

The essential non-science of eradication programmes: creating conditions for success

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Abstract Among conservationists, eradication of non-native vertebrates is widely recognised as an often necessary step to restore island ecosystems and protect native biota. Less understood is the great difficulty of actually conducting an eradication programme. The biological and technical aspects of eradicating a population represent one category of challenge: how to ensure that every individual of the target species is removed, and how to know when that point has been reached. Here, however, we focus on a less appreciated but nonetheless essential category: how to put in place enabling conditions that will help ensure the success of the eradication effort. The planning and preparation required to conduct an eradication programme extend far beyond the realm of science and technical planning. Eradication programmes increasingly are multidisciplinary endeavours, requiring comprehensive financial, logistical, political, communications, and legal preparation. Without such dedicated support, sponsors and managers of eradication programmes introduce additional risk to an already risky investment of limited conservation resources, because even minor delay or interruption of the programme can have significant ramifications. Here, we provide an overview of the extent of planning and preparation undertaken to implement one of the most intensive efforts to date to eradicate an insular population of feral pigs.

Keywords: California, feral pig, island conservation, planning, risk management, Santa Cruz Island

INTRODUCTION

Non-native vertebrate species can devastate biological and cultural resources of islands and eradication is often necessary to remove the threats posed by these animals (Reaser *et al.* 2007). However, eradications can be logistically complex, expensive, and controversial, and can represent high risk investments of scarce conservation resources; multi-year, multi-million dollar investments can be jeopardised if even one individual escapes detection and enables the population to re-establish. For an eradication to succeed, it must meet predetermined conditions of success and have a solid scientific and technical foundation to its strategic and tactical approach (Parkes 1990; Morrison *et al.* 2007). Such projects must also have a solid foundation of operational, administrative, legal, communications and other types of support. These “non-scientific” aspects of an eradication project are important for very biologically-based reasons: once initiated, an eradication campaign must not be interrupted, lest progress in reducing the unwanted population be lost.

Managers of eradication efforts generally recognise that projects risk failure due to the difficulty of detecting animals at very low abundance. That risk can be reduced through strategic planning and implementation of the eradication project (Morrison *et al.* 2007). Deploying sustained pressure on the population in a systematic and intensive manner reduces the likelihood that animals will escape detection, reinvade areas already cleared, or replace those removed via reproduction. That in turn enhances the likelihood of ultimate success, and may reduce the overall cost of the project as well as the number of animals that ultimately need to be dispatched (Morrison 2007).

Given the importance of being systematic and intensive, it is crucial that eradication attempts, once begun, are sustained to completion. Even slight delay can compromise the programme. Interruptions can stem from a variety of factors: funding shortfalls, accidents, breakdowns in logistical support, legal intervention, and loss of political or public support. Interruption in an eradication project can enable replacement of the population through redistribution and reproduction, and so a loss of accomplishment to date. When the effort is reinitiated, it could require substantial reinvestment to return to previous levels of population reduction. Making up lost ground can be expensive, perhaps prohibitively so. If animals were able to reproduce

because of the delay, the consequence will be even more animals ultimately needing to be eliminated. And those animals already eliminated would have died without any long-term conservation benefit.

Failed eradication attempts can incur substantial costs including not only the direct expenditures on the eradication effort (e.g., those paid to the eradication service provider), but also the indirect costs of administration and operations by the eradication sponsor and manager. Opportunity costs can also be high, because conservation funding and capacity invested in a failed eradication could have supported other restoration or biodiversity conservation initiatives. Failure may also have significant “reputational” consequences, and not just for those conducting the eradication but for the conservation tool itself, with effects that transcend the specific project. Failure of a high profile eradication effort could erode support for eradication programmes as a tool for conservation, making managers and funders less willing to invest in eradication efforts again or elsewhere. Failure could therefore have a cascading ecological cost: the biodiversity conservation outcomes needed on the subject island would not be attained, and the outcomes needed on other islands might not be attempted. Failed eradications can fate native species to extinction.

Thus, managers undertaking eradications must do so with an explicit focus on reducing the myriad risks of failure. Indeed, a principal responsibility of the sponsors and managers of an eradication project is to ensure that once launched it will be carried through to completion. As we outline below, that requires a focused, multidisciplinary support team – working well in advance of the actual on-the-ground effort – tasked with creating robust scientific, legal, administrative, and financial foundations for the project. As every eradication effort will encounter unique challenges and circumstances, it should be anticipated that projects will not go wholly as planned. The ability to implement adaptively requires a broad foundation of support.

Here we describe the support system developed for the eradication of feral pigs from Santa Cruz Island, approximately 40 km off the coast of Santa Barbara, California, USA. The Nature Conservancy (TNC) owns 76% of the 250 km² island and the United States National Park Service (NPS) owns the remainder. We do not describe

the methods of the hunting and monitoring component of the eradication project (i.e. the eradication effort); those are described elsewhere (Parkes *et al.* 2010). Rather, we describe the role of the sponsors and managers of the project in creating and sustaining conditions that allowed the eradication effort to proceed unimpeded. We discuss the process by which the project was planned, and how it was supported. Although our example is an eradication project on an island, the principles would apply to pest eradication projects generally. This case study illustrates the extent of support demanded of an eradication effort of this scale, and as such may provide a model for reducing investment risk in future eradication efforts.

METHODS

To increase the chances of successfully eradicating feral pigs from Santa Cruz Island, we developed a foundation of internal and external resources that would provide support through the various phases of planning and implementation. In doing so, we sought input from others with past experience of similar projects that could be applied adaptively to our situation. We tried to anticipate circumstances that could arise that would impede implementation, and prepared accordingly. Below, we outline the general components of that foundation, illustrated with specific examples from Santa Cruz Island. We first describe key roles that needed to be performed in the planning and implementation. We then discuss where we focused our preparation to ensure that, once underway, the eradication effort would be resilient to disruption.

Clarifying roles

Eradication projects differ fundamentally from other management and restoration programs: if the targeted population is to be reduced to zero, a very intensive and specialised campaign must be sustained uninterrupted. Because eradication projects are complex and multidisciplinary undertakings, it is important to clarify the various roles and responsibilities of those involved so that accountabilities are clear. Basic functions were categorised as follows:

Sponsors: initiate the eradication project and ensure that the conditions for success are in place, e.g., funding, environmental compliance, contract management, communication with stakeholders.

Providers: conduct the on-the-ground eradication effort; in our case, a contractor with specialised expertise in the techniques we needed.

Managers: control resources and logistics, and serve as the on-the-ground support for providers.

Analysts: provide expert counsel in planning and monitoring, e.g., initial assessment of the feasibility of meeting an eradication goal and independent audit of progress during implementation.

While other important roles could be described (e.g., “external champions” that lend support for the project at critical moments, such as independent scientists, supporting organisations, and community leaders), our emphases here are the “core” functions. We do not suggest that each of these functions is exclusive. For example, on Santa Cruz Island, both TNC and NPS performed the roles of sponsor and manager. Similarly, the provider (Prohunt, Inc.) had a key role in planning and analysis, in addition to conducting the eradication. Generally, “providers” conduct the actual eradication field work, which for our project is more fully described by Parkes *et al.* (2010). An example of a role of

the “analyst” in our project was evaluation of the probability that eradication had been achieved (see Ramsey *et al.* 2009). Below, we focus on the responsibilities we assumed as sponsors and managers of the eradication project.

Designing a “resilient” project

Expertise from many disciplines was needed to ensure that once initiated, the project would withstand disruptions and reach completion. The following were key elements of those foundations.

Scientific foundations

Scientific principles were not only important for the technical planning, implementation and monitoring of the project; they were also the basis of many of the non-science foundational components, such as our communications and legal strategies. Key components of the science foundations included:

Describing the threats posed by the target species: Well in advance of the actual eradication, we documented the extensive damage caused by pigs, based on published literature, observations, and inference (NPS 2002).

Understanding management options and preparing to defend the preferred method: We evaluated potential strategies that might achieve the desired conservation outcomes and were prepared to justify why we selected eradication by means of hunting over others (such as sustained control, translocation, and contraception.)

Developing an eradication plan: Once it was determined that pigs needed to be eradicated, we developed a plan that would address logistical challenges specific to Santa Cruz Island. External “analysts”, e.g., from Landcare Research (New Zealand), played a key consultation role to ensure the planned approach was feasible and represented best practice.

Assessing and mitigating possible adverse effects of eradication effort: The motivation for undertaking an eradication is to protect resources, so it follows that there should be measures to minimise adverse non-target impacts during and after the project. In our project, examples of such precautions included: inspecting all areas where ground disturbance was planned (e.g., due to installation of a pig trap) for presence of sensitive plants or archaeological resources; using only non-lead ammunition; and reducing risks to the endangered island fox (*Urocyon littoralis santacruzae*) posed by the presence of hunting dogs (e.g., all dogs underwent a vaccination and quarantine regimen, and fox aversion training.)

Monitoring and managing the ecological response of eradication: Monitoring is crucial not only to detect and mitigate anticipated and unanticipated adverse effects (Morrison 2007), but also to maximise learning from the eradication project. Clear hypotheses and pre-eradication baseline data on key systems or taxa can leverage the research opportunity. Our monitoring also included biological samples from the pigs in case of future questions about whether certain wildlife diseases had a reservoir in the pig population. These data will also be useful if pigs reappear on the island and we need to ascertain whether they derive from the original island population or from a new release (e.g., resulting from sabotage).

Documenting effort of the eradication project: Recording all hunting and monitoring effort and outcomes (pig dispatches) using GPS units aided the day-to-day decision making of the provider, generated evidence of performance for the sponsors, facilitated coordination

of activities by the island managers, and allowed for quantitative audit near the end of the project.

Contractual foundations

Contracting for eradication efforts poses unique challenges, in part because of the intensity and flexibility required in implementation and the degree to which it relies on coordination with the managers and analysts. Furthermore, it is impossible to know with certainty whether the provider has completed the eradication until sufficient time has passed without detection. Here the interests of the sponsor and provider may diverge: the sponsor might prefer withholding a substantial final payment to minimise risks to its overall investment, but doing so might not be financially realistic for provider. Meanwhile, the provider may prefer maximal payment up front to have the resources to mobilise an intensive initial effort. An important element of the contracting process was thus a fair and appropriate distribution of risks. This in turn required each party to understand and reconcile the needs and constraints of the other.

We sought to establish a fixed-price contract with a provider having demonstrated expertise and a long-term professional commitment to eradication projects and conservation outcomes. We considered the provider's experience and reputation to be crucial. When a provider begins to report that animals can no longer be detected, sponsors need to have confidence in the professional judgment of the provider's team and trust that the project was implemented in a manner that did not simply make remaining animals harder to detect (Morrison *et al.* 2007).

A fixed-price contract structure, versus one based on time and cost reimbursement, set in place incentives for efficiency that likely reduced the duration and cost of the programme (Morrison 2007). The provider's eradication plan for implementing the project was translated into a project timeline that could be incorporated into an enforceable contract. The contract outlined a framework for a general sequence of activities structured around performance milestones to which incremental payments would be pegged. Because eradication projects are idiosyncratic, even the most seasoned provider will face uncertainty as to how the actual eradication will transpire; time, effort, and cost are just estimates. All those involved understood that implementation would be necessarily adaptive within the contracted framework and that the contract would need to be amended periodically as the project progressed.

Legal foundations

Environmental compliance, permitting, and administrative process: The importance of strict and documented adherence to the regulatory compliance process is difficult to overstate, as the adequacy of environmental review can be a basis for legal challenge. The National Park Service was responsible for environmental analysis of project alternatives, impacts, and mitigations, in compliance with the National Environmental Protection Act (NEPA). This process included public review and resulted in the decision that eradication was the preferred alternative for protecting the natural and cultural resources on the island.

Legal preparation and defence: Individuals and/or organisations opposed to the goals or methods of the project may at any time mount a legal challenge. In addition to careful adherence to the compliance process, we proactively discussed all proposed work with legal counsel, so that defence teams were ready to engage if

needed. Preparation included identifying experts in many disciplines willing to serve as resources should we need to quickly respond to a challenge.

Ethical foundations

Some people believe that killing sentient animals is unacceptable, even for preventing extinction of other species. Still more people are likely uncomfortable with the notion of killing large numbers of animals. To maintain support for eradication programmes, projects must be planned, conducted, and communicated in a way that demonstrates attention and sensitivity to these issues. The projects must also focus on reducing, to the extent practicable, the stress and suffering of target (and non-target) populations. A strong ethical foundation requires conducting due diligence on alternative methods, and being able to articulate how animal welfare has been incorporated into project activities. Hiring highly skilled marksmen to implement the project was a key component of our efforts to meet standards for euthanasia of wildlife (AVMA 2001).

Community foundations

Community support for an eradication has two components: support for the project during its implementation, and help with protecting the investment once completed (e.g., partnering to prevent reinvasion). In our project, the social dimensions of eradication may have been less complex than on sites where there are resident human communities. Even without a resident population on Santa Cruz Island, there were still community groups with direct or indirect interests in issues associated with the eradication. We therefore conducted public meetings to discuss the project, and focused direct outreach to Native American representatives with ancestral connections to the island and to user groups (e.g., boating clubs) with active ties to the island.

We also recognised sport hunters as a major constituency that we did not want to alienate against our pig management efforts (e.g., by advocating wildlife agencies to oppose the eradication). We therefore coordinated with the State of California to offer a rare public hunting opportunity on the portion of the island owned by TNC. This was conducted well before the eradication so that there would be no residual effects of the "recreational hunt" on pig behaviours that would compromise the "eradication hunt" (see Morrison *et al.* 2007).

Several animal protection organisations expressed concerns about the project, specifically questioning the need to eradicate pigs. TNC and NPS tried to maintain open communications with these groups. Although we did not expect them to become project supporters, we had the goal of showing that the project was based on a serious assessment of environmental impacts and the methods and contractors were chosen to minimise the suffering of individual animals.

Because eradications can have a high media profile, appear controversial, and often require direct and or indirect governmental support, political engagement in the relevant arenas of government was a priority. In order to respond to the needs of elected officials, we gave regular briefings on issues and progress.

Communications foundations

Strategic communications and outreach: Well before implementation, we developed outreach strategies to build the necessary internal and external support for the project. This involved identification of the individuals and entities

important to inform about or otherwise involve in the effort, and effective delivery of information to them. In addition to individually tailored outreach to key partners, funders, and community leaders, our communications programme involved a proactive media strategy with information that was fact-based, constructive, and educational. We hosted opportunities for media to visit the island, discuss the project, and meet key staff. We also prepared media materials with frequently asked questions (FAQs) and other background information.

Two elements of our communication approach were especially important. First, we used messages that simplified the complexity of the eradication effort so that the project rationale was easily understood. Our primary emphasis was project outcomes: this was not just about killing pigs; it was about keeping the island fox and numerous rare plants from going extinct. Second, we were especially careful with the language we used to discuss the project. We focused on the science, and avoided terms that were emotionally charged or potentially insensitive. Because numerous entities were involved in the project, we invested considerable effort in developing and providing consistent messages. We provided guidance and training to key staff, including the pig hunting team, on how to effectively communicate and represent the project.

Internal communications: We developed crisis communication protocols that identified points of contact, internal communication channels, and delegations of authority. We also did not assume that all within our respective organisations were supportive of the eradication effort—or even aware of it. So, we conducted internal outreach to brief staff, answer questions, and outline instructions as to whom to direct inquiries regarding the project.

Information management: Information management during the eradication was essential, especially for safety. We were concerned that if details about the specific location of hunting activities found their way to opponents of the project, it might attract civil disobedience and so compromise the safety of the hunters as well as the protesters. We were therefore disciplined in our exchanges of information among the various personnel and partners involved in this project, making sure that documents, emails, photographs, maps, and so on would not be problematic if they found their way into the public arena.

Financial foundations

Because eradication projects can be expensive, providers must have the resources required to succeed. Funding for the whole project needs to be committed before the job is begun, and accessible as needed. In our case, project funds came from private (TNC) and public (NPS) sources.

Operational foundations

Dedicated institutional capacity through the planning and implementation: Planning and implementation of eradication efforts requires disciplines ranging from project administration to media and governmental relations. Orchestration of that effort required dedicated personnel, with the skills and capacity necessary to advance the project and address problems that arose. From the onset of the project, senior management of TNC and NPS made it clear to staff that there was no higher priority than success of the eradication and to organise and prepare accordingly.

Infrastructure, facilities, and equipment: The eradication team required considerable logistic support before and during the project. Prior to the eradication

effort, for example, we needed to install over 43 km of high-tension pig exclusion fencing to divide the island into smaller management zones. Improvements or upgrades were also needed for on-site housing and roads, power, water, and communication systems. We needed reliable information management systems to allow efficient downloading, backup, and analysis of project data. Adequate housing and facilities had considerable bearing on the maintenance of morale of the hunters, which surely affected their performance in the field and the attainment of our overall goal.

Safety: Human safety was the paramount consideration in all aspects of this project, not just among the hunters but for all island users. While the eradication was underway, there was still the full array of island activities on the island including research, resource management, maintenance, and recreation. We therefore needed to manage access and coordinate activities so that users would not interface or interfere with the hunt, and vice versa.

RESULTS

While the on-the-ground phase of the eradication effort took place between 2005 and 2007, efforts to establish the enabling conditions for the project were underway for years prior. The environmental compliance process was initiated in 1999, and culminated with the completion of the environmental impact statement in 2002. The search for a provider for the eradication service was conducted via a competitive Request for Proposals issued in 2004; and in 2005 Prohunt, Inc. was selected.

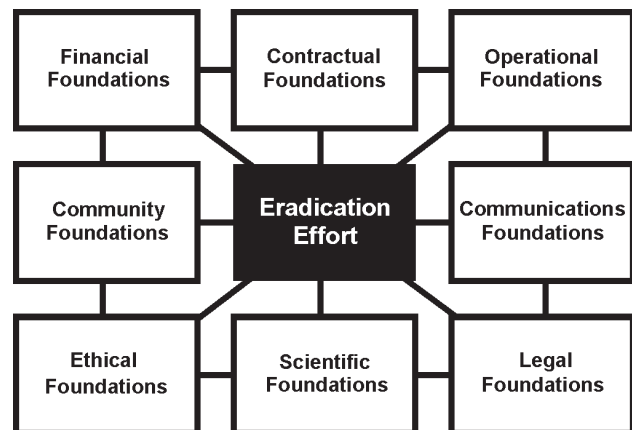


Fig. 1 A framework for resilience in eradication projects. When eradication sponsors and managers create adequate foundations of support for the project, they can buffer the eradication provider from disruptions that might compromise the on-the-ground effort.

The work described above created a support structure for the eradication project that enhanced its resilience to expected and unexpected challenges (Fig. 1). Below we highlight ways in which those foundations were tested. Some challenges were anticipated, others not. All required creativity and institutional agility to troubleshoot and resolve.

A capacity to adapt was required from onset of the project. Many of the provider’s employees, for example, were not US citizens, and securing visas and firearm importation permits was unexpectedly protracted, which in turn forced modification of the mobilisation schedule. Following Hurricane Katrina in 2005, the federal budget

to NPS was cut, which resulted in a 50% reduction in NPS boat service to the island. This affected our planned transport of personnel and equipment. Other surprises were biological: as the eradication effort mobilised, we discovered numerous eagle nests on the island; hunting efforts needed to be greatly curtailed in the vicinity of those nests until they were no longer active. Technological issues also surfaced. For example, we faced considerable challenges getting the radio- and GPS-collars for the pigs to perform reliably; much effort was spent in “R&D” and less in actual application – again precipitating a need to modify plans and amend the contract.

The implementation sequence also required flexibility. The eradication was designed and contracted to progress systematically from west to east across the island. But at the time of contracting, we could not know how long that progression would take. The easternmost zone was the portion of the island most accessed by Park visitors. As the programme advanced, we realised that unless the planned progression across the island was modified, active hunting would be underway during the peak visitor season. Disruption to Park visitors such as park closures could undermine community support for the project. We therefore modified our plan (and the contract) to advance that area of the island in the schedule, concentrate the provider’s efforts in that zone, and thereby reduce the disruption to visitors. Fortunately, the contract structure, and the commitment of the providers to the needs of the sponsors, meant that such amendments were straightforward.

Before and during the eradication effort, editorials in the nearest mainland newspaper consistently opposed the project, even publishing names and photographs of key personnel involved (e.g., Santa Barbara News-Press 2006). Our outreach to media before the eradication, however, helped ensure that the full conservation story was communicated broadly and well ahead of controversial coverage that accompanied the eradication (e.g., MSNBC 2005).

Throughout the project, we faced legal challenges from animal rights interests petitioning to have the project stopped, mostly based on allegations of inadequate environmental compliance process (e.g., US District Court 2005). Fortunately we had invested significantly in legal preparation. For example, we were able to quickly assemble formal declarations from subject area experts to address each of the plaintiff’s complaints. Our preparation was perhaps most tested when a former superintendent of Channel Islands National Park unexpectedly published an essay in a local newspaper suggesting that the NPS environmental review process was flawed (Setnicka 2005). Although his accusation was not supported by the formal administrative record (US District Court 2006), it did create issues that needed prompt attention so that public support and our legal position would not be compromised. All told, we faced five successive legal challenges, all of which were rejected by the court.

Our hunting dogs provided a final illustration of the need to expect the unexpected. We imported 23 trained dogs to the island. Each dog had to undergo an extensive vaccination and quarantine regimen due to concerns of introducing canine pathogens or parasites to the endangered island foxes. Protocols were developed by a team of wildlife veterinarians with years of experience in island fox conservation management issues. Midway through the eradication project, one dog dug from his kennel into that of another in oestrus, and soon thereafter she produced a

litter of pups. This revealed a deficiency in our biosecurity protocols: some parasites of concern can remain in cysts in mammary tissue and be released upon nursing. Had the whole dog team become re-infested, it could have prevented their use in the field and significantly disrupted the project. Again the veterinary team was mobilised to develop revised treatment protocols for the dogs so that risks of transmission to foxes could be contained. We also made it impossible for one dog to dig to another’s kennel! Had we not established a network of collaborators and advisers on the project and been able to mobilise a timely response, even something as seemingly benign as puppies could have compromised the programme.

DISCUSSION

The Santa Cruz Island feral pig eradication was completed in an unprecedentedly short time for an island of its size; the interval between the dispatch of the first and last pig was only 15 months (Morrison *et al.* 2007). While that is a clear testament to the skills and dedication of the hunting team, what enabled that accomplishment was the meticulous preparation preceding the actual implementation and the subsequent sustained comprehensive support by the sponsors and managers. This support ensured that there were relatively few surprises during implementation. It also helped us be prepared for and respond to the surprises that did arise.

Clarity about roles and responsibilities throughout the planning and implementation was essential. Simply put, a key role of TNC and NPS was to ensure that providers were able to focus on their job without disruption or delays. Delegations of responsibility among the multidisciplinary teams were clear, and communication was frequent and effective. Interestingly, once the provider was selected and the contract signed, the relationship between contractor and contractee quickly became a conservation partnership. A team ethic permeated all: we were committed to a common goal of eradication, and recognised that we were wholly reliant on the others excelling in their roles if we were to achieve it.

This case study highlights how it is not enough to plan an eradication based on biological and logistical considerations alone. Even though the scientific justification for removing feral pigs from Santa Cruz Island was compelling (NPS 2002), the preponderance of evidence that eradication was necessary did not beget eradication. Eradications are conducted within a social and political context, which may affect their feasibility to the same extent as biological factors. Our project required, in addition to technical planning, massive logistical coordination, public and private fundraising, garnering of political support, communications and outreach, and more. These “non-science” aspects of the eradication effort were an essential complement to its scientific underpinnings.

Every eradication project is unique and the strategies that we used to prepare this project may differ from those needed elsewhere. Because funding is limited, eradication teams need to assess the extent to which they invest in proactive versus reactive risk management strategies. Our emphasis on proactive strategies was influenced by Santa Cruz Island’s location adjacent to millions of southern California residents, its status as a National Park, co-owned by a high profile international conservation organisation, and the level of opposition to previous eradication efforts on neighbouring islands (e.g., Los Angeles Times 2002).

In that context, we found extensive outreach to key stakeholders – including potential project opponents – to be essential. Projects in other contexts, like islands that are more remote or that have permanent residents, may assess risks, costs, and opportunity costs differently than we did. What we underscore is the importance of risk management decisions and contingencies that reflect the unique challenges confronted by each eradication project.

Lessons from this case study can be applied to reduce risks inherent in eradication efforts. In the face of a global biodiversity crisis and extreme global change, it is imperative to increase the pace and scale of eradication programmes against invasive species, particularly on islands, so that ecosystems can gain greater resilience to future stresses. The past decades have seen a marked increase in the sophistication and rigour of eradication projects (Veitch and Clout 2002; Veitch *et al.* 2011). Those experiences, combined with better understanding of the full complement of skills and functions necessary to conduct successful eradication, should help to scale up and accelerate restoration efforts and so the conservation of highly imperilled biota.

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