Department of Environment and Conservation

Nomination of a Western Australian species for listing as threatened, change of status or delisting.

To fill out this form you must refer to the attached Guidelines. Incomplete forms will result in delays in assessment, or rejection of the nomination.

Answer all relevant sections, indicating when there is no information available. Note, this application form applies to both flora and fauna species, and hence some questions or options may not be applicable to the nominated species – for these questions, type or write "N/A".

Some questions on the form have additional information in a **Help** box and these are marked with an asterisk (*). If you require additional information, place your cursor in the text box into which you type your answer, press F1 and a Help box will pop-up.

SECTION 1. NOMINATION		
1.1. Nomination information		
Flora ☐	**Fauna** ☐	**Nomination for: Addition**
1.2. Scientific Name		
Bettongia penicillata ogilbyi		
1.3. Common Name		
Woylie, Brush-tailed bettong or Brush-tailed Rat-kangaroo. Indigenous names include Woylyer and Karpitchi.		
1.4. Current Conservation Status		
Select one category for each of the five fields. If none, select 'None'.		
International IUCN Red List: Lower Risk/Conservation Dependent (version 2.3, 1994) Categories and Criteria applicable to the highest rank category only: None		
National (*EPBC Act 1999*): None		
State of WA: Priority 5		

Is the species listed as 'Threatened' in any other Australian State or Territory No ☐ Yes ☐
If Yes, list the States and/or Territories and the status for each

Table 1: History of the conservation status of *B. p. ogilbyi* in Australia.

Jurisdiction	Legislation/Authority	Rank/Status	Year listed	Year removed
International	IUCN	Endangered	1982	-
		Endangered	1986	-
		Endangered	1988	-
		Endangered	1990	-
		Endangered	1994	1996
		LR/cd (ver 2.3 (1994))	1996	Current
National	Endangered Species Protection Act 1992	Endangered	-	1996
	Environment Protection and Biodiversity Conservation Act 1999	Not Listed	-	Current
	1992 Action Plan for Australian Marsupials and Monotremes	Endangered	1992	Superseded by 1996 action plan
	1996 Action Plan for Australian Marsupials and Monotremes	Lower Risk/ Conservation dependent	1996	Current
Western Australia	Wildlife Conservation Act 1950	Schedule 1 "Rare or likely to become extinct"	-	1996
	DEC Priority fauna list	Priority 4[#]	1996	2004
		Priority 5	2004	Current
South Australia	National Parks and Wildlife Act 1972	Schedule 7 (Endangered Species)	-	-
		Rare*	2000	Current
Victoria	Flora and Fauna Guarantee Act 1988	Threatened^	-	Current
Northern Territory	Territory Parks and Wildlife Act 2000	Extinct	-	Current
New South Wales	Threatened Species Conservation Act 1995	Not listed	-	Current
Australian Capital Territory	The Nature Conservation Act 1980	Not listed	-	Current
Tasmania	Threatened Species Protection Act 1995	Not listed	-	Current

[#] A copy of the review of the conservation status of the woylie that resulted in it being delisted is in Appendix I).
* Most recent review in 2002. Still listed as Rare.
^ Status refers to *B. penicillata* – no subspecies identified.

Does the species have specific protection (e.g. listed on an annex or appendix) under any other legislation, inter-governmental or international arrangements e.g. CITES? No ☐ Yes ☐
If yes, please provide details

Bettongia spp. are listed under Appendix I of CITES. This appendix lists species that are most endangered amongst CITES-listed species and means that international trade in specimens is prohibited except when the purpose of import is non-commercial (e.g. scientific purposes).

1.5. Nominated Conservation Status

Select one category for each of the five fields. If none, select 'None'.

International
IUCN Red List: Endangered
Categories and Criteria applicable to the highest rank category only: A3be; A4be

National (*EPBC Act 1999*): Endangered

State of WA IUCN Status: Endangered

1.6. Reasons for the Nomination

Briefly summarise the reasons for the nomination in dot points. Please include details relevant to the IUCN Categories and Criteria where appropriate.

- A greater than 50% decline in woylie trap success has been observed within five years for 12 monitoring sites (representing 5 out of 21 locations of occurrence), the cause of which is currently unknown.
- The decline is not restricted to Western Australia and includes occurrences that were previously considered secure (e.g. Dryandra, Perup/Lake Muir area).
- Current evidence indicates that these declines are still continuing.
- Of those monitoring sites that have shown a severe decline in woylie trap success, there is little evidence of signs of recovery to date.
- The species no longer meets all the criteria for success set out in the species recovery plan (ie there are fewer than six populations [subpopulations] in Western Australia with an increasing or stable trap success of 7.5% or higher and the successful establishment of a second mainland woylie population [subpopulation] in South Australia is threatened by a recent unexplained rapid decline in the Venus Bay population).
- Only five subpopulations currently exhibit an increasing trap success trend. Three of these have recently received individuals from translocations (ie North Karlgarin NR, Nambung NP and Paruna Sanctuary) and the other two are transects situated in the Perup/Lake Muir area (Warrup and Keninup) where other transects in the area have shown rapid declines. Changes in trapping frequency and transect placement over time for Warrup and Keninup transect have also impeded ability to interpret trends in trap success.
- In general, woylie subpopulations that reached greater than 40% trap success have declined to less than 5% trap success and populations that have persisted at less than 10% trap success have remained stable.
- It can be demonstrated that…

A population size reduction of ≥ 50%, is projected or suspected to be met within the next 10 years based on:

~~(a) direct observation~~

(b) an index of abundance appropriate to the taxon

~~(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat~~

~~(d) actual of potential levels of exploitation~~

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites."

And…

An observed, estimated, inferred or suspected population reduction of ≥ 50% over any 10 year period, where the time period must include both the past and the future, and where the reduction or its causes may not have ceased or be understood or may not be reversible based on:

~~(a) direct observation~~

(b) an index of abundance appropriate to the taxon

~~(c) a decline in area of occupancy, extent of occurrence and/or quality of habitat~~

~~(d) actual of potential levels of exploitation~~

(e) the effects of introduced taxa, hybridization, pathogens, pollutants, competitors or parasites."

A summary has been provided in Table 2 that outlines which IUCN criteria apply to the woylie and which recovery plan criteria have been met or not met.

From the information available it is recommended that the woylie be listed under Schedule 1 of the Wildlife Conservation Act and ranked as Endangered using criterion A3be and A4be.

Table 2: Summary of IUCN criteria and criteria for recovery set out in the species recovery plan, that are relevant to assessing the conservation status of the woylie.

IUCN Criteria	Applies?	
	Vu	En
A. Declining population (past, present and/or projected)		
1. Requires at least a 50% decline for Vulnerable or 70% decline for Endangered in the past 10 years where the causes are clearly reversible and understood and ceased.	No	No
2. Requires at least a 30% decline for Vulnerable or 50% for Endangered in the past 10 years where the causes may not have ceased or may not be understood or may not be reversible.	No	No
3. Requires at least a 30% decline for Vulnerable or 50% for Endangered projected or suspected to be met in the future 10 years.	Yes	Yes
4. Requires at least a 30% decline for Vulnerable or 50% for Endangered observed, estimated, inferred, projected or suspected over any 10 years period that includes both past and present where the causes may not have ceased or may not be understood or may not be reversible.	Yes	Yes
B. Geographic range size and fragmentation, decline or fluctuations (Requires an estimated extent of occurrence of less than 20 000km^2 or an area of occupancy of less than 2 000km^2 accompanied by other requirements).	No?	No
C. Small population size and fragmentation, decline or fluctuations (Requires a population size of less than 10 000 and a continuing decline of at least 10% within three years for Vulnerable or less than 2 500 and a 20% for Endangered)	Yes?	No
D. Very small population size or very restricted distribution (requires a population size of less than 1000 or known from a small area of occupancy or small number of locations)	No	No
E. Quantitative analysis of extinction risk (e.g. Population Viability Analysis) (requires a thorough risk analysis to have been performed)	No	No
Criteria for Recovery in the Woylie Recovery Plan	Met/not met?	
WA – At least 6 populations of woylies, each occurring in areas of at least 1500ha of suitable habitat and increasing in density (and area where contiguous suitable habitat) or plateaued with a trap success rate of greater than 7.5%.	Not met	
SA – Maintenance of two island populations on Wedge and St Peter Island.	Met	
SA – Establishment of at least one mainland population in addition to the Yookamurra population.	Met?	

SECTION 2. SPECIES

2.1. Taxonomy

Describe the taxonomic history, using references, and describe the key distinguishing features that can be used to separate this taxon from closely related taxa.

Two subspecies of *B. penicillata* are currently recognised: *B. p. ogilbyi* which occurs in the south-west of Western Australia and *B. p. penicillata* from eastern and southern regions of Australia which is presumed extinct. The taxonomic status of historical occurrences in central Australia is unknown. The historic extent of geographic overlap with *B. gaimardi* in eastern Australia is also unclear.

B. tropica from north-west Queensland is the subject of some debate between authorities and some consider it a third subspecies of *B. penicillata* (Winter and Johnson, 1995). Wakefield (1967) described *B. tropica* based on five specimens previously attributed to *B. penicillata* and he provided skull characteristics that can distinguish the two species. However, *B. tropica* is similar in external appearance to *B. penicillata* (Wakefield, 1967; Ride, 1970) and Sharman *et al*. (1980) concluded that there is no chromosomal basis for the distinction. *B. tropica* is known from less than five subpopulations and is unlikely to change the conservation status of *B. penicillata* if synonymised.

Finlayson (1957) provides preliminary descriptions of two additional subspecies of *B. penicillata*, *B. p. francisca* from St Francis Island in South Australia and *B. p. anhydra* from central Australia. However, the paucity of specimens makes it difficult to assess the validity of this taxonomy.

Is this species conventionally accepted? No ☐ Yes ☐ If no, explain why

Describe any known hybridisation with other species in the wild, indicating where this occurs and how frequently.

No hybrids known.

2.2. Description

Describe the physical appearance, habit, behaviour/dispersion and life history.

The woylie is a are small potoroid weighing 1-1.5 kg. They have a distinctive black brush at the end of their tail (Figure 1). They use their tail to carry nesting material (Troughton, 1973). They rest during the day in a well-concealed nest, built over a shallow depression that is most commonly built using long strands, preferably grasses, but will use other material such as strips of bark (in the forest) or dried seagrass and/or triodia (in arid coastal areas) (Christensen and Leftwich, 1980; D. Armstrong pers. comm. 6/12/2006). When disturbed from the nest, they will move quickly with head low and tail extended, sometimes colliding with obstacles in their haste to flee.

Woylies live to approximately 4-6 years in the wild and can breed in their first year (Christensen, 1995). They have the potential to breed continuously, producing a maximum of three young in a year (Serventy, 1970).

Figure 1: Radio-collared woylie on Keninup monitoring transect in the Perup/Lake Muir area

Photo by: A. Wayne

2.3. Distribution

Describe the distribution of the species in Australia and, if possible, attach a map.

The species once occupied most of the Australian mainland, south of the tropics including the arid and semi arid zones of Western Australia, the Northern Territory, South Australia, New South Wales and Victoria. Figure 2 shows the historic distribution of *B. penicillata*. The two most northern Queensland records have since been assigned to *B. tropica* (Wakefield, 1967).

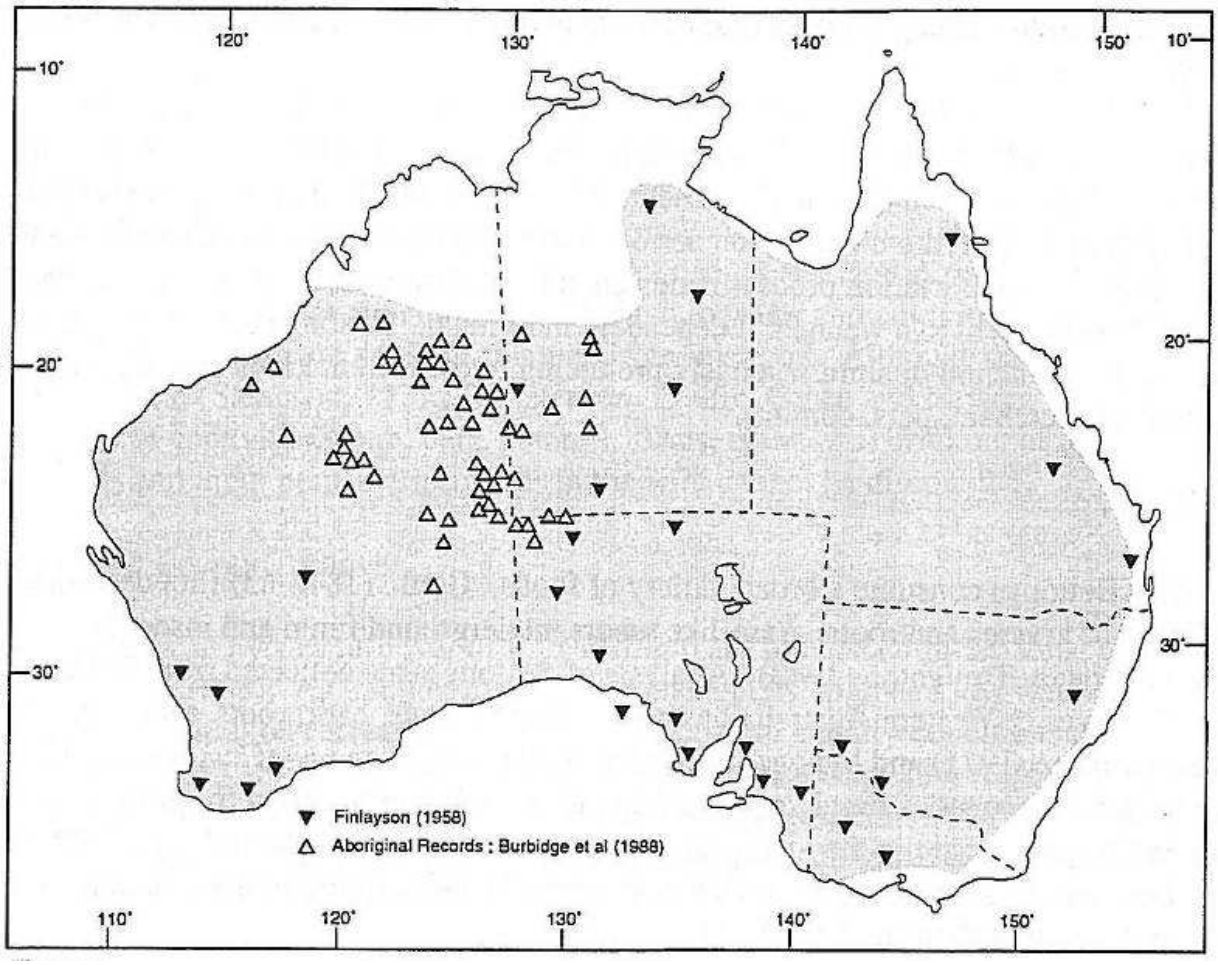


Figure 2: Historic distribution of *B. penicillata* (from Nelson *et al.* 1992).

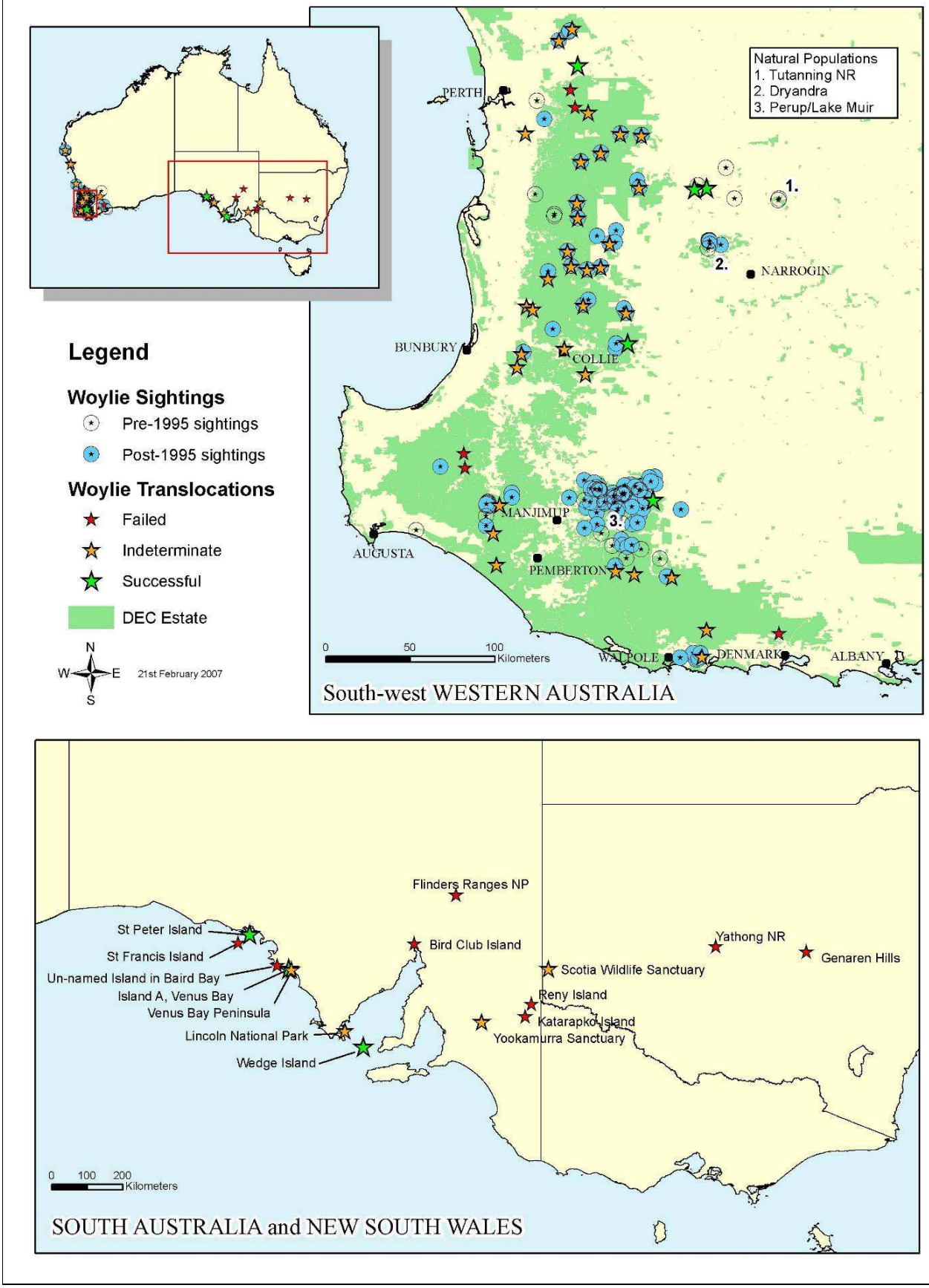
By the 1970's, its distribution had been reduced to three locations in Western Australia: Perup forest, Tutanning Nature Reserve and Dryandra Woodland. Like many medium-sized terrestrial mammals formerly occurring in arid and semi-arid Australia, the species had retreated to the most mesic parts of its former range since European settlement (Burbidge and McKenzie, 1989).

In 1975, the South Australian National Parks and Wildlife Service began a breeding program for the species at Para Wirra Recreation Park from animals sourced from Perth Zoo with the goal of providing stock to re-establish the species in South Australia. The first experimental releases were onto two small islands (Bird Club Island in 1979 and Venus Bay "Island A" in 1980) followed by two larger islands (St Francis Island in 1981 and Wedge Island in 1983).

In Western Australia, widescale fox baiting and reintroduction projects implemented under the *Western Shield* program, have led to an increase in the distribution and abundance of the woylie.

The species has been translocated (with mixed success), to 46 sites (including two privately-owned sanctuaries) in Western Australia, 12 sites (including one privately-owned sanctuary) in South Australia and three sites (including one privately-owned sanctuary) in New South Wales. Multiple release points were used at some of these sites. Figure 3 shows the current distribution of the woylie in Australia.

Figure 3: Current distribution of the woylie in Australia.



2.4. Habitat

Describe the non-biological habitat (e.g. aspect, topography, substrate, climate) and biological habitat (e.g. forest type, associated species, sympatric species). If the species occurs in various habitats (e.g. for different activities such as breeding, feeding, roosting, dispersing, basking etc) then describe each habitat.

Non-biological habitat	Biological habitat
Historically woylies occupied habitat in a variety of climatic zones including mediterranean, semi-arid and arid.	The woylie occupied a variety of habitat types from forest to grassland, coastal and inland. During the day it shelters under patches of dense undergrowth, logs and rock-cavities (Sampson, 1971; Christensen and Leftwich, 1980) and occasionally in burrows (Burbidge *et al*. 1988).

Does the (fauna) species use refuge habitat e.g. in times of fire, drought or flood? Describe this habitat.

Gastrolobium thickets provide refuges for woylies against introduced predators. Prior to widescale fox baiting, the species' distribution had been reduced to a handfull of locations in Western Australia with the common characteristic of the presence of *Gastrolobium* thickets (e.g. *Gastrolobium biloba*). *Gastrolobium* contains monofluoroacetic acid which is the compound present as sodium monofluoroacetate in the toxic bait '1080'. It is thought that habitat with *Gastrolobium* thickets provided the woylie with refuge from introduced predators, partly because of the ability to physically hide in the bushes but also the local reduction in predator numbers caused by secondary poisoning (Start *et al*. 1998).

In the event of fire, unburnt patches of vegetation become refuges for woylies. Woylies have been observed to remain in their nest until the fire front approaches, then move in front of the flames until an unburnt patch becomes available (Christensen, 1980). If no unburnt patch is available they will double back through the flames at the edge of their home range to the safety of burnt ground, demonstrating their fidelity to their home ranges (Christensen, 1980).

Is the species part of, or does it rely on, a listed threatened ecological community? Is it associated with any other listed threatened species?

The woylie does not rely on any listed threatened ecological community. However, many locations where woylies are found are also inhabited by other threatened species. The abundance of woylies in the mid to late 1990's also meant that woylies were often the first species translocated to sites where releases of more threatened species were planned, to determine if fox baiting in the area was effective.

Threatened species associated with woylie habitats include the chuditch (*Dasyurus geoffroii*), bilby (*Macrotis lagotis*), numbat (*Myrmecobius fasciatus*), western ringtail possum (*Pseudocheirus occidentalis*), brush-tailed phascogale (*Phascogale tapoatafa*) and greater stick-nest rat (*Leporillus conditor*).

2.5. Reproduction

Provide an overview of the breeding system.

For Fauna: Provide an overview of the breeding system and breeding success, including: when does it breed; what conditions are needed for breeding; are there any breeding behaviours that may make it vulnerable to a threatening process?

Woylies can breed continuously throughout the year (Sampson, 1971). It is not uncommon for a large portion of females at a monitoring site to be either carrying young or suckling a young at heal. The proportion of females caring for young tends to be lower in the drier months when conditions for survival are harsher. Woylies produce a single young at a time, but twins have occasionally been observed (Sampson, 1971). Woylies exhibit embryonic diapause, so it is possible for females to carry a blastocyst in the womb, young in the pouch and a young at foot (Smith, 1989; Smith, 1996). A summary of the reproductive characteristics of woylies is contained in Table 3.

The generation length for the woylie is estimated at between 2 and 3 years based on trapping data in FaunaFile (the database that stores fauna monitoring information from the *Western Shield* program).

Males tend to have larger home ranges than females (see Table 4 in section 2.8) which enables them to visit more than one female.

Table 3: Reproductive characteristics of the woylie.

Reproductive characteristic	Duration/Number	Reference
Age of female sexual maturity	170-180 days	Christensen, 1995
Gestation	21.2 days	Smith, 1992
Number of pouch young	1, rarely 2	Sampson, 1971; Christensen, 1995
Pouch life	90 days	Christensen, 1995
Maximum number of young produced in a year	3	Serventy, 1970

2.6. Population dynamics

Provide details on ages of sexual maturity, extent of breeding success, life expectancy and natural mortality. Describe population structure (presence of juveniles/seedlings, mature and senescing individuals).

Life expectancy for woylies is approximately 4-6 years (Christensen, 1995). From trapping data in FaunaFile for woylies at Batalling and Dryandra the maximum age reached was seven and six years respectively with an average of three years for both sites (Peter Orell unpublished data). In captivity, a male lived for over 14 years and was still breeding (Keynes, 1989). On Wedge Island in South Australia, a bettong first captured in 1999 was captured alive in 2006, making it at least seven years old (Gillam, 2006).

Highest mortality in bettong species is associated with young at foot and subadult age categories, and is lowest for pouch young and mature individuals (Vernes, 1999; Vernes and Pope, 2002; C. Freegard, unpublished data). As a result the woylie population consists largely of mature individuals. Sexual maturity in female woylies is reached at about 170 days (Christensen, 1995).

Woylies are solitary animals but nest sharing (usually mother and young at heel) has been recorded (Sampson, 1971; Christensen and Leftwich, 1980 and Start *et al*. 1995).

Questions 2.7 and 2.8 apply to fauna nominations only

2.7. Feeding

Summarise food items or sources and timing/availability.

A wide range of food types have been recorded in the diet of the woylie including leaf material, seasonal fruits/berries, roots, tubers, bark and invertebrates (Sampson, 1971; Nelson, 1989).

In southwest WA, woylies feed extensively on hypogeous fruiting bodies of ectomycorrhizal fungi (Christensen, 1980; Lamont *et al*. 1985). At Boyicup in Western Australia, dependence on fungi as a food source is most pronounced over the dry summer-autmn period (Christensen, 1980). A Venus Bay

Conservation Park woylies were found to consume fungi in similar proportions to other bettong populations but there were fewer species available and roots and tubers were eaten when fungi availability was low (Lee, 2003). On Venus Bay "Island A" however, fungi was not found to be a significant dietary component (Nelson, 1989).

Briefly describe feeding behaviours, including those that may make the species vulnerable to a threatening process.

During feeding activities at dawn, dusk or at night, woylies make a large number of small diggings that disturb the soil surface. In a study site at Dryandra Woodland a digging rate of 38 to 115 diggings/woylie/night was recorded which corresponds to approximately 6 tonnes of soil moved per woylie per year (Garkaklis, 2001).

Woylies are known to cache food such as the nuts from sandalwood trees (*Santalum spicatum*) and wheat seeds (Sampson, 1971; Christensen, 1980; Murphy *et al.* 2005). The seeds are buried and presumably the woylie returns at a later date to consume the seeds or germinating plants.

2.8. Movements

Describe any relevant daily or seasonal pattern of movement for the species, including relevant arrival/departure dates if migratory.

Seasonal or migratory movements have not been recorded for the species. Daytime movements of the species have been observed but the species is predominantly nocturnal.

Woylies rest during the day in nests they construct and forage at night. If danger approaches they will wait until the last minute to flee from a nest. Predators with a keen sense of smell, such as the European fox, are therefore able to detect the presence of the woylie and successfully ambush their prey.

Give details of home range/territories.

Woylies occupy home ranges, the size of which varies between habitats and sites (Table 4). Small home ranges are generally observed at high density occurrences (e.g. Karakamia Sanctuary).

Table 4: Home range sizes calculated for woylies (area in hectares).

Location	Males	Females	All	Reference
Tutanning NR, WA	35.0	23.0	29.0	Sampson, 1971
Yendicup, WA	35.0	15.4	33.0	Leftwich, 1983
Boyicup, WA	8.7 feeding area with non-overlapping core of 2.1 (nest area)	7.5 feeding area with non-overlapping core of 2.7 (nest area)	N/A	Christensen, 1980 in Nelson *et al.* 1992
Karakamia Sanctuary, WA	N/A	N/A	5.4 (min. convex polygon)	Hide, 2006
	N/A	N/A	4.3 (harmonic mean)	Hide, 2006
Lincoln NP, SA	N/A	N/A	17.6	Martin *et al.* 2006
Venus Bay "Island A", SA	N/A	N/A	4.0	Nelson, 1989 in Nelson *et al.* 1992

SECTION 3. INTERNATIONAL CONTEXT

For species that are distributed both inside and outside Australia

3.1. Distribution

Describe the global distribution.

Not applicable. Species occurs only in Australia.

Give an overview of the global population size, trends, threats and security of the species outside of Australia.

Not applicable. Species occurs only in Australia.

Explain the relationship between the Australian population and the global population. What percentage of the global population occurs in Australia? Is the Australian population distinct, geographically separate or does part, or all, of the population move in/out of Australia's jurisdiction? Do global threats affect the Australian population?

Not applicable. Species occurs only in Australia.

SECTION 4. CONSERVATION STATUS AND MANAGEMENT

4.1. Population

What is the total population size in terms of number of mature individuals? Has there been any known reduction in the size of the population, or is this likely in the future? – give details.

Because of the high trappability of woylies, the easiest method to observe trends in population size is to consider changes in trap success both within and between subpopulations. Trap success in highly correlated with "known to be alive" (KTBA) estimates and other population size estimates by mark and recapatures models (e.g. POPAN), albeit a somewhat more conservative means of estimating population change (Wayne, 2006).

Trap success figures are available for monitoring sites for woylies in Western Australia and South Australia. At some sites, trap saturation or competition for traps from other species, has reduced the effectiveness of the technique for monitoring trends in abundance of woylies (e.g. Karakamia Sanctuary).

There has been a rapid decline in trap success for woylies at a number of sites. Table 5 and 6 summarise the trends observed at woylie monitoring sites in Australia. For Table 5, if the difference between the three-year average trap success figures for 1998-2000 and 2004-2006 was less than 10 then it was considered that no change had occurred. The average percentage decline for the sites included in Table 5 is 51.7%. If only those monitoring sites that declined are average then the percentage decline is 82.8%. This is likely to be an underestimate because the three-year averages lessen the extremes of a decline that has, in general, continued steadily across the time intervals (see Figures 7 to 10 presented later in section 4.1)

Table 5: Summary of trap success for monitoring sites where woylies have been established and monitored for at least nine years (except Giants which was established in 1999, in which case only 1999-2000 data were averaged).

Monitoring site	Average trap success for three-year intervals			Percent decline between 1998-2000 and 2004-2006 average trap success
	1998-2000	2001-2003	2004-2006	
Batalling	41.7	36.5	13.1	68
St John	0.5	0.7	0	100
Winnejup	39	NA	2.5	93
Moopinup	46.8	61.8	9.9	79
Chariup	45.7	67	16.9	63
Boyicup	56.7	58	7.5	87
Myalgelup (Poorginup)	0.2	0.7	1.5	No change
Giants	0.8	0.9	0.3	No change
Denmark (Mt Lindesay)	1	0	0	100
Tutanning NR	5.3	8	7.5	No change
Boyagin NR East	3.3	4.7	6.67	No change
Boyagin NR West	41	27	21.3	48
Dryandra Woodland	52.9	17.9	5.5	90
Lake Magenta NR	2.4	0	0	100
Francois Peron NP	0.2	0.7	0.4	No change
Julimar	1.9	0.04	1.6	No change
AVERAGE:	**23.2**	**17.7**	**8.8**	**51.7**

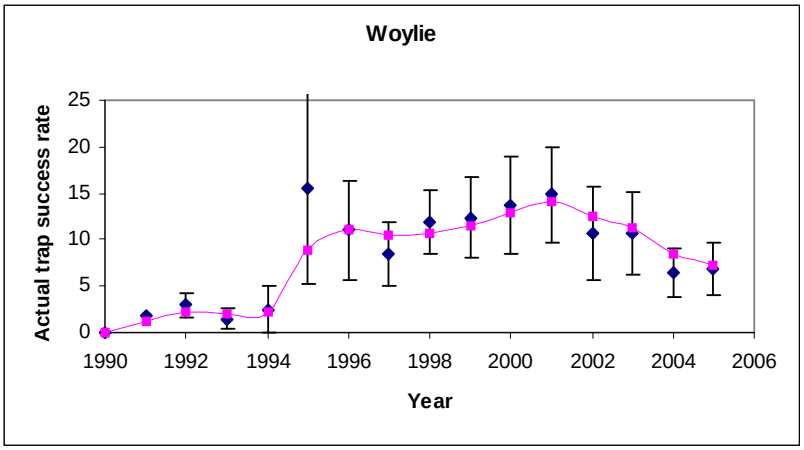
Table 6: Summary of the status of woylies at monitoring sites in Australia. Recent monitoring results were unavailable for some sites and these have been excluded from the summary.

		MONITORING SITES							
	Category	**Northern and central jarrah forest**	**Sunklands and Pemberton area**	**Perup/Lake Muir area**	**Walpole/ Denmark area**	**Isolated reserves**	**New South Wales**	**South Australia**	**TOTAL**
"SAFEST"	Sites where trap success increased in the past and now averages more than 7.5%.			Warrup Keninup		Karakamia Boyagin NR W Tutanning NR		Wedge Is "Island A" St Peter Is	**8**
"UNCERTAIN FUTURE"	Sites where recent releases of woylies from translocations is affecting ability to observe trends.	Paruna				Nambung NP N Karlgarin NR Kalbarri NP	Scotia		**5**
	Sites that have maintained a trap success rate below 7.5%.	Centaur Davis Gervasse Wellington NP Hadfield Driver Julimar		Myalgelup	Giants	Boyagin NR E Francois P NP		Yookamurra	**12**
"IN TROUBLE"	Sites where woylies have declined to, or are at, undetectable levels (including failed translocations)	Hills Forest	St John Gray	Tone Boyndaminup	Mt Lindesay	L Magenta NR Fitzgrld R NP	Yathong NR Genaren Hills	Lincoln NP Katarapko Is Flinders R NP Reny Island Bird Club Is Baird Bay Is St Francis Is	**17**
	Sites where trap success has declined over the last 5 years by more than 50%.	Batalling Avon Vly NP		Moopinup Boyicup Chariup Winnejup Balban Camelar Yendicup Yackelup		Dryandra		Venus Bay CP	**12**
	TOTAL	**11**	**2**	**13**	**2**	**11**	**3**	**13**	**54**

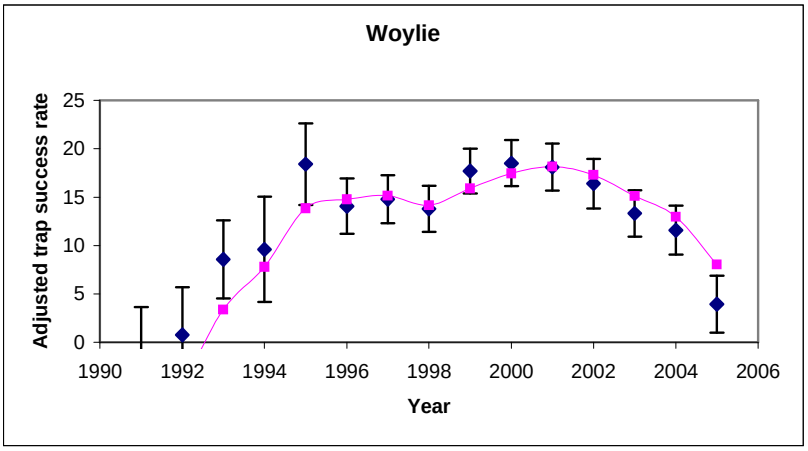
Williams (2006) conducted a preliminary analysis of trapping results under the *Western Shield* program with the aim of asssessing the ability of existing monitoring strategies to detect changes in abundance of species. Preliminary graphs for woylies are shown in Figure 4. A recent decline is apparent for both the raw trap success figures and those adjusted for site and seasonal differences. It is important to consider, however, that the averages calculated in these figures gives equal weighting to all transects, including the many sites that collectively contribute relatively little to the total population size. The most substantial recent declines observed to date appear biased toward those few areas that collectively support the most substantial proportion of the total population size (i.e. Perup/Lake Muir area, Batalling, and Dryandra). Consequently, these average trends do not directly reflect the magnitude of the actual decline in animal numbers (i.e. which is expected to be substantially greater than an average trap success rate derived from 32 equally weighted transects).

Figure 4: Average woylie trap success rates at 32 *Western Shield* monitoring sites showing (a) raw trap success rates and (b) estimated trap success rate after adjusting for site and seasonal differences in sampling. The fitted line is a 3 year moving average based on the current and previous two years of data with weights 3/6, 2/6 and 1/6 respectively.

(a)



(b)



A criterion for success of the species recovery plan (see Start *et al.* 1995) was that at least six populations [subpopulations] be established in Western Australia, each occuring in areas of at least 1500ha of suitable habitat and each increasing in density (and area where there is contiguous suitable habitat) or plateaued with a trap success of greater than 7.5%. **There is currently only one subpopulation (Boyagin Nature Reserve), in an area of 1500ha or more that maintains a trap success greater than 7.5%, therefore the woylie no longer meets this criterion for recovery.** Two monitoring transects in the Perup/Lake Muir area also maintain a trap success of greater than 7.5% but the subpopulation, as a whole, does not.

Actual population size estimates (rather than just trends) are difficult to obtain, particularly for the contiguous forest of southwest Western Australia. The review of the conservation status of the species in 1995 (see Start *et al.* 1998) did not attempt to estimate the total population size in its assessment against IUCN criteria. Instead, it focussed on the requirement that there is a continuing decline in the number of mature individuals or population structure that is required to accompany a population size of less than 10 000 for listing a species as Vulnerable. At the time, the population size was increasing and so this criterion for listing did not apply to the woylie. However, a decline is now apparent and it is therefore important to determine if the total population size estimate is less than 10 000 mature individuals.

The size of subpopulations occupying isolated reserves and islands are easier to estimate than the contiguous habitat because the boundary of the subpopulation is known and the distribution/density of woylies across the reserve/island is easier to determine. The number of mature individuals estimated to occur in South Australia is near 5 000 (with the majority of individuals in the Wedge and St Peter Island subpopulations).

The total woylie population size in 1980 was estimated to be less than 1000 and probably less than 500 (Letter from AA Burbidge dated 2/10/1980, folio 163 in departmental file 017465F3807). In 1992 the woylie population was estimated to be less than 5000 (Nelson *et al.* 1992). The woylie population reached a peak around 2001 and has since been declining. The declines in trap success have been most apparent for monitoring sites with high numbers of woylies. This means that the observed decline in trap success has had a disproportional impact on population size. Tables 7 and 8 detail attempts at estimating the population size in 2001 and 2006 respectively.

Two different methods have been used to estimate population size. The first is based on estimating extent of occurrence and woylie density, and multiplying the two. The extent of occurrence includes areas of unsuitable habitat and therefore the density estimate may be reduced to account for this. For example Batalling and the Perup/Lake Muir area had comparable densities of woylies in 2001 (A. Wayne pers. comm. 21/02/2007) but the density estimate in the table for woylies at Perup/Lake Muir is reduced to account for the farmland included in the extent of occurrence estimate. The second method involved obtaining guestimates, wherever possible, from individuals familiar with particular occurrences. Guestimates were based on personal experience, changes in trap success, characteristics of the site, the number of animals translocated (where applicable) and the time since establishment of the population. Both methods produce only approximate estimates of population size but they are documented here in detail for future improvement.

Table 7: Population size estimates for woylies in 2001.

	Extent of occurrence	Estimated population density (woylies/ha)	Estimated population size from density	Guestimate population size
Venus Bay "Island A"	15	2	30	30#
Wedge Island	947	2	1894	1500-3000*
St Peter Is	3439	2	6878	2000-3500*
Karakamia Sanctuary	280	2	560	500
Dryandra	12192	0.5	6096	6000^
Batalling	8000	0.5	4000	3000
Perup/Lake Muir area	236936	0.1	23694	20000[@]
Tutanning NR	2369	0.1	237	300
Boyagin NR	4781	0.05	239	1500
Paruna Sanctuary	2000	0.05	100	100
Venus Bay Peninsula	1100	0.05	55	100
Yookamurra Sanctuary	1100	0.05	55	70-80
Walpole/Denmark area	8988	0.01	90	50
Northern & central jarrah forest	774905	0.001	775	2000
Sunklands & Pemberton area	89925	0.001	90	200
Lake Magenta NR	107810	0.001	108	50
Francois Peron NP	52590	0.001	53	50
Kalbarri NP	183000	0.001	183	30
			45 000	**37 000 - 40 000**

van Weenen *et al.* 2006 * J. van Weenen pers. comm. 9/2/2007 [@] A. Wayne pers. comm. 21/02/2007 ^ Start *et al.* 1998

Table 8: Population size estimates for woylies in 2006.

	Extent of occurrence	Estimated population density (woylies/ha)	Estimated population size from density	Guestimate population size
Venus Bay "Island A"	15	2	30	30#
Wedge Island	947	2	1894	1500-3000*
St Peter Is	3439	2	6878	2000-3500*
Karakamia Sanctuary	280	2	560	500^
Tutanning NR	2369	0.1	237	300
Batalling	8000	0.05	400	400-500[@]
Boyagin NR	4781	0.05	239	400-500[@]
Dryandra	12192	0.05	610	400-500[@]
Avon Valley NP	4370	0.05	219	50
Paruna Sanctuary	2000	0.05	100	200^
Venus Bay Peninsula	1100	0.05	55	150”
Yookamurra Sanctuary	1100	0.05	55	70-80!
Perup/Lake Muir area	236936	0.01	2369	1000[@]
Walpole/Denmark area	8988	0.01	90	100
Northern & central jarrah forest	774905	0.001	775	500
Sunklands & Pemberton area	89925	0.001	90	200
North Karlgarin NR	5622	0.001	6	40
Francois Peron NP	52590	0.001	53	50
Kalbarri NP	183000	0.001	183	100
Nambung NP	18400	0.001	18	50
Scotia Sanctuary	64653	0.001	65	30!
		TOTAL:	**15 000**	**8 000 - 11 000**
		Percent decline between 2001 and 2006 :	**67**	**72-78**

van Weenen *et al.* 2006 * J. van Weenen pers. comm. 9/2/2007 [@] A. Wayne pers. comm. 21/02/2007
^ T. Gardner pers. comm. 7/2/2007 “D. Armstrong pers. comm. 6/12/2006 ! J. Bentley pers. comm. 1/2/2007

From these estimates it may be estimated that the woylie has undergone a population size reduction of greater than 60%, and probably greater than 70%, over the last five years.

It is also possible that the woylie population may no longer exceeds 10 000. The woylie may therefore qualify for listing as vulnerable under IUCN criterion C (version 3.1) because the population size of less than 10 000 individuals is accompanied by a decline of more than 10% over the last three years.

IUCN criterion A relates to reduction in population size. Criterion A1 does not apply to the woylie because it requires that the cause of the decline be known. Criterion A2 does not apply because it requires that the decline occurred over the last 10 years when the woylie has both increased and declined. The current woylie population size is likely to be similar to that observed 10 years ago before widescale fox baiting was implemented. Criteria A3 and A4 do apply because the observed decline has been active for the last five years and is projected to continue.

The current and projected decline in woylie population size is greater than 50% but less than 80% and so the woylie qualifies for listing as Endangered under IUCN criterion A3be and A4be (version 3.1).

Give locations of: captive/propagated occurrences or *ex situ* collections; recent re-introductions to the wild; and sites for proposed re-introductions. Have these sites been identified in recovery plans?

Woylies are relatively easy to keep in captivity. Many zoos around the world keep them in their collections. A total of 162 woylies are currently held in 33 zoos registered with the International Species Information System (Table 9).

Table 9: Locations and numbers of *B. penicillata* held in captive collections in Australia and around the world (Data sourced from the International Species Information System, www.isis.org on 21 December, 2006).

Country	Institution Name	Males	Females	Total
Australia	Perth Zoological Gardens (WA)	0	2	2
Australia	Adelaide Zoo (SA)	0	3	3
Australia	Monarto Zoological Park (SA)	1	0	1
Australia	Alice Springs Desert Park (NT)	2	6	8
Australia	Western Plains Zoo (NSW)	1	0	1
Australia	Sydney Aquarium (NSW)	4	2	6
Netherlands	Dierenpark Amersfoot	1	3	4
France	Zoo Parc de Beauval	3	0	3
Slovakia	Zoologicka Zahrada Bratislava	0	1	1
Czech Republic	Zoologica Zahrada Mesto Brna	2	3	5
Czech Republic	Zoological and Botanical Garden Plzen	4 +?1	6 +?1	11
Czech Republic	Zoolocal Garden Prague	3	4	7
Czech Republic	Zoologicka Zahrada Olomouc	0	1	1
Hungary	Budapest Zool. And Botanical Garden	1	3	4
Germany	Zoo Dortmund	1	3	4
Germany	Zoo Duisburg AG	3	12	15
Poland	Miejski Ograd Zoologiczny w Lodz	1	4	5
Israel	Zoological Center Tel Aviv Ramat Gan	?	?	2
Latvia	Riga Zoo	1	2	3
United Kingdom	South Lakes Wild Animal Park	1	8	9
USA	Gladys Porter Zoo	5	3	8
USA	Lincoln Park Zoological Gardens	0	1	1
USA	Cleveland Metropark Zoo	1	3	4
USA	Lake Superior Zoological Gardens	1	0	1
USA	Mesker Park Zoo	1	1	2
USA	Los Angeles Zoo and Botanical Gardens	3	1	4
USA	Kangaroo Conservation Center	12	13	25
USA	Wildlife World Zoo	2	0	2
Canada	Toronto Zoo	2	0	0
Japan	Saitama Children's Zoo	2	2	4
Japan	Osaka Municipal Tennosi Zoological Gdns	1	4	5
Japan	Tama Zoological Park	1	3	4
Japan	Ueno Zoological Park	4 +?1	2 +?1	7
			TOTAL:	**162**

Woylies are also kept in private collections and by wildlife carers. In Western Australia and South Australia, a license is required for individuals or private organisations to keep woylies. A summary of licenses currently issued in Western Australia is contained in Table 10.

Table 10: People, or organisations that they belong to, that are licenced to keep woylies under the Western Australian Wildlife Conservation Act (as at 5/1/2007).

Organisation	Number of woylies held	Individual	Number of woylies held
Chidlow Marsupial Hospital	1	R Reynolds	5
Wilderness Wildlife Park	3	L Harrison	2
Wave Rock Wildlife Park	12	B Giles	3
West Coast Wildlife Park	5	G Doyle	2
Quindalup Fauna Park	2	S Davies	3
Caversham Wildlife Park	17		
Kooikuna Wildlife Park	1		

In South Australia, for the financial year ending 30/06/2006 there were 75 permit holders keeping a total of 871 woylies in captivity.

The total number of woylies in captivity around the world therefore exceeds 1000 individuals.

Apart from zoos and private collections other non-natural occurrences have been established by translocation to parts of the species former range. Table 11 summarises woylie reintroductions that have been undertaken.

Table 11: Summary of woylie reintroductions in Australia.

State	Release Site	Release Years	Source Sites	Number released	Outcome
NSW	Genaren Hills, NSW	1998-1999	Dryandra, Karakamia Sanctuary	24	Failed
NSW	Yathong NR, NSW	2001	Venus Bay, St Peter Is, Dryandra	85	Failed
NSW	Scotia Stage 1	2004-2005	Scotia Sanctuary	164	Indeterminate
SA	Bird Club Island	1979	Para Wirra	6	Failed
SA	Flinders Ranges NP, Pantapinna Plain	1999-2001	Wedge Island, St Peter Island, Venus Bay	71	Failed
SA	Flinders Ranges NP, Wilpena Pound	2000	St Peter Island, Venus Bay	26	Failed
SA	Island A, Venus Bay	1980	Para Wirra	7	Successful
SA	Katarapko Island	1999	Wildlife carer	21	Failed
SA	Lincoln National Park	1999-2001	Venus Bay, St Peter Island	113	Indeterminate
SA	Reny Island, Calpernum Station	2001		21	Failed
SA	St Francis Island	1981-1987	Para Wirra, Venus Bay "Island A"	129	Failed
SA	St Peter Island	1989-1996	Adelaide Zoo, Roseworthy, Flinders University, Monarto Zoo, CSIRO, Dryandra	127	Successful
SA	Un-named Island in Baird Bay	1982	Venus Bay "Island A"	10	Failed
SA	Venus Bay Peninsula	1994-1995	Dryandra	67	Successful
SA	Wedge Island	1983-1995	Para Wirra, Dryandra	36	Successful
SA	Yookamurra Sanctuary	1991-1998	SA Museum, Venus Bay, Warrawong	84	Indeterminate

State	Release Site	Release Years	Source Sites	Number released	Outcome
WA	Amphion Forest Block	1995	Dryandra	25	Indeterminate
WA	Avon Valley NP	2002-2004	Karakamia Sanctuary, Wildlife carer	82	Indeterminate
WA	Batalling Forest	1982	Perup	52	Successful
WA	Boyagin NR East	1992	Dryandra	20	Successful
WA	Boyagin NR West	1992	Dryandra	20	Successful
WA	Boyndaminup Forest	2002	Perup	21	Indeterminate
WA	Bunnings (Site 1)	1995	Dryandra	31+	Indeterminate
WA	Bunnings (Site 2)	1995	Dryandra	20+	Indeterminate
WA	Cameron	1995	Dryandra	22	Indeterminate
WA	Centaur Forest	1998	Batalling Forest	39	Indeterminate
WA	Chalk	1995-1996	Dryandra	19+	Indeterminate
WA	Curara	1995	Dryandra	28	Indeterminate
WA	Davis State Forest	2000	Batalling Forest	37	Indeterminate
WA	Denmark Forest	1998	Perup	38	Failed
WA	Dobaderry NR	1995	Dryandra	27	Indeterminate
WA	Driver Forest Block	2002	Batalling Forest	71	Indeterminate
WA	Easter and Barlee SF	1998	Perup	40	Indeterminate
WA	Flybrook	2002	Perup	40	Indeterminate
WA	Francois Peron NP	1997-2000	Dryandra, Batalling	147	Indeterminate
WA	George	1995	Dryandra	34+	Indeterminate
WA	Giants Forest	1999-2000	Perup, Wildlife carer	48	Indeterminate
WA	Hadfield Forest	2000	Batalling Forest	29	Indeterminate
WA	Hills Forest	1996-1998	Dryandra	37	Failed
WA	Julimar Forest (Site 1)	1995	Perup	39	Failed
WA	Julimar Forest (Site 2)	2004	Batalling Forest, Karakamia Sanctuary	40	Indeterminate
WA	Kalbarri NP (N Junga)	2000	Dryandra	32	Indeterminate
WA	Kalbarri NP (S Junga)	2004-2005	Batalling Forest, Karakamia Sanctuary	81	Indeterminate
WA	Karakamia Sanctuary	1994-2004	Dryandra, Boyagin NR, Batalling, Perup, Manjuimup, Julimar, Wildlife carer'	41	Successful
WA	Lake Magenta NR	1997	Dryandra	37	Failed
WA	Leona	1995	Dryandra	29	Indeterminate
WA	Nambung National Park	2004-2005	Batalling Forest, Karakamia Sanctuary	64	Indeterminate
WA	North Karlgarin Nature Reserve	2005	Karakamia Sanctuary	40	Indeterminate
WA	O'Neil	1995	Dryandra	21	Indeterminate
WA	Paruna Sanctuary	2000-2006	Wildlife carer, Karakamia, Dryandra	360	Indeterminate
WA	Poorginup and Chitelup SF	1998	Perup	40	Indeterminate
WA	Proposed Wellington National Park	2002	Batalling Forest	95	Indeterminate
WA	Randall	1995	Dryandra	25	Indeterminate
WA	Shannon NP	2000	Perup	43	Indeterminate
WA	St Johns Forest (Site 1)	1983	Perup	67	Failed
WA	St Johns Forest (Site 2)	1998	Perup	39	Failed

State	Release Site	Release Years	Source Sites	Number released	Outcome
WA	Stene (Site 1)	1995-1996	Dryandra	21+	Indeterminate
WA	Stene (Site 2)	1995-1996	Dryandra	20+	Indeterminate
WA	Strickland FB	2000	Perup	40	Indeterminate
WA	Sullivan	1995	Dryandra	25	Indeterminate
WA	Sunnyvale	2000	Batalling Forest	19	Indeterminate
WA	Surface	1995-1996	Dryandra	24+	Indeterminate
WA	Taree	1995	Dryandra	35+	Indeterminate
WA	Thames Forest	2002	Perup	37	Indeterminate
WA	Wearne (Site 1)	1995	Dryandra	26	Indeterminate
WA	Wearne (Site 2)	1995	Dryandra	22	Indeterminate
WA	Wellington NP	2000	Batalling Forest	30	Indeterminate
WA	Wildwater	2000-2002	Batalling Forest, Wildlife carer	33	Successful
WA	Yendicup Forest Block	1977	Perup	53	Successful
			TOTAL:	**3396+**	

A translocation proposal has been written to reintroduce woylies to Corackerup Nature Reserve in Western Australia, but has not yet been implemented due to the current lack of a suitable source subpopulation. It is also considered necessary to top-up the subpopulations being established at North Karlgarin Nature Reserve and Nambung National Park.

The recovery plan for the woylies identified several translocation sites. It identified Venus Bay "Island A", Baird Bay unnamed island, Wedge Island, St Peter Island and Yookamurra Sanctuary as current translocation sites, and Julimar SF and Venus Bay Conservation Park as possible new translocation sites (Start *et al*. 1995). Woylies have now been released to all these sites.

Other woylie reintroduction sites are identified in the draft strategic plan for the *Western Shield* program in the tables listing species for reintroduction at the various fauna reconstruction sites and fauna recovery sites (see Department of Conservation and Land Management, 1999).

How many locations do you consider the species occurs in and why?

For flora, and where applicable, for fauna, detail the location, land tenure, estimated number of individuals, area of occupancy, and condition, for each known location or occurrence.

The woylie is currently known to occur at 21 locations (1 in New South Wales, 5 in South Australia and 15 in Western Australia). Locations have been identified using the definition contained in IUCN (2001). Subpopulations on islands and isolated reserves have been treated as separate locations because separate threatening events could affect all individuals present at each of these sites. Woylie subpopulations in the contiguous forest of southwest Western Australia are more difficult to separate into locations because different threatening events affect subpopulations at different scales. For the purpose of this review the forest subpopulations have been treated as four locations of occurrence. These are: the northern and central jarrah forest (reintroduced), the sunklands and Pemberton area (reintroduced), Walpole/Denmark area (reintroduced) and the Perup/Lake Muir area (extant subpopulation extended by reintroductions). The species is known from greater than 10 locations and therefore does not meet IUCN criteria under criterion B2 (version 3.1).

A criterion for success in the recovery plan (see Start *et al*. 1995), for the species in South Australia, was the maintenance of two island populations [subpopulations] (Wedge and St Peter) and the establishment of at least one mainland population [subpopulation] in addition to Yookamurra. Whilst the subpopulations at Wedge and St Peter appear stable, additional mainland subpopulations have

proven more difficult to establish. The population at Yookamurra is persisting but fox and cat incursions have severely impacted the occurrence (J. Bentley, 1/2/2007). Failed (or near failed) reintroduction attempts have been made to Lincoln National Park and Flinders Ranges National Park. The subpopulation established on Venus Bay peninsula underwent a rapid decline in 2005/06, the cause of which is currently unknown (D Armstrong pers. comm. 6/12/2006). **The woylie therefore no longer meets this criterion for recovery.**

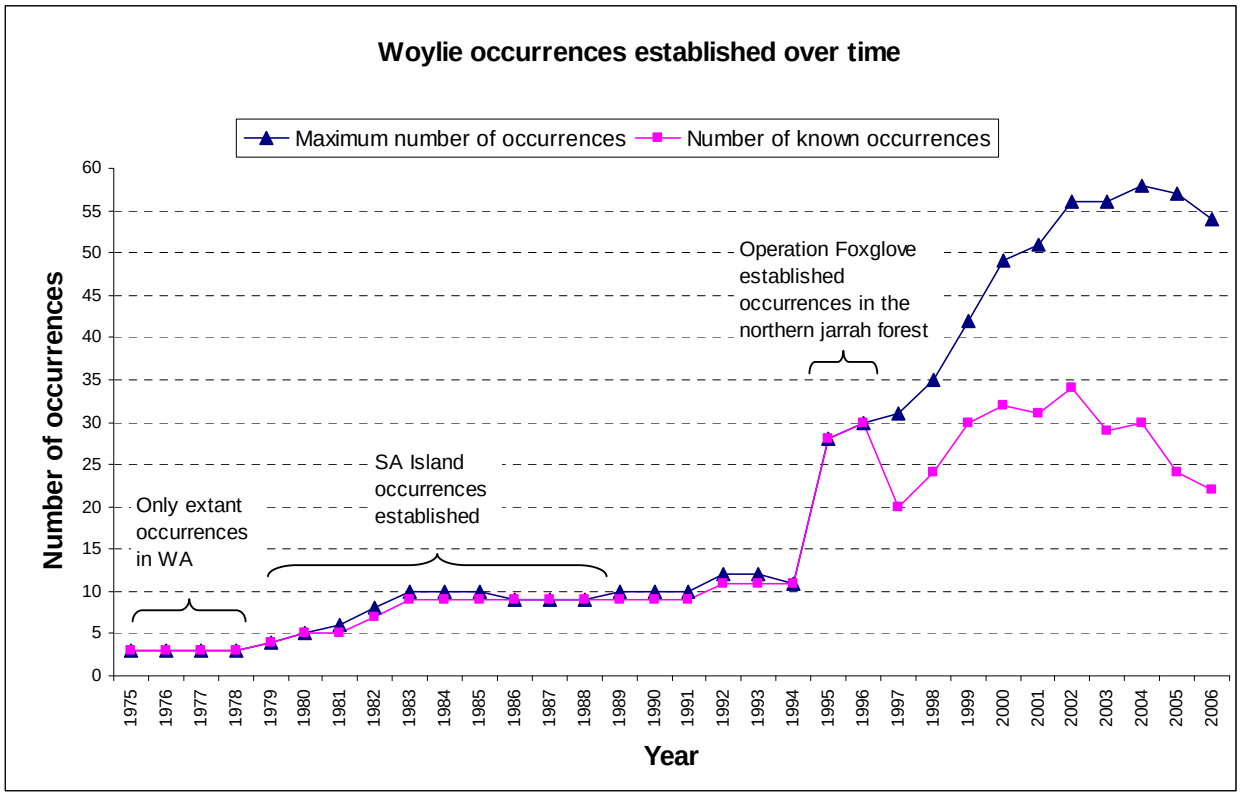
Has the number of individuals been counted ☐, or is this an estimate ☐. Provide details of the method of determining the number of individuals.

See previous section

Has there been any known reduction in the number of locations, or is this likely in the future? – give details.

The number of woylie occurrences has increased since the species was delisted in 1996. Figure 5 shows the number of woylie occurrences established over time. Known occurrences were added when a reintroduction took place and removed if no woylies were captured at the site for at least five years. The first peak (1995/1996) in the number of known occurrences is a result of translocations of woylies to various sites in the northern jarrah forest under Operation Foxglove. Recent monitoring results are unavailable for these sites and so they form the largest contribution to the difference between the number of known occurrence and the maximum number of occurrences. The overall trend has been for the number of occurrences to increase, but over the last five years a decline is becoming apparent in both the number of animals at each location and in number of occurrences where their presence can be confirmed.

Figure 5: Number of Woylie occurrences established over time in Australia.



In Western Australia, rapid declines in trap success over the last five years have been observed for 12 monitoring sites representing five locations. These rapid reductions could lead to local extinctions.

What is the extent of occurrence (in km^2) for the species; explain how it was calculated and datasets used. If an accurate estimate is unavailable provide a range of values or a minimum or maximum area estimate.

The current extent of occurrence of the woylie is estimated to be 18 300km^2. This was estimated by constructing a minimum convex polygon around records in the contiguous forest of southwest Western Australia and adding the total area of isolated reserves and islands on which the species is known to occur throughout Australia. As shown in Figure 6 the extent of occurrence in the forest was separated into four locations; the northern jarrah forest (reintroduced), the sunklands and Pemberton (reintroduced), Denmark/Walpole area (reintroduced) and the Perup/Lake Muir area (extant subpopulation extended by reintroductions). Records of occurrence in the forest were obtained from the Translocations Database, which contains information on the movement of animals for conservation purposes, and from the Threatened and Priority Fauna Database, which contains records from a variety of sources and including sighting records, roadkills and museum specimens. Only records with a high or moderate certainty of correct identification and more recent than 1995 were used to construct the polygons.

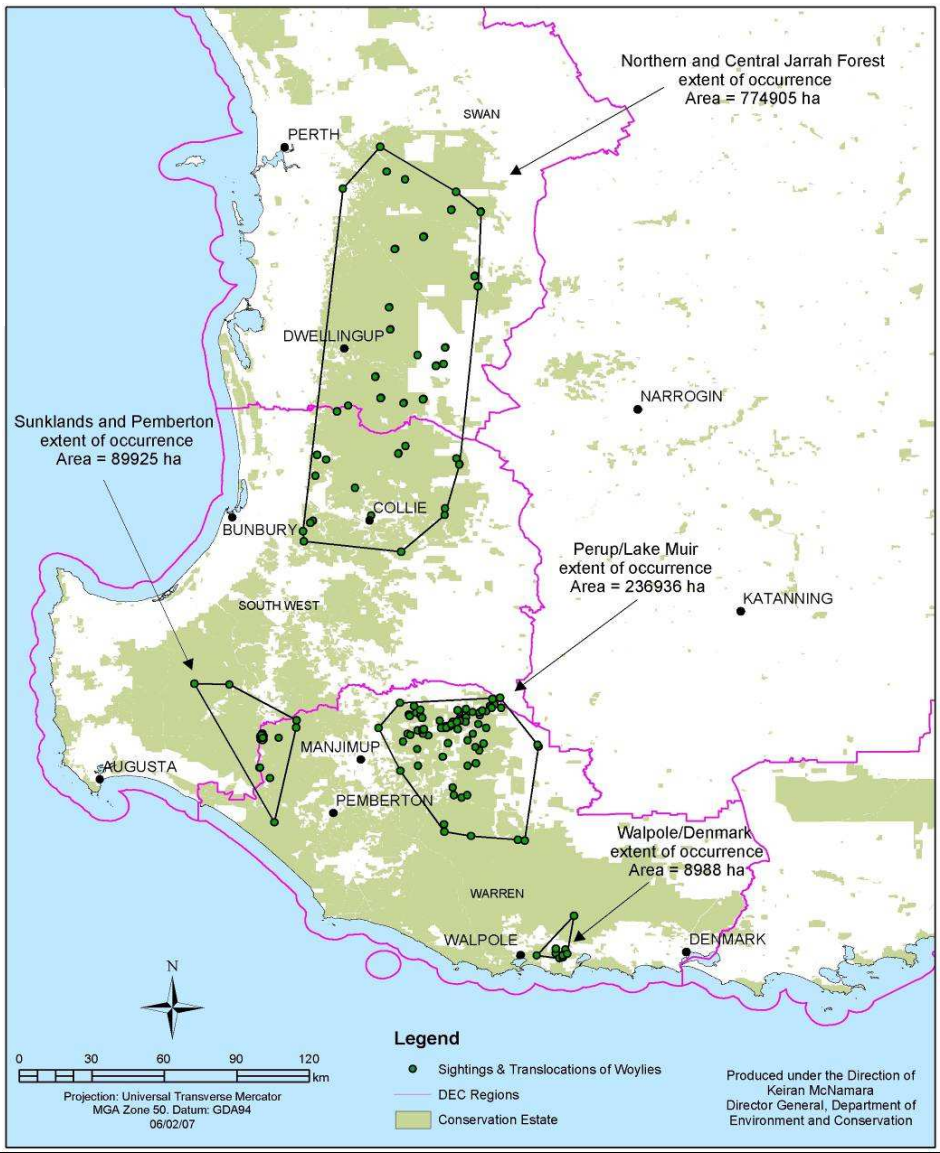


Figure 6: Extent of occurrence minimum convex polygons for the contiguous forest of southwest Western Australia.

The differences in estimated extent of occurrence over time are presented in Table 12 and are more reflective of differences in how the estimates were calculated than actual changes in extent of occurrence over time. However, it is clear that the historic extent of occurrence is far greater than the existing extent of occurrence.

Table 12: Extent of occurrence estimates for the woylie.

Year	Extent of occurrence (km^2)	Reference
Historic	1 771 786	Lomolino and Channell, 1995 using information contained in Strahan, 1983.
Extant (as at 1983)	53 451	Lomolino and Channell, 1995 using information contained in Strahan, 1983.
1992	Less than 1% of its former range	Nelson *et al*. 1992
1995	17 000 (WA only)	Start *et al*. 1998
2006	18 300	This nomination

To be listed as Vulnerable according to IUCN criteria, a species with an extent of occurrence of less than 20 000 km^2 and a continuing decline in extent of occurrence, area of occupancy or number of mature individuals must also be severely fragmented (known from less than 10 locations) or it must demonstrate extreme fluctuations. The distribution of the woylie cannot be considered threatened through fragmentation because it is known from more than 10 locations. Evidence for extreme fluctuations is discussed below.

Some evidence for periodic fluctuations in woylie abundance over a long time frame is available for the Perup area. A severe decline in the abundance of woylies was observed in the early 1970's, followed by a rapid increase, so rapid that Christensen *et al.* (1985) predicted that a severe drop in numbers was inevitable in the near future. Christensen *et al.* (1985) suggested that the woylie may be a species that undergoes cyclic fluctuations in numbers. Woylies may reach numbers at which the carrying capacity of their habitat is exceeded after which the population size rapidly decreases before an equilibrium is ideally reached sometime in the future. An historical account of changes in abundance of woylies is provided by WG Pearce (see folio 14-16 of departmental file 017465F3807) who reports that woylies were plentiful in the Mt Barker district around 1902 but disappeared around 1903/1904 (cause unknown). They were seen again around 1929 prior to the arrival of the fox but disappeared again once the fox was established. Other historical accounts indicate woylies once occurred in high numbers at some localities (e.g. Shortridge, 1909; Wood Jones, 1925).

Woylies are highly fecund and respond quickly to changes in their environment (e.g. removal of predators under the *Western Shield* program). However, when considering cyclic changes in abundance, most occurrences of woylie have been studied for a relatively short period of time (most since the mid-1990's). It is possible for cycles to take many years and the length of time we have been observing woylies may not have allowed repetition of cycles to be observed and therefore attempt to understand the factors involved. For comparison, cycles in the much-studied snowshoe hare and coyote/lynx abundance occur every 8-11 years (O'Donoghue *et al*. 1997). The majority of woylie reintroductions have been to a modified landscape with introduced predators and so it is likely that any possible natural cycle in abundance over time have been disrupted. Cyclic patterns are also not known in sympatric and analogous species.

The woylie has an extent of occurrence of less than 20 000 km^2 and there is evidence for a continuing decline, however, the woylie is known from greater than 10 locations and cyclic or extreme fluctuations in woylie abundance cannot clearly be demonstrated. The woylie therefore, does not qualify for listing as Vulnerable under IUCN criterion B1 (version 3.1).

What is the area of occupancy (in km^2) for the species; explain how it was calculated and datasets used. If an accurate estimate is unavailable provide a range of values or a minimum or maximum area estimate.

The current area of occupancy of the woylie is estimated to be between 5 600 km^2 and 6 800 km^2. These estimates were derived from a GIS analysis using 5 km^2 and 10 km^2 grid squares respectively, in which the woylie is known to occur based on records in the Threatened and Priority Fauna Database and translocation release sites for the forest areas of southwest Western Australia, and adding the total area of isolated reserves and islands on which the species is known to occur. The 1995 area of occupancy was estimated using all pre-1995 records and the 2006 area of occupancy was estimated using post, and including, 1995 records.

Area of occupancy is particularly scale dependent and difficult to estimate. Consideration was given to home range size when deciding on the grid square size. It is likely that the values in Table 13 are overestimates because woylies are not evenly distributed across isolated reserves and islands for which the total area of these locations has been used.

Table 13: Area of occupancy estimates for the woylie in Australia.

Year	Area of isolated reserves & islands occupied (km^2)	Area of forest in SW WA occupied (km^2)	Total area of occupancy (km^2)	Reference
1995	-	-	Probably exceeds 2000	Start *et al.* 1998
1995	248	575 (using 5 km^2 grid squares) 1 800 (using 10 km^2 grid squares)	800 (using 5 km^2 grid squares) 2 000 (using 10 km^2 grid squares)	This nomination
2006	3898	1 675 (using 5 km^2 grid squares) 2 900 (using 10 km^2 grid squares)	5 600 (using 5 km^2 grid squares) 6 800 (using 10 km^2 grid squares)	This nomination

An area of occupancy of less than 2 000km^2 is required for the woylie to be considered for listing as Vulnerable using IUCN criteria (version 3.1). The woylie therefore doesn't meet criteria for listing under IUCN criterion B2 (version 3.1).

Is the distribution of the species severely fragmented? Why?

The distribution of the woylie is severely fragmented in South Australia where it occurs on islands and isolated reserves. In Western Australia it occurs in isolated reserves and at numerous locations in the contiguous forest of southwest Western Australia. Whilst the habitat in the forest may be contiguous, some translocated woylie subpopulations are effectively isolated because of the distances between known subpopulations.

However, the species does not meet IUCN criteria relating to fragmentation because some subpopulations estimated to contain greater than 1000 mature individuals are known and the number of locations is greater than ten.

Identify important occurrences necessary for the long-term survival and recovery of the species? This may include: key breeding populations, those near the edge of the range of the species or those needed to maintain genetic diversity.

Occurrences at Perup, Dryandra Woodland and Tutanning Nature Reserve are considered the most important because these are the original occurrences. All other occurrences have been reintroduced using animals sourced from these occurrences.

The species recovery plan identifies Batalling Forest, Boyagin Nature Reserve, Dryandra Woodland, Julimar Forest, Perup and Tutanning Nature Reserve as key sites for recovery of woylies. Of these subpopulations, Batalling, Dryandra and Perup have declined by more than 50 % (Figures 7, 8 and 9). Boyagin has also declined but to a lesser extent (Figure 10). The reintroduced population at Julimar appeared to have failed and additional animals were released in 2004. Woylies currently persist at Julimar but trap success remains below 3% (Figure 11). The population at Tutanning appears stable at less than 10% trap success (Figure 12).

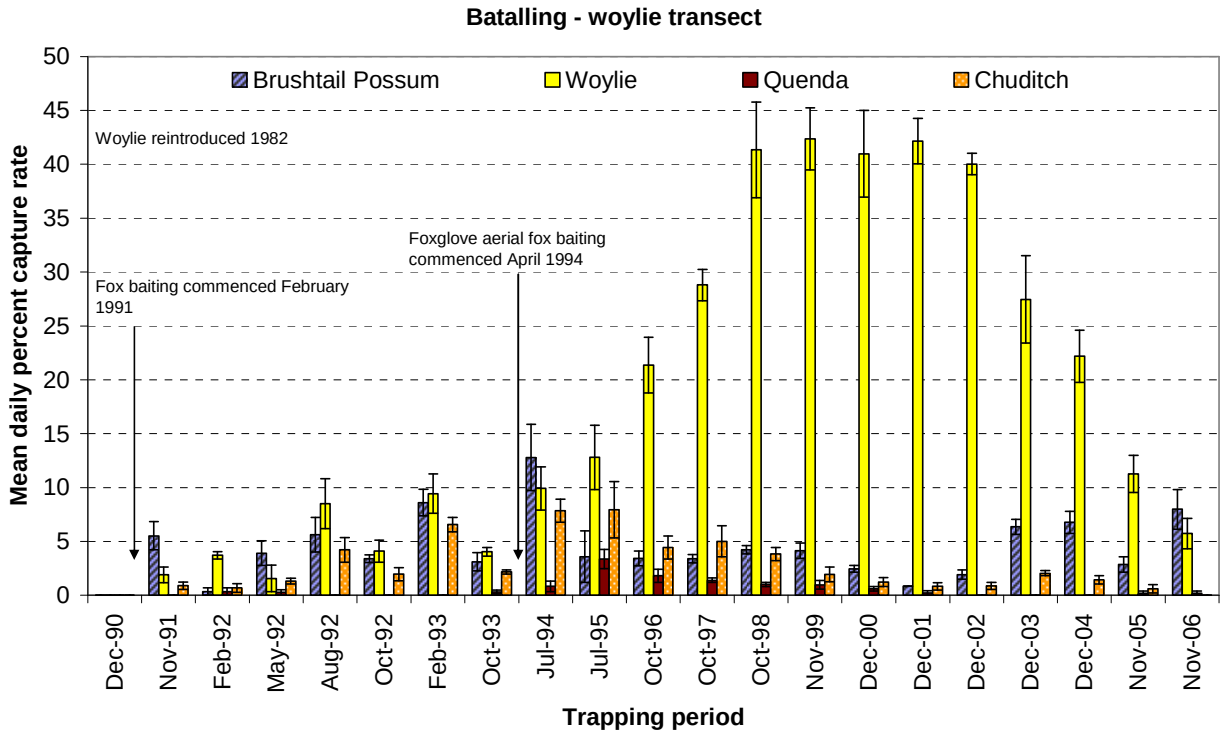


Figure 7: Woylie traps success rates at Batalling, east of Collie.

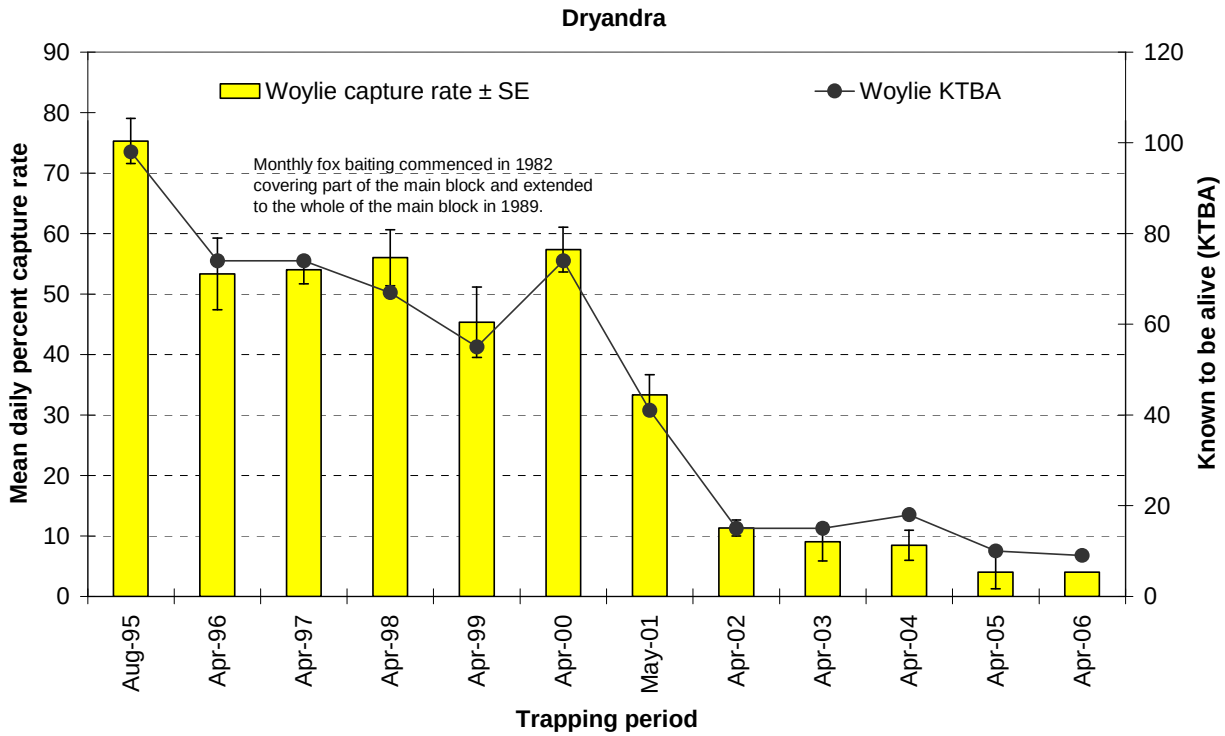


Figure 8: Woylie trap success rates for Dryandra Woodland.

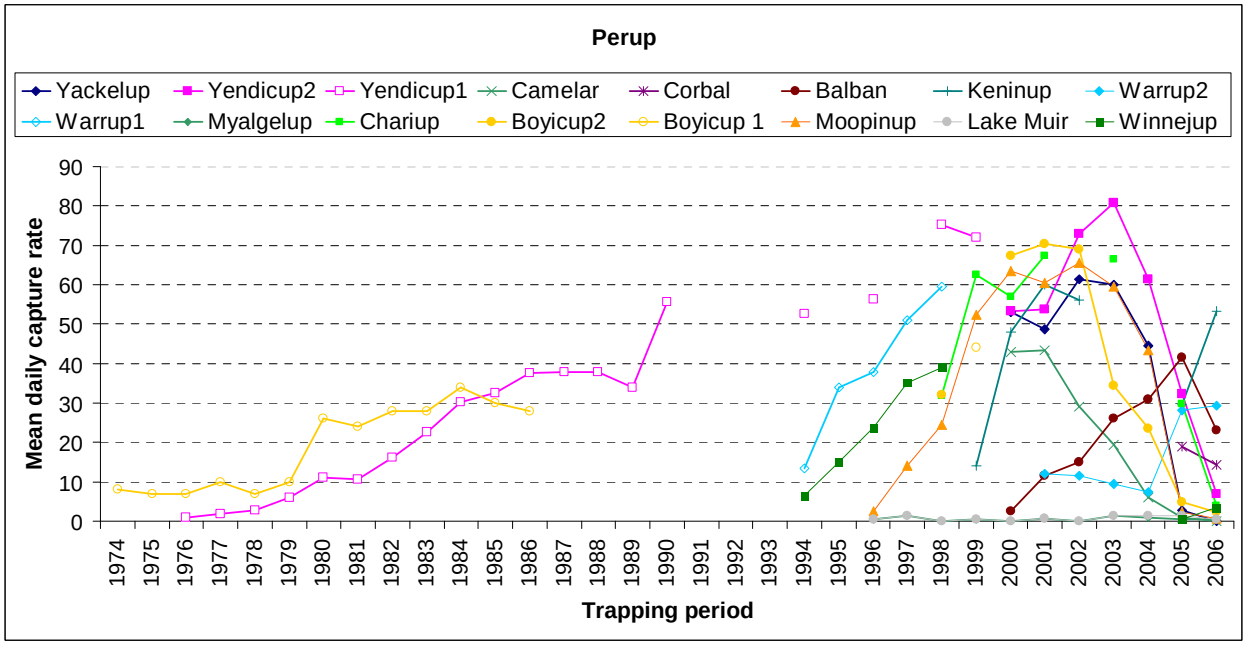


Figure 9: The annual average percentage trap success rates for woylies along transects in the Perup/Lake Muir area, east of Manjimup. (Data courtesy of Adrian Wayne and includes contributions from Donnelly District, Per Christensen, Neil Burrows, Graeme Liddelow, Bruce Ward, Adrian Wayne, Kingston Project and Forest Management Course).

Note: Transect names with suffix 1 and 2 distinguish relatively similar transects within the same area surveyed with slightly different methodologies (ie slightly different transect locations, trapping frequency etc).

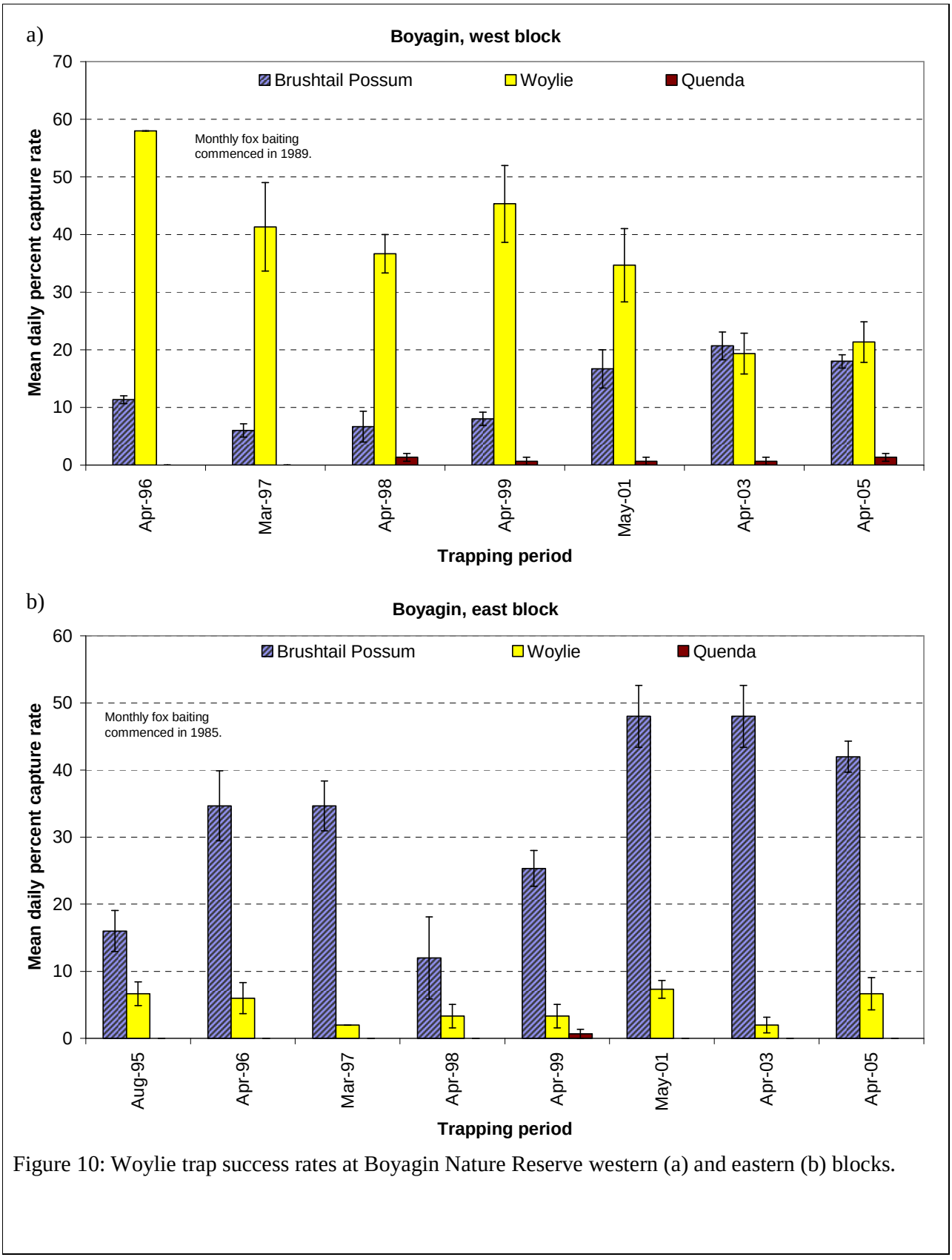


Figure 10: Woylie trap success rates at Boyagin Nature Reserve western (a) and eastern (b) blocks.

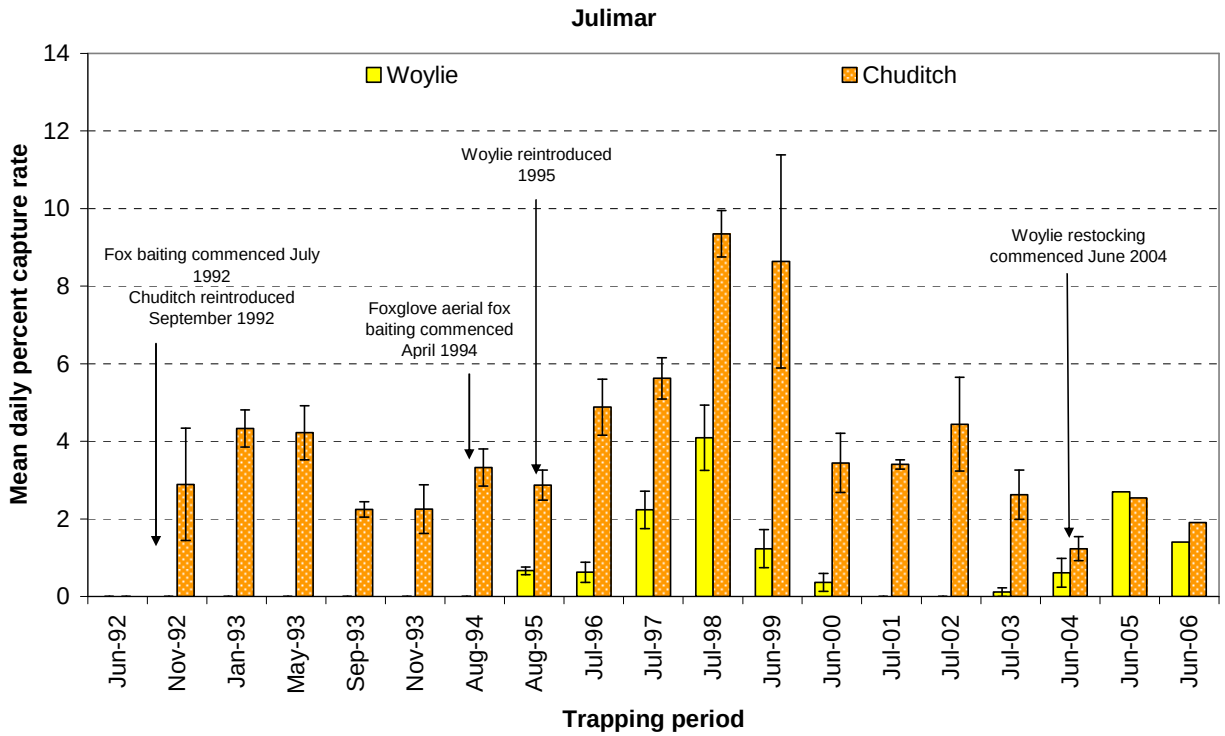


Figure 11: Woylie trap success rate for Julimar State Forest.

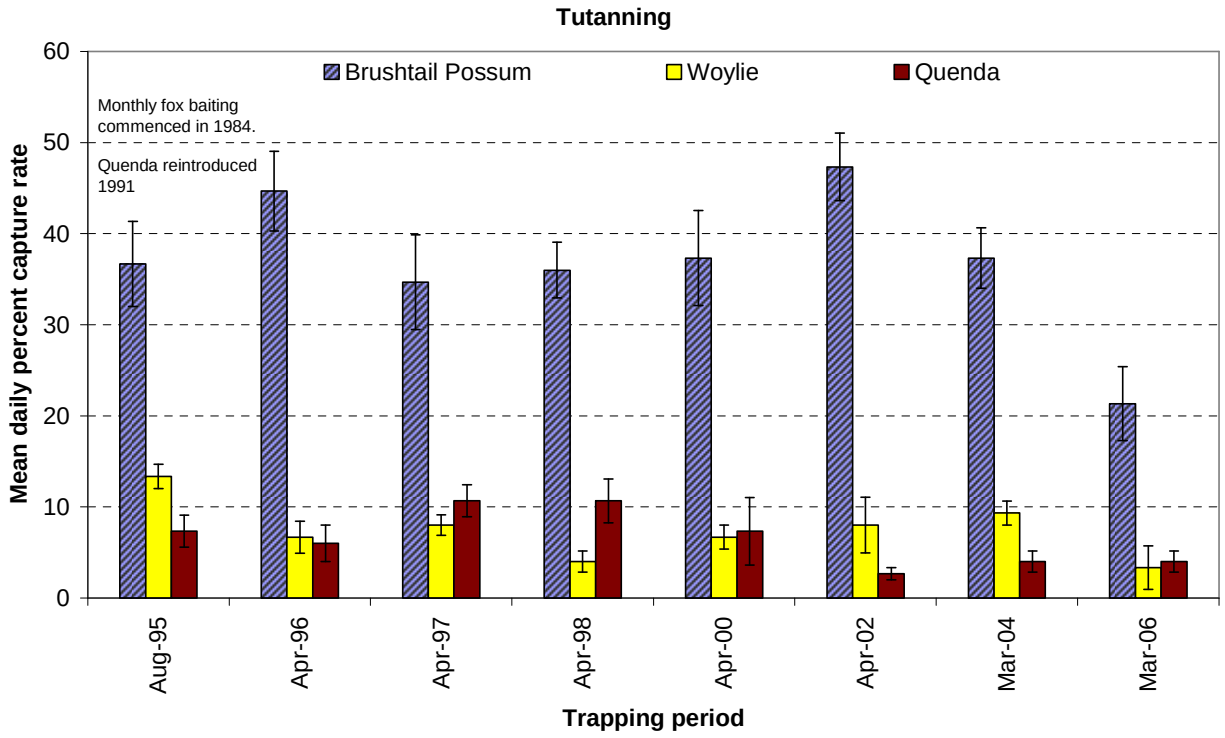


Figure 12: Woylie trap success rate for Tutanning Nature Reserve, east of Pingelly.

One of the criteria for success in the recovery plan for South Australian populations was for a population on the mainland, in addition to Yookamurra, to be established. The reintroduction to Venus Bay Peninsula has been the most successful of South Australia's mainland reintroductions, however, a rapid decline was observed between late 2005 and mid 2006 (Figure 13).

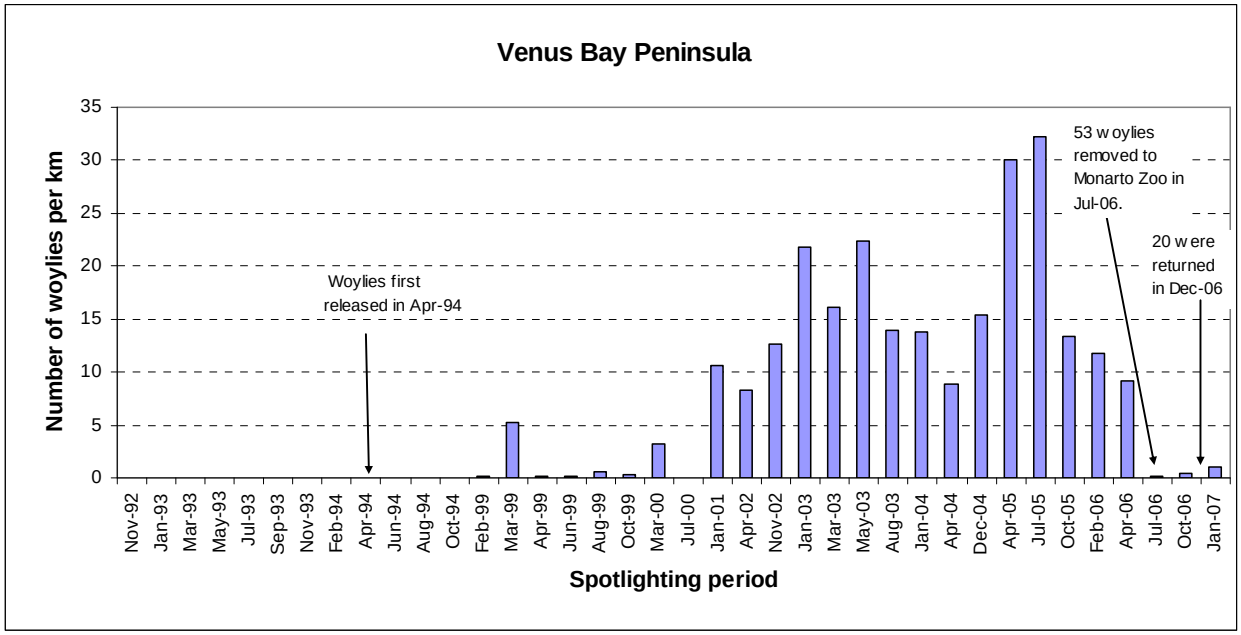


Figure 13: Number of woylies sighted per kilometre during spotlighting monitoring at Venus Bay Peninsula (Data courtesy of Dave Armstrong, Department for Environment and Heritage).

Island subpopulations in South Australia and the fenced population at Karakamia Sanctuary in Western Australia appear to be the largest, most secure, subpopulations at present. However, all island population in South Australia were established using animals originating from a small number held at Perth Zoo. The genetic diversity of these island occurrences have been shown to be considerably less than that of mainland Western Australian occurrences (e.g. “Island A”, St Peter Island and Wedge Island). Several attempts to add stock to South Australian island occurrences in the mid-1990’s appear to have been largely unsuccessful.

4.2. Survey effort

Describe the methods to conduct surveys. For example, (e.g. season, time of day, weather conditions); length, intensity and pattern of search effort (including where species not encountered); any limitations and expert requirements.

The most common method of monitoring woylie occurrences is by trapping. Woylies are readily trapped in small cages traps (e.g. Sheffield wire cage traps) baited with a mixture of rolled oats, peanut butter and sardines. Traps are usually placed at set intervals (usually 200m) along tracks in the study site but sometimes are set in a grid pattern. Woylies are noctural and so traps are set overnight and checked early in the morning. Trapping may be conducted at anytime of the year but consideration must be given to the weather conditions (e.g. too hot or too wet). There is no period to avoid trapping based on developmental stage of young, because they are asynchronous breeders. Given that woylies have been demonstrated to become increasingly trappable over time (Wayne, Williams and Mellican, unpublished data), the frequency of trapping is likely to influence trap success rates to some extent.

Woylies are prone to injury in the trap and to the ejection of young from the pouch. Trained persons are therefore required to conduct surveys for woylies via trapping.

Spotlighting is also used in some cases, especially where trap success (and therefore trap saturation) is high (e.g. Karakamia Sanctuary). Walking or driving transects may be used.

Diggings may also be used to determine the presence of woylies in an area but correct identification of diggings requires an experienced observer.

Give details on the distinctiveness and detectability of the species, or the distinctiveness of its habitat, that would assist survey success.

Woylies are easily trapped, relative to other small to medium sized mammals in southwestern Australia, if the traps are placed within the home range of individuals. They are not easily confused with other species.

Woylies build distinctive but well hidden nests, most commonly under dense bushes and these may be observed to determine the presence of the species. In jarrah forest woylies may be detected by observing bark strands removed from around the base of jarrah trees which is used in the construction of its nest.

Woylies contribute significantly to soil turn-over by their digging activities in search of food. Woylie diggings may be confused with other species, such as those by quenda, but with experience their presence can be detected by the presence of fresh diggings.

Woylies occur in a variety of habitats which makes it difficult to predict their likely presence based on habitat information.

Has the species been reasonably well surveyed? Provide an overview of surveys to date (include surveys of known occurrences and surveys for additional occurrences) and the likelihood of its current known distribution and/or population size being its actual distribution and/or population size. Include comments on potential habitat and surveys that were conducted, but where the species was not present/found.

The woylie has been the subject of a large number of research and conservation efforts. It is considered that its distribution is well known.

Woylie subpopulations are known to persist at undetectable levels. At these locations, considerable effort is required to confirm the presence/persistence of the species. For example, woylies have been reported as present within Fitzgerald River National Park (see Aitken, 1954 and sighting by SD Hopper and R Smith in the Threatened and Priority Fauna Database dated 1987). However, they have never been trapped on the two transects regularly trapped as part of the *Western Shield* program (ie 8340 trap nights between 1997 and 2006). At Julimar Forest, the woylie translocation was assumed to have failed following a steady decline in trap success (and corresponding high trap success for chuditch). By 2002, no woylies had been trapped for two years and in 2003 a single woylie was captured just prior to an additional release of woylies into the reserve. At Kalbarri National Park trap success on the monitoring transect was nil following release, however, radio-telemetry data indicated that the closest woylie was 500m from the trap line (P. Orell pers. comm 06/02/2007). Targeted trapping was then able to capture woylies.

In Western Australia, there are 40 transects that are regularly monitored (usually annually) under the *Western Shield* program (Orell, 2004) of which 23 are known to capture woylies. In addition to these sites, a total of 10 transects setup to monitor reintroduced woylie populations have also been monitored. A further 9 transects, primarily setup for research purposes, also capture woylies. The results from these 42 monitoring sites form the basis for assessing the conservation status of the species in Western Australia. Monitoring information was also gathered from sites in South Australia (13) and New South Wales (3). A summary of woylie monitoring effort is contained in Appendix II

4.3. Threats

Identify past, current and future threats indicating whether they are actual or potential. For each threat describe:

1. How and where they impact this species.

2. What the effect of the threat(s) has been so far (indicate whether it is known or suspected; present supporting information/research, does it only affect certain populations?).

3. What is its expected effect in the future (is there supporting research/information; is the threat only suspected; does it only affect certain populations?).

If possible, provide information threats for each occurrence/location:

Past threats:

Many factors are likely to have contributed to the decline of the woylie in different areas. Historically habitat alteration through land clearing, grazing and altered fire regimes have reduced the area of suitable habitat available to the species. Disease may also be implicated in their decline. Surviving occurrences and reintroduced occurrences are now present primarily on conservation estate.

Introduced predators such as the European fox and feral cat are likely to have reduced the distribution of the species and declines in some areas have been linked to the arrival of these predators. Introduced predators have been implicated as the cause of several failed reintroduction attempts. Cats were identified as the main cause of mortality of reintroduced woylie subpopulations at Yathong in New South Wales (Priddel and Wheeler, 2004) and Lincoln National Park in South Australia (James *et al*. 2002). Cats were actually deliberately introduced to St Francis Is by the family who first settled the island to exterminate the woylies who were doing damage to garden produce (Wood Jones, 1925). Predation by dogs was considered the cause of the failed reintroduction of woylies to Bird Club Island in South Australia (Delroy *et al*. 1986). Fox predation has been implicated in the failed reintroduction to Baird Bay unnamed island (Department for Environment and Heritage, 2006).

Native predators also impact on the persistence of small and establishing occurrences, especially where the ecosystem has been significantly altered. Predation by carpet pythons and white-breasted sea-eagles (*Haliaeetus leucogaster*) has been implicated in the failed woylie translocation to St Francis Island in South Australia (Department for Environment and Heritage, 2006) and wedgetail eagle (*Aquila audax*) predation contributed to the failed reintroduction to the Flinders Ranges in South Australia (Bellchambers, 2001).

Competition for resources with grazing species such as the rabbit and other stock may also have been a factor in the decline of the woylie, particularly in more arid areas.

Current threats:

Threats that are currently being investigated as possible causes of the recent woylie declines are described below (see also Wayne *et al*. 2006 in Appendix III).

Predators

Introduced feral predators, in particular the European red fox and feral cat are considered one of the greatest threats to the survival of woylie occurrences. In Western Australia, woylie subpopulations demonstrated spectacular recovery following the implementation of widescale fox baiting under the *Western Shield* program in 1996. The cause of recent declines is unknown, but could be a result of changed interactions between predators or abundance of predators. For example removal of foxes may have resulted in an increase in cat numbers that were previously limited by fox predation. Also, the abundance of native animals that may either eat the baits or move them to where foxes are unable to take them is likely to have increased at some sites (e.g. varanids and brushtail possums). This kind of bait take hampers the effectiveness of the current baiting density and frequency to reduce introduced predator numbers.

Native predators such as the carpet python (*Morelia spilota*) and large birds of prey may also impact on popuations of woylies.

Resources

A contributing factor to the recent decline in woylies could be a result of changes in the abundance, availability and/or suitability of resources such as water, food, shelter, reproductive mates and space (e.g. territories). These changes may be caused by environmental factors such as reduced rainfall or biological factors such as the woylie exceeding carrying capacity of its habitat.

Climate change may alter the availability of resources as rainfall and temperature patterns change, thereby acting as a threatening process. In South Australia the Venus Bay area experienced six frosts over a seven night period in 2006 in comparison with only one frost in the area in the three previous winters (D. Armstrong pers. comm. 6/12/2006). This has been implicated as a possible factor in the recent significant decline in the woylie subpopulation at Venus Bay. Rainfall in the southwest of Western Australia is declining as shown in Figure 14.

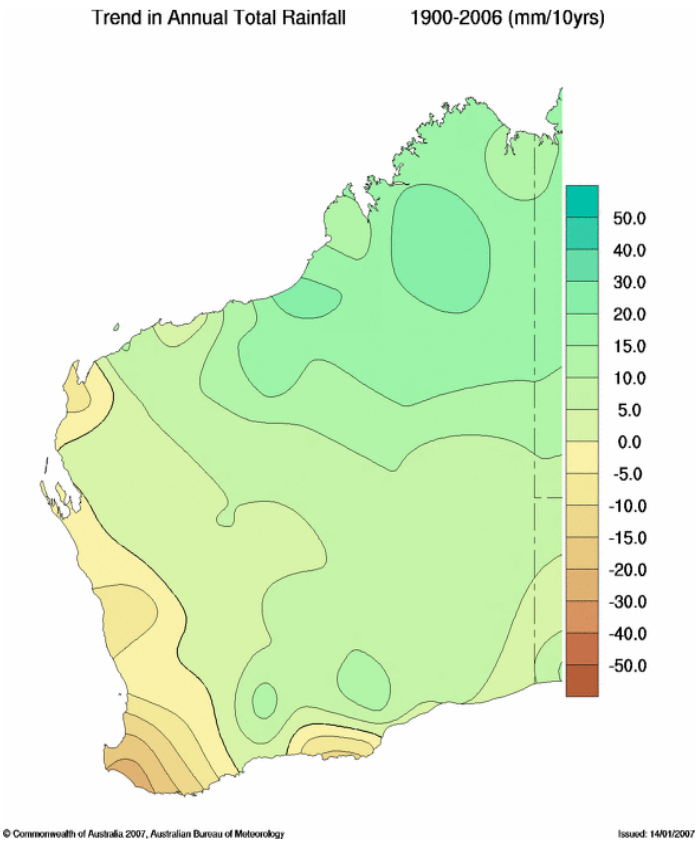


Figure 14: Trends in annual total rainfall for Western Australia (Map sourced from the Australian Bureau of Meterology).

Disease

Disease agents potentially responsible (in part or wholly) for woylie declines can be categorised into the following groups: viral, bacterial, haemaparasites, endoparasites, ectoparasites, toxic and nutritional.

Direct Human Influence

Is it possile that trapping frequency and intensity could be negaitively impacting on woylies. This is being investigated but no evidence to support the theory is yet apparent. Other human influence could come in the form of ecotourism. A study by Harvey (1999) of ecotourism at Dryandra found that the welfare of woylies was not being compromised by the level of and nature of ecotourism being conducted at the time of the study. Excessive removal of animals for translocation may also be a contributing factor and this is being investigated.

Additional threats may be impacting on the population but are unlikely to explain the recent rapid populations declines. These threats include feral pigs and *Phytophthora cinnamomi*.

Feral pigs may be impacting on woylie abundance at a local level through habitat destruction and competition for food. The predation, habitat degradation, competition and disease transmission by feral pigs has been listed as a Key Threatening Process under the Commonwealth's Environment Protection and Biodiversity Conservation Act 1999. *B. tropica*, a close relative of the woylie, has been included in the threat abatement plan as an affected species.

Phytophthora cinnamomi is a fungus that kills many plant species, changing the composition and structure of the vegetation and has the potential to change the suitability of habitat for woylies. The dieback caused by *Phytophthora cinnamomi* has also been listed as a Key Threatening Process under the Commonwealth's Environment Protection and Biodiversity Conservation Act 1999.

Future Threats:
Climate change has the potential to significantly impact on the distribution and abundance of the species.

Catastrophic events such as wildfire threaten the continued survival of subpopulations in South Australia and Western Australia. Such fires are likely to be most catastrophic at sites where recolonisation from the surrounding area is not possible (eg islands and isolated resevres).

Bauxite is proposed to be mined in forest areas currently inhabited by the woylie in Western Australia.

Identify and explain why additional biological characteristics particular to the species are threatening to its survival (e.g. low genetic diversity). Identify and explain any models addressing the survival of the species.

Burbidge and McKenzie (1989) showed that most terrestrial Australian mammals in the weight range of 35 g to 5.5 kg mean adult body weight have declined or become extinct. The woylie falls within this "critical weight range".

A preliminary Population Viability Analysis was conducted for the species by McComb *et al.* (1994) who modelled the effect of four scenarios (a 10 or 20 year burn cycle and with or without fox baiting). This study found that the likelihood of woylie persistence, predicted extinction time and the rate of genetic loss were all predicted to improve for woylies if either foxes were baited (ie juvenile survival improved) or if burning cycles were increased from 10 to 20 years.

A thorough quantitative analysis showing probability of extinction has not been undertaken for the species. The woylie therefore does not qualify for listing under IUCN criterion E (version 3.1).

4.4. Management

Identify key management documentation for the species e.g. recovery plans, conservation plans, threat abatement plans etc.

A recovery plan was first written for the woylie by Hall *et al.* (1991) and was substantially revised by Start *et al.* 1995. A plan of management for woylies in South Australia was developed by Nelson *et al.* (1992). A review of the conservation status of the woylie was conducted by Start *et al.* (1998) that resulted in the delisting of the species in the same year.

The woylie was not mentioned in any national threat abatement plan because it was not considered a threatened species when these documents were written. If these documents were revised, then it is likely that the woylie would be listed as an affected species for plans covering the impacts of the European fox, feral cat and possibly *Phytophthora cinnamomi* and feral pigs.

Does this species benefit from the management of another species or community? Explain.

The woylie is mentioned in management plans for various conservation reserves and sanctuaries in which it occurs (e.g. Dryandra Woodland Management Plan, Islands of the Western Eyre Peninsula Management Plan, Karakamia Sanctuary Management Plan).

In South Australia, several ecosystem reconstruction/revegetation projects are being undertaken (e.g. Ark on Eyre, Bounceback) and the reintroduction of the woylie has been considered as a desirable outcome following the restoration work and implementation of feral animal control programs at these sites. In Western Australia fox and cat baiting under the *Western Shield* program is aimed at improving the conservation status of many species. Reintroduction projects under the same program also benefit a range of species including the woylie.

How well is the species represented in conservation reserves or covenanted land? Which of these are actively managed for this species? Give details.

In Western Australia the species is well represented on conservation reserves or land managed by DEC (see Appendix II). Fox baiting under the *Western Shield* program is undertaken at all known locations where woylies occur in Western Australia. Forestry and fire management practices in these areas also consider the requirements of woylies in planning.

In South Australia secure subpopulations that occur in conservation parks include Venus Bay (peninsula), Venus Bay “Island A” and St Peter Island. Attempts have also been made to establish additional occurrences on the mainland in Conservation Parks and National Parks.

In both Western Australia and South Australia, reintroductions have also occurred onto private property where a long term commitment to conservation efforts has been demonstrated. Woylies have been reintroduced to two properties that are included in the Land for Wildlife program adjacent to the Harvey River in Western Australia. In South Australia woylies have been reintroduced to privately owned Wedge Island (part), Tom Bott’s and Banrock Station.

Woylies have been translocated to fenced sites that are effectively managed as wild subpopulations. Wildlife Sanctuaries that fit this category are Karakamia and Paruna in WA, Yookamura in SA and Scotia in NSW. These sanctuaries are owned and managed by Australian Wildlife Conservancy.

Are there any management or research recommendations that will assist in the conservation of the species? Give details.

There is currently an intensive study being undertaken of the woylie subpopulation in the Upper Warren area of Western Australia to determine the possible cause/s of the apparent decline in woylie numbers. Copies of the project proposal and a preliminary assessment that was conducted to obtain evidence for the declines are contained in Appendix III and IV. This study also involves obtaining samples from other occurrences for comparison (including Venus Bay peninsula, Batalling and Dryandra). Another study is underway examining the reasons for the decline in the Dryandra woylie population. It is intended that the results of these studies will have immediate management implications.

4.5. Other

Is there any additional information that is relevant to consideration of the conservation status of this species?

Woylies are considered to serve important ecosystem functions. The following are examples of studies that have been undertaken that demonstrate this. Garkaklis *et al*. (2003) studied how the diggings made by woylies in search of underground fungi allows greater water infiltration to the soil and may influence the distribution of surface soil nutrients. Murphy *et al.* (2005) investigated the role played by woylies in dispersing and caching the seeds of sandalwood (*Santalum spicatum*) which may serve an important role in the recruitment and regeneration of the species. Lamont *et al*. (1985) describe the role played by woylies in consuming and dispersing hypogeous fungi and how this plays a key role in the re-establishment of vegetation after fire. The decline in abundance of woylies or local extinctions may therefore have far greater impact on ecosystems than previously thought.

SECTION 5. NOMINATOR
Nominator(s) name. Christine Freegard
Signature(s) – This is not needed for emailed nominations as your email is proof of your identity.
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Date 23rd February, 2006

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SECTION 6. REFERENCES

What references or sources did you use to prepare your nomination? Include written material, electronic sources and verbal information. Include full references, address of web pages and the names and contact details of authorities with whom you had verbal communications.

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Experts consulted:

Armstrong, David (NPW SA Senior Ranger – Venus Bay Conservation Park). Phone: (08) 8625 5110. Email: armstrong.david@saugov.sa.gov.au

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SECTION 7. RECOMMENDATION	
7.1. Approval (to be completed by the TSSC Chair)	
Is the nomination accepted? Yes ☐ No ☐	
Status for the State of WA	
IUCN Status	
Categories and Criteria	
Priority	
CALM Region(s)	
CALM District(s)	

7.2. Non-approval

If nomination not accepted, give reasons.

_____
_____
_____
_____
_____
_____

7.3. Date of recommended change of status	

7.4. Comments

Were any conditions applied to the recommended change in conservation status? Provide details of actions required to be completed if nomination was deferred or rejected.

_____
_____
_____
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_____

Were any management or research recommendations made for the species? Provide details.

_____
_____
_____
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APPENDIX I

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

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APPENDIX II

Summary of woylie monitoring sites and trapping effort in Australia.

Location	Land status	Monitoring sites	Area of reserve (ha)	Date of most recent survey	Latest trap success (%) and trend	Max trap success reached (%) and year	Monitoring year range	Number of years monitored	Number of monitoring sessions
NEW SOUTH WALES									
Yathong Nature Reserve	NR	Yathong*	107000	May-02	0	-	2000-2002	3	-
Genaren Hills	PP	Genaren*	400	-	0	-	-	-	-
Scotia Sanctuary	PP	Scotia*	64653	Dec-06	11.5	32 (2005)	-	-	-
SOUTH AUSTRALIA									
Bird Club Island		Bird Clud Island*	7.8	-	-	-	-	-	-
Venus Bay Conservation Park	CP	"Island A"* Venus Bay*	15 1100	Nov-06 Jul-06	23.6 7.5↓	54.2 (1982) 42.5 (2005)	1980-2006 2005-2006	27 2	28 3
Bairds Bay Islands Conservation Park	CP	Baird Island*	13	Apr-92	22.9	72.7 (1985)	1983-1992	10	12
Isle of St Francis Conservation Park	CP	St Francis Island*	809	Oct-88	0.28	7.14 (1982)	1982-1988	7	6
Wedge Island	PP	Wedge Island*	947	May-06	64.2	84.1 (1994)	1989-2006	18	9
Nuyts Archipelago Conservation Park	CP	St Peter Island*	3439	2006	65.0	72.0 (1998)	1993-2006	7	7
Lincoln National Park	NP	Donington grid*	29214	May-01	20	25 (2001)	2000-2005	2+	6+
Flinders Ranges National Park	NP	Flinders Ranges*	94908	-	-	-	-	-	-
Katarapko Island, Murray River National Park	NP	Katarapko Island*	4000	Nov-01	1.3	1.7 (2000)	2000-2001	2	3
Yookamurra Sanctuary	PP	Yookamurra*	1100	-	-	-	-	-	-
Reny Island (Calpernum Stn)	PL	Reny Island*	1652	-	-	-	-	-	-

Location	Land status	Monitoring sites	Area of reserve (ha)	Date of most recent survey	Latest trap success (%) and trend	Max trap success reached (%) and year	Monitoring year range	Number of years monitored	Number of monitoring sessions
WESTERN AUSTRALIA									
Northern and central jarrah forest									
State Forest	SF	Julimar* Hills Forest Hadfield* Driver* Centaur* Batalling*	24117 5490 3175 3742 	Jun-05 Apr-02 Aug-05 Aug-04 Jun-06 Nov-06	2.69 0 0 8.05 0.5 5.74 ↓	4.09 (1998) 7.7 (1998) 2.45 (2004) 8.05 (2004) 6.67 (2002) 42.36 (1999)	1992-2006 1993-2002 2003-2005 2003-2004 1999-2006 1990-2006	15 10 3 2 8 17	19 19 3 2 9 21
Wellington National Park (16970ha)	NP	Davis* Gervasse* Wellington NP*	4748 6445 	May-05 Mar-05 May-05	0.98 0 0	8.11 (2001) 0.63 (2004) 6.67 (2001)	2001-2005 1992-2005 2001-2005	5 14 5	4 10 4
Sunklands and Pemberton area									
State Forest	SF	St John*	5633	Jun-06	0	1.82 (1999)	1997-2006	10	13
Greater Beedelup National Park (19270ha)	NP	Charley * (Beedelup) Gray	4091 3662	May-03 Apr-05	1 0	1 (2003) 3 (2001)	2003 1996-2005	1 10	1 10
Perup/Lake Muir area									
State Forest	SF	Tone Warrup*	7997 5838	Feb-06 Nov-06	0 26.5↑	1.33 (1999) 38.5 (2005)	1996-2006 2001-2006	11 6	13 11
Boyndaminup National Park	NP	Boyndaminup*	5440	Mar-06	0	2.5 (2003)	2003-2006	3	4
"Greater Kingston" NP (21090ha)	NP	Winnejup Corbal	3208 4717	Nov-06 Nov-06	0.5↓ 12.5	39.0 (1998) 19 (2005)	1994-2006 2005-2006	13 2	8 3
Shannon National Park	NP	Shannon NP* (Murtin)	52600	May-03	1.5	1.5 (2003)	2003	1	1
Lake Muir Nature Reserve	NR	Myalgelup (Poorginup)*	11310	Feb-06	0.5	1.5 (2005)	1996-2006	11	11

Location	Land status	Monitoring sites	Area of reserve (ha)	Date of most recent survey	Latest trap success (%) and trend	Max trap success reached (%) and year	Monitoring year range	Number of years monitored	Number of monitoring sessions
Tone-Perup Nature Reserve (55940ha)	NR	Keninup Balban Yendicup* Moopinup Yackelup Camelar Chariup Boyicup	6641 3874 5541 4636 6080 5784 7941 6086	Oct-06 Nov-06 Oct-06 Nov-06 Oct-06 Mar-06 Nov-06 Nov-06	55.5↑ 10 ↓ 6.67 ↓ 1.5 ↓ 0 ↓ 0 ↓ 2 ↓ 2 ↓	55.5 (2006) 41.5 (2005) 84 (2003) 65.5 (2002) 72 (2002) 43.5 (2001) 67.5 (2001) 70.5 (1999)	1999-2006 2000-2006 2000-2006 1996-2006 2000-2006 2000-2006 1998-2006 1998-2006	8 7 7 11 7 7 9 9	10 9 14 13 14 8 10 10
Walpole/Denmark area									
Walpole-Nornalup National Park	NP	Giants*	19450	Mar-06	0	2 (1999)	1997-2006	10	19
Mt Roe/Mt Lindesay National Park	NP	Denmark* (Mt Lindesay)	167270	Feb-06	0	3.75 (1999)	1997-2006	10	13
Isolated Reserves									
Tutanning Nature Reserve	NR	Tutanning	2369	Mar-06	3.33	13.3 (1995)	1995-2006	12	9
Boyagin Nature Reserve	NR	Boyagin East* Boyagin West*	4781	Apr-05 Apr-05	21.33 6.67	58 (1996) 7.3 (2001)	1995-2005 1996-2005	11 10	7 8
Dryandra Woodland	SF	Dryandra	12192	Apr-06	4 ↓	75.3 (1995)	1995-2006	12	12
Lake Magenta Nature Reserve	NR	Lake Magenta*	107810	Nov-05	0	4.16 (1997)	1996-2005	10	24
North Karlgarin Nature Reserve	NR	North Karlgarin*	5622	May-06	11.99 ↑	11.99 (2006)	1998-2006	9	5
Francois Peron National Park	NP	Peron*	52590	Sep-06	0	1.68 (2001)	1998-2006	9	14
Kalbarri National Park	NP	Kalbarri*	183000	May-06	1	4 (2005)	1999-2006	8	13
Nambung National Park	NP	Nambung*	18400	Nov-05	12.5 ↑	12.5 (2005)	2001-2006	6	6
Fitzgerald River National Park	NP NP	Twertup Moir Track	329880	Nov-06 Nov-06	0 0	0 0	1999-2006 1997-2006	8 10	9 13
Avon Valley NP	NP	Avon Valley*	4370	May-06	0.8	8.3 (2003)	2003-2006	4	4
Paruna Sanctuary	PP	Paruna*	2000	Aug/Sep-06	18.1	18.1 (2006)	-	-	-
Karakamia Sanctuary	PP	Karakamia*	280	Jul/Aug-06	High	High	-	-	-

* = Translocated population

PP = Private Property, NP = National Park, SF = State Forest, NR = Nature Reserve, CP = Conservation Park, PL= Pastoral Lease.

APPENDIX III

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(please see separate pdf file).

APPENDIX IV

Wayne A (2006). DRAFT Interim assessment of the evidence for a decline in woylie abundance in south-western Australia. Unpublished Report. Department of Conservation and Land Management.

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