The characteristics and success of vertebrate translocations within Australia

A final report to

Department of Agriculture, Fisheries and Forestry

by

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Cover photograph: 2,500 kilometres from home. Or is this home? Translocated Burrowing Bettongs at Roxby Downs in South Australia sourced from another translocated population – Heirisson Prong in Western Australia. Photo credit: Dr Jeff Short, Wildlife Research and Management.

Summary

This project aims to elucidate the underpinning strategies used for the successful translocation of threatened native vertebrates.

This report compiles 380 translocations of 102 species. Of these, 195 translocations (51% of total translocations) are of 50 threatened species (roughly half of all species translocated). This somewhat underestimates the proportion of translocations conducted on threatened species as the two species (Brush-tailed Bettong and Tammar Wallaby) that have the most translocations were de-listed as threatened species in the late 1990s, in part, because of the success of translocations. For the purposes of these calculations, they are regarded as non-listed species.

The first recorded translocations were of Koala to Phillip and French Islands in Victoria in the 1880s, Tammar Wallaby to Greenly Island in South Australia in 1905, and Red-bellied Pademelon to Wilsons' Promontory in Victoria in 1911. These were followed by the largely futile efforts to conserve threatened native mammals in the 1920s and 1930s in South Australia and New South Wales by marooning them on islands and so separating them from the predatory impact of foxes. There was also a keen acclimatization movement in the 1920s – 1940s to enrich the fauna of Kangaroo Island (South Australia). However, most translocations have taken place in the last 25 years – the bulk in Western and South Australia.

Reintroductions were the most common form of translocation (65% of 380 translocations), followed by introductions (22%) and restocking (13%). Some species have been highly favoured for translocation, with Brush-tailed Bettong being the species most moved, mostly since the mid-1970s. Other species with 10 or more translocations were Koala, Tammar Wallaby, Bilby, Brushtail Possum, Numbat, Southern Brown Bandicoot (WA form), Burrowing Bettong, Malleefowl, and Noisy Scrub Bird.

Relatively few reptiles and amphibians have been translocated for conservation purposes – the Western Swamp Tortoise in Western Australia and the Green and Golden Bell Frog in New South Wales being significant exceptions. However, a perusal of recovery plans suggest that translocation of amphibia is likely to become far more common in response to recent declines.

A frequent criticism of translocations is that they often fail (Griffith *et al*. 1989; Short *et al.* 1992; Fischer and Lindenmayer 2000) and that there has been little improvement in the success rate over time (Fischer and Lindenmayer 2000). Of those translocations in this study for which a definite outcome was attributed, the success rate was 54%. However, for 40% of translocations there was no attributed outcome. Lack of adequate monitoring and reporting is a theme common to most reviews of translocations (Short *et al.* 1992, Fischer and Lindenmayer 2000), and appears equally true today.

There were significant differences between jurisdictions in both reported success and in the percentage of translocations for which there was no reported outcome. South Australia had the highest success rate and, with the Northern Territory, the highest percentage of all translocations with a reported outcome. Victoria and Western Australia had the lowest success rates and

Queensland, Western Australia and Victoria had the greatest number of translocations with no reported outcome (all more than 50% of total translocations).

Over 18,000 individuals of mammals, birds and reptiles have been moved by translocation; with mammals making up the bulk of these. Numbers were comparatively evenly spread between threatened and non-threatened species. Numbers of individuals moved peaked in the 1990s, with > 2000 individuals of threatened species and > 5000 individuals of non-threatened species moved in a 5-year period. However, this data largely excludes the 10,000 Koalas translocated in Victoria in the period 1923 to 1988 (Martin and Handasyde 1990).

There was no clear trend of improving success of translocations over time, although this may be largely to do with practitioners moving to more vulnerable species. The success rate for mammal translocation (62% of those with a recorded outcome) was substantially higher than for birds (38%), reptiles (33%) and amphibians (10%). Translocations of threatened species were typically less successful than of non-threatened species of birds (32% versus 43%) and mammals (56% versus 67%).

The major factor affecting the success of translocations of mammals was predation, typically by an exotic predator. Predation was given as the key cause in 80% of failed translocations; success: fail ratios were greatest for translocations to islands without foxes and cats (82% successful), followed in order by mainland sites fenced to exclude predators (59% successful), islands without foxes but with cats (56% successful), and unfenced mainland sites (53% successful).

The differences would be greater if data were further portioned into “critical weight range” species and non-critical weight range species. For example, the high success rate of Koala and Southern Hairy-nosed Wombat (both non-critical weight range species) to unfenced sites would inflate values for this category.

In addition, predation was typically implicated in failures to fenced sites (due to the failure of the fence to exclude exotic predators).

Mammal translocations were favoured by size of release area. Mid-sized areas (5,000 - 50,000 ha) had a success rate of 79%; small areas 69% and large areas 26%. Hence there was a 3-fold difference in ratio between translocations to medium versus large areas. This may be in part related to the declining effectiveness of predator management at larger scales.

Typically introductions and restocking of mammals were far more successful than were reintroductions. Often, introductions were to islands (43 of 52 translocations). They included Prosperpine Rock-wallaby to Hayman Island in Queensland; Koalas to a variety of islands in Victoria, Queensland, and South Australia; Brush-tailed Bettongs and Black-footed Rock-wallabies to South Australian islands; and Gilbert’s Potoroo, Dibbler, and Rufous Hare-wallaby to islands off Western Australia. The absence of foxes (and often cats) is likely to be a key feature for ‘critical weight range species’ (Burbidge and McKenzie 1989) in their successful establishment on islands. Restocking often included the supplementation of existing populations within fenced sanctuaries such as Brushtail Possum and Brush Wallaby translocated to Karakamia Sanctuary in Western Australia to supplement resident animals or salvage translocations of Southern Brown Bandicoots from highway development.

Factors not apparently of significance in mammal translocations or with a suggested trend contrary to expectation included: size of release group; source of animal (whether captive or wild sourced); and type of release (soft versus hard). Size of release group had an inverse relationship with smaller release groups (< 50; n = 107) having higher success (64%) than releases of 50 or greater (53%; n = 47). Captive-sourced (60%; n = 35) and wild-sourced (63%; n= 84) had roughly equal success. Soft and mixed soft and hard releases (47%; n = 30) had a somewhat lower success to hard releases (65%; n = 43).

Factors suggested as potentially important in the international literature, but not implicated in the failure of mammal translocations, were habitat quality, disease, animal husbandry issues, and genetic deficiency of reintroduced stock.

The bird species most translocated included Noisy Scrub Bird, Malleefowl, Bush Thick-knee, Orange bellied Parrot, Black-eared Miner, and Helmeted Honeyeater. All, bar the Bush Thick-knee are threatened at the national level. Roughly equal numbers of individuals of threatened and non-threatened bird species were translocated. Little Penguin was the bird species with the most individuals translocated – over 800 were translocated following an oil spill off the coast of Tasmania.

The major factors affecting success of translocations for birds were size of release group and predation. There was a near four-fold difference in success of translocations utilizing 50 or more individuals (a success rate of 75%; n = 8) when compared to release groups of < 20 (19%; n = 26). The median number of birds used in releases was 15, considerably lower than that median of releases of mammals (36), and substantially lower than recommended in the international literature (Griffith *et al.* 1989 suggest releases of 80-120 birds to maximise success).

Predation was given as the key cause of failure in 64% of bird translocations for which a cause was given (n = 11). A high proportion of translocations to islands that were free of foxes but had cats were unsuccessful. Wildfire, influencing habitat quality and predation risk, was important in species such as Noisy Scrub Birds that utilized dense cover. Homing was an issue for more mobile species such as magpies.

Translocations of birds utilizing wild-sourced and captive animals had comparable success (42% versus 43%). A soft release strategy proved more effective than hard releases (67%; n = 3 cf. 27%; n = 26), although data was sparse for soft releases.

There were comparatively few examples of the translocation of reptiles and amphibians. Only one species of each taxa was represented by more than a single translocation - the Western Swamp Tortoise (5) and the Green and Golden Bell Frog (8). Because of the longevity of Western Swamp Tortoises, translocation outcomes were considered as uncertain. Fox predation was considered a key issue for this species. Translocations of Green and Golden Bell Frog were largely unsuccessful. A wide range of factors including disease, predation, and habitat issues interacted.

Most contemporary translocations typically are:

- Conservation translocations of threatened species (the primary focus of this report);
- Conservation translocations of species not formally threatened;
- Translocations dealing with locally overabundant species or species that are perceived to be a threat to humans or to the environment; and

- Translocations as conditions of development approvals and salvage translocations (where a species occurs on a development site).

Translocations of threatened fauna are guided and/or regulated by international, national and State guidelines and/or policies and procedure statements. IUCN's (1987) position statement 'Translocation of living organisms' provides the starting point for Federal and State policies. Four jurisdictions have comprehensive policies on translocation: Western Australia, South Australia, New South Wales, and the Northern Territory. Victoria, Tasmania, and the Australian Capital Territory do not appear to have policies on translocation of fauna. Queensland has a specific policy for the translocation of Koalas, but no general policy. The four jurisdictions with comprehensive translocation policies collectively make up 83% of recorded translocations (313/378) and 84% of reintroductions (208/247). The States and Territories without policies on translocation tend to have few active programs for translocation of fauna. Victoria is something of an exception to this with its historical program of translocation of Koalas as well as long-standing and high profile programmes to re-establish Eastern Barred Bandicoot, Orange-bellied Parrot, Helmeted Honeyeater, Black-eared Miner, and Brush-tailed Rock-wallaby.

Key areas where existing protocols could be strengthened include:

- More prominent emphasis on the necessity for long-term management of threatening processes;
- The removal of policy impediments to considered programs to mix genetic stocks from isolated sub-populations such as on islands where appropriate;
- Greater emphasis on health screening of animals coming from captive breeding facilities, carers, or kept as pets before use in translocations;
- Greater emphasis on monitoring and reporting.

However the most significant problems for regulatory authorities largely sit outside the existing protocols. These are:

- The pressure to use translocations as a humane alternative to culling – that is dealing with the problems of overabundant native fauna. Such translocations are often either introductions or restocking (cf. reintroductions) and have a particular set of problems;
- The pressure to shift native animals and plants away from proposed human developments such as urban developments, highways, mines, or processing plants; and
- The rise of conservation introductions and reintroductions, in part as a result of strong and growing interest from the non-government sector in conservation and in 're-wilding' the landscape. There is a concern in government that this may lead to poorly planned and under-resourced reintroductions.

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Table of Contents

The characteristics and success of vertebrate translocations within Australia

Scope of contract

1. Evaluate all translocations of native vertebrates (vulnerable and endangered) undertaken in Australia to date. This will be achieved by the collection and evaluation of data on all translocations of threatened native vertebrates undertaken in Australia to date.

2. Document all State and Territories protocols for the translocation of native vertebrates. This will be achieved by collecting and evaluating all State and Territories protocols for the translocation of vulnerable and endangered native vertebrates.

3. Produce a synthesis of the protocols used in the successful translocation of each of the principal vertebrate taxa within Australia. This will be achieved by producing a summary paper on the processes and procedure of the successful translocation of each of the vertebrate taxa within Australia.

Introduction

Translocation is defined in IUCN (1987) as "the movement of living organisms from one area with free release in another". It refers to the movement of animals from one location to another by humans where those animals are not successfully contained at the release location. Humans have moved animals, both wild and domesticated, between locations for much of their recorded history. Often these shifts have allowed the creation of new wild populations.

There are many reasons to move animals from one location to another. These include:

1. For aesthetic reasons – migrants to new continents typically took familiar animals with them to make their new environment more home-like.
2. For practical reasons – migrants and travellers often attempted to establish new populations of animals to provide an enhanced food supply at the new location. An example is the widespread practice of establishing rabbits on islands by early maritime explorers (Long 2003).
3. To create additional recreational opportunities or sporting activities, particularly associated with hunting. Examples are the fox and many species of deer introduced to Australia in the nineteenth century. A contemporary example is the unauthorized translocation of pigs within Western Australia to provide hunting opportunities (Spencer and Hampton 2005).
4. For the biological control of other organisms. Examples include the historical movement of cats to control rabbits within Australia and the introduction of cane toads (*Chaunus [Bufo] marinus)* to control beetles in cane fields in Queensland.
5. Animals may be "in the way" of expansion of human settlement or of human activities such as agriculture or mining or may be in conflict with humans. There is an increasing move to attempt to shift animals from such habitat prior to its loss or to shift animals away from the conflict zone (such as aggressive magpies).
6. Animals are perceived to be overabundant and causing conflict with humans or otherwise causing environmental damage. An example is that of introduced Koalas on Kangaroo Island in South Australia.
7. Animals may be rescued and rehabilitated and returned to native habitat. This may occur when animals are injured by collision with vehicles (such as kangaroos and their young), by hunting (such as elephants and their orphaned young in parts of Africa), or as a by-product of the pet trade (such as primates in Asia that make acceptable pets when young but outgrow this role as adults).
8. To supplement depleted animal stocks prior to hunting to enhance the hunting experience and hunter success. This is a common practice with game birds in the US and is discussed at length in Griffith *et al.* (1989).
9. To facilitate gene flow between populations as a means of enhancing the long-term likelihood of persistence of the species.
10. To facilitate the long-term persistence of a threatened species by establishing species in new locations that are protected from threatening processes.
11. To facilitate the long-term persistence of a threatened species by re-establishing the species in former habitat after ameliorating any threatening processes.
12. To improve knowledge of the species or the impact of various threatening processes.

Translocations can be broadly sub-divided into three categories: introduction, reintroduction, and re-stocking (IUCN 1987). These are defined thus in IUCN (1987):

Introduction: "the intentional or accidental dispersal by human agency of a living organism outside its historically known native range";

Re-introduction: "the intentional movement of an organism into a part of its native range from which it has disappeared or become extirpated in historic times as a result of human activity or natural catastrophe"; and

Re-stocking: "the movement of numbers of plants or animals of a species with the intention of building up the number of individuals of that species in an original habitat". An alternative term is "supplementation".

The twelve reasons for shifting animals given above can typically be sub-divided into these three categories: 1-4 and 10 above are typically introductions; 5-9 are typically restocking; and 11-12 are typically reintroductions.

This review concerns only threatened vertebrate species within Australia so is largely concerned with points 11 and 12 above.

A compilation and descriptive analysis of translocations of threatened and other vertebrates is provided under scope item 1.

Movement of animals today is typically regulated by government. Quarantine regulations restrict and regulate the movement of animals between countries. Movement of animals within Australia is subject to regulation by the States. The protocols developed to guide the modern movement of animals are detailed under scope item 2. These include protocols at international, national and State levels.

Factors affecting the success of translocations are discussed under scope item 3. Factors in success or failure are derived from an analysis of the available Australian data guided in part by the international literature on translocations.

Scope 1: Evaluate all translocations of native vertebrates (vulnerable and endangered) undertaken in Australia to date.

Method: This will be achieved by the collection and evaluation of data on all translocations of threatened native vertebrates undertaken in Australia to date.

Service: Collection and compilation of historic Australian vertebrate translocations conducted until the present date.

Milestone: Establish a database and use to compile relevant data on vertebrate translocations. Review published and grey literature for information on outcomes of translocation. Contact major practitioners to solicit further information as necessary.

Performance standard and date for completion: Access database and Procite bibliography prepared by September 2008.

Progress:

Establish database

An Access database was established to allow input of data on vertebrate translocations. Input of data has been ongoing through 2008 and 2009.

Data were compiled on:

- Species,
- National status of the species;
- Location of translocation,
- Organisation,
- State,
- Type of translocation (reintroduction, introduction, restocking),
- Year of first release,
- Source of animals,
- Area of release site (hectares),
- Tenure,
- Total number released,
- Type of release (hard or soft),
- Months of monitoring,
- Maximum months of survival reported,
- Presence of predator exclusion fence,
- Fox control (whether undertaken and whether perceived effective) ,
- Cat control (whether undertaken and whether perceived effective),
- Perceived cause of failure (if applicable),
- References, and

- Other comments.

The database has *c.* 380 records of translocations of Australia species. The scientific name and status of each species are given in Appendix I. The emphasis has been on translocation of species that are listed under the Federal Environment Protection and Biodiversity Conservation Act 1999, but translocations of other native species have been compiled also but with less rigour. For example, there has been no attempt to compile a comprehensive list of translocations of species such as Koala that have been widely moved around for over 120 years. However, when we have encountered a description of the translocation of such a species we have included this in the database. Introductions of non-native species have not been considered.

A bibliographic database (Procite) was used to compile relevant published and 'grey' literature that provided information on Australian translocations of vertebrates. Records that relate directly to a translocation of an Australian vertebrate are given in Appendix II, and records that relate largely to translocation protocols, procedures, and evaluation are given in Appendix III.

Vertebrate groups and translocations

Some 102 species of mammal, bird, reptile and amphibian have been translocated in Australia (Table 1). Approximately equal numbers of listed threatened species (50) and unlisted species (52) have been translocated.

Table 1: Vertebrate groups and translocations.

Taxa	Species listed as Critically Endangered, Endangered, or Vulnerable*	# listed species with at least one translocation (% of listed species)	# unlisted species with at least one translocation	Total species translocated
Mammal	82	29 (35%)	25	54
Bird	77	15 (19%)	20	35
Reptile	49	2 (4%)	6	8
Amphibian	28	4 (14%)	1	5
Total	**236**	**50**	**52**	**102**

*listed under the Environment Protection and Biodiversity Conservation Act 1999 (excluding marine species and subspecies, such as turtles, whales, seals, albatross, frigate birds, noddys, boobys and petrels).

Just over 50% of vertebrate species that have been translocated were mammals (54/102), with a little over a third of listed threatened mammal species (35%) having at least one translocation. Birds made up 34% of species translocated (35/102), with a lower percentage (19%) of threatened species having at least one translocation. Reptiles (7%) and amphibians (5%) made up the balance of species translocated. Hence, reptiles and amphibians are substantially under-represented in translocations.

Generally, few translocations of threatened reptiles and amphibian (4 and 14% of listed species) have taken place and many are comparatively recently.

Roughly equal numbers of unlisted species have been translocated. These include Brush-tailed Bettong (formerly listed), Tammar Wallaby (formerly listed) and Koala (formerly of conservation concern) for mammals; Bush Thick-knee and Australian Magpie for birds; Saltwater Crocodile, Carpet Python and Heath Monitor for reptiles; and Sharp-snouted Day Frog for amphibia.

Translocations by State and by year

The earliest translocations in our database are those of the Koala to Phillip and French Islands in Victoria in the 1880s, Tammar Wallaby to Greenly Island in South Australia in 1905, and Red-bellied Pademelon to Wilsons' Promontory in Victoria in 1911. Many of the early translocations (Table 2) were in South Australia (to Kangaroo and other islands) including pioneering conservation reintroductions of Brush-tailed Bettongs in the 1970s (Delroy *et al.* 1986). However, since the 1990s, the majority of reintroductions have been in Western Australia (56% of the national total in the 1990s and 50% in the 2000s). This followed the establishment of a strong link between fox predation and mammal decline and an increasing ability to control foxes within conservation reserves and across the broader landscape (e.g. Kinnear *et al.* 1988; Bailey 1996).

Table 2: Translocations by State and by year (n.d. = no date).

State	n.d.	< 1970	1970-79	1980-89	1990-99	≥ 2000	Total
WA	1	2	4	10	71	62	150
SA	5	33	19	7	23	20	107
NSW	3	1	1	5	13	19	42
Vic	6	7	2	3	12	10	40
Qld	5	3	0	1	6	8	23
NT	0	0	1	4	1	6	12
Tas	0	0	1	0	4	0	5
ACT	0	1	0	0	0	0	1
Total	**20**	**47**	**28**	**30**	**130**	**125**	**380**

Translocations by type and State

Most of the 380 documented translocations within Australia (65%) have been reintroductions. Introductions made up 22% and restocking of fauna made up 13% (Table 3).

The bulk of Australian reintroductions (47%) were carried out in Western Australia. They were often from islands to the mainland or from mainland refuges to sites recently protected from predator incursion. This is somewhat in contrast to translocations in South Australia, where there has been a strong theme of transferring animals from the mainland to offshore islands, often for either aesthetic or conservation reasons. Fifty eight percent of all introductions have been in South Australia, many in the early part of the twentieth century. Most examples of restocking (36%) come from Western Australia. These typically involve shifting animals in response to development (for example, Western Pebble-mound Mice from iron ore mining or Southern Brown Bandicoot from highway development or housing subdivisions).

Table 3: Translocations by type and State.

State	Reintroductions (% of total for States)	Introductions (% of total for States)	Restocking (% of total for States)	Total
WA	117 (47%)	16 (20%)	17 (36%)	150
SA	55 (23%)	47 (58%)	5 (10%)	107
NSW	27 (11%)	4 (5%)	11 (22%)	42
Vic	27 (11%)	6 (6%)	7 (14%)	40
Qld	12 (5%)	6 (7%)	5 (8%)	23
NT	8 (3%)	3 (4%)	1 (2%)	12
Tas	1 (< 1%)	0	4 (8%)	5
ACT	1 (<1%)	0	0	1
Total	**248**	**82**	**50**	**380**

Number of translocations by species

The number of collated translocations per species varies widely from one through to 47 per species (Table 4). The species with the most translocations was the Brush-tailed Bettong (47, 12% of all translocations), followed by the Koala (26), and the Tammar Wallaby (17). Both the Brush-tailed Bettong and the Tammar Wallaby were listed nationally (as well as in the various States) in the recent past. The Brush-tailed Bettong was de-listed nationally in 1996 and the Tammar Wallaby in 1998. Both were de-listed, in part, due to the successful establishment of new populations by translocation. However, Brush-tailed Bettong have been re-listed in Western Australia because of renewed concerns about its status (Mitchell and Wayne 2008). At least some of the translocations of Koala were also motivated by a concern for the species status at the time they were carried out; although many appeared to have been for largely aesthetic reasons or to manage over-browsing of habitat and tree death in confined populations.

The number of translocations of the Koala is greatly under-estimated. They have been widely moved around over the past 120 years (Warneke 1978, Martin and Handasyde 1990, Lee and Martin

1988; Taylor *et al.* 1997; Seymour *et al.* 2001, Hrdina and Gordon 2004). For example, Martin and Handasyde (1990) suggest translocation to at least 70 sites in Victoria in the period 1923 to 1976, while Hrdina and Gordon (2004) list numerous translocations in Queensland in the 1920s and 1930s. However, a detailed recording of translocations of this species is beyond the brief of this project.

The bird with the most translocations (11) is the Malleefowl – largely due to the extensive work prompted by conservation concerns for this species in western New South Wales in the 1980s and 1990s by New South Wales National Parks and Wildlife Service. The bird species with the second highest number of translocations is the Noisy Scrub Bird (10) in the south-west of Western Australia.

The 15 species most translocated - twelve mammal species, two bird species, and one amphibian species - account for 218 of the total of 377 recorded translocations (58%). The remaining 87 species make up the balance.

Table 4: Number of translocations by species. Status is as given under the Federal Environmental Protection and Biodiversity Conservation Act 1999.

Common name	Status	Animal type	# of translocations
Brush-tailed Bettong		Mammal	47
Koala		Mammal	26
Tammar Wallaby		Mammal	17
Bilby	Vulnerable	Mammal	15
Brushtail Possum		Mammal	14
Numbat	Vulnerable	Mammal	13
Southern Brown Bandicoot (WA form)		Mammal	12
Burrowing Bettong	Vulnerable	Mammal	12
Malleefowl	Vulnerable	Bird	12
Noisy Scrub-bird	Vulnerable	Bird	10
Green and Golden Bell Frog	Vulnerable	Amphibian	9
Black-footed Rock-wallaby	Vulnerable	Mammal	9
Eastern Barred Bandicoot	Endangered	Mammal	9
Greater Stick-nest Rat	Vulnerable	Mammal	9
Rufous Hare-wallaby	Endangered	Mammal	8
Southern Hairy-nosed Wombat		Mammal	7
Western Ringtail Possum	Vulnerable	Mammal	7
Bridled Nailtail Wallaby	Endangered	Mammal	6
Brush-tailed Rock-wallaby	Vulnerable	Mammal	6
Chuditch	Vulnerable	Mammal	6
Western Swamp Tortoise	Critically Endangered	Reptile	5
Eastern Bristlebird	Endangered	Bird	4
Shark Bay Mouse	Vulnerable	Mammal	4
Western Pebble-mound Mouse		Mammal	4
Black-eared Miner	Endangered	Bird	3
Bush Thick-knee		Bird	3
Helmeted Honeyeater	Endangered	Bird	3

Orange-bellied Parrot	Critically Endangered	Bird	3
Banded Hare-wallaby	Vulnerable	Mammal	3
Dibbler	Endangered	Mammal	3
Rufous Bettong		Mammal	3
Sugar Glider		Mammal	3
Western Barred Bandicoot	Endangered	Mammal	3
Yellow-footed Rock-wallaby	Vulnerable	Mammal	3
Spotted Tree Frog	Endangered	Amphibian	2
Australian Magpie		Bird	2
Emu		Bird	2
Magpie Goose		Bird	2
Western Bristlebird	Vulnerable	Bird	2
Gilbert's Potoroo	Critically Endangered	Mammal	2
Golden Bandicoot	Vulnerable	Mammal	2
Northern Hairy-nosed Wombat	Endangered	Mammal	2
Northern Quoll	Endangered	Mammal	2
Parma Wallaby		Mammal	2
Plains Rat	Vulnerable	Mammal	2
Quokka	Vulnerable	Mammal	2
Red-bellied Pademelon		Mammal	2
Rothschild's Rock-wallaby		Mammal	2
Southern Brown Bandicoot (Vic form)	Endangered	Mammal	2
Western Grey Kangaroo		Mammal	2
Orange-bellied frog	Vulnerable	Amphibian	1
Sharp-snouted Day Frog		Amphibian	1
Southern Bell Frog	Vulnerable	Amphibian	1
Southern Corroboree Frog	Endangered	Amphibian	1
Carpet Python		Reptile	1
Heath Goana		Reptile	1
Lancelin Island Skink	Vulnerable	Reptile	1
Saltwater Crocodile		Reptile	1
Sand Monitor		Reptile	1
Tiger Snake		Reptile	1
Woma Python		Reptile	1
Bar-shouldered Dove		Bird	1
Brush Turkey		Bird	1
Cape Barren Goose		Bird	1
Chestnut-rumped Heathwren (Mt Lofty Ranges)	Endangered	Bird	1
Crested Pigeon		Bird	1
Crimson Finch (white-bellied)	Vulnerable	Bird	1
Diamond Dove		Bird	1
Gang-gang Cockatoo		Bird	1
Golden Whistler (Norfolk Island)	Vulnerable	Bird	1

Gouldian Finch	Endangered	Bird	1
Gould's Petrel	Endangered	Bird	1
Laughing Kookaburra		Bird	1
Little Penguin		Bird	1
Lord Howe Island Woodhen	Vulnerable	Bird	1
Noisy Miner		Bird	1
Northern Rosella		Bird	1
Peaceful Dove		Bird	1
Pink Cockatoo		Bird	1
Regent Honeyeater	Endangered	Bird	1
Southern Cassowary	Endangered	Bird	1
Southern Emu-wren	Endangered	Bird	1
Spinifex Pigeon		Bird	1
Wonga Pigeon		Bird	1
Yellow-tailed Black Cockatoo		Bird	1
Zebra Finch		Bird	1
Australian Fur Seal		Mammal	1
Brush Wallaby		Mammal	1
Brush-tailed Phascogale		Mammal	1
Carpentarian Rock-rat	Endangered	Mammal	1
Common Ringtail Possum		Mammal	1
Common Wombat		Mammal	1
Eastern Grey Kangaroo		Mammal	1
Eastern Grey Kangaroo (Tasmania)	Lower risk (near threatened)	Mammal	1
Eastern Quoll		Mammal	1
Euro		Mammal	1
Julia Creek Dunnart	Endangered	Mammal	1
Long-nosed Potoroo		Mammal	1
Pilbara Leaf-nosed Bat (Pilbara form)	Vulnerable	Mammal	1
Platypus		Mammal	1
Proserpine Rock-wallaby	Endangered	Mammal	1
Red-tailed Phascogale	Endangered	Mammal	1
Swamp Antechinus		Mammal	1
Thevenard Island Short-tailed Mouse		Mammal	1

In addition there are a considerable number of species for which translocation has been recommended, often in Recovery Plans or similar, but there is no record of translocations yet happening (Table 5). Amphibian and bird species are far more numerous in this list than in the list of past translocations (Table 4), suggesting that practitioners concerned with the conservation of these taxa are increasingly turning to translocation as a conservation strategy.

Table 5: Species for which translocation has been recommended but for which there is no information on actions to date. Status is as given under the Federal Environmental Protection and Biodiversity Conservation Act 1999.

Common name	EPBC	Animal type
Armoured Mistfrog	Critically Endangered	Amphibian
Booroolong Frog	Endangered	Amphibian
Common Mistfrog	Endangered	Amphibian
Spotted Tree Frog	Endangered	Amphibian
Tinkling Frog	Endangered	Amphibian
Slater's Skink	Endangered	Reptile
Corangamite Water Skink	Endangered	Reptile
Pygmy Blue-tongue lizard	Endangered	Reptile
Broad-headed Snake	Vulnerable	Reptile
Buff-banded Rail (Cocos (Keeling) Islands	Endangered	Bird
Black-throated Finch (southern)	Endangered	Bird
Mallee Emu-wren	Endangered	Bird
Western Whipbird (eastern)	Vulnerable	Bird
Red-lored Whistler	Vulnerable	Bird
Striated Grass Wren		Bird
Chestnut quail-thrush		Bird
Southern Scrub Robin		Bird
Shy Heathwren		Bird
Northern Bettong	Endangered	Mammal
Christmas Island Shrew	Endangered	Mammal
Bramble Cay Melomys	Endangered	Mammal
Yellow-footed Rock-wallaby	Vulnerable	Mammal
Spectacled Hare-wallaby (Barrow Island)	Vulnerable	Mammal
Heath Rat	Vulnerable	Mammal
Tasmanian Devil	Vulnerable	Mammal
Southern brown bandicoot (SA form)	Vulnerable	Mammal

Number of translocations by outcome

Thirty two percent of translocations were identified as successful, 28% were identified as unsuccessful, and for the balance (40%) the outcomes were unknown or uncertain (Table 6). Predation (mostly foxes, cats, dingoes, avian predators, or some combination but also predation by a snake or predatory fish) was identified as a primary reason for failure in 45 of 105 cases (43%) that had demonstrably failed. No cause was given for 37% of failures.

Table 6: The number of translocations by outcome.

Outcome of translocation	Number of sub-category	Number (%) of category
Perceived successful	123	123 (32%)
Failed – reason not certain	39	105 (28%)
Failed – predation	45	
Failed – multiple causes	7	
Failed - other	14	
Outcome uncertain	86	152 (40%)
No outcome given	29	
Outcome given as pending	37	
Total	380	380

Reported success or failure of translocations by State

The apparent success of translocations varied greatly between States (Table 7) ranging from a high of 46% for South Australia (n = 107) to a low of 25% for Western Australia (n = 150). The state with the highest number of translocations – Western Australia - achieved a result substantially lower than the national average of 32.4%. Resolution of the high number of "uncertain" outcomes, particularly in Western Australia, Victoria and, Queensland, might significantly boost their 'successful' result.

Translocations in Tasmania did not involve 'critical weight range mammals', a key focus of translocations on mainland Australia. Similarly, Queensland, Victoria and New South Wales had a higher proportion of translocations of larger bodied species, particularly Koala.

Table 7: Outcome by State: success or failure of translocations (and percentage of total translocations for each State).

Outcome of translocation	WA	SA	NSW	Vic	Qld	NT	Tas	ACT	Total
Perceived successful	38 (25%)	49 (46%)	11 (26%)	11 (28%)	8 (35%)	4 (33%)	2 (40%)	0	123
Failed – reason not certain	33 (22%)	38 (36%)	17 (40%)	8 (20%)	2 (9%)	6 (50%)	1 (20%)	0	105
Failed – predation									
Failed – multiple causes									
Failed-other									
Outcome uncertain	79 (53%)	20 (19%)	14 (33%)	21 (53%)	13 (57%)	2 (17%)	2 (40%)	1 (100%)	152
No outcome given									
Outcome given as pending									
Total	150	107	42	40	23	12	5	1	380

Reported success or failure over time

Translocations are reported by ten year intervals from 1970 in Table 8. The ratio of success: fail peaked at 2:1 in the 1970s, declined below 1:1 in the 1980s, and has climbed to 1.5:1 in the current decade. Hence, there is no clear trend of improvement in success over time. Unfortunately, the large number of uncertain outcomes makes any firm conclusion difficult. In part the lack of a clear trend of improvement may be due to the translocation of more vulnerable species and less reliance on off-shore islands as refuges.

Successful translocations in the 1970s, the decade with the highest rate of success, included five of six translocations of Southern Hairy-nosed Wombat in South Australia, four of five translocations of Brushtail Possum in South Australia, and numerous translocations to offshore islands, again mostly in South Australia.

Table 8: Outcome of translocations by decade (note: 20 records had no date).

Outcome	< 1970	1970-1979	1980-89	1990-99	2000-09	Total
Successful	25	17	13	43	24	122
Failed	17	8	16	43	18	102
Uncertain	5	2	1	44	84	136
Total	47	27	30	130	126	360

The number of individual animals translocated

By taxa

Over 18,700 individuals of mammal, bird, and reptile have been translocated in Australia, with about 44% of these being threatened species (Table 9). Mammals make up the vast bulk of these (83%), followed by birds (15%) and reptiles (2.4%). However, this greatly underestimates the overall number as there have been an estimated 10,000 Koalas translocated from French and Phillip Islands in Victoria to the mainland since the 1920s (Martin and Handasyde 1990). Some 4,000 of the 6,488 mammals in our database are Koalas (of which only 800 are from French and Phillip Islands) so they make up the vast bulk of mammals translocated (> 13,000 individuals).

In addition, some 17,700 amphibian individuals (chiefly tadpoles) have been released. Almost all were of the one species – Green and Golden Bell Frog in New South Wales.

Table 9: The numbers of animals translocated in Australia. There were 50 translocations where no data were available on numbers. Note: the bulk of amphibians translocated were tadpoles of a single species.

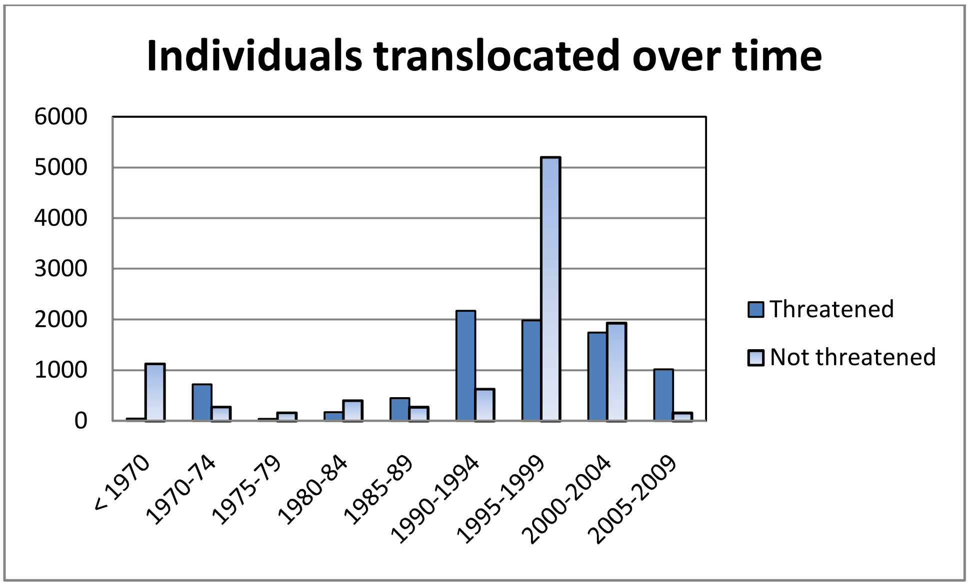
Taxa	Threatened	Not threatened	Total
Mammal	6488	9106	15594
Bird	1459	1270	2729
Reptile	385	69	454
Amphibian	17695	0	17695
Total	26027	10445	36472

By year

The trend in use of threatened animals (excluding amphibian) over time peaked in 1990-1994 when 2168 animals were translocated over the 5-year period and has declined slowly since then (Figure 1). There were nine species in which over 100 animals were translocated during the 1990-94 period – Greater Stick-nest Rat, Plains Rat, Eastern Barred Bandicoot, Western Swamp Tortoise, Shark Bay Mouse, Bridled Nailtail Wallaby, Malleefowl, Burrowing Bettong, and Western Ringtail Possum.

The use of non-threatened animals over time peaked in the period 1995-1999 (when 5203 animals were translocated) and has fallen away sharply since then. The translocation of Koalas from Kangaroo Island to mainland South Australia starting in 1998 was a major component of this total (Whisson *et al.* 1998; Duffy *et al.* 2004). This data excludes the *c.* 10,000 Koala translocated from French and Phillip Islands to over 70 locations throughout Victoria in the sixty year period to 1988 (Martin and Handasyde 1990) and nearly 900 Koala and Brushtail Possum within Queensland in the 1920s and 1930s (Hrdina and Gordon 2004).

Figure 1: The number of individuals of threatened and non-threatened species utilized in translocations over time (data excludes amphibians).



The bulk of amphibian translocations have taken place since the mid-1990s (Daly *et al.* 2008; Pyke *et al.* 2008; White and Pyke 2008).

Scope 2: Document all State and Territory protocols for the translocation of native vertebrates.

Method: This will be achieved by collecting and evaluating all State and Territory protocols for the translocation of vulnerable and endangered native vertebrates.

Service: Collection and compilation of translocation protocols (Federal and State).

Milestone: Obtain relevant State and Federal protocols, analyse comparative content and requirements.

Performance standard and date for completion: All State and Federal protocols obtained and reviewed by December 2008.

The Protocols

There are protocols for the translocation of fauna at international, national and State levels (Table 10). Many of these protocols are available on the web. Their web addresses, where available, are listed in Appendix V.

Definitions

There is a degree of confusion in the scientific literature and in the policy documents caused by the use of two different definitions of the terms “translocation” and “reintroduction”. The broad meaning of “translocation” is the movement of living organisations (either wild or captive) from one area with free release in another, including introductions, reintroductions, and restocking (supplementation). Thus it is used as an umbrella term. This is the usage of The IUCN Position Statement on Translocation of Living Organisms (1987) and most policy documents. It is also the usage in the Australian Network for Plant Conservation Guidelines for the Translocation of Threatened Plants in Australia (the ANPC Guidelines), and in many academic works (e.g. Griffith *et al.* 1989, Short *et al*. 1992).

However, Kleiman (1989) attempted to distinguish the source of animals for release in the terminology. Hence she used “translocation” to refer to the capture and transfer of free-ranging animals (i.e. wild) within their range and used “reintroduction” to refer specifically to animals sourced from captivity, either wild- or captive-born, and released within their native range. This confusion in terminology is compounded by the 1998 IUCN Guidelines for Re-introductions using the latter meaning for “translocation” (i.e. movement of wild individuals only), but using “reintroduction” to refer to the movement of animals sourced from both the wild and captivity. Some recent authors (e.g. Fischer and Lindenmayer 2000, Seddon *et al.* 2007) mix and match these definitions further adding to the confusion.

In this document, translocation is used as the overarching term for introductions, reintroductions and restocking as used by IUCN (1987), Griffith *et al.* (1989) and Short *et al*. (1992).

The IUCN Position Statement on the Translocation of Living Organisms (1987)

The IUCN Position Statement on the Translocation of Living Organisms (1987) provides the starting and reference point for State and Territory protocols for the translocation of native vertebrates. This document defines the various types of translocations:

- Introduction;
- Reintroduction; and
- Restocking.

These definitions have been given earlier.

A great deal of the document (7½ of 11 pages) is focused on the introduction of non-native (exotic) species. This includes 4½ pages specifically on Introductions and 3 pages on the “national, international and scientific implications of translocations” that focus largely on how to curtail introductions through national policies, legislation, quarantine regulation and penalties.

The document emphasises that translocations are a powerful tool with the “potential to cause enormous damage if misused” and the likely “disastrous consequences of poorly planned translocations”. Here they appear to be largely referring to introductions and to a lesser extent to restocking. They consider “the damage done by harmful introductions to natural systems far outweighs the benefit derived from them.”

Damage derives from the impact of the spread of alien species, breaking down the former “genetic isolation of communities of co-evolving species of plants and animals” and interfering with “the dynamics of natural systems causing the premature extinction of species”. They emphasise that many successful and aggressive species translocated to new sites come to dominate large areas. They note that invasive species are particularly influential in formerly isolated systems such as islands, mountain tops, and lakes. These formerly isolated systems often contain many rare endemics with highly specialised requirements that are negatively impacted.

A major emphasis is that successful translocations require detailed planning. They provide a structure for this planning.

<u>Introduction</u>

1. Assessment phase;
2. Experimental controlled trial; and
3. Extensive introduction.

<u>Reintroduction</u>

1. Feasibility study;
2. Preparation phase;
3. Release phase; and a
4. Follow-up phase.

They also provide detailed guidelines on what should be considered at each phase.

This planning process and many of the issues identified have been incorporated into State protocols and formalised as Translocation Proposals.

The IUCN/SSC Guidelines for Re-introductions (1998)

These are guidelines prepared by the Re-introduction Specialist Group of the IUCN Species Survival Commission. These guidelines have a particular focus on re-introductions using either captive-bred individuals rather than translocation of wild species, or species with small population size and so limited numbers of founders. The particular focus is on establishing viable populations – so excludes translocations for short-term, sporting or commercial purposes.

A starting point is the statement regarding reintroductions: “some succeed, many fail”. The emphasis is on improving success rates and learning from past experiences, both successful and unsuccessful. They argue for “more rigour” in “concepts, design, feasibility and implementation”.

The stated focus of the guidelines is to inform practitioners rather than decision makers in government.

Table 10: International, national and state/territory policies for the translocation of threatened fauna.

Jurisdiction	Document	Date
International	IUCN Position Statement: Translocation of living organisms; IUCN/SSC guidelines for reintroductions	1987; 1998
Federal	ANZECC Policy for translocations of threatened animals in Australia (draft)	*c.* 1999
Western Australia	DCLM Policy Statement No. 29 Translocation of Threatened Flora and Fauna	July 1995
New South Wales	Policy and Procedure Statement No. 9 Policy for the translocation of threatened fauna in NSW	October 2001
South Australia	Translocations of Native Fauna Policy (draft); Translocations of Native Fauna Procedure (draft)	Draft September 2006
Northern Territory	Translocating Threatened Animals Policy (revised draft)	March, 2009
Queensland	The management of captive colonies (threatened species) for wildlife conservation; Requirements for the translocation, relocation and release of Koalas	July 2007, 2005
Victoria	No specific policy	
Tasmania	No specific policy, but approvals required under various Acts (see # below)	
Australian Capital Territory	No specific policy, but must adhere to the Nature Conservation Act 1980##	

draft document "Background on legal and policy issues relating to the translocation of Tasmanian devils to offshore islands" (April 2008).

ACT: legislation (Nature Conservation Act 1980) available at www.legislation.act.gov.au . Translocation is not specifically addressed in this legislation but need to comply with the restrictions on the "taking"' of fauna (Section 45), "keeping" of fauna (Section 46) and "release from captivity" (Section 49) and through import and export licences (licensed through the Department of Environmental Protection) The 'take' of fauna is controlled by licensing. This provides allowance for the 'taking' of a sick or injured animal for a period up to 48 hours. This animal must be released within 500 m of the place where it was taken after treatment. There are special conditions relating to the take of "protected native animals" and species that have "special protection status" (Section 105) (Section 33: migratory species, threatened and endangered species). Licenses have special criteria (Section 106) for each category of fauna or flora and record keeping may be required (Section 112). However, the provisions regarding "taking", "keeping" and "release from captivity" of fauna do not apply to conservation officers (Section 128).

ANZECC Policy for translocations of threatened animals in Australia (draft)

The Australian and New Zealand Environment and Conservation Council (ANZECC) was a Ministerial Council operating between 1991 and 2001. ANZECC provided a forum for member governments to develop coordinated policies about national and international environmental and conservation issues. One such draft policy was the 'ANZECC Policy for Translocations of Threatened Animals in Australia'. They also produced the 'National Koala Conservation Strategy (http://www.environment.gov.au/biodiversity/publications/koala-strategy/pubs/koala-strategy.pdf) which provided guidelines for the translocation of this species.

The ANZECC policy on translocation draws heavily on the two IUCN documents. It refers to threatened animals only. It uses the definitions as per IUCN (1987). It was formulated as a national policy because recovery actions for many species crossed state boundaries.

It specifically identified releases of animals to "areas that are fenced to exclude predators", thus taking in releases to Sanctuaries such as those controlled by Earth Sanctuaries, Australian Wildlife Conservancy and/or community groups.

It detailed the requirements for a Translocation Proposal to be prepared by the proponent and provided guidance on the content of such a proposal. It also linked action to a species Recovery Plan. Issues to be considered included: whether reintroduction or introduction (the latter were discouraged); the choice of source population; principles of conservation genetics, particularly with regard to effective population size; the cause of the original decline; and the extent to which this cause has been ameliorated.

These international and national policies are compared with respect to scope and administrative process in Table 11 and content in Table 12. The ANZECC guidelines introduce the notion of being consistent with a species Recovery Plan, the use of Animal Ethics Committees, and the development of a Translocation Proposal.

State Policies

The various state policies are compared in Tables 13 and 14. The documents typically consist of an introduction or preamble which provides background information and definitions and general guidelines to assist interpretation of the policy, followed by the policy itself. The documents typically also provide detailed guidance on the content of the Translocation Proposal required for assessment.

The South Australian draft is in two parts – a policy document and a procedure document. New South Wales and Western Australia are in the process of revising their policies. The Northern Territory has recently produced a draft policy.

Table 11: International and national protocols to guide translocation compared with respect to scope and administrative process.

Scope	IUCN (1987) translocations	IUCN (1998) reintroductions	ANZECC
Concerned with all animal movements	Yes, all organisms, includes introduction, re-introduction and restocking	No, conservation reintroductions only	Threatened animals only
Definitions consistent with IUCN (1987)	Note: uses the term "beneficial introduction"	No, defines translocation as deliberate movement of wild individuals; introduces the term "conservation introduction"	Yes
Aims	To reduce the damage from introduction of alien species and provide a planning framework for all translocations	Viable, free-ranging population, with minimal long-term management	Provide for consistency across States, particularly for species that cross State boundaries
Primarily conservation focused	No, broadly focussed	Yes, particularly focused on captive-bred individuals or species with small populations and so limited number of founders	Yes
Reference to a standard	No	Builds on IUCN (1987) with more detail	Yes, IUCN (1987)
Recovery team	No	"Multidisciplinary team with access to expert technical advice"	No
Require to be consistent with a Recovery Plan or similar	No	No	Yes, if not then must be part of an overall plan
Require approval from an Animal Ethics Committee	No	No, but "welfare of animals for release is of paramount concern"	Yes, "properly constituted"
Require a written Translocation Proposal	No, not by name, but provides a strong planning structure analogous to a Translocation Proposal	No, not by name, but requires a feasibility study and background research	Yes
Guidelines for contents of Translocation Proposal	Provides lists of factors to be considered, focusing on ecology and animal husbandry	Provides lists of factors to be considered.	Yes
Translocation Proposals to be	No	Yes, should be "rigorously reviewed on	Yes, at least two experienced

peer-reviewed		its individual merits”	scientists

Table 12: International and national protocols to guide translocation compared with respect to content.

Scope	IUCN (1987) translocations	IUCN (1998) reintroductions	ANZECC
Guidelines for introductions	Yes	Only considers “conservation / benign introduction”; recommends “only as a last resort”	Requires “exceptionally strong conservation reasons”; bio-climatic modelling indicates likely former presence
Guidelines on island to mainland translocations	No	No	Only if species no longer occurs on mainland; must provide justification (over-riding conservation reasons)
Guidelines on mainland to island translocations	No	No	Demonstrate proposed introduction is more important than, or will have no effect on, other possible translocations to that island
Restocking	Yes, as a tool for genetic management and a rescue of a species whose population has dropped below critical levels, or natural growth dangerously slow. Not a substitute for good habitat management and something of a last resort. Danger of introducing disease to existing population. Prefer reintroduction over restocking for rehabilitating captive animals due to	If “reinforcement”, then “should be few remnant wild individuals”.	Not considered specifically

	disease risks and negative social interactions		
Guidelines of choice of source population	Yes, for reintroductions (closest race or type to original stock)	Same sub-species or race; preferable wild stock; similar ecological characteristics to original. If captive, then from a soundly managed population (demographically and genetically)	Must provide reasons why one source is chosen over another
Mandatory that causes of original extinction removed or ameliorated if known	Yes, for reintroductions and restocking	The need to identify and eliminate previous causes of decline is emphasised, particularly if due to human factors	Review causes of original decline and provide evidence of amelioration or removal
Monitoring of translocated and source populations mandatory	Emphasises that sufficient funds need to be available, including for follow-up phase (=monitoring)	Pre- and post-release monitoring of health and survival	Long-term resourcing available and committed
Reference required to past translocations of same or analogous species	Not specified	Yes, thorough research into previous reintroductions of the same or similar species recommended	Not specified
Requirement to ensure no detrimental impact on source populations	Not specified	Not specified	Not specified
Criteria for success	Not given	Identify short- and long-term success indicators	Not considered
A minimum area requirement for release location based on viable population size	Not considered	“sufficient carrying capacity” to support a self-sustaining population in the long run	Not considered
Translocation as a tool for preserving genetic diversity	Yes, see restocking	No	Yes, consider principles of conservation genetics – number of individuals to be translocated in relation to effective population size

Translocations as experiments to establish causal factors in decline	Suggests an "experimental controlled trial" before beneficial introductions	Each reintroduction "a carefully designed experiment" to test methodology	Not considered
Provision for emergency salvage operations	Not considered	Not considered	Not considered
Where appropriate, foster captive breeding	Not considered	Focuses on release of captive-bred animals	Not considered
Issues of overabundance post-translocation	Not considered	Provision for compensation where necessary if impact on neighbours	Not considered
Veterinary screening prior to translocation	Not considered	Recommended, test for non-endemic or contagious pathogens plus strict quarantine	Not considered
Pre-release training	Not considered	Yes, for captive stock. Survival skills should be to a level of wild counterpart	Not considered
Publicise efforts	Emphasises the need to publicise both successful and unsuccessful projects	Yes, education and mass media and publications in scientific and popular literature	Detailed records need to be kept and lodged with wildlife authority
Local community impact	Not considered	Cost-benefit to local community and engagement and support of local community	Not considered

Issues of *ex situ* management of fauna (i.e. captive breeding of threatened fauna) is largely beyond the brief of this consultancy. Note: IUCN developed *Technical Guidelines on the Management of Ex Situ Populations for Conservation* in 2002 (http://www.eaza.net/download/doc_EEP_IUCNGuidelines.pdf).

Table 13: Translocation policies of the States and Territories compared with respect to scope and administrative process.

Scope	WA	SA	NSW	NT	Qld*
Concerned with all animal movements	Threatened fauna and flora	No, for conservation only (focused on, but not limited to, threatened fauna)	Threatened vertebrates only, although principles apply equally to all species	Threatened animals for the purpose of conservation	Koalas only
Definitions consistent with IUCN (1987)	Yes	Broadly – translocation refers only to indigenous species; introduces the term "new introduction" for the introduction of an indigenous species for conservation; introduces the term "population supplementation" for restocking.	Yes	Yes	Yes, reference to IUCN (1987) and IUCN (1998)
Aims	To conserve threatened animals in the wild by carrying out translocations if warranted	Clear benefits for biodiversity conservation, ecological restoration of faunal assemblages, or in expected research outcomes contributing to biodiversity conservation	To guide the planning and implementation of translocation programs for threatened species	To decrease the probability of a species becoming extinct	To restrict translocations of Koala except where clear and demonstrated need; viability of regional Koala populations
Primarily conservation focused	Yes	Yes	Yes	Yes	Yes
Reference to a standard	Yes, IUCN (1987)	Yes, IUCN (1987, 1995)	Yes, ANZECC Policy for Translocations of	Yes, IUCN (1987, 1995)	Yes, ANZECC (1998) 'National Koala

			Threatened Animals in Australia’		Conservation Strategies’ and ‘ANZECC Policy on Translocations of Threatened Animals in Australia’
Recovery team	Not required	Desirable	Not required	Not considered	
Require to be consistent with a Recovery Plan or other approved program	Yes	Typically	Typically, or biodiversity reconstruction program	Yes, under “approved wildlife management programs”	Yes, ANZECC (1998) ‘National Koala Conservation Strategies’
Requires approval from an Animal Ethics Committee	Yes, “properly constituted”	Only when conducted in association with a university or other research body. Elsewhere it indicates approval must be sought from relevant SA-based animal ethics committee	Yes, but only if a research component	Translocation Proposal should provide information on “whether the translocation method is likely to be approved by an AEC”	Not stated
Require a written Translocation Proposal	Yes	Yes	Yes	Yes	Yes
Guidelines for contents of Translocation Proposal	Yes	Yes	Yes	Yes	No
Translocation Proposals to be peer-reviewed	Yes, two experienced scientists as reviewers	Yes	Yes, two experienced scientists as reviewers	Yes, to at least two experienced scientists, one external	Not stated

Table 14: Translocation policies of the States and Territories compared with respect to content.

Scope	WA	SA	NSW	NT	Qld (Koala only)
Guidelines for Introductions	Only if exceptionally strong conservation reasons and likely impact assessed as minimal (4 conditions specified)	"Good reasons" required	Where "conservation reasons are exceptionally strong"	Only if exceptionally strong conservation reasons	Prohibited
Guidelines on island to mainland translocations	Yes, only if mainland population extinct or over-riding conservation reasons	Not explicitly	No	Typically not, if species still exists on mainland, unless over-riding reasons	No
Guidelines on mainland to island translocations	Yes, require thorough assessment (5 conditions specified)	"Good reasons" required; case study provided	No	Must consider impact on other possible translocations of threatened taxa	No
Restocking	Yes, to increase genetic diversity or to assist a population to recover quickly	Yes = "population supplementation"	Yes, where natural recovery is so slow as to leave it vulnerable or to counter inbreeding, or to maintain genetic exchange	Not explicitly considered	Must follow the 'National Koala Conservation Strategies'; generally seen as an option of last resort
Guidelines of choice of source population	Yes, closest ecologically to original sub-population. Proposal to evaluate alternatives and provide reason for choice	Yes	Must provide reasons why one source is chosen over another	If more than one possible source, must provide reasons for choice of one source over	Must demonstrate that translocation will not lead to adverse outcomes through the

				another	introduction of highly divergent genotypes
Mandatory that causes of original extinction removed or ameliorated if known	Yes, provide evidence	Not explicitly	Yes, also temporary habitat supplement-ation (e.g. nest boxes, planting of food trees) considered important to ensure persistence	Must review the causes and provide evidence that cause(s) have been removed or ameliorated	Must demonstrate that the population is not likely to decline for reasons other than genetics
Monitoring of translocated and source populations mandatory	Yes. Commitment for the medium to long term. Translocation Proposal must demonstrate no detrimental effect on viability of source population.	Yes, strong emphasis	Long-term resourcing available and committed	PWSNT will monitor numbers of both; commitment to post-release monitoring by proponent	Yes, for minimum of three years, including health, reproductive status, movement patterns and habitat use.
Reference to past translocations of same or analogous species	Not required	Yes	Yes	Not considered	No
Requirement to ensure no detrimental impact on source populations	Yes	Not explicitly, but requirement to monitor source population	Yes, except for salvage operations	Not explicitly, but PWSNT will monitor source population	Requirement to monitor “other wildlife and habitats at the release site”
Criteria for success	Self-perpetuating population with 90% of the genetic diversity of	Proponent must provide for both source and release sties and for short- and long-term	Proponent must provide; no explicit definition of success	Proponent must provide in Translocation	No

	the source population, without expensive non-routine management		for a translocation given	Proposal; no explicit definition of success for a translocation given	
Guidelines for release	Not given	Not given	Not given	Not given	Must be soft release in non-breeding season
A minimum area requirement for release location based on viable population size	Not considered	Yes, site must be capable of carrying 500-1000 mature individuals for establishment of self-sustaining population	Suitable and sufficient habitat for the survival of the species	Translocation Proposal should provide information on "holding capacity of the habitat" and whether large enough to sustain a viable population	Research must demonstrate that the habitat in the target area will support a viable Koala population
Translocations as experiments to establish causal factors in decline	Yes, "experimental translocations"	Not explicitly, but mentions "research outcomes contributing to biodiversity conservation"	Yes, but must demonstrate a conservation benefit	Not considered	No
Provision for emergency salvage operations	Yes	Yes, "emergency translocations"	Yes, but requires a translocation proposal for subsequent release	Yes, "emergency transfer" to remove threatened fauna from a demonstrably life-threatening situation in the wild	Rehabilitation permits available. Must return to within one kilometre, but no greater than 5 km of capture site
Genetic considerations	Yes, undertake or facilitate research in	Encourages collection of genetic samples; consider	Consider principles of conservation genetics,	Must consider the principles of	No, require prior knowledge. Genetic

	relation to genetic variability /conserving genetic resources. Consider number of individuals to be translocated with respect to genetic variability	genetic risks such as founder effects, inbreeding depression, outbreeding depression, or genetic swamping	including effective population size, compatibility and hybridization	conservation genetics, in particular the number of individuals to be translocated in relation to effective population size	augmentation only if strong arguments to demonstrate necessary for viability of the population. A last resort option
Where appropriate foster captive breeding	Yes, when wild population reduced to a few individuals. Requires appropriate techniques (stud books, etc)	*In situ* conservation the first option; *ex situ* may be a fall-back or adjunct	Resource intensive, additional husbandry requirements, and problems of confinement so requires careful consideration. Details of captive breeding (housing, diet, etc) required.	Not explicitly, but issues re captive breeding (such as diet, housing, genetic management, hardening before release, disease risk) need to be detailed in Translocation Proposal	Not considered
Issues of 'overabundance"	No	Contingency plans for overpopulation on islands and in fenced areas	Provide management strategy to deal with overabundance	Not considered	Not considered
Veterinary screening prior to translocation	Not considered	Required to list disease screening tests undertaken to assess whether pathogens found in the source population are already present in release location	Not considered	Proponent to include information on risk of disease in Translocation Proposal, including at host environment	Health and reproductive status needs to be monitored before and after
Pre-release training	Not considered	Consider behavioural	Not considered	Not considered	Not considered

		training and acclimatisation (hardening)			
Publicise efforts	Yes	Yes	Encourage community awareness and involvement	Not considered	Not considered
Risks	Not considered	Risk assessment of biological, genetic, ethical, social, political, cultural and economic risks	Must identify	Not considered	Not considered
Local community impact	Not considered	Landholders identified as stakeholders		Not considered	Not considered
Assistance and advice to proponents of translocations	Yes	SA DEH staff will assist with risk assessment on a needs basis	No emphasis on assisting and advising proponents (e.g. community groups) of translocations	Not considered	Not considered

Scope 3: Produce a synthesis of the protocols used in the successful translocation of each of the principal vertebrate taxa within Australia.

Method: This will be achieved by producing a summary document on the processes and procedures for the successful translocation of each of the vertebrate taxa within Australia.

Service: Synthesis of the protocols used in the successful translocation of each of the principal vertebrate taxa within Australia.

Milestone: Submission of a summary paper on the processes and procedure of the successful translocation of each of the vertebrate taxa within Australia.

Performance standard and date for completion: A report synthesising and integrating the findings of the two key areas in Scope 1 and 2 submitted to DAFF by June 2009.

Introduction: This section seeks to understand the processes associated with successful translocation of threatened fauna by:

1. Examining the database compiled in Scope 1 to examine factors associated with success and failure;
2. Reviewing the literature on translocations world-wide to establish possible success factors; and
3. Examining the scope and content of State and Territory protocols to see if they provide adequate guidance to practitioners.

What is a successful translocation?

Griffith *et al.* (1989) defined a successful translocation as one that produced a viable, self-sustaining population in the wild. The time frame for assessing this was considered to vary from several years for short-lived species to several decades for long-lived species (Dodd and Seigel 1991). A problem is that self-sustaining does not necessarily equate to long-term persistence (Seddon 1999). Long-term persistence may be affected by demographic stochasticity if populations remain small, or major environmental variation after the population appears well established. There are examples of both in our Australian dataset.

Seddon (1999) gave a variety of alternative definitions of success used by practitioners: breeding by the first wild-born generation; a 3-year breeding population with recruitment exceeding adult death rate; and an unsupported wild population of at least 500 individuals. He made the point that any definition is limited in time and does not necessarily equate to long-term persistence.

Short and Turner (2000), in their reintroduction of the Burrowing Bettong to Heirisson Prong, gave two criteria for success: persistence of the population for greater than five years with likely ongoing persistence given the same management regime; and numbers of bettongs greater than a threshold set by a model assessing the ability of the population to withstand predation.

Unfortunately, none of the above definitions proved particularly useful for this study as the information available on most translocations was extremely sparse.

In this study we have used three definitions of successful translocation. The first is simply the absence of obvious failure. Many translocations within Australia have failed quickly and comprehensively, typically within 12 months of release of animals. A high proportion of monitored (often radio-collared animals) die within a short period of release or animals appear to initially establish but then decline after a time to undetectable levels. Clearly, this definition requires some ongoing monitoring to establish survival and possible breeding and recruitment.

Other definitions used in this study include persistence of the reintroduced population for the arbitrary periods of three and five years. One hundred and eighteen translocations of 49 species were classed as successful by the most liberal definition – the absence of failure (Table 15). These numbers declined to 109 translocations of 42 species for three year persistence and 77 translocations of 34 species for five year persistence.

However, at least 16 of 77 translocations (21%) where species persisted for greater than five years have subsequently failed (Table 15). Despite the limitations of defining success, such definitions provide an objective way of classifying translocations in relative terms that has broad application and allows for an examination of the factors contributing to those relative successes.

Seven species, all mammals, have had five or more successful translocations: Koalas, Tammar Wallaby, Brush-tailed Bettong, Bilby, Black-footed Rock-wallaby, Burrowing Bettong, and Numbat. The Noisy Scrub-bird has had three successful reintroductions. The Heath Goana, the Green and Golden Bell Frog and the Southern Corroboree Frog each have had one successful translocation.

Table 15: Species of Australian fauna having one or more successful translocations. Data are the number of translocations judged successful using each criterion.

Species	Absence of failure	> 3 years	> 5 years	Comment
Green and Golden Bell Frog	1	1	1	
Heath Goana	1	0	0	
Australian Magpie	2	0	0	
Brush Turkey	1	1	1	
Cape Barren Goose	1	0	0	
Crested Pigeon	0	1	1	Failed after > 25 years
Eastern Bristlebird	1	1	0	
Emu	1	2	2	One failed after > 65 years
Gang-gang Cockatoo	1	1	1	
Gould's Petrel	1	1	1	

Helmeted Honeyeater	0	1	0	
Laughing Kookaburra	1	1	1	
Little Penguin	1	0	0	
Lord Howe Island Woodhen	1	0	0	
Magpie Goose	1	1	1	
Malleefowl	1	1	1	
Noisy Scrub-bird	3	1		
Orange-bellied Parrot	1	0	0	
Pink Cockatoo	1	0	0	
Southern Emu-wren	0	1	1	
Banded Hare-wallaby	1	1	1	Failed after > 5 years
Bilby	7	5	2	
Black-footed Rock-wallaby	6	5	5	One failed after > 7 years
Bridled Nailtail Wallaby	2	3	2	
Brush Wallaby	1	0	0	
Brushtail Possum	4	5	5	
Brush-tailed Bettong	8	17	12	Two failed after 3 years; three failed after > 5 years
Brush-tailed Rock-wallaby	0	1	1	Failed after > 8 years
Burrowing Bettong	6	6	6	One failed after > 20 years
Chuditch	1	1	0	
Common Ringtail Possum	1	1	1	
Common Wombat	1	0	0	
Dibbler	1	1	1	
Eastern Barred Bandicoot	2	2	2	
Eastern Grey Kangaroo (Tasmania)	1	0	0	
Gilbert's Potoroo	1	1	0	
Greater Stick-nest Rat	4	3	3	
Koala	17	14	13	
Northern Quoll	2	2	0	
Numbat	5	3	3	One failed after > 12 years
Platypus	1	0	0	
Quokka	0	2	2	One failed after > 8 years
Rothschild's Rock-wallaby	2	0	0	
Rufous Hare-wallaby	2	1	0	
Shark Bay Mouse	0	2	0	
Southern Brown Bandicoot (Vic form)	1	1	1	
Southern Brown Bandicoot (WA form)	3	3	2	
Southern Hairy-nosed Wombat	0	1	1	Failed after > 10 years
Sugar Glider	2	2	2	
Tammar Wallaby	8	4	4	One failed after > 9 years
Thevenard Island Short-tailed Mouse	1	0	0	
Western Barred Bandicoot	2	3	3	One failed after > 9 years
Western Grey Kangaroo	2	2	2	
Western Ringtail Possum	1	1	1	

Yellow-footed Rock-wallaby	2	2	1	
Total	118	109	77	

Species with the highest reported success: fail ratio (Table 16) were the Koala (17:1), Tammar Wallaby (8:1), Black-footed Rock-wallaby (6:1), Bilby (3.5:1), Southern Brown Bandicoot (3:1), and Southern Hairy-nosed Wombat (2.5:1). All but one are either large species (with an adult weight falling beyond the 5.5 kg upper threshold of the critical weight range of Burbidge and McKenzie 1989) and/or are strongly linked to protective shelter such as rock piles or dense vegetation. The exception is the Bilby. For species extinct on the mainland but surviving on offshore islands the best success: fail ratios are for the Greater Stick-nest Rat and the Burrowing Bettong. All successful reintroduction of these two species are either to islands or to secure fenced sites.

Table16: Success: fail ratio for the species most commonly translocated within Australia. Status is as given under the Federal Environmental Protection and Biodiversity Conservation Act 1999.

Common name	Status	# of translocations	Success: fail ratio	No reported outcome
Koala		26	17:1	8
Tammar Wallaby		17	8:1	8
Black-footed Rock-wallaby	Vulnerable	9	6:1	2
Bilby	Vulnerable	15	3.5:1	6
Southern Brown Bandicoot (WA)		12	3:1	8
Southern Hairy-nosed Wombat		7	2.5:1	0
Brushtail Possum		14	2:1	8
Numbat	Vulnerable	13	1.7:1	5
Greater Stick-nest Rat	Vulnerable	9	1.3:1	2
Brush-tailed Bettong		48	1:1	32
Burrowing Bettong	Vulnerable	12	1:1	0
Chuditch	Vulnerable	6	1:1	4
Rufous Hare-wallaby	Endangered	8	0.7:1	3
Noisy Scrub-bird	Vulnerable	10	0.5:1	1
Eastern Barred Bandicoot	Endangered	9	0.5:1	3
Bridled Nailtail Wallaby	Endangered	6	0.5:1	3
Western Ringtail Possum	Vulnerable	7	0.3:1	3
Green and Golden Bell Frog	Vulnerable	8	0.2:1	1
Brush-tailed Rock-wallaby	Vulnerable	6	0:2	4
Malleefowl	Vulnerable	11	0.1:1	3
Shark Bay Mouse	Vulnerable	4	0:1	3
Western Swamp Tortoise	Critically Endangered	5	0:0	5
Western Pebble-mound Mouse		4	0:0	4

The best success: fail ratio for a bird was that for the Noisy Scrub Bird (one success for each two failed attempts). The best for an amphibian was 0.2:1 (one success for each six failed attempts).

Attributes affecting success:

The subsequent tabulations employ the absence of obvious failure as the definition of success. The key statistic is the ratio of successful to unsuccessful projects (the success: fail ratio).

Effect of taxa

Translocations of mammals have been much more successful than those of birds, reptiles and amphibian (Table 17). Some 62% of mammal translocations for which there was a declared outcome were successful. In contrast, only 38% of avian translocations, 33% of reptile translocations, and 10% of amphibian translocations were considered successful.

Table 17: The effect of taxon on outcome of translocations.

	Outcome				Success: fail
Taxon	Successful	Failed	Uncertain	Total	Ratio
Mammal	103	64	121	288	1.61
Bird	18	30	20	68	0.60
Reptile	1	2	9	12	0.50
Amphibian	1	9	2	12	0.11
Total	123	105	152	380	1.17

Effect of status of species (threatened versus non-threatened) on translocation success

Translocations of non-threatened species of mammals (67% successful for translocations with a stated outcome) and birds (43%) were marginally more successful than those of threatened species of the same taxa (56% for mammals and 32% for birds: Table 18). However, the differences were not that great and substantially less than that between all mammal and all bird species. There were insufficient data to compare the effect of status on the success of translocations of reptile and amphibian species.

Table 18: The success or otherwise of translocations of mammal, bird, reptile and amphibian compared by status.

		Outcome				Success: fail
Taxon	Status	Successful	Failed	Uncertain	Total	Ratio
Mammal	Threatened	46	36	53	135	1.28
	Non-threatened	57	28	68	153	2.04
Bird	Threatened	8	17	18	43	0.47
	Non-threatened	10	13	2	25	0.77
Reptile	Threatened	0	0	6	6	-
	Non-threatened	1	2	3	6	0.50
Amphibian	Threatened	1	8	2	11	0.11
	Non-threatened	0	1	0	1	0.00
Total		123	105	152	380	1.17

Effect of size of release group:

The number of animals released had a significant effect on success of translocations for birds but not for mammals (Table 19a, b). Translocation of birds that utilized 50+ individuals had a 75% success rate compared to 19% for those that utilized < 20. For mammals, there was no clear trend. Releases of intermediate numbers (20-49) had the greatest success (66%). Releases of <20 had a success of 63%, while releases that utilized 100+ individuals had a success of 57%. When classes were grouped, releases of < 50 were more successful (64%) than those of 50 or more (53%).

No conclusions could be drawn for reptiles or amphibians due to the small sample (Table 19c, d).

Table 19a: The effect of size of release group for mammals. No data are available for group size for 41 translocations.

	Outcome				
Release size	Successful	Failed	Unknown	Total	Ratio success/fail
< 20	34	20	19	73	1.70
20-49	35	18	47	100	1.94
50-99	12	12	14	38	1.00
100+	13	10	13	36	1.30
Total	94	60	93	247	1.57

Table 19b: The effect of size of release group for birds. Four records had no data on release size.

Release size	Outcome				
	Successful	Failed	Unknown	Total	Ratio success/fail
< 20	5	21	9	35	0.24
20-49	6	6	4	16	1.00
50+	6	2	5	13	3.00
Total	17	29	18	64	0.77

Table 19c: The effect of size of release group for reptiles. Four records had no data on release size. (Note: no information on release size is available for the apparently successful establishment of the heath goanna on Reevesby Island, South Australia).

Release size	Outcome				
	Successful	Failed	Unknown	Total	Ratio success/fail
< 20	0	1	2	3	0.00
20-49	0	0	2	2	---
50+	0	1	2	3	0.00
Total	0	2	6	8	0.00

Table 19d: The effect of size of release group for amphibians (note: primarily tadpoles)

Release size	Outcome				
	Successful	Failed	Unknown	Total	Ratio success/fail
< 1000	1	2	1	4	0.50
> 1000	0	3	1	4	0.00
Total	1	5	2	8	0.20

Captive versus wild-sourced:

There appeared to be little obvious difference in success rate between translocations of mammals or birds where individuals were sourced from captive populations as compared to those drawing animals directly from the wild (Table 20). Comparative values for mammals were wild-to-wild (63%) and captive-sourced (60%). Wild-to-wild translocations of birds had similar success to translocations where birds originated from captive sources (wild: 42% where a declared outcome versus captive success: 43%). There was insufficient data for reptiles and amphibians to suggest which source, if any, was more effective for translocations.

Table 20: The effect of source of animals (captive versus wild) on the outcome of translocations. Note: There was no information on source population for 110 translocations.

		Outcome				Success: fail
Taxa	Source	Successful	Failed	Uncertain	Total	Ratio
Mammal	Captive-sourced	21	14	23	58	1.50
	Wild-sourced	53	31	64	148	1.71
Bird	Captive-sourced	3	4	8	15	0.75
	Wild-sourced	8	11	6	25	0.73
Reptile	Captive-sourced	0	1	8	9	0.00
	Wild-sourced	0	0	1	1	0.00
Amphibian	Captive-sourced	1	8	1	10	0.13
	Wild-sourced	0	0	1	1	0.00
Total		86	69	112	267	1.25

Soft versus hard release:

Hard releases were typically more successful for mammals and less successful for birds (Table 21). The difference was very substantial for birds, but data were limited for soft release (soft: 67%; hard: 27%). The key releases of birds employing soft release were those of Gould's Petrel and Orange-bellied Parrot.

Table 21: The effect of type of release (soft/hard) on translocation success. Translocations where there was a mixed release strategy are grouped with soft release. Note: There was no information available on type of release for 249 translocations.

		Outcome				Success: fail
Taxa	Release type	Successful	Failed	Uncertain	Total	Ratio
Mammal	Soft	14	16	6	36	0.88
	Hard	28	15	13	56	1.87
Bird	Soft	2	1	5	8	2.00
	Hard	7	19	2	28	0.37
Reptile	Soft	0	1	0	1	0.00
	Hard	0	1	1	2	0.00
Total		51	53	27	131	0.96

Cause of failure:

Predation of one sort or another was the key cause of failure of translocations for both mammals (80% of all failures where a cause was given) and birds (64%) (Table 22). Of these, foxes and feral cats were invoked in 71% of mammal failures and 55% of bird failures. Predation was also a significant issue for reptile translocations (Mulga Snakes predating Woma Pythons) and for amphibians (various combinations of exotic Plague Minnows (*Gambusia holbrooki*), native Striped Marsh Frog (*Limnodynastes peronii*) and cannibalism on the Green and Golden Bell Frog at different sites). However, data for reptiles and amphibians were too sparse to draw firm conclusions.

Table 22: Reasons given for failure of translocations

Cause of failure	Mammal	Bird	Reptile	Amphibian	Total
Fox predation	11	5	0	0	16
Cat predation	13	0	0	0	13
Fox/cat predation	4	0	0	0	4
Dog predation (domestic)	2	0	0	0	2
Dingo/fox predation	1	0	0	0	1
Dingo/cat predation	1	0	0	0	1
Fox/cat/avian predation	1	1	0	0	2
Cat/drought	1	0	0	0	1
Avian predation	2	1	0	0	3
Snake predation	0	0	1	0	1
Exotic fish predation	0	0	0	1	1
Habitat unsuitable	1	0	0	4	5
Fire	0	2	0	0	2
Food shortage, possibly linked to captive breeding	0	1	0	0	1
Unfamiliarity/naivety	1	0	0	0	1
Lack of pre-release training	0	0	0	0	0
Homing	1	1	1	0	3
Multiple causes	6	0	0	1	7
Disease	0	0	0	0	0
Genetic attributes	0	0	0	0	0
Husbandry (transport/release)	0	0	0	0	0
Total	45	11	2	6	64

Effectiveness of predator management:

The degree of success of translocations relative to the effectiveness of predator management was assessed by comparing island sites, fenced sites and unfenced sites (Table 23).

Table 23: Success or failure of translocations to sites with different levels of exposure to terrestrial predators. Note: There were at least 16 translocations to islands for which the presence or absence of cats was not stated.

Taxa	Release type	Outcome				Success: fail Ratio
		Successful	Failed	Uncertain	Total	
Mammal	Island, no foxes, no cats	14	3	5	22	4.67
	Island, no foxes but cats	5	4	0	9	1.25
	Fenced	24	17	19	60	1.41
	Mainland, unfenced	32	28	49	109	1.14
Bird	Island, no foxes, no cats	2	1	0	3	2.00
	Island, no foxes but cats	4	11	1	16	0.36
	Fenced	1	1	2	4	1.00
	Mainland, unfenced	6	16	9	31	0.38
Reptile	Island, no foxes, no cats	0	0	0	0	-
	Island, no foxes but cats	1	0	0	1	-
	Fenced	0	1	2	3	0.0
	Mainland, unfenced	0	1	1	2	0.0
Amphibia	Island, no foxes, no cats	0	0	0	0	-
	Island, no foxes but cats	0	0	0	0	-
	Fenced	1	1	0	2	1.00
	Mainland, unfenced	0	2	1	3	0.00
Total		90	86	89	265	1.05

<u>Translocations to islands</u>

Clearly, islands without foxes and without cats are very effective places to re-establish mammal species – 82% of translocations were successful (Table 23). Islands without foxes but with cats were significantly poorer sites for translocation of mammals (a success rate of 56%). Translocations of birds to islands without foxes and cats had a relatively high rate of success (67%; n = 3). However, islands without foxes but with cats, provide poor translocation sites for birds (27%: n = 15). The latter result is heavily biased by the data from Kangaroo Island. Many bird species translocated to here had very small founder sizes and this may also have impacted on success rates.

Predation was implicated in all failed reintroductions of mammals at mainland sites with fences, suggesting a failure to effectively exclude predators. The failure of the reintroduction of the single reptile species to a fenced area (the Woma Python) was due to predation from an endemic snake. Relatively few bird species have been reintroduced to fenced areas. The one success is that of Malleefowl to Peron Peninsula in Western Australia. The loss of the reintroduced Bush Thick-knee from Venus Bay Conservation Park in South Australia was attributed largely to poor foraging skills of birds raised in captivity leading to malnutrition and snail shell impaction in crops (Wheaton 2008).

Translocation to fenced sites

Fenced sites varied greatly in effectiveness of predator control. Some sites have had a history of predator incursions (foxes to Yookamurra Sanctuary, feral cats to Heirisson Prong) and some fenced sites are fenced in name only (Peron Peninsula). In contrast, sites run by Australian Wildlife Conservancy and Arid Recovery have high levels of resourcing, high quality fences, permanent staff, and frequent fence checks to ensure integrity. Overall, fenced sites had a success: fail ratio of 1.41 (59% of translocations with a declared outcome were successful). When AWC and Arid Recovery projects were considered in isolation the success: fail ratio improved to 17:4 (4.25); roughly comparable to that of islands without foxes or cats.

Success or otherwise of translocations of reptiles to fenced sites (for example, Western Swamp Tortoise) could not be effectively evaluated because of the long life cycle of this species.

Unfenced sites

Seventy seven of 107 (72%) translocations of mammals were to unfenced sites that had active programmes of fox control. Presumably, these would have had varying levels of effectiveness. The success: fail ratio at these sites was 18:23 (0.78), with the balance having no declared outcome. There were 30 translocations of mammals to sites where there was no stated fox control, with a success: fail ratio of 12:5 (2.4). Successful translocations included those of Koala (4), Brushtail Possum (3), Eastern Grey Kangaroo, Common Wombat, Yellow-footed Rock-wallaby, Sugar Glider and Rothschild's Rock-wallaby. Hence, successes at unfenced site in the apparent absence of fox control were largely from species either outside the critical weight range, arboreal, or beyond the northern boundary of the range of foxes.

Effect of size of release area

The size of release area appeared important for mammals, favouring mid-sized (5,000 – 50,000 ha) and smaller over larger areas (Table 24). This largely reflects the lack of large predator-free islands and the difficulty of managing exotic predators in larger, and often remoter, areas. The bulk of translocations of mammals (67%) have been to areas of less than 5,000 hectares.

There appeared to be little trend for birds and insufficient data to make any conclusion for reptiles and amphibians.

Table 24: The effect of size of release area on success of translocation. There were no data on release area for 133 translocations

		Outcome				Success: fail
Taxa	Release area	Successful	Failed	Uncertain	Total	Ratio
Mammal	< 5,000 ha	59	27	44	130	2.19
	5,000 - 50,000 ha	11	3	19	33	3.67
	> 50,000 ha	5	14	12	31	0.36
Bird	< 5,000 ha	4	10	7	21	0.40
	5,000 - 50,000 ha	5	13	2	20	0.38
	> 50,000 ha	2	0	1	3	-
Reptile	< 5,000 ha	1	1	4	6	1.00
	5,000 - 50,000 ha	0	0	0	0	-
	> 50,000 ha	0	0	0	0	-
Amphibia	< 5,000 ha	1	1	1	3	1.00
	5,000 - 50,000 ha	0	0	0	0	-
	> 50,000 ha	0	0	0	0	-
Total		88	69	90	247	1.28

Effect of type of translocation: introduction, reintroduction or restocking

The relative successes of the various types of translocation (reintroduction, introductions, and restocking) are compared in Table 25.

Introductions of mammals were substantially more successful (80%) than were reintroductions (54%). Introductions included the release of species to islands for aesthetic reasons (such as to Kangaroo Island), conservation introductions often to islands (such as the release of Brush-tailed Bettongs and Black-footed Rock-wallabies to South Australian islands, and Northern Quoll to Northern Territory islands to escape the cane toad), and releases to fenced sanctuaries (such as Rufous Hare-wallaby to Scotia Sanctuary). Hence most introductions of mammals were to secure sites, free of key threatening processes.

Restocking was the most successful strategy for birds (60% successful), relative to 37% for introductions and 26% for reintroductions. Restocking of birds was often for conservation purposes. They included translocations of Orange-bellied Parrot, Malleefowl, Eastern Bristlebird, Bush Thick-knee, and Black-eared Miner. Practitioners have used restocking to supplement existing populations that were perceived to be declining or at risk.

Insufficient data are available for reptiles and amphibians for any useful comparison.

Table 25: The effect of type of translocation on success

Taxa	Release area	Outcome				Success: fail
		Successful	Failed	Uncertain	Total	Ratio
Mammal	Introduction	35	9	9	53	3.89
	Reintroduction	61	53	97	211	1.15
	Restocking	8	2	14	24	4.00
Bird	Introduction	7	12	0	19	0.58
	Reintroduction	5	14	10	29	0.36
	Restocking	6	4	10	20	1.50
Reptile	Introduction	1	0	5	6	---
	Reintroduction	0	1	1	2	0.00
	Restocking	0	1	3	4	0.00
Amphibian	Introduction	0	3	1	4	0.00
	Reintroduction	0	5	1	6	0.00
	Restocking	1	1	0	2	1.00
Total		124	105	151	380	1.18

Discussion

Translocation of fauna is often viewed in the scientific literature as a somewhat problematic solution to a significant conservation problem. There are a number of contributing factors to this:

1. Early international examples of translocations were of captive stock of third-world species raised in first-world zoos. These included species such as Przewalski's horse (*Equus przewalskii*), Père David's deer (*Elaphurus davidianus*), Arabian oryx (*Oryx leucoryx*), various rhino species, and primates such as golden lion tamarin (*Leontopithecus rosalia*) (Ehrlich and Ehrlich 1981; Kleiman 1989). This led to the suggestion from some that money and effort would be more effectively invested in habitat and species protection *in-situ i*n the third-world than captive breeding *ex-situ* in first-world zoos (Lindburg 1992; Balmford *et al.* 1995).
2. Concern was expressed over well-meaning but unregulated and presumably unhelpful releases of native animals for conservation in Britain (Griffiths *et al.* 1996);
3. Suggestions of resurrecting the historic fauna of islands such as Britain, including such species as wild boar *Sus scrofa* and beaver *Castor fiber*, would likely fundamentally change the appearance of the landscape to something very different to the current (Morris 1986). Because that former state was so far in the past and because of the potential new human-wildlife conflicts these ideas did not gain wide acceptance.
4. Translocation of fauna was often seen as a convenient off-set for development activities. It relied on the perception of successfully transferring animals away from harm. An example is that of the Gopher Tortoise *Gopherus polyphemus* in Florida where its habitat was being mined and many areas were undergoing rapid urban development (Dodd and Seigel 1991).
5. The introduction on non-native species to island ecosystems, including that of Australia, has created major and ongoing environmental problems.
6. The past introduction of native species to offshore islands such as Kangaroo Island has created major and ongoing environmental problems (Copley 1994a).
7. Translocation of fauna for conservation purposes is often perceived to be expensive and ineffective, particularly when reliant on captive breeding (Kleiman 1989).

Reintroductions of fauna probably work best when there is suitable but vacant habitat available for the species to be translocated. However, if the species does not occur at the destination site then there is typically a reason for this. This reason is likely to preclude the successful establishment of reintroduced individuals. If the species does occur at the destination site, then translocated individuals may have detrimental impacts on the existing population through competition for resources, disruption to social organisation, or introduction of disease.

However, in Australia, suitable, yet vacant habitat can occur through:

- Fragmentation of bushland and subsequent local extinction of sub-populations with few opportunities for recolonisation (such as in the Western Australian wheatbelt);
- The application of new technologies for control of predators such as the introduced fox (e.g. the Western Shield initiative in Western Australia, and Operation Bounce Back in South Australia) that provide opportunities for the re-establishment of prey species that formerly occurred there;

- Private and community involvement in the creation of “sanctuaries” that are fenced to exclude exotic predators (e.g. Short *et al.* 1994; Schmitz and Copley 1997), so providing new opportunities for the re-establishment of threatened species;
- Islands, where natural dispersal of the species has been prevented by a water barrier (Delroy *et al.* 1986);
- Arid ecosystems, where major fluctuations in numbers of a particular species may allow supplementation at the low point of the abundance cycle; and
- Intensively hunted species whose numbers fall well below carrying capacity due to elevated mortality rates (e.g. Koala in Australia in the late 1800s and early 1900s; trout in Australia; and game birds in the US and Europe).

The recognition of these opportunities has led to a resurgence of the use of translocation for conservation in Australia.

Serena and Williams (1994) suggested the need for policies at the national level to guide translocation procedures to ensure projects were “both warranted and properly planned and executed”. They highlighted the potential risks of translocation:

- the inadvertent introduction of diseases to the release site;
- the introduction of inappropriate genetic stock;
- negative impacts on other species at the release site; and
- poor return on investment relative to other conservation activities and the possible diverting of funds from direct protection of habitat of threatened species.

They saw the potential benefits as:

- establishing new populations of threatened species and thus improving their long-term prognosis for survival;
- improving the understanding of the ecology of threatened species;
- improving the understanding of impact of threatening processes;
- contributing to re-establishing diversity in rehabilitated habitats;
- raising the perceived value of natural areas by the public; and
- building interest in conservation in the wider community.

They suggested that policies to guide translocation should be based on IUCN (1987) and should consider:

- the possible deleterious impact of translocated animals on conservation values at the release site;
- the ability of the release site to sustain the transfer of animals;
- the selection of appropriate stock for release; and
- whether the original cause of extinction had been ameliorated or eliminated.

They also suggested the need for a comprehensive written proposal and the stipulation of post-release monitoring. A draft policy document (Endangered Species Advisory Committee 1994), the precursor to the draft ANZECC guidelines, was provided as a starting point for policy development.

Western Australia, South Australia, New South Wales and Northern Territory have developed comprehensive policies to regulate translocation of threatened species. South Australia's policy encompasses all species that are translocated for conservation purposes. These States and Territory collectively have undertaken some 84% of recorded reintroductions (208/248). It is unclear what process the other States and the Australian Capital Territory used to assess and manage their translocations. However, it is likely that they are guided to a large degree by the IUCN and ANZECC guidelines, which appear to have wide currency. It appears that policy development in this area is largely driven by need. Hence, the Commonwealth (ANZECC) and most mainland States where Koalas occur (Queensland, NSW, and Victoria) have specific policies on their translocation.

Thus the State and Territory regulatory authorities have largely responded to the need identified by Serena and Williams (1994). However, translocation of threatened fauna is only a small part of the overall number of species and individuals that are translocated – many reintroductions are of species not formally listed as endangered under State or Territory legislation, and most examples of restocking and introductions fall outside the scope of the policy documents of most States. These include most animals relocated where there is a human-animal conflict, animals obstructing development, and animals returned to the wild by carers and hobbyists.

Issues to do with translocation of threatened species

1. The lack of long-term monitoring and reporting of success or failure of translocations.

This is a common theme in all reviews of translocations (Griffith *et al.* 1989, Short *et al.* 1992, Fischer and Lindenmayer 2000) and is just as evident in the results of this report. The cause of decline was not explicitly stated in 57 of 116 published reintroduction case studies (49%) collated by Fischer and Lindenmayer (2000).

Similarly, some 40% of translocations identified in the current study had an indeterminate outcome (Table 6). The number of translocations of indeterminate outcome varied substantially by jurisdiction (Table 7) and suggested room for improvement in some States, chiefly Queensland, Western Australia and Victoria. Western Australia has recently introduced a scheme of on-line reporting that may aid collation and reporting of data.

Griffith *et al.* (1989) suggested that permit-granting agencies may need to assume the role of maintaining a database of translocations so that the predictability of success can be enhanced over time. Western Australia maintains a database of translocations and several states periodically report on outcomes of translocation (South Australia: Copley 1994a; Western Australia: Morris 2000, Mawson 2004).

2. The apparently poor prognosis for the success of translocations.

The poor prognosis for translocations has been highlighted by Griffith *et al.* (1989), Kleiman (1989) and Short *et al.* (1992). Fischer and Lindenmayer (2000) suggested a particularly high failure rate of translocations in Australia and New Zealand (56%) relative to the USA (10%). Fischer and Lindenmayer (2000) suggested that there has been no change in success over two decades of reintroductions.

There is no clear time-trend in the Australian data (Table 8). This is largely because of a period of successful translocations in the 1970s. However, these translocations were largely to islands off South Australia (6 of the 12 successful translocations) or were of mammals with a weight above the critical weight range reintroduced on the mainland (Southern Hairy-nosed Wombat: a further 4 of the 12).

Hence, part of the reason for no time trend is that practitioners have attempted more difficult and problematic translocations over time, with a consequent fall in success rate. This includes a focus on the translocation of critical weight range mammals to unfenced sites in Western Australia and the translocation of amphibian species in the past 15 years.

R. Cooney (pers. com. 2008) suggested a key risk for government might be the “waste of limited agency resources” if prognosis for translocations is poor or if other actions would achieve greater benefit for less resources. However, reintroductions have successfully increased the number of populations of many threatened species thus substantially reducing the risk of extinction. Examples include Greater Stick-nest Rat (previously represented by a single population), Bridled Nailtail wallaby (formerly a single population), Western Barred Bandicoot (formerly just two populations), Banded Hare-wallabies (two populations), and numerous others (Table 15). They have also provided valuable information on the effect of threatening processes on fauna.

3. Effect of status of species (threatened versus non-threatened) on translocation success

Griffith *et al.* (1989) found that translocations of native game species (86%) were twice as successful as those of threatened, endangered, or sensitive species (44%). The supplementation of game species by translocation is rare in Australia and there are few species where direct hunting by humans is the key threatening process.

Typically, translocation success for Australian species was higher for non-threatened species than for threatened species (mammals: 66% versus 55%; birds: 43% versus 40%) (Table 18). No comparison could be made for reptiles or amphibian.

Many of the State policies (for example, Western Australia, New South Wales) only apply to threatened fauna, whereas translocations may be proposed for non-threatened fauna. Clearly, a large proportion of translocations in the current database are for non-threatened native fauna. Similarly, many translocations of fauna are done for reasons other than conservation – such as local over-abundance or a conflict with urban expansion. It is unclear what protocols apply to such translocations.

The most significant problems for regulatory authorities appear to be:

- the pressure to use translocations as a humane alternative to culling – that is dealing with the problems of overabundant native fauna. Such translocations are often either introductions or restocking (cf. reintroductions) and have a particular set of problems;
- the pressure to shift native animals and plants away from proposed developments such as urban developments, highways, mines, or processing plants. Proponents often see translocation as a way of ameliorating the impact of the development. The alternative view is that translocations “can play an important and problematic cosmetic role of obscuring the real impacts of development” (R. Cooney pers. com. 2008).

Some states, such as New South Wales, have specific policies on problem possums and problem magpies. Neither policy supports translocation as an option for dealing with the problem (R. Cooney, pers. com., 2008). There are no relevant guidelines for other problem animals in New South Wales. Species such as Koalas have specific guidelines on translocation by ANZECC, Queensland, New South Wales and Victoria.

Translocation is used as mitigation to allow local development (for example Gopher Tortoise in Florida where its habitat was being mined and in areas where rapid development is occurring: Dodd and Seigel 1991). Dodd and Seigel were sceptical of the benefits and saw the promotion of translocation as acting to undermine efforts to protect existing habitat and providing "an easy way out of difficult land use questions". Much of such efforts were predicated on the "concern for the fate of individual animals" and the need to move them out of harm's way.

Clearly, this is a difficult area for regulators.

4. Understanding and controlling threatening processes

Fischer and Lindenmayer (2000) report that 49% of published case studies gave no explicit cause of decline. In 35% of cases, the cause of decline was known, explicitly stated and effectively removed. However only a fifth of these were considered successful (9 of 41), 7% unsuccessful, and the majority (71%) uncertain.

Kleiman (1989) identified the elimination of factors causing species decline as a key prerequisite for success of translocations. Short *et al.* (1992) emphasised the importance of controlling predators at reintroduction sites for macropods.

There is general agreement in the literature that the addition of extra animals to a population (restocking) is unlikely to be a solution to low numbers without the removal of some threatening process (Jordan 2003).

5. Habitat quality

Habitat quality is clearly a significant issue in translocation success. Griffith *et al.* (1989) found a success rate of 84% for translocations to "excellent" habitat, declining to 38% in "fair" or "poor" habitat. However, few of the Australian translocations in this study appeared to fail based solely on this attribute. Perhaps this is because translocations are typically to high quality protected areas. Griffith *et al.* (1989)'s data was dominated by supplementation of game species and so translocations presumably were to a range of habitat qualities.

Habitat quality issues may be important in the lack of success of some bird species. Some translocations of Noisy Scrub Bird have failed because of wildfire removing dense habitat for shelter and foraging (Burbidge 2003).

Similarly, complex fire-induced mosaics have been suggested as the key to the persistence of some species of mammals (Johnson *et al.* 1989, Burbidge and McKenzie 1989, but see Short and Turner 1994). However, an attempt to create such a complex mosaic of habitat and reintroduce threatened mammals ended in failure, due largely to cat predation (Christensen and Burrows 1994)

Issues such as water temperature (Pyke *et al.* 2008) and foraging habitat (White and Pyke 2008) were important determinants of success or otherwise in translocations of the Green and Golden Bell Frog.

A key determinant of success in translocation arising out of the work of Griffith *et al.* (1989) is the notion that translocations to the core of a species range may be more successful than those to or beyond the periphery. This was reinforced by Wolf *et al.* (1996). The theoretical basis is that the population dynamics of a species is more favourable to reintroduction success in the core of its range as its abundance is typically greater and variance in abundance is less towards the centre of its range. However, this result was challenged by Lomolino and Channell (1995, 1998), who argued that sites on the periphery of a species range provide critical refugia because of their apparent isolation from anthropogenic and other threatening processes. They argued that a key factor in range collapse of many species was the anthropogenic mixing of biotas, exposing ecologically naive endemic species to cosmopolitan human comensals.

6. Founding size influencing success

It appears self-evident that a larger release group should have a greater chance of successful establishment. A larger group potentially overcomes problems of both demographic stochasticity and genetic variability. Griffith *et al.* (1989) found that success increased with size of release group up to a threshold – they suggested an optimum size of 20-40 individuals for large game mammals and 80-120 for game birds. However, Short *et al.* (1992) found no clear-cut relationship for macropods. Many successes came from smaller releases. They concluded that a larger release was not a substitute for effective management of threatening factors, principally predation. Exotic predators, if not controlled effectively, would overwhelm the release, regardless of size (cf. Sinclair *et al.* 1998).

Wolf *et al.* (1996), in a follow-up study to Griffith *et al.* (1989), found no change in the success of translocations despite a general increase in median number of animals translocated from 31.5 to 50.5 between the two studies. Fischer and Lindenmayer (2000), in a review of 180 published case studies dealing with all kinds of animal species (36 from Australia) found translocation success was improved by a release group size greater than 100 individuals.

The current study found a markedly different result for mammals and birds. Releases of birds clearly benefitted from the release of larger groups (> 50 animals). In this taxon, success was four times that of releases of < 20 animals (86% versus 23%). The median number of birds released in Australian translocations (of those where a number was recorded) was 15, and this may be a major factor contributing to the low success rate.

New Zealand translocations of birds typically tend to use about 40 birds (Armstrong and McLean 1995). However, they note some significant successes with much smaller release groups (three populations of robins established from groups of five individuals). Similarly, there were successful releases of Brush Turkey, Laughing Kookaburra, and Cape Barren Goose on Kangaroo Island with founder group of two to seven (Copley 1994a), contrasting with releases of eleven bird species that failed to establish (with founder groups of two to 30, median of 4: Copley 1994a).

Briskie and Mackintosh (2004) provided evidence that severe population bottlenecks in birds led to decreased hatchability of eggs. They suggested that populations of New Zealand birds established from < 150 individuals had significantly greater hatchling failure and that such failure may even occur in populations founded by as many as 600 birds.

Clearly, translocations of birds in Australia would benefit from greatly increasing the size of release groups.

However, in contrast to birds, success in mammal translocation showed an inverse relationship to release size. Success was greatest for releases utilizing less animals (< 50). There were several examples of the failure of large releases of mammals to sites where exotic predators were not effectively controlled (673 Quokkas released to Jandakot, WA and releases of 318 and 142 Brush-tailed Bettongs to Paruna Wildlife Sanctuary and Francois Peron National Park, WA, respectively). The release of large numbers of animals did not allow the fledgling population to escape the impact of predators at the mainland sites. In addition the release of Brush-tailed Bettongs to St Francis Island Conservation Park, SA was also unsuccessful. The reason for the failure at this site is less clear. Delroy *et al.* (1986) suggest lower soil fertility, competition with bandicoots *Isoodon obesulus nauticus*, changed habitat, hotter climate or lack of water as possible explanations.

The median number of mammals released in Australian translocations (of those where a number was recorded) was 36.

7. Major differences in success of translocations of the different major taxa

One of the major differences in translocation success was between taxa, with mammal translocations substantially more successful (62%) when compared with avian translocations (38%), reptile translocations (33%), and amphibian translocations (10%). Wolf *et al.* (1996) similarly found that translocation of birds were less successful (63%) than those of mammals (73%).

Translocations of mammals were much more common in Australia than were those of birds, which were in turn more common than those of reptiles and amphibians. This is broadly consistent with the international sample of translocations obtained by Fischer and Lindenmayer (2000) from the published literature (mammals: 49%; birds 44%; reptiles, amphibians and invertebrates combined: 7%). Clearly, mammal translocations are disproportionately more prevalent in Australia relative to the other taxa than elsewhere in the world. In part, this is due to the common practise of supplementing game bird populations in North America which boosts the number of translocations of birds in the international sample.

Mammals

The success or otherwise of mammal translocations in Australia was overwhelmingly a function of the success or otherwise of predator management at release sites. Thirty six of 45 failures were attributed to some form of predation, predominantly from foxes and/or cats (Table 22). The success of mammal translocations was strongly linked to the effectiveness of fox and cat control (Table 23). Hence, there is a conceptual simplicity to management, even though the practical reality of long-term, continuous and effective predator management is one of extraordinary difficulty and ongoing expense.

Birds

The lower success rate for birds can be attributed to a number of factors. There were a substantial number of early translocations of bird species to Kangaroo Island. Many of these employed very small founder groups and this may well have contributed to poor outcomes. Sixteen unsuccessful avian translocations with no attributed cause of failure had an average release group size of 10.2 individuals, substantially less than the number recommended by Griffith *et al.* (1989) and others (see discussion re founding size above).

Translocations of Malleefowl in eastern Australia were largely about establishing the role of predators in this species decline rather than establishing new populations – so many releases were to areas where predators were not controlled (Priddel and Wheeler 1990, 1996, 1999). Hence, often these were successful experiments but unsuccessful as translocations. Seven of 11 failed translocations of birds where a cause could be reasonably suggested were attributed to predation from foxes or avian predators (Table 22).

Predation has been implicated as a key factor in the decline of island birds world-wide. Predation from introduced predators such as cats, rats, mustelids, mongooses and monkeys has been the cause of decline of thirty four of some 110 species of birds (31%) that have become extinct since *c.* 1600 (Groombridge 1992 in Cote and Sutherland 1997). Often these are birds that occupy islands and have therefore evolved in the absence of the new predator and have ineffective defensive behaviours (Atkinson 1985, Bunin and Jamieson 1995). Even in co-evolved faunas, predators such as the Red Fox *Vulpes vulpes* may become a problem for some birds (mallard) when humans alter a multi-predator system (such as the canid community dominated by the Wolf *Canis lupus*) to a single species system dominated by the Red Fox (Johnson and Sargeant 1977 in Cote and Sutherland 1997)). Sovada *et al.* (1995) similarly showed that duck nesting success was greater when Coyotes *Canis latrans* were the dominant predator rather than when the Red Fox was dominant. Hence, the Red Fox is a potent predator shaping bird communities even in co-evolved communities when it is the dominant predator.

Many threatened Australian bird species are weak flyers (for example, Emu Wren, Malleefowl, Ground Parrot, Noisy Scrub Bird), and hence are likely to be poor recolonisers after stochastic events or if habitat is fragmented. They also nest and roost close to the ground. These characteristics predispose a species to predation by mammals (Armstrong and McLean 1995).

A meta-analysis of 20 studies that examined the effects of predation on birds in co-evolved systems (Cote and Sutherland 1997) found that removing predators had a marked effect on hatching success and post-breeding population size. However this did not always translate into a greater breeding density of the prey species. Breeding densities tended to be constrained by food supply, territorial space and availability of nest sites, particularly for hole-nesting species.

Other key factors implicated in the decline of bird species include habitat change, through loss or fragmentation, or change in structure. Often habitat change and predation are linked, such as when fire opens up habitat and consequently makes resident species more vulnerable to predation. Fragmentation of habitat is believed to contribute to high rates of nest predation, as the relative amount of edge habitat is greater and this habitat typically suits generalist predators (Paton 1994).

Some bird species, such as Noisy Scrub Bird, were very cryptic and persist in and were translocated to dense habitat. Hence it was often difficult to develop a clear picture of what factors might be impinging on success. Possible candidate factors include cat predation, black rat predation, and issues to do with habitat quality such as possible reduced litter accumulation resulting from a fire frequency greater than that in past times (Allan Burbidge, pers. com.).

Scott and Carpenter (1987) have highlighted issues to do with the release of captive-raised birds: whether birds are hand-reared, parent-reared, puppet-reared, or reared by a surrogate species; whether fostered or cross-fostered as eggs or nestlings into the nest of wild birds; or released as juveniles or adults. A key recommendation was that birds be individually marked so that their survival or otherwise could be linked to their earlier husbandry and release technique.

The mobility of many bird species encourages widespread movement leading to homing or dispersal and loss of contact with other animals released at the same time and place. Australian examples include Little Penguin (Hull *et al.* 1998), Australian Magpie (Jones and Finn 1999), and Helmeted Honeyeater (Smales, Quin *et al.* 2000).

Wolf *et al.* (1996) found that factors important for the success of avian translocations were number of animals released, range (core versus periphery or beyond), and status (game versus threatened or sensitive). They found that respondents judged habitat quality/quantity and predation as the most influential factors in unsuccessful translocations of birds and mammals, while habitat quality/quantity and habitat improvement were judged the most influential biological factors contributing to self-sustaining translocations.

Griffith *et al.* (1989) have highlighted the importance of acting before the last resort stage when populations are in decline and density is reduced. Both these factors are associated with low translocation success. It also leads to problems in obtaining sufficient animals to translocate with a reasonable prospect of success. An example of such a situation is Kakapo (*Strigops habroptilus*) in New Zealand (Lloyd and Powlesland 1994). Even with successful physical transfer to offshore islands, limited production of young has limited success of the translocation of Kakapo (Lloyd and Powlesland 1994). Kakapo is a species that had declined to just 62 birds, and required heroic and sustained effort to effect recovery (Elliott *et al.* 2001).

Armstrong and McLean (1995) attributed the high rate of success of translocations in New Zealand, chiefly of birds, to: translocation to islands; animals sourced from the wild, rather than captive-reared; the species involved displaying adaptability, presumably to habitat; practitioners avoiding "translocations when the outcome seemed uncertain"; and using relatively high numbers of animals to initiate new populations.

Griffith *et al.* (1989) found that for birds morphologically similar species had a greater depressing effect on successful establishment than did congeneric species.

Reptiles and amphibians

In an early study of the translocation of reptiles and amphibians (Dodd and Seigel 1991), 19% were classed as successful, 23% were unsuccessful, and 58% of projects could not be classified. Four of the five successful projects involved crocodilians. Release groups of Muggers *Crocodylus palustris*, Saltwater Crocodiles *C. porosus* and Gharials *Gavialis gangeticus* all exceeded 1000. There were no examples of the establishment of self-sustaining populations of snakes, turtles, frogs, or salamanders, despite moving many thousands of individuals of several species including Ridley's Turtle *Lepidochelys kempi* and the Gopher Tortoise.

Ten years later, Seigel and Dodd (2002) remained cautious about translocation of amphibians, citing the only success to 1991 being the Natterjack Toad *Bufo calamita* in the United Kingdom. In this case, translocation was accompanied by a large-scale habitat restoration and maintenance effort. Projects to translocate critically endangered species were particularly unsuccessful, with the few successes being for non-endangered species. They were particularly concerned about the dangers of the spread of disease by translocation – fungal infections and iridoviruses – and the weakening of existing secure populations by taking eggs or tadpoles for high-risk translocation attempts. They saw translocation of amphibians as being in an experimental phase rather than being a proven technique for conservation.

Dazak *et al.* (1999) specifically cite translocation as a major issue in the spread of diseases (chiefly chytridiomycosis in Australia; also ranaviral disease in the UK and North America). Chytridiomycosis affects over 38 amphibian species in 12 families, including ranid and hylid frogs, bufonid toads and some salamanders (Dazak *et al.* 1999), and has been implicated particularly in population declines of amphibian species in montane rain forests. It is widespread in Australia (e.g. Obendorf and Dalton 2006).

In a recent review of amphibian and reptile translocations, Germano and Bishop (2008) reported a success rate twice that of Dodd and Seigel (1991), with no difference in success rate between the two taxa. Their data came from 85 translocations reported in the scientific literature: 45% amphibian and 55% reptile. Forty two percent of translocations were considered successful and 24% had failed. A key success factor for amphibians was the number of animals released: projects releasing greater than 1000 being most successful. Most amphibian translocations (71%) utilized eggs, larvae, and metamorphs, with 45% also including the release of adults. In contrast, most reptile translocations utilized juveniles and sub-adults (64%) and adults (75%). For reptiles, size of release group was not significant.

Factors implicated in unsuccessful projects were homing, migration away from release areas, and habitat quality, although in many projects the cause of failure was unknown or unreported (Germano and Bishop 2008). They emphasised the importance of long-term monitoring, particularly for long-lived and slow-to-mature species. The translocation of Saltwater Crocodiles (Walsh and Whitehead 1993) to deal with human-wildlife conflict is an Australian example of homing following translocation.

Dodd and Seigel (1991), in a discussion of reptile and amphibian translocations suggested the following:

- Understand the cause of decline or threat;
- Know the biological constraints of the organism;
- Understand the habitat constraints of the species for all phases of the life cycle (feeding, shelter, reproduction, effect of predation by feral, domestic and native predators, and habitat free of toxicants, corridors for movement, dispersal opportunities, vegetation and soil structure);

- Biophysical constraints (the presence of undisturbed basking sites, proper environment for egg development);
- Consideration of possible genetic factors (such as minimum viable population size, genetic variability, the 50-500 "minimum necessary to sustain a viable breeding population"), social structure (such as characteristic sex ratio).
- Consider the possibility of disease transmission (health checks prior to translocation, the discouragement of release of long-term captives, and embargo of movement of animals from areas with a known disease problem); and
- Undertake long-term monitoring (> 20 years for a tortoise) to establish survival and reproduction.

Factors causing the decline and impacting on the success of Australian translocations were often a complex mix with the relative importance of each largely unknown. Factors influencing outcome of translocations of Green and Golden Bell Frog included the presence of chytrid fungus; presence of the exotic fish Plague Minnow *Gambusia holbrooki*, a known predator of eggs and tadpoles; predatory eels; predatory native frog Striped Marsh Frog; black rats, foxes and native birds as predators of adult frogs; water quality and temperature; and lack of over-winter habitat at some sites (Daley *et al.* 2008; Pyke *et al.* 2008; White and Pyke 2008).

8. Captive breeding versus wild-sourced as stock for translocations

Over 66% of translocations documented utilized wild-caught animals (175 of 267 translocations) (Table 20). There was no clear difference in outcome for either source.

This is in contrast to the results of Griffith *et al.* (1989) who found translocations utilizing wild-caught animals were more successful (75%) than those utilizing captive-bred animals (38%). Fischer and Lindenmayer (2000) found success rates for reintroductions utilizing wild-sourced animals to be higher (31%) than for those utilising captive animals (13%).

However, Wolf *et al.* (1996) found no difference in success between studies that utilized wild caught versus captive reared animals in translocation.

The use of captive breeding is often seen as a high risk strategy of last resort. Key issues are the perceived higher risks of disease and behavioural and genetic modification (Ehrlich and Ehrlich 1981, Chivers 1991, Dodd and Seigel 1991, Lindburg 1992, Viggers *et al.* 1993, Snyder *et al.* 1996 and Sigg 2006). Seddon *et al.* (2007) identified poor health, individuals lacking fearfulness, and no opportunity to learn key behaviours, such as predator recognition as problems with captive-reared animals.

In one Australian case study, the number of taxa of faecal microflora of captive Dibbler held at Perth Zoo was higher than that of the wild source population and of the subsequent reintroduced population (Mathews *et al.* 2006). Potential explanations included the animals being held at higher density in the captive situation or infection being introduced via the foods or bedding supplied while in captivity.

Issues around genetic management of captive populations are discussed in Ebenhard (1995). Sigg (2006) demonstrated a significant genetic differentiation between captive Bridled Nailtail Wallabies and their wild source population over just four generations.

IUCN (1998) emphasise reintroductions should not be carried out merely as a mean of disposing of surplus stock or because captive stock exists. Serena and Williams (1994: 249) cite examples of Eastern Barred Bandicoots in Victoria and Chuditch in Western Australia. This is still a significant problem in many Western Australian facilities where there is an oversupply of animals or of animals of the wrong sex or those impacted by disease. The problem of maintaining animals in captivity for successive generations without a major increase in census size, as is typical in intensive captive breeding facilities, is discussed by Wang and Ryman (2001).

A captive breeding program for Greater Stick-nest Rats at Perth Zoo was suspended because of the high incidence of cataract disease (Fletcher and Morris 2003). The captive population originated from five pairs transferred from the Monarto Zoo in South Australia. Approximately 27% of the captive colony in Perth had cataracts compared with 7% of the wild population on Franklin Islands, South Australia. The problem was attributed to a deleterious recessive gene at high frequency in the captive colony, but presumably selected against in the wild population.

In contrast, Jordan (2004) suggests captive breeding of rodents “may allow for a more predictable and sustainable program of releases over a number of years”, allowing “rapid multiplication of limited numbers ... to enable larger-scale releases”.

Bowkett (2009) argues that there are significant emerging threats to biodiversity that are unlikely to be controlled in the short-term and that therefore may be best dealt with by establishing and maintaining species in captive colonies, despite the obvious disadvantages of limited capacity, high cost, and undesirable genetic changes. Chytrid fungus in the case of amphibians is one important example cited by Bowkett (2009). The spread of devil facial tumor in Tasmania is another (Hawkins *et al.* 2006).

Some species and taxa (for example, amphibians) may be more amenable to captive husbandry than others (Bloxham and Tonge 1995).

The expense of captive breeding has often been suggested as a major reason for limiting the use of translocations as a strategy in species recovery. One solution to this is to establish populations on islands or smaller protected free-range sites and to translocate progeny to larger sites. In New Zealand, Maud and Tiritiri Islands have been suggested for this role (Craig and Veitch 1990). Similarly, use of captive breeding facilities may be less successful in producing wild-ready animals than existing smaller free-range sites such as Heirisson Prong or Karakamia Sanctuary that can act as a half-way house to bigger and higher risk sites.

The strong differentiation between *ex situ* and *in situ* conservation is being increasingly blurred by the rise of sanctuaries, often managed by private conservation foundations or by community conservation groups in Australia. Key examples of the former are Australian Wildlife Conservancy (http://www.australianwildlife.org/), Arid Recovery in South Australia (www.aridrecovery.org.au*)*, and The Australian Ecosystems Foundation,Inc. (http://ausecosystems.org.au), that are increasingly establishing secure bushland reserves or sanctuaries on a larger physical scale than that of zoos.

Sourcing animals from captive breeding appears less common now than in the early history of translocations. For example, Germano and Bishop (2008) report some 76% of amphibian translocations and 93% of reptile translocations were carried out with wild individuals. However, captive breeding in amphibians is seen as likely approach to dealing with species declines from chytrid fungus (Bowkett 2009).

9. The possibility of transmission of diseases

There has been substantial attention in the literature to the potential for the spread of disease through translocation of fauna, although it has not been identified as a factor influencing translocation outcome (Wolf *et al.* 1996). There have been no recent Australian examples of this, although the translocation of Koalas in the past from sites such as Phillip Island in Victoria is an historic example. Martin and Handasyde (1999) discuss the spread of disease via a translocation of Koala from Phillip Island to The Grampians in Victoria. Australian species with known disease issues include the Koala (Brown and Carrick 1985; Martin and Handasyde 1999), Western Barred Bandicoot (Warren *et al.* 2005) and the Tasmanian Devil (Jones *et al.* 2007, Siddle *et al.* 2007). The identification of disease in some populations of wild and captive western barred bandicoots has led to these being excluded from subsequent translocation.

Disease was also an issue in attempts to re-establish Gouldian Finches from captive populations – disease was identified in aviary birds at the Northern Territory Wildlife Park being bred for release (http://www.mareebawetlands.org/gouldian.html) and this precluded their immediate inclusion in a release program. This species is susceptible to respiratory infections in the wild caused by an endoparasitic mite (air sac mite *Sternostoma tracheacolum)*, apparently linked to the stress associated with food shortages.

Viggers *et al.* (1993), Cunningham (1996) and Mathews *et al.* (2006) have addressed issues to do with the potential spread of disease through translocation of fauna. Jordan (2003) recommends intensive health screening, potentially taking several weeks, before release of small mammals. Jordan suggests that practitioners should assume as many as 10% of animals may not pass such a test.

Risks appear greatest with translocation following rehabilitation or captive breeding or when the translocation is by restocking (cf. introduction and reintroduction). Kleiman (1989) discouraged using captive-bred animals for restocking as captive animals may carry disease that they, but not the wild individuals, may be immune to. Particular problems arise when the target species is exposed to similar species (Viggers *et al.* 1993). International case studies include orang utan (*Pongo pygmaeus*) exposed to other primates, including humans, Mauritius pink pigeon (*Columba mayeri*) exposed to domestic pigeons (*Columba livia f. domestica*), and brown trout (*Salmo trutta*) to rainbow trout (*Oncorhynchus mykiss*).

Various recommendations to minimise the spread of disease by translocation include quarantine, diagnosis of disease through clinical examination, faecal examination, haematology, serology, tuberculin testing, microbial culture and necropsy.

Cunningham (1996) suggested the following strategies to reduce the risks of disease transmission:

- Maintain the animals in captivity as near to the site of capture/release as possible (preferably in the country/region of origin);
- Maintain the animals in captivity for as short a time as possible;

- Prevent contact (direct or indirect) between the animals in question and those from a different source or of a different species;
- Keep and handle the animals under hygienic conditions to minimise the risk of parasites being passed from the keepers to them;
- Avoid the transfer of parasites from foodstuff to the animals.

Disease is a particular issue for amphibians because of the widespread presence of the chytrid fungus (Dazak *et al.* 1999; Obendorf and Dalton 2006; Daley *et al.* 2008; Pyke *et al.* 2008; White and Pyke 2008).

10. Lack of planning contributing to a lack of success of translocations

Various authors have suggested that a lack of effective planning may have contributed to a poor success rate for translocations. Perhaps the most vocal critic has been Seddon (2007), who suggests that translocations have "often little planning and often no monitoring" (p 304) and that there have been "a proliferation of ill-conceived releases" (p 304). "In the early years many reintroduction projects were purely management manipulations, often doomed to failure due to poor planning, inappropriate founder animals (confiscations from illegal trade, surplus animals from captive breeding programs, or problem exotic pets), low sample sizes, and lack of resources" and "post release monitoring ..was .. negligible or absent .."(p 305).

The current practise of requiring a detailed Translocation Proposal that is peer-reviewed seems an adequate response to these criticisms.

11. Hard versus soft release.

Griffith *et al.* (1989) found no evidence to support the benefits of hard versus soft release. Short *et al.* (1992) similarly could find little or no evidence to support the benefits of soft release. Comparing soft versus hard release has become a popular manipulation when reintroducing threatened mammals (e.g. Hardman and Moro 2006b).

Jordon (2003) advocated soft-release for small mammals as they are typically prey species relying on established runs or subterranean burrows to evade predators. However, often avian and other predators may quickly learn that such sites are a rich source of prey and focus their hunting activities there if animals are held for any length of time.

Germano and Bishop (2008) recommended research into the possible benefits of soft release for reptiles and amphibians to decrease the problems of homing following translocation and to improve translocation success. An example of the recent successful use of this technique was that of the translocation of the Gopher Tortoise (Tuberville *et al.* 2005).

12. The importance or otherwise of genetics in determining which stock should be reintroduced where.

The translocation protocols suggest that practitioners should consider the principles of conservation genetics, particularly with regard to effective population size. It seems prudent, and consistent with genetic theory, to maximise the founder size and diversity in establishing new populations by translocation. However, having said that, there is no evidence that genetic deficiency has in any way contributed to the lack of success to translocations. Many successful translocations have emanated from small founder groups or from island stock, widely regarded by geneticists as of poor quality.

Geneticists have been very active in promoting their discipline as a means of making choices about the value of certain populations as potential source populations, highlighting the dangers of inbreeding and loss of genetic variability and the perils of outbreeding (lower viability or fertility as a result of mating between too distantly related individuals). Others have argued for maintaining the purity of stock with the dire consequence of "genetic genocide" if foreign stock is introduced (such as the introduction of Canadian beavers or other subspecies to Europe (Griffiths *et al.* 1996)).

However, a problem for practitioners is that guidelines emanating from genetic theory seem to come and go over time. An example is the 50/500 rule (Franklin 1980). Craig and Veitch (1990) argued for the abandonment of this rule, claiming it had little useful application to New Zealand birds. Jamieson (2009), in a recent review, has similarly recognized that requiring a minimum population of 500 individuals to ensure genetic viability in the longer term, would preclude many successful reintroductions of New Zealand birds. It was believed that historically inbred populations would have purged deleterious recessive alleles normally associated with inbreeding depression. However, other issues include the loss of evolutionary responsiveness that is associated with loss of genetic diversity.

Many marsupials, particularly those from islands, have low genetic diversity (Eldridge 1998, Eldridge *et al*. 1999, Eldridge *et al.* 2004, Smith *et al.* 2008) and this may make them more vulnerable to novel environmental stresses, including disease (Frankham 1997, Bradshaw and Brook 2005, Siddle *et al.* 2007, Jamieson 2009). Eldridge (1998) and Eldridge *et al.* (2004) questioned the value of many island stocks as source populations for mainland reintroduction citing the low variability of microsatellite markers in Black-footed Rock-wallabies, Tammar Wallabies, and Rufous Hare-wallabies relative to mainland individuals. The inference was that this would be reflected in ecological and behavioural traits (reduced dispersal abilities, lower reproductive rates, and lack of predator recognition).

Eldridge *et al.* (1999) studied the Barrow Island population of rock-wallabies, which has been isolated for 8,000 years (*c*. 1600 generations) and has an effective population size of 15. They examined three factors (proportion of females with pouch young, adult sex ratio, and fluctuating asymmetry) that they believed indicated reduced fitness. They compared the number of female rock-wallabies with young on Barrow Island (52%) to those of rock-wallabies from mainland populations (89%). They found that the population sex ratio was strongly biased to females. And they found high levels of fluctuating asymmetery in the population. However, it is unclear just how definitive these factors are. The comparison of female fecundity appears somewhat simplistic, ignoring the fact that an island population not subject to predation is more likely to occupy saturated habitat than those of mainland populations. Published data for another rock-wallaby *Petrogale xanthopus* (Sharp *et al.* 2006) give a proportion of females with pouch young varying between 67% and 83%, approaching the value obtained on Barrow Island. This study also has an adult sex ratio dominated by females (females making up between 63 and 88% of the adult population) compared with 71% on Barrow Island. Further, fluctuating asymmetry has been found to be an unreliable indicator of inbreeding in another macropod – the tammar (Kaori *et al*. 2009).

Seymour *et al.* (2001) examined inbreeding in Koala populations in South Australia. For example, the Kangaroo Island population originated from 18 animals from French Island in Victoria in 1923-5, which in turn originated from as few as two animals introduced to French Island from mainland Victoria in the 1890s. Koalas had low allelic diversity and heterozygosity. They demonstrated testicular aplasia in South Australian Koalas (13% in Koalas from Kangaroo Island), correlated with the level of inbreeding. Koalas from Kangaroo Island had an effective inbreeding co-efficient of derived from a heterozygosity value of 0.63. Hence, while South Australian Koala populations were "demographically secure" (= abundant, to the point of "overbrowsing and habitat damage" resulting in them being controlled as a pest species), their low levels of genetic variation "could have a significant impact on long-term viability of these populations, given that genetic diversity is required for adaptation to changing environments in the long term".

In contrast to the example of rock-wallabies from Barrow Island, Burrowing Bettongs originating from island stock have been successfully translocated to sites across their former latitudinal range within Australia (Short and Turner 2000, Finlayson and Moseby 2004, Finlayson *et al.* 2008). They have shown the flexibility to adapt to a range of environments and shown none of the typical signs of inbreeding such as reduced fertility predicted by Eldridge *et al.* (2004) for stock originating from islands. In an ironic twist, Burrowing Bettongs sourced from the mainland were transferred to an offshore island in the 1920s and failed to thrive (Short and Turner 2000).

However, somewhat in contrast to the earlier recommendation, Eldridge (1998) championed the notion of mixing island stock to re-create "a highly diverse population" that would be suitable for reintroductions – presumably mainland reintroductions would be a key way of implementing such mixing. Spencer and Moro (2001) also strongly recommended the mixing of closely related stocks from different populations, including island populations. They gave the example of the Rufous Hare-wallaby (Mala) that had persisted as two island populations as well as a small captive population derived from a recently extinct mainland population. They suggested the mixing of animals from each population to increase genetic diversity of translocated populations, while retaining the integrity of each source population.

Similarly, Smith and Hughes (2008) suggested mixing of island stock in reintroductions of Western Barred Bandicoot to overcome low genetic diversity in individual source populations. This would incorporate the genetic differences between island populations in new populations. This has already occurred in the creation of at least one captive colony, but the transfer of animals to the wild has been hampered by disease apparently transferred from one of the source populations (Bernier Island).

An example of the benefits of mixing genetic stocks is given by Pimm *et al.* (2006) for the Florida Panther *Puma concolor coryi*. Loss and fragmentation of habitat, and mortality due to road kills and conflict with intensifying human land uses had reduced extant Florida Panther populations to less than 100 individuals. Panthers were showing signs of inbreeding, exhibiting "a high frequency of unique morphological characters and physiological abnormalities such as kinked tail and cowlick, sperm defects and heart defects." In addition, some 90% of males born after 1990 had one or both testicles undescended. The addition of eight female panthers from a nearby population in Texas (a different sub-species) resulted in higher survival of kittens to adulthood (hybrid kittens had a three-fold higher survival than pure-bred kittens).

However, there are few or no examples in the Australian literature of reduced reproductive output in wild populations, at least for mammals, or of physiological abnormalities among individuals – common expressions of inbreeding. Many Australian species have been subject to wide fluctuation in numbers due to the highly variable environment in which they persist, so may have had a long exposure to bottlenecks. Others have persisted as small and isolated populations for many thousands of generations and this may provide some protection from the effects of inbreeding and low genetic variation.

Genetic considerations create many challenges for management. An example is the pressure to conserve highly specific genetic stock of Brush-tailed Rock-wallabies in eastern Australia versus the more pragmatic priorities of expanding range and numbers. In one example, Hazlitt *et al.* (2006) expressed concern for sub-populations of Brush-tailed Rock-wallaby occupying continuous escarpment that had "restricted gene flow over a small geographical scale (< 10 km)" due to intrinsic (behavioural) factors. Moritz (1999) suggested that historically isolated (and thus independently evolving) populations (termed 'Evolutionary Significant Units') should be conserved rather than specific phenotypic or molecular variants. He suggested that this emphasis on evolutionary process might counter "the tendency for well-meaning conservation managers to seek to preserve all phenotypic variants, regardless of the evolutionary processes that create, combine and replace them through time". Hence, he favoured the mixing of stock at a level below the ESU.

The risks of outbreeding following the mixing of diverse stock appear largely linked to the dilution or disruption of local adaption. It is largely based on a 50-year old case study (Turcek 1951) of the mixing of two stocks of the Ibex *Capra ibex*, resulting in the production of hybrids that gave birth at an inopportune time of the year. This example is discussed in Moritz (1999) and Pimm *et al*. (2006). In general, the evidence for outbreeding depression as a constraint on translocation success is much weaker than that for inbreeding.

Jamieson (2009), in his review of the loss of genetic diversity in New Zealand birds, concluded that genetic management "should not take priority over other management concerns such as controlling predators or improving habitat quality", but should receive more attention than currently given.

13. Effect of size of release area

Wolf *et al.* (1996) found that successful translocations of mammals and birds were to areas of suitable habitat that were seven times greater than that of unsuccessful translocations (median area of 29,800 ha cf. 4,050 ha). However, there was no evidence of such a trend in the Australian data. Mammal translocations were most successful in areas of 5,000 – 50,000 ha (77% successful). This compared to a translocation success for larger areas of 26%. Translocations to areas of less than 5,000 ha had similar high success (69%) relative to large areas. The most likely explanation for this is the increasing difficulty of managing threatening processes as release areas become larger.

Success of bird translocations were 33% for areas less than 5,000 ha; and 28% for areas between 5,000 and 50,000 ha. Translocations of reptiles and amphibians were typically to areas of less than 5,000 ha.

14. Effect of type of translocation: reintroduction (conservation motivated) versus restocking (human/animal conflict)

Fischer and Lindenmayer (2000) found that most translocations that addressed human-animal conflicts (typically restocking) were unsuccessful. Contributing factors were homing behaviour and the poor adaptation to a shift from an urban to a non-urban environment. Relocations to supplement game populations (common in the datasets of Griffith *et al.* 1989 and Fischer and Lindenmayer 2000) were not a part of the Australian scene.

Homing was evident after the translocation of highly mobile marine species such as penguin and crocodile (Walsh and Whitehead 1993; Hull *et al.* 1998). However, researchers were able to determine distance thresholds for pest bird species such as magpies to limit homing (Jones and Finn 1999; Jones and Nealson 2003).

15. Issues of overabundance following translocation.

Overabundance following translocation of species to islands or habitat isolates has been a significant issue in Australia. Koalas translocated to islands have been particularly troublesome (Lee and Martin 1988, Martin and Handasyde 1990, Copley 1994a, Whisson *et al.* 2008). Overpopulation of Koalas and the resultant widespread tree death and starvation, has been a key issue driving historical and current translocations of this species (Lee and Martin 1988). Tammar wallabies translocated to small islands in South Australia (Greenly Island, Boston Island) have caused major vegetation changes (Copley 1994a). Island populations of some translocated native species (Western Grey Kangaroos from Granite Island in South Australia) have subsequently been removed due to their environmental impact (Copley 1994a).

Overpopulation of Brush-tailed Bettongs at Karakamia Sanctuary was a major driver of unsuccessful releases to Paruna Sanctuary (A. Hide, pers. com). Similarly a build up of numbers of Bilbies in the Arid Recovery Project at Roxby Downs led to releases beyond the fence.

Recommendations

General

1. Ensure better documentation and reporting, particularly with in-house translocations by agencies. This should include greater accessibility of information to those outside the regulatory agency and greater efforts to publish the results of translocations, even those deemed unsuccessful.
2. Place less focus on "success" of individual translocations. Rather, encourage the management of isolated stocks as metapopulations where there is an acceptance that some sub-populations will inevitably fail and need to be resurrected by reintroduction in lieu of immigration.
3. Understand the ecology of the species to be reintroduced. Translocation may be part of the process of building this knowledge.
4. Effective management of threatening processes at the release site is fundamental to the success of any translocation. While this issue is currently addressed in Translocation Proposals it appears buried amongst a plethora of other requirements. This somewhat undermines the fundamental nature of this requirement.
5. Key threatening processes should be monitored at release site. Current protocols and practice emphasise the monitoring of reintroduced stock after release, but not the monitoring of threatening processes. This is a significant shortcoming in subsequent attempts to explain declines and failures.
6. The failure of numerous translocations after greater than five years of persistence suggests more care and planning needs to be invested in dealing with major stochastic events such as drought and fire that might occur well after releases often exacerbating the impact of exotic predators on the reintroduced species.

Improving the success of mammal translocations

1. Success or failure of translocations of mammals was overwhelmingly associated with effective management of exotic predators. Therefore continue to improve predator management by:
    a. Investing in new technologies for control (new baits and bait delivery methods);
    b. Develop an improved knowledge of the fox-cat interaction and the ecology and predator-prey dynamics of feral cats across Australia;
    c. Continue to seek areas of management advantage where predators may be more effectively controlled (peninsulas, sites with a strong seasonality in prey base for feral cats, etc)
    d. Continue to encourage the involvement of the non-government sector through the creation of fenced sanctuaries.
2. Intervene early before numbers of target taxa get to critically low numbers. For mammals, examples where this hasn't occurred might be Brush-tailed Rock-wallabies in the Grampians in Victoria and the Warrumbungle National Park in New South Wales.
3. Reduce reliance on intensive captive breeding facilities where possible. There are substantial issues associated with disease and genetic deterioration from holding animals for

many generations and in high densities and with a number of species in close association. Rather seek solutions in secure areas of natural habitat such as islands and sanctuaries or other large fenced sites. There is a trend to this already, particularly in Western Australia. Examples include the shift from intensive captive breeding of Gilbert's Potoroo to use of predator-free island and fenced enclosures; the use of sanctuaries such as Heirisson Prong and Karakamia to supply stock for many other mainland sites.

4. Attempt to encapsulate the full range of genetic diversity in isolated releases in addition to maintaining the integrity of isolated source stocks. Currently international, national and State protocols discourage such mixing. This applies particularly to species with island sub-populations. The genetic complement of these island sub-populations should be incorporated, with due care, into at least some mainland releases.
5. Encourage greater monitoring of disease risk before release for animals originating in captive facilities, from carers, or from species with a known disease issue. Develop more formalised protocols for trapping hygiene (cleaning of traps between sites).

Improving the success of avian translocations

1. Practitioners contemplating translocation of birds should have a working knowledge of the issues, procedures and practices of past translocation efforts within Australia, but also those derived from the *c.* 400 translocations of New Zealand birds (e.g. Armstrong and McLean 1995) and elsewhere.
2. Develop greater understanding of the fundamental ecology of the species and the impact of threatening processes (for example, granivorous birds in the tropical grasslands impacted by changing fire regimes).
3. Substantially increase the size of release groups where possible to numbers closer to those recommended in the international literature for birds (>100).
4. Be aware of the relatively high mobility of birds and the possible effect of this on any release via homing or dispersal away from the release group. Consider strategies to mitigate the effect of such mobility.
5. Invest more research into the impact of exotic species on birds. Black Rats *Rattus rattus* (and other mammalian nest predators) and feral cats have been widely implicated in the failure of translocations of birds elsewhere in the world. However, little is known about their role in the failure of Australian translocations of threatened birds, despite likely sympatry (for example, with scrub birds and bristle birds).
6. Consider whether translocation is the most appropriate response to the conservation problem. This applies particularly to restocking (supplementation) of threatened bird species. This practice appears more common for birds (Orange-bellied Parrot, restocking of Eastern Bristlebird in Queensland, Regent Honeyeater in Victoria). Adding more animals is unlikely to address the fundamental cause of low numbers.
7. Act early to avoid a species getting to very small numbers – a situation likely to make recovery more difficult and problematic.

Improving the success of translocations of reptiles and amphibians

1. The translocation of reptiles and amphibians remains very much in the experimental phase and successful examples in Australia are scarce. However, it is a dynamic international area

of study, and practitioners should have a good grasp of the current international literature to ensure they are aware of current trends and practise.

2. Practitioners should focus on the fundamentals:
    - Understanding the cause(s) of decline;
    - Understand the life history and ecology of the species;
    - Understanding the spatial distribution of the threat.
3. The potential further spread of disease is a major issue for amphibian translocations and may severely limit its widespread application.
4. The complex and apparently intractable environmental challenges facing many species of amphibians probably may require a strong focus on captive breeding for the immediate future.
5. Large release groups (> 1000) have been used in successful translocations of reptiles and amphibians and are likely to be required in Australia also.
6. Drawing on the experience of mammal and bird translocations, opportunities to escape threats to reptiles and amphibians may be present on islands or other isolated areas.
7. For long-lived reptiles, ensuring long-term continuity of conservation effort is likely to be important.

Appendix I – Species cited in this report listed alphabetically by common name within taxa

Common name	Genus	Species
Amphibia		
Armoured Mistfrog	*Litoria*	*lorica*
Booroolong Frog	*Litoria*	*booroolongensis*
Common Mistfrog	*Litoria*	*rheocola*
Green and Golden Bell Frog	*Litoria*	*aurea*
Orange-bellied frog	*Geocrinia*	*vitellina*
Sharp-snouted Day Frog	*Taudactylus*	*acutirostris*
Southern Bell Frog	*Litoria*	*raniformis*
Southern Corroboree Frog	*Pseudophryne*	*corroboree*
Spotted Tree Frog	*Litoria*	*spenceri*
Tinkling Frog	*Taudactylus*	*rheophilus*
White-bellied Frog	*Geocrinia*	*alba*
Reptiles		
Broad-headed Snake	*Hoplocephalus*	*bungaroides*
Carpet Python	*Morelia*	*spilotes*
Corangamite Water Skink	*Eulamprus*	*tympanum marnieae*
Grassland Earless Dragon	*Tympanocryptis*	*pinguicolla*
Heath Goana	*Varanus*	*rosenbergii*
Lancelin Island Skink	*Ctenotus*	*lancelini*
Pygmy Blue-tongue lizard	*Tiliqua*	*adelaidensis*
Saltwater Crocodile	*Crocodylus*	*porosus*
Sand Monitor	*Varanus*	*gouldii*
Slater's Skink	*Egernia*	*slateri slateri*
Tiger Snake	*Notechis*	*scutatus*
Western Swamp Tortoise	*Pseudemydura*	*umbrina*
Woma Python	*Aspidites*	*ramsayi*
Birds		
Australian Magpie	*Gymnorhina*	*tibicen*
Bar-shouldered Dove	*Geopelia*	*humeralis*
Black-eared Miner	*Manorina*	*melanotis*
Black-throated Finch (southern)	*Poephila*	*cincta cincta*
Brush Turkey	*Alectura*	*lathami*
Buff-banded Rail (Cocos (Keeling) Islands	*Gallirallus*	*phillippensis andrewsi*
Bush Thick-knee	*Burhinus*	*magnirostris*
Cape Barren Goose	*Cereopsis*	*novaehollandiae*
Chestnut quail-thrush	*Cinclosoma*	*castanotum*
Chestnut-rumped Heathwren (Mt Lofty Ranges)	*Hylacola*	*pyrrhopygia parkeri*
Crested Pigeon	*Ocyphaps*	*lophotes*
Crimson Finch (white-bellied)	*Neochmia*	*phaeton evangelinae*

Diamond Dove	*Geopelia*	*cuneata*
Eastern Bristlebird	*Dasyornis*	*brachypterus*
Emu	*Dromauus*	*novaehollandiae*
Gang-gang Cockatoo	*Callocephalon*	*fimbricatum*
Golden Whistler (Norfolk Island)	*Pachycephala*	*pectoralis xanthoprocta*
Gouldian Finch	*Erythrura*	*gouldiae*
Gould's Petrel	*Pterodroma*	*leucoptera leucoptra*
Helmeted Honeyeater	*Lichenostomus*	*melanops cassidix*
Laughing Kookaburra	*Dacelo*	*novaeguinea*
Little Penguin	*Eudyptula*	*minor*
Lord Howe Island Woodhen	*Gallirallus*	*sylvestris*
Magpie Goose	*Anseranas*	*semipalmata*
Mallee Emu-wren	*Stipiturus*	*mallee*
Malleefowl	*Leipoa*	*ocellata*
Noisy Miner	*Manorina*	*melanocephala*
Noisy Scrub-bird	*Atrichornis*	*clamosus*
Northern Rosella	*Platycercus*	*venustus*
Orange-bellied Parrot	*Neophema*	*chrysogaster*
Peaceful Dove	*Geopelia*	*striata*
Pink Cockatoo	*Cacatua*	*leadbeateri*
Red-lored Whistler	*Pachycephala*	*rufogularis*
Regent Honeyeater	*Xanthomyza*	*phrygia*
Shy Heathwren	*Hylacola*	*cauta*
Southern Cassowary	*Casuarius*	*casuarius johnsonii*
Southern Emu-wren	*Stipiturus*	*malachurus intermedius*
Southern Scrub Robin	*Drymodes*	*brunneopygia*
Spinifex Pigeon	*Geophaps*	*plumifera*
Striated Grass Wren	*Amytornis*	*striatus*
Western Bristlebird	*Dasyornis*	*longirostris*
Western Whipbird (eastern)	*Psophodes*	*nigrogularis leucogaster*
Wonga Pigeon	*Leucosarcia*	*melanoleuca*
Yellow-tailed Black Cockatoo	*Calyptorhynchus*	*funereus*
Zebra Finch	*Poephila*	*guttata*
Mammal		
Arnhem Rock-rat	*Zyzomys*	*maini*
Australian Fur Seal	*Arctocephalus*	*pusillus doriferus*
Banded Hare-wallaby	*Lagostrophus*	*fasciatus*
Bare-rumped Sheath-tailed Bat	*Saccolaimus*	*saccolaimus nudicluniatus*
Bilby	*Macrotis*	*lagotis*
Black-footed Rock-wallaby	*Petrogale*	*lateralis*
Bramble Cay Melomys	*Melomys*	*rubicola*
Bramble Cay Melomys	*Melomys*	*rubicola*
Bridled Nailtail Wallaby	*Onychogalea*	*fraenata*
Brush Wallaby	*Macropus*	*irma*
Brushtail Possum	*Trichosurus*	*vulpecula*

Brush-tailed Bettong	*Bettongia*	*penicillata*
Brush-tailed Phascogale	*Phascogale*	*tapoatafa*
Brush-tailed Rock-wallaby	*Petrogale*	*penicillata*
Burrowing Bettong	*Bettongia*	*lesueur*
Carpentarian Rock-rat	*Zyzomys*	*palatalis*
Central Rock-rat	*Zyzomys*	*pedunculatus*
Christmas Island Pipistrelle	*Pipistrellus*	*murrayi*
Christmas Island Shrew	*Crocidura*	*attenuata trichura*
Chuditch	*Dasyurus*	*geoffroii*
Common Ringtail Possum	*Pseudocheirus*	*peregrinus*
Common Wombat	*Vombatus*	*ursinus*
Dibbler	*Parantechinus*	*apicalis*
Dusky Hopping-mouse	*Notomys*	*fuscus*
Eastern Barred Bandicoot	*Perameles*	*gunnii*
Eastern Grey Kangaroo	*Macropus*	*giganteus*
Eastern Grey Kangaroo (Tasmania)	*Macropus*	*giganteus tasmaniensis*
Eastern Quoll	*Dasyurus*	*viverrinus*
Euro	*Macropus*	*robustus*
Gilbert's Potoroo	*Potorous*	*gilbertii*
Golden Bandicoot	*Isoodon*	*auratus*
Golden-backed Tree-rat	*Mesembriomys*	*macrurus*
Greater Stick-nest Rat	*Leporillus*	*conditor*
Grey-headed Flying-fox	*Pteropus*	*poliocephalus*
Hastings River Mouse	*Pseudomys*	*oralis*
Heath Rat	*Pseudomys*	*shortridgei*
Julia Creek Dunnart	*Sminthopsis*	*douglasi*
Koala	*Phascolarctos*	*cinereus*
Large-eared Horseshoe Bat	*Rhinolophus*	*philippinensis*
Large-eared Pied Bat	*Chalinolobus*	*dwyeri*
Long-nosed Potoroo	*Potorous*	*tridactylus*
Northern Bettong	*Bettongia*	*tropica*
Northern Hairy-nosed Wombat	*Lasiorhinus*	*krefftii*
Northern Hopping-mouse	*Notomys*	*aquilo*
Northern Quoll	*Dasyurus*	*hallucatus*
Numbat	*Myrmecobius*	*fasciatus*
Parma Wallaby	*Macropus*	*parma*
Pilbara Leaf-nosed Bat	*Rhinonicteris*	*aurantia*
Pilbara Leaf-nosed Bat (Pilbara form)	*Rhinonicteris*	*aurantius*
Plains Rat	*Pseudomys*	*australis*
Platypus	*Ornithorhynchus*	*anatinus*
Proserpine Rock-wallaby	*Petrogale*	*persephone*
Quokka	*Setonix*	*brachyurus*
Red-bellied Pademelon	*Thylogale*	*billardierii*
Red-tailed Phascogale	*Phascogale*	*calura*

Rothschild's Rock-wallaby	*Petrogale*	*rothschildi*
Rufous bettong	*Aepyprymnus*	*rufescens*
Rufous Hare-wallaby	*Lagorchestes*	*hirsutus*
Semon's Leaf-nosed Bat	*Hipposideros*	*semoni*
Shark Bay Mouse	*Pseudomys*	*fieldi*
Smoky Mouse	*Pseudomys*	*fumeus*
South-eastern Long-eared Bat	*Nyctophilus*	*spp.*
Southern brown bandicoot (SA form)	*Isoodon*	*obesulus nauticus*
Southern Brown Bandicoot (Vic form)	*Isoodon*	*obesulus obesulus*
Southern Brown Bandicoot (WA form)	*Isoodon*	*obesulus fusciventer*
Southern Hairy-nosed Wombat	*Lasiorhinus*	*latifrons*
Spectacled Flying-fox	*Pteropus*	*conspicillatus*
Spectacled Hare-wallaby (Barrow Island)	*Lagorchestes*	*conspicillatus conspicillatus*
Spotted -tail Quoll (Tasm population)	*Dasyurus*	*maculatus maculatus*
Sugar Glider	*Petaurus*	*breviceps*
Swamp Antechinus	*Antechinus*	*minimus*
Tammar Wallaby	*Macropus*	*eugenii*
Tasmanian Devil	*Sarcophilus*	*harrisii*
Thevenard Island Short-tailed Mouse	*Leggadina*	*lakedownensis*
Water mouse	*Xeromys*	*myoides*
Western Barred Bandicoot	*Perameles*	*bougainville*
Western Grey Kangaroo	*Macropus*	*fuliginosus*
Western Pebble-mound Mouse	*Pseudomys*	*chapmani*
Western Ringtail Possum	*Pseudocheirus*	*occidentalis*
Yellow-footed Rock-wallaby	*Petrogale*	*xanthopus*

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Appendix III – General references and references reviewing translocations of threatened fauna

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Appendix V – Web access to protocols

Document	Web address
IUCN Position Statement: Translocation of living organisms (1987);	http://www.iucnsscrsg.org/download/IUCNPositionStatement.pdf
IUCN/SSC guidelines for reintroductions (1998)	http://www.lcie.org/Docs/LCIE%20IUCN/IUCN%20Reintroduction%20guidelines.pdf
ANZECC Policy for translocations of threatened animals in Australia c.1999 (draft)	Apendix 1 of document http://www.environment.nsw.gov.au/resources/nature/policyFaunaTranslocation.pdf
WA: DCLM Policy Statement No. 29 Translocation of Threatened Flora and Fauna (July 1995)	http://www.dec.wa.gov.au/component/option,com_docman/Itemid,1/gid,3083/task,doc_download/
SA: Translocations of Native Fauna Policy (draft); Translocations of Native Fauna Procedure (draft)	In draft form – not available on the web
NSW: Policy and Procedure Statement No. 9 Policy for the translocation of threatened fauna in NSW (Oct 2001)	http://www.environment.nsw.gov.au/resources/nature/policyFaunaTranslocation.pdf
Vic:	None available
Qld: The management of captive colonies (threatened species) for wildlife conservation (July 2007); Requirements for the translocation, relocation and release of Koalas (2005)	Koalas only: http://www.epa.qld.gov.au/publications/p01469aq.pdf/ Draft_Nature_Conservation__Conservation_Plan_2005_and_Management_Program_20052015.pdf
Tas:.	No specific policy, but approvals required under various Acts (see Table)
NT: A strategy for the conservation of threatened species and ecological communities in the Northern Territory of Australia (no date)	No specific policy; closest is http://www.nt.gov.au/nreta/wildlife/programs/pdf/strategy_for_conservation_of_threatened_species.pdf
ACT:	No specific policy, but must adhere to the Nature Conservation Act 1980