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Ecological Restoration of Sub-Antarctic Macquarie Island

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ABSTRACT: Invasive vertebrate species have had devastating impacts on the flora, fauna and landforms of Macquarie Island over a period of 200 years. Following the successful eradication of weka by 1989 and feral cats by 2001, planning for the eradication of ship rats, house mice, and European rabbits began in 2004. Funding of AUD\$24.7M was secured in 2007 for a multi-year project based on aerial baiting targeting rabbits and rodents followed by ground hunting targeting surviving rabbits. The first aerial baiting attempt in 2010 was abandoned due to unfavourable weather and shipping delays. The degree of non-target seabird species mortality from limited baiting in 2010 led to a renewed examination of non-target mitigation options. Rabbit Haemorrhagic Disease Virus (RHDV) was introduced in February 2011 to reduce the pre-baiting rabbit population and thus minimise non-target mortality amongst scavenging seabirds. Aerial baiting resumed in May 2011 using 4 AS350 helicopters and a team of 27 people, and was completed by July 2011. No rodents have been detected post-baiting, and the estimated rabbit population of 150,000 has been reduced to fewer than 30 at the conclusion of baiting. The rabbit hunting phase commenced in July 2011 using a team of 15 hunters and 12 dogs and is ongoing, with 3 rabbits accounted for. Hunting and monitoring is expected to take a total of 5 years post-baiting and will be based on annual progress reviews. A minimum of 2 years monitoring will be conducted. Rodent detection dogs will deploy in 2013 to assist in determining rodent eradication success. Six months after baiting, vegetation recovery was already evident, and increased burrow-nesting seabird activity has also been observed in the first breeding season post-baiting.

KEY WORDS: aerial baiting, Australia, ecological recovery, eradication, follow-up hunting, introduced species, Macquarie Island, *Oryctolagus cuniculus*, rabbits, rodents, Tasmania

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INTRODUCTION

Macquarie Island (12,780 hectares) lies in the Southern Ocean (54°37'53"S, 158°52'15"E) 1,500 km from Hobart, Tasmania and 1,000 km from Bluff, in southern New Zealand (Figure 1). It is part of the state of Tasmania and is a listed World Heritage site. Discovered in July 1810 by sealers, early European activity centred on commercial exploitation of seals and later penguins, and continued until 1919 (Cumpston 1968). Sealing and oiling gangs deliberately or inadvertently introduced numerous mammal species. Five species, ship rats *Rattus rattus*, cats *Felis catus*, house mouse *Mus musculus*, European rabbits *Oryctolagus cuniculus*, and weka *Gallirallus australis scotti* (Copson and Whinam 2001) established feral populations and caused significant impacts on landscapes and native flora and fauna, including extinction of two endemic land birds (Taylor 1979). Weka were eradicated by 1989 and cats by 2001. Increasing landscape and vegetation impacts from rabbit grazing (Jenkin 1975, Taylor 1955), combined with greater capacity to achieve larger scale eradications (e.g., Howald et al. 2007), led to the establishment of the Macquarie Island Pest Eradication Project in June 2007. The project aimed to eradicate the three remaining vertebrate pest species (Department of Parks, Heritage and the Arts 2007).

PLANNING

Funding to implement the Macquarie Island Pest Eradication Plan was secured in 2007. Planning then commenced with aspects of regulatory work, environmental impact assessment, staff recruitment, contract management, field equipment procurement,

and training of dogs. Funding had been based on work already undertaken, meaning that an approved plan with considerable detail was already in place and could be implemented when funding was made available. The plan was based on a two-phase project with aerial baiting using brodifacoum baits spread by helicopter being followed by ground hunting of surviving rabbits. Based on previous projects elsewhere, aerial baiting was expected to achieve rodent eradication and reduce the rabbit population by >99% (Micol and Jouventin 2002, Torr 2002, McClelland 2011).



Figure 1. Location map.

A 3-year timeframe was allowed to get dogs trained to the required standards (including a tender process, acquisition of pups, training, and certification), to secure all regulatory approvals (38 approvals and permits were required), recruit staff, and to procure all supplies, equipment, and services. A significant logistical operation was needed to aerially bait an island of this size. A quantity of 305 tonnes of Pestoff 20R Bait containing brodifacoum at 20 ppm was ordered (Animal Control Products, Whanganui, New Zealand). A tender process resulted in Helicopter Resources Pty Ltd (Tasmania, Australia) being contracted to supply two AS350BA and two AS350B2 helicopters, along with engineering support, helicopter spares, pilots, and ground crew experienced at aerial baiting operations, bait spreading buckets, switching gear, and TracMap GPS systems. A team of 19 staff was recruited to provide bait loading, non-target mitigation, safety, and GIS technical support. Other support was received from the Australian Antarctic Division and Bureau of Meteorology staff at the Macquarie Island station, where the aerial baiting team was accommodated. A ship was chartered with the capacity to deliver the large quantities of bait and helicopter fuel to Macquarie Island, along with the baiting team, helicopters, and other equipment.

OPERATIONAL

2010 Aerial Baiting

Due to circumstances beyond the project's control, the selected ship was unavailable for the required departure date in April 2010. Consequently, a delay of 4 weeks was experienced before the team could be delivered to the island. On arrival, a small amount of baiting was conducted (<1,300 ha) before persistent strong winds and low clouds precluded helicopter operations for extended periods. Eventually, with winter ending and the imminent return of many seabird species to the island, the lack of progress forced a decision to cease operations and for the team to withdraw, with only 8% of the bait spread over about 10% of the island. Although non-target mortality had been predicted in the Environmental Impact Statement (Parks and Wildlife Service 2009), the Australian government initiated a review of the project because of the extent of the non-target mortality experienced after the limited baiting in 2010. About 960 individual birds of 6 species were found dead on the island, from a total of 27 native species known to be present. Eventually, approval was given for the project to proceed in 2011 with additional mitigation measures in place.

2011 Aerial Baiting

Previous suppliers of helicopters, bait, bait pods, shipping, and helicopter fuel were engaged to repeat the baiting operation in 2011. Additional bait was procured, because although the bait pods left on the island were expected to retain the bait in good condition, there was no guarantee that it would be usable by the middle of the following year. In the event that a large portion of the bait had spoiled, the project would fail, as there would be no opportunity to replenish the amount of bait required on short notice. Therefore, replacement bait to undertake two bait drops was ordered. This ensured that sufficient fresh bait would be on the island to complete the majority

of baiting, with the 2010 bait as a contingency, and to do a third bait application in high-density areas and off-shore rock stacks.

Non-Target Species Mitigation

The main strategy to reduce the incidence of non-target mortality was the release of Rabbit Haemorrhagic Disease Virus. The virus effectively reduced the rabbit population from an estimated >150,000 by about 80-90%. Two other primary non-target mitigation measures utilised were the earlier arrival at the island, allowing baiting to be completed well before the return of migratory birds in the spring; and deployment of search teams to remove carcasses containing poison residues. Helicopter overflights of king penguin (*Aptenodytes patagonicus*) colonies were monitored by an observer who filmed flights and relayed penguin behaviour or disturbance to the pilot. Wandering albatross (*Diomedea exulans*) nests had bait removed from a 5-m radius, with bait placed in a series of bait stations within the 5-m circumference.

Aerial Baiting

The baiting team totalled 27 people. This comprised a helicopter team of eight (4 pilots, 2 engineers, and 2 ground/equipment support), a management team of 3 (project manager, operations/safety officer, GIS technician), a bait loading team of 11 (two 5-person teams plus one rotating out for a break, to allow continuous operation of the loading), and a non-target mitigation team of 5. Further support was provided by the Australian Antarctic Division, who maintain a station on Macquarie Island and provide infrastructure support.

Following arrival at Macquarie Island in late April and establishing 3 bait depots, aerial baiting commenced in early May. Baiting began at the south end of the island and progressed north, working to the principle of a 'rolling baiting front' to ensure there were no isolated pockets of land left unbaited if weather interrupted proceedings. The first bait drop was finished by 21 May.

Although a period of 10-14 days is usually left between bait drops to allow time for animals to locate bait and die from the toxin (often about 8-9 days for rats), the rate of baiting progress up the island meant that by the time the first drop was completed the second could commence immediately, being about 3 weeks from the start of the first drop. The second bait drop was completed by 19 June. A third drop was undertaken that focused on rock stacks (both on and offshore), in areas of previously high rabbit density, and around areas attractive to rodents, such as penguin colonies. In addition, baiting was conducted by helicopter onto islands in lakes, and by hand in all buildings and caves.

Two AS350BA and two AS350B2 helicopters were used to ferry staff to baiting depots and to spread bait. The helicopters used TracMap GPS systems (<http://www.tracmap.com/>, TracMap NZ Ltd., Mosgiel, New Zealand) to generate flight lines 40 m apart and guide the pilot in maintaining the flight line. The swath width of bait spread from the bucket was 80 m, so the 40-m flight line separation gave a 50% overlap and reduced the chances of gaps in bait coverage. Light bars on the top of the instrument console aided the pilot in maintaining position

on the designated flightline. ArcView 9.0 GIS (www.esri.com, ESRI, Redlands, CA) was used to digitise baiting blocks for loading into GPS units, to evaluate actual versus plotted flight lines, and to determine any areas that needed re-sowing to cover suspected gaps in bait coverage. Baiting operations were not undertaken if (constant) wind speed was above 25 knots, but would proceed after snowfalls, pending other factors also being considered.

Application rates varied depending on the part of the island being baited, with the higher altitude areas holding few rats and lower rabbit densities receiving 12 kg/ha, and the higher rabbit and rat density areas around the escarpment slopes receiving 24 kg/ha. Coastal areas that provided additional rat foraging areas in the intertidal zone and around penguin colonies received an additional 4 kg/ha. This was applied via a double swath, flown parallel to the coast. Application rates for the second drop were half of those applied in the first. The third bait drop applied to rock stacks and areas of high rabbit density added another 8 kg/ha.

Dead animals began to be found within 4 days of the first baiting. No confirmed sign of rats was found after the end of the first bait drop. Some mice were seen after the first bait drop; however, no evidence of surviving mice has been found since the second bait drop. Relatively few dead target animals were located despite extensive searches, consistent with the method of action of the toxin, which leads to most animals dying in their nests or burrows.

Follow-Up Hunting

Following the RHDV and baiting programme, hunting commenced immediately, although the full hunting team didn't arrive on the island for a further month after baiting concluded. Anticipating a >99% kill, over 100 rabbits could have been expected to survive. However, in the period from July 2011 to March 2012, 13 rabbits were killed with only 9 of these being adults (i.e., survivors of the baiting). All were located in the first 5 months following baiting, and comprised 7 males and 2 females. A litter of 4 newly-weaned kittens was located in November 2011, shortly after a lactating doe was taken nearby. The comprehensive extent of hunting coverage gives confidence that any significant rabbit activity would be detected across all accessible parts of the island. While no sign has been detected since December 2011, some previous evidence of rabbits has not been accounted for. Therefore, the assumption must be made that a very small number survive, probably fewer than 5.

Hunting effort is organised into 6 hunting blocks. Two hunters are rostered into a block for a month before rotating. One hunter in each block has two dogs. All hunters use Garmin GPS CSX60 units to record their coverage on a daily basis. The main hunting technique is searching for sign, such as evidence of grazing, digging, scats, or footprints. When this was found, efforts intensified targeting the individual rabbit. Methods for killing rabbits, once found, included fumigating burrows, firearms, leg-hold traps, or cervical dislocation. The dogs proved invaluable and were involved in locating the majority of rabbits, allowing handlers to use other methods to dispatch them.

ENVIRONMENTAL RECOVERY

One austral summer has passed since completion of baiting. While neither rodent nor rabbit eradication is yet confirmed, anecdotal and survey evidence provides initial impressions of a changing environment.

Most visually, vegetation recovery across the island is very evident. Palatable species previously targeted by rabbits and subjected to wide scale overgrazing are all growing healthy stands, including tussock (*Poa foliosa*) and the two native mega-herb species Macquarie Island cabbage (*Stilbocarpa polaris*) silver-leaf daisy (*Pleurophyllum hookeri*). Other native plants, including *Agrostis magellanica*, *Ranunculus crassipes*, and the prickly shield fern *Polystichum vestitum* are all showing regeneration as are introduced species such as *Poa annua* and *Cerastium fontanum*.

Some bird species are showing a noticeable change in behaviour and/or breeding success in the absence of rat predation. Grey petrels (*Procellaria cinerea*) have only been confirmed breeding on the island since 2000, after a century of absence due to cat predation. The population has been monitored since 2000, and the 2011 breeding season showed a significant increase in both breeding success and number of chicks fledged over previous years. Blue petrels (*Halobaena caerulea*) have likewise been absent from the main island due to rat predation, with breeding restricted to offshore stacks. In the summer post-baiting, over a hundred active blue petrel burrows were observed on the island, mostly on North Head, which had been baited in 2010 as well as 2011. An Antarctic tern (*Sterna vittata bethunei*) census late in 2011/early 2012 recorded 51% of nests on cobblestone beaches or attached stacks on the main island (compared with 9% in the 2009/10 census) and 49% on off-shore stacks (91% in 2009/10) (Parks and Wildlife Service, unpubl. report).

Anecdotal observations have also noted a significant increase in invertebrate activity, especially spiders, which had formed a significant diet component of mice. Several months after baiting, cobweb development in grass has been observed at levels never before recorded on Macquarie Island.

CONCLUSION

The combination of RHDV and aerial baiting appears to have reduced rabbit numbers to <20 individuals and successfully eradicated rodents, although it is too early to confirm this. Surviving rabbits were expected and hunting planned to account for survivors. This strategy has been used successfully, with 13 rabbits killed post baiting and no confirmed sign seen since December 2011.

The eradication of invasive vertebrates was a measure designed to allow recovery of natural ecosystems on the island, and progress towards this goal is evident. In less than a year since removal of the vast majority of pest individuals, recovery of vegetation, bird life, and invertebrates are being observed. Biosecurity practices need further improvement to ensure that the efforts to date are not reversed as a result of re-invasion of pests.

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