

# An attempt to eradicate feral goats from Lord Howe Island

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**Abstract** Lord Howe Island is a 1455 ha World Heritage Site in the Pacific Ocean, about 700 km off the east coast of Australia. Feral goats became established soon after human settlement in 1834. Goats were removed from the northern part of the island in the early 1970s, but remained in the more rugged southern mountains despite efforts to eradicate them. A new plan to eradicate the goats was developed in early 1999 and an attempt made to do it later that year. This paper reports on how well the plan was matched by the operation. In the plan we used previous hunting tallies, kill rates, and guesses at rates of increase, to estimate that about 200 goats were present in 1999. To put all these animals at risk in one eradication campaign we estimated that both aerial hunting from helicopters (50 hours) and ground hunting with dogs (220 hunter-days) would be required, at a cost of NZ\$107,000. The campaign began on 6 September 1999 and finished on 15 October 1999 during which time 295 goats were killed, 189 by the aerial hunting and 106 by the ground hunters. Eradication was claimed after the operation, but reports of fresh droppings and footprints were made in late 2000 and three goats were seen in 2001, one of which was shot in June 2001. Attempts by animal liberation groups to stop the programme, and a subsequent attempt to prosecute the hunters highlight the need for careful planning and management of animal welfare issues.

**Keywords** Feral goats; eradication; Lord Howe Island; animal welfare

## INTRODUCTION

Lord Howe Island is a 1455-ha World Heritage Site located at 31°S 159°E in the Pacific Ocean about 700 km off the east coast of Australia (Fig. 1). The island was discovered in 1788 and has been inhabited since 1834. It has a resident population of approximately 350 people and can accommodate up to 400 tourists at any one time (Lord Howe Island Board 2000). Its native biota has suffered the usual catastrophes following invasion by alien vertebrates and weeds, with three species of birds being driven to extinction by the 1860s, and a further six species vanishing after the arrival of ship rats (*Rattus rattus*) in 1918 (Recher and Clark 1974). Feral pigs (*Sus scrofa*) and feral cats (*Felis catus*) were eradicated by the 1980s, and ship rats and house mice (*Mus* spp.) are currently controlled by poisoning in places, to protect the palm seed industry and seabird nesting sites (Eason 1996; Billing 2000; Billing and Harden 2000). Pickard (1984) lists 173 exotic angiosperms, with climbing asparagus (*Asparagus setaceus*), guava (*Psidium cattleianum*), and boneseed (*Chrysanthemoides monilifera*) being significant potential problems. Nevertheless, the rugged volcanic nature of most of the island (Mounts Gower and Lidgbird rise to 875 m and 777 m, respectively) has protected much of its natural biodiversity. Thus, the age of the island (7 million years), its recent occupation by humans (it was apparently never discovered by Polynesians), its protected status, and its remote location, has left Lord Howe Island as one of the least-modified of the few islands located at about this latitude in the Pacific Ocean.

Feral goats have been present since the island was settled. In the early 1970s, 228 goats were shot by the islanders in

an eradication attempt. This was effective in the northern part of the island, although a single goat was still present on the northern cliffs in 1988 (D. Hiscox, pers. comm.). However, goats remained in the south; Pickard (1976) estimated that about 50 were present in 1975.

No assessment of the detailed effect of goats on the biota of Lord Howe Island was made before the eradication attempt, although browse damage to species (such as terrestrial orchids) was obvious in many places and regeneration of tree species appeared to be limited in areas where cyclones had killed adult trees (J. Parkes, pers. obs.). Even without detailed information, the ability of goats to alter insular ecosystems is well reported elsewhere (e.g., Coblentz 1978; Parkes 1984b) and a precautionary approach was justified.

The southern mountains are within the Lord Howe Island Permanent Park Preserve which has similar status to a national park. It is managed by the Board in accordance with a plan of management (NPWS 1986) prepared in consultation with the community. The plan of management requires a vigorous and regular shooting programme to be maintained, with the aim of eradication of the feral goats. The Lord Howe Island Board commissioned a report on the feasibility of eradicating the remaining goats (Parkes and Macdonald 1999), and this paper compares the predictions made in this report with the events that transpired in the actual eradication attempt.

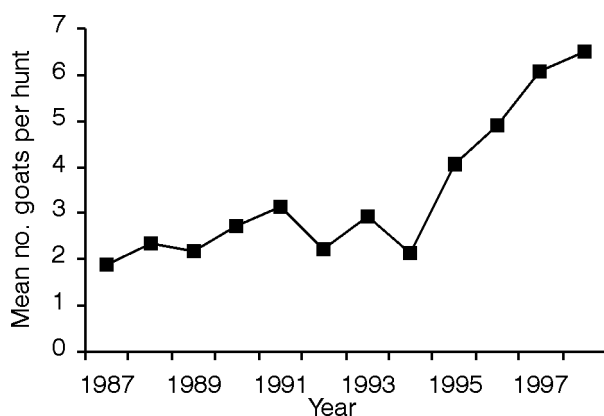


**Fig. 1** Lord Howe Island showing the southern mountains inhabited by feral goats (photograph by Ian Hutton).

## METHODS

### Estimating the population size

Annual control of the goats in the south began in 1987, and between then and 1998, an average of 13.1 (range 7-28) hunting expeditions in which at least one goat was shot, were conducted each year. A total of 579 goats were shot with an annual range of 19-88 animals. The annual average kill-rate remained at between two and three goats killed per hunting expedition between 1987 and 1994, but thereafter increased to an average of 5.7 goats killed/hunting expedition (Fig. 2). If we make two bold assumptions, it is possible to estimate the population size from these data. First, we assumed that this increase in kill-rate reflected an increase in the goat population and not an increase in hunting efficiency and skills. The same individual was largely responsible for the hunting over the period so hunting ability was likely to have been constant, at least during the latter years. Second, we guessed at the rate at which the population would increase if all hunting



**Fig. 2** Number of goats killed per hunting foray by Lord Howe Island rangers between 1987 and 1998.

stopped. We used a finite rate of increase of 1.45 based on some estimates from Australian mainland goat herds (Parkes *et al.* 1996). Simply, the number of goats present must have been able to at least double (the change in kill-rates) since about 1990 despite an average annual kill of 48.3 goats. We estimated the population to have been about 100 in 1987 and 200 in 1999.

### Meeting the strategic rules for eradication

A policy of eradication but a practice of sustained control usually leads to sub-optimal results either because the failure to achieve eradication leads to the campaign being abandoned, or because the more difficult strategic requirements of sustained control (setting target densities and harvests to achieve protection while avoiding over-kill and opportunity costs) are not considered. So, the first considerations in any plan to eradicate must be its practicality and likelihood of success.

Parkes (1990) described three critical conditions that must be met before eradication is possible, and Bomford and O'Brien (1995) added three desirable rules that should be met for success:

- Rule 1: all the goats must be able to be put at risk. This rule determines the tactics that must be employed. On Lord Howe Island, it was known roughly where goats were to be found, but it was likely that some goats would not be accessible to ground-based hunters and could only be killed using other methods. The use of dogs, aerial shooting from helicopters, Judas goats (e.g., Taylor and Katahira 1988), trapping, natural vegetation poisoning (e.g., Parkes 1983), and aerial poisoning (Forsyth and Parkes 1995) were all considered.
- Rule 2: the goats must be killed at rates faster than their rate of increase at all densities. This rule determines the likely intensity and length of the campaign. On Lord Howe Island, there were thought to

be only 200 goats, distributed over about 700 ha of forested habitat. Past experience suggested that a short, intensive campaign would be feasible, as well as desirable.

- Rule 3: the risk of re-colonisation must be zero.

Logically, because goats arrived once, this probability can never be zero. On Lord Howe Island, the risk is higher than zero as islanders keep a few domestic goats. Short of removing these animals, the plan recommended that: the risk that they could form a new feral herd could be reduced by banning anyone holding them on land adjacent to the forested reserves; setting fencing standards; keeping a register of domestic animals so that any escapees can be recaptured; sterilisation; or imposing a sunset clause on keeping goats (i.e., no new goats are kept as the current ones die).

- Rule 4: the social and economic conditions must be conducive to meeting the critical rules.

The Lord Howe Island Board was keen to eradicate the goats and had allocated the funds to do so. Not all the island residents were so convinced of the need. We estimated that about 36 hunter-days per year would have to be used in a sustained control campaign to hold goats at densities much lower than those in 1999. This would cost about NZ\$6000 per year, as opposed to an estimated one-off cost of NZ\$107,000 to eradicate the goats.

- Rule 5: where the benefits of management can be achieved without eradication, discounted future benefits should favour the one-off costs of eradication over the ongoing costs of sustained control.

This condition is only measurable when the benefits are accounted in the same currency as the costs; a difficult task for non-market conservation values and so not relevant for the Lord Howe Island case.

- Rule 6: ideally, goats surviving the campaign should be detectable and dealt with before an increased population size becomes obvious.

Failure to detect survivors increases the risk of operational failure. The plan recommended that two hunting sweeps in which no goats were seen should be a milestone to end the formal eradication campaign. However, the plan recommended some options to deal with any goats seen in *ad hoc* searches by local ranger staff after this milestone.

## Tactical options

Selecting appropriate control methods requires consideration of the constraints imposed by the particular physical, biological, and social environment that might limit achievement of the strategic rules. On Lord Howe Island, the main physical constraints are habitat and topography. Most of the goat habitat is forested and often very steep, so neither an aerial campaign nor ground hunting would (by itself) be sufficient to kill all the goats over a short time. Other techniques such as poisoning were not suitable because of the lush vegetation, presence of non-target animals, or for social reasons.

The thick vegetation also meant that ground hunting without the use of dogs to find the goats would be, at best, inefficient. However, the use of dogs was itself constrained

by the presence of the rare flightless rail, the Lord Howe woodhen (*Tricholimnas sylvestris*), so any dogs used would have to be trained not to molest non-target species. The programme also had to be scheduled so as to minimise potential impacts on native fauna, particularly seabirds which breed in the target area.

The main social constraint on the campaign was the presence of residents and tourists, the latter using many of the tracks to scenic areas in the areas inhabited by goats or taking guided tours to the summit of Mt Gower. This limited the campaign to a time of year when peoples' use of the area inhabited by goats was minimal.

The plan (Parkes and Macdonald 1999) recommended that a helicopter should be used to shoot all goats seen on the bluffs and ledges before the main ground campaign began. A Bell 206B (VH-HWS) owned by Helicopter Aerial Surveys Ltd was shipped from Australia to Lord Howe Island as deck cargo. The pilot was experienced in wild animal control operations, mainly on feral pig, goat, and buffalo control on mainland Australia. A Hughes 500C or 500D model would have been preferable in the windy conditions, but could not be arranged to meet operational deadlines. The helicopter was also used to ferry hunters and dogs during the ground hunting. To avoid any possible "incidents" with islanders and tourists, use of the helicopter over the whole island was constrained to the hours before 0800 h and after 1700 h, except for servicing the block being ground-hunted each day.

For the ground campaign, the plan recommended that a team of up to seven hunters using eight dogs in total would be ideal to cover a hunting block. The team hunting method used by the ground hunters has been developed by Prohunt NZ Ltd for use in New Zealand forested habitats where goats are difficult to find, do not usually associate in large groups, and where some usually escape any encounter with hunters or dogs (Parkes 1984a). The aim of the Prohunt system is to minimise the number of goats that escape death at the first encounter. The system uses a team of hunters each with one or two dogs that form a line across the area to be hunted with hunters being 100-150 m apart and in VHF radio contact with each other. The dogs are trained to chase and hold the goats, which are then killed by the nearest hunter. Dogs not immediately involved in the chase are trained not to join in so that the line is not broken, and the dogs doing the bailing are trained to return to their master once the goats are killed. The dogs used on Lord Howe Island had been trained to avoid kiwi (*Apteryx* spp.) in New Zealand. That training apparently worked for woodhen and nesting seabirds on Lord Howe Island, as the dogs ignored or avoided any encountered. No dogs spent any time "lost" during the campaign. Experience in New Zealand forested habitats suggested such a team could cover between 100 and 200 ha in a day, so the 700 ha area inhabited by goats on Lord Howe Island was divided into five hunting blocks. Again, experience from New Zealand campaigns suggested that most goats are killed in the first day of hunting, but up to six sweeps in each area would

**Table 1** Goats killed, hunting effort and number of hunting sweeps at the end of the campaign when no goats were seen or killed in each of seven hunting blocks on Lord Howe Island.

Hunting block	Area (ha)	Number hunting sweeps	Number goats shot	Number sweeps no goats
Intermediate Hill	157	6	7	4
Boat Harbour	162	6	17	2
Erskine	168	10	31	4
Big Pocket	15	8	24	2
Mt Gower	30	3	0	3
Far Flats	190	4	5	2
World's End	188	11	22	2

be needed to kill the last goat and give some measure of success (i.e., a sweep in which no goats were detected).

## RESULTS

The Lord Howe Island Board endorsed the plan to eradicate goats in March 1999, and contracted Prohunt NZ Ltd to do the work. The campaign began on 6 September 1999 and ended on 15 October 1999. A total of 295 goats were killed, but goats were reported in 2000 so the campaign failed to eradicate the population.

During the aerial hunting 11 sorties were flown between 6 and 27 September (Fig. 3a) accounting for 189 goats in 12.4 flying hours. Most goats shot from the air (94%) were shot in the first five days. The ground hunters shot 106 goats, accounting for 61% of the goats shot from the ground in the first sweep, and 95% in the first four sweeps of the hunting blocks (Fig. 3b). Seven hunting blocks were used, their boundaries being natural features or tracks, and between one and four hunting sweeps when no goats were seen or shot were achieved in each (Table 1). The goats were surprisingly difficult to hunt for animals that had never been exposed to dogs, and could often outrun the dogs in

**Table 2** Predictions made in the plan and the actual data collected during the eradication campaign.

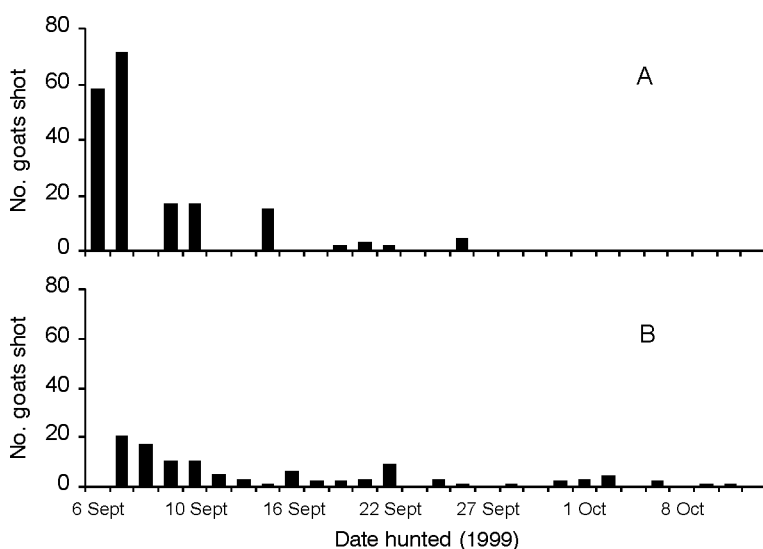
Parameter	Prediction from plan	Data collected during the operation
No. of goats	c. 200	295
Helicopter time (hours)	50	12.4 (hunting) + 19.7 (ferrying hunters)
Hunter days	220	168
No. hunters	7	6
No. hunting blocks	5	7
No. hunting sweeps/block	6	4-11
No. goats left	0	?

areas of boulder fields. The ground hunters countered this by hunting towards the major bluffs so that escaping goats would take refuge there. The hunters then radioed the helicopter to deal with any seen.

## DISCUSSION

### How did the plan match the event?

We underestimated the number of goats present (Table 2). This was not surprising given the rough estimates we had for rates of increase and changes in kill-rates in the years before the eradication campaign on which the number was based. Only 64% of the helicopter time and 76% of the ground-hunting effort planned was expended because of budget limitations. As it turned out this was a mistake because eradication was not achieved in the initial operation. In late 2000, fresh droppings and footprints (of a small but unidentified number of goats) were found in one place under Mt Lidgbird. In March 2001, three goats (all apparently females) were reported at East Point at the northern end of the original range. The strategy to deal with these survivors was for the Board's ranger, who was involved with the original campaign, to hunt over the island

**Fig. 3** Number of goats shot (A) in 11 helicopter sorties and (B) by ground hunters in the eradication campaign, 1999.

on one day each week. In June 2001, a goat that matched the description of one of those seen in March was shot about 4 km away on the western side of Mt Gower in an area with sign of a small number of goats (M. Carter pers. comm.). This area now appears to be the only place with goat sign (M. Carter pers. comm.) suggesting that only one small group of goats (perhaps now only two animals) is ranging over much of the former range of the herd. A Judas goat operation is planned for 2002 (S. Olson pers. comm.).

The main technical weaknesses in the campaign were largely caused by the fixed budget. The costs of transporting dogs from New Zealand meant that the hunters had only one spare dog to rest or replace injured dogs. The costs of the helicopter meant that the machine was not available for the last two weeks of the operation, with an increased risk that some goats might have survived on bluffs out of sight of the ground hunters, and the campaign lacked any systematic post-operational monitoring to detect survivors. In part, the ground-hunting control technique, with repeated sweeps of an area and careful recording of animals that escaped, gives some measure of success or failure, although the hunters thought another two weeks of hunting would have made them more confident of success.

More structured systems to detect low-density populations could be used if a high degree of certainty of success was essential. Such systems could be based on search theories developed as part of anti-submarine warfare (Koopman 1980) and now often developed to optimise search and rescue operations, or the presence of dangerous diseases in wildlife (Cannon and Roe 1982). The basic parameters in the theory are the need for coverage at an intensity related to the known or expected density of the items being sought, and to the detection range of the method used. Of course, in the case of presence/absence as in an eradication campaign or missing person search, the coverage must be complete, and some form of systematic sampling is required. It is feasible to search for (mobile) goats or their (stationary) sign over a small island such as Lord Howe, and detect their presence with high certainty, but very high intensity sampling is required to detect a survivor with a high degree of confidence somewhere in a large area by direct sampling methods (e.g., Choquenot *et al.* 2001). The Judas goat method is one way to increase the search range and confidence of detection for animals such as goats, and it would be worth exploring the optimal search parameters for a large eradication campaign such as Project Alcedo on Islas Isabela in the Galapagos Islands (Anon 1997).

### **Socio-political and animal welfare issues**

The local island community was consulted during preparation of the plan to eradicate the goats and again prior to the Board's endorsement of the plan. Whilst there was

generally strong community support, not all island residents were convinced of the need.

A group of island residents with previous experience in feral pig and goat control expressed interest in undertaking the eradication programme and, together with Prohunt NZ, were invited to bid for the work. However, the local consortium were unable to undertake the aerial shooting, which was considered an essential element of the programme. Nevertheless, provision was made for one local resident, who was also a member of the local consortium and on the Board's staff, to assist Prohunt NZ with the eradication operations.

Prior to and during the project, the Board liaised with the Australian Royal Society for the Prevention of Cruelty to Animals (RSPCA) to ensure that animal welfare considerations were properly addressed. Specific conditions were included in the contract to ensure that all goats were destroyed in a humane manner in accordance with legislative requirements and applicable codes of conduct. Board officers monitored operations in the field to ensure they were conducted to the required standards.

The Board distributed information about the eradication programme to local residents and visitors prior to and during the operation. This addressed the need for the programme, how it would be undertaken, the potential benefits, area closures, and other safety provisions. Regular progress reports were also provided to the community through the local island newspaper and one of the major Sydney daily newspapers ran a story on the project. This information assisted in raising community awareness, understanding and support for the eradication programme, and assisted to ensure that people did not enter the area during hunting operations.

Two issues arose. The first related to the proposed extent of the areas closed to the public for operational and safety reasons. Following representations from tourism operators, the proposed closures were revised and limited to the specific areas where eradication operations were being undertaken each day. This restricted operational flexibility and necessitated higher levels of planning and management, but did not adversely affect safety or the overall operation.

The second issue related to animal welfare concerns and disagreement about the need to kill the goats. Immediately prior to the programme commencing, a small number of island residents, including at least one associated with the unsuccessful bid for the work, collaborated with voluntary animal welfare groups to lobby for the programme to be stopped. Australian and international animal welfare organisations made numerous political and other representations and disseminated information over the internet. The major focus was on aerial shooting. However, there was also considerable public support for the programme from on the island, the Australian mainland, and overseas, much of it an apparent reaction to the emo-

tive and misleading information distributed over the internet by the animal welfare groups.

Allegations of cruelty were referred to, and investigated by the local police and the RSPCA, neither of whom were able to establish any evidence to substantiate the allegations. Despite this, a private prosecution alleging offences against the (NSW) Prevention of Cruelty to Animals Act, 1997 was initiated by Animal Liberation New South Wales almost six months after the programme was completed. These were later withdrawn and costs were awarded against the prosecution.

Although animal welfare was carefully addressed in the planning and operational phases, and the operation inspected by animal welfare agencies, the level and manner in which this issue was pursued by animal liberation groups was not foreseen. In retrospect, this opposition was not surprising given past experience elsewhere in the world (e.g., during the goat and sheep eradication campaign on San Clemente Island off California (Van Vuren 1992)), and more recently against feral horse control in Australia (English 2001). No significant disruption to the programme was caused although some additional costs were incurred, mostly relating to the failed prosecution. We believe this signals an increasing interest by animal welfare organisations in invasive species control programmes which may have implications for other areas. It highlights the need for careful planning and management to ensure that control programmes are demonstrably needed to protect indigenous values, and are conducted in a humane manner consistent with legislative requirements and the highest standards of animal welfare. However, we note that despite the careful and skilful conduct of the control operation, adherence to standard operating procedures laid down by the Australian Government for aerial control of alien animals, the lack of evidence to the contrary, and the failure of the litigation, animal welfare groups are still using the Lord Howe case as an example of inhumane management and absence of evidence of the need for control of unwanted animals (Seymour and Oogjies 2001).

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