Increasing the return on investments in island restoration

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Abstract The effects of invasive species are now being reversed through successful eradications of unwanted organisms on increasingly large and remote islands. Although these successes represent an encouraging trend, we suggest that it is time to examine their pace and scale, given current advances in the science and practice of eradication. To date, most eradications have been implemented as "one-off" projects, with little coordination across islands. As a consequence, opportunities are missed to achieve economies of scale in planning, permitting, staffing, and purchasing that could lead to a considerable increase in time- and cost-efficiency in reaching eradication goals. A more coordinated cross-island effort could also allow for greater development and retention of specialised capacity, which would not only further enhance the efficiency, but also reduce risks of failure inherent to eradication programmes. More funding is needed to support eradication efforts. Should these funds become available, a programmatic and coordinated approach to their use could greatly increase the outcomes achieved. This coordination could include multiple invasive taxa and/or multiple islands that are managed in strategic sequence. By developing and supporting a planned sequence of projects, e.g., for archipelagos or regional clusters of islands, eradication efforts could be designed to achieve efficiencies in planning and implementation that could result in greater return on investment than an island-by-island approach. A regionally- or internationally-supported systematic initiative could also help overcome a major limiting factor in island restoration: insufficient in-country capacity to support a sustained eradication programme. A ship-based platform may be a highly effective tool to implement this more programmatic approach; for example, it could help overcome obstacles to implementation on remote and/or small and/or inaccessible islands.

Keywords: Economy of scale, efficiency, eradication, invasive species, planning

INTRODUCTION

Invasive alien species are a key threat to native biodiversity (Vitousek *et al*. 1997), particularly on islands (Mulungoy *et al*. 2006). Fortunately, invasive species are increasingly being eradicated from islands as planning and technical tools improve (Parkes and Panetta 2009). Unlike continents, islands can be more easily defended from new invasive species by good quarantine and border security (Jarrad *et al*. 2011; Russell *et al*. 2008). If eradication is achieved, unlike sustained control, threats are entirely removed, which maximises benefits to native species and ecosystems. The relative cost/benefit ratios of eradication can be better than those for sustained control (Panzacchi *et al*. 2007), although there are very few adequate analyses of these comparisons for protection of non-market values (Hone 2007). Furthermore, sustaining control, and the budget to support it, is very difficult for funding agencies (Parkes and Murphy 2003). Eradication does not require such long-term commitments, and there are many examples where eradication of a pest has resulted in major improvements of native biodiversity (e.g., Rauzon 2007; Rodrigues 2006).

Perceptions of eradications have also shifted from 'too hard' in the 1970s for views about rodents (e.g., Wodzicki 1978) to one of 'can do' due to successes for such diverse species of mammals as rodents (Howald *et al*. 2007), goats (*Capra hircus*) (Campbell and Donlan 2005), cats (*Felis catus*) (Nogales *et al*. 2004), pigs (*Sus scrofa*) (Cruz *et al*. 2005), and other species (Parkes and Panetta 2009) (see also the Global Island Invasive Vertebrate Eradication Database at www.islandconservation.org/db). The future still holds challenges. Some invasive species, or groups of species, remain intractable or difficult to eradicate either due to a lack of effective management tools as the case for *Suncus murinus* (Varnham *et al*. 2002) and most amphibians (Campbell and Kraus 2002), or because of life histories and behaviours that make it difficult to place all individuals at risk (e.g., most birds, invertebrates, weeds). Invasive species in aquatic habitats are often intractable because we lack suitable tools, they occupy habitats inaccessible to managers, and because aquatic species often produce vast numbers of cryptic, mobile dispersal stages. Eradication failure rates for species such as mice (*Mus musculus*) remain frustratingly high, often for reasons that remain unclear (Howald *et al*. 2007; Mackay *et al*. 2007). It is also unclear whether dealing with invasive species on large islands is just a matter of scaling up what works on small islands or whether new strategies and tactics will have to be developed (Parkes and Panetta 2009; Parkes *et al*. 2008). Nevertheless, accumulating successes have led to growing national (e.g., Aguirre-Muñoz *et al*. 2008; Anon 2009) and international (e.g., Genovesi and Shine 2004) interest in the role of eradication of invasive species as part of island restoration.

To date, only a fraction of the thousands of islands with invasive species have received management action. Reasons for this include the relative novelty of eradication methods, the inaccessibility, remoteness or large size of islands, and limits on the capacity of managers to engage beyond islands in their charge. As a consequence, eradication efforts are often *ad hoc*, planned and executed as "one off" efforts, driven by the presence of a local champion or proponents, focused on one pest species at a time, and on one island at a time. The economic and opportunity costs of this approach may be significant. If there are multiple pests on an island, there may be economies of scale in addressing them comprehensively while the eradication infrastructure is in place (Morrison 2007). Also, if island projects could be lined up in a strategic sequence, eradication activities among the islands could be sequenced efficiently, and the accrued expertise and experience of the eradication team could be retained.

In this paper, we argue that with advances in the strategies and tactics of eradication of invasive species on islands, it is time to ask how to increase the pace and scale of these achievements. Of course, one means of increasing the rate of eradications is to increase funding. We underscore the importance of increased private and public investment

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in this proven and timely conservation approach. But in addition to more funding, we may be able to increase returns on the available funds by investing in more programmatic and systematic efforts. With this investment one could develop a pipeline of projects planned and implemented in strategic sequence, using infrastructure and capacity across multiple island systems and international borders.

OPTIMISING INVESTMENT

Increased investment in pest eradication results in disproportionately large returns on island investment – even if it follows the single species, single island model. For example, the eradication of Norway rats (*Rattus norvegicus*) from Campbell Island (McClelland 2011) covered a much larger area than previously attempted and had benefits for many invertebrates and terrestrial and marine birds. Different proponents vary in their criteria for nominating one project over others, but because of the uniqueness and sensitivity of island ecosystems, they are usually underpinned by goals to protect biodiversity and, increasingly, to improve human health and livelihoods.

The trajectory of eradication successes might increase, however, if a systematic approach was designed, and funding was invested in its planning, infrastructure, and implementation. The incremental development of aerial spread methods against rats that led to the Campbell Island project demonstrates the value of such an approach (Towns and Broome 2003). Similarly, 'lining up the islands' and dealing with them as groups can: 1) reduce costs to assemble and apply the logistics required to conduct an eradication, 2) retain specialised skills in planning, delivering and monitoring eradication operations, and 3) improve the economies of scale and duration that would facilitate building community and local stakeholder support for proposed actions and anticipated outcomes. In some cases, local capacity building will be an important element. Experience has shown that community engagement and the facilitation of substantive stakeholder involvement can be crucial to success. In any event, ensuring stakeholder needs and perspectives are incorporated will be an essential part of the development of any regional or international proposal.

Several countries and regions are now prioritising islands for restoration, with examples in New Zealand, the Aleutians (USA), Mexico, the Caribbean, South Atlantic Territories (UK), and parts of the tropical Pacific. We believe that the next step could involve evaluating the benefits and strategies for implementing those priorities in a sequence designed explicitly to seek minimised programme costs, provide high quality eradication plans, satisfy the prerequisites for eradication, and achieve the biodiversity, economic and social goals set by stakeholders.

A MECHANISM – "THE GOOD SHIP RESTORATION"

Dealing with groups of islands in some planned sequence, especially oceanic groups or those in remote places, is constrained by logistics, including the transport of staff and equipment and their maintenance on site throughout projects. Where the lack of a suitable vessel and/or on-island facilities limits progress with eradication programmes, addressing this issue should perhaps be a priority for national and international partners.

A solution for logistic issues could be a fit-for-purpose ship. For example, a ship could be designed for use in the mid-Atlantic and deal with everything from reindeer (*Rangifer tarandus*) on South Georgia to mice on Gough to rabbits (*Oryctolagus cuniculus*) on Ascension islands. Such a vessel would be different from one required to sail round the Chagos Islands in the tropical Indian Ocean and deal with rats, or around Baja California and deal with suites of pests and weeds, or the Red Sea and deal with rats and goats (and pirates). Ships as a means of transporting the people and equipment required to eradicate pests from islands would be most appropriate where there is no shore-based infrastructure. Elsewhere, a ship may only be needed to provide transport and support for existing shore-based facilities.

NEXT STEPS

We propose that it is now time to discuss how to scale up these approaches to a global collaboration, and rigorously examine the economic merits of doing so. This should include an analysis of the economic feasibility and an assessment of the return on investment (relative to other options) of a ship-based approach using some specific island examples from different regions. A system for identifying and prioritising islands and archipelagos for restoration would also be needed (e.g., Donlan and Wilcox 2009). This might include assessments of the extent of regional or national interest in having particular islands or archipelagos included, relative biodiversity benefits, anticipated costs and local stakeholder engagement and "ownership". Where costs and benefits are about equal, projects offering the most local and national support should outrank those offering the least.

Once islands are prioritised, the specifications of vessels and infrastructure to support particular programmes would be defined and the availability of appropriate vessels and the costs of securing them (e.g., buying, leasing, chartering) could then be investigated. Our initial investigations indicate that many suitable vessels may be available for such programmes.

If these assessments were positive, agencies and individuals with interests and capacity to contribute could form a collective to develop and refine strategies and actions, to liaise with national and regional agencies, and to promote identified programmes to potential funders.

SOME SCENARIOS

We explored these ideas for three island groups and examined how they might benefit from a coordinated approach. Many other archipelagos, regions or sub-regions could have also been selected including:

- Equatorial islands in the Indian Ocean (Chagos, Maldives, Laccadives and Socotra) and other important seabird islands of the Red Sea.
- Eastern Indian Ocean chains of the Andaman and Nicobar Islands
- Southern Indian Ocean islands of South Africa and France
- Various island groups in the Caribbean
- Tierra del Fuego and associated islands
- South Atlantic Ocean islands from South Georgia and the Falklands/Malvinas north to the UK and Brazilian islands.

The following short list illustrates the range of physical and political constraints and opportunities that different island groups present.

Equatorial Pacific

Over 500 main islands and hundreds of smaller islands are situated within about 10 degrees of the equator in the central Pacific. The islands extend from Palau, the Federated States of Micronesia (FSM), the Republic of the Marshall Islands (RMI), Tuvalu, Nauru, Tokelau, the Northern Cooks to the Phoenix and Line Islands of Kiribati, and the Marquesas in the east. Most have one or more species of invasive animals as well as weeds of varying management difficulty. Most islands are populated but some are too remote or too small to support permanent human habitation.

Some eradication projects have been conducted in the area, including Demonstration Projects under the Pacific Invasives Initiative (www.issg.org/cii/PII). There has been some prioritisation of the biodiversity values on these islands through National Biodiversity Strategies and Action Plans, and of potential invasive species eradication projects. For example, 1402 potential eradication projects have been identified on 79 islands or groups of islands in Palau, FSM, and RMI and ranked to list the top 20 eradications (mostly of rats) to maximise biodiversity gains (Wegmann 2007). Seven of the eight islands in the Phoenix chain (Kiribati) were surveyed by Pierce *et al*. (2006) and PII subsequently coordinated the removal of *Rattus tanezumi* from McKean Island (49 ha) and *Oryctolagus cuniculus* from Rawaki Island (58 ha). A planned eradication of *Rattus exulans* from Birnie Island (48 ha) was not undertaken (Pierce *et al*. 2008). These eradications used a ship to transport people and equipment, were limited to small scale operations manageable without helicopters, and avoided long periods ashore. Eradication operations on larger islands in the chain (Enderbury and Orona are over 500 ha) and with rats and cats (the latter at least on Orona) would require more sophisticated infrastructure and more time. The operations undertaken were quite risky to the people involved and in terms of the narrow "window" of time in which suitable weather could be exploited. Nevertheless, the campaigns demonstrated that eradications on some of the most remote unpopulated islands in the world could be successfully undertaken with appropriate planning, a determination to succeed, and a vessel supporting the operation.

Western Mexico

There are about 300 islands off the Pacific coast of Mexico and in the Gulf of California. These islands are important biodiversity resources with high levels of endemism (Case *et al*. 2002). Mexican organisations have been successfully managing invasive species on some islands over the last decade (Aguirre-Muñoz *et al*. 2008). Recent rat eradications (Samaniego *et al*. 2009) relied on a combination of Mexican Navy ships and private helicopters. Key constraints have been a lack of reliable access or any suitable on-shore facilities on many of these unpopulated, arid islands. While the support of the Navy has been invaluable, they have other duties and cannot necessarily commit to fit in with a restoration project's needs and timing. A vessel dedicated to restoration programmes would allow the Mexicans to increase the rate of eradications and potentially begin some of the currently less feasible projects on some larger islands. These could include removing feral cats and goats from Espiritu Santo and Cerralvo, cats and mice from Guadalupe, sheep (*Ovis aries*) and cats from Socorro, and ungulates and rodents from the islands of the Tres Marías Group.

Tasmania

The island State of Tasmania is an important repository for many Australian species extirpated by introduced predators and herbivores such as the red fox (*Vulpes vulpes*) on the mainland. The State also includes about 300 smaller islands that are themselves important nesting sites for seabirds, as well as potential arks for sustaining species threatened on the main island of Tasmania – a threat that is increasing since foxes have arrived (Parkes and Anderson 2011), and Tasmanian devils (*Sarcophilus harrisii*) are dying from disease.

The Australian Federal Government has identified which invasive species are present on 56 Tasmanian islands (Terauds 2005), and indicated its intention to do something about them on these and all other Australian islands (e.g., for exotic rodents; Anon 2009), and prioritised these intentions for the top 100 islands of the thousands of islands in Australia (Ecosure 2009). The prioritisation listed 15 Tasmanian islands.

Some of these islands are easily accessed by boats or helicopters from the main island, but many are either remote (e.g., Macquarie Island) or off uninhabited coasts. A ship is required to access these islands and, perhaps, to support ship-based eradication operations.

CONCLUSIONS

Exciting advances in the past decade have led to increases in the number of invasive species targeted, the size of islands treated, the pace of developments and, the number of countries involved. Yet, constraints associated with a lack of continuity, capacity and funding remain significant impediments to further progress. Furthermore, eradications of pests on remote or inaccessible islands and in countries without extensive experience and capacity will require an 'industrial scale' response. We suggest that it is time to initiate a coordinated and progressive international programme to address these constraints and to maximise the return on investment from limited restoration budgets.

Our suggestion is to assess whether a more systematic and perhaps ship-based approach might achieve these goals. Like the *Calypso* and *MV Steve Irwin*, which are seen as symbols for marine conservation, a ship-based programme focused on island restoration could become both a practical tool and a symbol of cooperation and conservation – two imperatives for islands in this time of uncertain global change.

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