

RESEARCH

The eradication of feral goats from Auckland Island

Derek A. Brown¹, Keith G. Broome^{2*} and Kingsley G. Timpson³¹102 Cullensville Road, RD1 Picton 7281, New Zealand²Department of Conservation, Private Bag 3072, Hamilton 3240, New Zealand³Department of Conservation, PO Box 349, Rangiora 7440, New Zealand

*Author for correspondence (Email: kbroome@doc.govt.nz)

Published online: 28 November 2022

Abstract: Feral goats (*Capra aegagrus hircus*) were eradicated from Auckland Island, a National Nature Reserve and World Heritage site, between 1989 and 1991. Goats had established on the main Auckland Island following several releases in the 19th century. The population, amongst the most southerly ever recorded, was restricted to the northernmost areas of the island, with environmental conditions appearing unfavourable for southward spread, and the population stable at c. 100 individuals during scientific studies in the 1970s and 1980s. These studies recommended eradication of the goats because of their damaging effect on indigenous vegetation, especially subantarctic endemic species. The main cull occurred in November 1989 when two full-time and three part-time hunters shot 103 goats over 74 hunter-days effort. At least two more were poisoned using 1080 toxin applied to cut foliage of highly palatable species. A subsequent operation in February 1991 found limited sign, saw no animals, and again used poisoned foliage which possibly accounted for further animals. The last known goat was a solitary male shot from a helicopter in October 1991. Eradication was relatively straightforward, with unfavourable weather and logistical constraints due to the island's isolation the greatest challenges to success. Scientific monitoring of vegetation recovery has been insufficient but anecdotal observations suggest a dramatic recovery of many flora species. This recovery is tempered by the continuing presence of feral pigs (*Sus scrofa*) in the same location.

Keywords: Auckland Island, biodiversity benefit, eradication, goat, subantarctic, vegetation

Introduction

The Auckland Islands are situated at 50.69°S, 166.08°E, 465 km south of the South Island of New Zealand. The island group consists of seven islands and numerous smaller islets, with the main Auckland Island covering approximately 45 891 ha. Vegetation largely comprises a coastal forest of low-growing southern rata (*Metrosideros umbellata*), below a dense band of shrubland dominated by species such as *Dracophyllum longifolium*, *Raukaua simplex*, *Myrsine divaricata* and in places the introduced *Olearia lyallii*. Above c. 300 m tussock grassland occurs with associated subantarctic megaherbs such as *Pleurophyllum* spp., which yields to fellfields at c. 500 m (Godley 1965). Between 1833 and 1907, several ships are known to have been wrecked in the group (Ingram 1990) and the islands were the scene of many shipwreck survival dramas (e.g. Raynal 1885). Such risks were the main motivation for the liberation of goats (*Capra aegagrus hircus*) to act as a food source for the survivors. There were abortive attempts at settlement 1842–1856 and farming 1874–1910 in the Auckland Island group (Russell et al. 2020). In 1934 the entire Auckland Island group was designated as a Flora and Fauna Reserve, and then altered to a Nature Reserve in

1977 with an overarching National Reserve status applied in 1986. They are also part of the New Zealand subantarctic UNESCO World Heritage site (Russell et al. 2022).

On many islands worldwide, goats were kept as domestic animals that later escaped to become feral, or were liberated to provide food for shipwrecked mariners. They have been eradicated from over 100 islands (e.g. Campbell & Donlan 2005). Goats on most subantarctic islands (i.e. south of 50°) died out naturally or were eradicated (see Parkes 2021 for the fate of those on New Zealand islands). Currently, feral goats remain on only one southern island, Isla de los Estados (Staaten Island) at 54°S at the southern tip of Tierra del Fuego in Argentina where they have persisted since their liberation in 1868 (Ponce & Fernandez 2014). On the Auckland Islands, goats were liberated at about 10 sites around the main island and on six other islands in the group in the 19th century (Rudge & Campbell 1977). Several recorded liberations were made in 1865 including at Erebus Cove (part of the spatial distribution of the discussed population) to provide a food source for shipwreck survivors. However, no goats were observed for some time (c. 26 years) after these releases, and they may have died out. Other (including possible unrecorded) releases occurred at later dates (Rudge & Campbell 1977), with further introduction of goats to the Port Ross area reported in the late

1880s (Russell et al. 2020), which may have been the founding source of the established Port Ross population.

A few goat populations persisted for a time but only two succeeded long-term, in the Port Ross area of the main island (the focus of this paper) and on 12 ha Ocean Island (from a release in 1885). The goats on the latter (numbering between 12–14 animals) were eradicated from 1941–1944 by members of the Cape Expedition (Russell et al. 2020). The goat population that established on the main Auckland Island was restricted to the extreme northern sector of the island, bounded to the south by Laurie Harbour and Grey Duck Creek. The total area inhabited has been variously estimated, at about 4000 ha (Anon 1986) to about 1835 ha, of which only 327 ha was regularly frequented by goats (McIvor & Sherley 1988). Timpson and Anderson (1990) produced a map based on their work suggesting the total area occupied was c. 3400 ha. This latter figure is based on the most detailed fieldwork and is considered the most accurate (see Fig. 1).

The Auckland Island goat population was one of the most southerly populations of feral goats and appeared to be living in an extreme and marginal habitat for the species. This theory is supported by the fact that releases elsewhere on Auckland Island did not establish, and that the utilised range was restricted to the northern low-altitude areas of the island, apparently with the warmest temperatures and driest climate. The most favoured habitat within this area was

coastal grassland, followed by coastal rata forest. Less use was made of *Oreobolus pectinatus* moorland or high-altitude tussock (Rudge & Campbell 1977; McIvor & Sherley 1988). The vital component of the habitat appeared to be the fine-grass swards that occurred only on the McCormick Peninsula (the informal name applied to the headland north of Terror Cove), and these grasses were prominent in the diet. Even so, the goats had to devote virtually the whole of each long summer day to feeding (Rudge & Campbell 1977). Over 50 species were recorded in the goats' diet. However, only three species, southern rata (*Metrosideros umbellata*), snow tussock (*Chionochloa antarctica*) and kelp (*Durvillaea antarctica*) made up more than 50% of the diet by dry weight (Chimera et al. 1995). Goats were observed to stop foraging and rapidly move to shelter as soon as a rain squall or other unfavourable weather arrived, and made frequent use of shelters such as dry caves and rock overhangs.

The general behaviour and ecology of the goats on Auckland Island has been described by Rudge and Campbell (1977), Campbell and Rudge (1984), Russell et al. (2020) and summarised in Parkes (2021). It is clear from these studies that the goat population was barely maintaining itself in an unfavourable environment, and some related factors may have been conducive to eventual eradication success. The goats spent a very high proportion of their time feeding to maintain nutritional demands, but exhibited

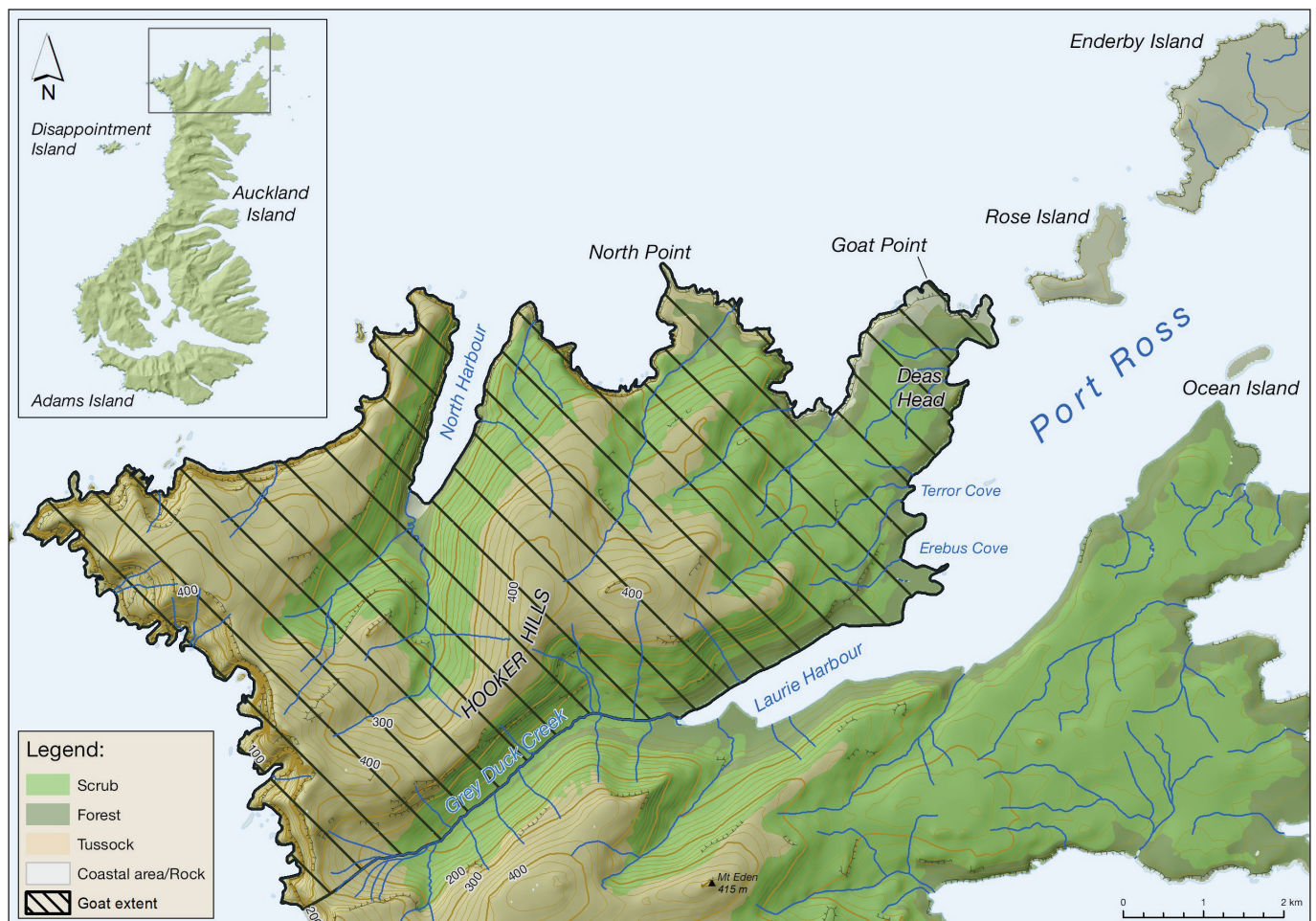


Figure 1. Map of northern Auckland Island with former goat range indicated by diagonal hatching.

behavioural avoidance of unfavourable weather events and a proclivity for dry sheltered overnight camps. There was a high proportion of aged or very aged individuals in the population (evidence of a stable population with little recruitment), the animals were described as bony and carrying little fat, there were noted health issues such as loose incisors (indicating mineral deficiency) and grossly overgrown hooves, and a single breeding season each year with an apparent high neo-natal mortality limiting recruitment. Goats shared their range with feral pigs (*Sus scrofa*), a potential competitor for some foods, with the exception of a small area bounded by cliffs at colloquially named Goat Point (see Fig. 1), where a small number of goats had found their way down cliffs but had not been able to exit. These goats supplemented their diet by eating kelp (*Durvillaea antarctica*) cast up on the rocks (Rudge 1986).

The presence of goats, an introduced species, was not compatible with the Nature Reserve status of Auckland Island, or with the administering Reserves Act 1977. As early as 1968 the possibility of eradication was being discussed within the administering Department of Lands and Survey, but prior to any policy being formulated, surveys were commissioned on the status and impacts of the population. Lee and Kennedy (1986) reported that feral goats and pigs were seriously modifying the vegetation and restricting the distribution of endemic subantarctic herbs, and therefore should be eradicated or removed.

In contrast, there were arguments that the goats had intrinsic value and should not be eradicated (Rudge & Campbell 1977), although these arguments were countered by Wardle et al. (1978). This point was again raised in the 1980s (Rudge 1986; Muir 1986) but resolved in part by the capture and transport of 67 goats to New Zealand (Trotter & Willis 2022). The commercial interest in the goat population was due to their potential for considerable meat production and likely survival characteristics (Muir 1986). The debate about a goat policy within the Auckland Island management plan coincided with a boom in interest in farming goats, particularly for their cashmere fibre, but also for meat production.

Ecologically, the goats mainly ate introduced pasture grasses, with palatable forest plants only surviving if they grew within thickets of unpalatable plants. However, the coastal association of the palatable *Veronica elliptica* was destroyed and while goats only ate small amounts of the tussock grass *Chionochloa antarctica* they virtually eliminated it from their home range area due to their continuous browsing (Rudge 1990). The latter was compounded by the rooting behaviour of feral pigs in the same area.

The limited range of goats meant their impact could be gauged by comparison of the vegetation within their range to that on the neighbouring uninhabited areas to the south of Grey Duck Creek. Campbell (1986) reported that within the goat browse zone *Zealandia pustula* subsp. *pustula*, *Fuchsia excorticata* and *Raukaua simplex* were either absent or very uncommon, and *Carex aucklandica* was very much more common than on the south shore of Laurie Harbour. Bark-biting on *Raukaua simplex* shrubs was also very obvious. Subsequent re-measurement of vegetation plots conclusively showed that *Chionochloa antarctica* was less abundant over a 10-year period (Campbell 1986) as a result of combined effects of goats and pigs. Another species severely affected by goat browsing was the ground

fern *Asplenium bulbiferum*. However, it was considered that although the goats were doing considerable damage to vegetation, no rare or localised plant species were considered to be 'at risk' because of the browsing. Gut samples taken from animals shot in 1989 showed that goats preferred *Anisotome* spp., *Pleurophyllum* spp. and *Azorella polaris* whenever available but browsed a wide range of other species, including epicormic shoots of *Raukaua simplex* and *Coprosma foetidissima* (Timpson & Anderson 1990).

Goats appeared to be largely found on the lower slopes of the Hooker Hills, below a very dense band of *Myrsine divaricata* scrub. However, goats were seen on the summit of the Hooker Hills in 1985 by botanist M. Foggo. It appeared that they had utilised a large slip that had cut a path through the scrub to gain access to the higher slopes. Concern was raised that from there, goats could more easily spread along the ridge (around the head of the catchment) to occupy the extensive eastern forest areas further south, significantly extending the zone and scope of the damage. Campbell and Rudge (1985) were concerned about the serious consequences of the potential spread of goats as they would be physically harder to hunt in the forested valleys of the eastern seaboard, and the relatively rich food supply and sheltered habit would enable more rapid breeding.

In 1985, a draft management plan recommended the eradication of the goats, but several submissions urged for the opportunity to undertake research on the goats' commercial and genetic value (e.g. Lough 1985). Therefore, the approved 1986 management plan for the Auckland Islands offered a stay of execution for the goats with a policy to provide for further research and live capture, but with the proviso that this was not to compromise the primary policy to eventually eradicate the feral goat population. Details of the live capture events in 1986–87 including information on captured goats were reported by McIvor and Sherley (1988) and Trotter and Willis (2022).

Methods

An initial planned control attempt, in 1986, to shoot any goats found in the upper tussock areas or making their way around the head of Grey Duck Creek was unsuccessful, due to unfavourable weather for almost the entire duration of the short trip. Advice was then sought from experts in the field of goat control as to the potential methods that could be employed. Several options, such as hunting with dogs were dismissed due to the potential risk to non-target species such as penguins and sealions. Helicopter hunting was considered only as a back-up to ground hunting, being expensive and logistically difficult. Shooting (foot-hunting) without dogs was selected as the principal method. Another method selected as follow-up was the application of poison onto cut portions of highly palatable vegetation (Parkes 1983) such as *Anisotome latifolia* and *Azorella polaris* (obtained from cliffs or outcrops out of reach of the goats). A gel containing 10% 1080 (sodium fluoroacetate) poison was to be used to target specific sites such as sheltered 'camps' or 'dens' that the goats used during nights or during inclement daytime weather. 'Track pads' of loose soil were also made on known goat tracks to enable monitoring of movement of goats between areas, by viewing the pads for fresh footprints.

Bases for hunters were established at Deas Head and at North Harbour. The known range of the goats was within

a day's walk from either camp (Timpson & Anderson 1990). A basic operational plan was developed (Timpson 1989). The goats' range was first established through field observations of animals or sign (browse or droppings), and animals in an area were observed and counted if possible before shooting began (to ensure as far as possible that all animals seen were subsequently accounted for and none were missed or escaped). A specific area would be hunted thoroughly by two dedicated hunters, and then left for some time for any sign to deteriorate, before revisiting the area to inspect for fresh sign. More remote areas (largely the extremities of the range) were worked first to reduce potential for further dispersal. The direction of hunting was always towards a point of 'no escape', i.e. a headland or other confined landforms such as cliff-faces. People not specifically assigned to goat hunting and based at the Deas Head camp also indulged in some localised hunts. Rumen and jaw samples were to be taken from some of the shot animals for diet and age analysis. After extensive hunting effort in an area, 1080 gel was applied to cut vegetation. Rifles used were .223 calibre, chosen for their suitability for use on goats, and for their accuracy and range. Subsequent ground-hunting trips were planned for the following summer to account for any survivors, while the very infrequent presence of helicopters in the area could also be utilised for surveillance and mop-up.

Results

The main culling operation took place between 30 October and 9 December 1989. Thirty-seven days were spent hunting mainly by the party of two dedicated hunters, supplemented by occasional hunting effort by three staff based at Deas Head, although some of this time would have been lost to

bad weather. A total of 105 goats were destroyed in this period, including two that were poisoned. Of these animals, 47 were male and 58 were female. Most (77%) were adults with only 17% and 6% being classed as juveniles or kids, respectively. A number of pigs (41) were shot and one was poisoned during the goat operation. There were no reports of any non-target kills from hunting or poisoning.

Most (c. 80%) of the goats were shot in the Erebus Cove to North Point area, the most north-easterly portion, an area less than one-third of their total known range. This area was anecdotally regarded as the warmest and most favourable habitat. Four goats were shot in the 'alpine' area of Hooker Hills. All goats were north of Laurie Harbour/Grey Duck Creek and no goats or sign were seen south of there. Some hunting was challenging due to the terrain, with risk of falls a regular possibility. One goat living in a very restricted 'no-exit' area below a cliff had to be accessed via ropes down the cliff-face.

The daily numbers of goats killed by both the dedicated hunters and the less-formal Deas Head staff never reached a sequence of zero kills to give confidence that the 1989 campaign had achieved eradication (Fig. 2). However, follow-up application of 1080 was planned, as was a hunting programme for the following summer to account for any survivors. The team reported upon their departure that they knew of at least five remaining goats with potentially up to 12 in total (Timpson & Anderson 1990). Some poison baits were left, and it was thought these would kill some animals, but it was considered unlikely that the poison would account for all of the remaining animals. At least one goat is considered to have succumbed to these baits, with a carcass not attributable to the hunting being located at Terror Cove (where the toxic baits had been laid) by a subsequent tourist party (P. McClelland pers. comm.). Rumen samples were taken from 49 shot goats, with over 40 plant species recorded in their diet, the result of which

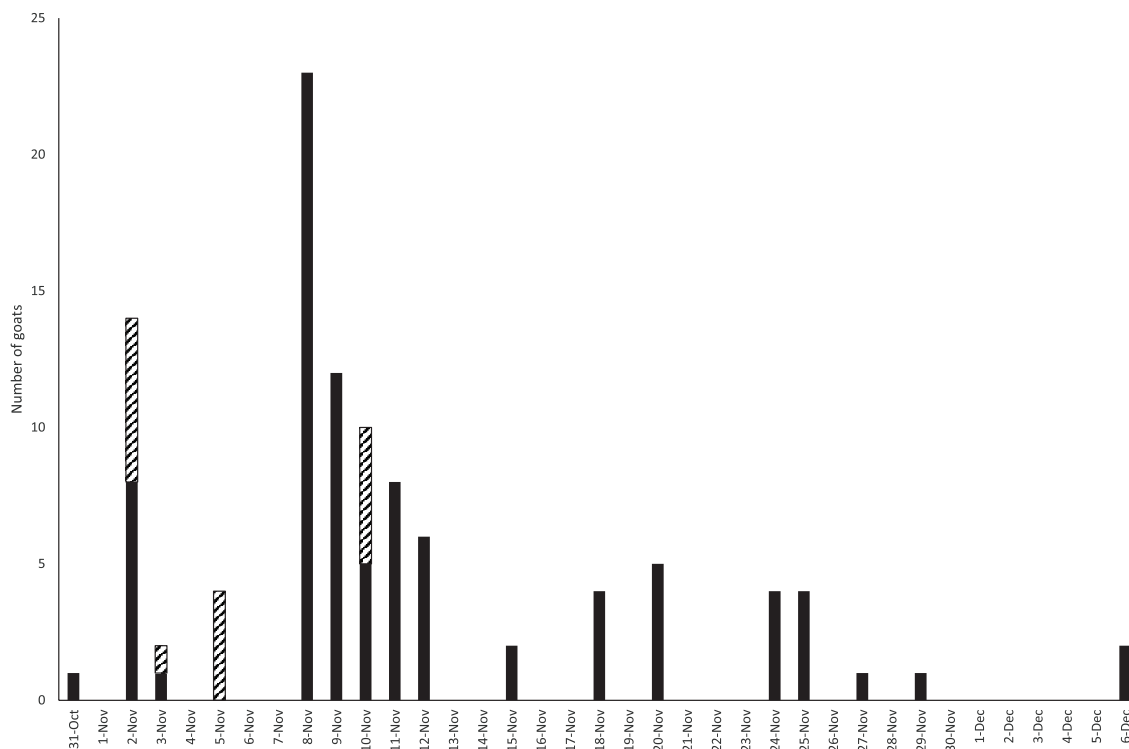


Figure 2. Daily kills of goats in 1989 by the dedicated hunters (black bars) and Deas Head staff (hatched bars).

is summarised in Chimera et al. (1995).

In February 1991 a two-person field team spent approximately 10 days searching for goat presence, and located fresh sign on the true right (eastern) side of the head of North Harbour. They attributed these signs to two or three goats (Willemse 1991), but saw no live animals during their trip. However, towards the conclusion of the trip 1080 baits (on cut *Azorella polaris* leaves) were placed out at all the locations of fresh sign. It is highly possible that this poison accounted for some of the remaining goats. The last goat shot was dispatched on 26 October 1991. This lone adult male goat was observed and shot from a helicopter on the eastern headland of North Harbour (Main 1991). The helicopter was on a pre-determined flight plan deliberately searching for goats or their sign. Specific searches for goat sign were made in 1994 and 1996, but no further sign has been observed.

Discussion

Earlier estimates of the number of goats present were borne out by the eventual cull. The population was estimated to be approximately 100 animals in 1972–3 and again in 1983 (Campbell & Rudge 1984), and in the 1970s and 1980s this was judged to be relatively static. In 1987, 42 goats were observed after 58 had been captured and removed (Sherley 1988). Prior to the 1989 eradication operation, the population was considered to be between 50 and 100 animals (Timpson 1989).

The eradication was relatively straightforward, and with experienced and goal-focused hunters, the ground-based shooting was a highly effective technique. However, hunting by itself in 1989 failed to eradicate the goats in the time available. Major constraints were logistical difficulties due to the island's isolation, and its frequent adverse weather. Difficulty of access prevented rapid follow-up for such purposes as determining the effectiveness of poisoning, or for monitoring for remaining sign.

The use of 1080 gel on cut portions of palatable vegetation appeared effective, but due to the nature of the operation the precise numbers of animals killed by this technique, and any possible avoidance of baits or sub-lethal doses acquired by other animals, could not be observed or documented. However circumstantial evidence suggests it could have been an important and even a critical tool in accounting for the last goats on the island. It was known that between five and 12 goats survived the 1989 hunting but only one was subsequently shot (from a helicopter in 1991). An unanswered question is whether the 1080 technique by itself could have eradicated the goats. A project using the 1080 gel technique on feral goats in a North Island forest habitat was estimated to have killed over 90% of the population (Parkes 1983). Choice of plant material may be important, as Timpson and Anderson (1989) suggest *Anisotome latifolia* was far more effective than *Stilbocarpa polaris* in that it lasted in a palatable state for much longer (3 weeks or more).

Lack of knowledge of the fate of the survivors of the hunting was a risk, but hunting effort was limited by tight logistical constraints. Ideally, more time should have been devoted to hunting in 1989 to account for surviving goats and to achieve a series of zero-kill days for greater confidence of operational success. However, further trips had been planned to ensure eventual eradication, and the extreme environment inhabited by the goats favoured the eventual eradication outcome through reducing possible dispersal and productivity of survivors. The 1080 baits left in areas where goats were

known to be present in 1989 and again in 1991 extended potential eradication effort beyond the hunting timeframe. The subsequent absence of any sign of goats in specific searches in 1994 and 1996 or wider visitation of the area since indicate eradication has been achieved.

The main Auckland Island has rarely been visited by botanists in recent years, and monitoring has not been undertaken to evaluate any response of vegetation to removal of goats. However, vegetation plots installed by Rudge and Campbell in 1972/73 should provide a base for comparison. Some inference of the species likely to stage a recovery in distribution and abundance is provided by on-site observations. For example, Rudge (1986) noted that many plants such as *Anisotome latifolia*, *Poa foliosa* and *Veronica elliptica* grew on cliff ledges out of reach of goats, and this seed source would facilitate regeneration in former goat areas. Two years after the main operation it was noted that areas of favoured habitat and nesting contained prolific growth of grasses and herbs, and that even juvenile *Stilbocarpa* spp., *Anisotome* spp. and *Pleurophyllum* spp. megaherbs were seen where historically they had been heavily browsed by goats (P. Willemse pers. comm.). These observations are supported by KGT (pers. obs.) who found that by 1996 the vegetation recovery was amazing, with megaherbs flourishing in places where previously there were goat travelling tracks, including significant recovery of *Pleurophyllum speciosum*. While some ecological benefits will accrue as a result of the goat eradication, the continued presence of pigs will have an inhibitive effect on recovery of some natural vegetation communities.

Author contributions

DAB compiled historical records; KGT led the eradication team and collected field data; and DAB wrote the manuscript with input from KGB and KGT.

Acknowledgements

Kingsley Timpson and Dave Anderson were the principal hunters in the main operation, while Pete McClelland, Andy Cox and Chris McMillan undertook some hunting from Deas Head. Pete Willemse and Mark Mawhinney undertook the February 1991 survey and poison baiting. Chris Main carried out the helicopter survey, shot the last goat in 1991, and monitored for goat sign in 1994. Thanks to all the above for providing information for the 2002 unpublished report that formed the basis for this paper, and to Pete McClelland for facilitating that report. Thanks to Greg Sherley and John Parkes for helpful review of this paper, and John Parkes for extracting and graphing data from field diaries.

References

- Anon 1986. Auckland Island – goat and pig eradication: feasibility study. Unpublished report to Outlying Island Reserves Committee. NZ Forest Service.
- Campbell DJ 1986. Report on a visit to the Auckland Islands, 30 January – 3 February 1986. Ecology Division Report No. 2. Lower Hutt, Ecology Division, DSIR.
- Campbell DJ, Rudge MR 1984. Vegetation changes induced

- over ten years by goats and pigs at Port Ross, Auckland Islands (subantarctic). *New Zealand Journal of Ecology* 7: 103–118.
- Campbell DJ, Rudge MR 1985. Goats on the Auckland Islands. Unpublished letter to the Department of Lands and Survey, 28 Feb 1985. Ecology Division, DSIR.
- Campbell KJ, Donlan CJ 2005. Feral goat eradications on islands. *Conservation Biology* 19: 1362–1374.
- Chimera C, Coleman MC, Parkes JP 1995. Diet of feral goats and feral pigs on Auckland Island, New Zealand. *New Zealand Journal of Ecology* 19: 203–207.
- Godley EJ 1965. Notes on the vegetation of the Auckland Islands. *Proceedings of the New Zealand Ecological Society* 12: 57–63.
- Ingram CWN 1990. *New Zealand shipwrecks 195 years of disaster at sea*. 7th edition. Auckland, Beckett. 501 p.
- Lee WG, Kennedy PC 1986. Botanical studies undertaken on the Auckland Islands, March 1982. In: Penniket A, Garrick A, Breese E eds. *Preliminary reports of expeditions to the Auckland Islands Nature Reserve 1973–1984*. Wellington, Department of Lands & Survey. Pp. 110–122.
- Lough D 1985. Goats – the strategic overview and the importance of the Auckland Island feral goat population. Wrightson NMA report to the Scientific Subcommittee. Department of Lands & Survey. 7 p.
- McIvor A, Sherley GH 1988. A study and live capture of Auckland Island goats. Wellington, Landcorp. 40 p.
- Main C 1991. Auckland Island goats 1991. Unpublished report. Dunedin, Department of Conservation.
- Muir P 1986. Unpublished letter to Department of Lands & Survey, 10 December 1986. Ministry of Agriculture and Fisheries.
- Parkes JP 1983. Control of feral goats by poisoning with compound 1080 on natural vegetation baits and by shooting. *New Zealand Journal of Forestry Science* 13: 266–274.
- Parkes JP 2021. *Capra hircus*. In: King CM, Forsyth DM eds. *The handbook of New Zealand mammals*. 3rd edn. Melbourne, CSIRO Publishing. Pp. 393–445.
- Ponce JF, Fernandez M 2014. *Climatic and environmental history of Isla de los Estados, Argentina*. Netherlands, Springer. 128 p.
- Raynal FE 1885. *Wrecked on a reef or twenty months in the Auckland Isles*. London, Thomas Nelson and Sons. 356 p.
- Rudge MR 1986. Report on a visit to Auckland Islands 29 January – 5 February 1986. Unpublished report. Lower Hutt, Ecology Division, DSIR. 19 p.
- Rudge MR 1990. Feral goats. In: King CM ed. *Handbook of New Zealand mammals*. Oxford University Press. Pp. 406–423.
- Rudge MR, Campbell DJ 1977. The history and present status of goats on the Auckland Islands (New Zealand subantarctic) in relation to vegetation changes induced by man. *New Zealand Journal of Botany* 15: 221–253.
- Russell JC, Horn SR, Miskelly CM, Sagar RL, Taylor RH 2020. Introduced land mammals and their impacts on the birds of the subantarctic Auckland Islands. *Notornis* 67: 247–268.
- Russell JC, Horn SR, Broome KG 2022. Restoration of New Zealand subantarctic islands. *New Zealand Journal of Ecology* 46: 3482.
- Sherley GH 1988. Auckland Island management with particular reference to feral goats (*Capra hircus*). Unpublished report. Wellington, Conservation Sciences Centre, Department of Conservation.
- Timpson KG 1989. Feral goat eradication plan for Auckland Island expedition 30 October – 9 December 1989. Unpublished report. Stewart Island, Department of Conservation.
- Timpson KG, Anderson D 1990. Auckland Island feral goat eradication expedition 30 October – 9 December 1989. Unpublished report. Stewart Island, Department of Conservation.
- Trotter M, Willis M 2022. Introduction, rescue and subsequent history of Auckland Islands livestock. *New Zealand Journal of Ecology* 46: 3487.
- Wardle P, Moar NT, Given DR 1978. Goats on Auckland Islands. *New Zealand Journal of Botany* 16: 291–292.
- Willemse P 1991. Auckland Islands expedition 1991. Unpublished report. Invercargill, Department of Conservation.

Editorial board member: James Russell

Received 5 February 2021; accepted 22 March 2021