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Conserving the Black-flanked Rock-Wallaby (*Petrogale lateralis lateralis*) through Tourism: Development of a habitat ranking system for translocated animals and the need for on-going management

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ABSTRACT

The Black-flanked Rock-Wallaby (*Petrogale lateralis lateralis*) was once widespread throughout Western Australia but due to a combination of factors its range has declined significantly and its present distribution is limited to a few widely scattered isolated populations. It is gazetted as vulnerable under Western Australian legislation and requires active management to ensure its survival. Translocating species to areas of suitable habitat, when coupled with predator control, is an effective method of expanding species distribution as well as increasing population numbers.

This study investigated the requirements for both effective translocation and site assessment in relation to the development of tourism based on black-flanked rock-wallabies. A species-specific habitat ranking system was devised to identify suitable areas for translocated populations. This was followed by an assessment of the tourism potential of the identified sites. When both sets of results were added together potential sites were identified that could satisfy both habitat and tourism requirements. Avon Valley National Park and Billyacatting Nature Reserve were found to be the most suitable sites for translocating rock-wallabies on the basis of suitable habitat and the potential for subsequent development of wildlife tourism.

Viable breeding population size, feral predator control, competing introduced herbivore control and fire management are all identified as aspects that require management action. Tourism management requires stakeholder liaison, possible zoning and separation strategies and appropriate waste disposal at tourism sites. Public contact with translocated animals requires an educative approach that avoids any feeding of wildlife. Relatively close contact between visitors and wildlife may be achieved through a process of habituation. Such strategies should however be subject to review.

Key words: Black-flanked Rock-Wallaby, translocations, habitat ranking, tourism potential, wildlife management

INTRODUCTION

Many species of Australian fauna are threatened with extinction (Ride and Wilson, 1982; Recher, 1990), with the southern arid zone and the Western Australian wheatbelt (agricultural area of Western Australia) seriously affected (Short and Smith, 1994). To aid conservation, Australia requires income to fund environmental protection agencies and national park services (Figgis, 1993). Ecotourism is perceived to be an environmentally benign industry that can generate these much-needed funds (Figgis, 1993). Translocation of a species and the subsequent development of wildlife tourism can assist conservation efforts. Wildlife tourism research is urgently needed in Australia if wildlife tourism is to provide benefits for the much-needed conservation of Australian native wildlife. Wildlife tourism can thus be an instrument of conservation and can benefit both wildlife and local communities. Benefits include education of visitors, economic benefits to local communities and the development of an economic incentive to protect the wildlife on which the tourism is based (Higginbottom *et al.* 2001a).

In the Macropodidae and Potoroidae families (kangaroos, wallabies and rat-kangaroos) the majority of the smaller species have suffered range reduction in areas where humans have settled and eliminated suitable habitat and where introduced species have established (Ride and Wilson, 1982; Morton, 1990). The Black-flanked Rock-Wallaby (*Petrogale lateralis lateralis*) is one such species that has shown considerable decline during the 20th century (Pearson and Kinnear, 1997) and is the focus of this study. The reasons for the decline of the Black-flanked Rock-Wallaby are varied but include predation by foxes and feral cats, degradation of habitat due to introduced grazers such as sheep and rabbits, as well as changed fire regimes (Kinnear *et al.*, 1988; Johnson *et al.*, 1989; Pearson, 1992; Maxwell *et al.*, 1996; Kinnear *et al.*, 1998). Although there is no single cause of decline, Kinnear *et al.*, (1988, 1998) demonstrated that fox predation has played a major role in the reduction of Black-flanked Rock-Wallabies in the wheatbelt.

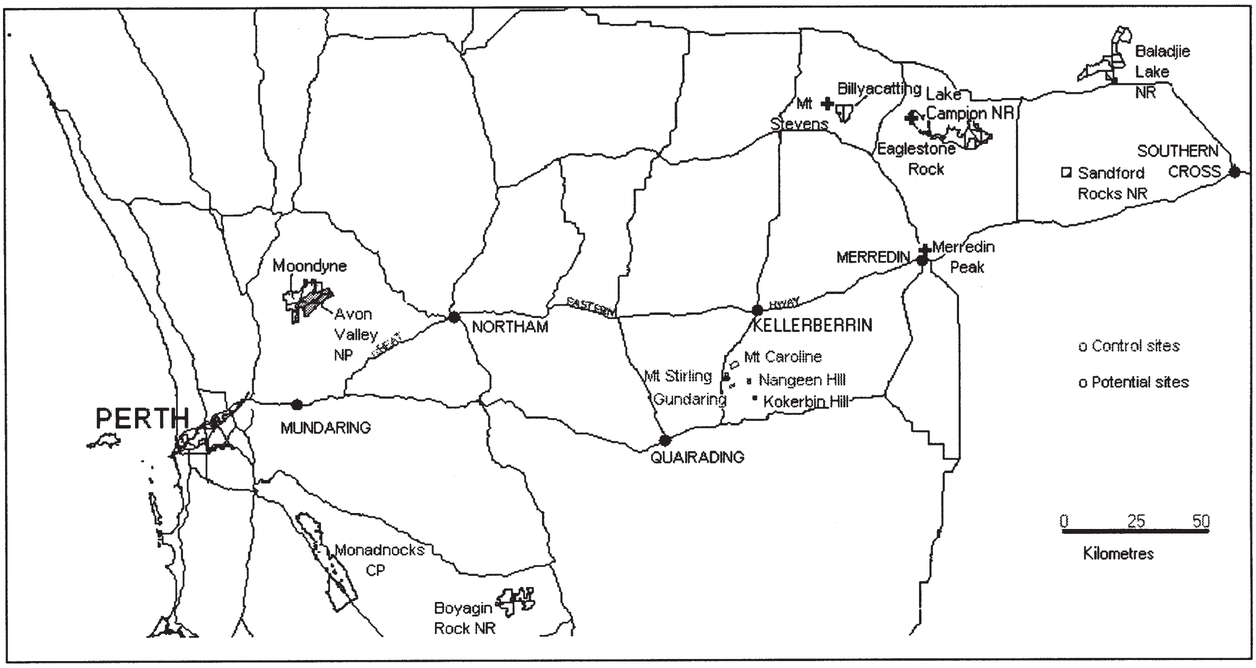

Figure 1. Location of control sites and potential sites.

Currently there are seven wheatbelt Black-flanked Rock-Wallaby populations restricted to isolated granite outcrops (Figure 1) and natural dispersal is difficult due to the surrounding agricultural landscape. Translocations are therefore a necessary management strategy to increase long-term viability of the species. By translocating animals away from the source population, the risks of catastrophic events destroying all the populations are reduced.

Marsupials are particularly important to the tourism image of Australia (Higginbottom *et al.,* 2001b). Croft and Leiper (2001) believed rock-wallabies were good candidates for wildlife tourism as they often inhabit spectacular landscapes, are visible particularly in the cooler parts of the day and most mainland states possess good localities for viewing rock-wallabies. Green *et al.* (2001) also stated rock-wallabies had suitable tourism potential due to their large size compared with other marsupials and their international uniqueness. The vulnerability status of Black-flanked Rock-Wallabies may also add to their appeal as visitors have shown a preference to viewing threatened or unusual animals (Gray, 1993). Therefore an opportunity exists to develop responsible wildlife tourism based around Black-flanked Rock-Wallabies. For rock-wallaby tourism to be successfully developed, research is required on many levels including site surveys to determine habitat suitability and tourism potential.

The aim of this study was to aid the Department of Environment and Conservation (DEC) in identifying translocation sites suitable for rock-wallaby tourism. Selected sites needed to fulfill both habitat requirements for Black-flanked Rock-Wallabies and possess sufficient potential for recreation and tourism. We are not aware of any assessment combining both habitat suitability and wildlife tourism potential that has been previously conducted in Australia.

METHODOLOGY

Site selection

A site survey was conducted on potential translocation sites for Black-flanked Rock-Wallabies in the southwest of Western Australia. A rapid methodology for assessing the recreation potential of reserves in the Merredin District (Fig. 1), developed by Moncrieff (1996), was used as a basis for site selection. The top 21 ranked sites selected in the Merredin District, which received high scores for topographical complexity (a sub-category used in the recreation assessment system) and contained granite outcrops, were initially selected as the study sites. However distance from a major travel route was also factored in. The potential translocation sites in the Merredin District that were assessed included: Sandford Rocks, Baladjie Lake, Eaglestone Rock, Merredin Peak, Mount Stevens and Billyacatting Reserve (Fig. 1). Kokerbin Hill Nature Reserve was also included in the assessment as Black-flanked Rock-Wallabies were recorded here up until 1970 (Kinnear, 1998). Sites closer to Perth such as Boyagin Rock and Monadnocks Conservation Park were also examined. These two sites are established tourism sites and display topographical complexity. The Bibbulmun Track bisects the latter and attracted 35 000 walkers during 1999/2000 (Hunt, 2000).

Avon Valley National Park was also selected, as there is evidence that *P.l.lateralis* formerly occupied this site from an account by John Gould (Eldridge and Close, 1995). Avon Valley National Park is located closer to Perth than the other sites and is an established tourism destination with approximately 10 000 visitors per year. This site was therefore examined to assess whether the vegetation or granite formations were significantly different from the sites where Black-flanked Rock-Wallabies currently occur.

Fox baiting appears to be essential to the survival of the Black-flanked Rock-Wallaby (Kinnear *et al.*, 1988). Of all the potential sites assessed, only Kokerbin Hill, Boyagin Rock, Monadnocks Conservation Park and Avon Valley National Park are fox baited under the Department of Environment and Conservation's current Western Shield baiting strategy.

Development of a habitat ranking system

Four control sites (sites where rock-wallabies are present) and ten potential sites (no rock-wallabies present) were assessed for their suitability as rock-wallaby habitat. All sites were close to a major travel route. Sites in the wheatbelt were close to the Great Eastern Highway and Avon Valley National Park is off Toodyay Road. Monadnocks Conservation Park straddles the Albany Highway and Boyagin Rock is adjacent to the Brookton Highway (Figure 1). All sites were characterised by a large granite outcrop being a predominant feature within the site.

The control sites were used as standards against which desirable habitat characteristics were identified. Potential translocation sites were then compared with the control sites based on these characteristics. Incomplete museum records of the former distribution of the Black-flanked Rock-Wallaby restricted the assessment of sites. The co-ordinates indicated in the museum records of sites of past occurrence in the wheatbelt appear to be of the nearest town and not of the actual record location. Another limitation to including more control sites in the assessment includes the remaining two rock-wallaby colonies occurring on private property potentially restricting access.

No documented systematic assessments of habitat requirements of the Black-flanked Rock-Wallaby has been conducted in Australia, although studies have been undertaken on other rock-wallaby species. Lobert (1988) developed a recording system to describe sites of occurrence of Brush-tailed Rock-Wallabies (*P. penicillata*) in Victoria. Lobert (1988) found the variables most accurate in predicting preferred rock-wallaby habitat included colour of the rock and complexity of the habitat. Colour of rock (which may be important with regards to temperature regulation) could not be applied to the sites in this study due to all the outcrops being composed of granite and consequently of similar composition and colour.

Short (1982) measured six variables which were shown to be significant in predicting the presence of Brush-tailed Rock-Wallabies (*P. penicillata*) in New South Wales. The six significant variables were:

1. The number of ledges
2. Aspect of cliff
3. Number of caves of restricted accessibility
4. Length of ledges
5. Percentage of sheltered sites
6. Number of apparent routes from cliff top to cliff face.

Copely (1990) used a simple ranking system to assess the habitat of Yellow-footed Rock-Wallabies (*P. xanthopus*) in New South Wales. Habitats were scored on their

TABLE 1

Ranking system assessment of rock complexity for black-flanked rock-wallaby habitat

Rock Complexity *	
20	Predominantly weathered rock face consisting of mainly medium boulders, caves, ledges and fissures present
19	Predominately weathered rock face consisting of mainly large boulders, caves, ledges and fissures present
18	Predominately weathered rock face consisting of mainly small boulders, caves, ledges and fissures present
17	Extensively weathered rock faces consisting of mainly medium boulders, caves, ledges and fissures present
16	Extensively weathered rock faces consisting of mainly large boulders, caves, ledges and fissures present
15	Extensively weathered rock faces consisting of mainly small boulders, caves, ledges and fissures present
14	Isolated boulder piles consisting of medium and small boulders, caves, ledges and fissures present
13	Isolated boulder piles consisting of large boulders, caves ledges and fissures present
12	Isolated boulder piles consisting of small sized boulders, caves ledges and fissures present
11	Predominately granite pavement structure with mainly medium boulders, caves, ledges and fissures present
10	Predominately granite pavement structure with mainly large boulders, caves, ledges and fissures present
9	Predominately granite pavement structure with mainly small boulders, caves, ledges and fissures present
8	Predominately weathered rock faces consisting of mainly medium boulders, ledges and fissures present, no caves
7	Predominately weathered rock faces consisting of mainly large boulders, ledges and fissures present, no caves
6	Predominately weathered rock faces consisting of mainly small boulders, ledges and fissures present, no caves
5	Predominately granite pavement structure with mainly medium boulders, ledges and fissures present, no caves
4	Predominately granite pavement structure with mainly large boulders, ledges and fissures present, no caves
3	Predominately granite pavement structure with mainly small boulders, ledges and fissures present, no caves
2	Granite pavement with predominately small boulders, no caves, ledges or fissures present
1	Granite pavement with no boulders

* Rank of 20 represents ideal score with a rank of 1 representing unsuitable habitat for black-flanked rock-wallabies

Large boulders = > 5 metres in diameter
Medium boulders = 1 to 5 metres in diameter
Small boulders = <1 metre in diameter

physical complexity on a scale of one to five. The abundance of rock-wallabies was described as either uncommon or abundant depending on the abundance of scats or animals sighted. It was found that rock-wallaby abundance was positively correlated to habitat complexity. Two physical features, cliffs and large boulders, were seen as critical to rock-wallaby occurrence, although no definition for "large" was given.

Lim and Giles (cited in Lim *et al.*, 1992) developed a more detailed ranking system in 1987 for assessing actual and potential colony sites of Yellow-footed Rock-Wallabies (*P. xanthopus*) in New South Wales. The highest ranked habitat featured steep cliffs, outcrops, gorges, terraces, caves, rock piles and water. Additional points were awarded for boulder size and the smoothness of boulders, with large (>1 metre) smooth boulders receiving the highest score. There was a strong correlation between the presence of rock-wallabies and a high habitat score (Lim *et al.*, 1992).

In summary, the habitat requirements of rock-wallabies have been listed by most researchers as complex boulders with caves and cervices and a food source dominated by grass species (genera not specified). The analysis of the four control sites confirmed these characteristics. It was thus decided to develop a habitat ranking system using these habitat criteria to compare and contrast sites currently supporting Black-flanked Rock-wallabies to sites that appeared to be suitable but lacked rock-wallaby populations. A qualitative rank was assigned to each habitat component. Scores for each component recognised that some were more critical to rock-wallaby survival than others (eg. rock complexity was scored out of twenty whereas the presence or absence of fox control was assigned a score of one or zero).

The variables that were assessed were:

1. Rock complexity
2. Vegetation type
3. Fox control (Absent/Present)
4. Area of suitable habitat (ha)
5. Evidence of past/present distribution
6. Aspect
7. Rock to vegetation ratio

Complexity of the rocky outcrop and the presence of caves, ledges and fissures was considered as one of the most important attributes of a site and thus ranked highly (Table 1). Medium boulders were considered to be more desirable than larger and smaller boulders as this size allowed for the formation of the most suitable caves, ledges and fissures that could be utilised by rock-wallabies.

Flat granite pavement landscapes lacking boulder formations received the lowest score as this habitat failed to provide protection for rock-wallabies. The scores increased with a) increasing complexity and b) area of complexity (i.e. outcrops made up of predominantly granite pavement would score less despite the presence of cracks, ledges and boulders).

If sites received a score of 10 or higher for rock complexity, they were then assessed for vegetation type, presence of fox control, aspect, rock to vegetation ratio and area of suitable rocky habitat (Table 2). Sites failing to score ten or above were regarded as being unsuitable rock-wallaby habitat and excluded from further consideration.

The presence of grass growing on the outcrop would enable rock-wallabies to forage close to their sites of refuge. Proserpine Rock-Wallabies (*P. persephone*) in Queensland were found to require rocky outcrops with a canopy of vine forest in the vicinity of open forests, and vegetation for grazing on the edges of the habitat (Davidson, 1991). A canopy of trees was also considered to be desirable for Black-flanked Rock-Wallabies, as it would provide more protection from predators, in particular wedge-tailed eagles, than open grasslands with sparse tree cover. Vegetation comprising dense woody thickets with patchy grass cover was considered undesirable, as it lacked sufficient grass for foraging. Fox control was an additional managerial advantage to an area but not essential as an area could be fox baited before the translocation of rock-wallabies.

The ratio of rock to vegetation area was considered important as at Mt Caroline rock-wallabies had started to feed on crops in surrounding farmlands. This may be due to the carrying capacity of the habitat being exceeded. This problem has not been encountered at Nangeen Hill as this reserve has a larger area of vegetation surrounding the granite outcrop. A low ratio of rock to vegetation area thus ranked higher.

Area of suitable habitat was considered important, as it would dictate population size. Area of suitable habitat was an estimate of the percentage of suitable habitat multiplied by the area of the outcrop. In sites like the Avon Valley where the granite boulders are spread throughout the park, the total area of suitable habitat was added together to form the estimate, as animals could easily move between these areas.

Evidence of past or present occurrence was also factored in, although this component was not weighted highly due to lack of extensive records of past occurrence. Two sites received a score for evidence of past occurrence, Kokerbin Hill and Avon Valley National Park. All the control sites displayed evidence of present occurrence. This was confirmed by sightings of rock-wallabies and the presence of scats.

Aspect was included in this ranking system, however there are no data on the preference of Black-flanked Rock-Wallabies in relation to aspect. A northerly aspect was shown to be an important factor in studies of Brush-tailed Rock -Wallabies (*P. penicillata*) in New South Wales (Short, 1982). However, Yellow-footed Rock-Wallabies (*P. xanthopus*) were found to favour a southerly aspect in New South Wales (Lim *et al.*, 1992). Aspect was not the most accurate indicator in the presence of Brush-tailed Rock-Wallaby in Victoria (Lobert, 1988).

Due to these conflicting findings, aspect was allocated a low overall weighting. A northerly aspect was assumed to be preferred, as rock-wallabies at Mount Stirling and Gundaring Nature Reserve were observed to inhabit the

TABLE 2

Assessment of habitat characteristics of sites receiving a score of 10 or above in the rock complexity category

Vegetation Type	
12	Grass and trees growing on outcrop with surrounding woodlands and grasslands
11	Grass and trees growing on outcrop with surrounding woodlands, grasslands and thicket
10	Grass and trees growing on outcrop with surrounding grasslands, trees sparse
9	Grass and trees growing on outcrop with surrounding thickets
8	Grass and bushes growing on outcrop with surrounding woodlands and grasslands
7	Grass and bushes growing on outcrop with surrounding woodlands, grasslands and thicket
6	Grass and bushes growing on outcrop with surrounding grasslands, trees sparse
5	Grass and bushes growing on outcrop with surrounding thicket
4	Bare rock outcrop with surrounding woodlands and grasslands
3	Bare rock outcrop with surrounding woodlands, grasslands and thicket
2	Bare rock outcrop with surrounding grasslands, trees sparse
1	Bare rock outcrop with surrounding thicket
Fox Control	
1	Present
0	Absent
Area of Suitable Habitat (Hectares)	
10	>100
9	91-100
8	81-90
7	71-80
6	61-70
5	51-60
4	41-50
3	31-40
2	21-30
1	11-20
0	<10
Evidence of Past/Present Occurrence	
2	Yes
0	No
Aspect	
5	North
4	Northwest/Northeast
3	East/West
2	Southeast/Southwest
1	South
Rock: Vegetation (Ratio)	
10	1: <1
5	1: 1-5
1	1: > 10

northern face of the outcrops, as these faces were more weathered. Kinnear *et al.* (1998) found most refuge sites faced north or northeast at Mount Caroline.

Recreation and tourism assessment

Moncrieff's (1996) recreation and tourism assessment methodology was based on three broad categories: "physical attributes" (maximum score =100), "threats and use" (30), and "current management" (45). In this study, the "current management" was substituted for a rating based on ease of viewing wildlife on the rock outcrops (Table 3). "Current Management" was excluded as the management of the chosen site would alter once rock-wallabies were translocated there. "Viewing wildlife" was allocated a score out of ten, hence the maximum score for the altered recreation and tourism potential ranking system was 140.

Sites that contained exposed complex boulder formations on granite outcrops were awarded a higher score than sites where the most suitable habitat was in a valley and could not be viewed from a distance. Lower scores were also awarded for sites that were densely vegetated around the outcrop, as the rock-wallabies would be more difficult to view from a distance. If sites received a score below five they were excluded and deemed unsuitable for rock-wallaby tourism.

Only sites that received high scores for both rocky complexity (Table 1) and ease of viewing wildlife on rock outcrops (Table 3) were assessed in the recreation assessment system. The sites receiving the highest scores in both the habitat ranking system and the tourism

Table 3
Break down of scores for ease of viewing wildlife on rock outcrops

Score	Vegetation and Position of Outcrop
10	Raised outcrop surrounded by predominantly grasslands and open woodlands around base
9	Raised outcrop surrounded by woodlands around base
8	Raised outcrop surrounded by dense vegetation viewed with ease from surrounding rock platforms
7	Raised outcrop surrounded by dense vegetation
6	Outcrops on a slope surrounded by predominantly grasslands and open woodlands around base
5	Outcrops on a slope surrounded by woodlands around base
4	Outcrops on a slope surrounded by dense vegetation
3	Outcrops in a valley surrounded by predominately grasslands and open woodlands around base
2	Outcrops in a valley surrounded by woodlands at the base
1	Outcrop in a valley surrounded by dense vegetation

potential assessment system would be considered as potential translocation sites.

RESULTS

Potential translocation sites

Sites satisfying both rock complexity requirements and ease of viewing requirements were: Mount Caroline, Nangeen Hill, Mount Stirling, Gundaring, Kokerbin Hill, Sandford Rocks, Baladjie Lake, Billyacatting and Avon Valley (Table 4). Sites failing to satisfy both criteria were Merredin Peak, Eaglestone Rock, Mount Stevens, Boyagin Rock and Monadnocks Conservation Park (Table 4). Sites were further refined based on the categories outlined in Table 2. These results are summarised in Table 5.

By further refining the ranking allocated to each site, it was found that Mount Caroline received the highest score for habitat suitability (35/40). Nangeen Hill and Billyacatting ranked equal second (31/40), with Avon Valley National Park ranking third in habitat suitability (29/40). Gundaring and Mount Stirling received the same score (27/40) and were ranked fourth in habitat suitability. Kokerbin Hill (20/40), Baladjie Lake (18/40) and Sandford Rocks (14/40) scored the lowest.

Table 6 shows Baladjie Lake had the highest score for "physical attributes" and ranked highest overall for tourism potential (107/130). Avon Valley also scored second highest in the assessment (99/130). Mount Caroline, Nangeen Hill, Mount Stirling, Gundaring and Kokerbin Hill all received equal scores for "physical attributes" and "threats and uses" (Table 6). The individual scores for habitat suitability and tourism potential are shown in Figure 2. Just over half the sites

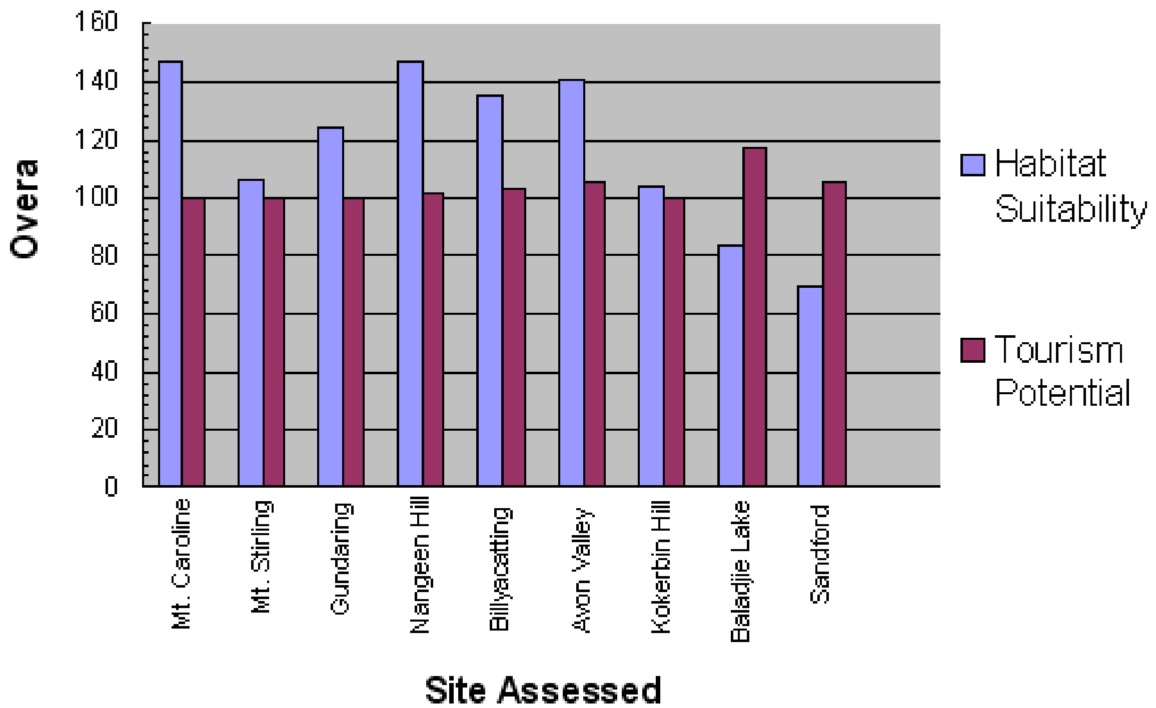

Figure 2. The habitat and tourism rank assigned to each site.

Table 4

Results of the rock complexity and ease of viewing wildlife assessment

SITE	ROCK COMPLEXITY (x/20)*	EASE OF VIEWING WILDLIFE (x/10)*	**ACCEPTED/ REJECTED**
Nangeen Hill	20	10	✔
Avon Valley	20	6	✔
Mount Caroline	16	9	✔
Gundaring	16	9	✔
Kokerbin Hill	16	9	✔
Billyacatting	16	7	✔
Boyagin Rock	14	2	✗
Monadnocks	14	4	✗
Baladjie Lake	11	10	✔
Mount Stirling	10	8	✔
Sandford Rocks	10	8	✔
Eaglestone Rock	7	10	✗
Merredin Peak	2	10	✗
Mount Stevens	2	10	✗

Table 5

Ranking of habitat suitability of potential rock-wallaby sites against actual sites of occurrence

Site (Maximum score)	*Vegetation Type (x/12)*	*Fox Control (x/1)*	*Rock:Veg Ratio (x/10)*	*Area Of Suitable Habitat (x/10)*	*Aspect (x/5)*	*Known Past/ Present Occurrence (x/2)*	*Total (x/40)*
Mt. Caroline	12	1	5	10	5	2	35
Nangeen	10	1	10	3	5	2	31
Billyacatting	11	0	5	10	5	0	31
Avon Valley	12	1	10	1	4	2	29
Gundaring	12	1	5	2	5	2	27
Mt. Stirling	12	1	1	6	5	2	27
Kokerbin	7	0	5	1	5	2	20
Baladjie	8	0	5	0	5	0	18
Sandford	3	0	10	0	1	0	14

Table 6

Tourism potential of sites assessed for rock-wallaby habitat suitability

Site	*Physical Attributes (x/100)*	*Threats and Uses (x/30)*	*Total (x/130)*
Baladjie	95	12	107
Avon Valley	83	16	99
Sandford	80	17	97
Billyacatting	85	11	96
Mt. Caroline	78	13	91
Nangeen	78	13	91
Mt. Stirling	78	13	91
Gundaring	78	13	91
Kokerbin	78	13	91

attained a higher score for habitat suitability than tourism potential.

DISCUSSION

Suitable sites for translocation

Of all the sites examined (potential and control sites) Nangeen Hill would be the best site for rock-wallaby tourism. This site already has a large population of rock-wallabies and the outcrop is surrounded by open grasslands adjacent to the northern faces which allows for ease of viewing rock-wallabies. Several rock-wallabies were observed when this site was assessed, and this was at midday which is not a prime time to see rock-wallabies. The outcrop has a dirt vehicle track, accessible to two-wheel drive vehicles, which encircles the base of the outcrop and aids ease of viewing the rock-wallabies. Nangeen Hill is highly weathered with tumulus boulders predominating and with limited vegetation growing in soil pockets on the outcrop itself therefore providing better viewing opportunities. This is in contrast to Mount Caroline and Gundaring Nature Reserve, which have extensive areas of vegetation growing on the outcrop. Nangeen Hill is located approximately 23 km south of Kellerberrin (Figure 1) and is closer to the Great Eastern Highway than any of the potential sites examined in the wheatbelt, and therefore more convenient for transient travellers to visit. There are no recreational facilities (e.g. rubbish bins, picnic tables, toilets) and no public access to this site as it is surrounded by private property. If this site were opened for rock-wallaby tourism these factors would need to be taken into account and remedied. Nangeen Hill is a nature reserve, and recreation is discouraged under current legislation. It also has the added protection of being gazetted as a 'prohibited area' under the CALM Act in order to protect the rock-wallabies from human disturbance. To develop tourism facilities would require (a) a change from nature reserve status to national park or conservation park, which have a greater emphasis on provision of recreation opportunities, and (b) the lifting of the 'prohibited area' classification.

Notwirhsatnding that Nangeen Hill appears to be the most suitable site for rock-wallaby tourism, translocations still need to be carried out to expand the range of Black-flanked Rock-Wallabies. Rock-wallabies at Mount Caroline are already targeted for translocation as the animals at this site are increasingly foraging further from the reserve and feeding on the crops of surrounding private property (Matt Dowling, *pers. comm*) and therefore may have exceeded the carrying capacity of the site. A site further away from the current populations needs to be considered, even if purely for conservation purposes. A site that is separate from existing colonies will have two purposes. If a catastrophe such as disease or fires threaten the existing colonies, a population at a separate location is less likely to be affected due to the isolating effect of distance. Although linkages between populations help overcome inbreeding, they can also facilitate the spread of catastrophic events as migrating animals can spread disease or fire can move along corridors of natural vegetation (Mangel and Tier, 1994). Avon Valley National Park and Billyacatting Nature Reserve are two potential translocation sites that satisfy the habitat and recreation potential requirements as well as being sites that are separate from the current rock-wallaby colonies.

Considerations for future management of translocated populations

Management of Black-flanked Rock-Wallaby tourism is required at three levels: (1) initial translocations should be carefully managed and monitored to ensure survival and reproductive success, (2) a commitment to the long-term management of the reserve and habitat is also essential, and (3) the long-term management of rock-wallaby and human interactions must be continually

Table 7

Management strategies to increase the success of rock-wallaby translocations and long term management of the reserve and habitat

Management Strategy	Description
MANAGEMENT OF INITIAL TRANSLOCATIONS	
Heterozygosity	• Translocated individuals should be genetically distinct from one another and should possess high levels of heterozygosity to prevent inbreeding and to ensure the founder population has the maximum viability and fecundity
Effective Population Size	• Founder population of 10 to 20 pairs of breeding adults, or as many as can be managed • Long term monitoring of distribution, abundance and genetic variation should be carried out to establish success rate
LONG TERM MANAGEMENT OF THE RESERVE AND HABITAT	
Fox Control	• Achieved by 1080 poisoning or exclusion by fencing
Fire Management	• Firebreaks may need to be managed at the new translocation site to reduce impacts from wild fires. • Fires should be irregular and seasonally spread
Feral Cat and Rabbit Control	• Introduced animals controlled to decrease the stress on translocated populations
Monitoring	o Some or all of the founder individuals be fitted with radio-transmitters. Source population monitored to determine any marked differences between source and translocated populations
LONG TERM MANAGEMENT OF ROCK-WALLABY AND HUMAN INTERACTIONS	
Stakeholder liaison	• Discussions with landholders, local shires and local communities conducted regarding their opinions on rock-wallaby tourism and how it might impact on operational management and social and economic development
Education/ interpretation	• Provide opportunities for people to experience and learn about nature through the provision of information on wildlife and other environmental issues
Public contact	• Provide areas for wildlife observation, nature centres and guided nature walks including spotlighting tours
Waste Disposal	• Litter should be controlled as rock-wallabies are known to feed on discarded food items causing nutritional problems and digestive upsets
Separation and Zoning	• Separating visitors through strategies such as fencing • Dividing the area into different zones such as recreation, access and conservation.
Other Management Strategies	• Limit group numbers • Entry fees

Source: Hair and Pomerantz (1987); Shaw (1987); Kinnear *et al.* (1988); Johnson *et al.* (1989); Spencer (1991); Bolton (1997); Kinnear *et al.* (1998); Lobert (1998); NPWS (2003) monitored to ensure there are no adverse effects. These management strategies are outlined in Table 7.

A high level of heterozygosity should be possessed to prevent inbreeding and to ensure the founder population has the maximum viability and fecundity (Table 7). Eldridge *et al.* (2001) reported evidence of high fecundity levels of recovering wheatbelt rock-wallaby populations as a result of ongoing fox control. Johnson *et al.* (1989) suggested a founder population of 10 to 20 pairs of breeding adults, or as many as can be managed (Table 7). Translocations are deemed successful when the founder population reaches at least 500 individuals and is not being supported through human intervention, such as food provisioning, and are self-sustaining (Bolton, 1997). Although a minimum viable population size of between 50 and 500 should be striven for, the initial and subsequent management will be a significant determinant of success (Johnson *et al.*, 1989).

Bolton (1997) states that conservation objectives have rarely been specifically targeted in ecotourism. The development of rock-wallaby tourism must be managed to be sustainable and this can be achieved by identifying the needs of tourists and employing successful methods of stakeholder and site management that meet the expectations of visitors and by ensuring conservation benefits outweigh any negative impacts arising from tourism activities.

Recreation and tourism management

Stakeholder liaison

Stakeholder cooperation is required and is particularly important in the sustainability of rock-wallaby tourism. Discussions with landholders, local shires and local communities will need to be conducted regarding their opinions on rock-wallaby tourism and how it might impact on operational management and social and economic development (Table 7). For example, landholders may need to cooperate with fox baiting on their property to ensure adequate predator control is practiced.

Zoning and separation of visitors from wildlife

The designation of specific recreation zones can be used to concentrate wider recreational activities like picnicking and can be set in areas that are separate from the outcrops inhabited by rock-wallabies. This can reduce problems associated with inadequate waste disposal. Different levels of access can be planned within the reserve, for example to allow only visitors on foot to enter the zone where the rock-wallabies are located. At the same time sanctuary zones can be designated to act as refuge areas, where public access is either not encouraged or prohibited.

Public contact with translocated animals

No studies of human interaction with Black-flanked Rock-Wallabies have been reported to date. Rock-wallabies live in large communities and like other large macropods tend to feel more secure when in larger groups. Personal observations indicate Black-flanked Rock-Wallabies are curious and only retreat if sudden movements by humans are made or if they are approached too closely. Kinnear (2000) observed that Black-flanked Rock-Wallabies appear to adapt easily and are generally tolerant of human presence.

Higginbottom *et al.* (2001b) stated that visitor surveys and subjective impressions indicated that getting close to macropod species increased visitor satisfaction. If close contact is desired as part of the tourism experience then rock-wallabies may need to be deliberately habituated to human presence. Higginbottom *et al.* (2001b) state this can be achieved by repeated exposure to human visitors who behave in a non-threatening manner. This includes minimising noise and sudden movement, not approaching too closely as well as curbing the approach if the animal indicated a high level of alertness (eg. animal stands upright and faces the visitor before fleeing). The process of habituation is likely to reduce panic responses that result in the separation of groups and especially adults from young. It is also important that individuals do not flee from sheltered sites as rock-wallabies that are displaced from their rocky habitats may become more exposed to predation. A deliberate habituation strategy should focus on getting the animals accustomed to human presence by slowly allowing the controlled presence of small groups under close supervision. This would be best achieved via exposure to humans at regular intervals in order to allow the rock-wallabies to habituate to human presence. By allowing animals to become habituated to visitors, disturbance and potential stress can be reduced (Higginbottom *et al.*, 2001b).

Although close approach may be desired, a safety margin of potential disturbance should be maintained and visitors must not be allowed to approach the rock-wallabies too closely. Changes in the natural behaviour of rock-wallabies would need to be monitored in response to human presence. If rock-wallabies are displaying altered behaviour in relation to visitor presence, then alternative arrangements such as viewing platforms and hides may need to be considered to overcome this problem.

The importance of educational programmes as a management strategy

Shaw (1987) states an important function of wildlife management is to provide opportunities for people to experience and learn about nature through the provision of information on wildlife and other environmental issues (Table 7). Education is considered by Alcock (1991) to be the most important strategy for managing wildlife. A system needs to be in place so that the public can be made aware of rock-wallaby biology and ecology, threats facing Black-flanked Rock-Wallabies, and their conservation.

Various interpretive techniques are available and include the use of signs, guided tours and brochures.

All forms of interpretation have advantages and disadvantages and the effectiveness of the different techniques will depend on both site and visitor characteristics (Newsome *et al.*, 2002). Basic interpretation dealing with the above issues could be in the form of a visitor information stand located at the site entry or take the form of smaller signs throughout the reserve. Guided tours of rock-wallaby sites add the advantages of personal contact. Organised tours can be arranged for the times when the wallabies are active by means of small tours on foot or spotlighting activities at night. The success of such programmes, however, is dependent on the availability of informed and effective interpreters.

In the case of spotlighting tours, visitor satisfaction can be increased if spotlights are of a low intensity to prevent the dazzling and blinding effects of bright lights. Guides and tour operators are in a strong position to manage the use of lights (Newsome *et al.* 2005). Spotlights can be provided to visitors for safety reasons but the visitors should be discouraged from using spotlights on rock-wallabies. Hides and viewing areas can be utilised to concentrate use, for example in the case of Avon Valley National Park, a platform already overlooks an area of complex boulder formation, and, if rock-wallabies colonised this area, visitors could be encouraged to bring binoculars to view the rock-wallabies.

Waste Disposal

Inadequate disposal of litter should be dealt with as rock-wallabies are generalists and Mareeba Rock-Wallabies (*P. mareeba*) have been known to feed on discarded food items including oats, bread, carrots, spaghetti, lettuce, chips, apples, breakfast cereals and potato peels (Hodgson, 1998) (Table 7). None of this foodstuff is the natural food source of rock-wallabies and may cause nutritional problems and disorders of the digestive system. Additionally, rock-wallabies captured in Kokerbin Rock were found with cut feet from broken glass (Moncrieff, 2000). Rubbish bins should be provided at the site if picnicking is allowed and interpretive signs should be erected detailing the negative effects of littering and feeding of wildlife.

CONCLUSION

In 2001, 50 rock-wallabies were translocated to Avon Valley National Park. This site is advantageous for both conservation and tourism, as it is located away from the current colonies. Avon Valley National Park has the benefit of being a site of past occurrence and is currently fox baited. The Park is also an established recreation destination and possesses campsites and walk trails along with other facilities. Other Western Australian translocations of Black-flanked Rock-Wallabies include reintroductions to Paruna Sanctuary (2001), Walyunga National Park (2002) and more recently Cape Le Grand National Park (2003). This study therefore provides an important insight into the factors that need to be considered in conserving vulnerable species using wildlife tourism, and has the potential to be used as a model for other projects of this nature.

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REFERENCES

Alcock, D. (1991) Education and extension: Management's best strategy. *Australian Parks and Recreation* 27, 15–7.

Bolton, M. (1997) *Conservation and the Use of Wildlife Resources*, Chapman and Hall, UK

Copely, P. (Compiler) (1990) *Proceedings of the Yellow-footed Rock-wallaby Workshop*, South Australian National Parks and Wildlife Service, SA, Australia

Croft, D.B. and Leiper, N. (2001) *Assessment of Opportunities for International Tourism Based on Wild Kangaroos*, (Wildlife Tourism Research Report Series No 17). Gold Coast, Queensland: Cooperative Research Centre for Sustainable Tourism.

Davidson, C. (1991) *Recovery Plan for the Proserpine Rock-wallaby (Petrogale persephone)*, Unpublished report to the Australian National Parks and Wildlife Service Endangered Species Program, Queensland Department of Environment and Heritage, Brisbane, Australia

Eldridge, M.D.B. and Close R.L. (1995) Black-footed Rock-wallaby, In: Strahan, R. (Ed), *The Mammals of Australia*, Reed books, NSW, Australia, pp. 377, 381

Eldridge, M.D.B., Kinnear, J.E. and Onus, M.L. (2001) Source population of dispersing rock-wallabies (*Petrogale lateralis*) identified by assignment tests on multilocus genotypic data. *Molecular Ecology* 10(12): 2847–2876

Figgis, P. (1993) Eco-tourism: Special interest or major direction? *Habitat Australia* (February): 8–11

Gray, G.G. (1993) *Wildlife and People: The Human Dimensions of Wildlife Ecology*, University of Illinois Press, USA

Green, R., Higginbottom, K. and Northrope, C. (2001) *A Tourism Classification of Australian Wildlife* (Wildlife Tourism Research Report Series No 7). Gold Coast, Queensland: Cooperative Research Centre for Sustainable Tourism.

Hair, J.D. and Pomerantz, G.A. (1987) The Educational

Value of Wildlife, In: Decker, D.J. and Goff, G.R., *Valuing Wildlife: Economic and Social Perspectives*, Westview Press, Colorado, USA, pp. 197–207

Higginbottom, K., Northrope, C. and Green, R.J. (2001a) *Positive Effects of Wildlife Tourism on Wildlife* (Wildlife Tourism Research Report Series No 6). Gold Coast, Queensland: Cooperative Research Centre for Sustainable Tourism.

Higginbottom, K., Green, R.J., Leiper, N., Moscardo, G., Tribe, A. and Buckley, R. (2001b) *Evaluation of Organized Tourism involving Wild Kangaroos* (Wildlife Tourism Research Report Series No 18). Gold Coast, Queensland: Cooperative Research Centre for Sustainable Tourism

Hodgson, A.J. (1998) *The Effects of Provisioning on the Behaviour and Body Condition of the Mareeba Rock-Wallaby, Petrogale mareeba, at Granite Gorge, North Queensland*, Unpublished honours thesis, James Cook University of North Queensland, Townsville, Australia

Hunt, I. (2000) Increasing Demand by Bibbulmun Track Walkers, In: *CALM News* September – October, CALM Corporate Relations Division, Crawley, Australia

Johnson K.A., Burbridge A.A. and McKenzie N.L. (1989) Australian Macropodoidea: Status, cause of decline and future research and management, In: Grigg, G., Jarman P. and Hume, I. (Eds.) *Kangaroos, Wallabies and Rat-kangaroos*, Volume 2, Surrey Beatty and Sons Pty. Limited, NSW, Australia

Kinnear, J.E. (1998) Kokerbin Rock Nature Reserve (11043): *A Translocation Site for the Rock-Wallaby Species Petrogale lateralis* (Gould), Unpublished report for CALM, Perth, Australia

Kinnear, J.E. (2000) *Tourism Impact On Black-flanked Rock-wallabies at Yardie Creek*, Unpublished report for CALM, Perth, Australia

Kinnear, J.E., Onus, M.L. and Bromilow, R.N. (1988) Fox Control and Rock-Wallaby Population Dynamics, *Australian Wildlife Research* 15: 435–50

Kinnear, J.E., Onus M.L and Sumner, N.R (1998) Fox Control And Rock-wallaby Population Dynamics – An Update, *Wildlife Research* 25: 81 – 88

Lim, L., Sheppard, N., Smith, P., and Smith, J., (1992) *The Biology and Management of the Yellow-footed Rock-wallaby (Petrogale xanthopus)* in NSW, Report for the NSW National Parks and Wildlife Service, Australia

Lobert, B. (1988) *The Brush-tailed Rock-wallaby (Petrogale penicillata) in the Grampians National Park and the Black Range, Victoria: Part 1*, Australian Biological Research Group Pty Ltd, Victoria, Australia

Mangel, M. and Tier, C. (1994) Four Facts Every Conservation Biologist Should Know About Persistence, *Ecology* 75(3): 607–614

Maxwell, S., Burbridge A.A. and Morris K (Eds.), (1996) *The 1996 Action Plan for Australian Marsupials and Monotremes*, Department of Conservation and Land Management, WA Wildlife Research Centre, Wanneroo WA, Australia (online), Available on World Wide Web, http://www.environment.gov.au/bg/plants/threaten/plans/action/marsupials/20.htm, (Accessed 25/1/00)

Moncrieff, D (1996) A Basis For A Recreation And Tourism Plan For The Merredin District, Unpublished discussion paper, Department of Conservation and Land Management, Perth, Australia

Moncrieff, D. (2000). Managing tourism and recreation on Wheatbelt granite outcrops. *Journal of Royal Society of Western Australia* 83: 187–196

Morton, S.R. (1990) The impact of European settlement on the vertebrate animals of arid Australia: a conceptual model, *Proceeding of the Ecological Society of Australia* 16: 201–213

Newsome, D., Moore, S. and Dowling, R. (2002). *Natural Area Tourism: Ecology, Impacts and Management.* Channel View Publications, Clevedon, UK

Newsome, D., Dowling, R. and Moore, S. (2005). *Wildlife Tourism.* Channel View Publications, Clevedon, UK

NPWS (2003) Warrumbungle Brush-tailed Rock-wallaby Endangered Population Recover Plan. NSW National Parks and Wildlife Service, Hurstville, NSW, Australia

Pearson, D.J. (1992) Past and Present Distribution and Abundance of the Black-footed Rock-wallaby in the Warburton Region of Western Australia, *Wildlife Research* 19: 605–22

Pearson, D.J. and Kinnear, J.E. (1997) A review of the distribution, status and conservation of rock-wallabies in Western Australia. *Australian Mammalogy.* 19: 137–152

Recher, H.F. (1990) Wildlife Conservation in Australia: State of the Nation, *Australian Zoologist* 26(1): 5–11

Reid, N. (undated) *Ecosystem Management 422/522*, Parks and Wildland Management, The university of New England, NSW, Australia

Ride, W.D.L. and Wilson, G.R. (1982) The conservation status of Australia mammals, In: Groves, R.H. and Ride, W.D.L. (Eds.) *Species at Risk: Research in Australia*, The Australian Academy of Science, Canberra, Australia, pp. 13–26

Shackley M. (1996) *Wildlife Tourism*, Thomson Business Press, London

Shaw, W.W. (1987) The Recreational Benefits of Wildlife, In: Decker, D.J. and Goff, G.R. (Eds.) *Valuing Wildlife: Economic and Social Perspectives*, Westview Press, Colorado, USA, pp. 208–213

Short, J. (1982) Habitat Requirements of The Brush-tailed Rock-wallaby, *Petrogale pencillata*, in New South Wales, *Australian Wildlife Research* 9: 239 – 246

Short, J. and Smith, A. (1994) Mammal Decline and Recovery in Australia, *Journal of Mammology* 75(2): 288–297

Spencer, P.B. S. (1991) Evidence of predation by a feral cat, Felis cattus (Carnivora: Felidae) on an isolated Rock-wallaby colony in tropical Queensland, *Australian Mammology*, 14: 143–144

Personal Communications

Dowling, Matt (May 2000) Wildlife Officer, CALM, Merredin, Western Australia, Australia