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Authors

Whisson, Desley A.
Shimmin, Glenn

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Managing an Overabundant Koala Population for Conservation of Riparian Habitats on Kangaroo Island, South Australia

Desley Whisson

Department for Environment and Heritage, South Australia, Kingscote, SA, Australia

Glenn Shimmin

Department for Environment and Heritage, South Australia, Adelaide, SA, Australia

ABSTRACT: The koala population on Kangaroo Island, South Australia has increased from 18 individuals, released in the 1920s for conservation purposes, to an estimated 27,000 in 2001. The selective browsing pressure of koalas on some eucalypt species, particularly rough-barked manna gum, has resulted in significant detrimental impacts to the riparian habitats of the island. In 1997, a management program was initiated to reduce koala densities and restore damaged habitats. Due to the iconic status of koalas, lethal control measures were rejected in favor of a program based on surgical sterilization and translocation. To date, around 6,000 koalas have been sterilized with around 2,700 of those translocated to suitable habitat in the koala's former range in southeast South Australia. Although criticized as an expensive approach, the Koala Management Program has resulted in reduced population densities and improved tree condition in areas of intensive management. The Koala Management Program has been adaptive to match improved understanding of koala distribution, population size, and ecology on the island. This paper provides an overview of the koala issue on Kangaroo Island, and the management program implemented to restore damaged riparian habitats.

KEY WORDS: charismatic species, island populations, koala, *Phascolarctos cinereus*, riparian habitat, species introduction

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HISTORY AND STATUS OF KOALAS IN AUSTRALIA

Historically, koalas (*Phascolarctus cinereus*) occurred throughout eucalypt forest and woodland from north eastern Queensland to the south eastern corner of South Australia (Lee and Martin 1988, Martin and Handasyde 1999). Following European settlement of Australia, habitat clearance for agriculture, hunting for the fur trade, disease, fire, and drought resulted in a severe population decline. By the late 1930s, koalas were considered extinct in South Australia and severe declines had occurred in NSW, Victoria, and Queensland (Lee and Martin 1988, Martin and Handasyde 1999).

Concern for the conservation of koalas resulted in protective legislation and the establishment of island populations in the 1920s (Lee and Martin 1988, Martin and Handasyde 1999). In addition, koalas were relocated from colonies on French and Phillip Islands in Victoria, to re-establish koalas in their former range in Victoria and to a lesser extent in South Australia and the Australian Capital Territory (ACT) (Lee and Martin 1988, Martin and Handasyde 1999). In South Australia, koala populations were established outside the natural range at 4 sites, including Kangaroo Island (Robinson *et al.* 1989).

Today, the regional conservation status of the koala varies from overabundant in some areas to vulnerable or extinct in others (Australian and New Zealand Environment and Conservation Council 1998). In Queensland, koalas occur throughout most of their range, although overall, populations may be declining due to continued clearing and fragmentation of woodland and forest (Gordon *et al.* 1991). In New South Wales, koalas have disappeared from 50-75% of their range, and they now occur mostly on the north coast and are uncommon, rare,

or extinct in other parts of the state (Reed *et al.* 1991). There are relatively low population densities in the ACT (Lee and Martin 1988, Martin and Handasyde 1999). Koalas are widespread throughout suitable habitat in Victoria, largely due to translocation of koalas from island populations (Lee and Martin 1988, Martin and Handasyde 1999). In South Australia, the koala now has a greater range than at the time of European settlement, due to reintroduction of koalas to their former natural range and establishment in areas where they did not occur naturally (Robinson *et al.* 1989).

The koala is protected by legislation in all states and territories in which it occurs (Australian and New Zealand Environment and Conservation Council 1998). In New South Wales, it is listed as "vulnerable" on Schedule 2 of the Threatened Species Conservation Act 1995; in Queensland, it is listed as "common wildlife" under the Nature Conservation (Wildlife) Regulation 1994; and in South Australia, it is listed as "rare" under Schedule 9 of the National Parks and Wildlife Act 1972.

Overabundant Populations

In many areas of Victoria and parts of South Australia where koalas occupy islands or disjunct habitats, they have reached high densities and cause severe damage (over-browsing), including the death of their food trees. In some instances, severe reductions in available food resources have led to koala starvation and death (Martin 1985).

Management of overabundant populations is complicated by the iconic nature of koalas, as well as conservation concerns in other areas. A National Koala Conservation Strategy was developed in 1996 to deal with these management issues and to provide a national

framework for the conservation of the koala (Australian and New Zealand Environment and Conservation Council 1998). Culling (by any means) as a management option for overabundant populations was rejected by Ministers prior to the development of the strategy. The National Strategy therefore restricted the management of overabundant populations to translocation, fertility control, and habitat manipulation. The deliberate introduction of *Chlamydia* (a disease that affects fertility of the koala) to populations free of the disease was discounted as a management tool for population control in the National Strategy.

KOALAS ON KANGAROO ISLAND

Kangaroo Island covers an area of 438,000 ha and lies about 12 km from the coast of South Australia (Figure 1). Almost 47% of its native vegetation still remains, with approximately 55% conserved in national and conservation parks (Ball and Carruthers 1998). Koalas were introduced to Kangaroo Island in an attempt to conserve a species that was declining in number on mainland Australia. From 1923 to 1925, 18 koalas (and possibly a number of pouch-young) from French Island, Victoria (a *Chlamydia*-free population), were introduced into Flinders Chase National Park. Koalas thrived on the island, probably due to the absence of native predators and disease (Paton *et al.* 2002, Rodger and Kay 2002). By 1948, koalas were frequently observed in Flinders Chase National Park (Robinson *et al.* 1989).

In the 1940s, koalas were relocated to the Dudley Peninsula; however, they failed to establish in the area.

Between 1955 and 1958, 20 koalas were relocated from Flinders Chase National Park to the Cygnet River Valley following bushfires in the park (Robinson *et al.* 1989). Other relocations also occurred within Flinders Chase NP, including 47 individuals to Scotch Thistle Flat, a small (approximately 15 ha), rough-barked manna gum-dominated vegetation community approximately 4 km north of the initial release point.

In 1994, the koala population was estimated to be between 3,000 and 5,000 animals (St John 1997). This estimate was based on surveys in the Cygnet River Valley that contains about 76% of the island's preferred koala habitat (St John 1997). Koalas were found to be widespread throughout the Cygnet River Valley, with densities as high as 10 koalas per hectare in some areas (St John 1997).

Table 1. Population estimates by two methods, and distribution of koalas between habitat types based on surveys in 2001 (Masters *et al.* 2004).

Habitat Quality for Koalas ¹	Area (hectares)	Koala density	Koala population estimate (2001)	
			Catchment × Habitat Quality	Habitat Quality
High	750	2.16	1,508	1,621
Medium	12,909	0.87	8,284	11,290
Low	40,706	0.35	12,426	14,141
		Total	22,218	27,052

¹ based on vegetation map (Ball and Carruthers 1998)

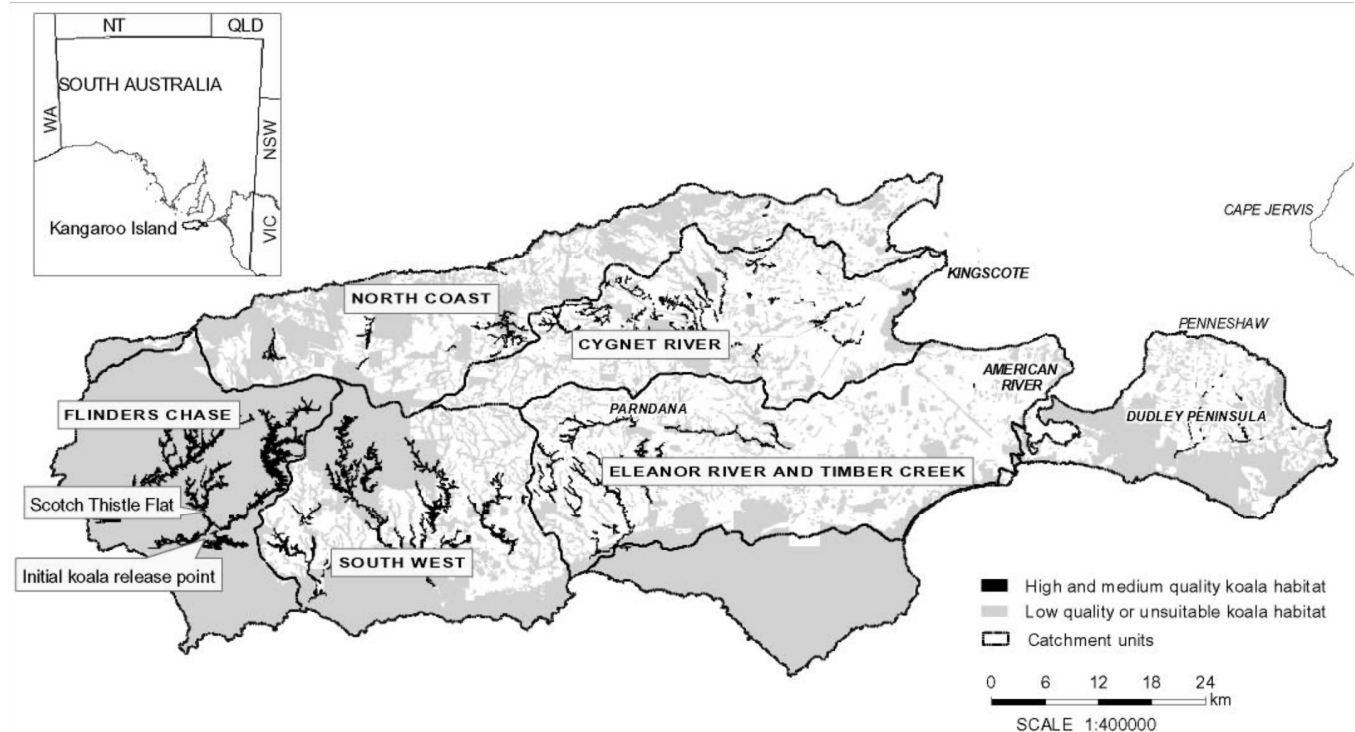


Figure 1. Kangaroo Island, South Australia, showing areas of high and medium quality habitat preferred by koalas, and major river catchment units.

In 2001, an island-wide and comprehensive population estimate was derived based on surveys at 115 sites across 5 different catchments (Figure 1) and 3 classifications of habitat (low, medium, and high quality for koalas) on the island (Masters *et al.* 2004). The island-wide population estimates by two different approaches were $22,487 \pm 2,961 SE$, and $27,053 \pm 2,830 SE$ (Table 1). The lower estimate accounted for variation between different catchment units as well as habitat type, while the upper estimate was based solely on habitat type.

Koala Impacts on Riparian Ecosystems

Koalas have distinct preferences for some eucalypts (Hindell and Lee 1990, Martin and Handasyde 1999). On Kangaroo Island, koalas prefer rough-barked manna gum (*E. viminalis* ssp. *cygnetensis*), south Australian blue gum (*E. leucoxylon*), red gum (*E. camaldulensis*), and swamp gum (*E. ovata*). Stringybarks (*E. baxteri* and *E. obliqua*) and peppermint box (*E. odorata*) are utilized to a lesser extent (St John 1997).

Koala damage to trees in Flinders Chase National Park was first reported in 1965 (Philpott 1965, Eberhard 1972). In 1994, surveys in the Cygnet River Valley indicated that koalas had caused significant damage to rough-barked manna gum, south Australian blue gum, and red gum (St John 1997). Of these, rough-barked manna gum had been impacted the most with greater than 50% canopy loss in 78% of trees assessed. Subsequent surveys in different catchments have indicated that koalas have caused the local extinction of rough-barked manna gum in some areas.

Impacts to rough-barked manna gum are especially significant, considering its relatively limited distribution on the island. Communities containing this subspecies occur over about 160 hectares and mostly in discrete patches along waterways (Ball and Carruthers 1998). The subspecies is classified as 'rare' on Kangaroo Island (Lang and Kraehenbuehl 1999) and has a limited distribution in mainland South Australia. Local extinctions of rough-barked manna gum on Kangaroo Island therefore significantly reduce the current distribution and genetic diversity of this subspecies.

The full ecological implications of koala damage to ecosystems are not well understood but are likely to be significant. Local extinction of rough-barked manna gum, death of trees, and damage to tree canopies affect both community composition and stream health.

In many areas, pink gum (*E. fasciculosa*), a species that is unpalatable to koalas and other browsers, has replaced the canopy species, with bracken fern (*Pteridium esculentum*) replacing the understory in many instances. This change in plant species composition and habitat structure is likely to have significant impacts on the fauna community. The regionally-rare white-naped honeyeater (*Meliphreptus lunatus*) is just one species that is known to be closely associated with rough-barked manna gum (Paton *et al.* 2002). Loss of trees can also result in erosion of stream banks, increased sedimentation in waterways, and changes to light and temperature regimes of waterways with consequential impacts on in-stream flora and fauna.

DEVELOPMENT AND IMPLEMENTATION OF A MANAGEMENT PROGRAM

In 1996, a task force comprising several ecologists, an animal welfare specialist, a veterinarian, and community representatives was established by the state government to provide independent advice on koala issues and management in South Australia. This task force recommended several management options with culling as the most cost-effective option. However, this option could not be considered under the recently agreed National Koala Conservation Strategy (Australian and New Zealand Environment and Conservation Council 1998).

The management program initiated in 1997 comprised:

- A large scale fertility control program to reduce population growth
- Translocation of koalas from critically damaged areas to suitable habitat on the South Australian mainland
- A habitat protection and restoration program, and
- A community education program.

A population model was used to determine targets for sterilization and translocation. The model indicated that a sterilization program would need to achieve and maintain an infertility rate of 70% in both sexes before any reduction in population size would be realized. Based on the population estimate of between 3,000 and 5,000 koalas, and the assumption that sterilizing a male would have the same benefit as sterilizing a female, between 2,100 and 3,500 koalas would need to be sterilized in the first 18 months of the program.

To immediately reduce browse pressure in critically damaged areas, the program aimed to translocate approximately 30% of the population in the Cygnet River Valley. It was also recognized that following the intensive phase, ongoing but less intensive management would be necessary to maintain the 70% infertility rate and low population densities (<1 koala per hectare) in managed areas.

Management Procedures

Procedures were developed for the safe capture, handling, surgical sterilization, and relocation of koalas. For females, transection and cautery of the oviduct was determined to be a safe, effective, and relatively quick (15 to 20 minutes per animal) sterilization procedure. A standard vasectomy technique previously developed and used in Victoria was considered suitable for male koalas. These sterilization techniques do not affect the production of hormones and therefore should have only minimal effects on koala mating behavior.

Only areas within the former range of the koala in South Australia were considered as translocation sites (Figure 2). Criteria used to assess suitable habitat included presence of palatable species, the area of suitable tree species, tree species composition, tree size and health, proximity to related vegetation, and land tenure. Approximately 1,300 hectares of suitable habitat containing rough-barked manna gum was identified. Guidelines were developed to ensure high survival of

translocated koalas, and to avoid koala damage to trees at release sites:

- A minimum of 10 koalas (gender balanced) at a rate of up to 1 koala per hectare would be released at a site
- Only young animals in good condition would be translocated
- Koalas would not be translocated when temperatures exceeded 30°C.

Studies to address animal welfare concerns were conducted prior to implementation of the management program. These included the effect of sterilization techniques on animal health and behavior, and survival of translocated koalas. Following favorable results, the management program was implemented in February 1997.

Habitat Protection and Restoration Program

Habitat protection and restoration efforts focused mostly on extension efforts whereby landholders were encouraged to apply for government grants for revegetation (e.g., Bushcare and Landcare programs). Some demonstration sites for revegetation were also established. Metal collars were fitted around some critically damaged trees, primarily in Flinders Chase, to stop koala access and to monitor tree recovery rates.

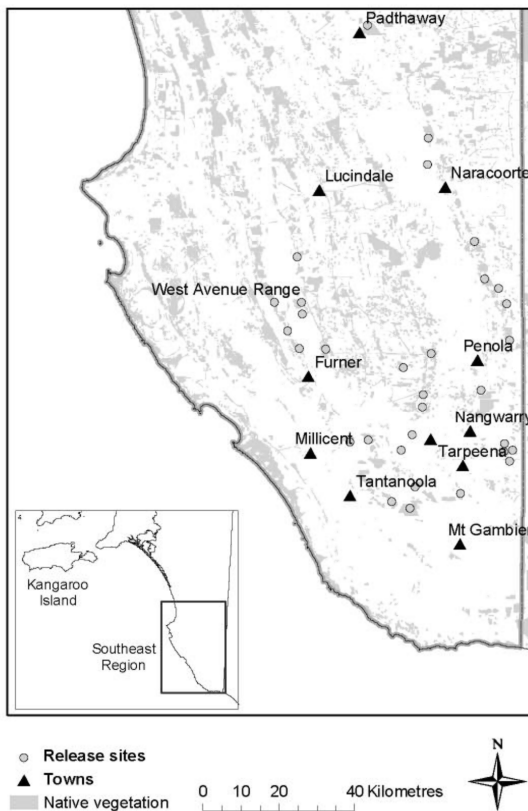


Figure 2. Release locations of translocated koalas in southeast South Australia.

Community Education Program

Information sheets, school education packs, newsletters, and a web site were produced and disseminated in

1997 and 1998. The significant positive public and government response to this program suggested that this approach was effective in improving awareness of the issue and management options.

PROGRAM EFFECTIVENESS

The results of the program from February 1997 to June 2000 are reported in Duka and Masters (2005). From February 1997 to June 2000, 3,447 koalas were sterilized, and 1,109 of those were translocated to southeast South Australia. Management focused on the Cygnet River Valley and Flinders Chase National Park. Population density in the Cygnet River Valley was reduced from a mean 3.7 koalas per hectare in 1996 to 1.84 koalas per hectare in 2000. Population density in Flinders Chase National Park was initially reduced from a mean 10.9 koalas per hectare in 1996 to 3.1 koalas per hectare in 1999, but then increased to 7.1 koalas per hectare in 2000. Tree condition improved in localized areas where translocation of koalas immediately reduced population densities.

From July 2000 to June 2001, management was suspended while surveys were being conducted to derive an island-wide koala population estimate. The program then continued at a reduced level of intensity until June 2004, with 706 koalas sterilized and 440 of those translocated to southeast South Australia. In June 2004, the government increased funding to the Program to AU\$400,000 for the year, in recognition of the greater numbers of koalas spread over a wider distribution than originally estimated and the need to intensify management efforts. This resulted in 600 koalas translocated from high quality habitats in the Cygnet River Valley and an additional 150 koalas sterilized and re-released on the island. Surveys following management showed that management reduced population density to 1.16 koalas per hectare in high quality habitats of the Cygnet River Valley.

In June 2005, the government further committed AU\$1M per year for 4 years to the management program. This fund was to intensively manage all high quality habitats and a large proportion of medium quality habitat, and to improve the habitat restoration and communication components of the program. In 2005-06, it is estimated that a further 1,600 koalas will be sterilized and 600 of those relocated to southeast South Australia. This will reduce koala densities in all high quality habitats, and will reduce breeding and population growth in a large proportion of medium quality habitat. As the density of fertile koalas decreases due to management, search time per koala caught and sterilized will increase such that numbers managed will likely be lower in subsequent years. The number of koalas translocated will also decrease as available habitat in the southeast is occupied. The effectiveness of the program will continue to be assessed through annual assessment of koala population densities and tree condition at established sites on Kangaroo Island and in southeast South Australia.

A habitat management strategy is being developed that involves activities such as tree planting, seed collection, and tree collaring. Management areas will be

prioritized based on the history and extent of koala damage, other impacts such as presence of feral animals and weeds, and the long-term potential to restore or protect habitats. The extent of high, medium, and low quality koala habitat will also be reviewed. In some areas, a decline in tree condition due to koala browsing has reduced the quality of habitat for koalas. Surveys and management activities in 2005-06 have also highlighted possible deficiencies with the vegetation mapping that may have resulted in the misclassification of habitat quality for koalas and consequently the estimated number of koalas in the area.

A comprehensive communication strategy that targets local, national, and international audiences is also being developed to improve understanding of the koala issue on Kangaroo Island, as well as the management options available to protect and restore riparian ecosystems. This is essential for facilitating management (e.g., gaining landholder permission for property access) as well as raising awareness of wildlife management in general.

AN ADAPTIVE FRAMEWORK

The Koala Management Program has been adaptive in response to improved understanding of koala ecology, the density and distribution of koalas across the island, the relationship between koala density and tree condition, and the effect of management on koala densities. This approach enables resources and management activities to be targeted to maximize ecological benefits.

A program to monitor the effectiveness of management and to prioritize management activities was implemented in 1996 with permanent monitoring sites established in different habitat types along the Cygnet River (20 sites), Flinders Chase NP (3 sites), Eleanor River (2 sites), Middle River (1 site), and on the Dudley Peninsula (4 sites). An additional 85 sites were established in 2000-01 to monitor koala populations and damage in other areas of the island. Koala density, proportion of tagged (i.e., sterilized) koalas, and tree health are monitored annually in these sites.

Also, discrete studies have addressed aspects such as the effect of sterilization on koala behavior and habitat use; koala movement and behavior in different habitat types; the relationship between koala density and tree condition; mating behavior; koala population density, distribution, and habitat type and survivorship of translocated koalas. In addition, significant data have been collected from captured koalas on the demographics and health of the koala population and tree species and habitat use.

Prioritizing Management

The disjunct distribution of koalas between catchments and habitats allows management to focus on relatively small areas with high koala densities causing damage to preferred food trees (Table 1). From a vegetation map of the island (Ball and Carruthers 1998), the tree species preferred by koalas occur as the dominant species (high quality habitat for koalas) or subdominant species (medium quality habitat for koalas) over approximately 13,659 hectares. Approximately half of the koala population occurs in these habitats.

Studies have indicated that only females need to be sterilized when animals are not being translocated, as although male koalas may hold territories, this does not stop other males from mating with many of the females in an area. DNA analysis of one population on Kangaroo Island indicated that 18 young were the result of 14 fathers. This has been observed in other koala populations (Ellis *et al.* 2002).

Management efforts between June 2004 and June 2006 have focused on koala translocation, to immediately reduce koala densities in high quality habitats. Generally, as koalas are resident with small home ranges, with dispersal primarily in young males (Horgan 1998), translocating koalas immediately reduces browse impact and this persists for relatively long periods. How long still needs to be quantified.

Factors Limiting the Effectiveness of Management

Factors that limit the effectiveness of koala management on Kangaroo Island include the limited amount of suitable habitat in southeast South Australia for translocation, and logistical constraints, including access to properties. To effectively reduce koala populations and impacts, management must occur at a landscape scale. In some areas, this is hindered by rough terrain and dense vegetation, or access denied by landholders. Over 60% of high and medium quality koala habitat occurs on private land; therefore, permission must be gained from landholders for koala management.

FUTURE OUTLOOK

The aim of the Koala Management Program on Kangaroo Island is to conserve riparian ecosystems through reducing koala densities to sustainable levels. Sterilization and translocation remain the only approved methods of achieving this aim. The approach has proven to be effective; however, it has been limited by its high cost and therefore the area of habitat effectively managed. The recent increase in resources to the Program will enable management to occur on a broader scale. Ongoing management will be needed after the 4-year intensive program to maintain these benefits.

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