Department for Environment and Heritage

Translocation Proposal

Re-introduction of Mainland SA Tammar Wallaby to Innes National Park

2004

Government of South Australia

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Front Cover Photos (clockwise from top left): Landscape of Innes National Park (DEH); Tammar Wallaby and joey (L Pedler); Heath landscape (DEH);Innes National Park Office (DEH); Grassland landscape (DEH); and Tammar Wallaby (A Robinson, DEH)

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1 SUMMARY

The South Australian mainland sub-species of the tammar wallaby (*Macropus eugenii eugenii*) is listed under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), as 'extinct in the wild'. The SA mainland form of the tammar wallaby once occurred on Yorke Peninsula, Eyre Peninsula, the Mid North and Adelaide Plains, and the Fleurieu Peninsula east to the Murray River. By the 1930's, they had become extinct from mainland SA, due to predation by the introduced European red fox (*Vulpes vulpes*), and broad-scale clearance of their preferred habitats for agriculture. Hunting also played a role in their demise.

However, recent DNA analysis showed that the mainland SA tammar sub-species survives as a feral population on Kawau Island and in scattered areas near Rotorua on the North Island, New Zealand. These populations were established in the 1800's by Sir George Grey, the former Governor for the Colony of South Australia (1841). Although there are no records of where Governor Grey obtained his original stock of tammars, Poole, *et al.* (1991) suggested that the skull morphology of the feral Kawau Island and Rotorua populations closely matched museum specimens collected on the South Australian mainland. In 1996, Environment Australia released the "Action Plan for Australian Marsupials and Monotremes" (Maxwell *et al.* 1996), which recommended that, i) the identity of the Kawau Island wallabies be confirmed, and ii) if the wallabies were originally from the SA mainland, then a re-introduction program should be developed. Subsequently, Taylor and Cooper (1999) examined the genetics of the New Zealand wallabies and confirmed that the Kawau wallabies were indeed the South Australian mainland sub-species.

This re-discovery of a wallaby once considered extinct prompted the Commonwealth and South Australian Governments to initiate the repatriation of these wallabies. The timing of this repatriation program was critical, because the New Zealand Department of Conservation (NZDoC) and Auckland Regional Council proposed to eradicate the wallabies from Kawau Island (Shaw and Pierce 2002), commencing in May 2004 (Auckland Regional Council pers. comm.). The mainland SA tammar was listed under the EPBC Act (1999; following public consultation) as an appropriate species for import into Australia. Following disease screening and veterinary checks, the necessary permits and approval for import were obtained from Biosecurity Australia (BA), Australian Quarantine Inspection Service (AQIS) and Environment Australia (now the Commonwealth Department of Environment and Heritage) in July 2003. Ongoing consultation took place with the NZ Department of Conservation and the Auckland Regional Council, who granted approval to commence trapping on Kawau Island and to export animals to Australia.

A total of 85 adult wallabies (52F, 33M) and 7 female pouch young have now been successfully repatriated to South Australia from Kawau Island. It is very unlikely that there will be further opportunity to obtain additional animals. These tammars are being held in quarantine at Monarto Zoological Park (Monarto ZP) for a required minimum period of six months (Biosecurity Australia/AQIS requirement). Following quarantine surveillance and further AQIS veterinary examinations, it is proposed that animals be re-introduced to suitable sites within their known former range on the South Australian mainland.

Due to large-scale habitat clearance across much of its former range, opportunities for re-introduction of the SA mainland tammar are limited. Suitable release sites must; i) have habitat of sufficient size (>3,500ha) and quality to support a self-sustaining population of at least 500 mature wallabies, ii) be suitable for the establishment and maintenance of appropriate predator control programs and iii) be located where the effects of total grazing pressure on biodiversity values and agricultural production can be monitored and managed. Following a comprehensive site selection process, Innes National Park (Innes NP) was chosen as the first release site. A critical component of the re-introduction program is to create a fox-controlled (i.e. a low fox density) environment that encompasses the release area. An intensive fox control program began on Innes NP in October 2003 and it is anticipated that fox numbers will be substantially reduced before the proposed release of wallabies occurs in November 2004. While it is expected that bait-take by foxes will continue to be recorded along the park boundary tracks each month, and that some foxes will also frequently advance beyond the baited boundary, the re-introduction program is aiming to maintain an essentially fox-free zone over the majority of the park. Maintenance of a rate of ≤ 5% bait-takes per fortnight for all internal track bait-stations will be aimed for. Since the beginning of February 2004, this target has been achieved for all but three of 17 fortnightly baiting periods (up to mid-September 2004).

It is proposed that 60 tammar wallabies will be re-introduced to Innes NP. Animals will be released in stages, with a trial release of 20 wallabies (16F, 4M) occurring in November 2004, with a further two releases proposed thereafter. The timing of the subsequent releases will be determined by the results of the trial release and the environmental (seasonal) conditions at the time. The number and composition of wallabies in the subsequent releases will be dependent on the number and composition of wallabies held at Monarto ZP, the results of the first release and research objectives defined in light of the results of the trial release.

Property owners adjoining Innes NP are concerned that tammars may have similar effects on agricultural production on the southern Yorke Peninsula as seen on Kangaroo Island. It is acknowledged that tammars (KI sub-species) exist in high numbers and are an agricultural pest on some parts of Kangaroo Island. Wallabies are known to eat crop and pasture plants and are often seen at the edge of paddocks. The high densities of tammars on Kangaroo Island are for the most part considered due to an absence of foxes and the large amount of the wallaby's favoured edge habitat.

The SA Department for Environment and Heritage (DEH) considers it a low probability that tammars at Innes NP will ever reach densities to approximate those on Kangaroo Island, due to the variability of the environment on the southern Yorke Peninsula (eg less reliable and patchy rainfall) and the ongoing threat from foxes. However, DEH are cognisant of the fact that if the tammars become successfully established at Innes NP, some are likely to become established along the edges of the park and to feed in adjacent pastures or crops.

Outside of Innes NP, fox predation is expected to severely limit the range of the tammar population. Fox control activities of adjacent landholders are restricted to the lambing season and therefore do not control fox densities year round. Although, under these circumstances, it would be very difficult for a tammar population to become established outside of Innes NP, the possibility of this occurring has not been discounted in this preliminary planning phase.

During the preliminary stages of the re-introduction program, every individual tammar is of high conservation value, contributing significantly to overall genetic and demographic diversity. Thus, any tammars that move off-park, and outside of the fox-baited zone, in the first <u>two</u> year trial period of the program are at high risk of being killed by foxes. Therefore they will be recaptured as soon as practicable and returned to the release area.

Following the <u>two</u> year trial period of the program, if the number of tammar movements off-park cause serious concerns for either i) the survival of the population beyond the initial trial period or ii) agricultural production, a range of management options will be developed in consultation with the local community. While the tammars retain a high conservation rating (i.e. fully protected under both the SA *National Parks and Wildlife* Act and the Commonwealth *Environment Protection and Biodiversity Conservation* Act), these options may include the capture and translocation of some individuals to other re-introduction sites, the management of total herbivore grazing pressure, and the construction of fences to limit the foraging of tammars along the edges of the park.

In the longer-term, should the tammar wallaby population become abundant and have significant impacts on agriculture, the tammars may be managed in accordance with other abundant macropod species in South Australia.

The monitoring program associated with the initial trial release of tammars, outlined in this proposal, will provide data that will enable DEH to determine the likely growth and spread of the tammar population.

A community consultative committee has been established to provide a forum for community concerns and to provide feedback on the status of the re-introduction program. The consultative committee has had the opportunity to discuss and comment on the contents of the translocation proposal.

A considerable amount of long-term monitoring and follow-up activities, associated with the re-introduction program, will be necessary. All released animals will be fitted with mortality-sensing radio-collars and monitored intensively during the early stages of the re-introduction. A population monitoring protocol has been developed, to enable the future size of the tammar population to be estimated. Kangaroo surveys and vegetation monitoring will be undertaken to assess the impacts of total grazing pressure. Ongoing fox control will be essential to the success of the tammar re-introduction. The effectiveness of the fox control program is being monitored through passive-tracking stations.

The proposed re-introduction of tammars to Innes is the first of several releases planned for SA, with the overall aim to establish at least two separate, self-sustaining tammar populations within their former range, thereby ensuring the ongoing conservation of the sub-species. The recovery team is currently developing a captive breeding program to increase the number of wallabies that will be available for future releases. Some animals will be retained and managed as a captive population within Australian zoos. If the Innes release is successful some tammars may also be relocated from there to other release sites.

This translocation proposal is intended to guide the trial release and monitoring of an initial 20 to 60 tammars to Innes NP and will be reviewed after 6, 12 and 24 months, in light of the results obtained.

2 BACKGROUND TO THE RE-INTRODUCTION OF THE SOUTH AUSTRALIAN MAINLAND TAMMAR (*Macropus eugenii eugenii*) TO INNES NATIONAL PARK

Scientific Name: *Macropus eugenii eugenii*

Family name: Macropodidae

Common Name(s): tammar (SA mainland sub-species), dama wallaby

Source location: Kawau Island, Auckland Regional Council Area, New Zealand.

Holding location: Monarto Zoological Park, South Australia.

Release location: Innes National Park, Yorke Peninsula, South Australia.

Lead agency: South Australian Department for Environment and Heritage (DEH).

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Project Officer: Julia Bignall, Landscape Restoration Ecologist, Yorke/Mid North Region, DEH.

Associated agencies: Australian Department of the Environment and Heritage.

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Royal Zoological Society of South Australia.

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John McEvoy, Adjoining landholder.

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Rudy Pieck, Friends of Innes NP.

Jutta Rigoni, Adjoining landholder.

Marilyn Stead, Local Tourism Operator.

Mark Timberlake, Adjoining landholder.

Kent Treloar, Yorke Peninsula landholder.

Lesley Wanganeen, Narungga Aboriginal Progress Association.

Michael Wanganeen, Narungga Aboriginal Progress Association.

Michael Webb, Adjoining landholder.

Trevor Webb, Adjoining landholder.

Rick Wilkinson, Yorke Peninsula District Council.

Peter Yeomans, President, Marion Bay Township Committee Inc.

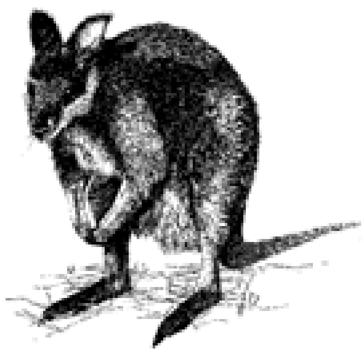
Irene Vale, Yorke Peninsula resident.

3 CONSERVATION STATUS

There are at least four recognised sub-species of tammar in Australia:

- *Macropus eugenii eugenii* on mainland SA. Status: extinct in the wild, but introduced to Kawau Island and Rotorua, New Zealand, where an eradication program is now underway.
- *M. eugenii decres* on Kangaroo Island SA. Status: Locally abundant (Robinson and Armstrong 1999). Also introduced onto Greenly Island and Boston Island SA (Poole *et al*. 1991).
- *M. eugenii flindersi* on Flinders Island SA. Status: Extinct since the 1960's (Poole *et al*. 1991).
- *M. eugenii derbianus* on the mainland of south western WA, and recorded for five offshore islands. Status: Conservation dependent at mainland sites; vulnerable on islands (Kinnear *et al*. 2002).

The mainland South Australian sub-species of the tammar is currently classified as "extinct in the wild" under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), "endangered" under the SA National Parks and Wildlife Act (1972) and "presumed extinct in the wild" under the proposed revisions to the SA National Parks and Wildlife Act (2003-2004).



Tammar Wallaby (*Macropus eugenii*).
Credit: Kellee Merritt/The Illustration Library

The SA mainland sub-species of the tammar (*Macropus eugenii eugenii*) once occurred on Yorke Peninsula, Eyre Peninsula, the Mid North, the Adelaide Plains, and the Fleurieu Peninsula east to the Murray River. Due to broad-scale clearance of its preferred habitats, fox predation and hunting, tammars had become extinct from mainland South Australia, by the 1930's.

Distribution of Tammar Wallaby (*Macropus eugenii*) in Australia
Source: (McKenzie, N.L., Burbidge, A.A., Baynes, A., Australian Mammal Map Updates, CALM WA)
Dark grey – extant, Mid grey – historic (>30years).

However, recent DNA analysis indicates that the mainland sub-species survives as a feral population on Kawau Island and in scattered areas near Rotorua on the New Zealand North Island (Taylor and Cooper 1999). The Kawau Island population was introduced over a century ago by Sir George Grey, the former Governor for the Colony of South Australia (1841). Governor Grey purchased Kawau Island, near Auckland NZ, for his personal residence when appointed for a second term as Governor of New Zealand in 1862. Governor Grey introduced many plant, bird and animal species to the island including brush-tailed rock-wallabies, parma wallabies, swamp wallabies and tammars. With an absence of predators, the tammar population on Kawau Island has increased substantially and it is now considered a pest species. The New Zealand Department of Conservation and the Regional Council of Auckland are currently embarking on an ecological restoration program for the island, which incorporates the eradication of all non-native species, including tammars.

Eighty-five tammars (52F, 33M) and 7 female pouch young have successfully been repatriated from New Zealand.

4 REASONS FOR DECLINE

Although limited historical data exist on the decline of the mainland tammar sub-species, extensive habitat clearance for agricultural production and predation by foxes (*Vulpes vulpes*) are considered to be the prime causes of extinction, over the sub-species entire former range. Predation by the introduced fox and feral cat (*Felis catus*) are considered responsible for the decline and extinction of many 'critical weight range' mammals, and pose a major threat to their survival in natural and managed habitats (Burbidge and McKenzie 1989). Many of the native fauna species on Yorke Peninsula declined in abundance and range as a result of drastic changes to the vegetation following European settlement, and with the arrival of foxes (Copley *et al.*, in Paterson *et al.* 1984). Other contributing factors included hunting, fire, predation by cats, competition with rabbits (*Oryctolagus cuniculus*), and possibly disease.

The extent to which foxes contributed to the wallaby's decline can be inferred from the wallabies rapid demise on Yorke Peninsula so soon after the arrival of the fox. It can also be inferred from the positive response of the WA tammar populations in areas where foxes have been controlled (see section 12). During the mid-1800's, large tracts of land on Yorke Peninsula were cleared for agricultural production (South Australian Government Printing Division 1986). This clearance created a mosaic of remnant woodlands within pasture and cropping lands. The large amount of "edge" habitat, created by this clearance, favoured the wallabies and they soon came into conflict with local farmers as highlighted by the following historical records of the bounties paid for their destruction;

"District Council of Ninnes offered three pence for wallabies" (Minutes, District Council of Ninnes, August 1885);

"…wallaby scalps nine pence each" (District Council of Ninnes, Minutes, July 1898)";

"Wallabies causing a nuisance at Alford" (District Council of Ninnes, Minutes, August 1899).

The first record of the fox on Yorke Peninsula was in 1897 and by 1908 foxes were considered 'numerous' at Willamulka. The arrival of the fox followed closely on the arrival and spread of the rabbit, which had first been first recorded on northern Yorke Peninsula in 1884. Sources therefore indicate that the fox took about 10 years to establish itself in the district (Copley *et al.*, in Patterson *et al.* 1984).

It is presumed that cats reached the peninsula either with, or just before, the first agricultural settlers (Copley *et al.*, in Patterson *et al.* 1984).

By the 1930's, the tammar had become extinct on Yorke Peninsula.

The rapid decline in tammar abundance, between 1900 and 1930, coincides with the establishment of foxes on the peninsula. This period also saw the further expansion of agriculture, with the advent of modern farming techniques. Today, there is very little native vegetation left on Yorke Peninsula north of Warooka. However, sufficient tracts of remnant vegetation remained south of Warooka that could have provided habitat for a population of tammars. This supports the notion that fox predation played a significant role in their local extinction. There are no records of any other calamitous event (eg disease, wildfire) occurring in the area at the time of the wallaby's ultimate demise.

5 PROGRAM OBJECTIVES

The primary goal of the current translocation proposal is to contribute towards a down-grading in the conservation status of the mainland sub-species of the tammar, over the next 10 to 20 years, to a “near threatened - conservation dependent” classification under the Commonwealth EPBC Act (1999). That is, this species would remain the “focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered” (EPBC Act 1999). To achieve a downgrading in its conservation status under the EPBC Act (1999), the SA mainland tammar would need to have a stable or increasing overall population, comprised of at least two sub-populations located within the species' former range, where i) each sub-population is stable or increasing in size, ii) each sub-population is comprised of at least 500 mature individuals (ie overall population size >=1000 individuals), and iii) each sub-population covers an area of occupancy of >20km2 (as interpreted and adapted from http://www.iucn.org/themes/ssc/redlists/redlistcatsenglish.pdf).

The SA Tammar Recovery Team intends to achieve this goal by establishing at least two self-sustaining populations of the sub-species on mainland South Australia. The selection of suitable translocation sites in South Australia was based upon;

- their occurrence within the wallaby’s known former range,
- availability of an area of greater than 3,500 ha of suitable habitat,
- the ability to implement an effective fox-baiting program,
- ease of access for management and monitoring, and
- minimal subsidiary effects to biodiversity and agricultural production.

Of the five possible sites identified, Innes National Park was chosen as the first re-introduction site. Other locations being considered for later translocations include; Lincoln National Park, Coffin Bay National Park, Kulliparu Conservation Park and Mt Remarkable National Park.

Within this framework, the specific goals of the current translocation proposal are to;

- develop and maintain an essentially fox-free zone within Innes National Park to benefit local native fauna species that are at risk from high rates of predation by foxes. This will require maintenance of a bait-take rate of less than or equal to 5% of baits laid per fortnight at all bait stations along internal tracks within Innes National Park,
- establish a self-sustaining, free-ranging, viable population of mainland tammars within Innes NP,
- minimise any adverse effects to other native flora and fauna and/or to natural habitats, resulting from the translocation process,
- minimise any adverse effects to agricultural production, resulting from the translocation process,
- develop a plan of management to ensure that total grazing pressure on both Innes NP and adjoining properties is sustainable,
- contribute to the ecological restoration of the Southern Yorke Peninsula large habitat remnant,
- collect scientific data and refine management principles, such that a constructive contribution can be made to subsequent tammar wallaby translocation programs in other parts of South Australia,
- increase community awareness and involvement in the conservation of the ecosystems of the southern Yorke Peninsula and of the tammar wallaby,
- develop the community’s capacity to make informed decisions regarding the long-term conservation of the tammar wallaby, and
- allow for the removal of excess individual tammars, from Innes NP, to establish other populations of tammar in other areas within their former range.

6 JUSTIFICATION

The SA mainland sub-species of tammar is currently extinct in the wild in Australia and the NZ Department of Conservation and the Regional Council of Auckland are actively working to eradicate the New Zealand populations. To prevent the total extinction of this sub-species of tammar, the Australian Department of Environment and Heritage and the South Australian Department for Environment and Heritage have repatriated 85 tammars (plus 7 pouch young) from Kawau Island, for release to suitable sites in the wild in South Australia and to contribute to a captive breeding program.

A down-listing of the sub-species conservation status cannot be achieved simply through the establishment of captive populations. To achieve a down-listing from "extinct in the wild" to at least "near threatened - conservation dependent" under the Commonwealth EPBC Act (1999), requires a stable or increasing overall population, comprised of at least two sub-populations located within the species' former range, where i) each sub-population is stable or increasing in size, ii) each sub-population is comprised of at least 500 mature individuals (ie overall population size >=1000 individuals), and iii) each sub-population covers an area of occupancy of >20km2 (as interpreted and adapted from http://www.iucn.org/themes/ssc/redlists/redlistcatsenglish.pdf). For these reasons it is essential to establish a population of tammars in the wild, as soon as possible. Further, with 85 animals already housed at Monarto ZP, there is limited scope to contain additional captive wallabies.

Tammars were once widespread across Yorke Peninsula. Today, the little remnant habitat left on Yorke Peninsula is virtually confined to the Peninsula's southern end, much of the rest having been cleared for agricultural production.

The re-introduction of tammars to Innes NP represents a significant part of the first stage in the ecological restoration of biodiversity on southern Yorke Peninsula.

7 HISTORICAL DISTRIBUTION

The mainland SA tammar was historically found from the western shores of Lake Alexandrina, through the Mt Lofty Ranges and Adelaide Plains to Yorke Peninsula and the Mid-North and on Eyre Peninsula (Poole *et al.* 1991). This sub-species was also known from St Peter Island near Ceduna, and a population (possibly also this taxon) occurred on Thistle Island near Port Lincoln, Eyre Peninsula. The List of Vertebrates of South Australia (DEH 2000) reports a reliable historical record of tammar on southern and northern Yorke Peninsula.

Aitken (in Corbet 1973) provides the following historical information on the 'dama' (ie tammar) wallaby, "Only one example is preserved in the mammal collection of the SA Museum, collected at Tickera before 1922. Dama wallabies must once have been plentiful on the Peninsula, however, since in the anthropological collection of the South Australian museum there is a rug made by Louisa, probably just before 1900, from the skins of such wallabies trapped around swamps near Marion Bay."

Tindale (1936) reports tammar, or 'dama' wallabies, as playing a significant role in local Aboriginal culture, providing a source of food and clothing and featuring in Narunnga stories, eg "At Mildidjari, near Cape Spencer, Ngarna made a rug of wallaby fur sewn with sinews, and left it near the beach. It remains as a large rock; there are seams on it like the scarified marks on a rug."

Aboriginal people captured wallabies using snare-nets made from wallaby sinews. These were placed between gaps in brushwood fenced runs. When animals entered the nets, a noose string tied to a branch closed the mouth of the nets (Tindale 1936). Wallaby skin rugs were made from the pelts of tammars and worn as cloaks (Tindale 1936).

Jones (1923-1925, pp. 238) indicates that "It is extremely difficult to define the former range of this complex species on the mainland of South Australia, or even to discriminate with any certainty between the mainland form and the type of animal now living on Kangaroo Island. Only a few years ago it swarmed in scrub covered districts all over the State, to-day it seems impossible to secure a single mainland specimen for scientific study. In places where annual battues were held by the present landowners less than twenty years ago it has disappeared almost altogether. It is almost certain that some still linger upon the mainland, notably at the Southern end of Eyre's Peninsula and in the South-eastern districts, but so far these animals have not been properly studied or preserved."

Jones (1975) reports that "Wallabies were quite numerous at Curramulka until just before World War 1. Then, due mainly to the destruction of their habitat (last major area of scrub was cleared in 1923), they died out."

There are six references in the skeletal records at the South Australian Museum for the location of tammars on Yorke Peninsula (Medlin pers. comm., SA Museum);

- "January 24, 1970. An incomplete skull of a tammar wallaby found on Brown's Beach. Registration no. M08560. Held in the Mammal Section collection. No other details."
- "May 1970. Curramulka Quarry. Held in Palaentology collection"
- "June 1974. Daly Head. Held in Palaentology collection."
- "October 1972 through January 1992. Material collected at a gypsum lunette site near Lake Fowler about 12 km W of Edithburgh."
- "May 17, 1986. Plenty of *Macropus eugenii* remains (up to 28 specimens) collected in a dune blow-out about 7km N of Balgowan."
- "January 14, 1994. Bones collected from a sand dune blow-out on the eastern side of West Cape, in Innes NP."

The proposed release location at Innes National Park is almost central to the historical geographic range of the species.

8 CURRENT DISTRIBUTION

The SA mainland tammar is extinct across its entire former Australian range.

9 DISTRIBUTION OUTSIDE HISTORIC RANGE

The SA mainland tammar is currently found outside its former range at two locations in New Zealand; Kawau Island and near Rotorua on the North Island. There are also some animals in zoos and private collections around the world, but the genetics of these animals is not clear and they are considered unsuitable for repatriation. For example, over 300 tammars have been exported from New Zealand (since January 1998) for various private collections around the world, including Belgium, Czech Republic, Japan, Netherlands, Spain, Thailand, United Arab Emirates, USA and Yugoslavia. Tammars are considered a noxious pest in New Zealand and eradication plans are in place for both populations.

10 SOURCE POPULATION

The only potential sources of the South Australian mainland sub-species of tammar are from feral New Zealand populations, on Kawau Island and near Rotorua, North Island. However, only the Kawau Island population has been considered suitable for repatriation to Australia for the following reasons:

- The Rotorua population originated from a small sub-sample of Kawau Island animals and is consequently 'genetically inferior' to the Kawau population.
- The Rotorua population has been exposed to many additional native, feral and domestic animal species, and therefore poses a significantly greater disease risk compared with the Kawau population.
- The specimens to be repatriated from Kawau Island are genetically pure. The species has not been known to hybridise in the wild and this is supported by observations on Kawau Island where it has lived in close proximity to three other species of wallaby for over 100 years and has not hybridised with these (DEHA 2002).

Tammars are considered a pest on Kawau Island and their eradication from the island is impending. The New Zealand Government has commenced a wallaby eradication program on Kawau Island with the goal of total eradication by 2005. The commencement of the eradication program at Kawau Island was postponed until May 2004, to allow the South Australian Department for Environment and Heritage (and other Australian environmental organisations collecting other wallaby species) a final opportunity to retrieve animals. The removal of tammars from Kawau Island will therefore have no effect on the island's wallaby population and no secondary detrimental ecological effects.

11 ECOLOGICAL REQUIREMENTS

11.1 Habitat requirements

Tammars require dense low vegetation for daytime shelter and more open grassy areas for feeding. They typically inhabit coastal scrub, heath, dry sclerophyll forest and thickets in mallee and woodland (Smith and Hinds, 1995). During the day they rest in thick cover and, although they begin to forage at dusk, they do not venture into the open until after dark and return before dawn.

11.2 Diet

Tammars preferentially eat grass, but will also eat other herbs, shrubs and small trees. They eat seedlings of many perennial plant species and, if at very high densities, can totally prevent recruitment of many species. Dietary studies on the tammar in WA record the tammar eating 25 different species of plant, ranging from small restionaceous species such as *Loxocarya spp* and the coarse, herbaceous sub-shrub *Opercularia hispidula*, to larger plants such as *Juncus pallidus*. Species that have tough leaf spines or stem spines were also frequently grazed. Only a few of the species consumed were grasses (Shepherd *et al*. 1997).

McArthur (1998) reported the selective grazing of *Callitris* and *Melaluca* seedlings by tammars following fire on Garden Island (WA), totally preventing recruitment of these species in small burned areas. Comparison between fenced and unfenced quadrats showed native ground covers, small grasses and herbs, annual species and introduced species such as *Myrsiphyllum asparagoides* (*nee Asparagus asparagoides*), agricultural grasses and clovers were more common in fenced quadrats suggesting grazing by tammars had some affect on these species.

Bell *et al.* (1987) assessed the diet of the tammar population on Garden Island (WA) and found tammars to be versatile feeders. Eleven species were documented as dietary species of the tammar, with special preference for the introduced ephemeral herb *Asphodelus fistulosus*, the dominant shrub *Acacia rostellifera*, young shoots from resprouting *Asparagus asparagoides* and the native grass *Stipa flavescens*, and seedlings of *Solanum symonii* and *Thomasia cognata*. Grazing damage to these species was generally restricted to localised sites.

While these studies were conducted in WA and many species do not occur in SA, they do indicate the types of plants consumed by tammars. Information regarding the species at Innes that are considered palatable to wallabies does not exist, however this will be a focus of the research program associated with the tammar re-introduction. Apparently, tammars can survive without permanent freshwater supplies and animals in one Western Australian island population are known to drink sea-water (Main and Yadav 1971, DEHA 2002).

11.3 Home ranges and population densities

Tammar wallabies have defined home ranges that overlap the home ranges of other individuals. While several wallabies may feed in the same area, no social grouping has been observed, except between females and their young-at-foot. Inns (1980) found a mean summer home range size of 42.4ha (+/- 17.6) on Kangaroo Island, while in winter this contracted to 15.9ha (+/- 8.1). Inns (1980) study site included about 50 hectares of mostly cleared land with grass cover, surrounded by forest and woodland with a relatively dense understorey. The radio-tracking data used to plot home ranges of individual animals suggested that the total marked study population was occupying an area of approximately 500 to 600 hectares. Over the three-year period of Inns' (1980) study, population estimates suggested that there were between 100 and 150 females and 60 and 130 males present. These data suggest a population density of about one animal per 2-3 hectares (0.46/ha) in near-optimum habitats.

Robinson (1980) estimated that there were in the order of 50 tammars on Greenly Island (SA), in November 1976. These wallabies, which occupied the main 150ha southern portion of the 202ha island, represent the descendants of an unknown number of Kangaroo Island wallabies, released in 1905 as a food-source for shipwrecked sailors. This also suggests a density of about one animal per three hectares (0.33/ha) (DEHA 2002).

Tammars in Western Australia, while distinct from South Australian populations at the sub-specific level at least, are similar in size and ecological requirements. Main and Yadav (1971) have provided population estimates for tammars on three of the five islands where the species has been recorded in Western Australia. These are: *ca* 112 animals on 180ha North Island in the Abrolhos (0.63/ha), 175 animals on 280ha North Twin Peaks Island in the Recherche Archipelago (0.63/ha), and 224 animals on 360ha East Wallabi Island in the Abrolhos (0.62/ha). The North Island population increased in size, following its initial introduction to the island in the 1950's, but has since become extinct (Main and Yadav 1971). Tammars were re-introduced to North Island in 1987 and the current estimate of the population size is 200 animals (1.11/ha). The population estimates for each island suggest densities of between 0.33 and 1.11 animals per hectare.

11.4 Minimum viable population size and minimum area requirements

As a rule of thumb, populations of less than about 500 mature individuals (where sex ratios are even), are considered to have a high risk of extinction in the medium to long-term (IUCN 1994). Applying the population densities mentioned above, and allowing for a proportion of sub-adult animals in the population density estimates used, the minimum area of suitable habitat necessary to support a viable population of tammars over the long-term would be at least 600 hectares. However, this estimate is likely to be too small because the density estimates used were calculated under near optimum conditions and in the absence of predation. Allowing for droughts, some predation and a likely mix of good quality and poor quality habitats, a more realistic minimum area should be accepted as about 1,000 hectares.

As a further test of this, the only island populations of tammars in South Australia at the time of European exploration were Kangaroo Island (440,188 ha), Thistle Island (3,925 ha), Flinders Island (3,642 ha) and St Peter Island (3,439 ha). These islands had been separated from the mainland for more than 6,000 years and none had predators present that were likely to limit tammar populations. Tammars did not survive on any of South Australia's smaller islands, despite evidence of former occurrences such as the presence of skeletal remains found on 344ha Reevesby Island and 947ha Wedge Island (Robinson, *et al.* 1996). This circumstantial evidence implies that, under conditions of negligible predation and availability of suitable habitat, tammars should not be released into sites smaller than about 1,000-1,500 hectares (DEHA 2002).

12 PAST TRANSLOCATIONS

Many past attempts to conserve macropods by re-introduction to mainland Australia have failed. These have included the brush-tailed bettong in NSW and WA, the quokka and tammar wallaby in WA, parma wallaby and red-bellied pademelon in Victoria, brush-tailed rock wallaby in NSW and rufous hare wallaby in the Northern Territory (Priddel and Wheeler 2004; Short *et al.* 1992). Short *et al.* (1992) state that "the success of re-introduction of macropods appears to depend critically on control or exclusion of exotic terrestrial predators."

An early attempt to re-establish tammar wallabies (*M. e. derbianus*) was undertaken at a University of WA field station, on the coastal plain near Perth, between 1971 and 1988. Six animals, were introduced in 1971 and at least 3 of these animals were recorded as fox kills by 1972. A further 60 tammars were re-introduced in 1975, followed by 19 more animals in early 1981. During the 1981 to 1982 period, there were only 2 sightings of wallabies and 3 deaths recorded in the reserve. Subsequently, there were no sightings of tammars after 1982 and the population is considered to have failed to establish itself and become extinct. The exact fate of most of the tammars was unknown but the most likely explanation was that they were killed by foxes and cats (Short *et al.* 1992). Similarly, tammars were introduced to North Island (Abrolhos Islands) in the 1950's, but died out and were only re-introduced successfully in 1987. However, the long-term viability of this population remains questionable, given its former failure and the lack of changed circumstances on the island. There were several translocation attempts between 1971 and 1988 on mainland WA, but only one of these was successful – that from Perup Forest to Batalling Forest (Long 2003).

A number of Western Australian (WA) tammar (*M. e. derbianus*) re-introductions have been undertaken on mainland WA as part of the Department for Conservation and Land Management's (CALM) Western Shield Project. Between 1998 and 2004, 429 tammars have been removed from Tutanning Nature Reserve (NR) (2,310ha) and translocated to eight other locations without any measurable impact on the Tutanning population. Between 1994 and 2002, 181 tammars have been removed from Perup Forest (40,000ha) and translocated to four other locations (WA CALM, pers. comm.). Most of the release sites have been large remnants (eg > 20,000ha) or surrounded by other areas of appropriate habitat. CALM have conducted translocations of tammars into reserves as small as 1, 810ha (WA CALM, pers. comm.).

Tutanning NR supports one of the largest populations of tammars in WA. Intensive fox baiting at Tutanning NR has been carried out since 1984 and has led to a dramatic recovery of the tammar population. Spotlight sightings at Tutanning increased from <2 per hour in 1984 to 40 per hour in 1988 (Kinnear *et al.* 2002).

Tammar populations are monitored by CALM at least once a year. The re-introduced populations are initially monitored by means of spotlighting observations prior to the break of season. Tammar numbers have remained stable between 5.5 and 7.7 wallabies per kilometre at Tutanning NR between 1998 and 2002 (WA CALM, pers. comm).

Until recently, the WA tammar was listed as Schedule 1: "Fauna which is rare or likely to become extinct" under the WA Wildlife Conservation Act 1950. It was removed from this list in July 1998 and is now listed by CALM as Priority Four Fauna and is considered 'Conservation Dependent' (conservation dependent upon ongoing predator control).

Farmers adjacent to Tutanning Nature Reserve in WA have experienced some crop and fence damage due to tammars. CALM have initiated a control program to manage the populations, including; relocation to other sites, harvest licences and electric and wire barrier fencing. Data collected on movement patterns, following the WA releases, indicates that the majority of dispersal is over small distances. The grazing issues encountered at WA's Tutanning Nature Reserve (2,310ha) may result from the small size of the reserve.

13 RELEASE SITE

Innes NP was chosen as the site for the proposed translocation due to the following features:

- the park is located within the recorded historic distribution of the species;
- the park is of sufficient size to sustain a population of tammars;
- suitably large areas of habitat of dense mallee, coastal thickets and grassland exists on the park;
- a fox control program has been operating on Innes for several years, which has been intensified since October 2003;
- the proximity of on-site personnel to enable regular monitoring and management.

Innes NP is located 300 kilometres by road from Adelaide on the southern extremity of Yorke Peninsula. The reserve is 9,322 hectares in size and comprises one of the largest areas of native vegetation remaining on Yorke Peninsula. Coastal heath dominates the cliff tops and merges further inland with extensive mallee woodlands, salinas and grasslands. These habitats support approximately 333 native plant species, (including 115 of conservation significance), 111 species of native birds, 10 species of native mammals and 17 species of native reptiles (DEH 2003). The large areas of mallee and dense coastal heath are suitable for tammars to shelter in during the day, and open grassland areas are suitable for the animals to forage in at night. Approximately ten percent of the park is grassland.

There are several water points within the park, including natural soaks between Pondalowie and Casuarina campground, and near Browns Beach. There is also a number of overhead filling water tanks that provide an overflow source of water. As the reserve is adjacent to farming and grazing properties, it is likely that pastures and waterpoints will attract tammars in hot weather and dry conditions, when other food and water resources on park may become depleted.

It is proposed that the first group of tammars will be released near the village of Inneston, located within the southern section of Innes NP (GPS location 53 672707, 6094225, see Figure 1). This site provides an excellent combination of protective refuge and open grazing areas visible from a vehicle access track for low level monitoring, and is appropriately distanced from adjoining properties.

Innes NP is exposed to the climate-modifying effects of the Southern Ocean. While the park experiences the full force of winter storms, it benefits from cool breezes during summer. Winds are predominantly from the south-west during winter and the south-east during summer. The average summer temperature is 28°C inland and cooler toward the coast. Winter temperatures are ameliorated by the coastal location and do not usually fall below 10°C. Maximum rainfall occurs during winter, with an average of 230mm for the months June through August (Bureau of Meterology 2004). Total annual rainfall can vary considerably, but on average, the park receives approximately 500mm each year (DEH 2003).

Figure 1. Tammar Wallaby Release Site

14 TRANSLOCATION DESIGN

14.1 Captive housing protocol

Prior to release, tammars will be housed in selected groups, or individually, based on genetics, sex and research objectives. The aim is to retain maximum genetic variation in the captive population and release groups, although preserving some degree of relatedness may also be important (Blumstein *et al*. 2002). Animals are housed at Monarto ZP in accordance with AQIS quarantine requirements, in high wire mesh holding pens, covered with shadecloth to prevent animal injury. To make the re-trapping of released wallabies easier, the wallabies will be acclimatised to entering traps prior to release, by placing feed into traps that have been wired open.

14.2 Transfer Protocol

Prior to release, animals will be checked by a vet, given a vitamin and selenium injection, microchipped, fitted with a radio-collar, tagged, weighed and measured. Animals will also be given an anti-parasite treatment to reduce the added pressure of tick load in the first few months. Animals will be transferred from Monarto to Innes in hessian bags suspended from a purpose built metal frame, in air conditioned vehicles.

Macropods are particularly susceptible to capture myopathy, a stress induced condition that causes degeneration of skeletal and or cardiac muscle, and often leads to impairment of normal physical function, or death. All precautions will be taken to avoid stress to animals in handling and capture. Animals will be released into small holding pens in the late afternoon, and then pens will be opened at, or after dusk, less than 24 hours from the initial time of capture. This will prevent undue stress and allow the animals time to forage and become accustomed to their new surrounds during their normal nocturnal activity period.

14.3 Group size and Composition

Larger founding population sizes are considered better for maximising the chances of successful establishment, both in terms of survivorship and genetic diversity. Considering that there are only 85 mainland tammars available at present (of which some need to be retained for a captive breeding program), the maximum number of animals available for release to Innes NP is 60 animals. Monitoring logistics also restrict the numbers that can be practically released at one time. A key research objective of the re-introduction is to study the effect of group size, group familiarity and predator training on the response of animals when released and the overall success of the re-introduction. Given this, it is proposed that a staged release be undertaken, where animals will be released in smaller groups, and staggered over time.

It is proposed that 20 animals (16F:4M) be released within Innes NP in November 2004. The female bias in the release group serves three functions, i) it approximates the social structure of the animals in the wild, ii) it increases the breeding capacity of the founder population, thereby improving the likelihood of successful establishment of the population in the park, and iii) with a strong female bias, the released males are unlikely to disperse away from the release site, in search of mates.

The release animals will be chosen based on sex, age, genetics, familiarity and body condition. Selection of females with large pouch young will be avoided given the risk that the young may be ejected from the pouch during handling or transfer. The first 20 animals will be released in four separate groups (4F:1M). Two of these groups will be composed of animals which are unfamiliar with the other animals in their group (ie those that have been housed separately whilst at Monarto), and the other two groups will be composed of familiar animals (ie those that have been housed together whilst at Monarto). Depending on the success of the first release, second and third groups of animals will be released in the park in 2005. Genetic analysis will be performed on all wallabies, to ensure that a broad spectrum of genetic diversity is exhibited by both the groups of wallabies to be released and those retained within the captive breeding program at Monarto ZP.

14.4 Release Protocol

The first 20 tammars will be "hard released" to Innes NP. Upon their arrival, the wallabies will be temporarily held in small pens (10m x 10m) for several hours, to reduce stress levels before they are released. The pens will be located near Inneston village, where the wallaby's habitat requirements are best catered for. This area is also a suitable distance from the boundaries of the park (6.5km) where they would be most likely to encounter foxes. Second and third release groups of tammars may be provided with water and supplemental feed when first released, dependent on seasonal conditions and what is learnt from monitoring of the initial release group. It is anticipated that this will encourage the animals to remain near the release site. The 2nd and 3rd releases may incorporate "soft" or "hard" release methods, also dependent on the success of the first release.

15 CAPTIVE POPULATION

Some quarantined tammars will be retained and managed as a captive population within the Monarto Zoological Park and potentially other major zoos affiliated with the Australasian Regional Association of Zoological Parks and Aquaria (ARAZPA). The aim is;

- to provide a secure population of animals, in the event that the trial re-introduction at Innes NP fails;
- to supplement the population at Innes NP, in the event of animal loss following release;
- to provide a source population for other release sites in South Australia.

The need to retain a captive population in the long-term will be reassessed in light of outcomes of these re-introduction attempts. If the Innes NP re-introduction is successful, the Innes population may become a source for other re-introductions of SA mainland tammars and animals may be trapped and re-located to other areas, as defined in future translocation proposals.

16 POPULATION MONITORING

16.1 Trapping protocol

Tammars will be trapped using soft mesh cage traps surrounded by shadecloth, which are specifically designed to reduce the risk of injury to the animals. Traps will be baited with carrot, kangaroo pellets, whole oats, or chaff mixed with molasses, and/or water. All animals in the initial release group (and any pouch young) will be tagged for individual recognition and micro-chipped prior to release.

Trapping will occur on a bi-annual basis in late summer (February) and late winter (August), with trapping being conducted over a period of seven nights within each trapping session. Newly captured individuals will be checked (as above), then tagged, micro-chipped and ear-notched to obtain a DNA sample. Betadine will be applied to the ear-notch wound. Captured animals will be placed in hessian bags and processed on site (in a sheltered and shaded area). Animals will be weighed, sexed, measured, and checked for breeding status and physical condition. These data will contribute to a demographic and genetic profile for the population. If any young is ejected from the mother's pouch, without injury, it will be reinserted and the pouch opening will be secured with elastoplast. Trapping of animals fitted with a radio-collar will enable the function of the collars to be checked and batteries to be replaced if required. Traps will be cleared at midnight and in the early morning to prevent undue stress and exposure to animals.

16.2 Tracking and monitoring protocol

All animals in the initial release group will be fitted with radio-collars, and monitored in accordance with AQIS requirements. Each individual will be located regularly using radio-tracking techniques, to determine survival, movement patterns, group cohesion and individual survivorship. Regular spotlighting will also be undertaken, with tags assisting to identify the translocated animals. Animals will be monitored very closely when first released. Mortality switches will be used in the transmitter collars, to enable any corpses to be retrieved in sufficient time to allow an appropriately trained veterinarian to perform a *post mortem*. Radio-tracking will allow for long-term monitoring (eg of home range, habitat preferences). Animals will need to be re-captured to replace the transmitter batteries (approximate life of one year).

16.3 Protocol for the re-capture of wallabies that move off-park

During the initial 2-year trial period of the re-introduction program, all wallabies will be of considerable genetic, demographic and conservation value to the Innes population. Therefore, any wallabies that move off-park during this period will be re-captured and returned to the release site as safely and as quickly as possible. This will be done in consultation with relevant landholders, to minimise disturbance to farm activities. Consideration will be given to returning individual tammars that repeatedly move off-park to Monarto ZP.

As tammar numbers increase on Innes NP, some individuals may attempt to establish home ranges along the boundary of the park and forage into adjacent crops or pastures. Animals frequenting the edges of the park, or moving off-park, are considered to be at greatest risk of predation. Given the conservation value of each individual animal during the initial population establishment phase (estimated to be <u>two</u> years), all wallabies that disperse off park during the 2-year re-introduction trial period, addressed by this proposal, will be re-captured and returned to the release area as soon as practicable (see section 17.3).

Following the initial 2-year period addressed by this proposal, the comparatively high density of foxes beyond the boundary of Innes National Park is expected to restrict the tammar population to the park. Ongoing monitoring will be used to verify this. Because wallabies will be initially released in small groups (20 individuals), there will be considerable time available to evaluate the efficacy of the various retrieval techniques, while the animals are in very low numbers. The various options for relocation of wallabies back onto Innes NP include;

a) The placement of traps in areas of known wallaby activity, as determined though radio-tracking, population surveys and/or landholder advice. Given that the traps will be baited with food and free water, this strategy will work best in summer, when feed is less abundant and high temperatures will induce the wallabies into the traps to drink. Baited traps will be wired open for a few days prior to being set, to encourage animals to enter the traps and increase the likelihood of capture.

b) The use of a spotlight and dab net, in the early morning and at night. This proved effective when catching wallabies on Kawau Island, particularly when aided by the background sound of a vehicle motor to distract the wallabies (personal observations).

c) The use of temporary and/or permanent fence-line traps (eg mesh, shadecloth, soft hanging nets) to provide a barrier to wallaby movement and allow wallabies to be directed into a confined area for re-capture. Temporary fences can be constructed during the day. Soft nylon nets laid out on the ground, across frequented wallaby pads will further assist to direct herded wallabies. When the wallabies move away from cover, to feed at night, the soft-net is raised and the wallabies are slowly driven back along the fences, into the soft-net. These techniques have proved successful on Kawau Island (personal observations) and in other parts of New Zealand (Lentle *et al.* 1997).

In most cases, passive methods of animal retrieval (option a) will be attempted before employing more direct methods (options b or c). Only DEH staff or local contractors (see 17.3) are permitted to capture and re-locate animals. There is the potential that individual tammars may move off-park to feed in adjacent crop-land. However, they will still shelter in surrounding native vegetation, so attempts to recapture animals will be undertaken in these areas to minimise disturbance to adjacent private property.

16.4 Population size

A range of techniques will be used to monitor the tammar population at Innes NP, over the short and long-term. As the number of wallabies in the first release will comprise the total population, population size will initially be monitored using radio telemetry data (ie. N = number released - mortality). Wallabies will be trapped bi-annually, with trapping being conducted over a seven-night period within each trapping session. Following the first breeding season and the subsequent release of additional wallabies, population size will be monitored using mark-recapture and mark-resight techniques. Animals will be trapped using soft-mesh traps placed at known locations of wallaby activity (determined by radio-telemetry data), or caught by hand or by herding/driving into fenced enclosures. Population size will be estimated using the following mark-recapture estimators; i) Chapman's unbiased derivative of the Peterson index (Krebs 1989), ii) closed population models (Otis *et al.* 1978), iii) the Jolly-Seber-Cormack open population models (Pollock *et al.* 1990) and iv) Pollock's robust technique (Pollock *et al.* 1990). Mark-resight estimates of population size will also be obtained by using the data collected during the trapping period and subsequent data collected during spotlight surveys. These data will be analysed using; i) the Minta-Mangel technique (Minta and Mangel 1989) and ii) the Arnason maximum liklihood technique (Arnason *et al.* 1991). As the number of tammars increases on Innes NP, it will be possible to use line transect methodology (Buckland *et al.* 2001) to estimate population densities. Data will be collected along transects conducted at night, along formed tracks, using a spotlight and laser range finder. The transects will be sampled across consecutive nights and the data pooled to constitute a single long transect. Density estimates will be obtained on a bi-annual basis in late summer and late winter. Additional transects will be established along the boundaries of the park, to detect the presence of tammars close to agricultural lands and to estimate their density.

16.5 Demographic parameters

The trapping of wallabies, throughout the study, will provide the following demographic data; adult sex ratio, pouch young sex ratio, population age structure, body condition, reproductive output, recruitment, pouch young survival rate. As the population increases, dispersal rate, dispersal distance and identity of dispersers will be estimated by placing radio-collars on juvenile wallabies. Estimates of adult mortality/survival rates will be obtained from radio-telemetry data. All released wallabies will be fitted with a mortality sensing radio-collar. Wallaby survival will be monitored on a daily basis for the first 4 weeks post-release, then 3 times a week for the subsequent 2 months and once a week for the remainder of the study. The above demographic data will be input into matrix population models (Caswell 1989) to estimate the population's rate of growth and to evaluate the accuracy of the population estimates. During the first 4 weeks of intensive monitoring, all dead wallabies will be collected within a day of death, and taken to Monarto ZP for autopsy. Following the first month of intensive monitoring, all deceased animals with functional radio collars or found through opportunistic sightings will be collected as soon as possible for autopsy.

16.6 Wallaby space use patterns

All released wallabies will be fitted with radio-collars and their movement patterns monitored intensively using radio-telemetry. Initially, location data will be collected on a daily basis, to evaluate whether the wallabies remain within the proximity of the release site. If any wallabies do move off-park, hand tracking will be used to determine their location and attempts made to recapture the wallabies. The accumulation of this data, over the long-term, will allow for the analysis of home range size, habitat use and other behavioural patterns (eg group cohesion, foraging behaviour, water use, etc).

17 POPULATION MANAGEMENT

17.1 Population projection

As part of the risk assessment process, a population modelling exercise was undertaken to gauge the rate at which the tammar population could be expected to increase, once they had been re-introduced to Innes NP (see Appendix B). This model was based on demographic data, collected from the Kangaroo Island population of tammar wallabies, during a three year period of average environmental conditions Demographic parameters were calculated from observations on 401 adult wallabies, 136 juvenile wallabies and 198 pouch young. The results indicated that the re-introduced population could be expected to remain stable or undergo a slight decline over a 50-year period. Such long-term stability is expected of a population that exists under average environmental conditions. It can be predicted that the population will fluctuate in size, increasing during periods of resource abundance and decreasing during periods of resource scarcity. The model, therefore, highlights the need for ongoing monitoring and possible active management (eg the provision of supplemental feed or water for short periods) if the re-introduction occurs during a period of low resource availability. Similarly, because the model was based on data from the predator-free Kangaroo Island population, the effects of predation were not reflected in the survival rates of the various age-classes of wallabies. In relation to fox predation, there are four possible scenarios;

i) The Innes NP baiting program is ineffective at reducing fox abundance to levels where fox predation does not have a limiting effect on the tammar population. Under this scenario, the tammar population would fail to establish itself on Innes NP.

ii) The baiting program reduces fox densities within the core of the park, but the immigration rate of foxes is sufficiently high to ensure that some foxes always penetrate the edges of the park and limit the distribution of the tammar population on the park.

iii) The baiting program reduces fox densities across the entire baited region and the tammar population extends to the boundary of the park. However, fox predation does not allow tammars to establish a population outside of the park. Under this scenario, there is the potential that some individuals may access adjacent cropping or pasture land. This would be identified through the monitoring program before impacts occur. If impacts do occur, appropriate management options would be developed in consultation with those affected.

iv) The baiting program reduces fox densities within the park, the tammar population extends to the boundary of the park and there is some movement of tammars off-park. However, fox predation does not allow tammars to establish a breeding population outside of the park. Under this scenario, there is the potential that some individuals may access adjacent cropping or pasture land. This would be identified through the monitoring program before impacts occur. If impacts occur, appropriate management options would be developed in consultation with those affected.

v) The baiting program reduces fox densities within the park, the tammar population extends to the boundary of the park, there is movement of tammars off-park and fox predation is insufficient to restrict the establishment of a <u>breeding</u> tammar population outside of the park. Under this scenario, appropriate management options would be developed in consultation with the local community and affected interests. However, the Tammar Wallaby Recovery Team is of the firm and informed opinion that this scenario is most unlikely to occur, because fox predation has been observed to be a limiting factor on many populations of macropods, including tammars (Friend 1996, Kinnear *et al.* 1998, Banks *et al.* 2000, Rummery *et al.* 2001a, 2001b, DePreu *et al.* 2001, Sharp 2002).

17.2 Population crash

Short-term population fluctuations may occur during the early stages of the re-introduction program, due to difficulties with the wallaby's ability to adjust to their new environment. Possible losses may result from a) predation by remaining feral carnivores, b) insufficient quality or quantity of feed, c) insufficient access to water, d) the movement of wallabies off-park, and/or d) the presence of parasites or pathogens. Other potential causes of mortality include predation by birds of prey and road kill.

a) Levels of predation will be monitored through the placement of mortality-sensing radio-collars on all released wallabies (see 16.2). Dead wallabies will be located as soon as possible after death and an autopsy performed. The loss of a considerable number of tammars through predation, over a short period of time, would indicate that the 1080 baiting program was insufficient to reduce the resident fox population or the migration of foxes into Innes NP. Under such a scenario, any remaining wallabies would be trapped and returned to Monarto ZP, pending the resolution of the predation problem.

   It is expected that the Innes NP fox-baiting program will reduce the resident fox population to low levels, as there are numerous examples of the effectiveness of 1080 fox-baiting programs elsewhere in southern Australia. Data are currently being collected on fox activity within and along the boundaries of Innes NP (see 18.1). These data will indicate where the majority of fox activity is occurring on the park. Given that the baiting frequency and intensity on Innes NP is already very high and that bait medium is varied regularly, any further increase in baiting activity within the core of the park is unlikely to have any substantial additive effects on fox mortality. It is probable that any noted high levels of fox activity within the park will be due to the movement of foxes from adjacent land and along beaches into the park and that the baiting program along the edge of the park is insufficient to effectively curtail this migration.

   Several potential options have been suggested to resolve the predator problem.

   The creation of a baited buffer zone around Innes NP (minimum of 10km from park boundary) would reduce the migration rate of foxes onto the park. However, this scenario is currently impractical, due to local landholder concerns and opposition regarding the possible spread of tammars off-park and their potential effects on agricultural production.

   The erection of a predator-proof fence around Innes NP is also not a preferred option because,

   - a fence surrounding Innes NP would impede the movement of other animals across the landscape, resulting in disruptions to population and ecosystem processes and the possible extinction of some local populations of species.
   - conservation reserves should not be viewed as "zoos", or as disjunct and separate from the surrounding landscape, rather they are an integral part of the landscapes and communities in which they are located.
   - predator proof fencing is expensive and labour intensive to maintain and would not prevent movement of foxes into Innes NP via the beachfronts
   - although previous re-introductions in controlled, fenced environments have been successful, the tammar re-introduction program aims to trial whether the wallabies can successfully establish a self-sustaining population in an environment where the threat from fox predation is minimal, rather than non-existent.

   Similarly, the suggestions to house tammars within a small fenced enclosure within the park is contrary to the aims of the re-introduction program; ie to establish a self-sustaining population of tammars in the wild.

   The only remaining option would be to increase the intensity and frequency of the baiting program along the boundaries of Innes NP, to reduce the number of foxes migrating into the core of the park. The effectiveness of this strategy could be evaluated through a comparison of baiting effort with levels of fox activity. Once fox activity had undergone a (further) significant decline, a second trial re-introduction of tammars could occur.

b) Dependent on the season of release, forage species may exist in insufficient quantity, or quality, to provide adequate nutrition for the wallabies. Such deficiencies will be detectable through changes in the body condition of the released wallabies, which will be monitored during the trapping component of the population study (16.1). Poor body condition can result in reduced reproductive rates, poor survivorship of pouch young and young-at-foot and, in the extreme case, the death of adults through starvation. The dietary studies being conducted by the University of Adelaide (section 20) will supplement the body condition data and provide insights into whether any loss in condition is related to an inability to quickly adjust to a new environment (eg learning which plant species are palatable) or simply low resource availability, due to poor environmental conditions. Any indications of death through starvation will be readily identifiable during autopsy. Following any suggestion of a rapid and substantial decrease in body condition within the wallaby population, consideration will be given to the provision of supplemental feed (eg kangaroo pellets). However, it may be deemed necessary to capture all such animals and hold them in captivity until a more suitable release site is found. Other means of providing additional forage for the wallabies (eg cropping within the park boundaries) are not consistent with the acceptable land-uses on conservation reserves and would not be appropriate.

c) Tammars are reputed to be able to subsist without access to free-water, by gaining their moisture needs from the plants they consume, or from dew. Tammars in several wheatbelt reserves in WA, and on islands such as the Abrolhos group, have no access to free water other than rainfall and then only for limited periods. However, it is highly probable that the wallabies will require access to free-water to survive the hot, dry summers of mainland South Australia. Assessing whether the wallabies have sufficient access to free-water will be difficult, because water turnover studies require the repeated and regular capture of the same individuals over consecutive days. An indication of water deficiency may be gained from an examination of their movement patterns. If the wallabies make repeated trips to the coastline, to drink saltwater, or make long trips to the few soaks remaining on the park, it can be assumed that they do require access to free water or are suffering from water stress. Under these conditions, it would be appropriate to clean out fouled soaks and fence them to allow access by tammars whilst restricting access to the larger herbivores on the park. During the initial stages of the re-introduction program, it may also be necessary to provide a temporary artificial water source at the release site, in the form of a small tank and trough.

d) Immediately following the release of the trial groups of tammars, it is possible that some individuals may disperse away from the release site. Some movement is to be expected as the wallabies explore their new surroundings and seek out areas of optimal habitat in which to establish home ranges. However, some wallabies may also undertake long distance movements, taking them off park. The release of wallabies in distinct social groups (4 females:1 male) should go some way to preventing this possibility. During the early stages of the release program, when each wallaby makes a substantial demographic contribution to the population, all wallabies that move off-park, in the first two years of the program, will be recaptured and returned to the proximity of the original release site.

e) The newly released tammars will be exposed to parasites, pathogens and diseases to which they are unaccustomed or have not developed an immunity to. Of some concern is the kangaroo tick, which is known to be present on kangaroos in Innes NP. Indications of excessive parasite burdens and/or the presence of disease in the population will be expressed as poor body condition and/or external symptoms. These indicators will become apparent during the trapping and handling of the wallabies. Any death due to parasites, pathogens or disease will be discernible during autopsy. An excessive level of mortality due to parasites, pathogens or disease will be a cause for concern and considerations will be given to catching and relocating the remaining wallabies to a quarantine enclosure at Monarto ZP until the cause of the problem has been identified and ameliorated.

A summary of appropriate options to manage the tammar population is contained in Appendix D.

17.3 Carrying capacity

The goal of the current re-introduction program is to establish a self-sustaining, wild population of tammars on Innes NP. With the successful establishment of a founder population, wallaby numbers are expected to gradually increase, with minor fluctuations dependent on seasonal conditions and residual densities of predators on the park. No breeding populations of tammars are expected to become established off-park, because i) the presence of foxes will probably remove any individuals that attempt to establish home ranges off-park, and/or ii) predation on juvenile wallabies will limit the successful recruitment of young into any populations outside of the Innes NP baited area. Nevertheless, even under conditions of slow growth, the tammar population will, at some point, achieve carrying capacity on Innes NP. The definition of carrying capacity will be determined within the context of total grazing pressure and be linked to the densities of the other resident herbivores on the park. An assessment of total grazing pressure will be made by comparing herbivore densities with the effects of grazing on the plant species and communities of the park.

An additional indicator of carrying capacity will be attempts by juvenile wallabies to disperse into habitats outside the park boundary. It is, therefore, important that procedures be put in place for adjacent landholders to report any tammars they notice on their properties and that a monitoring program be established on adjacent lands. This monitoring program could be conducted in collaboration with kangaroo surveys, providing a measure of total grazing pressure off-park.

There are two mutually compatible options for the management of the tammar population, once carrying capacity has been reached. The current re-introduction program forms only one part of a broader state-wide re-introduction program. Excess individuals from the Innes population could be incorporated into re-introduction programs for other parts of the State. Indeed, these individuals may be better propagules than captive-bred animals, as they are likely to exhibit a higher fitness (in the wild) due to their exposure to native pasture species, diseases, parasites, pathogens and predators.

A second option for the long-term management of the Innes population is to modify the predator control program, as slight increases in predation would be expected to regulate the population's growth. This may be achieved by periodically reducing either the frequency, intensity or spatial scale of the predator control program. An adaptive management approach should be taken in regard to determining the optimal period of time over which the baiting regime should be reduced. The resolution of the optimal period for the temporary reduction in baiting is likely to be a medium-term experimental process. Such adaptive management will also need to have regard for other predator-affected species on the park and the period of greatest and least risk for each of these species. While the option of altering the fox-baiting regime may provide a means to manipulate tammar population levels, such an option may be at odds with i) other biodiversity enhancement programs, ii) DEH's responsibility for managing threatening processes within best practice standards and iii) the implementation of a community-based broad-scale fox-baiting program in the district. Further, altering the baiting regime may expose a very large proportion of the tammar population to a rapid rise in predation rates and would need to be monitored very closely. The implementation of this option would require substantial consideration.

Even under conditions where the tammar population is being managed below carrying capacity on Innes NP, some wallabies may attempt to establish home ranges along the boundaries of the park in order to forage in adjacent crops. The level of resultant crop damage is likely to be minimal and short-lived, as foxes are expected to be constantly penetrating the boundaries of the park and limiting the numbers of wallabies that frequent this area. Nevertheless, the possibility of crop damage has not been discounted and appropriate measures to manage grazing impacts would be developed in consultation with the local community, if significant damage occurs.

Studies on Kangaroo Island indicate that adult wallabies consume around one tenth the quantity of food that sheep consume (0.1 DSE). Given a park boundary of 19.5km length and the movement of tammars up to (say) 100m into adjoining farmland, a local population of 50 tammars established along the park boundary, for example, would represent a tammar density of ≈ 0.25/ha feeding on that farmland, which equates to ≈ 0.025 sheep per hectare.

In any event, the implementation of potential management actions would not be necessary for several years, because; i) the re-introduction will occur in a staged fashion (i.e. 3 releases of 20 animals) over a 12 to 18 month period, ii) the total size of the re-introduced population is limited to 60 animals and iii) the re-introduced population is predicted to have a slow rate of growth (see section 17.1). (Indeed, the success of the entire re-introduction program is uncertain and if the 1st release is a failure, subsequent releases may not occur at all).

The primary reason for undertaking a staged release is to collect sufficient data on the wallaby's demography and behaviour, to confidently predict i) what the population will do, ii) to what extent predation limits the population and iii) the probability of wallabies dispersing away from the protection provided by the intensive fox control program on Innes NP. Following on, because the intial releases will be of small groups of wallabies (20 individuals), this allows time for the evaluation of the efficacy of various retrieval techniques (see section 16.3) and management strategies (see below) that may be required, based on real data, rather than supposition.

Because SA mainland tammars are listed under the Commonwealth's Environment Protection and Biodiversity Conservation Act (1999) as "extinct in the wild", they will remain totally protected until such time as their numbers and distribution have increased to the point where their conservation status has been down-graded to "near threatened/conservation dependent". Therefore, the management of the sub-species' numbers and/or grazing effects through culling will be illegal, and likely to remain so for several years to come.

A range of management options have been identified to reduce the potential effects of tammar grazing on crop-lands adjacent to Innes NP. The decision about which management action is appropriate to implement will be dependent upon a number of variables, including; the tammar's conservation status, tammar population density, rabbit density, kangaroo density, degree of damage to crops and/or pastures, and the time since commencement of the project. The Tammar Wallaby Community Consultative Committee and local landholders will be invited to play a role in the decision making process. A range of management options is outlined below.

While the tammar's conservation status remains 'threatened' (i.e. from "extinct in the wild" through "critically endangered" and "endangered" to "vulnerable" / "rare") population management options might include the following:

a) During the first two years of the program any tammars that are present on adjacent properties will be trapped and removed for return to Innes NP or for movement to other re-introduction sites.

b) The management of the tammar population within the context of total grazing pressure and the development of a total grazing management plan for all native and introduced herbivores (see section 18.2). Both the abundance of all large native herbivores, and rabbits, and the impact they have on agricultural enterprises would be assessed. A sufficient number of "permits to take" would then be issued to affected landholders to reduce herbivore populations (excluding tammars) to sustainable levels for both agricultural productivity and biodiversity. The success of any native herbivore control program would be intensively monitored.

c) The construction of tammar exclusion fencing along sections of the park boundary that abut onto cropping lands, if significant grazing impacts occur. To effectively keep wallabies off crops, and based on experiences in Western Australia, such a fence would need to extend up to one kilometre past the boundary of the cropping lands. The fence would be based on a simple stock fence, with netting of a sufficiently small mesh size to prevent the passage of wallabies. The purpose of such a fence would be to limit the tammar's access to crops.

Should the tammar wallaby population become abundant and its conservation status be down-listed to "near-threatened – conservation dependent", the tammars may then be managed in accordance with other abundant macropod species in South Australia.

The supposition that fox predation resulted in the extinction of the tammar on Yorke Peninsula is based on a logical and deductive assessment of the historical data and on the plethora of evidence linking fox predation with the decline and extinction of many small to medium-sized native species. In addition, at least four adult male tammars were recently killed by a fox at Monarto Zoological Park, when nine wallabies escaped from a holding pen into a vacant section of the park that surrounds the tammar quarantine yards. This vacant area had been considered essentially fox-free, but all four wallabies were taken by foxes in just two nights. As such, the existence of foxes outside the heavily baited area on Innes NP is expected to limit the spread of the wallabies outside the park. However, it is possible that, at some point in the future, the local community may decide to increase its fox-baiting activities, to produce a measurable reduction in fox abundance. Under such conditions, the tammars are likely to expand their range into the baited areas. Such a scenario is not expected to occur in the foreseeable future, as the limited economic gains would not offset the cost of such an intensive baiting program. The development of more efficient fox control technologies may, at some point, change this balance. Under conditions where fox predation has not limited the range of the tammar population, or where effective fox control occurs outside the park, it may be considered appropriate to issue "permits to take" to reduce tammar abundance. However, a clear demonstration of the impacts of tammar grazing on crop production would be required before any permits were issued.

A summary of appropriate options to manage the tammar population is contained in Appendix D.

18 SITE MANAGEMENT

18.1 Predator Control

An intensive fox baiting program has been under way on Innes NP since October 2003, with baits being laid on a fortnightly basis along all internal and boundary tracks, at 0.5km intervals. The effects of baiting on fox abundance is being measured using passive track counts (Edwards *et al.* 2000). Two transects have been established; 1) along the north-eastern boundary of the park (15 km), to provide an index of fox reinvasion rates and 2) along the main thoroughfare of the park between Stenhouse Bay and the Shell Beach turnoff (19 km), to provide an indication of fox abundance within the core of the park. Data from each transect will be analysed separately. Tracking stations have been established at 1km intervals along each transect, allowing for independence between sampling points (Edwards *et al.* 2000, Wilson and Delahay 2001). At each sampling point, the number of distinctive sets of tracks per species will be recorded (ie. "number of incursions"). Quadrats are sampled over four consecutive mornings during the last week of July, October, January and April each year. The resultant data will be analysed using the Allen Activity Index (Allen *et al.* 1996, Engeman and Allen 2000). As a comparative measure, any fox sightings during the tammar spotlight surveys will be recorded and converted to a density estimate. Tracking stations will also be established outside of the park, to provide a measure of fox abundance in a non-baited area.

The baiting program currently in place at Innes NP is very intensive, with all tracks baited on a fortnightly basis. To date, percent bait-take has been observed to fluctuate, but has remained generally under 10%. Bait-take and the relative index of fox abundance (passive tracking stations) are mapped regularly to identify hotspots in fox activity. Figure 2 shows the total percent and location of bait-take for the boundary and inner tracks at Innes NP from October 2003 to October 2004. Figure 3 shows the total percent and location of bait-take for the most recent baiting round in October 2004. The results show markedly higher levels of activity along and near the park boundary than further into the park. This pattern is consistent with an ongoing invasion of foxes into the park from surrounding unbaited lands.

Bait-take and fox and cat activity will be closely monitored leading up to the release and increased baiting will occur around the release site and at hotspots, during the month prior to the release. Once the indices of fox activity suggest that the fox population has been reduced to very low levels, the baiting program will be reviewed. It is probable that the current baiting program will reduce fox numbers within the park to low numbers, but that there will still be substantial fox activity along and immediately within the boundaries of the park, as foxes migrate into the park from adjacent areas. Under such a scenario, baiting frequency within the park may be reduced, but kept at a high level along, and adjacent to, the park boundaries. To determine the required level of baiting within the park, the baiting frequency will be gradually decreased and the indices of fox activity monitored until an optimal frequency of baiting is reached (though there will be seasonal peaks).

A fox activity index of less than or equal to 5% bait-take (per fortnight) for all bait stations on internal tracks within the park will need to be maintained leading up to and following the release of the first trial group of tammars.

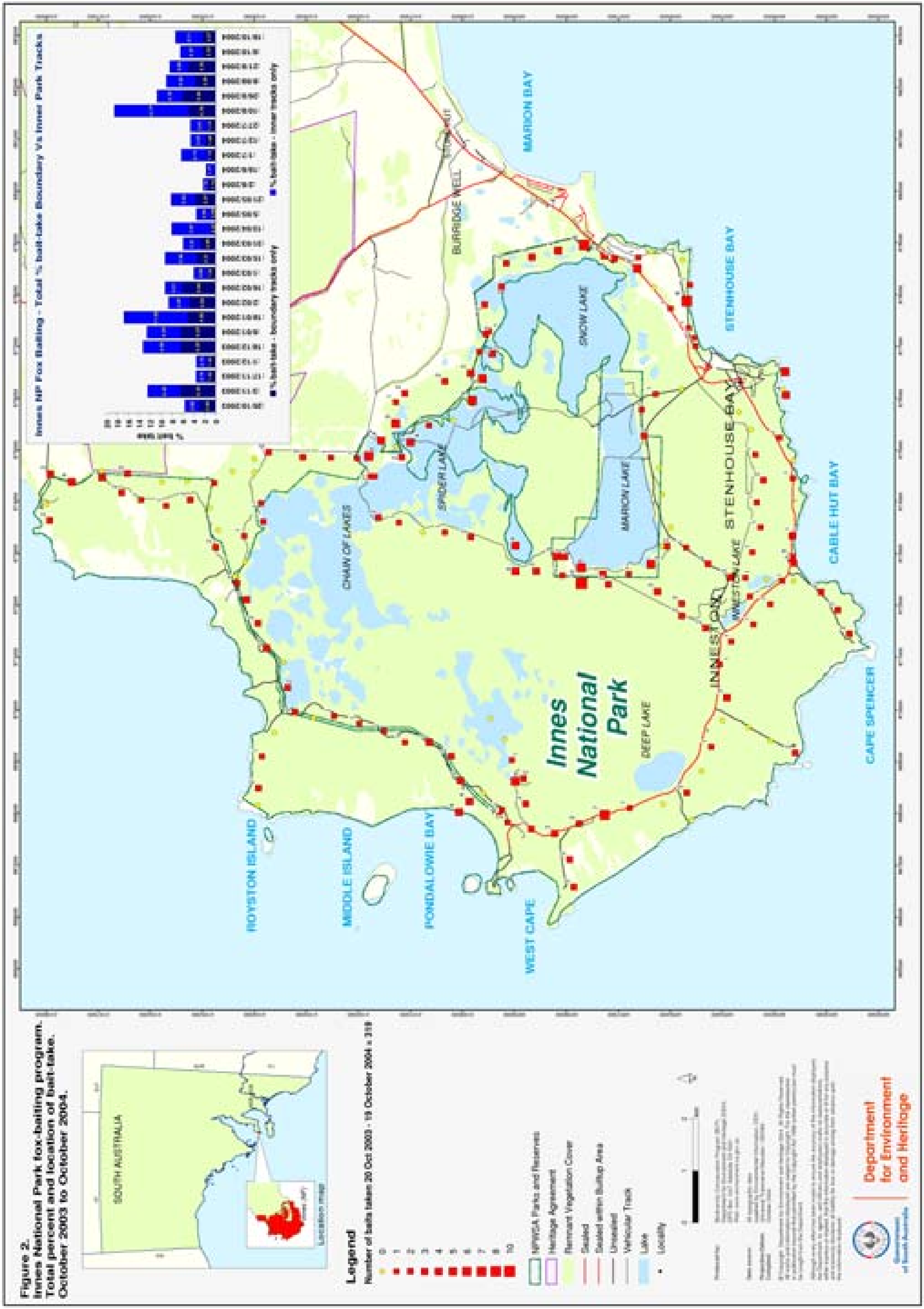


Figure 2.
Innes National Park fox-baiting program.
Total percent and location of bait-take.
October 2003 to October 2004.

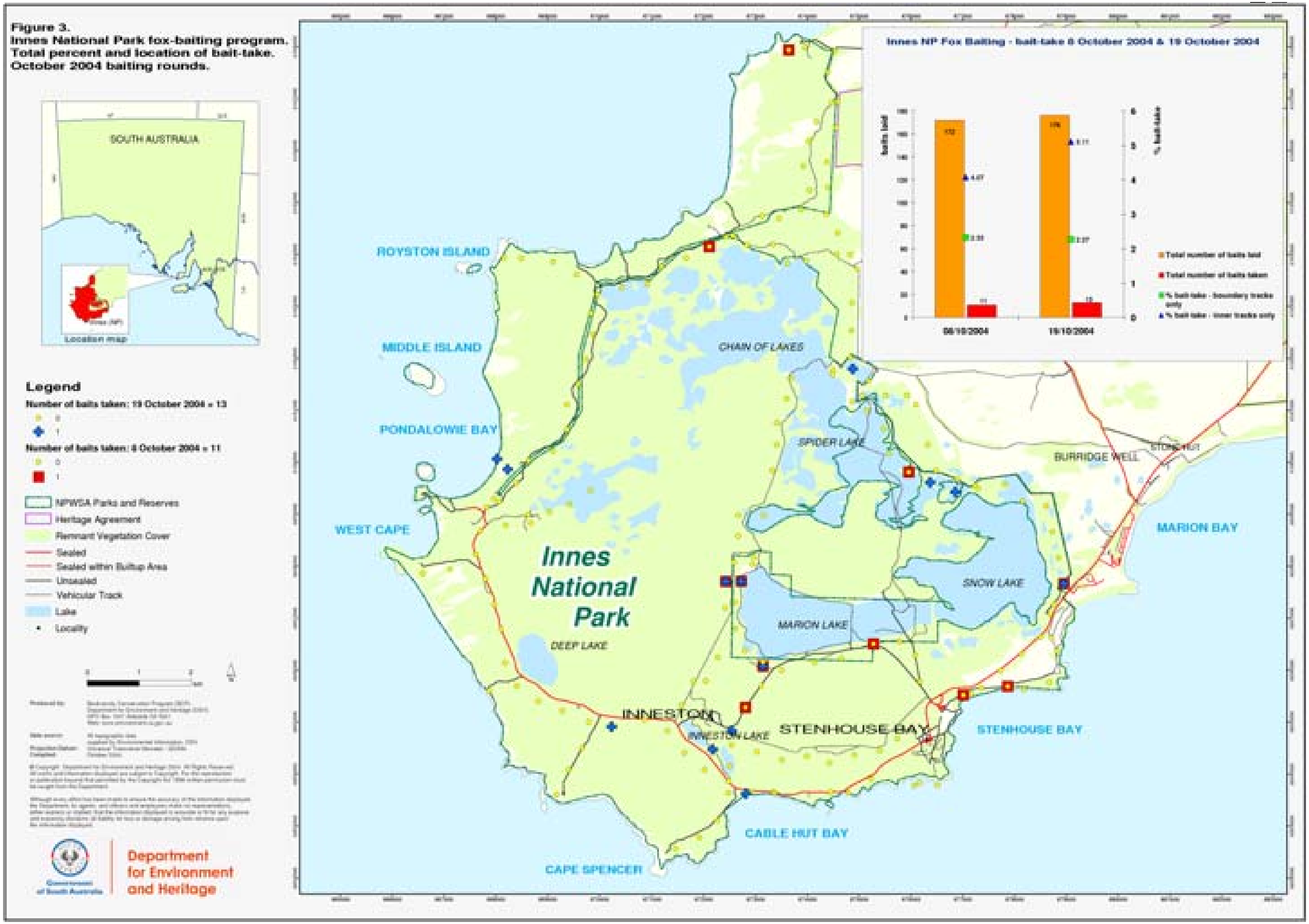


Figure 3.
Innes National Park fox-baiting program. Total percent and location of bait-take. October 2004 baiting rounds.

18.2 Total Grazing Pressure Management

Because tammars are being re-introduced into a system that they were once a significant and "natural" component of, it is unlikely that tammars *per se* will have a significant effect on native plant species. However, the re-introduction of tammars to Innes NP will increase the total grazing pressure on Innes NP. The park contains 115 plant species of conservation significance, of which 24 species are listed as threatened under the NPW Act (1972) and 4 under the EPBC Act (1999) (see Appendix C for a full vegetation list). Forty-four plant species endemic to SA have been recorded on Yorke Peninsula (DEH Biological database), of which twelve have been recorded at Innes (DEH 2003). None of these species are specifically endemic to Yorke Peninsula.

The park is also home for a population of the rare yellow sedge skipper butterfly, whose larvae are dependent on the smooth leaved saw sedge, a species which often displays signs of intensive grazing.

Substantial efforts have been made to document the biodiversity values of Innes NP. In August 2004, a survey was conducted to determine the composition and status of orchid populations at the proposed release sites. This survey revealed a plethora of orchid species and populations and all indications were that grazing pressure on these species was currently low. Considering tammars are likely to feed preferentially in open areas of the park (where orchids are noticeably absent or scarce), the risk to orchids posed by tammars is considered low. The DEH Biological Survey team undertook a comprehensive survey of the flora and fauna of the southern Yorke Peninsula (including Innes NP) in October 2004. Further, a baseline survey of the plant communities of Innes NP was also conducted in October 2004 by the DEH Threatened Plant Ecologist, with a focus on the detection of populations of threatened species in the vicinity of the release site.

At present, overgrazing by native and feral animals is considered one of the potential threats to the native vegetation of the park (DEH 2003). It is, therefore, important that total herbivore numbers are monitored and their effects on native vegetation evaluated. Surveys conducted in winter 2004 indicate that kangaroos, within the open grassy habitat of Innes NP, were at densities of 8 km^{-2}. This density is slightly higher than that predicted for a sustainable population (4 km^{-2}). Densities within the park's mallee habitat would have been lower than this figure, due to its dense nature. Total grazing pressure will be calculated by converting the estimated densities of western grey kangaroos (*Macropus fuliginosus*), emus (*Dromaius novaehollandiae*), rabbits and tammars into dry sheep equivalents (DSE).

The dense vegetation at Innes NP limits the ability to derive accurate estimates of kangaroo abundance. Nevertheless two approaches will be used in the current study. A spotlight transect will be established within each of; a) the mallee regrowth habitat along the park's main fire trails - 14.5km and b) the shrublands along the main thoroughfare of the park - 21.0km. A simple strip transect approach will be used, with all kangaroos within a 50m distance from the vehicle being recorded. Although density estimates can be derived from strip transects, they are often inaccurate and imprecise and the data should be more appropriately used as an index of population size. Due to the dense nature of the mallee vegetation, it is probable that the counts along the mallee transect will not provide useable data and these counts may be dropped from the monitoring program following an evaluation of their efficacy. To allow an evaluation of population dynamics, the spotlight counts will be conducted during the last two weeks of May and November each year. Counts will occur over four nights along each transect and will be conducted from the back of a utility vehicle travelling at 10 km hr^{-1}. The data from each of these transects will be analysed separately.

Line transect methodology (Buckland *et al.* 2001) will be used to estimate kangaroo density, within the park's grassland habitats. The success of this approach is dependent on the number of clusters recorded (ie. groups of kangaroos), which ideally needs to be greater than 60-80 to construct a reliable sighting probability curve. The grassland transects will be divided into numerous sub-transects, which will be sampled at either 1 to 2 hours after sunrise, in the late afternoon, or after dark (depending on the success of trial surveys). Sub-transects will be sampled at the same time of day across consecutive days and the data pooled to constitute a single long transect. The number of sub-transects required, and/or the number of repeated samples along each sub-transect, will be evaluated in a pilot study conducted in August 2004. Density estimates will be obtained on a bi-annual basis, during the last two weeks of May and November.

The control of fox numbers may lead to an increase in rabbit density. Rabbit numbers will be monitored during the spotlight counts conducted to quantify both tammar and kangaroo abundance. Control measures such as the release of myxomatosis, or RHD baiting may be implemented if rabbit numbers appear to be increasing.

If kangaroos are shown to be having an impact on vegetation, culling will be considered as a method of managing these impacts. The culling of kangaroos on NPW Act reserves requires definitive evidence that kangaroos are at sufficient densities to be having detrimental effects on native vegetation or plant communities, and also that culling is the only practicable option for managing an overpopulation of kangaroos (refer to section 38 NPW Act). Further, the Macropod Conservation and Management Plan for SA: Conservation and Management of Common Kangaroos stipulates that all introduced herbivore populations must be effectively managed before permission is granted for a kangaroo culling program. Current estimates of kangaroo numbers on Innes NP suggest that there are approximately 4 km^{-2} (DEH 2003), though this is based on somewhat unreliable data. Surveys conducted in winter 2004 indicate that kangaroos, within the open grassy habitat of Innes NP, were at densities of 8 km^{-2}. Densities within the park's mallee habitat would have been lower than this figure, due to its dense nature. At such densities, it is unlikely that kangaroo grazing pressure is having a major effect on native vegetation. If a cull of kangaroos is considered for Innes NP, it will take place in accordance with DEH policy for culling kangaroos on reserves, and with the utmost concern for animal welfare. Until the conservation status of tammars has been down-graded, it will be illegal to cull tammar numbers on Innes NP.

The effects of total grazing pressure on vegetation communities will be monitored using 6 pairs of herbivore exclusion plots and control sites. Three sets of paired plots will be placed in the shrubland habitat, while another 2 will be placed at the interface between the shrubland and mallee habitats and the final pair will be placed with the sedge habitat, along the edge of one of the lakes. Vegetation sampling will be conducted using the nested quadrats approach (Morrison *et al.* 1995) at 6 to 8 permanently marked sampling points at each site. The variables recorded will be; relative frequency of each species, species diversity and biomass (Tothill *et al.* 1992, Morrison *et al.* 1995). An emphasis will be placed on examining the effects of grazing on palatable and unpalatable species and incursions of weed species. Sampling will occur on a bi-annual basis, at the end of summer and winter each year. Photos will be taken at permanent photopoint locations in the park, and new photopoint locations will also be established as an additional measure to assess any changes in vegetation.

18.3 Other interactions

The most likely direct competitors for tammars will be western grey kangaroos and rabbits. As this proposal is for a re-introduction to an area within the species known former range, rather than an introduction into an area where the species did not previously occur, issues of competition with native herbivores should be minimal and viewed as the restoration of a previous "ecological balance". Although it is likely there will be some overlap in feeding and habitat requirements, tammars are not expected to have deleterious impacts on other native fauna species that they used to co-occur with at Innes NP. To the contrary, re-introduction of the tammar is expected to have a significant positive ecological effect through the creation of run-ways through the understorey and through the maintenance of relatively open areas where they choose to feed preferentially. Such open areas would also benefit bush thick-knees (southern stone-curlews) that require relatively open habitats to live in. Competition with rabbits will be addressed via the park's integrated pest management strategy and the management of total grazing pressure (see 18.2).

The frequency with which wildfire occurs in natural areas has changed radically since European settlement. These altered patterns have resulted in the destruction of much of the tammar's natural habitat (CALM 1987). Ironically, studies in WA have also shown that fire may also play an important role in tammar ecology, by producing optimal habitat conditions. With an absence of natural fires, tammars in Perup Forest (WA) are dependent on prescribed burns to regenerate the tea-tree (*Melaleuca*) thickets that they inhabit. The requirement for prescribed burns on Innes NP, to regenerate mallee habitat, may need to be considered in the future. The development of a fire management plan for Innes is scheduled for 2006-2007.

Disease, pathogens and parasites also play an important role in the regulation of populations of wild animals. In macropods, parasite loads have been observed to fluctuate with seasonal conditions (Smales and Mawson 1978, Arundel *et al.* 1990, Dawson 1995) and produce increased mortality when infestations are heavy (Arundel *et al.* 1990, Dawson 1995), possibly due to immunosuppression (Speare *et al.* 1989).

19 DISEASE MANAGEMENT

19.1 Disease screening

Potential importation of disease into Australia is a major risk assessed by Biosecurity Australia (BA) and is monitored by Australian Quarantine Inspection Service (AQIS). Comprehensive disease screening and veterinary pathology checks are carried out to meet BA, AQIS and the Australian Government Department for Environment and Heritage (DEHA) requirements. In particular, animals are checked for freedom from bovine tuberculosis, and parasite loads. Bovine tuberculosis has been eradicated from Australia but remains a major problem in parts of New Zealand where it is perpetuated in possums (of Australian-origin). The disease status of animals on Kawau Island (tammars, other species of wallabies and possums), and for animals previously exported from the island to other countries, has been checked on various occasions. No concerns have arisen from available information or inspections to date, with the health risk deemed sufficiently low to allow importation of tammars (DEHA 2002).

Veterinary checks were undertaken prior to shipment of the current contingent of wallabies from Kawau Island. To all intents and purposes, Kawau Island has essentially been a quarantine site for the wallabies because of its isolation. However, the wallabies have also been quarantined for at least six months within holding facilities modified to meet AQIS specifications at Monarto Zoological Park (ca 70km east of Adelaide). During post-arrival quarantine, the animals have been held in isolation from mammals (other than humans), and observed daily. Cases of sickness or death have been few, and all have been investigated and found to be related to capture and transfer stress or trauma. AQIS veterinary checks, meeting BA's requirements, will be undertaken whilst animals are in the quarantine facilities (DEHA 2002).

Provided the quarantine requirements are met, release to the wild is proposed with ongoing surveillance of all animals released initially, using radio-transmitters that include mortality switches, to ensure rapid location and retrieval of any dead individuals for prompt *post mortem* assessments.

19.2 Pathology Results

Health assessment was conducted on 10 tammar wallabies and 20 parma wallabies conspecific on Kawau Island, New Zealand, that were live trapped in May and June 2003. Following euthanasia, gross pathology, histopathology, virology, bacteriology, serology and parsitology was carried out. Serology for leptospirosis, brucellosis, Johne's disease, chlamydiosis, and macropod herpesvirus were either negative or undetermined. No viruses were isolated and there was no histological evidence of viral infection. The animals did not have tuberculosis. The only significant bacterium cultured was *Yersinia enterocolitica* that was present in low numbers in faeces from four animals. This could be significant as a pathogen and as a zoonosis if infected animals are stressed during shipment. Other problem diseases or infections noted were coccidiosis and capture myopathy. The potential susceptibility of naïve tammars from Kawau to macropod herpesvirus and orbiviruses endemic in Australia is also noted (DEHA 2002).

Furthermore, there is no evidence that wallabies in New Zealand act as vectors for bovine tuberculosis. The diseases of greatest concern are bovine tuberculosis and Johne's disease and assuming that these diseases are unlikely to occur at a prevalence of higher than 10% in the population, a sample of 29 animals was deemed sufficient to give 95% confidence of detection (DEHA 2002).

Coccidiosis is apparently a common finding in tammars in Australia, but rarely causes disease, although it has the potential to do so in young animals. Overall some 35 species of diprotodonts (macropods and koalas) have coccidian parasites with some 50 species of *Eimeria* described. In larger species of macropods in Australia, coccidiosis frequently takes a peracute form in which the animal is found dead without premonitory signs. At necropsy there is severe haemorhagic enteritis with blood throughout the small intestine, but normal contents in the large intestine. For tammars, mortality has been observed in young animals in mid-winter. The stress of capture and shipping could be a factor in precipitating clinical coccidiosis in the animals from Kawau Island (DEHA 2002).

19.3 Source population pathogens

Interim laboratory results from veterinary research on Kangaroo Island have shown that some kangaroos and wallabies have tested positive for the presence of Ovine Johne's disease (OJD) bacteria within their intestinal tracts. However, this may just reflect ingestion of the bacteria through eating sheep-fouled pastures.

There was no evidence from pathology, bacteriology, or serology that the Kawau wallabies were infected by brucellosis, chlamydiosis, leptospirosis, salmonellosis, Johne's disease, or tuberculosis. The only bacterium of concern was *Yersinia enterocolitica* isolated from faeces of four out of seven animals tested. This bacterium can cause zoonotic infection in people and is regarded as an emerging disease. Infection of people results from faecal contamination and ingestion of bacteria and clinical signs range from self-limiting gastroenteritis to fatal systemic infection. It has been previously isolated from marsupials among other zoo and wild mammals. It is of little consequence in free-living animals and rarely causes clinical disease. However, it can be a concern in animals that are concentrated or stressed and could be significant in wallabies that are stressed by capture, held in pens, and shipped. There was no evidence of gastroenteritis in the wallabies examined and the number of bacteria was small requiring up to 14 days enrichment culture for isolation (DEHA 2002).

The risk of spreading potential pathogens is considered sufficiently low to allow re-introduction to the wild to occur, especially following the extended six months quarantine surveillance (DEHA 2002).

19.4 Release location pathogens

Among the viral diseases of wallabies, macropodid herpesviruses (macropod herpesvirus I and II) are probably of greatest concern because of their potential to cause disease outbreaks in stressed animals. Epidemics have previously been recorded in captive and free-ranging parma and tammar wallabies in Australia and serologic surveys have shown high seroprevalence in several macropod species. Herpesviruses were not isolated from the tammar wallabies from Kawau Island and all of the animals tested for antibodies were negative. This would indicate that it is likely that the viruses do not occur on Kawau Island. Thus, the tammar wallabies shipped to Australia could be at risk when they come in contact with endemically infected animals. Other viruses that do not occur in New Zealand and to which tammars may be exposed in Australia are the arthropod borne orbiviruses. Wallal and Warrego viruses have usually been associated with epidemics in the larger macropods. However, an as yet uncharacterized tammar orbivirus has caused epidemics of sudden death in captive animals at zoos and research facilities beginning in October 1998. This could pose a significant threat to newly-arrived naïve animals (DEHA 2002).

Ticks are present in the Innes environment and will be a novel parasite for animals to contend with. These factors will need to be considered, should any animals released to the wild become debilitated or die. Ongoing monitoring through radio-tracking and the use of mortality sensors plus protocols for rapid retrieval and post mortem assessments of any corpses, will provide timely important indicators of population health.

20 RESEARCH OBJECTIVES

The trial re-introduction program in November 2004 will provide numerous research opportunities. The University of Adelaide and the Department for Environment and Heritage have developed a cooperative research program that aims to collect data on; tammar population dynamics, habitat use, movement patterns, social structure, behaviour and dietary requirements. Research will also focus on the effects of group size, group familiarity and possibly predator training on the behaviour and survival of animals when released. The various components of this research program will contribute towards an understanding of the science of species re-introductions. More specifically, the information collected during the Innes NP re-introduction program will provide insights that will be useful for subsequent tammar release programs in other parts of South Australia.

The speed and extent to which tammars adapt to their new environment at Innes NP will be assessed through an examination of their diet, from time of release to 18 months following release. The degree of dietary overlap between tammars and western grey kangaroos at Innes NP will be a specific focus of study by the University of Adelaide. This research will provide valuable data for the effective management of both species. Results from the program will be published, where appropriate, in scientific publications.

21 LEGAL REQUIREMENTS

21.1 International

Approval was granted through the Auckland Regional Council to undertake trapping on Kawau Island, New Zealand. A scientific permit to trap animals was required from the NZ Department of Conservation.

The import of tammars from New Zealand to Australia required approval both from BA/AQIS and the Australian Department of Environment and Heritage.

21.2 Commonwealth Legislation

The importation of tammars into Australia required approval from AQIS and Environment Australia (now the Australian Government Department of Environment and Heritage (DEHA)). A permit to import (subject to conditions) was granted by a Director of Quarantine (Quarantine Proclamation 1998, made pursuant to the *Quarantine Act 1908* administered by AQIS).

The Mainland SA tammar was listed on an approved list under the Commonwealth *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*, administered by DEHA (Canberra), as a specimen permitted for live import.

The EPBC Act 1999 provides a Commonwealth approval process for assessment of proposed actions that has, will have or is likely to have a significant impact on identified matters of national environmental significance, including Nationally listed threatened species and ecological communities. Commonwealth approval is additional to any State approval that may be required. Actions that will have or are likely to have a significant impact on the Mainland SA tammar (under their current listing) will trigger the EPBC Act.

In consultation with relevant State authorities, the Commonwealth Minister for the Environment and Heritage may develop and implement recovery plans and threat abatement plans for threatened species and ecological communities listed under the EPBC Act. Where applicable, DEH should contribute to and incorporate these plans into park management regimes and operational procedures.

21.3 State Legislation

National Parks and Wildlife Act 1972 - written consent of the responsible Minister (or delegate) is required before native fauna can be released into the wild (Section 55 NPW Act). Any person conducting research as part of the proposed re-introduction program will also require a scientific research permit.

Prevention of Cruelty to Animals Act 1985 - approvals are required through an appropriate animal ethics committee for the conduct of research on released animals.

22 MANAGEMENT PLANS AND STRATEGIES

The re-introduction of tammars to Innes NP is consistent with the objectives stated in the following key management plans and strategies;

- Biodiversity Plan for the Northern Agricultural Districts (1999). The Biodiversity Plan for the Northern Agricultural Districts of South Australia is a guide for the community and government on the biodiversity assets of the region, major threats and recommendations on priority management strategies for conservation. “Biological diversity conserved and enhanced, in particular the genetic and species diversity of flora and fauna populations maintained.”

- Northern and Yorke Agricultural District Integrated Natural Resource Management Plan (2003). The NYAD INRM Plan is a strategic planning document that establishes a framework of broad actions and targets to guide the management of the region’s natural resources. “Ecosystems conserved, restored, linked and managed to provide security and viability for endemic native species; Decrease in number of listed threatened species due to recovery and long-term sustainability.”

- Innes National Park Management Plan. A Supplement to the Innes National Park Management Plan has been prepared identifying the re-introduction of tammar wallabies as a key objective. The supplement to the Innes NP Management Plan is subject to a three month public consultation period (ending 24 September 2004).

- Action Plan for Australian Marsupials and Monotremes (1996). “Subject to reasonable proof that NZ populations were derived from SA (but not Kangaroo Island), re-introduce from NZ to suitable SA sites.”

- A Triple Bottom Line for the Bush, South Australian Farmers’ Federation Rural South Australia Policy for the Future (2004). “Recognising emerging triple bottom line objectives as an essential ingredient of modern thinking about life in Australia, simultaneously meeting economic, social and environmental goals. The core idea is to create more non-agricultural employment opporunities for people in the regions, including farmers.”

23 STRATEGIC DIRECTIONS

The Innes NP tammar re-introduction program contributes towards;

- The Australian Department of Environment and Heritage's strategic direction to "ensure the environment, especially those aspects that are matters of national environmental significance, is protected and conserved."
- The South Australian Department for Environment and Heritage's strategic direction to "Conserve and restore the environment for all generations."

24 SOCIAL AND ECONOMIC CONSIDERATIONS

The re-introduction of tammars to Innes NP represents a significant environmental achievement. Additional benefits derived from the re-introduction include:

- Better knowledge, understanding and awareness of the biodiversity of Innes NP.
- Improved scientific knowledge of macropod ecology.
- Improved public knowledge and perception of the environment.
- Opportunities for involvement and training in ecological restoration.
- An icon conservation species for the Yorke Peninsula.
- Enhanced opportunity for eco-tourism experiences at Innes NP.

24.1 Public consultation and participation

Innes National Park was identified as the preferred initial re-introduction site for tammars and consultations were begun with local stakeholders in November 2003. As part of this process, DEH staff visited property owners adjacent to Innes NP in January 2004 to discuss the proposed release. This process highlighted some major community concerns and raised the interest of other stakeholders to know more about what was proposed. A Consultative Committee was identified as the most appropriate avenue for the local community to have input into the release planning process and as a forum for any concerns to be addressed. This committee represents local farming, residential, conservation, Aboriginal, tourism and local council interests. All adjacent property owners were invited to participate on the Tammar Wallaby Community Consultative Committee, with only one declining to take part.

The Consultative Committee provided comments on the first draft of the translocation proposal. An amended draft translocation proposal was then released for a formal six-week public comment period, ending 10 September 2004. Fourteen submissions were received and amendments were made to the proposal, where deemed appropriate.

To date, public participation has been limited primarily to stakeholders on southern Yorke Peninsula. It is envisaged that the Tammar Wallaby Community Consultative Committee will continue to function after the proposed release, to ensure the local community is provided with up to date and accurate information. Updates for this project are also proposed through a project website. The re-introduction program will provide a range of opportunities for the involvement of local schools and interest groups.

24.2 Community Awareness and Education

Information on the tammar re-introduction will be made available to visitors at Innes NP and on a SA DEH website. Interpretive signs will be placed in Innes NP. A presentation regarding the tammar re-introduction will be offered to the local community, local schools, environmental agencies and other interested groups or individuals. Visitor programs will be run in the park on request. The re-introduction will be publicised through the local and wider press, media releases, the DEH website and e-mail updates.

Education of local residents and tourists will be undertaken to avoid hand-feeding and attempts to tame the wallabies. This will be particularly important near the Inneston release site, as there are long-term lease holders, nearby campgrounds and high levels of visitors. Options may exist to provide low impact visitor interactions associated with the tammar re-introduction, such as observational hides.

24.3 Economic considerations

Although considered very unlikely, DEH recognises that there is the potential for individuals from an established tammar population at Innes National park to disperse and survive off-park, and that this may impact on adjacent areas used for cropping and pasture production. Should tammars pose a significant threat to local agriculture, the management strategy options identified in this proposal (or its future iterations), will be assessed and developed, as appropriate, in collaboration with the local community.

Innes National Park contributes significantly to the regional economy through direct employment and tourism. Innes National Park is the main tourist destination for approximately 40% of visitors to Yorke Peninsula, attracting up to 150,000 visitors each year. While annual visitation numbers can fluctuate by 20,000, surveys indicate the park is attractive to local, state and interstate visitors, who enjoy recreational experiences, natural settings and coastal scenery that are a feature of the region. It is likely that tourist interest in southern Yorke Peninsula will increase following the release of the tammar.

25 OUTCOMES AND TARGETS

25.1 Criteria for success

Criteria for assessing the success of each stage of the release program have been developed (refer to Appendix A – Decision Tree), and appropriate responses to success or failure have been identified. If less than 75% of released tammars are surviving one month following release (ie five animals lost), or less than 50% following six months, then the suitability of the re-introduction program will be reconsidered. The re-introduction will also be reconsidered if there is a consistent weight loss of more than 30% within the male population after three months. If three years after the initial release of 60 animals, the population at Innes still comprises only 60 animals or less, and the underlying causal factors cannot be identified and managed, then the re-introduction program will be reviewed.

Not proceeding with the current translocation will represent the loss of a significant opportunity to improve the long-term security of the species through the establishment of a secure population of tammars in the wild.

This Translocation Proposal is intended to guide the trial release and monitoring of an initial 20 to 40 tammars to Innes NP and will be reviewed after 6, 12 and 24 months, in light of the results obtained.

25.2 Operational targets

2004

- Establish a community consultative committee, to have input into the translocation process.
- Develop a Translocation Proposal with public input, and promote the re-introduction program throughout the local and broader community.
- Continue and evaluate the intensive predator control and monitoring program on Innes NP.
- Establish a vegetation monitoring program to assess the effects of total grazing pressure.
- Establish surveys to measure kangaroo abundance on Innes NP and adjoining properties.
- Undertake a successful translocation of tammar wallabies to Innes NP (target of >50% survival after a 6 month period).
- Assess the causes of mortality of any released wallabies, through comprehensive autopsies.
- Monitor tammar wallaby movement patterns following release.
- Refine the protocols for the capture and return of any tammars that move off-park.

2005

- Continue community consultation.
- Develop an extension program and encourage community awareness and participation in the recovery program.
- Continue and regularly evaluate the predator control and monitoring program, the vegetation monitoring program and the kangaroo monitoring program.
- Undertake two further successful translocations of tammar wallabies at Innes NP.
- Model the survival probabilities of the released tammar wallabies and their offspring, to evaluate the success of the translocation and to provide data for inclusion into demographic models.
- Assess the causes of mortality of any released wallabies, through comprehensive autopsies.
- Establish and commence surveys to accurately measure tammar wallaby population size and demographics.
- Evaluate the demographic performance of the translocated tammar wallaby population, to determine if the population is likely to become self-sustaining.

- Develop a model to predict the growth and dispersal of the tammar population baased on the data obtained.
- Develop a plan of management for total grazing pressure on both Innes NP and adjoining properties.
- Review the Translocation Proposal, and the strategies therein, in light of the results obtained from the initial re-introductions.
- Monitor tammar wallaby movement patterns following release.
- Refine the protocols for the capture and return of any tammars that move off-park.

26 BUDGET

The repatriation project has been funded by the Australian Government and the SA Department for Environment and Heritage through the Natural Heritage Trust, with contributions from the South Australian Zoological Society, Monarto Zoological Park, University of Adelaide, University of California Los Angeles (UCLA) and the UniSense Foundation.

While the initial focus of this project is the re-introduction of SA mainland tammar wallabies to the wild in Innes National Park, the overall investment indicated below is making a significant contribution to a much wider ecological restoration program within the park through management of introduced predators and total grazing pressure.

Budget Description 2004/05	Funding	Source
Animal capture and holding Exporter fees Air travel/freight Disease screening Captive management	$70,000 + in kind	DEHA (NHT2) SA DEH Monarto ZP
Tammar release at Innes NP (salaries, assets and consumables, running costs, predator control and monitoring)	$160,000 + in kind	DEHA (NHT2) SA DEH Uni of Adelaide Monarto ZP
Research (monitoring, radio-tracking, DNA analysis)	$80,000 + inkind	DEHA (NHT2) SA DEH Uni of Adelaide
	$11,485	WCF
Total	$310,000 + inkind	

Proposed Budget for 2005/06 - $200,000 + inkind

27 PERMITS AND APPROVALS

- Commonwealth EPBC Act approval to list tammar wallaby as a suitable species for import to Australia (approval granted 2002).
- Environment Australia Permits to Import – Permit Numbers WT2004-3808, WT2004-3278, WT2003-8007, WT2003-5702, WT2003-2584.
- AQIS Permit to Import Quarantine Material (including AQIS checks before animals are cleared from quarantine) – Permit Number 200403962.
- New Zealand Department of Conservation permit and Auckland Regional Council approval to trap animals on Kawau Island, New Zealand.
- Scientific Research Permits under the NP&W Act to cover all research aspects of the proposal.
- Ethics approval from University of Adelaide Animal Ethics Committee and SA DEH Wildlife Ethics Committee.

28 APPROVALS AND ENDORSEMENTS

Endorsed by:	SA Tammar Wallaby Recovery Team, Peter Copley (Chair)
	SA DEH Yorke/Mid North Conservation Programs Manager, Andy Sharp
	SA DEH Biodiversity Programs Manager, Stephanie Williams
	SA DEH Yorke/Mid North Conservator, Trevor Naismith
Noted by:	Yorke Peninsula Tammar Wallaby Consultative Committee, Clyde Hazel (Chair)
	Yorke Mid North Consultative Committee, Clyde Hazel (Chair)
Approved by:	SA DEH Regional Conservation Director, Lindsay Best
	………………………………………………………………….. Date: ………….
	SA DEH Science and Conservation Director, Steven Forbes
	………………………………………………………………….. Date: ………….
	SA DEH Natural and Cultural Heritage Director, Greg Leaman
	………………………………………………………………….. Date: ………….
Noted by:	SA DEH Chief Executive, Allan Holmes
	………………………………………………………………….. Date: ………….
	SA Minister for Environment and Conservation, Honorable John Hill
	………………………………………………………………….. Date: ………….

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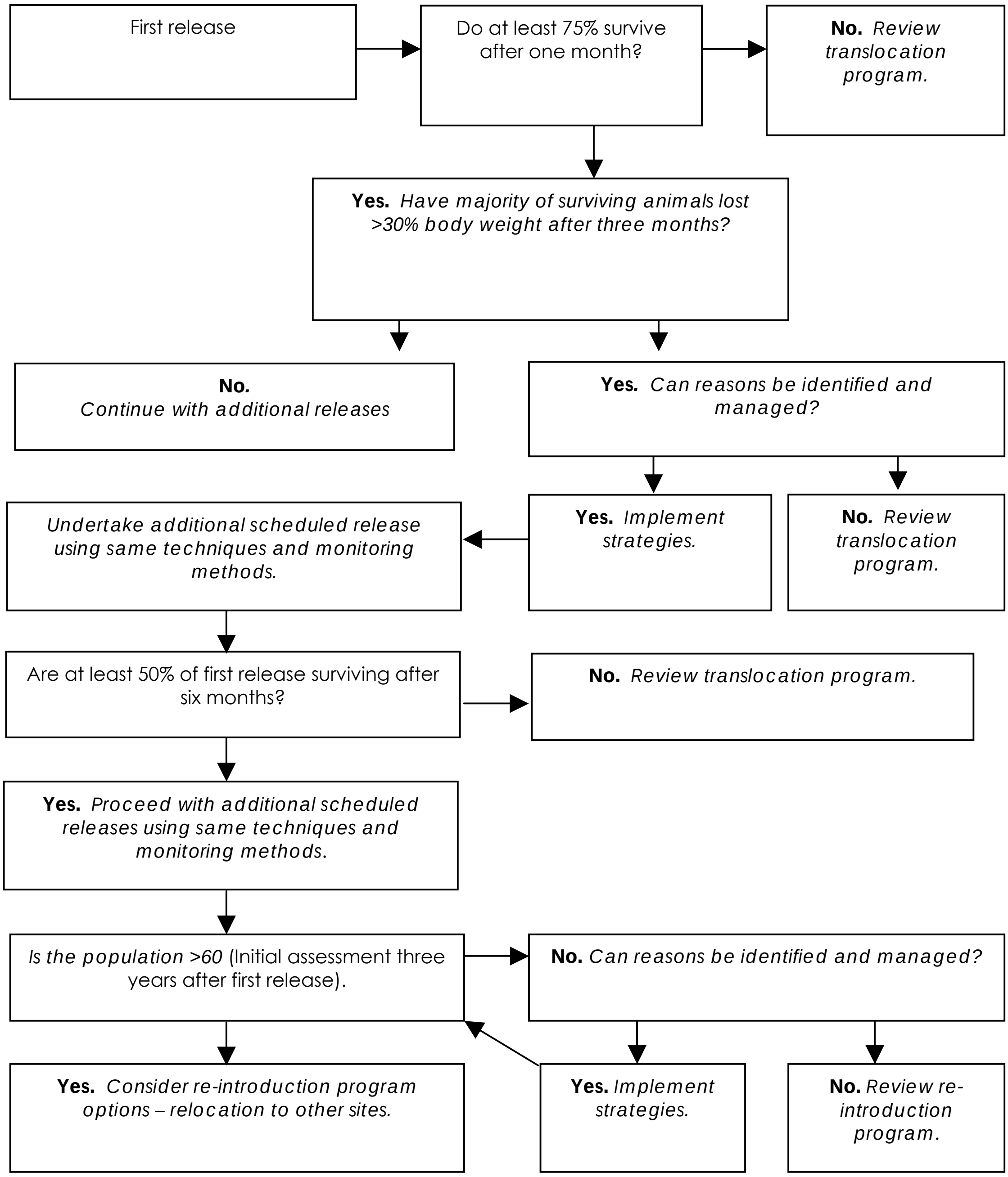
30 DEFINITIONS (IUCN 1987)

"Re-introduction" means the movement of an organism into part of its native range from which it has disappeared or become extirpated in historic times as a result of human activities or natural catastrophe.

"Translocation" means the movement of living organisms from one area with free release in another and includes introductions, re-introductions and re-stocking.

"Translocation Proposal" means a written statement of intent to carry out a translocation.

APPENDIX A – DECISION TREE



APPENDIX B – ESTIMATED POPULATION GROWTH RATE OF RE-INTRODUCED TAMMAR WALLABIES AT INNES NP

Estimates of the population growth rate for the proposed re-introduced population of tammar wallaby at Innes NP were derived using age structured population transition matrices (Caswell 1989). Data analysis was performed using the Microsoft Excel add-in Poptools (Hood 2001).

Demographic data for the proposed Innes population were approximated using data collected from a population of tammar wallabies on Kangaroo Island (Inns 1980), see Table 1. These data were collected over a three year period which was initially characterised by good environmental conditions, followed by a period of scarcity. As such, the data derived from Kangaroo Island represent estimates of parameter values over "average" environmental conditions. It should be noted that the data is also based on a population at or near carrying capacity, and parameters such as fecundity and mortality of a re-introduced population that is well below carrying capacity may be different. Further, foxes are not present on Kangaroo Island and, therefore, do not have an additive effect on the mortality estimates.

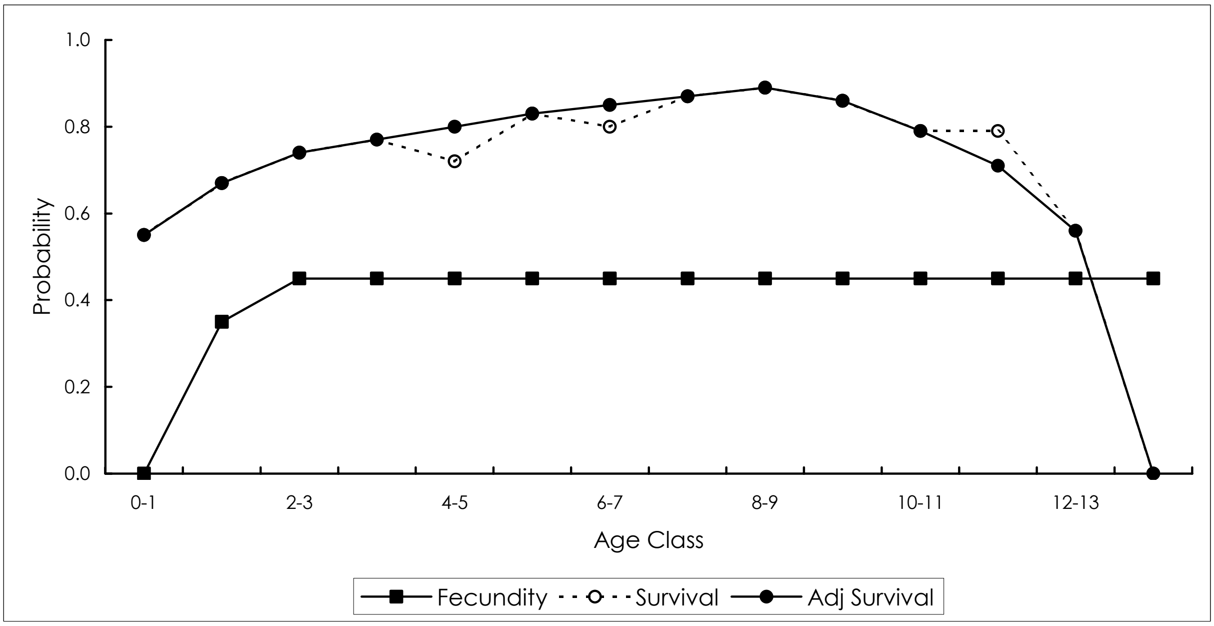
The Kangaroo Island data enabled the division of the population into 14 age classes, with the 0 to 1 age class representing the period from birth, through pouch life, to the end of the individual's first summer. Inns (1980) reported that juvenile females had a birth rate of 0.70, while mothers older than 2 years had a mean birth rate of 0.90. Because population transition matrices are only calculable on the female portion of a population, and because the sex ratio of pouch young has been reported at 1:1 (Inns 1980, Sunnucks and Taylor 1997), these birth rates were revised to 0.35 and 0.45, respectively. Fecundity in macropods is generally considered to decline with age (Arnold *et al.* 1991, Higginbottom 1991, Ashworth 1995, Delaney 1993) and is often attributed to a deterioration of the reproductive organs. However, more recently Pople (1996), Fisher (1998) and Sharp (2002) have questioned the occurrence of this phenomena in red kangaroos, bridled nailtail wallabies and yellow-footed rock-wallabies. With limited data for the older age classes of tammar wallabies, fecundity was considered constant between 2 and 14 years of age (following Inns 1980).

Table 1: Demographic data from Inns (1980), including adjusted survival rate.

Age class	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
Fecundity	0	0.35	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Survival	0.55	0.67	0.74	0.77	0.72	0.83	0.80	0.87	0.89	0.86	0.79	0.79	0.56	0
Adjusted Survival	0.55	0.67	0.74	0.77	0.80	0.83	0.85	0.87	0.89	0.86	0.79	0.71	0.56	0
Mortality	0.45	0.33	0.26	0.23	0.28	0.17	0.2	0.13	0.11	0.14	0.21	0.21	0.44	1

Age-specific survival data, for females, were calculated from the age-specific mortality rates reported in Inns (1980). Survival between birth and the end of the first summer (ie. 0 – 1 year old) was estimated by calculating the survival rate of pouch young (birth to permanent pouch evacuation; 0.85) and then calculating the subsequent survival rate between pouch evacuation and the end of the individual's first summer (0.35). In the model, fourteen years of age was the longest age allowable. An examination of Inns' (1980) survival rates suggested that some age-specific survival rates were influenced by specific population and/or environmental factors during the period of the study (see Figure 1). These effects were reflected as minor deviants from the overall survival probability distribution. The survival data for these age classes were adjusted by simply revising them, either up or down, until they conformed with the general shape of the distribution. These adjusted figures were used in further analysis.

Figure 1: Age-specific fecundity and survival data from Inns (1980) and adjusted age-specific survival rates.



Analysis of the population transition matrix indicated that a population displaying these demographic characteristics would have a finite rate of increase of 0.99, an exponential rate of increase of –0.01, and a net reproductive rate of 1. These results suggest that the population would decline at a rate of 1% per annum, due to low levels of successful recruitment.

Table 2: The age structure of the starting propagules.

Age class	Propagule composition			
	Normal dist.	Normal dist. + pouch young	Stable age dist.	Stable age dist. + pouch young
0 - 1	0	15	0	12
1 - 2	2	2	7	7
2 - 3	3	3	5	5
3 - 4	4	4	3	3
4 - 5	4	4	3	3
5 - 6	5	5	2	2
6 - 7	6	6	2	2
7 - 8	5	5	2	2
8 - 9	4	4	1	1
9 - 10	4	4	1	1
10 - 11	3	3	1	1
11 - 12	2	2	1	1
12 - 13	0	0	1	1
13 - 14	0	0	0	0
Total	42	57	28	40

Population projections were made for a period of 50 years and were initiated using numerous propagule populations of varying age structures, including;

i) a normally distributed propagule, with pouch young present (based on 35% of propagule size),

ii) a normally distributed propagule, without pouch young (ie. to reduce initial stress on adult wallabies),

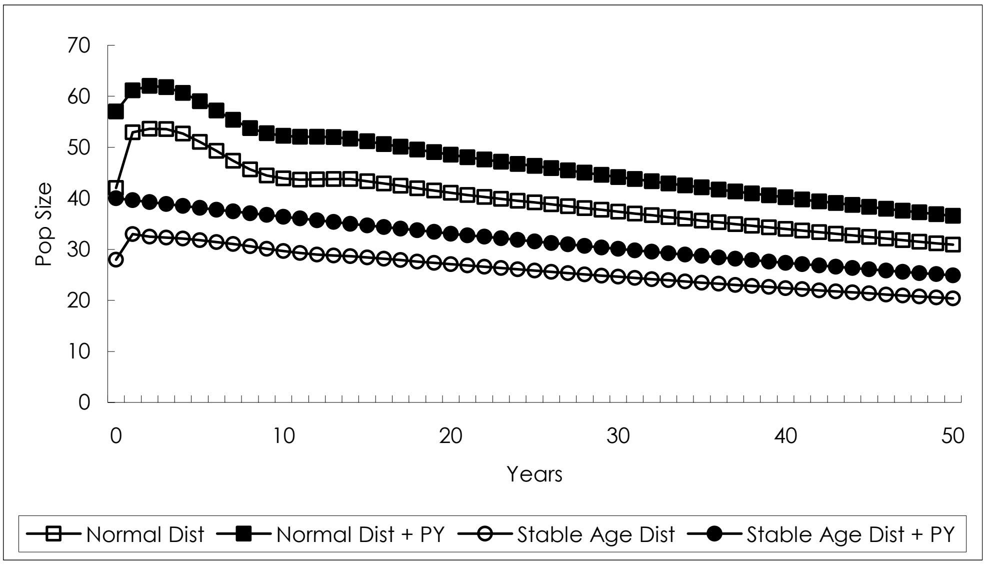
iii) a propagule with a stable age distribution, with pouch young (calculated using Poptools), and

iv) a propagule with a stable age distribution, without pouch young.

The age structure of the starting propagule populations is contained in Table 2. Initial propagule size approximated half the suggested release population size (ie. 40 females).

The results of the population projection modelling demonstrate the predicted slow decline of the population, through time (Figure 2). Propagules with a normal distribution will display a small increase in size over the first few years, then undergo a decline in subsequent years, irregardless of whether pouch young are excluded from the initial propagule. The propagules with a stable age distribution underwent a (predictable) monotonic decline throughout the time period. Over the 50 year period, all hypothetical propagule populations declined to range between 20 and 37 individuals. These results indicate that, to ensure the success of the re-introduction program, the survival or fecundity rates of the re-introduced population would need to be higher than those reported by Inns (1980).

Figure 2: Population projection models for the various initial propagules.



To determine the most appropriate demographic parameter to manipulate to achieve a positive rate of population growth, sensitivity analysis was performed on the population matrix (Table 3). These results indicate that the finite rate of population increase was most sensitive to changes in the survival rates of the pouch young and juvenile age classes. That is, to change the population's rate of decline to one of increase, smaller changes would be required in the survival rates of pouch young or juveniles, than any other parameter. For example, if the survival rate of the 1 - 2 year old wallabies was increased from 0.67 to 0.76, then the population would begin to increase.

Table 3: Sensitivity analysis of the parameters of the population matrix.

Age Class	0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	10-11	11-12	12-13	13-14
	Fecundity													
	0.00	0.10	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01
	Survival													
0-1	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1-2	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2-3	0.00	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3-4	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4-5	0.00	0.00	0.00	0.00	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5-6	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6-7	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7-8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00
8-9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00
9-10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00
10-11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00
11-12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
12-13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13-14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

In most macropods, pouch young survival appears to be linked to maternal health, which in turn is predominantly dictated by environmental conditions (Frith and Sharman 1964, Poole 1973, Bolton *et al.* 1985, Ashworth 1995). This relationship has been attributed to the inability of mothers to provide a sufficient milk supply, or one of sufficient quality, as environemntal conditions deteriorate (Frith and Sharman 1964) and is often reflected in lower survival rates for older pouch young (Frith and Sharman 1964, Newsome 1965, Johnson 1989, Fisher 1998).

Similarly, for most macropod species, it is the period between permanent pouch evacuation and weaning during which the highest mortality occurs (Newsome 1965, Johnson 1989, Higginbottom 1991, Ashworth 1995, Delaney 1997, Fisher 1998). Two explanations have been advanced to explain this phenomenon. The first suggests that mothers may be unable to meet the high lactational burdens, due to poor environmental conditions or strong competitive interactions with conspecific mothers (Newsome 1965, Bolton *et al.* 1985, Johnson 1989, Delaney 1993, Delaney 1997). The alternative explanation suggests that the juvenile age class suffers from higher levels of predation (Kinnear *et al.* 1988, Higginbottom 1991, Spencer 1991).

The data used in this modelling exercise were derived from a study of tammar wallabies on Kangaroo Island, during a three year period of "average" environmental conditions. It is, therefore, not unusual that the projected population estimates displayed a minor rate of decline, through time. The results of the current analysis indicate that, if the Kangaroo Island data are also indicative of the average parameter values for the re-introduced Innes population, then;

i) A large propagule is required to initiate the re-introduction program, to counter against the possibility that the re-introduction occurs during a period of environmental scarcity and to ensure the population's short and medium term survival.

ii) To ensure the successful establishment of the re-introduced population, an increase in population size is required over the short term, until a minimum viable population is established. The simplest way to achieve this is by increasing the pouch young and juvenile survival rates above the long-term average. The provision of supplementary feed, or water, may have this effect, by increasing juvenile survival rates and by increasing the resources available to nursing mothers, which would subsequently increase the survival rates of pouch young and newly emergent young at foot. However, in the context of this initial trial to re-establish tammars within Innes National Park, the provision of supplementary food or water would need to be assessed from a risk management perspective and it is more likely that as many surviving animals as possible would be re-captured and taken into captivity until an alternative and better release site is found.

iii) Once the Innes population has attained a minimally viable population size, it is highly probable that the population will remain relatively stable over the long-term, unless other extraneous factors act to increase mortality rates, eg increased predation rates.

iv) It is extremely important that an effective and comprehensive fox control program continues on Innes NP. Any additive contributions to juvenile mortality rates will act to decrease recruitment into the population, resulting in the population entering a state of decline. The results of the sensitivity analysis indicate that juvenile survival rates will play a determining role in the dynamics of the population. As such, even a minor increase in mortality may result in a population crash.

v) The significant role played by juvenile survival rates in the determination of the wallaby's population dynamics indicates that the proposed strategy of allowing fox predation to restrict the wallaby population to Innes NP will be effective. Because most predation is likely to be focused on the juvenile and sub-adult age classes and because it is these two age classes that are most likely to disperse off the park, fox predation will act to prevent the establishment of subsidiary populations outside the boundaries of the park.

vi) It is very important that an effective population monitoring program is undertaken in conjunction with the re-introduction. This will ensure that data on vital demographic parameters are collected, from which more precise population modelling can be undertaken.

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Appendix B References

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APPENDIX C – FLORA OF INNES NATIONAL PARK (DEH 2003)

Native Flora

Species marked with an * have been recorded for the park but are unverified by DEH.

Species	Common Name	Conservation Status			
		EPBC Act	NP&W Act	Regional YP	*
Acacia anceps	Angled Wattle				
Acacia anceps x nematophylla	Hybrid Wattle				
Acacia ancistrophylla var. *lissophylla*	Hook-leaf Wattle			K	
Acacia argyrophylla	Silver Mulga-bush			R	
Acacia brachybotrya	Grey Mulga-bush			U	
Acacia cupularis	Cup Wattle				
Acacia leiophylla	Coast Golden Wattle				
Acacia longifolia var. *sophorae*	Coastal Wattle				
Acacia nematophylla	Coast Wallowa				
Acacia rupicola	Rock Wattle				
Acacia spinescens	Spiny Wattle				
Acacia triquetra	Mallee Wreath Wattle				
Acaena echinata	Sheep's Burr				
Acaena ovina var. *velutina*	Downy Sheep's Burr				
Acianthus pusillus	Mosquito Orchid				
Acrotriche affinis	Ridged Ground-berry			U	
Acrotriche cordata	Blunt-leaf Ground-berry				
Acrotriche patula	Prickly Ground-berry				
Adriana klotzschii	Coast Bitter-bush				
Agrostis aemula	Blown-grass				
Agrostis avenacea var. *avenacea*	Common Blown-grass				
Allocasuarina muelleriana ssp. *muelleriana*	Common Oak-bush			K	
Allocasuarina pusilla	Dwarf Oak-bush			R	
Allocasuarina verticillata	Drooping Sheoak				
Alyxia buxifolia	Sea Box				
Amyema melaleucae	Tea-tree Mistletoe				
Angianthus preissianus	Salt Angianthus				
Aphanes australiana	Australian Piert			U	
Apium annuum	Annual Celery				
Apium prostratum ssp. *prostratum*	Native Celery				
Atriplex cinerea	Coast Saltbush				
Atriplex paludosa ssp. *cordata*	Marsh Saltbush				
Beyeria lechenaultii	Pale Turpentine Bush				
Billardiera sericophora	Silky Apple-berry			U	
Brachycome cuneifolia	Wedge-leaf Daisy			U	
Brachycome exilis	Slender Daisy			U	
Brachycome goniocarpa	Dwarf Daisy			U	
Bromus arenarius	Sand Brome			U	
Bulbine semibarbata	Small Leek-lily				
Bursaria spinosa	Sweet Bursaria				
Caladenia bicalliata	Western Daddy-long-legs		R	R	
Caladenia brumalis	Winter Spider-orchid	V	V	V	
Caladenia cardiochila	Heart-lip Spider-orchid			R	
Caladenia carnea var. *carnea*	Pink Fingers				
Caladenia dilatata complex	Green-comb Spider-orchid				
Caladenia filamentosa var. *tentaculata*	Wispy Spider-orchid				
Caladenia fragrantissima ssp. *fragrantissima*	Scented Spider-orchid		R	R	

Species	Common Name	Conservation Status			
		EPBC Act	NP&W Act	Regional YP	*
Caladenia latifolia	Pink Caladenia				
Caladenia patersonii complex	White Spider-orchid				
Caladenia stricta	Upright Caladenia			R	
Calandrinia brevipedata	Short-stalked Purslane			K	
Callitris canescens	Scrubby Cypress Pine				
Callitris preissii	Southern Cypress Pine				
Calytrix tetragona	Common Fringe-myrtle				
Carpobrotus rossii	Native Pigface				
Cassytha glabella forma dispar	Slender Dodder-laurel				
Cassytha melantha	Coarse Dodder-laurel				
Cassytha pubescens	Downy Dodder-laurel				
Centrolepis cephaloformis ssp. *cephaloformis*	Cushion Centrolepis		R	E	
Centrolepis polygyna	Wiry Centrolepis			Q	
Choretrum glomeratum	Sour-bush				
Chrysocephalum apiculatum	Common Everlasting				
Clematis microphylla	Old Man's Beard				
Comesperma volubile	Love Creeper				
Convolvulus erubescens	Australian Bindweed				
Correa pulchella	Salmon Correa				
Corybas despectans	Coast Helmet-orchid				
Corybas unguiculatus	Small Helmet-orchid		R	K	*
Cotula vulgaris var. *australasica*	Slender Cotula				
Craspedia glauca	Billy-buttons				
Crassula decumbens var. *decumbens*	Spreading Crassula				
Crassula sieberiana ssp. *tetramera*	Australian Stonecrop				
Cyanicula deformis	Bluebeard Orchid				
Cyrtostylis robusta	Robust Gnat-orchid				
Danthonia caespitosa	Common Wallaby-grass				
Daucus glochidiatus	Native Carrot				
Daviesia benthamii ssp. *humilis*	Mallee Bitter-pea		R	K	
Dianella brevicaulis/revoluta var.	Black-anther Flax-lily				
Dichondra repens	Kidney Weed				
Disphyma crassifolium ssp. *clavellatum*	Round-leaf Pigface				
Diuris aff. corymbosa	Wallflower Donkey-orchid			R	
Diuris palustris	Little Donkey-orchid			U	
Dodonaea bursariifolia	Small Hop-bush			K	
Dodonaea humilis	Dwarf Hop-bush				
Dodonaea viscosa	Sticky Hop-bush				
Drosera macrantha ssp. *planchonii*	Climbing Sundew				
Epilobium billardierianum ssp. *x intermedium*	Variable Willow-herb			V	
Eriochilus cucullatus	Parson's Bands				
Eriostemon pungens	Prickly Wax-flower			U	
Erodium crinitum	Blue Heron's-bill				
Eucalyptus 'anceps'	Sessile-fruit White Mallee				
Eucalyptus diversifolia	Coastal White Mallee				
Eucalyptus gracilis	Yorrell				
Eucalyptus incrassata	Ridge-fruited Mallee				
Eucalyptus leptophylla	Narrow-leaf Red Mallee				
Eucalyptus oleosa	Red Mallee				
Eucalyptus porosa	Mallee Box				
Eucalyptus rugosa	Coastal White Mallee				
Eucalyptus socialis	Beaked Red Mallee				
Euphrasia collina ssp. *tetragona*	Coast Eyebright			U	

Species	Common Name	Conservation Status			
		EPBC Act	NP&W Act	Regional YP	*
Eutaxia microphylla var. *microphylla*	Common Eutaxia				
Exocarpos aphyllus	Leafless Cherry				
Exocarpos cupressiformis	Native Cherry			U	
Exocarpos sparteus	Slender Cherry				
Exocarpos syrticola	Coast Cherry				
Frankenia pauciflora	Southern Sea-heath				
Frankenia pauciflora var. *fruticulosa*	Southern Sea-heath				
Gahnia deusta	Limestone Saw-sedge				
Gahnia filum	Smooth Cutting-grass			U	
Gahnia lanigera	Black Grass Saw-sedge				
Galium gaudichaudii	Rough Bedstraw			Q	
Genoplesium nigricans	Black Midge-orchid				
Geranium retrorsum	Grassland Geranium				
Geranium solanderi var. *solanderi*	Austral Geranium				
Gnaphalium indutum	Tiny Cudweed				
Goodenia blackiana	Native Primrose			U	
Goodenia geniculata	Bent Goodenia				
Goodenia pinnatifida	Cut-leaf Goodenia				
Goodenia varia	Sticky Goodenia				
Goodia medicaginea	Western Golden-tip			R	
Gyrostemon australasicus	Buckbush Wheel-fruit			U	
Gyrostemon thesioides	Broom Wheel-fruit			R	
Haegiela tatei	Small Nut-heads		R	R	
Haloragis acutangula	Smooth Raspwort				
Halosarcia flabelliformis	Bead Samphire	V	V	T	
Halosarcia halocnemoides ssp. halocnemoides	Grey Samphire				
Halosarcia indica ssp. bidens	Brown-head Samphire			R	
Halosarcia lepidosperma			R	R	
Halosarcia pergranulata ssp. pergranulata	Black-seed Samphire			Q	
Halosarcia syncarpa	Fused Samphire			Q	
Hardenbergia violacea	Native Lilac				
Helichrysum leucopsideum	Satin Everlasting				
Hibbertia riparia	Guinea-flower				
Hibbertia riparia (glabriuscula)	Smooth Guinea-flower				
Hibbertia sericea var. sericea	Silky Guinea-flower				
Hibbertia sp. A	Port Lincoln Guinea-flower				
Hibbertia sp. C	Round-leaf Guinea-flower			U	
Hibbertia virgata	Twiggy Guinea-flower				
Hydrocotyle callicarpa	Tiny Pennywort			Q	
Hydrocotyle capillaris	Thread Pennywort				
Hydrocotyle foveolata	Yellow Pennywort			Q	
Hydrocotyle medicaginoides	Medic Pennywort			R	
Hydrocotyle rugulosa	Mallee Pennywort				
Hypoxis glabella var. glabella	Tiny Star				
Isoetopsis graminifolia	Grass Cushion				
Isolepis cernua	Nodding Club-rush			K	
Isolepis marginata	Little Club-rush				
Isolepis nodosa	Knobby Club-rush				
Isolepis platycarpa	Flat-fruit Club-rush			R	
Isotoma scapigera	Salt Isotome		R	R	
Ixiolaena supina	Coast Plover-daisy				
Ixodia achillaeoides ssp. achillaeoides	Coast Ixodia			U	

Species	Common Name	Conservation Status			
		EPBC Act	NP&W Act	Regional YP	*
Ixodia achillaeoides ssp. alata	Hills Daisy			U	
Juncus bufonius	Toad Rush				
Kennedia prostrata	Scarlet Runner				
Lasiopetalum discolor	Coast Velvet-bush				
Lasiopetalum schulzenii	Drooping Velvet-bush				
Lavatera plebeia	Australian Hollyhock			K	
Lawrencia spicata	Salt Lawrencia			R	
Lawrencia squamata	Thorny Lawrencia				
Lepidosperma congestum	Clustered Sword-sedge				
Lepidosperma gladiatum	Coast Sword-sedge				
Lepidosperma viscidum	Sticky Sword-sedge				
Leptorhynchos scabrus	Annual Buttons		R	R	
Leptorhynchos squamatus	Scaly Buttons				
Leptorhynchos waitzia	Button Immortelle				
Leucophyta brownii	Coast Cushion Bush				
Leucopogon cordifolius	Heart-leaf Beard-heath			R	
Leucopogon parviflorus	Coast Beard-heath				
Linum marginale	Native Flax				
Lobelia gibbosa	Tall Lobelia				
Logania crassifolia	Coast Logania				
Logania ovata	Oval-leaf Logania				
Lomandra collina	Sand Mat-rush				
Lomandra effusa	Scented Mat-rush				
Lomandra micrantha ssp. micrantha	Small-flower Mat-rush				
Lotus australis	Austral Trefoil				
Lythrum hyssopifolia	Lesser Loosestrife				
Maireana oppositifolia	Salt Bluebush				
Melaleuca acuminata	Mallee Honey-myrtle				
Melaleuca decussata	Totem-poles				
Melaleuca gibbosa	Slender Honey-myrtle			U	
Melaleuca halmaturorum ssp. halmaturorum	Swamp Paper-bark				
Melaleuca lanceolata ssp. lanceolata	Dryland Tea-tree				
Microcybe pauciflora	Yellow Microcybe			U	
Microlaena stipoides var. stipoides	Weeping Rice-grass				
Microlepidium pilosulum	Hairy Shepherd's-purse		R	K	
Microseris lanceolata	Yam Daisy				
Microtis arenaria	Notched Onion-orchid				
Millotia muelleri	Common Bow-flower				
Millotia tenuifolia var. tenuifolia	Soft Millotia				
Minuria leptophylla	Minnie Daisy				
Muehlenbeckia adpressa	Climbing Lignum				
Myoporum insulare	Common Boobialla				
Myoporum parvifolium	Creeping Boobialla		R	R	
Myoporum viscosum	Sticky Boobialla			R	
Myosotis australis	Austral Forget-me-not			Q	
Neurachne alopecuroidea	Fox-tail Mulga-grass				
Nitraria billardierei	Nitre-bush				
Olearia axillaris	Coast Daisy-bush				
Olearia ciliata var. ciliata	Fringed Daisy-bush				
Olearia minor	Heath Daisy-bush				
Olearia ramulosa	Twiggy Daisy-bush				
Olearia rudis	Azure Daisy-bush			U	
Opercularia turpis	Twiggy Stinkweed				

Species	Common Name	Conservation Status			
		EPBC Act	NP&W Act	Regional YP	*
Opercularia varia	Variable Stinkweed				
Orobanche cernua var. australiana	Australian Broomrape		V	V	
Oxalis perennans	Native Sorrel				
Parietaria debilis	Smooth-nettle				
Pelargonium australe	Australian Pelargonium				
Pelargonium littorale	Native Pelargonium				
Phyllangium divergens	Wiry Mitrewort				
Phyllangium divergens/sulcatum	Wiry Mitrewort				
Picris angustifolia ssp. angustifolia	Coast Picris			Q	
Pimelea flava ssp. dichotoma	Diosma Riceflower				
Pimelea glauca	Smooth Riceflower				
Pimelea microcephala ssp. microcephala	Shrubby Riceflower			Q	
Pimelea subvillifera	Silky Riceflower			T	
Pittosporum phylliraeoides var. microcarpa	Native Apricot				
Plantago drummondii	Dark Plantain				
Plantago gaudichaudii	Narrow-leaf Plantain			K	
Poa drummondiana	Knotted Poa		R	K	
Poa fax	Scaly Poa		R	R	
Poa poiformis	Coast Tussock-grass				
Podolepis canescens	Grey Copper-wire Daisy			U	
Podolepis rugata	Pleated Copper-wire Daisy				
Podolepis rugata var. littoralis	Coast Copper-wire Daisy			R	
Podotheca angustifolia	Sticky Long-heads				
Pogonolepis muelleriana	Stiff Cup-flower			U	
Pomaderris obcordata	Wedge-leaf Pomaderris				
Pomaderris paniculosa					
Pomaderris paniculosa ssp. paniculosa	Mallee Pomaderris				
Poranthera microphylla	Small Poranthera			Q	
Poranthera triandra	Three-petal Poranthera			U	
Prasophyllum "carnosum"				R	
Prasophyllum calcicola	Limestone Leek-orchid		V	V	
Prasophyllum fitzgeraldii	Fitzgerald's Leek-orchid			V	
Prasophyllum occidentale	Plains Leek-orchid			K	
Prasophyllum odoratum	Scented Leek-orchid				
Prasophyllum odoratum complex	Leek-orchid				
Prostanthera serpyllifolia ssp. microphylla	Small-leaf Mintbush			V	
Prostanthera serpyllifolia ssp. microphylla (purplish-green flowers)	Small-leaf Mintbush			V	
Prostanthera serpyllifolia ssp. serpyllifolia	Thyme Mintbush			R	
Prostanthera serpyllifolia ssp. serpyllifolia (purplish-green flowers)	Thyme Mintbush			R	
Pseudognaphalium luteoalbum	Jersey Cudweed				
Pterostylis erythroconcha	Red Shell-orchid			U	
Pterostylis longifolia	Tall Greenhood				
Pterostylis nana	Dwarf Greenhood			Q	
Pterostylis pedunculata	Maroon-hood			U	
Pterostylis plumosa	Bearded Greenhood			Q	
Pterostylis robusta	Large Shell-orchid				
Pterostylis sanguinea	Blood Greenhood				
Ptilotus spathulatus forma spathulatus	Pussy-tails				
Puccinellia stricta var. stricta	Australian Saltmarsh-grass				
Pultenaea acerosa	Bristly Bush-pea			U	
Pultenaea rigida var. ovata	Rigid Bush-pea			U	

Species	Common Name	Conservation Status			
		EPBC Act	NP&W Act	Regional YP	*
Pultenaea rigida var. rigida	Rigid Bush-pea			U	
Pultenaea tenuifolia	Narrow-leaf Bush-pea				
Pultenaea vestita	Feather Bush-pea			R	
Pultenaea villifera var. glabrescens	Splendid Bush-pea	V	V	V	*
Ranunculus pumilio var. pumilio	Ferny Buttercup			R	
Ranunculus sessiliflorus var. pilulifer	Annual Buttercup		V	K	
Ranunculus sessiliflorus var. sessiliflorus	Annual Buttercup			U	
Rhagodia candolleana ssp. candolleana	Sea-berry Saltbush				
Rhagodia crassifolia	Fleshy Saltbush				
Rumex brownii	Slender Dock			R	
Samolus repens	Creeping Brookweed				
Santalum acuminatum	Quandong				
Sarcocornia blackiana	Thick-head Samphire				
Sarcocornia quinqueflora	Beaded Samphire				
Scaevola angustata	Coast Fanflower			U	
Scaevola crassifolia	Cushion Fanflower				
Schoenus deformis	Small Bog-rush			U	
Schoenus nitens	Shiny Bog-rush			R	
Scleranthus pungens	Prickly Knawel				
Sclerostegia arbuscula	Shrubby Samphire				
Sebaea ovata	Yellow Sebaea				
Senecio glossanthus	Annual Groundsel				
Senecio lautus	Variable Groundsel				
Senecio picridioides	Purple-leaf Groundsel			U	
Senecio quadridentatus	Cotton Groundsel			R	
Solanum symonii	Symon's Kangaroo-apple				
Sonchus hydrophilus	Native Sow-thistle				
Sonchus megalocarpus	Coast Sow-thistle				
Spinifex hirsutus	Rolling Spinifex				
Spinifex sericeus	Rolling Spinifex				
Spyridium leucopogon	Silvery Spyridium		R	K	*
Spyridium phylicoides	Narrow-leaf Spyridium				
Stackhousia annua	Annual Candles	V	V	V	
Stackhousia aspericocca ssp. "Cylindrical inflorescence"(W.R.Barker 1418)	Bushy Candles				
Stackhousia aspericocca ssp. "One-sided inflorescence"(W.R.Barker 697)	One-sided Candles				
Stackhousia monogyna	Creamy Candles				
Stackhousia spathulata	Coast Candles			K	
Stenopetalum lineare	Narrow Thread-petal				
Stipa echinata	Spiny Spear-grass		R	R	
Stipa elegantissima	Feather Spear-grass				
Stipa eremophila	Rusty Spear-grass				
Stipa flavescens	Coast Spear-grass				
Stipa multispiculis			R	K	
Stipa stipoides	Coast Spear-grass			U	
Stuartina muelleri	Spoon Cudweed				
Stylidium calcaratum	Spurred Trigger-plant			R	
Suaeda australis	Austral Seablite				
Templetonia retusa	Cockies Tongue				
Tetragonia implexicoma	Bower Spinach				
Tetragonia tetragonioides	New Zealand Spinach				
Thelymitra antennifera	Lemon Sun-orchid				

Species	Common Name	Conservation Status			
		EPBC Act	NP&W Act	Regional YP	*
Thelymitra nuda	Scented Sun-orchid				
Threlkeldia diffusa	Coast Bonefruit				
Thysanotus baueri	Mallee Fringe-lily			K	
Thysanotus patersonii	Twining Fringe-lily				
Trachymene pilosa	Dwarf Trachymene				
Tricoryne tenella	Tufted Yellow Rush-lily				
Triglochin centrocarpum	Dwarf Arrowgrass				
Triglochin minutissumum	Tiny Arrowgrass		R	R	
Triglochin mucronatum	Prickly Arrowgrass			Q	
Triodia compacta	Spinifex			U	
Triodia irritans complex	Spinifex				
Triptilodiscus pygmaeus	Small Yellow-heads				
Velleia arguta	Toothed Velleia				
Veronica hillebrandii	Rigid Speedwell				
Vittadinia australasica	Sticky New Holland Daisy				
Vittadinia dissecta var. hirta	Dissected New Holland Daisy				
Vittadinia megacephala	Giant New Holland Daisy				
Wahlenbergia communis	Tufted Bluebell			Q	
Wahlenbergia gracilenta	Annual Bluebell				
Westringia eremicola	Slender Westringia			R	
Wilsonia backhousei	Narrow-leaf Wilsonia			R	
Wilsonia humilis var. humilis	Silky Wilsonia			U	
Wurmbea dioica ssp. dioica	Early Nancy				
Zygophyllum ammophilum	Sand Twinleaf				
Zygophyllum apiculatum	Pointed Twinleaf			Q	
Zygophyllum billardierei	Coast Twinleaf				
333		**4**	**24**	**115**	**3**

Introduced Flora

Innes National Park has 139 introduced plants recorded, many the result of previous agricultural land use or as adjuncts to mining and domestic activities. On Yorke Peninsula, a number of these are proclaimed under the *Animal and Plant Control Act*, and require control under Section 57(2). Proclaimed plants include Bridal Creeper (*Myrsiphyllum asparagoides*), African Boxthorn (*Lycium ferocissimum*), Boneseed (*Chrysanthemoides monilifera*), False Caper (*Euphorbia terracina*), Salvation Jane (*Echium plantagineum*), Cut-leaf Mignonette (*Reseda lutea*) and Onion Weed (*Asphodelus fistulosus*).

Conservation Status codes

Australian Conservation Status Codes

The following codes are based on the current listing of species under Section 179 of the *Environmental Protection and Biodiversity Conservation Act 1999*.

EX	Extinct: there is no reasonable doubt that the last member of the species has died.
EW	Extinct in the Wild: known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	Critically Endangered: facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	Endangered: facing a very high risk of extinction in the wild in the near future, as determined in accordance with the prescribed criteria.
V	Vulnerable: facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	Conservation Dependent: the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

South Australian Conservation Status Codes

The following codes are based on the current listing of species under Schedules of the *National Parks and Wildlife Act 1972*, as amended in 2000.

E	Endangered: (Schedule 7) in danger of becoming extinct in the wild.
V	Vulnerable: (Schedule 8) at risk from potential or long term threats which could cause the species to become endangered in the future.
R	Rare: (Schedule 9) low overall frequency of occurrence (may be locally common with a very restricted distribution or may be scattered sparsely over a wider area). Not currently exposed to significant threats, but warrants monitoring and protective measures to prevent reduction of population sizes.

Regional Status Codes

The categories below apply to the species distribution at a regional level.

Plants

Regional conservation ratings for plants follow:

Lang, P.J. & Kraehenbuehl, D.N. (2001). Plants of Particular Conservation Significance in South Australia's Agricultural Regions. January (2001) update of unpublished database: Florlist. Department for Environment and Heritage.

The regions are as defined by the State Herbarium (Plant Biodiversity Centre), illustrated in the back cover of 'A List of the Vascular Plants of South Australia (Edition IV)' (Ed. Jessop, 1993).

NW	North-Western	FR	Flinders Ranges	NL	Northern Lofty	SL	Southern Lofty
LE	Lake Eyre	EA	Eastern	MU	Murray	KI	Kangaroo Island
NU	Nullarbor	EP	Eyre Peninsula	YP	Yorke Peninsula	SE	South-Eastern
GT	Gairdner-Torrens						

In order of decreasing conservation significance:

X Extinct/Presumed extinct: not located despite thorough searching of all known and likely habitats; known to have been eliminated by the loss of localised population(s); or not recorded for more than 50 years from an area where substantial habitat modification has occurred.

E Endangered: rare and in danger of becoming extinct in the wild.

T Threatened: (*Plants only*) likely to be either Endangered or Vulnerable but insufficient data available for more precise assessment.

V Vulnerable: rare and at risk from potential threats or long term threats that could cause the species to become endangered in the future.

K Uncertain: likely to be either Threatened or Rare but insufficient data available for a more precise assessment.

R Rare: has a low overall frequency of occurrence (may be locally common with a very restricted distribution or may be scattered sparsely over a wider area). Not currently exposed to significant or widespread threats, but warrants monitoring and protective measures to prevent reduction of population sizes.

U Uncommon: less common species of interest but not rare enough to warrant special protective measures.

Q Not yet assessed: but flagged as being of possible significance.

N Not of particular significance (*Plants only*) Also indicated by a blank entry.

APPENDIX D – SUMMARY OF MANAGEMENT OPTIONS TO BE CONSIDERED TO MAINTAIN TAMMAR ABUNDANCE AT SUSTAINABLE LEVELS

Scenario	Conservation status of tammars*	Conditions/trigger	Action
Tammar population crash	Critically Endangered / Endangered / Vulnerable	Significant mortality due to predation	Intensify 1080 baiting regime
	Critically Endangered / Endangered / Vulnerable	Significant mortality from insuffcent feed and/or substantial decline in body condition	Retrieve as many animals as possible, maintain in captivity and seek alternative (more suitable) site(s)
	Critically Endangered / Endangered / Vulnerable	Significant mortality from insuffcent water, noted by decline in body condition and movement patterns	Retrieve as many animals as possible, maintain in captivity and seek alternative (more suitable) site(s)
	Critically Endangered / Endangered / Vulnerable	Significant mortality from disease or parasites	Removal of tammars to quarantine, until cause identified and amerliorated
Tammar movement off-park (within first two years)	Critically Endangered / Endangered / Vulnerable	Any wallabies moving off-park in the first 2 years will be re-caught and returned to Innes NP	Capture of tammars and return to park
Tammar movement off-park (after first two-year trial)	Critically Endangered / Endangered / Vulnerable	Any wallabies moving off-park after the first 2 years will be managed according to protocols developed in light of first two-year establishment period results	To be determined and based upon results and analysis of first two years' monitoring
Tammar over-abundance on Innes NP	Critically Endangered / Endangered / Vulnerable	High level of total grazing pressure – (a) significant grazing pressure from rabbits	Control of rabbit population
	Critically Endangered / Endangered / Vulnerable	High level of total grazing pressure – (b) significant grazing pressure from kangaroos after rabbit grazing pressure has been managed	Control of kangaroo population to sustainable levels on Innes NP
	Critically Endangered / Endangered / Vulnerable	High level of total grazing pressure – (c) significant grazing pressure from tammars after rabbit and/or kangaroo grazing pressure has been managed	Capture of tammars and removal to other re-introduction sites
	Downgraded to conservation dependent	High level of total grazing pressure	Manipulate fox baiting regime to allow predation to regulate tammar population
Crop / pasture damage	Critically Endangered / Endangered / Vulnerable	Significant impact to agricultural production	To be determined on basis of first two year monitoring and analysis results, but could include: • Manage total grazing pressure off-park by issuing "permits to take" kangaroos to reduce kangaroo abundance to sustainable levels (if rabbit grazing pressures have been managed also) • Construction of tammar-barrier fence along boundary of park, where it adjoins cropland • Capture tammars and move to other re-introduction sites
	Downgraded to conservation dependent	High numbers of tammars observed off-park	Tammars may be managed in accordance with other abundant macropod species in SA; this may include issuing of "permits to take" tammars to reduce tammar abundance to sustainable levels

***** Table assumes that once animals are released to the wild, they become a "critically endangered" taxon.