Eradicating feral goats from Kangaroo Island, South Australia

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Summary

Feral goats are a common pest in island ecosystems, causing habitat destruction through selective over-browsing, weed dispersal and soil erosion. Eradication of goats has been achieved on a number of islands but to date, most successful eradications have occurred on small, uninhabited islands. Kangaroo Island (KI), South Australia, is a large island (4400 km^2) with a population of 4500 people. A goat eradication program was initiated in 2005 using a long-term strategic approach, the 'Judas goat' technique, and a small team of local staff. The program followed established principles for successful eradication which include effective planning, gaining support from stakeholders, developing and implementing effective control and monitoring and minimising reinfestation risks. Surveys of the local community about feral and domestic goats on KI indicated that support for the eradication of feral goats was very high (94%) but support for the complete removal of domestic goats was moderate (52%).

The distribution of feral goats was identified using community observations and the occupied area of the island was divided into seven management units (MU). These MUs were distributed along the coastal margins and creek systems of the north and western end of KI, apart from one isolated population in the centre of the island. Control activities targeted each MU sequentially. Judas goats were an essential part of the program for control and monitoring. Judas goats were left in each MU for 24 months after the last known feral goat was destroyed. Following this the Judas goats were destroyed and the area checked for scats and tracks annually. Judas goats assisted in the location and destruction of over 1150 feral goats. Since the program began, restrictions for keeping domestic goats have been tightened and a risk assessment developed. A permit system for keeping goats on KI is currently being investigated.

Native vegetation has responded rapidly to the elimination of goat browsing. Vegetation monitoring using photopoints and repetitive sampling shows that she-oak recruitment and survival and ground cover have increased since feral goats were removed. Other benefits include a reduction in ongoing management costs, reduced competition with stock and native herbivores for pastures, and the removal of a weed seed disperser. The eradication is now in the monitoring phase and if support and effort are maintained, this program will be one of the few successful feral mammal eradications carried out on a large inhabited island.

Introduction

Feral goats are a common pest in island ecosystems, causing habitat destruction through over-browsing, weed dispersal and soil erosion (Coblenz 1978; Parkes 1990; Biodiversity Group 1999). The removal of feral goats can have great benefits for ecosystem integrity. On islands where goats have been eradicated, the vegetation has recovered rapidly, even when feral goats have been resident for a long period of time (Parkes *et al*. 2002; Campbell and Donlan 2005). Following goat removal on Trindade Island in Brazil, barren areas rapidly became revegetated

and two endemic plant species, previously considered extinct, were rediscovered (Alves *et al.* 2011). Similarly, on Pinta and Santiago Islands in the Galapagos, the native vegetation recovered following goat removal despite being heavily affected by feral goats over many decades (Hamann 1979, 1993). To date, goats have only been removed from a number of small, uninhabited islands around the world but with improved technologies, planning and commitment, eradication of goats from larger islands is becoming feasible (Cruz *et al*. 2009; Oppel *et al*. 2011).

Kangaroo Island (KI) is Australia's third-largest island (4400 km^2) and is located 14 km off Cape Jervis, South Australia (Fig. 1). It is nationally important for biodiversity conservation, primary production and tourism and has a resident population of around 4500 people. It has a high cover of native vegetation and is free of a number of pest animals, including rabbits and foxes, which has allowed most endemic species of fauna to persist. However, there are a number of resident feral animal species on KI, including goats, which have had impacts on native vegetation, particularly along the coast.

Goats were brought to KI nearly 200 years ago by early settlers (Taylor 2002; Nunn 1989) and feral populations became established around the west coast of the island. This has resulted in overgrazing of native vegetation and land erosion, particularly on sand dunes and around high impact areas such as caves and watering points. Accordingly, in 2005 a feral goat eradication program commenced on KI and has continued until the present time (2012). This paper provides an outline of the crucial components of the program that were necessary to achieve successful eradication on a relatively large and inhabited island. The program followed the principles for successful eradication outlined by Parkes (1993) and Bomford and O'Brien (1995). These were as follows:

1. Assess, gain and maintain public and government support for a goat eradication program.
2. Plan for cost-effective eradication and implement the program using skilled and dedicated staff.
3. Develop and implement control options that can reduce the population faster than it can reproduce and ensure every individual is at risk.
4. Detect goats at low densities and continue to monitor areas once they are perceived as goat free.
5. Develop an understanding of the impacts of goats on KI so the community will recognise the importance of the program and support the concept of a goat-free Kangaroo Island.
6. Minimise re-infestation risks by developing effective management of domestic goats.

Figure 1: The location of Kangaroo Island

1. Assess, gain and maintain public and government support for a goat eradication program

Public opposition is the most common obstacle to the implementation of an eradication program so it is important to gauge the scope of public opinion prior to initiation (Genovesi 2007; Oppel *et al*. 2011). On KI, public support was gauged through public meetings, a survey of residents and through conversations at local shows and field days. Issues assessed included perceptions of feral goat impacts and benefits, requirements for managing domestic goats, and the level of resident support for an eradication program.

Goats were of little concern to most Islanders due to their distribution on the remote western end of the island, mostly in conservation reserves, however overall the local community strongly supported eradication (94%) and government agencies were keen to foster a cooperative approach. Survey results showed domestic goats were kept for meat, milk and pets but about half of the community (52%) supported their removal from the island, and 65% believed that domestic goats should be identified and registered, and properties with goats should comply with more stringent fencing requirements. The community also helped clarify the distribution of feral goats on KI by identifying locations where they had been sighted, as well as their potential impacts.

Articles about the feral goat program were placed in the local newspaper and newsletters, and information was provided at public events and seminars, and through displays in public places, such as the airport and library window. Public lands (national parks, wilderness protection areas etc.) were selected first for goat eradication. This was done to demonstrate to the community that

the program could achieve success and to reduce the likelihood of community criticism that private land was being targeted while goats were uncontrolled on government lands.

One of the greatest challenges for the program was gaining access to all private properties that were occupied by feral goats. Most landholders were supportive and accommodating but others liked their goats because they hunted them or allowed other people to hunt them on their land. These properties were left until last so the owners could see that the inevitability of eradication was a reality. It also gave the control officers time to visit the landholders and build relationships prior to control operations starting in the area. The danger was that access to critical properties would be denied. This would have resulted in a less optimal solution of geographic containment.

It was important throughout the program for control officers to maintain one on one contact with all relevant landholders. When visiting a property they would contact the landholder both before and after to let them know when they would be arriving and what happened during their visit. If landholders needed a hand with a task they would offer to help out where they could. Officers ensured that they followed any procedures required by the landholder when on their property, e.g. to avoid certain paddocks or how to close gates or access particular areas. By maintaining continual contact with each landholder, few access problems were encountered and landholders willingly provided information relevant to the program.

2. Planning for cost-effective eradication and implementing the program using skilled and dedicated staff.

Prior to 2005, goat management on KI involved recreational hunting on the north coast and intermittent shooting by National Parks staff and Sporting Shooters in conservation areas on the west coast. Few records were available on the intensity, extent or success of control operations and little was known about the ecology, distribution or abundance of the feral goat population.

As a first step, a working group was set up to gather information and assess the feasibility of an eradication program. This included staff from the Kangaroo Island Natural Resources Management Board, the state conservation agency and the Biosecurity Unit of Primary Industries who had eradicated a small population of goats in the Adelaide Hills at Pewsey Vale (Williams and Henzell 1992).

The working group developed a strategy to assess the potential for successful eradication. Information about goat population distribution was gathered from community sightings, rough estimates of density were calculated using information from other areas and potential impacts of goats were assessed from information collected by local naturalists and Parks staff and recorded in the literature. Using the distribution information provided through community sightings and assuming a density of between 1–4 goats/km^2 (see Parkes *et al.* 1996) the population of feral goats on Kangaroo Island in 2006 was estimated to be between 800 and 3200.

The program plan was documented in a management strategy (Masters 2007) and encompassed timeframes, roles and responsibilities of partner organisations and control strategies. The program was fortunate to receive funding for three years from the Invasive Animals CRC, with the potential for a further three years of funding. This provided a budget foundation and the ability to plan for the long term. The working group decided that since the goal was eradication, skills in hunting, data collection and monitoring would be important and long-term staff would be

essential. Locals with a good standing in the rural community and a good knowledge of local conditions were preferable, to maximise trust and minimise the potential for confrontation with Islanders. A number of local people had pointed out that they did not support control on their properties by off-island hunters. Fortunately the necessary skills were available locally.

3. Developing and implementing control options that can reduce the population faster than it can reproduce and ensuring that every individual is at risk of destruction

The area occupied by goats was divided into seven management units on the basis of land area, natural barriers for containment and road lines for access (Fig. 2). The creation of management units (MU) was designed to deliver systematic eradication of goats sequentially over a set of discrete and achievable geographic areas, each with limited potential for reinvasion. A trial was undertaken in one management unit first to assess methods, costs and the feasibility of complete eradication. The management unit selected for the trial (MU1) had a small isolated goat population located on one of the major rivers. The land uses included conservation, sheep grazing and forestry.

Judas goats were selected as the major control tool and Roger Roberts, who had been part of a previous program in the Adelaide Hills (Williams and Henzell 1992), came to Kangaroo Island and assisted staff to develop the skills to capture, collar, sterilize and radio-track goats.

The MU1 eradication trial was completed in 12 months and eradication of feral goats from KI was deemed to be achievable within a six-year timeframe using the current resources of around $100,000 per year. It was decided that monitoring for signs of previously undetected goats would continue for two years beyond the destruction of the last known feral goat and that management of domestic herds would be on-going.

Deploying Judas Goats

The Judas goat method exploits the sociability of goats and the need for individuals to find a mob. Goats are fitted with radio collars and released to associate with and reveal the location of other feral goats in the area. Radio-collared goats can also be used to gather information about movements, habitat use and social behaviour to enhance hunting and shooting operations (Taylor and Katahira1988; Rainbolt and Coblentz 1999), or as a monitoring tool to help confirm eradication. The use of Judas goats followed the Standard Operating Procedures developed by the Department of Primary Industries, NSW (Sharp and Saunders 2004).

All Judas goats were feral (because they work better as Judas animals than domesticated goats), in good condition, between 6–36 months of age, not pregnant, calm in nature (not highly alert or dominant) and white in colour. White Judas goats were easier to spot at a distance or in thick vegetation and contrasted with the local dark feral goats. This helped with identification and reduced the chances of accidental shooting.

We found that releasing Judas goats early in the program was more successful than when numbers were low following control actions, because this allowed the Judas animal time to find other goats and to become familiar with feral goat movement patterns, terrain and location of resources such as watering points, shelter belts, caves and feeding grounds. Those released later in the programme in places where there were no or few feral goats, moved only short

distances and had a high mortality. This may have been because most of them were sourced off-island (from Salt Creek or Iron Knob, SA) and were naïve to the local area and conditions.

Judas goats were kept in a pen for at least one week to allow all weed seeds to pass through their guts and thereby reduce the chance of introducing new weeds to the release site. In addition, each goat was photographed, measured, weighed, ear tagged, fitted with a radio-collar and sterilised at a local veterinary clinic either by vasectomy (males) or transection of the fallopian tubes (females) so that sexual motivation and other behaviours associated with intact animals were maintained. It is important to sterilise Judas goats, to increase their need to socialise and to limit any additional breeding. Goats that are given a tubular transection cycle into oestrus every 21 days during the breeding season and remain social. In contrast, intact, breeding female goats remain solitary for one month to a year after giving birth. A vasectomy has no negative effects on the social and sexual behaviours of male goats (Campbell *et al.* 2005).

The movements of Judas goats were monitored intensively for two years and results showed that the feral goats generally stayed on the coastline and moved back and forth along a coastal strip of around 9 km in length, although some groups also moved inland along creek lines for a similar distance. Judas goats were individually released at a distance of 2-5 km apart to reduce the chances of the Judas goats re-uniting and forming their own group.

VHF collars were used more widely than satellite collars because they are cheaper and have a longer battery life. They were most suitable for use in easily accessible terrain that could be covered on foot or by vehicle. In larger, inaccessible locations, satellite/VHF collars were more suitable because they allowed a rough location to be determined before covering large distances in the field. Judas goats were located using a Titley 26k receiver, three-element Yagi antenna and an omnidirectional, vehicle-mounted whip antenna. We used around 80 Judas goats during the course of the program.

Control operations

Once the feasibility trial had been successfully completed and the monitoring program was established, control operations began in MU2 and MU3 along the west coast of KI in Flinders Chase National Park (Fig. 2). This subpopulation occupied a narrow strip of coastal vegetation dominated mostly by heathland and often accessible only on foot or by air. Park closures were required for control operations and were put in place every three months, avoiding the holiday periods.

Control teams consisted of two or three people capable of destroying mobs of up to 16 feral goats at a time. The teams were comprised of highly-skilled hunters, to ensure all goats were destroyed humanely and that the whole mob was eradicated during each control event to prevent creating a population of escapees that had learned how to avoid hunting methods (Parkes 1990; Cruz *et al.* 2009).

Initially, when the number of feral goats was high, control officers walked the length of the MU destroying all feral goats encountered along the way. As the numbers of feral goats declined, control activities focussed around the Judas goats. Feral goats were completely removed from the west coast (MU2 and MU3) by 2009 and the program then moved on to the north coast where

the terrain was steeper, the vegetation thicker and property ownership more diverse. During the course of the program over 1,000 goats were destroyed by ground control.

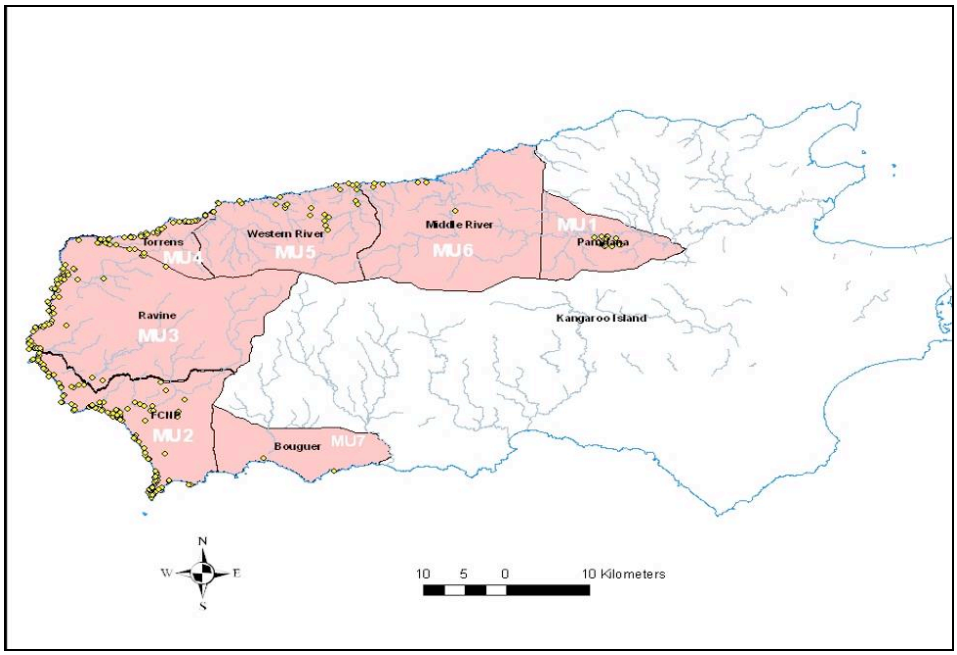

Figure 2: Location of goat management units

On two occasions aerial control was conducted with a helicopter and accredited shooters. The first aerial shoot was undertaken in early 2008 following a large bush fire and 111 goats were destroyed. The aim of the second aerial shoot in 2012 was to target the few remaining goats and search areas for undetected feral goats. Only five goats were destroyed during a one-day control effort. Aerial control was weather-dependent and costly because windy conditions which are common on KI limited flying time.

4. Detecting goats at low densities and monitoring areas once they were perceived as goat-free

After the last known feral goat was destroyed in a management unit, Judas goats were monitored for a further 24 months. If no feral goats were found, Judas goats were removed and the area was checked for goat scats and tracks annually by walking the length of the coast and focusing on previously highly favoured areas such as water holes and river outlets. The community was encouraged to report sightings of goats through a media program '*Bleat on a Goat*'. Rangers, fishermen and tour operators who utilised the area frequented by goats were regularly asked if they had seen any goats. Remote sensing cameras were used in previous high-use areas towards the end of the program to quantify the number of feral goats remaining based on photos of individuals.

5. Developing an understanding of the impacts of goats on KI

When the program began, knowledge of the impact of feral goats on native plant species was limited to information from community members and local naturalists. A vegetation monitoring program was therefore established to determine plant community responses to a goat free environment. Additionally, rumen samples were collected and analysed from 62 destroyed goats to identify what plants they were consuming. A total of 75 plant species were identified in the samples. The majority were native species, but weeds were also present, including cape weed, phalaris and barley grass. The plant consumed most frequently (45%) was drooping she-oak (*Allocasuarina verticillata*) (Fig. 3), which is an important food source for the endangered glossy black-cockatoo (*Calyptorhynchus lathami halmaturinus*).

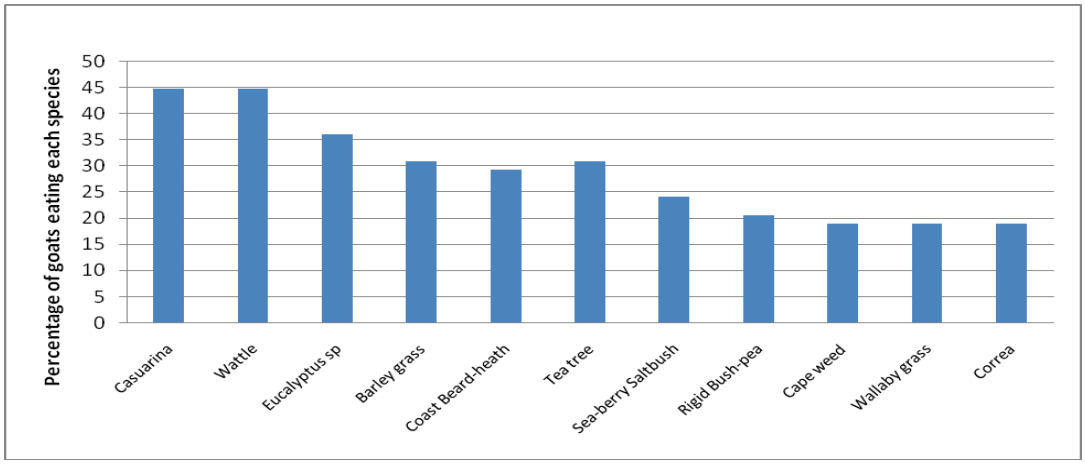

Figure 3: Percentage of goats eating each plant species as detected in the rumen of destroyed goats. Only the most commonly detected plant species are displayed.

Monitoring the recruitment of *Allocasuarina*

The growth of *Allocasuarina verticillata* and other plant species was monitored annually from 2008 at 11 sites along the north coast of Kangaroo Island. Transects were established and individual plants mapped and their growth monitored. Preliminary results suggest that the removal of feral goats has resulted in higher recruitment and survival rates of *A. verticillata* but this research needs to be continued. There has also been an increase in the cover of succulent species such as *Myoporum, Rhagodia, Carpobrotus* and *Enchylaena*. Some of these species were not commonly found in the diet of goats, probably because they were previously at low abundance due to over-grazing.

Photopoints, which were first established in 2005 before control began, have shown a dramatic change in vegetation cover. Areas of high feral goat use, such as caves, were devoid of vegetation before control began but now support a thick ground cover, particularly of succulent

species (Fig. 4). High use areas along cliff tops had little vegetation cover with few succulent species, and are now well covered with pigface and saltbush (Fig. 5). Other areas now support a thick cover of regenerating drooping sheoak (Fig.6). Monitoring the vegetation changes will continue for a number of years.

Figure 4: Beach cave (MU2) clearly shows the regeneration of succulent vegetation following the removal of feral goat. Left image was taken prior to the program in 2005, the right image was taken in 2010.

Figure 5: Changes in the vegetation on north coast monitoring site. Left image was taken in 2008, the right image was taken in 2012.

6. Minimising reinfestation risks by developing effective management of domestic goats.

While domestic goats remain on Kangaroo Island, there will always be a risk of reinfestation from the release or escape of animals from private property. To counter this possibility, the feral animal program has:

- established a consultation program targeting domestic goat owners
- developed a risk assessment to calculate the chances of domestic goat escape and establishment of a feral population from each property

- assessed all domestic herds as being of either low, medium or high risk of goat escape and establishment.

Risk assessment criteria included:

- history of escapes
- adherence to legislation (Property Identification Code (PIC))
- nature of enterprise (pet, milk, meat)
- location (terrain, vegetation, population)
- risk and detection for escape (vegetation cover, fencing, stock monitoring)
- consequence of escape (chance of entering suitable habitat).
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Properties assessed as being low risk are unlikely to be the source of new feral populations and are of little concern. Land managers with properties in the medium or high risk categories have been advised about ways to reduce their risk to low, and these will be revisited to assess progress towards risk reduction.

Of the 22 properties with domestic goats, four were assessed as medium to high risk. The KI NRM Board is reviewing legislative requirements for domestic goat management on Kangaroo Island. Currently the KI NRM Board is consulting with the community about a proposal to implement a permit system that will only allow people to own domestic goats if the risk of goats escaping and becoming established in the wild is assessed as low. This would require a change to the *Natural Resources Management Act 2004*. Without this legislative change, or a similar strategy, it is possible that a feral population of goats will become established again on KI in the future.

Conclusion

The goat eradication program on Kangaroo Island is now moving into the monitoring phase with a focus on the management of domestic goats. The program has demonstrated that a well thought out strategic approach can work on a large occupied island when the community is supportive and the resources and skills for control and monitoring are available.

Regular post-eradication monitoring will continue on KI for at least another two years. This will include walking the coast searching for goat scats and sign and garnering information from the community relating to potential goat sightings. A higher level of attention will be focused on domestic goats and effective legislative control will be developed based on the risk assessment process.

Monitoring to date shows *Allocasuarina* species and succulent plants are recolonising at a rapid rate now the feral goats have been removed. This will benefit other species, such as rock parrots and glossy black-cockatoos, which are dependent on the vegetation impacted by feral goats. These results are consistent with those from other islands where feral goats have also been removed (Campbell and Donlan 2005).

The program has taken seven years to complete and has cost around $900,000, not considering the ongoing management of domestic goats. However, the benefits of the program are considerable, including savings to government agencies and landholders who no longer need to control goats, improvements in habitat quality and diversity as previously grazed species regenerate, removal of competition with stock for food and water, and removal of one weed vector.

The KI eradication program is now in its final stage. Unsuccessful eradications in other areas have been attributed to a lack of political support, inappropriate methods, lack of effort or the failure to detect the final goats at low densities. The KI program has to ensure that none of these factors prevent its successful completion.

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