Review

Eradication of Invasive Mammals on Islands Inhabited by Humans and Domestic Animals

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Abstract: *Non-native invasive mammal species have caused major ecological change on many islands. To conserve native species diversity, invasive mammals have been eradicated from several islands not inhabited by humans. We reviewed the challenges associated with campaigns to eradicate invasive mammals from islands inhabited by humans and domestic animals. On these islands, detailed analyses of the social, cultural, and economic costs and benefits of eradication are required to increase the probability of local communities supporting the eradication campaign. The ecological benefits of eradication (e.g., improvement of endemic species' probability of survival) are difficult to trade-off against social and economic costs due to the lack of a common currency. Local communities may oppose an eradication campaign because of perceived health hazards, inconvenience, financial burdens, religious beliefs, or other cultural reasons. Besides these social challenges, the presence of humans and domestic animals also complicates eradication and biosecurity procedures (measures taken to reduce the probability of unwanted organisms colonizing an island to near zero). For example, houses, garbage-disposal areas, and livestock-feeding areas can provide refuges for certain mammals and therefore can decrease the probability of a successful eradication. Transport of humans and goods to an island increases the probability of inadvertent reintroduction of invasive mammals, and the establishment of permanent quarantine measures is required to minimize the probability of unwanted recolonization after eradication. We recommend a close collaboration between island communities, managers, and social scientists from the inception of an eradication campaign to increase the probability of achieving and maintaining an island permanently free of invasive mammals.*

Keywords: biosecurity, community involvement, eradication, invasive species, mammal

Erradicación de Mamíferos Invasores en Islas Habitadas por Humanos y Animales Domésticos

Resumen: *Especies de mamíferos no nativos invasores han causado cambios ecológicos mayores en muchas islas. Para conservar la diversidad de especies nativas, las especies invasoras han sido erradicadas de varias islas no habitadas por humanos. Revisamos los cambios asociados con campañas para erradicar mamíferos invasores de islas habitadas por humanos y animales domésticos. En estas islas, se requieren análisis detallados de los costos y beneficios sociales, culturales y económicos de la erradicación para incrementar la probabilidad de que las comunidades locales apoyen la campaña de erradicación. Los beneficios ecológicos de la erradicación (e.g., mejoramiento de la probabilidad de supervivencia de especies endémicas) son difíciles de intercambiar por los costos sociales y económicos debido a la carencia de una moneda común. Las comunidades locales se pueden oponer a una campaña de erradicación por riesgos de salud percibidos, inconveniencia, cargas financieras, creencias religiosas u otras razones culturales. Además de estos retos sociales, la presencia de humanos y animales domésticos también complica la erradicación y los procedimientos de bioseguridad (medidas para reducir a casi cero la probabilidad de que organismos no deseados colonicen una isla). Por ejemplo, casas, áreas de disposición de basura y áreas de alimentación para ganado pueden*

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proporcionar refugio a ciertos mamíferos y por lo tanto pueden reducir la posibilidad de una erradicación exitosa. El transporte de humanos y bienes a una isla incrementa la probabilidad de la reintroducción inadvertida de mamíferos invasores, y se requiere el establecimiento de medidas cuarentenarias permanentes para minimizar la probabilidad de recolonización no deseada después de la erradicación. Recomendamos una mayor colaboración entre las comunidades insulares, manejadores y científicos sociales desde el inicio de una campaña de erradicación para incrementar la probabilidad de mantener una isla libre de mamíferos invasores permanentemente.

Palabras Clave: bioseguridad, erradicación, especies invasoras, mamífero, participación comunitaria

Introduction

Non-native invasive species are the second greatest driver, behind habitat loss, of the human-caused extinction of species worldwide (Grosholz 2005; Sax & Gaines 2008). On islands, the introduction and spread of non-native species, particularly of mammals, has become a major threat to native island species that evolved in the absence of mammals (Blackburn et al. 2004; Towns et al. 2006; Jones et al. 2008). For example, through the assistance of humans three species of rats (ship rat [*Rattus rattus*], Norway rat [*R. norvegicus*], and Pacific rat [*R. exulans*]) have colonized 90% of the world's island archipelagos on which they were not native species. These rats are associated with the extinctions of at least 50 species on more than 40 different islands (Blackburn et al. 2004; Towns et al. 2006; Jones et al. 2008).

Over the past 40 years, eradications of mammals have reduced the negative effects of non-native mammals on native species (Towns & Broome 2003; Campbell & Donlan 2005; Howald et al. 2007). The improvement of eradication techniques has facilitated the removal of mammals from increasingly larger islands. For example, some islands >100 km^2 have been successfully cleared of cats (*Felis silvestris catus*), goats (*Capra hircus*), and rats (Nogales et al. 2004; Campbell & Donlan 2005; Howald et al. 2007). The eradication of house mice (*Mus musculus*) and mustelids (*Mustela* spp.) from large islands, however, remains challenging (MacKay et al. 2007; King et al. 2009).

Most eradication campaigns have been conducted on islands that are not permanently inhabited by humans because such operations are less complicated on uninhabitated than on inhabited islands. Nevertheless, more than half of islands (55%, $n = 38$) where eradication of non-native mammals has a high conservation benefit-to-cost ratio are inhabited permanently by humans (Brooke et al. 2007). The eradication of invasive mammals from permanently inhabited islands is now being considered for islands inhabited by an increasingly greater number of humans (Supporting Information). We addressed the operational challenges associated with eradications on islands with permanent human populations. We did not conduct a formal search of peer-reviewed literature because we sought to document the current state of knowledge of eradication projects on inhabited islands, most of which are still in their early stages and documented mostly in the gray literature. Thus, we informally contacted internationally known researchers and managers who are directly involved in eradication projects on inhabited islands in Europe, North and South America, Australia, and New Zealand.

Conditions for Successful Eradication Campaigns

There are several basic factors to take into account to maximize the probability of a successful eradication of non-native invasive mammals (Bomford & O'Brien 1995; Cromarty et al. 2002; Zavaleta 2002). The biology and distribution of both the target and sympatric nontarget species determines whether eradication is feasible with existing technology and has a high probability to achieve a conservation benefit without detrimentally affecting other native species (Howald et al. 2010). For mammal eradications on inhabited islands, the additional social dimension requires the consideration of how an eradication campaign will affect human inhabitants, their domestic animals, and human activities. Both the ecological and social factors need to be considered for each target species and island.

The basic biological and technical prerequisites (i.e., by what means a target species can be killed and whether it is possible to kill all individuals) for successful eradication are discussed elsewhere (Bomford & O'Brien 1995; Cromarty et al. 2002; Zavaleta 2002). We discuss the operational challenges of eradicating non-native invasive mammals on islands with permanent human settlements. The probability of successful eradication is higher if the project is socially acceptable to the community involved; social and ecological benefits outweigh the social and ecological costs; the probability of recolonization can be reduced to near zero; and all individuals of an invasive species can be removed by the eradication technique. These conditions are equally important, often interdependent, and require simultaneous evaluation.

Social Acceptability

The probability of successful eradication of invasive mammals can be reduced substantially if one or a few human individuals oppose the eradication effort (Myers et al. 2000; Simberloff 2002). Thus, full support, or at least compliance, of the local community is needed. There are numerous examples of eradication campaigns targeting species detrimental to human health and food crops that were successfully carried out in populated areas, some of which drew substantial opposition from interest groups concerned with animal welfare or human health because toxins were used (Myers et al. 2000; Simberloff 2002). It can be difficult to obtain community support for an eradication of invasive mammal species that have no, or marginal, effect on human health and economic well being.

In preparation for an eradication campaign, a detailed analysis of economic, cultural, or subsistence values and emotions or religious beliefs associated with the presence and removal of the target species is needed to understand key concerns of all sectors of the community that could be affected (Bath 1999; Genovesi 2007). If the results of these analyses suggest there is opposition to the program, then a public outreach campaign on the social, economic, and ecological trade-offs associated with the campaign is warranted (Blackburn et al. 2010; Towns et al. 2010). Proponents of the campaign may lack important knowledge of the social values associated with a target or potentially affected nontarget species. A learning process that engages all segments of a community as early as possible before an eradication is planned may have the greatest probability of identifying eradication goals that reflect community aspirations. Successful mutual learning encourages the community to take ownership of the eradication campaign and thus have greater motivation to actively participate in the project than if the project is operated by individuals from outside the community without consideration of the community's perspectives (Saunders et al. 2007).

If invasive species are considered a problem by the community, then support for eradication is easier to obtain (Myers et al. 2000; Simberloff 2002). For example, on Lord Howe Island (1455 ha), Australia, rats cause major damage to crops (Lord Howe Island Board 2009), and many inhabitants would prefer a rat-free island. Community members, however, are still concerned about the possible side effects of the eradication operation. On the same island, the eradication of feral goats failed partly because some members of the local community opposed it and caused delays by filing lawsuits alleging cruelty to animals (Parkes et al. 2002). A study of this eradication campaign showed that strict adherence to animal welfare protocols, open information about procedures, and government approval of protocols was necessary to avoid potential legal issues in mammal eradication campaigns (Parkes et al. 2002). In addition, having local stakeholders participate in on-the-ground work of the eradication increases support, as has been shown on islands in Chile, Galapagos, Mexico, New Zealand, and Fiji (Aguirre-Muñoz et al. 2009; Cruz et al. 2009; Towns et al. 2010).

Lack of involvement and open communication with the public may have played a role in the failure of some eradication campaigns (Campbell & Donlan 2005). For example, the eradication of American grey squirrels (*Sciurus carolinensis*) in Italy and pigs (*Sus scrofa*) on Santa Catalina Island (194 km^2) in the United States were heavily opposed by animal-welfare groups (Genovesi & Bertolino 2001; Schuyler et al. 2002). The cat eradication project on Ascension Island (97 km^2) in the United Kingdom Overseas Territories faced major opposition after 38% of pet cats were accidentally killed by poison bait (Bell & Boyle 2004; Ratcliffe et al. 2010). Avoidance of the accidental death of pets and thus better relations with the community may have justified the higher financial cost of a longer campaign (Ratcliffe et al. 2010).

Based on experiences elsewhere, managers of proposed eradication campaigns of invasive mammals in the Pacific have begun to actively engage the public years in advance of publishing plans describing the eradication operation (Saunders et al. 2007; Beaven 2008; Lord Howe Island Board 2009; Ogden & Gilbert 2009). In 2009 on Great Barrier Island (28,500 ha), New Zealand, many of the 852 inhabitants supported the idea of a rat eradication campaign, but were opposed to the aerial spread of poison and were skeptical that the campaign would succeed (Ogden & Gilbert 2009). Because of general concerns over poison and other biosecurity measures (measures taken to ensure the probability of unwanted organisms colonizing an island is near zero), community support was low and easily undermined by inaccurate public commentaries by individual opponents. Similarly, the ambitious proposal to eradicate cats, common brushtail possums (*Trichosurus vulpecula*), and rats from Stewart Island, at 169,464 ha the third largest island of New Zealand, has been met with skepticism by some of the 402 local inhabitants (Beaven 2008). Concerns focus on possible lifestyle changes and loss of control of the community to govern itself. The possibility of an aerial broadcast application of poison bait is of particular concern to local hunters, who supplement their diet with deer (*Cervus elaphus* and *Odocoileus virginianus*) present in the forested areas of the island. The eradication of invasive mammals that are highly valued by a segment of the local community is considered politically infeasible regardless of their potential ecological effects (Bomford & O'Brien 1995; Genovesi 2007; Beaven 2008; Blackburn et al. 2010).

Even the eradication of animals over which there is little public concern can result in complicated legal issues at the national or international level. The agency planning and carrying out the eradication must have the authority required by different legal frameworks when, for example, a target species has different levels of legal protection at regional, national, and international levels (Genovesi & Bertolino 2001; Genovesi 2007). In areas where there is a strong distrust of government, the possibility that a government institution may be in charge of an eradication campaign may automatically generate opposition. Building trust with the local community over the years prior to an eradication attempt may improve the public perception of an agency and thus increase the probability of success of an eradication project.

Costs and Benefits of Eradication

As with any substantial project that has social and economic effects, an eradication campaign is unlikely to succeed unless the benefits exceed the costs. Standard procedures are available for evaluation of ecological benefits and costs of eradication projects (Cromarty et al. 2002; Zavaleta 2002), but social costs and benefits are challenging to integrate into these analyses because the ecological benefits of eradication cannot be measured with the same currency as social costs and benefits and are therefore difficult to compare (Martins et al. 2006; Donlan & Wilcox 2007; Genovesi 2007).

Costs to the community inhabiting the island on which an eradication is planned can be manifold, including financial costs of the operation, subsequent biosecurity, and monitoring; loss of income from temporarily suspended commercial activities; time (e.g., volunteer participation); inconvenience (e.g., changing existing habits of garbage disposal, pet, and livestock treatment); social tensions arising from polarizing debates (e.g., about the use of toxins); and adjustments to new regulations. If livestock and other domestic animals are present on the island, additional costs will accrue. In many cases the social and economic costs and benefits of an eradication project are uncertain, and ecological researchers and managers are not necessarily qualified to objectively assess the social, economic, and cultural effects of the project (Chan et al. 2007). Involving anthropologists, social scientists, or other community engagement experts early in the planning process may help identify gaps in knowledge, and investing in social and economic research may raise awareness and demonstrate the potential costs and benefits of the eradication to the community. Such investigations may reveal the costs incurred by the continued presence of invasive mammals and the increased economic benefit that could be expected by their successful removal. Economic benefits may be slow to materialize and may accrue only to certain sectors of the community, which may cause negative attitudes when all members of a community share the costs, but only a few benefit (Chan et al. 2007). Discussing such issues with the community as part of the planning process may considerably increase local support.

Many eradication operations use poison bait to kill the target animals, and domestic animals could consume bait and die, resulting in financial or emotional costs and potential health risks to humans. To avoid accidental loss of domestic animals, they could be temporarily or permanently removed from the island, held in an enclosure, and provided with food during the time of the operation or remain in baited fields if potential losses and associated health risks from unintentional poisoning are acceptable (Brown 2007*a, b*). Usually, loss of domestic animals during an eradication campaign lowers public morale (e.g., Ascension Island cat eradication; Ratcliffe et al. 2010). In areas where both domestic and feral individuals of the same species occur, live trapping could facilitate selective removal of feral individuals, but such an approach has a higher probability of failure, is more labor intensive, and increases the financial cost of an operation (Ratcliffe et al. 2010).

Making the community aware of the costs and potential outcomes of specific eradication techniques is critical to avoid creating overly optimistic expectations. People may need to change their behavior (e.g., garbage handling and feeding of domestic animals) to ensure successful eradication and to prevent recolonization. The financial cost of eradication includes both the cost for the operation and the potential loss of income from agriculture or tourism, which may have to be suspended during the operation (Merton et al. 2002). Frequently, the costs associated with physical eradication are covered by outside funding sources, which may reduce the availability of financial resources for alternative projects on an island. For example, on Pitcairn Island (460 ha), United Kingdom Overseas Territories, local inhabitants opposed a rat eradication project because of concerns over the availability of funding for an airstrip, and the eradication campaign failed (E. Bell, personal communication).

If there is ongoing control of invasive species, the cost of an eradication can be considered a long-term investment because the cost of permanent, ongoing control is often more expensive with comparatively smaller increases in breeding success of birds or similar biological benefits than a successful one-time eradication (Myers et al. 2000; Simberloff 2002; Pascal et al. 2008).

Maintaining an island free of invasive mammals requires ongoing monitoring and quarantine regulations, which could increase the cost of transport of goods to an island and thus increase the general cost of living after eradication. Effective quarantine measures may also increase the inconvenience for visitors, potentially diverting capital to islands with less stringent regulations.

There can be social and economic benefits of a successful eradication. Some invasive mammals reduce human food stocks and function as disease vectors (Chanteau et al. 1998); thus, their eradication benefits the community's economy and physical health (Saunders et al. 2007). Economic and health benefits of eradicating these species may justify removal of other species toward which the community has an indifferent or even positive attitude. For example, on many islands cats or mustelids were introduced as predators to decrease the numbers of rodents or rabbits. Removal of only one of these species may increase the detrimental effect of another on native plants and animals (Caut et al. 2007; Bergstrom et al. 2009; Dowding et al. 2009). Hence, the simultaneous removal of trophically linked invasive mammal species in a single operation may increase the probability of achieving ecological and economic goals.

On islands where there is no evidence of invasive species causing economic damage to the community, eradication could nonetheless improve an island's attractiveness to ecotourists (Johns et al. 2006; Brown 2007*a*; Beaven 2008; Ogden & Gilbert 2009). Successful eradication of rodents and subsequent reintroduction of native plants and animals have turned several smaller islands in New Zealand and the Seychelles into major attractions for visitors and facilitated the establishment of local tourism businesses (Samways et al. 2010). If invasive species are the primary reason for the absence of charismatic animals, then successful eradication could lead to marketable increases in their abundance.

Reducing Probability of Invasion to Near Zero

An eradication campaign will only yield long-term benefits if the target species does not recolonize the island. Non-native invasive mammal species have a high probability of overcoming genetic bottlenecks associated with founder effects and can establish a population from a small number of colonizing individuals (Clout & Russell 2008; Russell et al. 2009*a*). Hence, recolonization by very few individuals could reverse the success of an eradication campaign, and the establishment of physical measures such as permanent traps and bait stations around all possible points of entry is required to minimize the probability of recolonization. The probability that such biosecurity measures will be effective is higher when measures are implemented and tested by the local community prior to the eradication operation.

On inhabited islands with commercial ship and aircraft traffic, the probability of recolonization is substantially higher than on remote, uninhabited islands because every ship or aircraft arrival is a potential vector for invasive species (Russell et al. 2008). Small nocturnal mammals, such as mice and rats, have substantial opportunities to arrive on an island on ships or hidden in commercial cargo. Because more people require more supplies, the probability of recolonization is positively related to the number of humans inhabiting an island (Ratcliffe et al. 2009), especially on islands dependent on food imports. Additional factors that can increase the probability of recolonization include the presence of military installations, large wharves offering access for large ships, natural resource extraction on or near the island, and proximity of the island to major trade routes or continents (Atkinson 1985).

Preventing colonization by rodents is not impossible. The Pribilof Islands, Alaska (U.S.A., 684 inhabitants), in the Bering Sea have implemented a strict rat prevention program, which includes public ordinances barring infested ships from entering the harbor and requiring onshore fish processing plants to establish rat prevention measures (Ebbert & Byrd 2002; Fritts 2007). Similarly, the sub-Antarctic islands of Australia, South Africa, and New Zealand strictly regulate the access of visitors with quarantine efforts designed to minimize the probability of mammal introductions.

A robust plan to respond to rodent incursions facilitated by shipwrecks is an integral part of any quarantine operation on rodent-free islands (Brown 2007*a*; Russell et al. 2008). For island archipelagos, or islands that are close enough to mainland source populations to be invaded without human assistance, it is essential to also consider whether the probability of rodent colonization from nearby land masses can be reduced to near zero by controlling or eliminating rodents on adjacent islands or mainland areas (Ratcliffe et al. 2009; Russell et al. 2009*b*).

Because ecotourism can be a major benefit of a successful eradication campaign, the subsequent increase in boat traffic to an island may in turn increase the probability of colonization (Veitch 2002). Ulva Island (259 ha), New Zealand, a wildlife sanctuary open to the public, has received three times as many visitors per year since the successful eradication of rats in 1997, and approximately one rat arrives on the island every year (Beaven 2001). A trap and bait station system that is checked once a month and rodent-control measures at points from which boats visiting the island depart help lower the probability of rats recolonizing Ulva Island (Beaven 2001; Russell et al. 2008).

When it is unclear whether individuals survived an eradication or were reintroduced in the months after eradication, the cause of a failed eradication campaign is ambiguous (Veitch 2002; Pacific Invasives Initiative 2009). Hence, strict quarantine measures are essential to the evaluation of the outcome of an eradication. If tissue samples of rats from both old and new populations on an island are available, genetic tests, such as microsatellite genotyping and assignment tests, can be used to distinguish between individuals that survived the eradication and new arrivals (Abdelkrim et al. 2007; Russell et al. 2008).

The transport of building materials, food items, and animal products associated with livestock or other domestic animals can increase the probability of rodents arriving on an island (Brown 2007*a*). Furthermore, some domestic animals may escape and become feral. Strict enforcement of strong regulations is needed to minimize the probability of reestablishment of a feral population of non-native domestic animals (Brown 2007*a*; Beaven 2008). Regulations on where domestic animals can be kept, enforcement of fencing regulations around properties with domestic animals, maintenance of a register of all domestic animals, and sterilization of all pets are examples of successful tactics of the cat eradication project on Ascension Island (Bell & Boyle 2004; Bell 2005; Ratcliffe et al. 2010) and the dog and goat eradications on Lord Howe Island. Regulations are best considered in advance of the eradication campaign, and community consultation and involvement is required to establish regulations that will be adhered to in perpetuity by people on the island.

Due to trophic and competitive interactions among mammal species, the effects of some non-native species may become apparent only after competitors or predators have been removed (Caut et al. 2007; Bergstrom et al. 2009; Dowding et al. 2009). On Stewart Island, which currently has no house mice, the eradication of rats could potentially make the island more susceptible to colonization by mice due to the absence of competition with rats (Beaven 2008). Thus, effective biosecurity and quarantine measures must be strict enough to greatly reduce the probability of colonization by animals other than the target species.

Increasing the Probability of Eliminating all Individuals

The techniques used to eradicate invasive species depend on the target species and the size and geographical structure of an island. Eradication strategies include hunting, trapping, introduction of disease, and distribution of poison bait by personnel on the ground or in aircraft (Nogales et al. 2004; Campbell & Donlan 2005; Howald et al. 2007). On islands inhabited by humans, primarily ground operations have been used to eradicate invasive mammals (Parkes et al. 2002; Nogales et al. 2004; Saunders et al. 2007). For uninhabited islands >1000 ha, aerial broadcast application of poison bait is the most effective technique for rodent eradication (Towns & Broome 2003; Howald et al. 2007). Aerial broadcast of poison bait on islands inhabited by humans may involve substantial risks to the health of humans, pets, and livestock. Depending on the spatial distribution of humans and livestock on an island, it may be possible to use aerial techniques in some areas and, for example, bait stations and manual distribution of bait in areas with humans and livestock (Brown 2007*a*; Beaven 2008; Ogden & Gilbert 2009). When two different strategies are used, it is important to ensure that bait is present simultaneously in all areas so that target individuals cannot move into an area without bait. Because the construction of physical barriers that prevents the movement of animals is expensive, prone to public opposition (Beaven 2008), and frequently ineffective (Schuyler et al. 2002), it is critical that all treatment areas have bait available for the duration of both ground and aerial operations.

Regardless of how aerial and ground-based treatment areas are integrated, successful rodent eradication in areas of human habitation requires placement of baits and traps in every domestic, industrial, educational, military, administrative, and commercial building and in all other areas associated with human inhabitants (e.g., gardens, recreational areas, and arable land). Ensuring complete coverage and rigorous implementation of methods is a major challenge because it interferes with the privacy of human inhabitants and safety regulations at, for example, military or other high-security installations. Because the survival of a few individuals in a single structure could jeopardize the success of an island-wide eradication campaign, virtually universal community support and compliance is required if eradication campaigns are to be successful on inhabited islands (Gardener et al. 2010).

To maximize the attractiveness of bait to rodents, eradication campaigns are generally timed to coincide with the lowest food availability (Cromarty et al. 2002). Many islands inhabited by humans have agricultural lands, and it is often impossible to prevent rodent access to the feeding pens of domestic animals. These alternative food sources for invasive mammals are present year round, and may reduce attractiveness of bait and thus increase the probability of failure of the eradication. In addition, if livestock remain in pastures during the eradication, the consumption of bait by livestock may reduce the availability of bait to target species. On Lord Howe Island, all livestock will be removed during the eradication and all owners will receive financial compensation and replacement livestock after the eradication has been completed (Lord Howe Island Board 2009).

Once the eradication campaign has been completed, surveys that are designed to detect signs of surviving individuals facilitate rapid implementation of measures to prevent recovery of populations of some animals (Ramsey et al. 2009; Rout et al. 2009; Russell et al. 2009*b*). For rodents, such surveys are ineffective because the likelihood of detecting single individuals is too small, and success is generally declared if no rodents are detected 2 years after the eradication. For larger target species, detection surveys and potential follow-up operations have to be conducted until the absence of individuals can be ascertained with an a priori determined level of confidence. Predicting the exact duration of posteradication measures is difficult during the planning stage, and economic pressures (e.g., reopening of tourism, resumption of agricultural activity) could enforce a timeline that is beyond the control of the agency conducting the eradication operation. It is important therefore to emphasize to the community that an eradication campaign, unlike a control operation, has only two distinct outcomes: success (all target individuals removed) or failure (not all target individuals removed). Failure could result in increased opposition, and thus preclude further eradication attempts (Towns et al. 2010). Making the local community aware of the unpredictability of success of an eradication and establishment of contingency plans contributes to a successful eradication.

Recommendations for Mammal Eradication on Inhabited Islands

We encourage conservation managers to consider eradication of invasive mammals on inhabited islands. An iterative approach to involving local communities and conducting eradication campaigns on inhabited islands that starts with small islands and communities and builds on those experiences before planning eradications on larger islands with larger communities may be the most efficient way to build global expertise in mammal eradications on inhabited islands. Experiences from eradication campaigns can be reported in international, peer-reviewed journals and in online databases (e.g., Island Conservation Global Islands Invasive Vertebrate Eradication Database [http://db.islandconservation.org/]). Reports detailing failed eradication attempts (Seymour et al. 2005; MacKay et al. 2007; Pacific Invasives Initiative 2009) will be especially instructive for future operations, even if the cause of failure is poorly understood or embarrassing.

Successful ecosystem restoration on inhabited islands is essentially a social activity and the concern for the urgency of an eradication cannot preclude the importance of community control over associated decisions and project activities (Campbell & Vainio-Mattila 2003). Public meetings and discussions and regular public review and consultation increase local inhabitants' understanding of proposed eradication efforts and teaches implementers of eradication efforts about social customs of the island community. A fair and transparent decision-making process may be more important to a community than technical details or specific outcomes, and it may be useful for the performance of decision makers to be reviewed periodically by those affected by their decisions. Engaging the community and facilitating participation at all stages of project implementation—from information gathering, to consultation, to decision making, to eradication work, and to final evaluation—avoids top-down implementation of a project and is most likely to yield public ownership of an eradication project. If members of the community take pride in their project, otherwise complicated tasks, such as maintaining high biosecurity standards, are more likely to be carried out and enforced by the community over the long term. Likewise, community ownership of an eradication project may foster development of activities that promote or further improve the ecological status of an island, for example through tourism businesses. Ultimately, eradication projects yield long-term benefits for native island species only if the benefits for human inhabitants are strongly linked to biological gains and are economically and socially sustainable.

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Supporting Information

A list of islands permanently inhabited by over 10 people on which invasive mammal eradication has been planned or carried out is available as part of the online article (Appendix S1). The author is responsible for the content and functionality of these materials. Queries (other than absence of the material) should be directed to the corresponding author.

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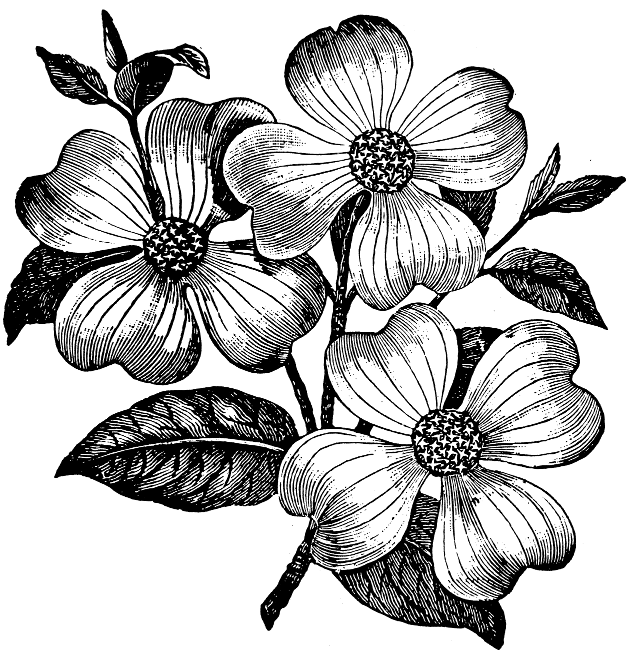

Appendix 1: List of islands permanently inhabited by >10 people on which invasive mammal eradication has been planned or carried out. Human population numbers marked with an asterisk refer to predominantly or exclusively industrial, military, or tourism personnel and dependent families. Traffic volume refers to aircraft and vessels routinely traveling between the island and areas of mainland or adjacent islands where invasive mammals are present (low: <2 times per week, medium: 2-6 times per week, high: daily or more). Islands without a cited reference were extracted from the Island Conservation Global Islands Invasive Vertebrate Eradication Database http://db.islandconservation.org/, accessed 5 May 2010. Number of endemic species refers to higher plants and vertebrates and was gleaned from http://islands.unep.ch/Tiendtot.htm, accessed 6 May 2010. The authors would be grateful to be made aware of any omissions or errors in this compilation.

Island	Country	Size (ha)	resident human population	target species	endemic species	dominant land cover	distance to nearest landmass (km)	traffic volume	stage of progress	success
Adak[1]	USA	71118	316	arctic fox	0	tundra	1	low	completed	yes
Alejandro Selkirk[27]	CHI	4460	40	rat	63	forest	181	low	planned	
Amami Oshima[2]	JP	71235	66000	Indian mongoose		forest	21	high	completed	no
Anegada[3]	UK	4138	200	dog	5	open coral, scrub	24	medium	completed	yes
Angel	USA	3107	57	cow, dog, horse, cat	0	plantation forest	1	high	completed	yes

Ascension[4]	UK	9700	940	cat	11	open scrubland/rock	1300	medium	completed	yes
Baltra[5]	EC	2620	40*	cat, goat		open rock, scrub	0.5	high	completed	yes
Barrow[6]	AUS	23000	150*	rat	24	desert, scrub	54	high	completed	yes
Benbecula[7]	UK	8200	1219	American mink	0	tundra	22	high	completed	yes
Bird[8]	ROS	101	40*	rat, rabbit	0	open parkland	50	medium	completed	yes
Bruny	AUS	36200	600	goat	0	pasture, woodland	2	medium	completed	yes
Canna/Sanday[9]	UK	1314	12	rat	0	open grassland/pasture	3	medium	completed	yes
Cedros[10]	MX	348300	1350	cow	13	desert, dry forest	15	high	completed	yes
Corvo[28]	POR	1745	468	rat, cat, goat	0	farmland	30	high	planned	
Cyprus[11]	CYP	925100	870000	pig	134	shrub, agriculture	68	high	completed	yes
Diego Garcia	UK	3000	2000*	pig	2	palm plantation	160	low	completed	yes
Diego Garcia[12]	UK	3000	2000*	cat	2	palm plantation	160	low	in progress	
East Falkland	UK	660500	2197	goat	1	grassland	5	medium		unknown

Flinders	AUS	133000	897	goat	0	forest, pasture	53	high	completed	yes
Floreana[30]	EC	17253	90	cat, rat		shrub	50	high	planned	
Floreana[30]	EC	17300	90	cow, donkey, goat		shrub	50	high	in progress	
Giannutri[33]	IT	300	102	rat	0	shrub	12	high	completed	yes
Great Barrier	NZ	28500	852	goat		forest	21	high	completed	no
Great Barrier[13]	NZ	28500	852	rat, mouse, cat		forest	20	high	planned	
Guadalupe[14]	MX	24171	100	rabbit, goat, horse, donkey, dog	36	arid shrubland and herbs	241	low	completed	yes
Guadalupe[14]	MX	24171	100	cat, rat	36	arid shrubland and herbs	241	low	planned	
Hiiumaa	EST	98900	11087	American mink	0	forest, pasture	6	high	completed	yes
Ile aux Moines[15]	FRA	320	542	goat, rat	0	agriculture	0.5	high	completed	yes
Île de Riou[15]	FRA	100	20	rat		open scrubland/rock	3.5	medium	completed	yes
Isabel[14]	MX	80	100	cat, rat	0	arid shrubland and herbs	30	medium	completed	not yet determined

Isabela[16]	EC	464000	2200	goat, donkey		shrub	4	high	in progress	
Kangaroo[17]	AUS	440500	4259	goat	47	agriculture	13	high	in progress	
King	AUS	109800	1723	goat	0	agriculture, forest	85	high	completed	yes
Koolan	AUS	2580	220*	goat	0	shrub	0.5	high	completed	yes
Korppoo[15]	FIN	16885	846	American mink	0	heath/grassland	1	high	completed	yes
Lana'ii	USA	36400	3193	pig, goat	0	agriculture, shrub	15	high	completed	yes
Lewis/Harris[7]	UK	222480	20 473	American mink		tundra	5	high	in progress	
Little Cayman[32]	UK	2590	150	cat		open coral, scrub	140	high	in progress	
Lord Howe[18]	AUS	1455	350	goat	77	forest/shrubland	600	medium	completed	no
Lord Howe[19]	AUS	1455	350	rat, mouse	77	forest/shrubland	600	medium	planned	
Lord Howe[20]	AUS	1455	350	pig, cat	77	forest/shrubland	600	medium	completed	yes
Lundy[21]	UK	345	28	rat	1	heath/grassland	19	medium	completed	yes
Mauritius	MAU	204000	1288000	pig	314	agriculture, urban	168	high	completed	no

Natividad[14]	MX	736	384	cat, dog, goat, sheep	3	open rock, grassland	15	medium	completed	yes
Nauvo[15]	FIN	24688	1428	American mink	0	heath/grassland	0.5	high	completed	yes
Ni'ihau	USA	18000	130	goat	0	shrub	29	low	completed	yes
Norfolk	AUS	34600	2141	goat, pig, rabbits	58	agriculture, forest	735	low	completed	yes
North Uist[7]	UK	30305	1271	American mink	0	tundra	0.5	medium	completed	yes
Pitcairn[29]	UK	460	35	rat	3	forest/shrubland	611	low	completed	no
Port-Cros[22]	FR	640	40	cat	0	forest/shrubland	1	high	completed	yes
Praslin[23]	ROS	3800	6500	mongoose		forest/shrubland	5	medium	completed	yes
Rakino[31]	NZ	151	15	rat	0	farmland	5	medium	completed	yes
Robinson Crusoe[27]	CHI	9300	674	rat, cat	72	farmland, forest	700	medium	planned	
Robinson Crusoe	CHI	9300	674	goat	72	farmland, forest	700	medium	completed	no
Saltspring	CA	182700	10500	goat	0	forest, agriculture	1	high	completed	yes
San Cristobal	EC	55800	5600	goat, donkey		shrub	45	high	completed	yes

Santa Catalina[10]	USA	19400	5000	pig, sheep, cow		shrub	32	high	completed	yes
South Uist[7]	UK	32026	1818	American mink	0	tundra	0.5	medium	completed	yes
St. Helena	UK	12200	4255	goat	51	shrub, desert	1250	low	completed	yes (but re-invaded)
Stewart[24]	NZ	169464	402	rat, cat, possum		forest	25	high	planned	
Trinidade	BR	10400	32*	goat		open rock, grassland	0.5	low	completed	yes
Tristan da Cunha	UK	9837	285	goat, cat, pig	57	natural grassland	2430		completed	yes
Tristan da Cunha[25]	UK	9837	285	rat, mouse	57	natural grassland	2430	low	planned	
Utö[15]	FIN	100	50	American mink	0	heath/grassland	11	medium	in progress	
Viwa[26]	FIJ	60	100	cat, dog, rat		farmland, plantation	1	medium	completed	yes (cats, dogs), no (rats)
Wake[29]	USA	737	200	rat		coral attoll	2430	medium	planned	

Country abbreviations: AUS – Australia, BR – Brazil, CA – Canada, CHI – Chile, CYP– Cyprus, EC – Ecuador, EST – Estonia, FIJ – Fiji, FIN – Fiinland, FR – France, IT – Italy, JP – Japan, MAU – Mauritius, MX – Mexico, NZ – New Zealand, POR – Portugal, ROS – Republic of Seychelles, UK – United Kingdom (includes Overseas Territories), USA – United States of America

List of scientific species names: possum –Trichosurus vulpecula, rat – Rattus rattus, Rattus norvegicus, and Rattus exulans, mouse – Mus musculus; cat – Felis silvestris catus, cow - *Bos taurus, dog – Canis familiaris, goat – Capra hircus, horse – Equus caballus, sheep – Ovis aries, pig – Sus scrofa, Indian mongoose – Herpestes javanicus, fox – Alopex lagopus, Vulpes vulpes and Dusicyon griseus, donkey – Equus asinus, Asian mongoose – Herpestes auropunctatus,European polecat* - *Mustela putorius, American mink* - *Neovison vison; rabbit* - *Oryctolagus cuniculus*

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31. D. Galloway, personal communication
32. S. Roy, personal communication
33. N. Baccetti, personal communication