Eradication planning for invasive alien animal species on islands – the approach developed by the New Zealand Department of Conservation

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Abstract New Zealand's Department of Conservation is now highly experienced in the field of invasive alien animal species eradication on islands, particularly rodent eradication. The approach which has been developed addresses eradication planning at an operational level and building capacity at an organisational level. At an operational level this is done by: planning the eradication operation to be as robust and as meticulous as possible to prevent the operation failing; avoiding failure of an operation which is frequently linked to a casual approach or a 'can't be done' attitude; recognising pre-conditions for eradication. These are: (i) all target animals can be put at risk by the eradication technique(s), (ii) target animals must be killed at a rate exceeding their rate of increase at all densities, (iii) immigration must be zero. Building of capacity has been achieved by: (1) strategic approach – planning island eradication programmes to maximise learning opportunities and minimise the risk of failure, (2) skills development - identifying training opportunities by participating in eradication operations elsewhere, (3) team approach - maintaining a committed project team and the support of higher level management, (4) peer review - an eradication advisory group provides advice on major pest eradication operations, (5) review and debrief – effectively transferring the lessons learnt with each operation to future projects. The approach outlined has application wherever eradication of invasive alien animal species on islands is planned.

DEVELOPMENT OF TECHNIQUES

NZ Department of Conservation and island eradications

Views have changed radically over recent years on the feasibility of eradicating invasive alien animal species from islands, as illustrated by historical rodent eradications. As recently as 1976, Yaldwyn (1978) concluded a conference on the ecology and control of rodents in New Zealand by stating that the possibility of complete extermination of rodent populations from New Zealand's offshore islands was "remote, or at least a very, very difficult thing indeed". By the early 1980s it was still widely held that no real breakthrough was in sight (Atkinson 1986).

New 'second generation' anticoagulant poisons became available in the 1980s. These poisons allow rats to consume a lethal dose well before they begin to experience poisoning symptoms (Taylor and Thomas 1989). This potency and late onset of toxic effects eliminated many of the causes of rats surviving poisoning using other pesticides. During the 1980s, using these poisons and a new eradication 'mindset', a number of rodent eradication operations were successful. Examples include the removal of Norway rats (*Rattus norvegicus*) from 9 ha Hawea Island in 1986 (Taylor and Thomas 1989) and from 170 ha Breaksea Island in 1988 (Taylor and Thomas 1993), plus the removal of Pacific rats/kiore (*Rattus exulans*) from 18 ha Korapuki Island in 1986 (McFadden and Towns 1991). Most early projects in New Zealand involved the removal of rodents from islands less than 200 ha in size by hand-laying poison baits.

By 1990 the practicality of eradicating rodents from small islands had been demonstrated and the possibility of removing rodents from islands greater than 200 ha in size began to be explored. Various eradication techniques were tested, such as a 'rolling front' of bait stations on Ulva Island (259 ha (Atkinson and Taylor 1992)) in 1992 (Thomas and Taylor 2002), and the aerial application of poison baits on Tiritiri Matangi Island, 220 ha, in 1993 (Veitch 2002b) and on Lady Alice Island, 120 ha, in 1994 (Ogilvie *et al.* 1997). By the late 1990s rodent eradications had been completed on two islands over 1300 ha in size – Kapiti Island off the south-west coast of the North Island and Whenua Hou/Codfish Island off the west coast of Stewart Island. The Department of Conservation progressively set aside funding for eradication projects on larger islands providing the impetus for a co-ordinated approach. A peer review team was established to provide advice on the allocation of funds and trials of eradication techniques.

The eradication of rats from Kapiti Island (1965 ha) was confirmed as successful in 1998 (Empson and Miskelly 1999) and Whenua Hou/Codfish Island (1396 ha (Atkinson and Taylor 1992)) was declared rat free in December 2000 (McClelland 2002). These operations represented new milestones in terms of island rodent eradication achievements. They were on islands eight times larger than any that rodents had previously been removed from in New Zealand and two species of rodents were eradicated on Kapiti Island. Until then, only single species eradications

Pages 85-91 In Veitch, C. R. and Clout, M. N. (eds.). *Turning the tide: the eradication of invasive species*. IUCN SSC Invasive Species Specialist Group. IUCN, Gland, Switzerland and Cambridge, UK.

had been attempted in New Zealand. Both operations involved resolving non-target species issues. Each had to both achieve the eradication objective and to be another stage in a planned series of trials leading to the capacity to undertake even larger operations, such as the planned removal of rodents from Campbell Island (11,216 ha) in the remote Subantarctic (Atkinson and Taylor 1992).

CURRENT APPROACH

An Island Eradication Advisory Group has evolved from the peer review team and continues to focus on research, skills development, review and audit. The Advisory Group's efforts are currently directed at eradications on Tuhua/Mayor Island (1277 ha (Atkinson and Taylor 1992)), Raoul and Macauley (2938 and 306 ha (Atkinson and Taylor 1992)), Hauturu/Little Barrier Island (3083 ha (Atkinson and Taylor 1992)), and Campbell Island (11,216 ha). In early 2000 these were all in the early planning or implementation stage. All are more complex than the Kapiti and Whenua Hou/Codfish Island operations, and involve large islands, some with several species of invasive alien animals, and some in remote locations. That they are being attempted reflects confidence in the ability to plan and carry out successful operations.

One challenge facing the Department of Conservation, as eradication operations become more complex, is to ensure that effective communication and knowledge transfer take place within the organisation. It is vital that the lessons learned from each operation are recognised and disseminated.

The approach adopted addresses eradication planning at an operational level and capacity building at an organisational level.

KEY CONSIDERATIONS FOR PLANNING AN ERADICATION OPERATION

A number of issues must be dealt with in planning an eradication operation. Failure to consider any one of these can result in an unsatisfactory outcome.

The difference between eradication and control

Control operations manage the impacts of invasive alien animal species by sustained harvesting of the invasive species populations (i.e. reduced numbers of animals leads to reduced impacts). They are not concerned with removing the 'last animal'.

Eradication permanently removes the impacts of invasive alien animal species by eliminating the entire population. Pre-conditions for considering eradication are (Parkes 1993):

i. All animals can be put at risk by the eradication technique(s);
ii. Animals must be killed at a rate exceeding their rate of increase at all densities; and
iii. Immigration must be zero.

In planning an eradication the likely response of individual animals is important. Failure to recognise and account for individual variation in vulnerability could lead to survivors.

The following examples illustrate the importance of the behaviour and response of individual animals in an eradication operation:

i. Bitrex is added as a safety precaution to make some commercial rat bait less attractive to young children, by making it taste bitter. In laboratory efficacy tests involving bitrex in ICI rodenticidal formulations with albino rats and mice (20 animal groups, 3 day choice tests) some rats did not eat sufficient bait with bitrex in it to be killed (i.e. 3 out of 60 rats were not killed) (Kaukeinen and Buckle 1992). These tests are required as part of USA registration studies (EPA protocols). The ICI rodenticidal formulations all passed the minimum EPA test criteria of at least 90% kill, and led to the EPA's statement in their letter to ICI of 29 March 1990, that "The efficacy tests submitted for (bitrex-containing brodifacoum products) are acceptable" (Kaukeinen and Buckle 1992). The test result is acceptable for a control operation. However, for an eradication operation such information suggests a risk that should not be taken - it is not acceptable to have a percentage of the population not eating sufficient bait to be killed. On uninhabited islands closed to the public there is no benefit in including bitrex. Differences in consumption of bait containing bitrex and bait that did not contain it were observed in a 1996 trail on wild caught Pacific rats/kiore on Hauturu/Little Barrier Island (Veitch 2002a).
ii. Over a four-year period 17 person-years of effort using traps, poison and hunting removed more than 3000 weka (*Gallirallus australis*) from Whenua Hou/Codfish Island. After all known weka had been accounted for (i.e. no sign could be found) 3 weka were located and caught using taped calls. These were all mature individuals who had been fully exposed to all previously used methods. Taped calls were used in an early phase of the weka eradication, but had not been used for over two years prior to their use in the last phase of the operation (Andy Cox pers. obs.).
iii. In the Kapiti Island eradication of brushtail possums (*Trichosurus vulpecula*) a total reliance on trapping as the eradication technique would have resulted in the operation failing. After a trapping effort of approximately 1,388,330 trap nights, dogs were used and the last 32 possums were found. Many of these animals showed signs of previous encounters with traps and may have been trap shy (Cowan 1992).

Eradication operations may use the same techniques as control operations, but the goal and therefore the essential mindset for everyone involved is different. If there is not the determination to remove every target animal and to plan, manage and implement an operation to achieve this goal, then there is a risk that the operation will be compromised. In addition the reasons for failure will be poorly understood. An eradication operation requires 100% focus and effort from all members of the project team.

Robust and meticulous planning

Planning for an eradication operation will involve research, contingency measures, incorporation of best available techniques and the flexibility to cope with unexpected difficulties. Biological, technical and logistical considerations such as seasonal variation in vulnerability of target and non-target species, type of bait and toxin used, and correct storage and presentation of bait are all taken into account.

Evidence (e.g. bait palatability, population dynamics and, non-target risks) supporting the assumption that a selected option will work must be critically reviewed. Techniques or operational practices that could expose the operation to an increased risk of failure need to be identified and avoided.

Data from previous control or trials on target population(s) must be considered. For example, if a proportion of the target population develops bait-shyness, toxin resistance or trap aversion due to pre-eradication activities, the eradication is likely to fail if similar techniques are deployed. Techniques used need to take into account past history. Toxic trials, if required, are usually carried out elsewhere to ensure that the eradication is not compromised.

On islands where new or complex scenarios are present, planning must ensure each targeted animal species is eliminated. Planning should be started early to identify issues to be solved. Trials are often essential to provide information or test modifications to existing methods. When developing new methodology test one thing at a time. Examples include:

i. The Tuhua Island eradication which is being used to trial methodology for planned concurrent rat and cat eradication on the larger and logistically more difficult Raoul Island. The trial includes clarifying the feasibility of eradicating cats by secondary poisoning and, if possible, determining what contingency technique would be appropriate for follow-up.
ii. Campbell Island's weather and large size make it impossible to use proven aerial bait application methodology without modifications. Non-toxic bait trials have been undertaken at Campbell Island to test the durability of different bait formulations and their acceptability to rats. Research has also been undertaken to define the most appropriate method for storage of bait in Subantarctic conditions, to ensure its optimum condition at the time of distribution by helicopter.

Timing of an operation is often critical. For example, poison baits will be delivered to any surviving cats on Raoul Island after their main prey, rodents, have been eliminated, but before they have substantial alternative prey available (i.e. nesting seabirds).

Identifying risks, and taking actions to eliminate or minimise them, is mandatory. If we are to learn from failed operations we have to identify possible causes of failure and act accordingly. For example:

i. In a rodent eradication operation, put poison bait on rock stacks around an island even if it seems unlikely that there are any rats on them.
ii. Test the toxicity of the bait before the operation to ensure it meets the minimum standards required for a successful outcome.
iii. Collect random bait samples during the operation for more detailed analysis in the event of a failure.
iv. Prior to the eradication operation take DNA samples from rats. If rats subsequently turn up it is possible to determine whether it was the eradication or quarantine precautions that failed, by comparing DNA samples with the pre-eradication samples.
v. Write operational standards and adhere to them. For example with a helicopter operation it is better to wait for suitable weather than fly in high winds and not achieve the necessary bait coverage.
vi. Assume that if something can go wrong it will and plan for it.

Successful eradication requires that all target animals are killed. To allow for variations in individual vulnerability due to age, behaviour, food supply, range size, etc., techniques must be 'over-engineered'. Therefore:

i. Lay more bait than you think you need.
ii. Despite a good shelf life use only fresh bait.
iii. Every trap must be perfectly set and sited. Each trap may be the one to catch the last target animal, or conversely the trap that loses and educates one of the remaining animals – so every trap counts.
iv. Re-sow even the smallest gap in bait coverage indicated on the navigational guidance printout, even though baits may actually be there due to the spread pattern using overlapping swaths which are conservatively set smaller than the sowing bucket actually delivers.
v. Take two helicopter buckets (one might break down).
vi. Use multiple eradication techniques for cat eradication (i.e. poison and traps).
vii. With cat eradication do not assume that no sign means no cats. Assess the probability of finding cats given the total level of effort that has gone into the eradication. A wide range of techniques (e.g. telemetry, trapping, searches using dogs etc.) and a lot of effort needs to go into eradicating cats. This is also important with other target species.

This attitude of 'over-engineering' should be adopted, not only by the project team but also by management. Manag-

ers often operate in an environment geared to cost efficiency. The focus for eradication must always be to eliminate failure. An eradication operation is more cost effective and more likely to succeed if it is carried out properly at the first attempt.

Overarching all the above is the need to rigorously monitor progress so that problems can be recognised and addressed.

Frequent causes of failure

Determination to succeed is essential in an eradication campaign. Where those involved take a 'casual approach', assumptions are not stated, questioned or tested. Scientific findings are often taken at face value without considering their validity in a new site or the relevance of that experimental design to other situations. For example, it cannot be assumed that bait stations work where more than one species of rodent is present. On Kapiti Island non-toxic bait trials revealed that Pacific rats/kiore would not use bait stations that Norway rats had used (Raewyn Empson pers. obs.).

A 'can do' attitude is essential, particularly in detecting and killing target animals at low densities. A project team has to be motivated and dedicated to achieve its goal. This requires considerable effort when few animals remain. For example, in the Kapiti Island possum eradication the last 32 possums were all located using dogs. This took 4502 man-dog hours (Cowan 1992).

Project teams must understand and agree with an eradication plan, know the importance of their role and how integral the effort of each and every one of them is to achieving a successful outcome. They also need to be aware of how they could compromise the operation by sloppy work. For example, poor servicing of bait stations could result in animals failing to get exposed to palatable bait and/or becoming bait-shy.

Eradication techniques (traps or toxic bait) must operate at optimal capacity to ensure a successful outcome. To achieve this the whole team must be motivated for the duration. Examples include:

i. In the latter stages of the Kapiti Island possum eradication dogs used to locate possums were periodically taken to the mainland to hunt where possums were common (Cowan 1992). This improved dog morale and handler confidence in the dog's ability to detect possums at extremely low densities.
ii. Difficult terrain combined with low to non-existent pest tallies in the latter stages of the Rangitoto Island possum and wallaby eradication proved a constant challenge to maintaining staff morale and motivation. This was met by:
    -using people with a positive attitude;
    -stimulating staff with other tasks (i.e. trips to other locations where they caught pest animals);
    -praise and acknowledgement throughout the latter stages of the eradication operation (Simon Mowbray pers. comm.).
iii. In the Whenua Hou/Codfish Island possum and weka eradication, motivation and morale was maintained by allowing the team to focus on the task of eradication. The team leader handled all other issues (e.g. resourcing, administration, and requests to do other work). Another essential element was involving all team members in the testing and development of better practice. This resulted in team 'ownership' of the techniques (Andy Cox pers. obs.).

A "can't do" attitude from other experts not involved in the operation can impinge on its success. Those planning an operation need to be explicit about the assumptions they are making and demonstrate that the planning has taken into account any points of concern raised by these experts. For example, the results of a study of possums on the West Coast of the South Island were used to justify the belief that the eradication of possums from Whenua Hou/Codfish Island was impossible and a recommendation was put forward to change the objective to control. The eradication project team believed that differences in habitat, climate and behaviour as a result of prolonged hunting pressure meant that the findings on the West Coast could not be used to predict the outcome. They were proved correct.

A "can't do" attitude by higher level management could have serious implications for resourcing, particularly in an extended programme. Operations need to be well justified and researched, robustly planned and documented, and effectively communicated with senior managers. Research, which measures the impacts and benefits of an operation, will help gain support for future operations and should be an integral component of all operations.

Building capacity at the organisational level

The New Zealand Department of Conservation has a commitment to learn from all eradication attempts, to reduce the risk of failed operations, and to build the capacity to attempt more complex projects. The approach adopted when planning invasive alien animal species eradication programmes on islands has several key components.

1. Strategic approach

By considering island eradication programmes collectively, rather than operation by operation, learning opportunities are maximised improving techniques for future eradication operations, and providing evidence of the benefits of eradication programmes.

2. Skills development

New project teams gain experience by participating in eradication operations elsewhere. This exposes team mem-

bers to the reality of eradication operations and the issues and debate associated with them. This expands their horizons, builds up their network of contacts, and fosters the motivation needed to achieve a successful outcome. For example, the Raoul Island eradication project manager has been involved with planning aspects of the Tuhua cat and rat eradication, to maximise the potential for refining techniques that could be applied on Raoul.

3. A team approach

Major eradication operations require a committed project team. When appointing members, team dynamics must be taken into account. Project managers must be responsible for co-ordinating the respective contributions of team members to ensure programme goals are met within the agreed timeframe. It is important to have a well-briefed understudy for a project manager as insurance. Tasks need to be assigned explicitly to team members throughout the planning and operational phase. Team dynamics need to be considered, ensuring motivation and support are high and the skills required are transposed into clearly defined roles.

Project teams require the support of higher level management to effectively carry out their role. Pressures of other work often compromise time and quality of time spent on eradication projects. Time needs to be allocated and tailored to the requirements of an operation. For example a project manager may spend 25% of their time on the project in the initial planning phase, increasing up to 100% as approval to carry out the operation is being obtained, reducing back to 25% as contracts are let, and increasing up to 100% just prior to operation and throughout it.

Project teams must not operate in isolation. Each operation has local issues to address, but to ensure 'best practice' and skills development it is vital to involve people with relevant expertise and future project team members. This has the added bonus of sharing techniques and knowledge across a wider base.

4. Peer review

Peer review focuses on planning and readiness before an operation takes place. This is very important in operations that involve a 'single hit' technique. Everything has to be decided and all resources have to be assembled before a single animal is killed (i.e. in an aerial rodent eradication).

Peer review of major island eradication programmes now involves meetings between the Island Eradication Advisory Group, project managers, and other experts as required. Issues pertaining to current or upcoming island eradication projects are debated during these meetings. This has proved particularly beneficial to project managers, as it highlights points relevant to their project which may not have been raised.

The Island Eradication Advisory Group's brief is to provide expert advice to project teams and support managers in their decision to proceed with an operation. The group has been instrumental in getting organisational features (forward planning, skills, and review) operating across the Department. Focus is on:

i. Ensuring that lessons from past operations are transferred and that quality planning occurs;
ii. Looking ahead to the needs of future operations;
iii. Minimising political risks, which could affect the success of an operation or future operations;
iv. Ensuring island quarantine and monitoring is adequately planned for at the outset, to prevent re-invasion;
v. Continuing to act in an advisory capacity during eradication operations or when an alien animal species invasion is detected.

5. Review and debrief

Review needs to occur throughout all phases of an operation. Errors can be made during an operation and it can still be successful through sheer luck. Review assumes we cannot be lucky every time, and that mistakes should only occur once.

Debrief, at the end of an operation, assesses all aspects of the operation to determine possible improvements, make planning for future operations as robust as possible, and document successes. Debriefs effectively transfer the lessons learned with each operation to future projects, and involve current project team members and operators, as well as any contract staff, the Island Eradication Advisory Group, and project team members of upcoming eradication programmes. An example of this transfer of lessons learned relates to a failed eradication attempt. The documentation seen by the advisory group, before the operation, suggested planning for the project was adequate, but the eradication failed. Although some members of the project team had reservations about the project prior to the operation, these were not expressed until the operational debrief. This has led to an extra step in the planning process – members of the advisory group now visit the project team in the final stages of planning to check 'state of readiness' and does not rely solely on reports to the group.

THE FUTURE

Prevention

The next major challenge is improving the planning and implementation of island quarantine and contingency. Island quarantine consists of the precautions taken to minimise the risk of an alien animal species invasion. Contingency is the response to a new alien animal species invasion.

Island quarantine is particularly important as the number of successful eradication operations increases and we move into a situation where we are likely to be dealing with

newly-established invasive alien animal species populations. Prevention is better than cure because it avoids the impacts of new invasive alien animal species establishing in vulnerable ecosystems.

Information dissemination

If we are to keep the eradication tools (i.e. toxins) currently available to us then we must use them wisely, and improve public understanding of the risks associated with using them and the benefits of successful eradication operations. To ensure that we all learn from island eradication attempts and to improve public understanding we need to make the results of eradication operations available through presentation and publication.

Wider issues

Although we have some understanding of the immediate benefits to threatened species of eradicating invasive alien animal species, we do not have a good understanding of the long-term effects of eradication, particularly the perturbations caused in an ecosystem by the removal of the alien species. Further work is required on defining long-term restoration goals for islands and island groups, so that invasive alien animal species eradication occurs within a context of restoration.

Refinement of techniques

There are further opportunities to improve eradication techniques and our understanding of how they operate. There is a requirement for more sensitive techniques for detecting and managing invasive alien animal species at low numbers, and for techniques which address issues associated with problematic animals such as those that have developed toxin resistance or become trap shy. Also, for more information and options for poison baits taking into account: bait life, palatability and attractiveness for a wide range of species.

The global challenge

The Department of Conservation approach has proved to work effectively in New Zealand where there are few native mammals and where invasive alien mammals are of special concern. We believe the aopproach has application elsewhere because invasive alien animals are a problem on many islands around the world. Many of the gains made in New Zealand have come about through forward planning, with each eradication supporting and leading on to the next. At the global level the challenge is to ensure that we all learn from all island eradication attempts. To do this will involve making the results of eradication operations available and developing effective international co-operation.

ACKNOWLEDGMENTS

We would like to thank Janet Owen, Simon Kelton and Wendy Evans for reviewing the paper during its development. We also thank Andrew Burbidge and Rowley Taylor, the referees, for their valuable comments. Finally, we wish to thank all those involved with the eradication of invasive alien animal species from New Zealand's islands. It is their work that has led to the development of the approach outlined in this paper.

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