Planning processes for eradication of multiple pest species on Macquarie Island – an Australian case study

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Abstract Eradications of multiple target species challenge managers, especially those seeking to conduct simultaneous eradication programmes. Macquarie Island presents additional challenges because of its remoteness, large size, terrain, weather, and mix of target species. Long lead times for planning are required, reflecting the scale and complexity of logistics and regulatory requirements. Many components of eradications are contingent on initial feasibility and planning decisions. The best options for eradicating target species must be selected early in the planning timeframe. Planning for the eradication of ship rats (*Rattus rattus*), house mice (*Mus musculus*), and European rabbits (*Oryctolagus cuniculus*) on Macquarie Island used many concepts and techniques from previous eradications. These experiences identified that both species of rodents would take the same baits, that the only feasible distribution method was aerial application, and that mice could be harder to eradicate than rats. Other campaigns indicated that most rabbits would consume bait, but some would not, meaning that rabbits were unlikely to be eradicated by aerial baiting. Comprehensive follow-up hunting would therefore be required to remove surviving rabbits, with their detection best assisted by trained detector dogs. These factors formed the basis for bait trials, the results of which were used in a permit application to use the toxin (unregistered in Australia for rabbits) and in state and federal environmental impact assessments. Since approvals are specific to the toxin, techniques and/or bait nominated in applications, commitment to the selected method increases as planning evolves. Procurement priorities were also determined by these early decisions. Dog training was expected to take two years and was the first major procurement item. Bait, bait pods, shipping and helicopter contracts were also required, some of which were interlinked. Intended rabbit eradication techniques also determined staffing levels and the equipment required to support them. Approximately half of the projected costs are associated with post-baiting rabbit hunting.

Keywords: Planning, logistics, aerial baiting, regulatory environment, dog training, rabbit, *Oryctogalus cuniculus*, ship rat, *Rattus rattus,* house mouse, *Mus musculus.*

INTRODUCTION

Macquarie Island (12,780 hectares) is a World Heritage site administered as part of the Australian state of Tasmania. The island is in the Southern Ocean (54°37'53"S, 158°52'15"E) approximately 1500 km from Tasmania and 1000 km from Bluff, New Zealand (Fig. 1). Early European activity centred on commercial exploitation of seals and later penguins, and continued until 1919. Sealing and oiling gangs deliberately or inadvertently introduced numerous alien species. Some species, such as dogs (*Canis familiaris*), established wild populations that subsequently died out. Others, including sheep (*Ovis aries*) and goats (*Capra hircus*) were maintained for domestic use. Five species established feral populations with significant detrimental effects on native flora, fauna and landscapes: ship rats (*Rattus rattus)*, cats (*Felis catus)*, house mouse (*Mus musculus)*, European rabbits (*Oryctolagus cuniculus)* and weka (*Gallirallus australis scotti)*.

Rabbits were introduced to the island for food in about 1879 (Cumpston 1968). Grazing impacts were observed in the 1950s (Jenkin 1975; Taylor 1955) and by the 1960s there was increasing concern about damage to vegetation (Costin and Moore 1960). Rabbit control commenced with the release of the myxoma virus in December 1978, with annual releases until 2006 (although stocks used in the last few years had an expiry date of 2002). Initial control of the population was achieved within five years as myxomatosis spread through the population (Brothers and Copson 1988) but was reduced in its effectiveness after 20 years (Dowding *et. al.* 2009).

Rodents were recorded from the early 20th century, although mice may have established before 1830. The rodents probably established from shipwrecks or were landed with stores (Cumpston 1968). The impacts of rodents are less visible, but damage includes suppression of invertebrate and seabird populations, especially burrowing Procellariformes, and impeded plant recruitment and flowering (Shaw *et. al.* 2005).

Cats were introduced shortly after the island's discovery in 1810, and co-existed with two species of endemic land bird until the establishment of rabbits allowed their population to expand (Taylor 1979). Both land bird species, a parakeet and a rail, were extinct by 1895 (Taylor 1979). Before the introduction of myxoma virus, in the mid 1970s cats annually killed about 60,000 seabirds (Jones 1977). Cat control commenced in about 1974 and emphasis shifted to eradication from 1984. An abatement plan prepared in 1996 (Scott 1996) resulted in additional resources from 1998. With increased hunting effort, cats were eradicated by 2001 (Copson and Whinam 2001).

Weka were introduced to Macquarie Island at about the same time as rabbits, also as food. After rabbit numbers were reduced by myxomatosis in the early 1980s, weka came under increasing predation pressure from cats. Weka were eradicated by 1989, primarily by shooting (Copson and Whinam 2001).

Rabbit numbers began to increase in the late 1990s and by 2000 there was increasing concern about grazing damage to vegetation (Parks and Wildlife Service unpublished data). Awareness of rodent impacts was also growing. With the successful eradication of Norway rats on Campbell Island (11,300 ha) (McClelland 2011) plus increasing numbers of rodent eradications worldwide, similar measures were considered for Macquarie Island.

This paper outlines how decisions taken early in the process of planning simultaneous eradication of rabbits and rodents on Macquarie Island, along with some explicit expectations and assumptions, led to an increased commitment to these early decisions as planning progressed. Those commitments then influenced logistical requirements, many of which were sequential in nature and could not be determined until preceding decisions were made. I reinforce the importance of undertaking trials of techniques and materials to inform subsequent planning components, because early decisions and recommendations can increasingly commit planners to the proposed course of action as approvals and permits are secured.

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INITIAL PLANNING FOR RODENT AND RABBIT ERADICATION

The first challenges faced by those planning the eradication operation on Macquarie Island were remoteness, climate, island size and terrain. This combination of challenges meant that any operation attempting to eradicate three species needed commensurate resources in staff, supplies and equipment. This in turn meant that securing funding would also be a significant challenge. Experiences on Campbell Island proved that Norway rats could be successfully eradicated from large sub-Antarctic islands, but the mix of three target species found on Macquarie was uncommon in island eradication projects. The same mix of species was on Saint-Paul Island (800 ha, 38°42”30’S, 77°32”30’E), where a helicopter-based eradication project with follow-up rabbit hunting succeeded in eradicating rabbits and ship rats, but not mice. The survival of mice may have been related to issues with spreader malfunction and bait spoilage (Micol and Jouventin 2002). The remoteness of Macquarie Island challenges deployment of staff and supplies to the island; as there is generally only one resupply voyage annually to the Australian Antarctic Division (AAD) Station (Fig. 1), and up to 10 tourist vessel visits in summer, with limited available berths. The climate is cool, wet, windy, and cloudy – suggesting immediate issues for the condition and longevity of bait pellets and for flyable weather in which to spread them by helicopter. The terrain is mostly traversable by foot but there are sections of cliffs, steep faces and coastlines which cannot safely be traversed by people, increasing challenges to achieving rabbit eradication.

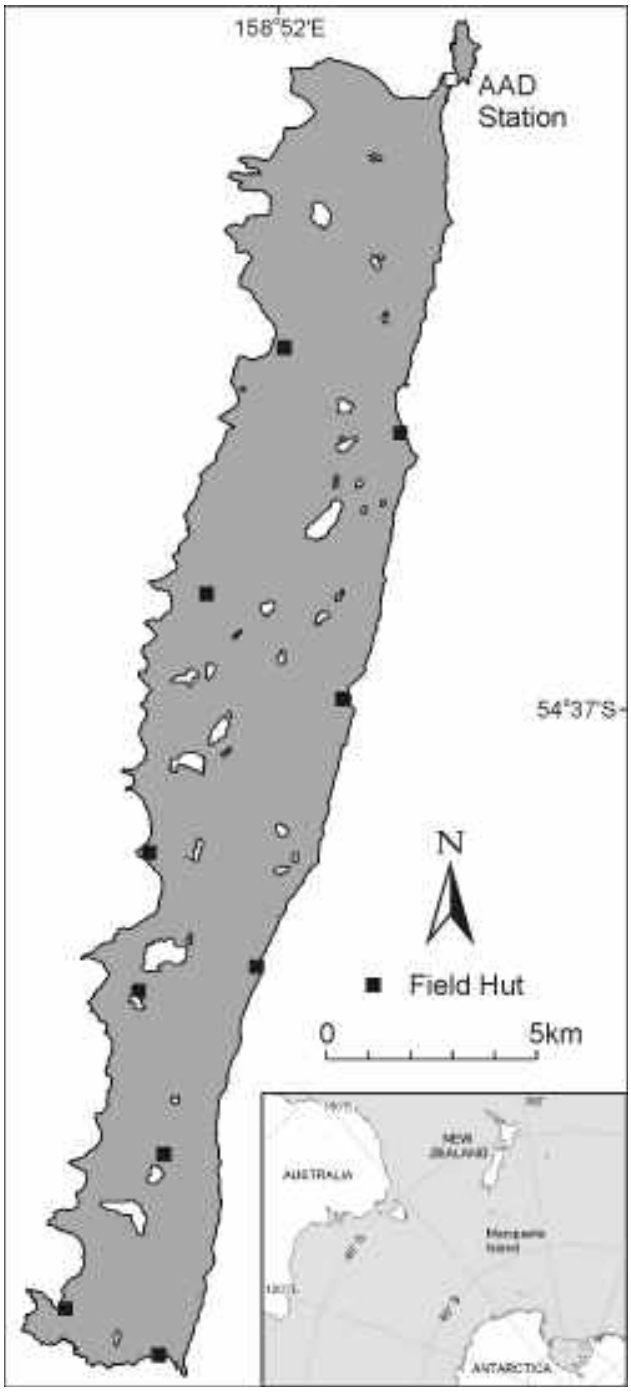

Fig. 1 Macquarie Island showing the location of the Australian Antarctic Division (AAD) Station base station (also known as the ANARE Station) and field huts.

A draft eradication plan was prepared in 2004 (PWS unpublished data), and a project officer was appointed in 2004 to prepare an overview of the situation, recommend eradication methods, and draft an operational plan (PWS 2007). Concurrently, tests of bait weathering and palatability, non-target response to bait, and rodent distribution on the plateau were conducted on Macquarie Island in the autumn and winter of 2005 (PWS 2009). The evaluation of options, the recommendations in the draft eradication plan, and the trial results formed the basis for many of the subsequent planning actions, which commenced in 2007 and continued until the end of the planning phase in May 2010.

Planning lapsed from September 2005 until October 2006, when a further 12-month project officer position was established. Eradication planning was interrupted by the need to prepare a case for funding. The Tasmanian and Australian governments announced joint funding of the project in June 2007, with a projected budget of $24.7 million. From this point, planning could focus on the requirements for eradication. Components of the plan were identified and separate but inter-related plans prepared for the project, comprising 10 parts: A - Eradication Plan Overview; B - Operational Plan; C. - Environmental Impact Assessment; D - Occupational Health and Safety Plan; E - Project Biosecurity Plan; F - Monitoring Plan; G - Communications Plan; H - Project Plan; I - Procurement Plan; J - Staff Recruitment and Training Plan.

Many of the subsequent planning decisions and the sequence of regulatory and procurement processes hinged on key recommendations and assumptions, particularly the choice of toxin and its method of delivery.

Brodifacoum was recommended as the most suitable toxin to attempt rodent and rabbit eradication on Macquarie Island, on the basis of the susceptibility of target species and its documented success in island pest eradications (e.g., Howald *et al*. 2007). Pestoff 20R (Animal Control Products, Wanganui, New Zealand) was selected for the 2005 trials as a suitable bait to carry the toxin, because it had been used on Campbell Island (after testing of various bait types in 1999), and proven success in other island eradications (http://www.pestoff.co.nz/start.htm). Brodifacoum can eradicate rats and mice, although reasons for previous mouse eradication failures where mice co-existed with rats are unclear (MacKay *et al*. 2007). Aerial broadcast was recommended as the only feasible delivery mechanism on Macquarie Island.

Rabbits are also susceptible to brodifacoum (Crosbie *et. al.* 1986; Godfrey and Lyman 1980; Godfrey *et. al.* 1981). Not all rabbits consume bait (Torr 2002), but kill rates >95% are likely. Given the size and terrain of Macquarie Island and a rabbit population estimated at about 124,000 in 2006 (Terauds 2009), comprehensive follow-up ground hunting would be necessary to mop up survivors.

Implications of key aspects

The 2006 Eradication Plan (PWS 2007) determined the regulatory, procurement, planning and budgeting processes for the project, which commenced after appointment of a project manager in August 2007. It soon became apparent that aerial baiting could not begin for at least three years, i.e. winter 2010. Two bait drops were planned, with the second drop targeting rabbits in high density areas and rodents that may not have had access to bait during the first drop.

Regulatory implications

Brodifacoum is not registered in Australia either for aerial application or for use against rabbits. A permit was thus required from the Australian Pesticides and Veterinary Medicines Authority (APVMA). Applications to this agency were known to take a considerable time for assessment, so preparing and submitting an application was a priority. The APVMA has a particular interest in impacts on human health and on non-target species. The New Zealand Department of Conservation (DoC) review on brodifacoum (Fisher and Fairweather 2006) was invaluable for both of these aspects. Reports on non-target species trials undertaken on Macquarie Island added essential information specific to the treatment area, as the project involved species not commonly found on mainland Australia. An application for a Minor Use Permit was lodged with APVMA in June 2008, and the permit issued in May 2009. The use of a consultant to prepare the detailed information in the required format was vital to having the application assessed without further information being sought by APVMA, which would have extended the timeframe still further.

Brodifacoum is not an approved pesticide for use against rabbits in Tasmania; hence an application was also made to the Animal Welfare Advisory Committee and it was recommended for use on Macquarie Island under the state *Animal Welfare Act 1993*.

The scale of the project and the island's World Heritage status required referral of the eradication project to the Commonwealth Department of Environment, Water, Heritage and the Arts under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The Environment Minister could then determine whether the proposed project was a controlled action and whether conditions should be imposed on its implementation. An Environmental Impact Statement (EIS) was prepared, which incorporated the 2005-6 bait and non-target species trials, and subsequent trials undertaken in 2007 and 2008 to further assess non-target species impacts. These latter included the results of over-flights of king penguin (*Aptenodytes patagonicus)* colonies. These trials provided information for the assessment of environmental impacts that was not available in the published literature or in Australian operational experience. The EIS acted as supporting information for the EPBC Act referral and included actions to minimise impacts on non-target species and the environment within which baits would be spread. Following a public notification period, the Minister determined in October 2009 that the project was not a controlled action as long as it was undertaken in the manner specified in the referral.

In addition, the state environmental impact assessment process needed to be completed. The required Reserve Activity Assessment was approved in July 2009.

Procurement implications

Trials on Macquarie Island using non-toxic Pestoff 20R bait confirmed its suitability. The bait to be used contains brodifacoum at a concentration of 20 parts per million. State Treasury Instructions require all purchases over $100,000 to be undertaken by public tender. However, a public tender would not have delivered alternate bait with the proven track record of Pestoff 20R (especially in sub-Antarctic conditions). In addition, all trials undertaken on Macquarie Island over three years, the preparation of APVMA permit applications, and the EIS would be nullified if a different bait was selected; weathering and non-target palatability characteristics may not apply to different bait formulations. An exemption from the requirement to tender was thus sought, which effectively required preferred supplier status for Animal Control Products to enable procurement to proceed. Tender processes can take from six weeks to several months to complete, so the exemption received from Treasury in late 2008 allowed the project team to arrange bait orders with greater certainty, within a shorter time frame, and maintain project timelines.

In addition to processes driven by initial project decisions, the results of one tender sometimes influenced the specifications required for the next. For example, the helicopter tender determined the number and type of helicopters to undertake the aerial baiting. Only once the helicopter model (and thus lifting capacity) was known could a tender be let for bait pods (containers) used to transport and store the bait. Once the number of helicopters and the quantity of bait and bait pods was known, a tender was let for a vessel to support the project by delivering passengers, helicopters, bait and fuel to Macquarie Island and to retrieve helicopters at the conclusion of the aerial baiting phase.

Planning implications

Given that rabbits had never been eradicated from large islands with toxic baits alone, previous rabbit eradication operations (Torr 2002; Micol and Jouventin 2002) were analysed and two key requirements emerged.

Use of dogs

The first requirement was that highly trained dogs must be used to detect surviving rabbits, particularly as vegetation recovered from grazing. Dogs trained to the standards required cannot be acquired as an 'off the shelf' item and especially not in the numbers required. Procurement decisions early in the project timeline thus focused on dogs. The timeline allowed for up to two years to train dogs to effectively locate rabbits, to ignore non-target species, and to display absolute obedience to the handler. Timing of the deployment of fully trained dogs, therefore, had to synchronise closely with the date of the intended bait drop.

Handlers can be particularly effective when working with their own trained dogs. However, this model posed an insurmountable risk. With a minimum of six dogs required each year for up to five years, at least 30 highly trained dogs would have been required at specific timeframes for 12-month deployments. The likelihood of finding six people each year with the requisite hunting and dog-handling skills, same standard of dog training, and the personal qualities to work harmoniously in a small isolated community, was considered remote. Furthermore, if suitable handlers (with trained dogs) available for a 12 month deployment could not be recruited each year in time for the ship's departure, then detection dog capacity would drop, pressure on surviving rabbits would ease, and there would be an increased risk of eradication failure. There was also a risk with variability of training standards that the extensive wildlife present on the island may be susceptible to disturbance by dogs that were not properly controlled.

Consequently, an alternative model was developed with trained dogs procured by Tasmania Parks and Wildlife Service (PWS) following a tender process, the dogs remaining the property of PWS, and remaining on Macquarie Island throughout the project. The training

standard for the dogs was developed by PWS and adapted from the DoC predator dog and protected species dog programmes, based on 'initial' and 'final' certification levels. The training standards incorporated Macquarie Island-specific aspects, recognising the need to avoid disturbance to non-target species (including dense penguin colonies and extensive seal populations) and an ability to work in steep terrain.

The training of 12 dogs for PWS was spread across three contractors to minimise risks of non-delivery. Additional dogs were trained as backup for any dogs that failed their final certification assessment. Deploying 12 dogs also allowed for mortality of up to 50% of dogs during the course of the project without dropping below the desired minimum of six (which was based on the number of hunting blocks on Macquarie Island). A dog training coordinator was employed to oversee the consistency of training between contractors (two in New Zealand and one in Australia) and conduct the necessary certifications. This process managed the risks of an inconsistent supply of dogs over the course of the project. The converse risk was that by employing new dog handlers to work on Macquarie Island each year the dogs needed to adapt to different handlers annually (or more frequently) throughout the project. This approach could reduce the effectiveness of a well-established hunter-dog team, and required PWS dog handlers to be instructed in how the dogs had been trained to work. However, this seemed to be a lower risk to project success than the risks of not sourcing suitably trained dogs, or dogs with variable training standards. The decision to procure dogs for the duration of the project helped determine the breeds of dogs to be used. Because they had to have a strong hunting drive and be amenable to working for different handlers, Springer spaniels and Labradors were the breeds chosen. The time taken to seek industry advice, prepare and manage tender documentation, draft training standards, prepare contracts for successful tenderers, and allow for pups to be born two years before deployment added another 10 months to the project timeline. As a result, aerial baiting could not begin before the winter of 2010.

Hunting pressure

The second requirement was for sufficient staff to be available after aerial baiting to ensure that the rabbit population continued to decline, rather than breed faster than hunters could kill them. This requirement had significant logistical implications. The only regular voyage for staff deployment is through annual logistics support provided by the Australian Antarctic Division (AAD), who also provide food, clothing and accommodation on the island. Thus, planning for pest eradication on Macquarie Island could not proceed without close liaison with the AAD, and required their commitment to the project goals in order for them to engage with the staff and logistics resources required to support the eradication team in the field.

Support for these field teams also needed assessment of the likely duration of rabbit hunting. In the 2005 draft plan, this was estimated as three years post-baiting, with a further two years of monitoring for sign of rats, mice and rabbits. Hunting teams present over such extended periods also required extensive support in the field. Planning included additional field huts to provide ready access to plateau, west and south coast areas; annual resupply of food, equipment and fuels to new huts as well as to existing huts on the island (maintained by AAD); clothing suitable for extended year-round field work in sub-Antarctic conditions and, crucially, field equipment designed to give hunters the best chance of eradication success. Rabbits are traditionally hunted with firearms, but other methods are used to minimise disturbance to surviving rabbits, and to suit the individual location of rabbits once located. Accordingly, traps, burrow fumigants and nets were purchased, as well as .17 HMR rifles and a small number of .223 rifles and 12 guage shotguns. Additional field equipment included excavating tools, laser range finders, spotlights and filters, night vision and thermal imaging equipment, binoculars, traps, fumigants, smoke generators, GPS units, satellite phones, VHF radios and a range of consumable items and outdoor equipment. The effectiveness of hunters will be enhanced by training in the use of all hunting techniques, as well as in the principles of eradication.

Bait application rate calculations were based on accurate sowing and providing sufficient bait for target species, baits cached by rats or consumed by dominant rabbits before losing their appetite, and the need for sufficient baits remaining to allow access by mice and sub-dominant rabbits. The planned second bait drop is largely to extend the period that bait is available and to ensure that interactions within or between species have not prevented some individuals from encountering bait.

Finally, trials undertaken on Macquarie Island to ascertain the suitability of techniques, materials and equipment have included: 1) aerial distribution of non-toxic bait containing pyranine to determine palatability; 2) weathering of baits; 3) palatability of baits to non-target species; 3) the effects of helicopter over-flights of king penguin colonies; 4) collection of rodent samples for DNA analysis; 5) trials of bait storage pods of different materials and 6) tests of assorted field equipment.

Budget implications

Recommendations and decisions made early in the planning process were crucial in preparing a realistic budget. Trials with Pestoff 20R baits in 2005 enabled reasonably accurate costing of bait and their transport to Macquarie Island. During project planning, budgets were revised to reflect the additional costs of such a challenging project. After an initial estimate of approximately A$12.5M in 2005, the final estimate increased to approximately A$20M. A project contingency of 20% was added to reflect unknown aspects such as fluctuating fuel prices and exchange rates several years ahead of budget preparation, and the dependence of shipping and helicopter costs on weather and fuel. The final budget approved was $A24.7M. Of this, approximately half stemmed from the expectation that rabbits would not be eradicated by aerial baiting, and the long period of post-baiting hunting and monitoring.

One of the most significant early successes of the Macquarie Island Pest Eradication Project was the agreement between the Australian and Tasmanian governments to commit funding to the entire multi-year duration. At that time, the project was expected to take at least eight years. The ability to plan several years ahead without the uncertainty of annual funding applications was a major commitment by government and boosted planning certainty.

CONCLUSION

Early decisions taken in planning any eradication of multiple species need to be based on each species' eradication history. In addition, understanding the characteristics of target species in isolation, and collectively with other target and non-target species is also important. With larger and more complex island eradications, funding can become increasingly difficult to secure. It is vital to recognise that the implications of early decisions can increasingly commit the project to those decisions as the planning process continues. For Macquarie Island, trials of Pestoff 20R baits for weathering, target and non-target palatability informed regulatory permits and approvals. However, had the proposed bait type been changed because of constraints on procurement (tender processes) the trials would have been negated, the environmental impact

assessments partly invalidated, and applications to use alternative baits delayed until new trials were conducted. In addition, it would have negated the historical success of the bait in this type of operation. Preparing for the survival of some rabbits after an aerial baiting operation is vital. It is better to have prepared and budgeted for extended follow-up hunting and not need it, than to assume eradication will be achieved by aerial baiting and to find that more work is needed when the budget has been expended. It is usually easier to return any surplus funds than to seek more at short notice.

Some key lessons that apply in particular to large or complex island pest eradications include:

- Secure funding commitments for the full project timeframe if at all possible. Not only does this overcome annual funding bids, which if unsuccessful derail the project, it also promotes awareness and buy-in from project sponsors.
- Rabbits and mice can be difficult to eradicate, even from small islands. Planning should include comprehensive measures designed to minimise the risk of eradication failure.
- Procurement and recruitment by government agencies can be very time consuming and may not reflect eradication staffing or supply needs. Sufficient time and staff need to be allowed for to allow compliance with these processes.
- Time and staff resources to complete all of the planning requirements should not be underestimated. This need for planning should be allowed for in project budgets and timeframes to ensure that the operational phase has realistic timeframes allocated to all permit and procurement aspects. Pre-departure workloads are high, especially for ship-based eradications, so additional staff may be necessary to take some of the workload for this busy period.
- Peer support is very important and the global network of eradication practitioners readily provides invaluable information, support and experience.
- Island-specific trials and comparable island eradication projects provide a sound basis for planning documents. If at all possible, undertake relevant trials on the subject island on target and non-target responses to proposed eradication techniques.
- Many procurement aspects are interlinked. Dependencies should be mapped to clarify the critical order of procuring goods and services. For example the amount of bait required needs to be determined to enable the scale of transport to be arranged. If this means chartering a ship the cost implications can be significant.
- The basic principles of successful eradication should be at the forefront of planning and are outlined in numerous sources including Broome *et al.* (2005).
- Biosecurity (minimising risk of reinvasion) is crucial, may need commitment from non-aligned agencies, and should be planned for and developed from an early stage.

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REFERENCES

Broome, K.; Cromarty, P. and Cox, A. 2005. Rat eradications – how to get it right without a recipe. *Proceedings of the 13th Australasian Vertebrate Pest Conference,* pp. 152-157. Landcare Research, Lincoln, New Zealand.

Brothers, N.P. and Copson, G.R. 1988. Macquarie Island flora and fauna management - Interpreting progress and predictions for the future. *Papers and Proceedings of the Royal Society of Tasmania 122 (1)*: 129-135.

Copson, G. and Whinam, J. 2001. Review of ecological restoration programme on subantarctic Macquarie Island: Pest management progress and future directions. *Ecological Management & Restoration 2(2)*: 129-138.

Costin, A.B. and Moore D.M. 1960. The effects of rabbit grazing on the grasslands of Macquarie Island. *Journal of Ecology 48*: 729-732.

Crosbie, S.F.; Laas, F.J.; Godfrey, M.E.R.; Williams, J.M. and Moore D.S. 1986. A field assessment of the anticoagulant brodifacoum against rabbits, *Oryctolagus cuniculus. Australian Wildlife Research 13*: 189 -95.

Cumpston, J.S. 1968. Macquarie Island. Publication 93, ANARE Scientific Reports Series A91, Antarctic Division, Department of External Affairs, Australia.

Dowding, J.E.; Murphy, E.C.; Springer, K.; Peacock, A.J.; Krebs, C.J. 2009. Cats, rabbits, Myxoma virus, and vegetation on Macquarie Island: a comment on Bergstrom *et al*. (2009). *Journal of Applied Ecology 46*: 1129-1132.

Fisher, P. and Fairweather A. 2006. Brodifacoum a review of current knowledge. Department of Conservation Pesticide Information Review Series No. 6.

Godfrey, M.E.R. and Lyman, C.P. 1980. Preliminary dosing trials of a new anticoagulant, brodifacoum, as a toxicant or the rabbit, *Oryctolagus cuniculus* (L.). *New Zealand Journal of Experimental Agriculture 8*: 1-5.

Godfrey, M.E.R.; Reid T.C. and McAllum, H.J.F. 1981. The oral toxicity of brodifacoum to rabbits. *New Zealand Journal of Experimental Agriculture 9*: 23-25.

Howald, G.; Donlan, C.J.; Galvan, J.P.; Russell, J.C.; Parkes, J.; Samaniego, A.; Wang, Y.; Veitch, D.; Genovesi, P.; Pascal, M.; Saunders, A. and Tershy, B. 2007. Invasive rodent eradication on islands. *Conservation Biology 21(5)*: 1258–1268.

Jenkin J.F. 1975. Macquarie Island, subantarctic. In: Rosswall T. and Heal O.W. (eds.). Structure and function of tundra ecosystems. *Ecological Bulletins (Stockholm) 20*: 375-397.

Jones, E. 1977. Ecology of the feral cat, *Felis catus* (L.), (Carnivora: Felidae) on Macquarie Island. *Australian Wildlife Research 4*: 249-262.

MacKay J.W.B.; Russell J.C. and Murphy, E.C. 2007. Eradicating house mice from islands: success, failures and the way forward. In: Witmer, G.W.; Pitt, W.C. and Fagerstone, K.A. (eds.). *Managing Vertebrate Invasive Species: Proceedings of an International Symposium,* pp. 294-304. USDA/APHIS/WS, National Wildlife Research Center, Fort Collins, CO.

McClelland, P.J. 2011. Campbell Island – pushing the boundaries of rat eradications. In: Veitch, C. R.; Clout, M. N. and Towns, D. R. (eds.). *Island invasives: eradication and management*, pp. 204-207. IUCN, Gland, Switzerland.

Micol, T. and Jouventin, P. 2002. Eradication of rats and rabbits from Saint-Paul Island, French Southern Territories. In: Veitch, C.R. and Clout, M.N. (eds.). *Turning the tide: the eradication of invasive species,* pp. 233-239. IUCN, SSC, Invasive Species Specialist Group, IUCN, Gland, Switzerland and Cambridge, U.K.

Parks and Wildlife Service. 2007. Macquarie Island pest eradication plan part A – overview. Department of Environment, Parks, Heritage and the Arts. Hobart, Tasmania, Australia.

Parks and Wildlife Service. 2009. Macquarie Island pest eradication plan part C. – environmental impact statement. Department of Primary Industries, Parks, Water and Environment. Hobart, Tasmania, Australia.

Scott, J.J. 1996. A feral cat threat abatement plan for Macquarie Island, Parks and Wildlife Service, Department of Environment and Land Management, Hobart, TAS, Australia.

Shaw, J.; Hovenden, M. and Bergstrom, D. 2005. The impact of introduced ship rats (*Rattus rattus*) on seedling recruitment and distribution of a subantarctic megaherb (*Pleurophyllum hookeri*), *Austral Ecology 30*: 118-125.

Taylor, B.W. 1955. The flora, vegetation and soils of Macquarie Island. *ANARE Reports. B(2) No. 19*, Botany.

Taylor, R. H. 1979. How the Macquarie Island parakeet became extinct. *New Zealand Journal of Ecology 2*: 42-45.

Terauds, A. 2009. Changes in rabbit numbers on Macquarie Island 1974-2008. Unpublished PWS report.

Torr, N. 2002. Eradication of rabbits and mice from subantarctic Enderby and Rose Islands. In: Veitch, C.R. and Clout, M.N. (eds.). *Turning the tide: the eradication of invasive species,* pp. 233-239. IUCN, SSC, Invasive Species Specialist Group, IUCN, Gland, Switzerland and Cambridge, U.K.