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A review of the conservation status of the woylie, *Bettongia penicillata ogilbyi* (Marsupialia: Potoroidae) using IUCN criteria

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ABSTRACT

A Recovery Team oversaw implementation of a Recovery Plan for the woylie (*Bettongia penicillata ogilbyi* (Waterhouse 1841)) from 1990 to 1995, and then reviewed its conservation status. Using the 1994 IUCN Red List criteria, the team showed that the species had been recovered from Vulnerable to Lower Risk (Conservation Dependent). Furthermore, it no longer met the requirements for listing as a threatened species under Western Australian or Commonwealth legislation and all but one of the specific targets of the Recovery Plan had been achieved. The exception, at least 7.5 per cent trap-success in a new population at Julimar Conservation Park, had not been met at that time because translocation to Julimar had been delayed. However, a population had been established and was increasing.

Criteria for listing threatened species under Western Australian and Commonwealth legislation are based on the subject's status nationally. South Australian legislation requires consideration of its status within the State. The Recovery Team recommended that the authorities responsible for advising the Western Australian and Commonwealth conservation Ministers should convey to them the Recovery Team's conclusions. The woylie has since been removed from categories of threatened taxa established under those jurisdictions. The team recommended to the South Australian authorities that they should review its status within that State.

The review is an unpublished report addressed to those authorities who would have to progress the Recovery Team's recommendations. However, as it was the first to use the 1994 IUCN criteria to assess the outcome of an Australian Recovery Plan, the issues encountered by the recovery team provide a useful case study for other people preparing Recovery Plans and reviewing the outcomes. Therefore it is published here.

INTRODUCTION

At European settlement the brush-tailed bettong, *Bettongia penicillata* Gray, 1837 (Marsupialia: Potoroidae) occurred in suitable habitat over most of southern and central Australia (e.g. Christensen 1980, and Nelson *et al.* 1992). The nominate subspecies, which occurred in eastern Australia, is presumed extinct and the Western Australian subspecies, the woylie, *Bettongia penicillata ogilbyi* (Waterhouse, 1841) declined, in the wild, to three small populations in forests and woodlands of the south-west of the State (Start *et al.* 1995; Maxwell *et al.* 1996).

A Recovery Team oversaw the implementation of a Recovery Plan[1] which was written by Hall *et al.* (1991) but substantially revised by Start *et al.* (1995). In 1995, at the conclusion of the Plan's five-year life, the Recovery Team used criteria established by the International Conservation Union (IUCN 1994) to review the conservation status of the woylie and recommend amendments to lists of threatened species maintained under Commonwealth and Western Australian legislation. They were endorsed by the relevant Ministers and the taxon has been removed from Schedule 1 'Listed Species' in the Commonwealth Endangered Species Protection Act (Commonwealth of Australia Gazette, 8 May 1996). It is no longer declared by the Western Australian Minister for the Environment to be 'Fauna which is likely to become extinct or is rare' (Western Australian Government Gazette, 30 April 1996) and it is classified Lower Risk (Conservation Dependent) on the 1996 IUCN List of Threatened Animals (IUCN 1996).

The woylie was the first Australian taxon to be removed from formal lists of threatened taxa because conservation actions had sufficiently improved its conservation status (as opposed to improved knowledge of its status). Furthermore, the review was the first in

[1] The terms Recovery Plan and Recovery Team are defined in Anon (1997): A Recovery Plan is a comprehensive plan that details, schedules and costs all actions including research necessary to support the recovery of the species or ecological community. There should be one national Recovery Plan for a species or ecological community.
Recovery relates to the process of halting or reversing the decline of a species in the wild and ensuring its future chance of survival (and if appropriate, expansion). It is not the process of re-establishing a species throughout its former range. That should be a subsequent action in so far as it is possible.

Australia to use the IUCN Red List criteria (IUCN 1994) to assess the outcome of a Recovery Plan managed by a Recovery Team.

Interpretation of the IUCN requirements posed several problems. In particular, the rules require that transfer from categories of higher to lower risk should be made after none of the criteria for the higher category has been met for five years or more although movement the other way should take place without delay. The Recovery Team assumed that the IUCN had not intended to freeze transfers from categories of higher to lower risk for five years from the date of publication. Therefore it prepared a supplementary review that retrospectively examined the conservation status of the woylie as it had been in 1990, five years previously.

One important lesson concerned the criteria that must be addressed by the reviewers. Most Recovery Plans specify Recovery Actions and set criteria by which the success of those actions will be measured. It is often assumed that successfully meeting the criteria will mean that the subject of the Plan has been recovered. However, if formal lists of threatened taxa developed under the auspices of the IUCN or State or Commonwealth legislation are to reflect the recovered status of the subject, the review process must also address their listing criteria. Therefore, it is necessary for Recovery Teams to foreshadow the latter and set success criteria that will, if attained, satisfy them. Indeed it is desirable that the Plan clearly specifies all the criteria that will have to be considered when the conservation status of the subject is reviewed.

The review and its supplement are unpublished reports addressed to the people who had to consider and, if they concurred, implement the recommendations. However, our approach to various issues may be useful to people drafting Recovery Plans or addressing the review process for other taxa. Therefore we reproduce them here, in full, except that reference lists have been amalgamated and Tables that were common to both reports are not duplicated, necessitating some renumbering. Some text passages were also common to both and have been treated similarly (e.g. the recommendations of the Recovery Team). Three appendices have been deleted. They comprised copies of relevant sections from the IUCN criteria (IUCN 1994) and the Recovery Plan (Start *et al.* 1995) and a list of the Recovery Team members. The latter is incorporated into our Acknowledgements. We have also corrected some typographical, grammatical and other minor errors and changed 'personal communications' to text references where data have been published since the review was written.

WOYLIE (*BETTONGIA PENICILLATA OGILBYI*): A REVIEW OF ITS STATUS. DECEMBER 1995[2]

1. Background

1.1 Historical Distribution of *Bettongia*

The genus *Bettongia* is currently recognized as having had four species at European settlement (Table 1). The most widespread were *B. lesueur* and *B. penicillata*. Two subspecies of *B. penicillata* are recognized; typical *B. p. penicillata* (brush-tailed bettong) in eastern Australia and *B. p. ogilbyi* (woylie) in Western Australia (WA).

TABLE 1

The distribution and current conservation status of *Bettongia* species (including subspecies of *B. penicillata*) that were present in Australia at European settlement.

TAXON	COMMON NAME	FORMER DISTRIBUTION	CURRENT STATUS
B. gaimardi	Tasmanian Bettong	South-eastern Australia and Tasmania	Secure
B. lesueur	Burrowing Bettong	Most of southern and western Australia	Endangered
B. p. ogilbyi	Woylie	South-western mainland Australia	Endangered
B. p. penicillata	Brush-tailed Bettong	South-eastern mainland Australia	Presumed Extinct
B. tropica	Northern Bettong	North-eastern Queensland	Endangered

The geographical relationship between the two subspecies and the subspecific status of central Australian *B. penicillata* is not clear. Indeed the former distribution of the species is not fully known. Figure 1 presents the locations at which it is known to have lived. The map was compiled by Nelson *et al.* 1992. The data come from two sources, European (including specimen) records (adapted from Finlayson 1958; the north Queensland record is now referred to *Bettongia tropica*) and the knowledge of Aboriginal people who used to hunt it for food (Burbidge *et al.* 1988). The incomplete status of both data sets is emphasized by their differences. The species may have been present in some of the large areas south of the Tropic of Capricorn for which there are no records. However, it was probably not widespread in the wet-dry tropics.

1.2 Pattern of Decline

Regardless of our incomplete knowledge of the former distribution of *B. penicillata* and its infra-specific variation across that distribution, the only form of the species

[2] Prepared by A.N. Start, A.A. Burbidge and D. Armstrong for the Woylie Recovery Team.

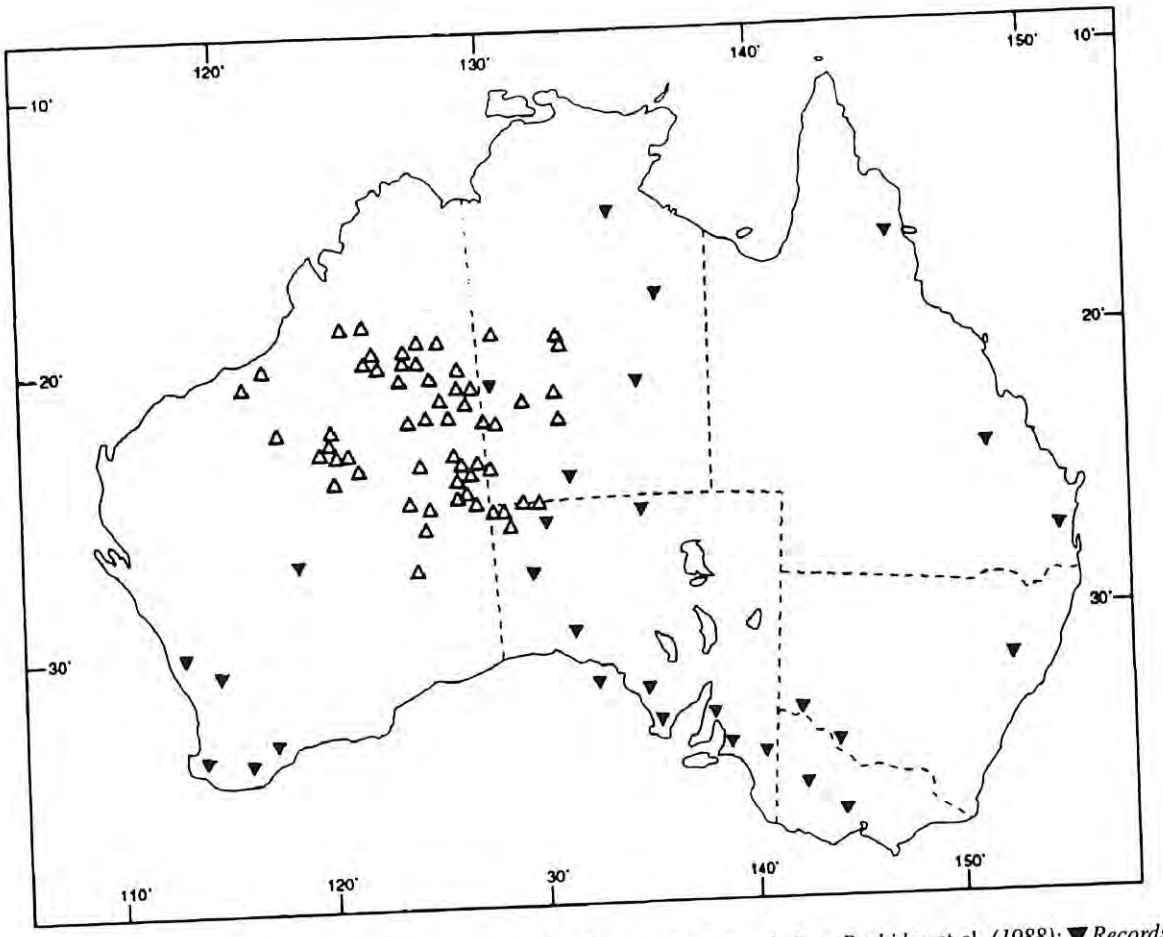

Figure 1.The historical distribution of Bettongia penicillata. △ *Aboriginal records from Burbidge* et al. *(1988);* ▼ *Records from Finlayson (1958). Redrawn from Nelson* et al. *(1992). The north Queensland record of Finlayson is now referred to* B. tropica.

known to be extant is the woylie, *B. p. ogilbyi,* which survived in its natural habitat as three relict populations in the forests and adjacent woodlands in the far south-west of WA. Those were declining until active management, principally protection from foxes, was initiated in the last fifteen years or so. There were also some captive animals as well as introduced colonies on four South Australian (SA) islands (Wedge Island, St Peter Island and two other very small islands). The founders were captive-bred, Western Australian stock.

The woylie, like many Australian mammal species, had declined drastically, almost to extinction, since European settlement. Several hypotheses have sought to explain the causes of the declines (see Burbidge and McKenzie 1989, and Morton 1990 for reviews).

Burbidge and McKenzie showed that most non-marine Australian mammals that have become extinct or have significantly declined fall within a Critical Weight Range (CWR), now recognized as 35 g to 5.5 kg mean adult body weight. The decline has been more severe in the arid zone than in better watered areas. The woylie (1-1.5 kg) lies within the CWR and conforms to the typical pattern, surviving in the most mesic part of its former range.

Several authors (e.g. Troughton 1957; Calaby 1971; Christensen 1980; King *et al.* 1981; Christensen and Maisey 1987) implicate the fox as a predator of woylies and this is now supported in the south-west of WA by quantitative data. For example, at Batalling Forest the capture rate was <1 per cent before baiting commenced in February 1991. In areas baited for foxes it rose to about 2 per cent in November 1991, 7.2 per cent in October 1992 and 11.4 per cent in October 1993 (Morris *et al.* 1995) and 24 per cent in July 1995 (Keith Morris[3] personal communication). Data from other sites are presented in Courtenay (1994). At Batalling, woylies are being trapped in adjacent unbaited areas where they were previously not known to occur, probably a consequence of immigration from the baited area. However, trap success in unbaited areas remains <1 per cent (Morris *et al.* 1995).

Calaby (1971) suggested that *B. penicillata* survived in south-west WA because it inhabited vegetation in which thickets of *Gastrolobium* species were abundant. *Gastrolobium* contains monofluoroacetic acid. Compound 1080 (sodium monofluoroacetate) is very toxic to non-indigenous mammals including domestic stock and feral predators such as foxes, but indigenous mammals (and other animals) of the south-west have evolved a high level of tolerance.

Gastrolobium thickets are a feature at Perup, Dryandra and Tutanning, the three sites where woylies are known to have survived in the wild. Secondary poisoning of feral predators eating animals that have ingested *Gastrolobium* may account for the phenomenon. Foxes eating rabbits

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poisoned with compound 1080 have died (Algar and Kinnear 1996). Compound 1080 is the toxin now used in baits to control foxes for protection of threatened fauna in south-western WA and in SA.

A more detailed account of the history of the status of the woylie is contained in the Recovery Plan (Start *et al.* 1995).

1.3 Statutory Status

In WA *Bettongia penicillata* is declared by the Minister to be 'fauna which is likely to become extinct or which is rare' pursuant to the Wildlife Conservation Act. In SA it is listed on Schedule 7 (Endangered Species) pursuant to the National Parks and Wildlife Act. It is listed as endangered nationally by ANZECC (Anon. 1991) and is included in Schedule 1, Part 1 (species that are endangered) of the Commonwealth Endangered Species Protection Act. The 1992 Marsupial and Monotreme Action Plan (Kennedy 1992) listed the woylie as Endangered.[4]

2. Recovery Plan

In 1990 The Australian Nature Conservation Agency (ANCA)[5] introduced to Australia the concept of preparing and implementing Recovery Plans for threatened species. A Recovery Plan for the woylie (Hall *et al.* 1991) was one of the first to be written. That edition specified recovery actions to be implemented during the next ten years in SA and WA by a Recovery Team comprising people from the Western Australian Department of Conservation and Land Management (CALM) the South Australian Department of Environment and Natural Resources (DENR) and ANCA. However, there were so many positive developments during the first two years that the Recovery Team revised the plan extensively (Start *et al.* 1995). A major change was the foreshortening of the life of the plan to five years (to December 1995).

The specific objectives of the revised Woylie Recovery Plan were to:

(1) Determine the current wild distribution of the woylie in WA;
(2) Establish a population of woylies on a mainland area in SA without using predator-proof fences;
(3) Develop prescriptions for the maintenance and extension of woylie populations in multiple-use forest in WA;
(4) Ensure that translocated woylie populations maintain genetic variability;
(5) Review the conservation status of the woylie using internationally accepted criteria, and recommend changes if necessary.

The actions implemented by the Recovery Team comprised:

(1) Control of exotic predators, particularly foxes;
(2) Survey and establishment of monitoring programs;
(3) Range expansion (where feasible) and translocation;
(4) Setting up experiments to determine the effects of forest management practices;
(5) Genetic assessment and restocking;
(6) Employment of a scientist, SA;
(7) Education and publicity.

3. Purpose of this Review

The Recovery Plan requires the Recovery Team to 'Review the conservation status of the woylie, using internationally accepted criteria, and recommend changes if necessary' at the conclusion of its recovery action program in December 1995 (Objective 5). This paper constitutes the Recovery Team's review using the current IUCN Red List criteria (IUCN 1994). The Recovery Plan also contains criteria which, being specific to woylies, enabled the Recovery Team to set specific targets for its actions program. They are also reviewed. Nevertheless it is the IUCN criteria that are definitive.

3.1. International Criteria

The IUCN Red List Categories: Version 2.2 (IUCN 1994) details the criteria that are currently used to classify the conservation status of species. It uses five independent topics to allocate the conservation status of a species to one of the categories outlined in Table 2 and Figure 2.

TABLE 2

Definitions of the categories used in the IUCN (1994) Red Lists.

CATEGORY	SUMMARY EXPLANATION
EX Extinct	No reasonable doubt the last individual has died
EW Extinct in the Wild	Survives but not wild in its natural range
CR Critically Endangered	Extremely high risk of extinction in the wild in the immediate future
EN Endangered	Not CR but very high risk of extinction in near future
VU Vulnerable	Not EN but high risk of extinction in mid-term future
LR Lower Risk	None of the above nor DD but warrants monitoring
DD Data Deficient	Insufficient data to classify
NE Not Evaluated	Not yet assessed against the criteria

The category Lower Risk has three sub-categories.

LOWER RISK SUB-CATEGORIES	SUMMARY EXPLANATION
cd Conservation Dependent	Cessation of management would result in qualification for a threatened category within 5 years
nt Near Threatened	Not qualifying for cd but close to qualifying for VU
lc Least Concern	Not qualifying for cd or nt

The species being assessed is allocated to the highest category determined by any one of five topics (A to E below). In the following analysis we assessed the woylie against the lowest of the Threatened classifications

[4] In the 1996 Action Plan for Australian Marsupials and Monotremes (Maxwell *et al.* 1996) it is listed as Lower Risk (Conservation Dependent) as a consequence of the review's outcome.

[5] Now Environment Australia

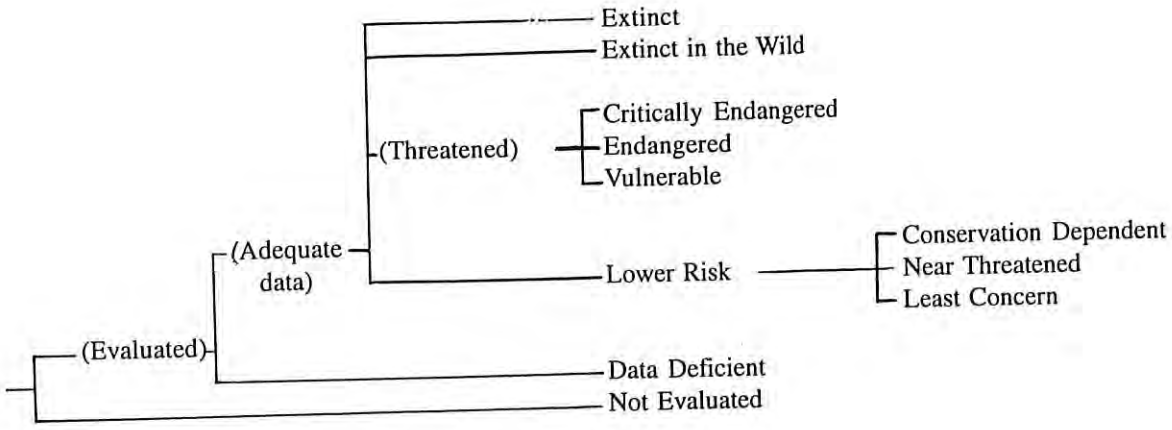

Figure 2. The Structure of the IUCN Red List categories (IUCN 1994).

(Vulnerable). Had it met that classification we would have assessed it against the next (Endangered) etc.

A. *Substantial past or projected future decreasing population trends*

For woylies to qualify as vulnerable there must have been a reduction in population size of at least 20 per cent over the last ten years or a projected reduction of 20 per cent in the next ten years. Table 3 summarizes the conservation status of woylies 20 years ago compared with now. Data to 1994 are detailed in Courtenay (1994) or Morris *et al.* (1995) and data since then have been supplied by various people implementing the monitoring program established as Action 2 of the Recovery Plan.

The increase in the number of populations has resulted from translocations after fox (and, at Venus Bay Peninsula, cat) control. In WA the increase in population density (measured by trap success) has occurred since fox control measures have been introduced.

The population at Yookamurra is contained within a fox-proof fence. The managers, Earth Sanctuaries, plan to maintain the population in a wild state within the fence. Introduced populations on two additional, small SA islands with carrying capacity of <50 animals were recognized by the Recovery Team to be too small to maintain in the long-term as viable populations. One became extinct in early 1994. The other persists but will not be maintained if it declines.

Table 3 demonstrates that a substantial increase has occurred over the past 20 years in population density as well as the number of populations and area occupied at sites identified in the Recovery Plan for key populations. A substantial proportion of the increase occurred in the last ten years.

Woylies do not qualify as Vulnerable under this category.

Besides sites identified in the Recovery Plan for protection or introduction of woylies, there are a number of other relevant sites. In WA fox control has now been extended to 550 000 ha of jarrah/wandoo forest, much of which is probably suitable habitat[6]. Woylies have been translocated to ten sites within that area under another program (Operation Foxglove and Project 3.4 of the Co-operative Research Centre for the Biological Control

TABLE 3

Change in the conservation status of *Bettongia penicillata* populations during the past 20 years.

STATE	LOCATION	AREA (ha)	PAST	STATUS NOW (December 1995)
WA	Batalling	3617	Presumed extinct	Re-introduced 1983; TS 24% (July 1995)
WA	Boyagin	4781	Presumed extinct	Re-introduced 1992; TS 47% (Oct 1995)[a]
WA	Dryandra	12192	TS <1% (1975)	TS variable but consistently >50%
WA	Julimar	24117	Presumed extinct	Re-introduced 1995; established
WA	Perup	37640	TS 3-10% (1974)[b]	TS 35% (Feb 1994)[c]
SA	St Peter Island	3493	Not naturally present	Introduced 1989; TS 53% (March 1995)
WA	Tutanning	2369	TS 0 - 6% (1984)	TS 13% (July 1995)
SA	Venus Bay	1600	Presumed extinct	Re-introduced 1994; established
SA	Wedge Island	947	Not naturally present	Introduced 1983; TS 77% (June 1995)
SA	Yookamurra	1100	Presumed extinct	Re-introduced 1991; established

TS = Trap success expressed as a percentage.

[a] Data from West Boyagin recorded by Jackie Courtenay. Woylies are present in the east and west blocks of this reserve.

[b] Boyicup. The forest block at Perup monitored by Christensen 1974-1981. Data using cage traps (as in present monitoring program) and excluding additional pre-baited funnel traps.

[c] Yendicup. The forest block at Perup monitored by Burrows 1989-1994 using cage traps.

[6] Western Shield, a program to extend the area baited for foxes to >5 million hectares, has commenced since the review was written.

of Vertebrate Pest Populations (VB CRC)). That program will translocate woylies to another eight sites before the end of 1995[7]. Providing feral predator control is maintained, all populations that are still below carrying capacity throughout the accessible habitat are likely to increase in density and area of occupancy in future. CALM is committed to protecting or expanding these populations.

B. *Extent of occurrence and areas of occupancy*
(see IUCN 1994 for definitions)

To qualify as Vulnerable, a species will have an extent of occurrence of less than 20 000 km² or area of occupancy of less than 2000 km² and furthermore meet two out of three additional criteria. Woylies now have an extent of occurrence many times 20 000 km² extending from WA to SA. The extent of occurrence in WA alone exceeds 17 000 km². However, the area of occupancy is difficult to determine in forested areas where populations are expanding in the shelter of effective fox control. Although it probably exceeds 2000 km² the additional requirements are considered.

(1) *Populations are severely fragmented (no population is estimated to contain more than 1000 mature individuals) or found at no more than ten locations*
The Dryandra population is estimated at about 6000 individuals (Jackie Courtenay, unpublished data). The Perup (including Kingston to Lake Muir) area contains a much larger population, Batalling supports several thousand individuals and there are more than 1000 on Wedge and St Peter islands. There are ten populations (six in WA and four in SA) even recognizing the Lake Muir-Perup-Kingston (>40 km across) as one population and excluding the small SA island population and the area covered by Operation Foxglove.

(2) *The species continues to decline in any of the following*
(a) Extent of occurrence: it has been increasing in WA and SA (Table 3).
(b) Area of occupancy: it has been increasing in WA and SA (Table 3).
(c) Area, extent or quality of habitat: these factors are increasing/improving with extension of fox control in natural vegetation on State lands in WA and SA.
(d) Number of locations or sub-populations: they are projected to expand in WA until populations coalesce.
(e) Number of mature individuals: Woylies breed in their first year. Therefore populations that have been increasing in recent years (Table 3) will contain increasing numbers of mature individuals in WA and SA.

(3) *Extreme fluctuations in any of the following*
(a) Extent of occurrence: they are increasing in WA and stable in SA (Table 3).
(b) Area of occupancy: they are either stable or increasing, depending on site, in WA and SA (Table 3).
(c) Number of locations or sub-populations: they are increasing in WA and stable in SA (Table 3).
(d) Number of mature individuals: they are more or less stable or increasing, depending on site, in WA and SA (Table 3).

Woylies do not meet any of the additional characters. Thus they do not qualify as Vulnerable under this category.

C. *Population size (for larger populations) and predicted decreasing trends*

For woylies to be assessed as Vulnerable this category requires that the total number of individuals is less than 10 000 and, either there is an estimated continuing decline of at least 10 per cent in ten years, or there is a continuing decline in the number of mature individuals or population structure (severe fragmentation or all mature animals in one sub-population).

The Dryandra population is estimated at about 6000 individuals (Jackie Courtenay, unpublished data). The Perup area (including Kingston to Lake Muir) contains a much larger population, Batalling supports several thousand individuals and there are more than 1000 on both Wedge and St Peter Islands. Furthermore, the total number of mature individuals is increasing as Western Australian populations spread with the extension of fox baiting and a continuing translocation program.

Woylies do not qualify as Vulnerable under this category.

D. *Population size (of smaller populations) irrespective of population trends*

To qualify as Vulnerable this category requires the population to be very small (<1000 individuals) or the population to be acutely restricted in its area of occupancy (typically <100 km²) or number of locations (typically <5). Data presented above clearly indicate that woylies can not be classified as Vulnerable under this category.

E. *Quantitative analysis showing probability of extinction in specified time units or generations*

To qualify as Vulnerable this category requires a quantitative analysis showing probability of extinction is at least 10 per cent within 100 years. No analysis has been undertaken for woylies. Given the population size and trends discussed above, a population viability analysis would be unlikely to show a significant probability of extinction. Assuming climatic change does not eliminate suitable habitat, current feral predator controls are sustained or improved and State lands which now support woylie populations are not alienated, and that there are adequate monitoring programs, there is no reason to believe factors operating at present will reverse the current trend of increasing populations and densities (where populations are still below carrying capacity). Thus woylies would not qualify as Vulnerable under this category.

[7] The number of translocation sites under this program has risen to 20 since the review was written.

Conclusion on the status of woylies as assessed by the 1994 IUCN Red List criteria

Woylies do not qualify as Vulnerable, the least critical of the Threatened group of categories (Table 2 and Figure 2). However, they would probably be Endangered or Critically Endangered if remnant populations had not been protected from fox predation and new populations established in the safety of feral predator control. Undoubtedly their status would revert to a Threatened category if active management, particularly of feral predators, were to be discontinued. Woylies are therefore unequivocally classified as 'Lower Risk (Conservation Dependent)'. Conservation Dependent taxa are those which are the focus of a continuing taxon-specific or habitat-conservation program, the cessation of which would result in the taxon qualifying for one of the threatened categories within five years (IUCN 1994).

3.2 Recovery Plan Criteria

The criteria set by the Recovery Team for successfully achieving the objectives are:

3.2.1 Western Australia

At least six populations of woylies, each occurring in areas of at least 1500 ha of suitable habitat and each increasing in density (and area where there is contiguous suitable habitat) or plateaued at a trap-success rate greater than 7.5 per cent

In WA the six primary sites selected by the Recovery Team for achieving this criterion are listed in Table 4 which also indicates recent trap success rates. At all sites except for Julimar, woylies occupy substantially more than 1500 ha at densities that yield trap success rates substantially greater than 7.5 per cent (Table 4).

Woylies were not translocated to Julimar until early 1995 and the trap success rate has not reached 7.5 per cent. Animals were released at two points. One group has established well but there was high predation of the other to begin with. Fox control has been intensified in that area and the prognosis is now good for woylies at Julimar.

It is difficult to provide precise area data and trap success data for the forest site at Batalling because woylies are still spreading into contiguous suitable habitat. The population of woylies in the Perup region is actually considerably larger than indicated in Tables 3 and 4. The trap success data in Table 4 is from the proposed Perup Nature Reserve, about 37 640 ha. Woylies are also abundant in Kingston and Warrup Forests up to 25 km west of Perup and have been caught in the intervening Corbal and Dwalgan Forests (16 per cent and 7 per cent trap success respectively). They have also been caught in low numbers in several forest areas at least 15 km south of Perup along the Muir Highway between Tone Forest and Lake Muir (Courtenay 1994). Thus woylies probably occur over an area of at least 60 000 ha in this region, but in variable densities.

It should be noted that interpretation of trap success (TS) becomes increasingly difficult as populations of fauna recover. This is illustrated by data from Tutanning. In July 1995 fifty traps were set over three nights to give 150 trap nights. Table 5 presents the results.

Woylie trap success is:

- 13.3 per cent using all captures
- 10.6 per cent using all individuals but excluding recaptures during the session
- 24.6 per cent assuming all traps that caught other species were unavailable to woylies.

In presenting trap success data we have used total woylie captures because some early data did not differentiate new from recaptured animals during any one trapping session. Our assumption that all traps were available means that, in many instances, the data are conservative.

TABLE 4

Area, trap success (expressed as a percentage of traps-nights on which woylies were captured) and notes on the six Western Australian sites identified in the Woylie Recovery Plan (Start *et al.* 1995) as key sites for recovery of woylies.

SITE	TRAP	AREA (ha)	NOTES
Batalling	24%	3617	33 565 ha now baited. Woylie density varies as they spread from the original Batalling site
Boyagin	47%	4781	Data from West Boyagin but woylies are present in both Blocks of this reserve
Dryandra	>50%	12192	Population estimated about 6 000 woylies. This has been the source of animals sent to SA
Julimar	New	24117	There is approx. 16 000 ha additional, contiguous, fox-baited forest on Commonwealth land to the north
Perup	35%	37640	Excludes areas outside proposed Perup Nature Reserve, e.g. Kingston and Lake Muir where there are woylies
Tutanning	13%	2369	69 of 150 traps caught other species and were at least partially unavailable to woylies

TABLE 5

Fauna captured in traps set in mid-1995 on a transect established for routine woylie monitoring at Tutanning Nature Reserve. (Numbers in parentheses exclude animals recaptured during the trap session.)

DATE	WOYLIE	POSSUM	QUENDA	BIRD
31 July 1995	6 (6)	22 (22)	2	1
1 August 1995	8 (7)	14 (12)	4	2
2 August 1995	6 (3)	19 (15)	5	0
TOTAL	20 (16)	55 (49)	11	3

Clarification of the status of the woylie in conservation reserves and State forest of the south-west of WA

The discovery of a woylie population at Kingston Forest and a road kill near Lake Muir were among the factors prompting the revision of the first edition of the Recovery Plan. Courtenay (1994) surveyed for woylies in forests between Perup and Kingston and also between Perup and Lake Muir. She found woylies in all but one of the areas she surveyed as far south as the Muir Highway, although trap rates were low in areas south of Perup. This suggests that woylies are probably present in varying numbers from Kingston to Lake Muir (see above for more detail).

Establishment of experiments to determine the effects of timber harvesting (at Kingston Forest) and fuel-reduction prescribed burning (at Batalling Forest) on woylies and commitment in a Wildlife Management Program to modify forest management prescriptions to ensure compatibility with maintaining woylie populations

The discovery of woylies at Kingston was made during a pre-logging fauna survey. There were also other threatened mammals present. These species occupied unlogged forest as well as forest logged about six years previously. Logging was postponed to allow time to set up experiments to quantify the impact of operational timber harvesting on fauna in the jarrah forest. Information from the experiment will be used to determine whether it is necessary to modify management prescriptions so that the species like woylies can recolonize all suitable forest habitat irrespective of tenure or use but under cover of fox control.

The experiments have been set up. Pre-logging data have been collected. Logging took place this year (1995). Preliminary results indicate woylies were not seriously affected by the operation. The experiment will run its full, planned course and CALM will assess the suitability of the current prescriptions when the results are available. The results of the experiment will be published.

An experiment to assess the impact of prescribed fuel-reduction fire on woylies and other mammals has been set up at Batalling. Preliminary results indicate woylies were not seriously affected by the operation. The experiment will run its full, planned course and CALM will assess the suitability of the current prescriptions when the results are available. The results of the experiment will be published.

3.2.2 South Australia

Maintenance of two island populations, on Wedge and St Peter Islands

Populations on Wedge and St Peter Islands are thriving. Trap success rates have commonly exceeded 50 per cent. David Groth and John Wetherall of Curtin University of Technology, assessed DNA profiles of animals from Wedge and St Peter Islands compared with animals from Tutanning. They reported to the Recovery Team that the island stocks (0.80 band-sharing) had very limited genetic variability and considerably less than the Tutanning stock which, at 0.50 band-sharing, approached that 'seen in a well maintained population of sheep or cattle'. Therefore wild-caught woylies from Dryandra have been introduced to Wedge Island in an attempt to increase the genetic variability of that population. If successful this process will be extended to St Peter Island.

Establishment of at least one mainland population in addition to the Yookamurra population

On 5 April 1994, after extensive work to control feral predators and rabbits, wild-caught woylies from Dryandra were released at Venus Bay Nature Reserve on Eyre Peninsula. The future of this reintroduction appears secure, with recent systematic trapping (September 1995) producing 33 per cent trap success (20 captures from 60 trap nights) five of which were new (untagged) animals. No further losses of radio-collared woylies to predators have occurred since the capture of a large male cat in March and seven of the 14 collared females were observed with large young at foot. In addition, all females handled were found to have pouch young and weights of all animals continue to be above weight at release, reaffirming the suitability of habitat and availability of adequate food resources.

The population at Yookamurra persists. DENR staff assist with monitoring. The status of genetic diversity of the Yookamurra population is probably similar to that of the SA island populations as it is derived from the same founder stock. Any decision to introduce wild-caught animals from elsewhere to broaden the genetic base will be for the managers to make. The DENR will continue to assist with monitoring for the time being.

3.2.3. Both States

Establishment of monitoring programs (to include genetic diversity) and action plans to address any adverse trends detected

In SA the annual monitoring of woylie populations on Wedge and St Peter Islands will continue. Fixed transects have been established to ensure comparability of data from year to year. Intensive monitoring of the establishing Venus Bay population, including systematic trapping three times per year and on-going radio tracking, will continue at least to the end of 1996 by research staff. DENR will determine the responsible personnel and program for monitoring thereafter.

In WA a monitoring program using standardized transects, with permanently marked trap locations, has been established (Courtenay 1994) and regular monitoring, at least annually, will be undertaken by CALM staff responsible for the management of the areas occupied by each of the woylie populations. This will be added to as more populations are established by translocation or as woylies extend into new districts under cover of CALM's program to control foxes in the south-west of WA. Samples from all populations have been collected to provide base line data on the genetic variability of wild woylie populations.

3.3 Criteria under CALM Policy

CALM Policy Statement No. 33 'Conservation of Threatened and Specially Protected Fauna in the Wild' (endorsed 1991) provides the mechanism and criteria by which species are assessed for inclusion and removal from the Schedule of 'fauna which is likely to become extinct or which is rare' pursuant to the Western Australian Wildlife Conservation Act.

It establishes a Threatened Fauna Scientific Advisory Committee[8] to review and advise the Executive Director on all proposals to amend the schedule. An indigenous taxon may be recommended for inclusion on the list if it is:

- ***presumed to be extinct*** The woylie is not presumed extinct.
- ***in imminent danger of or threatened with extinction, i.e. it is likely to decrease in numbers and possibly become extinct if factors causing its decline continue to operate*** The number of woylie populations and, where there is natural vegetation adjacent to that already containing woylies, the area occupied by woylies, are increasing.
- ***dependent on or restricted to habitats that are vulnerable and/or subject to factors that may cause its decline*** This criterion is pertinent to situations such as salt encroachment threatening habitat. Although woylies could decline to extinction if fox control were to cease, there is an on-going commitment by CALM to maintain fox control in all areas occupied by woylies (which also contain other threatened fauna in need of protection from foxes). Given that commitment, habitat occupied by woylies is not vulnerable or subject to factors that may cause their decline (see below).
- ***very uncommon, even if widespread*** The woylie is now very common in several locations in the south-west of WA in addition to the populations in SA.

Policy Statement No. 33 provides for the Threatened Fauna Scientific Advisory Committee to recommend that a taxon be removed from the schedule where:

- ***recent zoological survey has shown that the taxon no longer meets the above criteria***

- ***the taxon is no longer threatened because it has been adequately protected by habitat protection and its numbers have increased beyond the danger point*** This point clarifies the third dot-point in the criteria for listing (above).

Policy Statement No. 33 also requires the Threatened Fauna Scientific Advisory Committee to prepare a 'Reserve List' listing (among other categories) taxa that have recently been removed from the schedule of threatened fauna.

The Recovery Team considers that the woylie no longer meets the criteria for inclusion on the schedule of threatened fauna. It satisfies both requirements for removal from the schedule and should be placed on the Reserve List. The Recovery team recognizes that the Policy will require the Executive Director to refer its recommendations (below) to the Threatened Fauna Scientific Advisory Committee for review.

3.4 Criteria under South Australian Legislation

The South Australian National Parks and Wildlife Act requires assessment for declaration be in accordance with a species status within that State's borders, irrespective of its status elsewhere (unlike the Western Australian and Commonwealth legislation). The Recovery Team has implemented a National Recovery Plan and its conclusions pertain to the global status of woylies. It is the prerogative of the South Australian Government to assess the status of the woylie within that State, but the Recovery Team draws its conclusions to the attention of the SA Government and would be pleased to see its status reviewed in SA.

3.5 Criteria under Commonwealth Legislation

The Endangered Species Protection Act lists Endangered and Vulnerable native species on Schedule 1, Parts 1 and 2 respectively. It defines a species as endangered if:

(a) *it is likely to become extinct unless the circumstances and factors threatening its abundance, survival or evolutionary development cease to operate; or*

(b) *its numbers have been reduced to such a critical level, or its habitats have been so drastically reduced, that it is in immediate danger of extinction; or*

(c) *it might already be extinct, but is not presumed extinct.*

It defines a species as vulnerable if, ***within the next 25 years, the species is likely to become endangered unless the circumstances and factors affecting its abundance, survival or evolutionary development cease to operate.***

In the areas it now inhabits, the principal threat has been predation. That threat has been sufficiently controlled to allow substantial increases in population density as well as in area of occupancy. Translocations have increased the number of populations and will continue to do so. The increases which will be sustainable as long as foxes are controlled mean that the woylie no longer meets criteria as Endangered or Vulnerable.

4. Recommendations

1. We recommend to the Chief Executive Officers of CALM and ANCA and to ANZECC that our conclusions are conveyed to their Ministers together with a recommendation that *Bettongia penicillata* be downgraded:

- under the Commonwealth Endangered Species Protection Act, by deletion from Schedule 1, 'Listed Species';
- under the Western Australian Wildlife Conservation Act, by removal from listing as 'fauna which is likely to become extinct or which is rare' and addition to the Reserve List as defined by Policy Statement No. 33.

[8] This committee has been replaced by the Western Australian Threatened Species Scientific Committee which considers fauna and flora issues.

And we recommend to the Chief Executive Officer of DENR that in South Australia its conservation status within the State be reviewed.

2. CALM and DENR write or review monitoring and management programs to ensure that the management necessary to maintain woylies as Conservation Dependent species is implemented and effective[9]. The plans should:
• provide for further improvement in the conservation status of woylies, and
• commit to action to address any significant decline detected by the monitoring programs.

WOYLIE (*BETTONGIA PENICILLATA OGILBYI*):A REVIEW OF ITS STATUS IN DECEMBER 1995. SUPPLEMENT: THE STATUS OF WOYLIES IN 1990.[10]

1. The Purpose of this Review

The Woylie Recovery Plan required the Recovery Team to 'Review the conservation status of the woylie, using internationally accepted criteria, and recommend changes if necessary' at the conclusion of its program of recovery actions in December 1995 (Start *et al.* 1995). That review was undertaken (above) using the IUCN Red List criteria (IUCN 1994). The Recovery Team found that the woylie did not qualify as Threatened but did qualify as Lower Risk (Conservation Dependent). The Recovery Team made the following recommendations[11].

In addition to defining criteria for classification of species the 1994 IUCN Red List document states 'There are rules to govern the movement of taxa between categories. These are as follows: (A) A taxon may be moved from a category of higher threat to a category of lower threat if none of the criteria for the higher category has been met for five years or more...' (the other rules are irrelevant here). In the woylie's case the subject has a short generation time and a rapid recovery rate when protected from adverse factors such as predation. New populations are readily established from translocated stock and woylies are now secure in conservation reserves where there is an on-going commitment to fox control (a key factor).

Furthermore, there are commitments to on-going monitoring and State and Commonwealth legislation would require relisting in a Threatened category if its status again declined. In view of those factors, and given that its status will be under review routinely through the monitoring program, the Recovery Team recommended re-classification immediately and not pending yet another review in five years.

It must be understood that the IUCN Red List Categories used here were not published until 1994 and that they were not available five years ago for use in classifying woylies. Nevertheless, the Recovery Team thought it would be useful to examine the status of woylies five years ago. We have used the current IUCN criteria to retrospectively assess the conservation status of the woylie as it would have been in 1990.

2. The Status of Woylies in 1990

The IUCN Red List categories (IUCN 1994) details the criteria that are currently used to classify the conservation status of species. It uses five independent topics to allocate the conservation status of a species to one of the categories (Table 2 and Figure 2). The species being assessed is allocated to the highest category determined by any one of five topics (A to E below). In the following analysis we assessed the woylie against the lowest of the Threatened classifications (Vulnerable). Had it met that classification we would have assessed it against the next (Endangered) etc. This was the method used in the principal review.

A. *Substantial past or projected future decreasing population trends*

For woylies to qualify as vulnerable there must have been a reduction in population size of at least 20 per cent over the last ten years or a projected reduction of 20 per cent in the next ten years. Table 6 summarizes woylie status in 1980 compared with that five years prior to the review, i.e. December 1990.

Introduced populations on two additional, small SA islands with carrying capacity of <50 animals were recognized by the Recovery Team to be too small to remain viable in the long-term (one became extinct in early 1994).

There is no evidence of a net deterioration in the size or number of populations between 1980 and 1990. Instead there were improvements in both factors. At Dryandra and Tutanning the increase in population density (as measured by trap success) had occurred since fox control measures were introduced and, at Perup, since habitat management and some fox control had been implemented. Although the improvement was not as dramatic as it has been in five years since 1990, the criterion of a reduction of at least 20 per cent in the decade preceding 1990 clearly had not happened. As the prospect of recovery after 1990 improved with the endorsement of the first Recovery Plan (Hall *et al.* 1991) there were no grounds for anticipating a decline in the succeeding ten years. Indeed improvements in the last five years have vindicated the optimism for improvement after 1990.

Woylies would not have qualified as Vulnerable under this category in 1990.

[9] In WA, Western Shield has incorporated woylies into monitoring and fauna reconstruction programs. The latter will establish new populations in many conservation reserves.
[10] Prepared by A.N. Start, and A.A. Burbidge for the Woylie Recovery Team.
[11] The original supplementary review reiterated the recommendations. For reasons of economy they are not repeated here.

TABLE 6
Change in the conservation status of *Bettongia penicillata* between 1980 and December 1990.

LOCATION	STATUS IN 1980	STATUS IN DECEMBER 1990
Batalling	Presumed extinct	Re-introduced 1983. Small, but established, new population
Dryandra	TS 0% in 1975[a] No data for 1980	TS variable but mean 16% in baited area in 1989. Data not available for December 1990
Perup	TS 24.6%[b]	TS variable but consistently >39.5% in December 1989; 62% in April 1990[c]
St Peter Island	Not naturally occurring	Introduced 1989; established new population
Tutanning	TS mean 2.7% 1984[d]	TS mean 21.5% in 1989 Data not available for 1990
Wedge Island	Not naturally occurring	Introduced 1983; well established new population

TS = Trap success expressed as a percentage.

[a] None could be trapped but woylies must have been present in very low numbers. Baiting of a small part of Dryandra commenced in 1982.

[b] Boyicup Block, the forest block at Perup that was monitored by Christensen 1974-1981. Data include captures in cage traps (as in the present monitoring program) as well as pre-baited funnel traps.

[c] Yendicup Block, the forest block at Perup monitored by Burrows 1989-1994. Cage traps only.

[d] No data available when fox-baiting began.

B. *Extent of occurrence and areas of occupancy*
(see IUCN 1994 for definitions)

To qualify as Vulnerable a species will have an extent of occurrence of less than 20 000 km² or area of occupancy of less than 2000 km² and, furthermore, meet two out of three additional criteria. In 1990 woylies had an extent of occurrence many times 20 000 km² extending from WA to SA. However, the area of occupancy is difficult to determine where populations were expanding in the shelter of fox control so the additional requirements are considered.

(1) *Populations are severely fragmented (no population is estimated to contain more than 1000 mature individuals) or found at no more than ten locations*
The Dryandra population is estimated at about 6000 individuals (1994, Jackie Courtenay, unpublished data). Trap success rates in 1990 (mean = 16 per cent in baited areas and half that in unbaited areas) suggest that in that year there were many more than 1000 individuals. Perup (including the area from Kingston to Lake Muir) contains a much larger population which has persisted without regular fox control over much of the area. It too would have contained more than 1000 individuals in 1990.

(2) *The species continues to decline in any of the following*
(a) Extent of occurrence: it had been extended from south-western WA to SA.
(b) Area of occupancy: by 1990 it was increasing with introductions in WA and SA.
(c) Area, extent or quality of habitat: in 1990 these were increasing/improving with expansion of fox control in WA and translocations to SA islands and Batalling in WA.
(d) Number of locations or sub-populations: these had increased in WA and SA.
(e) Number of mature individuals: Woylies breed in their first year. Therefore populations that had been increasing prior to 1990 would have contained increasing numbers of mature individuals in WA and SA.

(3) *Extreme fluctuations in any of the following*
(a) Extent of occurrence: this was increasing with translocation to SA islands.
(b) Area of occupancy: it was stable or increasing, depending on site, in WA and SA.
(c) Number of locations or sub-populations: it had increased in WA and SA.
(d) Number of mature individuals: this was presumed to have stabilized or increased, depending on site, in WA and SA.

Woylies did not meet any of the additional characters. Thus they would not have qualified as Vulnerable under this category in 1990.

C. *Population size (for larger populations) and predicted decreasing trends*

For woylies to be assessed as Vulnerable, this category requires that the total number of individuals is less than 10 000 and either there is an estimated continuing decline of at least 10 per cent in ten years or there is a continuing decline in the number of mature individuals or population structure (severe fragmentation or all mature animals in one sub-population).

Although it is not possible to estimate the total number of woylies in 1980 and 1990 it has been shown above that woylie populations had improved, not declined in the decade preceding 1990. Furthermore, there was a good prospect over the decade from 1990 for increases in the number of mature individuals in populations and an associated expectation of improvement in the fragmented nature of habitat occupation. These would be the outcomes of actions spelled out in the Recovery Plan. Progress since 1990 shows that these were realistic expectations.

Woylies did not meet either of the additional characters. Thus they would not have qualified as Vulnerable under this criterion in 1990.

D. *Population size (of smaller populations) irrespective of population trends*

To qualify as Vulnerable, this category requires the total population to be very small (<1000 individuals) or the population to be acutely restricted in its area of occupancy (typically <100 km^2 = 10 000 ha) or number of locations (typically <5).

Table 6 identifies six locations at which woylies were present in 1990. At Dryandra they occupied an area exceeding 12 000 ha and Perup comprises an area of 37 640 ha but it has since been found that woylies extended up to 25 km west of Perup to Kingston Forest and 15 km south to near Lake Muir. Populations at Dryandra and Perup (and probably one of the SA islands) would have exceeded 1000 individuals.

Woylies would not have been classified as Vulnerable under this category in 1990.

E. *Quantitative analysis showing probability of extinction in specified time units or generations*

To qualify as Vulnerable by this category a quantitative analysis must show a probability of extinction of at least 10 per cent within 100 years. No analysis was undertaken for woylies in 1990. However, by then the key factor (fox predation) in the decline of woylies in south-western WA had been identified and successfully addressed and translocation had been shown to be an effective means of establishing new populations. The status of woylies had already improved and a recovery plan which built on the factors that had produced the improvements had been written and endorsed. The principal recovery actions were to be fox control and increasing the number of populations in WA and SA through translocation. Monitoring was also an essential component. Given these factors, a population viability analysis would have been unlikely to show a significant probability of extinction.

Thus woylies would probably not have qualified as Vulnerable under this category in 1990.

3. Conclusion

Woylies would not have qualified as Vulnerable, the least critical of the Threatened group of categories, if assessed in 1990 by the 1994 IUCN Red List criteria. They would have been classified as 'Lower Risk (Conservation Dependent)' if the classification system had existed then. Never-the-less they were much less secure than they are now (compare Table 6 with Tables 3 and 4).

We do not believe that the 1994 IUCN Red List rules for transfer intended a moratorium on reclassification for five years from publication. Rather we believe that in adopting the new criteria, it is sensible to re-evaluate species by them and, if appropriate, adjust their conservation classification. In the case of woylies the species has met the criteria for 'Lower Risk (Conservation Dependent)' for at least five years and its status continues to improve.

The Recovery Team firmly believes that its recommendations are sound and that to postpone reclassification of woylies pending a further review in five years time is unnecessarily bureaucratic, is not the intention of the IUCN system, will debase the credibility of the classification Threatened when a species clearly no longer meets the criteria and will divert resources and attention from much more critically threatened species.

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