow or orange-yellow spores on infected plant parts, and produces lesions on young, actively growing leaves and shoots. Rust spores are highly transportable, most commonly transmitted by wind, but also by pollinators and the movement of infected material (Dumbrell 2011).

The jarrah leafminer (*Perthida glyphopa*) is an insect species that has a caterpillar stage which lives between the outer surfaces of jarrah leaves and feeds on the green leaf tissue. This diminishes vigour and deteriorates crown condition as branches progressively die back from their tips (Wills 2009).

Gumleaf skeletoniser (*Uraba lugens*) is a moth which feeds differentially on a range of eucalypts, with jarrah and marri being intermediate larval food hosts. Consecutive warm winters lead to damaging

outbreaks that may substantially reduce tree leaf area across extensive areas (tens or hundreds of thousands of hectares) for months or years. Given current knowledge of climate change predictions, outbreaks will become more common in the southern jarrah forest leading to higher levels of canopy defoliation (Farr 2009).

Tuart decline is most severe at Yalgorup NP, likely to be caused by several factors including pathogens, insects, hydrological changes, nutrient enrichment, climatic changes and even competition with peppermint. This has led to a decline in tuart health at Yalgorup NP and may amplify if these stressors increase in the future (Barber and Hardy 2006). The recently discovered dieback pathogen *Phytophthora multivora* has also been implicated in tuart decline and may be a cause of habitat tree loss in tuart forests south of Mandurah (Scott *et al.* 2009, Scott *et al.* 2012).

All of these impact western ringtail possums at different intensities, in slightly different ways and across different regions. However, all pathogens and insects listed cause some level of reduction of tree foliage and canopy resulting in a reduction of food source and shelter, and as a follow-on effect increased predation pressure for western ringtail possums and increased susceptibility from fire. Death and a reduction in growth of susceptible trees will alter the structure of the vegetation, and may remove suitable western ringtail possum habitat over time. The swiftness and severity of some of these pathogens and insects could also lead to localised extinctions of western ringtail possums, particularly in isolated populations or remnants.

3.8 Un-regulated relocation of orphaned, injured and rehabilitated western ringtail possums

Issues can arise in populated areas where people co-occur with western ringtail possums. Injury and death to possums occur through loss of habitat from further urban development, exposure to increased traffic, electrocution on power lines when used as transport corridors, poisoning and attack from domestic dogs and cats. Possums may pose problems to humans by taking residence in buildings and other structures and feeding on, or causing damage to, gardens. These issues often result in relocation or rehabilitation and eventual release of injured or orphaned possums.

Approximately 200 western ringtail possums are rescued for rehabilitation per year in the Busselton area. Between 50-100 animals per year are thought to successfully survive the rehabilitation process and are released (Williams and Barton 2012). As there may be a number of sources for these relocations and a number of individuals or groups involved, they are not always correctly recorded or relocated to suitable and registered relocation sites, nor monitored for post-release survival. Unregulated releases can affect monitoring programs, artificially extend known geographic range, spread diseases, increase pressure on existing habitat, disturb resident western ringtail possums at release sites, genetically mix populations and may even cause death of western ringtail possums through predation or inappropriate habitat availability at release sites. Unregulated releases may also contravene the regulations of the WC Act and the WA *Animal Welfare Act 2002*.

The appropriate coordination and management of rehabilitation and release of injured or orphaned western ringtail possums can provide greater conservation outcomes from this activity, and provide a greater incentive for the wildlife rehabilitators.

3.9 Disease

Western ringtail possums can be at a greater risk of disease due to human disturbance and exposure to exotic species and pathogens (de Tores *et al.* 2008). Cat predation may also expose western ringtail possums to toxoplasmosis infection, although investigations into the disease load of captive and wild populations has revealed only low rates of contagion (de Tores *et al.* 2008, Grimm and de Tores 2009, McCutcheon *et al.* 2010). Understanding diseases is particularly important for the management of injured and orphaned possums and translocation programs, where novel diseases may be moved from place-to-place and diseases may be harboured in cages.

A drying climate may expose western ringtail possums to more physiological diseases. Low rainfall years can result in a lack of fresh growth (especially on peppermint tress) on which the possums survive. In such situations, possums may resort to eating older growth leaves which may have elevated levels of calcium and toxicity. These in turn may lead to physiological dysfunctions as has been observed by some wildlife rehabilitators (Barbara Jones pers. comm. 2013). Whilst this phenomenon has not been scientifically validated it may be worthy of further investigation.

3.10 Gaps in knowledge

Limited short term studies and anecdotal accounts have contributed most of the knowledge on the western ringtail possum. An understanding of the ecology and conservation status has also been constrained by the difficulty in surveying (detection of) this species (Inions *et al.* 1989, Jones *et al.* 1994b, de Tores 2000).

Some of the shortfalls in knowledge include:

- A lack of information on most populations that are small, isolated, and/or at the margins of the extant distribution, including the Waroona, Harvey, Collie, Shannon, Lower Warren and D'Entrecasteaux areas.
- No strategic or co-ordinated long-term monitoring program across the species range that can quantify and track population trends over time.
- The causes for decline are not completely understood.
- The relative importance and extent of threatening processes is generally not known for the species or for individual populations.
- Factors influencing population persistence in urban environments.
- The reasons for translocation failure and how these compare with other *in situ* strategies for the conservation of the species.
- Understanding the factors that improve the success of translocations.
- Habitat restoration/creation parameters/prescriptions and effectiveness.

4. International obligations

This plan is 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 the appendices to the United Nations Environment Program World Conservation Monitoring Centre's (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 western ringtail possum and its habitat occur across south-west WA on, and adjacent to many different land tenures. Thus there may be many interests potentially affected by this recovery plan. In most cases, little impact upon current land use is likely; however, to achieve the objectives of this plan there may be an effect on land use planning and landowners who may wish to develop land or change their management practices. Landholders and land management agencies may thus be affected through statutory planning and land use and environmental impact assessment processes, when seeking to alter the landscape or undertake actions that may cause any of the resulting effects to the western ringtail possum as outlined in Section 11 Guide to Decision Makers. Where populations occur on lands other than those managed by DPaW, 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:

- private and commercial land owners and managers;
- local government authorities;
- non-government organisations;
- State government agencies (for example DPaW, Department of Water, Department of Mines and Petroleum, Environmental Protection Authority (EPA), Forest Products Commission (FPC), WA Planning Commission (WAPC);
- Commonwealth government (DoTE);
- traditional owners and managers (for example SWALSC); and
- development and infrastructure providers.

6. Role and interests of Aboriginal people

The *Conservation and Land Management Act 1984* and the WC Act provide rights for Aboriginal people to undertake certain activities for customary purposes. They recognise the special connection Aboriginal people have to the land and the existence, or otherwise, of native title rights.

DPaW will enter into collaborative discussions with Aboriginal people in the regions identified in this plan and ensure consideration of their role and interests in the implementation of this plan. Input and involvement will be welcomed from any Aboriginal groups that have an active interest in areas that the ngwayir/western ringtail possum 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 appropriate input to proposed recovery actions.

SWALSC, an Aboriginal umbrella group, covers the areas considered in this plan. Comment was sought from the council about aspects of the plan, particularly about the proposed on-ground actions.

7. Social and economic interests

The implementation of this recovery plan has the potential to have social or economic impacts through the identification and recommendation to protect significant habitat in urban and near-urban areas. Western ringtail possums occur within a variety of habitats spread out across public and private lands. Some proponents of particular land uses, for example agriculture, forestry, mineral extraction and urban or industrial land development, may need to demonstrate through statutory processes that they will have no significant impact on western ringtail possums 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 introduced predators may have a social impact if pets ingest toxic baits that have been laid for western ringtail possum protection. However, DPaW 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 the DPaW's baiting programs.

8. Broader biodiversity benefits

In working towards effective conservation of the western ringtail possum, other species with similar habitat needs to the western ringtail possum are likely to benefit. Such threatened fauna species include Baudin's cockatoo (*Calyptorhynchus baudinii*), brush-tailed phascogale (*Phascogale tapoatafa* ssp. (WAM M434)), chuditch, Carnaby's cockatoo (*Calyptorhynchus latirostris*), forest red-tailed black cockatoo (*Calyptorhynchus banksii naso*), malleefowl (*Leipoa ocellata*), noisy scrub-bird (*Atrichornis clamosus*), numbat (*Myrmecobius fasciatus*), quokka (*Setonix brachyurus*) and woylie (*Bettongia penicillata ogilbyi*). An improved understanding of the similar and competing habitat requirements for these species may also be achieved. Increases to chuditch numbers through recovery actions may lead to increased predation of western ringtail possums in areas where they co-occur.

A number of declared rare flora occur at sites where western ringtail possums are located and are thought to share similar habitat, these include Augusta kennedia (*Kennedia lateritia*), Bussell's spider-orchid (*Caladenia busselliana*), Carbanup king spider-orchid (*Caladenia procera*), Christine's spider orchid (*Caladenia christineae*), giant spider-orchid (*Caladenia excelsa*), Harrington's spider orchid (*Caladenia harringtoniae*), long-leaved daviesia (*Daviesia elongata* subsp. *elongata*), round-leafed honeysuckle (*Lambertia orbifolia* subsp. Scott River Plains) and the southern tetraria (*Tetraria australiensis*). These species may benefit where recovery actions improve their habitat. Many records for priority flora are also located within western ringtail possum habitat, and locations of priority flora should be sought before undertaking recovery actions in an area which have the potential to disturb native vegetation.

The recovery actions put in place for the western ringtail possum may potentially be of benefit to the following threatened and priority ecological communities (TECs and PECs):

- *Eucalyptus calophylla* - *Eucalyptus marginata* woodlands on sandy clay soils of the southern Swan Coastal Plain (TEC)
- *Eucalyptus calophylla* woodlands on heavy soils of the southern Swan Coastal Plain (TEC)
- *Corymbia calophylla*, *Melaleuca raphiophylla*, *Banksia littoralis*, *Eucalyptus rudis*, *Agonis flexuosa* low open forest with seasonal subsoil moisture (Dunsborough area) (PEC)
- *Eucalyptus cornuta*, *Agonis flexuosa* and *Eucalyptus decipiens* forest on deep yellow-brown siliceous sands over limestone (PEC)
- *Eucalyptus rudis*, *Corymbia calophylla*, *Agonis flexuosa* Closed Low Forest (near Busselton) (PEC)
- Southern *Eucalyptus gomphocephala*-*Agonis flexuosa* woodlands (PEC)
- Quindalup *Eucalyptus gomphocephala* and/or *Agonis flexuosa* woodlands (PEC).

These communities contain habitat used by the western ringtail possum and some actions to protect this habitat will benefit the western ringtail possum and the threatened and priority ecological communities.

9. Existing conservation measures

Existing recovery actions include:

- Ongoing heightened awareness of western ringtail possum conservation requirements with local and State government planning authorities, through statutory and local government planning approvals, including conditions placed on developments to deal with impacts on the western ringtail possum.
- DPaW and the FPC have developed a Fauna Distribution Information System (FDIS) map of known populations of a suite of fauna (including the western ringtail possum) and flora to inform timber harvesting activities (Christensen *et al.* 2004). This system also promotes increased predator control in and around harvesting coupes where ringtail possum populations are likely to be present.
- Revegetation of 40 hectares of ex-pasture land with peppermint trees to generate suitable habitat for the western ringtail possum (Jones 2001) and other offset areas and rehabilitation areas around the Busselton and Bunbury areas.
- Translocations of western ringtail possums to various sites.
- Production of guidelines for care and an information pamphlet aimed at educating residents of Bunbury and Busselton about western ringtail possum issues.
- Release of a pamphlet called "Living with Possums" aimed at educating urban residents on how to deter and what to do with 'problem' brushtail and western ringtail possums.
- The 'Peppies for Possums' community Natural Resource Management (NRM) project, developed and implemented a western ringtail possum school education program, a tourism program, a community awareness and engagement program, in conjunction with the community and undertook infill planting and revegetation efforts.
- The Western Ringtail Action Group has assessed localised habitat within the Busselton urban area to identify priority areas for protection and corridors, revegetating these areas with peppermint trees, raising awareness in the community, and training community members in surveying techniques.
- Development of fire management guidelines S8 – Ngwayir (Western Ringtail Possum) and E4 – Tuart Woodlands (Wayne 2006, FMS 2008).
- In parts of the western ringtail possum's range where timber harvesting occurs there have been modification of logging practices including:
 - i. the retention of more key habitat elements within logging cells; such as hollow-bearing trees, large logs, logs with hollows, stumps and balga (*Xanthorrhoea* spp.), with an overall focus on maintaining stand complexity and structural diversity.
 - ii. an increase in the frequency of 1080 baiting during and immediately after timber harvesting disturbance to reduce the vulnerability of western ringtail possums to fox predation.

- iii. the establishment of a network of 'Fauna Habitat Zones' that incorporate western ringtail possum habitat requirements (>200 ha each, > 50,000 ha in total) across the forest estate available for timber harvesting; and
- iv. substantial additions to the formal reserve system including NPs and NRs (Conservation Commission WA 2004, 2013).
- There have been five tertiary student studies undertaken on the western ringtail possum over recent years. These studies have been undertaken on a variety of topics such as translocation success (PhD, Clarke 2011), genetics (Honours, Wilson 2009), ecology in the jarrah forest (PhD, Wayne 2005), physiology (Honours, Yin 2006) and refuge use (Honours, Driscoll 2000).
- A review of the western ringtail possum habitat availability from Bunbury to Dunsborough and east to the Whicher Range. The review provides a basis for the identification, protection and enhancement of key habitats and aims to provide a greater level of habitat definition and prioritisation than previously reported (Shedley and Williams 2014).

10. Management practices and policies

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

- Policy Statement No. 33 Conservation of endangered and specially protected fauna in the wild (CALM 1991)
- Policy Statement No. 29 Translocation of threatened flora and fauna (CALM 1995)
- Policy Statement No. 3 Management of Phytophthora and disease caused by it (CALM 1998)
- WA Forest Management Plan 2004-2013 (Conservation Commission WA 2004)
- *Western Shield* Fauna Recovery Program Draft Interim Strategic Plan 2009-2010 (DEC 2008)
- Guidelines for Protection of the Values of Informal Reserves and Fauna Habitat Zones, SFM Series, Guideline No. 4 (DEC 2009a)
- South Coast Regional Fire Management Plan 2009-2014 (DEC 2009b)
- 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)
- Perup Management Plan 2012 (DEC 2012a)
- Chuditch Recovery Plan (DEC 2012b)
- Woylie Recovery Plan (Yeatman and Groom 2012)
- Quokka Recovery Plan (DEC 2013)
- EPBC Act Policy Statement 3.10 – Significant impact guidelines for the vulnerable western ringtail possum (*Pseudocheirus occidentalis*) in the southern Swan Coastal Plain, Western Australia (DEWHA 2009)
- Shire of Busselton Environmental Strategy (EMRC 2004)

- Stirling-Harvey Redevelopment Scheme Stirling-Harvey pipeline and Harvey Reservoir Management Strategy for the Western Ringtail Possum (Ninox Wildlife Consulting 1999a, 1999b)
- Shire of Augusta Margaret River Biodiversity Conservation Strategy (SAMR 2005)
- Busselton Wetlands Strategy (WAPC 2005)
- Fire Management Guideline: S8- Ngwayir (Western Ringtail Possum) (Wayne 2006)
- Fire Management Guideline: E4- Tuart Woodlands (FMS 2008)
- Threat abatement plan for dieback caused by the root-rot fungus *Phytophthora cinnamomi* (DEH 2001)
- Threat abatement plan for predation by European red fox (DEWHA 2008a)
- Threat abatement plan for predation by feral cats (DEWHA 2008b).

11. Guide for decision makers

Under the Commonwealth EPBC Act any person proposing to undertake actions that may have a significant impact on listed threatened species (including the western ringtail possum) should refer the action to the Commonwealth 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.

Whether or not an action is likely to have a significant impact depends upon the sensitivity, value and quality of the environment which is impacted, and upon the intensity, duration, magnitude and geographic extent of the impacts. The potential for an action to have a significant impact will therefore vary from case to case (DEWHA 2009).

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

- clearing/loss of western ringtail possum habitat;
- decrease in canopy continuity and canopy condition in western ringtail possum habitat;
- decrease in food availability;
- decrease in refuge site availability;
- increased likelihood of predation on the western ringtail possum beyond natural levels;
- increased likelihood of competition of the western ringtail possum with other fauna beyond natural levels; or
- reduced ability of the western ringtail possum to disperse.

12. Recovery

12.1 Recovery goals and objectives

The long term goals of the recovery program for the western ringtail possum are:

- to improve the population status, leading to future removal of the western ringtail possum from the threatened species list of the EPBC Act and the WC Act; and
- to ensuring that threatening processes do not impact on the ongoing viability of the western ringtail population.

This recovery plan guides recovery actions for the western ringtail possum for the next 10 years. The 10 year goal is to slow the decline in population size, extent and area of occupancy through managing major threatening processes affecting the subpopulations and their habitats, and allowing the persistence of the species in each of the identified key management zones: Swan Coastal Plain, southern forests and south coast.

It is acknowledged that over the period of this plan populations fringing key management zones are likely to decline due to a range of threatening processes. A change in the conservation status of this taxon to a more threatened category is likely within the life of this plan, before the reversal of the impacts of threatening processes can take effect.

Criteria for success:

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

- habitat critical for survival of the western ringtail possum is retained and effectively managed for the conservation of western ringtail possums;
- an evidence-based approach is applied to conserve and manage western ringtail possums; and
- there is increased recognition of the status of the western ringtail possum and support towards its conservation.

Criteria for failure:

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

- there is substantial loss of habitat and/or increasing threatening processes that result in a further contraction of the population size, extent or area of occupancy; or
- an evidence-based management approach cannot be applied to all populations.

The specific recovery objectives for the next 10 years are listed below in a general order of priority. This priority order is based on the recovery needs of the species over the next 10 years. However, priorities will vary across the distribution of the species dependant on the type and immediacy of local threatening processes, and the level of knowledge and understanding of populations and associated threats. Thus the order of priority of the objectives may not clearly represent the priorities for each management zone. To address this, each objective is assigned a priority ranking for each of the three key management zones (see Figure 1 for approximate location of key management zones). This approach is also taken for prioritising the recovery objectives below. The three levels of priorities should be interpreted as follows:

- Priority 1: Taking prompt action is necessary in order to mitigate the threats and ensure the persistence of the species.
- Priority 2: Action is necessary to mitigate threats and work towards the long-term recovery of the species.
- Priority 3: Action is desirable, but not critical to recovery at this point in time but will provide for longer term maintenance of recovery.
- N/A: not relevant in this key management zone.

Objective		Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority
1	To protect and effectively manage habitat critical for survival to maintain viable populations of western ringtail possums.	1	2	1
2	To mitigate threatening processes constraining the recovery of western ringtail possums.	1	2	1
3	To achieve an evidence-based management approach for western ringtail possums.	1	1	2
4	To manage displaced, orphaned, injured and rehabilitated western ringtail possums for the best conservation outcome for the species.	1	3	2
5	To raise awareness of the status of western ringtail possums and gain support and behaviour change to improve mitigation of threatening processes.	1	2	1

12.2 Recovery Actions

Recovery actions associated with each of the recovery objectives identified for the recovery of the western ringtail possum are described below. All recovery actions are assigned a priority ranking for each of the key management zones separately (see Section 12.1 for priority ranking definitions and Figure 1 for approximate location of key management zones).

Objective 1: To protect and effectively manage habitat critical for survival to maintain viable populations of western ringtail possums.

It is recognised that the loss of existing or potential habitat critical for the survival of western ringtail possums will not only result in a loss of individuals and populations, but also reduce the ability for recovery into the future. To prevent further habitat loss or degradation, habitat critical for survival, as well as potential habitat and habitat connectivity need to be defined, identified and mapped. This will provide an important tool for local and landscape scale management. Identification of habitat critical for survival presents numerous challenges including defining characteristics and thresholds and contextualising data at the landscape level, to allow for continuity between areas. There will be habitat critical for survival on both private and public lands and this presents further challenges.

Action	Description	Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority	Performance Criteria	Responsibility
1.1	Develop a decision support tool to assist in habitat management based on: <ul style="list-style-type: none"> • habitat characteristics required for western ringtail possum occupation and density thresholds; • priority landscape level habitat linkages; and • identification of key habitat. 	1	1	1	<ul style="list-style-type: none"> – Habitat characteristics and thresholds are defined. – Important ecological linkages are identified and mapped. – Existing and potential habitat is mapped and ranked. 	DPaW

Action	Description	Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority	Performance Criteria	Responsibility
1.2	Identify and implement strategies to achieve the protection of higher ranked habitat, on public and private land, in each of the key management areas. Strategies may include: <ul style="list-style-type: none"> • investigating mechanisms to enhance the protection afforded to identified high quality habitat; • protection of western ringtail possum habitat values in the assessment of development proposals by environmental regulation agencies; • encouraging planning authorities to facilitate the creation of habitat reserves and linkages when amending town planning schemes or developing land use structure plans; • liaising with local and state government planning agencies to implement strategies to mitigate the effect of development, and provide for management of high quality habitat. 	1	2	1	Effective strategies to protect high value habitat have been implemented on both public and private land.	DPaW, DER, EPA, DoTE, DOP, WAPC, LGA
1.3	Evaluate the effectiveness of these strategies and amend strategies as required to improve effectiveness	2	3	2	Effective strategies to protect high value habitat have been implemented on both public and private land in each key management area.	DPAW, DOP, WAPC, LGA

Action	Description	Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority	Performance Criteria	Responsibility
1.4	Undertake climate change modelling to assess the potential effects on the distribution and abundance of the western ringtail possum, and identify refuges or future suitable habitat to mitigate the climate pressures.	1	1	1	Climate modelling completed.	DPaW, Researchers

Objective 2: To mitigate threatening processes constraining the recovery of western ringtail possums.

The impact of threatening processes is complex and interactive for this species. They not only involve habitat loss or degradation (see objective 1) but also a variety of other factors. The relative importance of the processes threatening the western ringtail possum also varies across the species' range and through time. At any one locality, several threatening processes may be interactive (for example Wayne *et al.* 2000, Wayne 2005, Wayne *et al.* 2006).

Action	Description	Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority	Performance Criteria	Responsibility
2.1	Work with fire management agencies to implement better fire management strategies that minimise the impact of fire prevention, fuel reduction and fire suppression activities on western ringtail possums and their habitat.	2	1	1	Fire management actions have minimal negative impacts on western ringtail possums.	DPaW, DFES, LGA
2.2	Support and develop programs aimed at identifying, restoring or creating suitable habitat, including ecological linkages for the species.	1	2	2	Effective programs are undertaken that create additional western ringtail possum habitat and ecological linkages.	DPaW, DER, EPA, LGA, WAPC
2.3	Implement management strategies to minimise, or compensate for the impacts of disease, pathogens or insects that are likely to impact western ringtail possum habitat quality, including Myrtle Rust surveillance, <i>Phytophthora</i> dieback hygiene protocols etc.	1	2	1	Important and high quality habitat is not significantly impacted by disease, pathogen/insects. Diversity of habitats important to western ringtail possums are identified and protected.	DPaW, LGA
2.4	Develop and implement hygiene protocols for all activities in which western ringtail possums are handled or transported.	1	2	1	Hygiene protocols are written and utilised by researchers, consultants and wildlife rehabilitators.	DPaW

Action	Description	Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority	Performance Criteria	Responsibility
2.5	Continue introduced predator control programs on DPaW managed land and seek to have a coordinated approach to baiting across different land tenures to maximise effectiveness.	2	1	1	Introduced predator control programs on DPaW managed lands continue or improve. Predator control programs are undertaken in a coordinate way across land tenures in key management areas.	DPaW, NRM groups, LGA
2.6	In accordance with other management strategies, develop and implement control measures for hollow-using introduced pest species where identified as a threat.	2	2	2	Areas where hollow-using pests are impacting western ringtail possums are identified and effective control strategies are implemented.	DPaW, DAFWA, LGA
2.7	Implement management strategies to protect important habitat trees and habitat of extant populations during planning, timber harvest and other forest management activities under the FMP.	N/A	2	N/A	Important western ringtail possum habitat trees and habitat of extant populations are protected in forest management areas consistent with the FMP.	DPaW, FPC
2.8	Establish a robust process for negotiating development offsets that will benefit short and long term western ringtail conservation objectives.	1	1	1	Offsets are used to benefit western ringtail possum recovery.	DER, EPA, DoTE, DPaW

Action	Description	Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority	Performance Criteria	Responsibility
2.9	Evaluate and enhance the effectiveness of management practices associated with threat mitigation, including fire management and predator control. For example: <ul style="list-style-type: none"> • pre and post fire baiting • pre and post fire fauna monitoring • quantifying habitat characteristics pre and post fire events. 	1	1	1	Fauna management strategies maximise the likelihood of western ringtail possum persisting after a disturbance event.	DPAW, Researchers
2.10	Assess the outcomes and relative conservation values of different mitigation strategies to determine the highest value for money and conservation benefit, including habitat creation, rehabilitation, relocations, artificial habitat connectors etc.	1	2	2	Assessment of mitigation strategies complete and value of outcomes determined.	DPaW, Developers, Researchers
2.11	Assess relative impacts of biotic factors constraining recovery, including competition (with brushtail possums and pest hollow competitors), pathogens, fauna disease, foliage nutrients etc.	3	1	2	Management actions relating to biotic factors prioritised.	DPaW, Researchers
2.12	Improve scientific understanding of the benefits of an urban environment, strategies to enhance urban environments, and its role in the future conservation.	2	2	2	Improved information to influence urban planning and design.	DPaW, LGA, Researchers, Developers

Objective 3: To achieve an evidence-based management approach for western ringtail possums.

Applying an evidence-based management approach requires pursuing the gaps in our knowledge required to make strategic and effective decisions. For western ringtail possums, a large part of this is effective monitoring and evaluation which can enable the detection of population trends and responses to management actions or other variables. Undetected declines in some populations, or increase of threats could cause a rapid contraction of the species distribution and/or decrease in population size before effective intervention is able to occur.

As the western ringtail possum is a relatively elusive species and is difficult to trap or detect at low numbers there are several areas where knowledge of the abundance and distribution of is lacking. A full understanding of the distribution of the species including low density populations and reasonable measures of population size will enable a more accurate assessment of the species conservation status and provide data and information to determine status and trends. This information can then be used to evaluate management effectiveness and ensure that decisions and strategies are evidence-based.

Action	Description	Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority	Performance Criteria	Responsibility
3.1	Develop consistent and reliable protocols for monitoring population size, extent and area of occupancy to ensure that data are comparable over time, while noting that different areas may require different techniques.	1	1	1	Monitoring protocols are developed to evaluate population changes over time.	DPaW, Researchers Consultants
3.2	Standardise monitoring protocols for other variables known, or suspected, to influence western ringtail possums such as brushtail possum density, predator density, climatic variables, site productivity and habitat condition, quality and variability.	1	1	1	Monitoring protocols are developed for influencing factors.	DPaW

Action	Description	Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority	Performance Criteria	Responsibility
3.3	Establish a long-term monitoring and evaluation program to detect population changes, within defined sites.	1	1	1	Monitoring, evaluation and reporting program established that can reliably detect rates and magnitudes of population change.	DPaW
3.4	Develop information management system for storing, retrieving and analysing data, including recording absences and survey effort.	1	1	1	Information management system used to store, retrieve and analyse data as per monitoring protocols.	DPaW
3.5	Investigate and trial new methodologies and technologies for detecting low density populations of western ringtail possums.	2	2	2	New technologies investigated.	DPaW, Researchers, Consultants
3.6	Survey areas where western ringtail possums have been known to occur within the last 10 years, areas at the edge of known distributions, and areas with suitable habitat to clarify distribution (i.e. extent of occurrence) and occupancy (i.e. area of occupancy).	1	1	1	Accurate distribution of western ringtail possums is mapped and extent of occurrence and area of occupancy accurately calculated.	DPaW. Researchers, Consultants
3.7	Identify and map extant populations across the species range.	3	3	3	Extant populations are mapped.	DPaW
3.8	Use Population Viability Analyses (PVA) to forecast population viability and extinction risk.	1	2	2	Health and extinction risks determined.	DPaW, Researchers
3.9	Determine the genetic characteristics of the remnant western ringtail possum populations to sufficiently inform appropriate management within and between populations.	3	3	3	Information on genetic characteristics inform management actions.	DPaW, Researchers

Action	Description	Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority	Performance Criteria	Responsibility
3.10	Improve knowledge of the novel benefits and costs of habitat in urban environments and their role in the conservation of western ringtail possums.	1	3	2	The characteristics and conservation value of urban western ringtail possum habitats are better defined.	

Objective 4: To manage displaced, orphaned, injured and rehabilitated western ringtail possums for the best conservation outcome for the species.

Orphaned, injured and rehabilitated possums typically come from urban areas where they have been displaced or injured. Wildlife rehabilitators care for these animals until they can be released. Some animals are released as part of approved translocation programs (de Tores 2005), though an unknown number are released that are not part of a formal process and their fates are unknown. Improved conservation outcomes can be achieved with better management of this activity.

Western ringtail possums may also be displaced by approved land development or land use intensification. As part of impact mitigation, capture and translocation of animals that will be displaced may be set as approval conditions by the regulating authorities. The coordinated and well planned implementation of such relocations is essential to maximise the survival of displaced animals, as well as optimising long term benefits for the conservation of the species. However, studies have shown that survival rates are very low after relocation and thus they should only be undertaken as a last resort. Improved relocation methods are required and need to be demonstrably effective before translocations can be adopted as a viable recovery action.

Action	Description	Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority	Performance Criteria	Responsibility
4.1	Develop rehabilitation protocols and standard operating procedures to manage and ensure best-practice rehabilitation and release of orphaned, injured and displaced western ringtail possums.	1	3	2	Formal rehabilitation and release protocols developed and used by stakeholders. Strategic sites identified and monitored. Success of rehabilitation quantified.	DPaW, Wildlife Rehabilitators, Developers, Consultants
4.2	Where the need to relocate animals is unavoidable, identify appropriate sites considering climate change modelling, habitat assessment modelling etc.	1	3	2	Criteria developed to select appropriate relocation sites.	DPaW
4.3	Regularly review the outcomes of translocations to ensure translocation protocols are both evidence-based and best-practice.	1	2	2	Protocols for release of relocated and/or translocated animals are evidence-based and use best-practice.	DPaW, Wildlife Rehabilitators, Consultants

Objective 5: To raise awareness of the status of western ringtail possums and gain support and behaviour change to mitigate threatening processes

While the presence of western ringtail possums in the urban areas confronts wildlife managers with many challenges, it also increases opportunities for people to re-connect with nature in the urban context. Community groups are already active in the conservation of the western ringtail possum and are involved by reporting sightings, assisting with surveying and monitoring, and engaging with local government seeking preservation of habitat. Local involvement should be encouraged to help with the conservation effort and increase awareness of the species, particularly in areas of high development potential.

Despite the involvement of some members of the public and previous educational initiatives over many decades, there remains a general lack of broad scale awareness of the conservation status and plight of the species within the community. At the urban interface this manifests itself as apathy towards conserving habitat and for a small group, intolerance to 'living with possums'. Targeted effort to increase community understanding will assist in improving support for conservation of western ringtail possums.

Action	Description	Swan Coastal Plain Zone Priority	Southern Forest Zone Priority	South Coast Priority	Performance Criteria	Responsibility
5.1	Develop information aimed at increasing community understanding and gaining support for western ringtail possum conservation issues and management.	1	3	1	An observed increase in community support.	DPaW, LGA
5.3	Encourage, co-ordinate and enhance the involvement of groups engaged in western ringtail possum conservation.	2	3	3	Improved coordination of community groups.	DPaW, LGA, Community Groups
5.4	Increase awareness of the species conservation requirements in areas of high development potential.	1	3	1	Increased awareness of conservation requirements.	LGA, WAPC, DOP, DPaW
5.5	Adopt a proactive role to reduce illegal activities that threaten western ringtail possums, and support regulatory actions through the relevant agency.	2	2	2	Greater regulation of illegal activities.	DPaW, LGA, DER, WA Police

13. Implementation and evaluation

The coordination and implementation of this recovery plan will be overseen by DPaW. This may involve formation of a western ringtail possum working group/s consisting of representatives directly involved in addressing recovery actions and management of western ringtail possum populations, habitats and threats. DPaW recognises that partnerships will need to be developed to assist in the coordination and delivery of the recovery actions.

This plan will be implemented for a minimum of 10 years from the date of its approval, or until replaced by another approved plan. DPaW, in consultation with relevant partners, 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 no longer than five years, or sooner if necessary. All western ringtail possum recovery initiatives will be documented and made available for the periodic reviews. The recovery plan may be revised in light of such review and as other information or research findings become available.

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