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Eradications of invasive mammals from islands: why, where, how and what next?

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The United Nations, under the auspices of the Convention on Biological Diversity (CBD) has proclaimed 2010 as the International Year of Biodiversity. This has led to numerous initiatives to highlight the importance of biodiversity, increase awareness of the unprecedented level of threats to the world's fauna and flora, and encourage action to help safeguard its future. Included among the major commitments made by signatories to the CBD is to rehabilitate and restore degraded ecosystems, and prevent the introduction of, and control and eradicate, alien species that could threaten ecosystems, habitats or species (http://www.cbd.int/, accessed 19 November 2010). The level of resource allocated by governments to these issues varies enormously, but, by any standard, New Zealand and Australia stand out among the developed nations in terms of the breadth and scope of their efforts to eradicate alien species, particularly on islands (Hilton and Cuthbert 2010). Earlier this year, Australia attempted one of the most ambitious alien species eradication campaigns to date, to remove European Rabbits (*Oryctolagus cuniculus*), Black Rats (*Rattus rattus*) and House Mice (*Mus musculus*) from the 12 870-ha Macquarie Island (54°30′S, 158°57′E). The team were unlucky, experiencing an unseasonally prolonged period of bad weather as a consequence of which the aerial baiting will now have to recommence in 2011. However, that the project was even attempted not only underlines both a highly laudable financial commitment, but a striking change in attitude in the last decade to the scale of eradications that are considered technically possible. The latter results largely from pioneering efforts in New Zealand since the 1970s, and the development of an expertise base that has since become a global export (Towns and Broome 2003; Rauzon 2007).

The records of most other countries are rather less impressive. For example, despite its much larger gross domestic product (GDP) and the availability of completed or well advanced feasibility and operational plans for much-needed eradications on Gough Island (40°21′S, 9°53′W), Tristan da Cunha (37°07′S, 12°17′W), South Georgia (54°20′S, 36°40′W) and Henderson Island (24°22′S, 128°20′W) in its Overseas Territories, the United Kingdom Government has thus far not made the necessary financial commitment to ensure even one of these projects goes ahead (Hilton and Cuthbert 2010). Clearly, given the current global economic downturn, it is possible to offer the excuse that large-scale eradications are luxuries that countries can ill afford. However, this may well be false economy; a draft agreement (see Acknowledgements) before negotiators at the CBD meeting in Nagoya in October 2010 suggested that to properly safeguard nature across the planet would cost between US$30 billion and $300 billion per year (10 to 100 times the current investment). Although these are impressive figures, they pale by comparison with the US$2–5 trillion that loss of nature is currently estimated to cost the global economy.

Although vastly greater commitment by governments worldwide to preventing loss of biodiversity, including the allocation of funds to headline eradication projects, would clearly provide a fitting conclusion to the International Year of Biodiversity, the purpose of this editorial is not to lambast those with power and influence over government coffers for a lack of progress. Instead, it is to highlight the many possibilities for action at much smaller scales by those not currently involved in eradications of or research on invasive species. The widespread presence of introduced mammals on islands inhabited by globally threatened birds means there are numerous potential candidates for eradication programmes. In addition, there is clearly value in removing introduced vertebrates from islands that were formerly occupied, or stand a good chance of being colonised, by species of conservation concern. This editorial therefore provides a brief background on the impacts of invasive mammals on populations of island birds and hence the conservation imperative for carrying out eradications, and highlights the risks and practicalities associated with the execution of such programmes. The latter is supplemented by a list of online resources (Table 1). The text has been formulated primarily with temperate and polar islands in mind, but many of the same principles apply to tropical islands and mainland sites.

These aims explain the 'why', 'where' and 'how' of the title, but the 'what next' refers to an appeal for much improved representation of the science of invasive species eradication in the peer-reviewed literature. This issue was highlighted by Donlan *et al*. (2003*a*), but, to date, little appears to have changed. A search of the ISI Web of Knowledge (Thomson Reuters, http://wok.mimas.ac.uk/) on 26 October 2010 for the word 'conservation' in titles, abstracts and keywords of papers published in the last 5 years produced hits for 25% of papers in *Emu*, compared with 27, 22 and 17% in *Ibis*, *Condor* and *Auk*, yet a search for 'eradication', 'eradicate' or '(impact or effect) and (alien or invasive)' produced not a single paper of relevance in *Emu* or *Condor*, and only five in *Ibis* and two in *Auk* (both representing <0.1% of papers published). Similar searches in *Biological Conservation* and *Conservation Biology* produced

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Table 1. List of online resources on invasive species and eradications
All websites last accessed 19 November 2010 except where indicated in the table

http://www.issg.org/index.html#ISSG	Homepage of the IUCN Invasive Species Specialist Group (ISSG). Includes: links to a database on introduced species; feasibility studies; the bi-annual newsletter (*Aliens*), and; the Proceedings of the International Conference on Eradication of Island Invasives, Auckland University, February 2001.
http://www.ntsseabirds.org.uk/File/Conference%20proceedings.pdf	The proceedings of the Invasive Alien Mammals conference, Edinburgh in 18–19 September 2007.
http://www.feral.org.au/	Website and database on vertebrate pest species in Australia and New Zealand.
http://www.environment.gov.au/biodiversity/threatened/publications/tap/exotic-rodents.html	Background document and threat abatement plan to reduce the impacts of exotic rodents on biodiversity on Australian offshore islands of <100 000 ha.
http://www.invasiveanimals.com/	Website of the Invasive Animals Cooperative Research Centre.
http://www.invasivespeciesinfo.gov/international/main.shtml	US Department of Agriculture National Invasive Species Information Center.
http://www.rspb.org.uk/ourwork/conservation/projects/tristandacunha/publications.asp	Various reports on the impacts of introduced rodents, and the potential for their eradication from the islands of Tristan da Cunha and Gough.
http://www.falklandsconservation.com/wildlife/conservation_issues/rat_eradication-guidelines.html#An15 (accessed 27 October 2010)	Guidelines for the eradication of rats from islands within the Falklands, including a list of contacts.
http://www.parks.tas.gov.au/index.aspx?base=13013	Full details of the Macquarie Island Pest Eradication Project.
http://www.acap.aq/en/index.php?option=com_docman&task=cat_view&gid=39&Itemid=33	Includes Inf 3. which is an annotated bibliography of published material outlining eradication programmes in New Zealand.
http://www.acap.aq/english/english/advisory-committee/ac5/ac5-meeting-documents	Includes link to Doc 19, which provides guidelines on biosecurity and quarantine procedures for remote islands.
http://www.doc.govt.nz/conservation/threats-and-impacts/animal-pests/	New Zealand Department of Conservation site with information on animal pests and their control.
http://www.doc.govt.nz/upload/documents/science-and-technical/sfc282.pdf http://www.doc.govt.nz/upload/documents/science-and-technical/sfc263.pdf http://www.doc.govt.nz/upload/documents/science-and-technical/sfc040.pdf http://www.doc.govt.nz/upload/documents/science-and-technical/DSIS59.pdf	NZ Department of Conservation reviews on factors influencing palatability and efficacy of toxic baits in rodents (2008), current knowledge of rodent behaviour in relation to control devices (2006), and baits and bait strategies targeting feral cats and multiple species (1996), and developing tools to detect and respond to new rodent invasions (2002).
http://www.gisp.org	Useful source of toolkits, training materials and publications from the Global Invasive Species Programme.
http://www.islandconservation.org/	US-based organisation with experience of eradications in the US and Caribbean.

hit rates of 84 and 91% of papers for 'conservation', which is unsurprising, but only 4% for the keywords relating to invasive species research and eradication. The last aim of this editorial is therefore not only to encourage submission to peer-reviewed journals of the wealth of data that must exist in the vast, and difficult to access, grey literature, but to provide scientists whose previous research focus has not been on impacts or management of invasive species, with a list of unresolved issues that present potential avenues for future research with immediate practical application.

Why target islands for invasive mammal eradication?

There is plenty of evidence worldwide that invasive alien species have had catastrophic effects on biodiversity, in particular on insular fauna and flora, which show high rates of endemism (Diamond 1989; Courchamp *et al*. 2003). Birds provide one of the best documented examples: currently, of the 1100 globally threatened bird species, 625 (51%) are considered to be negatively affected by invasive aliens (BirdLife International 2008). Most birds known to have become extinct since 1500 were island endemics (87% of 127; BirdLife International 2000), with mammalian invasions implicated in many cases (Courchamp *et al*. 2003; Blackburn *et al*. 2004; Towns *et al*. 2006). There are also many examples of substantial reductions in population size, or extirpation of birds from formerly isolated islands following predator invasion (Priddel *et al*. 2003; Cuthbert 2004; Schulz *et al*. 2005). Although the main threat on islands is often from predatory rats *Rattus* spp. and cats *Felis catus*, invasive ants are also very destructive, introduced herbivores and plants cause deleterious habitat modifications, and introduced microorganisms and insects cause or act as vectors for disease (Courchamp *et al*. 2003; Frenot *et al*. 2005). The problem is particularly severe on more isolated islands which, compared with continental land masses, hold disproportionately high numbers of susceptible species that evolved in the absence of native ground predators; indeed, 75% of the 430 threatened birds on oceanic islands are at risk from introduced species (BirdLife International 2008). Given that many of the regions of high biodiversity worldwide are made up partly or wholly of islands (Myers *et al*. 2000), the frequent occurrence of invasives is an issue of global conservation concern.

Many of the species currently at risk on islands are seabirds. Seabirds are key components of marine ecosystems, and consume an estimated 70 million tonnes of prey annually, which is equivalent to 7% of global oceanic primary productivity and represents approximately the same level of harvesting as in human fisheries (Brooke 2004). Seabirds are also major conduits of nutrients to relatively unproductive terrestrial systems, including on islands, allowing them to support dense communities of arthropods and other consumers (Polis and Hurd 1996; Towns *et al*. 2009). The most widespread and detrimental of the introduced species affecting seabirds are Norway (Brown) Rat (*Rattus norvegicus*), Black (Ship or Roof) Rat, and Polynesian Rat or Kiore (*R. exulans*), which affect large, surface-nesting albatrosses, frigatebirds and larids least, and small, burrow-nesting storm petrels and other ecologically similar taxa greatest; however, even adults as large as Laysan Albatrosses (*Phoebastria immutabilis*) are vulnerable to predation by Polynesian Rats (Jones *et al*. 2008). Recent work at Gough Island indicates that the introduced House Mouse, which was formerly not considered to pose a problem for large seabirds, kills so many Tristan Albatrosses (*Diomedea dabbenena*) chicks that the population is unlikely to recover even if the other key threat, fisheries-related mortality of adults and juveniles, were eliminated (Wanless *et al*. 2009). There are also suggestions that if global climate amelioration improves conditions for mice, they may become an important predator of seabirds on other islands (Angel *et al*. 2009). Other introduced mammals considered to pose threats to seabirds either directly through predation or indirectly through habitat degradation and destruction include Pigs (*Sus scrofa*), Goats (*Capra hircus*), cats, rabbits and mustelids (Croxall *et al*. 1984; Croxall 1991). These have all been the target of previous eradication programmes (Courchamp *et al*. 2003; Nogales *et al*. 2004; Campbell and Donlan 2005). Eradications of invasive mammals from islands are therefore not only feasible, but highly beneficial for both seabirds and other components of the ecosystem, including terrestrial birds, lizards, amphibians, native mammals, invertebrates and plant communities, and, on inhabited islands, agricultural productivity (Newman 1994; Towns and Broome 2003; Croll *et al*. 2005).

Where and when is invasive mammal eradication a viable option?

For a successful eradication it is imperative that: (*a*) all individuals of the target pest species can be put at risk; (*b*) the target species cannot breed faster than it can be killed; and (*c*) risk of reinvasion can be managed to at or near zero (Parkes 1990). The traditional view was that long-term control was the only practical solution on very large islands, or islands where re-invasion seems inevitable (Zino *et al*. 2001; Jouventin *et al*. 2004; Ratcliffe *et al*. 2009). However, in New Zealand, recent attention has been directed towards developing mechanisms by which islands can be cleared of alien rodents, and procedures put in place that prevent full recolonisation even though the likelihood of (temporary) re-invasion remains high. On very remote islands, the logistical challenges and therefore the cost of eradication increases, and it might also be difficult to collect the baseline data on ecology of native and invasive species to help guide the campaign. Nevertheless, accepting the continuing decline of species of conservation concern, or the control of the introduced mammals in perpetuity, are clearly much less satisfactory and potentially more costly options (Pascal *et al*. 2008). This explains the considerable recent interest in eradications on several large and remote oceanic islands (see above), despite the risk of failure. The complex issues involved with these ambitious projects should not, however, distract from the realisation that many, much smaller islands are sufficiently isolated, particularly given the limited swimming ability of rats and mice, that if human activities can be controlled appropriately and the future risk of re-invasion reduced to an acceptable level, eradication can be achieved with modest financial investment.

Introduced vertebrates vary enormously in the level of effort required for eradication, but in general, ungulates, cats and rats are easier to eradicate than rabbits, mice, mongooses, mustelids and birds (Courchamp *et al*. 2003; Towns and Broome 2003; Martins *et al*. 2006). Knowledge of rodent eradication in particular is high and growing. By 2007, they had been eradicated from at least 284 islands worldwide, although many of these were relatively small (<100 ha) (Howald *et al*. 2007). The species were mainly Black Rat (159 islands) and Norway Rat (104 islands), and, to a lesser extent, Pacific Rat (55 islands) and House Mouse (30 islands). Mice have proven the hardest to eradicate, with a 38% failure rate compared with 5–10% failure rates for attempted eradications of rats, related potentially to incomplete bait coverage given the small home-range sizes of individual mice, dietary neophobia, reduced access to bait where rats co-occur, and toxin resistance (Howald *et al*. 2007; Angel *et al*. 2009).

Despite recent high-profile successes, the effort and commitment required to eradicate introduced mammals, particularly from large islands, should not be underestimated. Historical precedence can indicate the likelihood of success of particular eradication methods at different spatial scales. In novel situations, formal techniques for assessing and balancing risks and constraints can be used to develop the necessary responses, actions and contingency plans (Zavaleta 2002). Good planning and management, thorough analysis of risks, constraints and solutions, testing of assumptions and equipment, clear lines of responsibility and authority, and institutional and public support greatly improve the chances of success (Courchamp *et al*. 2003). Public support is particularly important for eradications on inhabited islands as there may be health and safety concerns about spreading of poison baits and its contact with people and livestock (Towns *et al*. 2006). These may be allayed by providing clear evidence of impacts of introduced species on native biota and the potential economic benefits to agriculture, tourism etc.

Clearly one of the major limiting factors to eradication is the overall cost. There have been attempts to estimate this; in a review of 41 programmes, Martins *et al*. (2006) concluded that costs have gradually declined as technology has developed, that rodent eradications cost 1.7–3.0 times those of ungulates, and that expense increases with remoteness (distance to nearest airport). In general, total cost increases but cost per hectare decreases with island size, eradications are generally harder with increasing ruggedness of terrain and vegetation cover, and ungulates, cats and rats are easier to eradicate than mice and birds (Martins *et al*. 2006). Economies of scale might be possible if concurrent eradication on adjacent islands is a viable option. Many eradications in temperate and polar regions take place during the winter when alien mammal populations are likely to be lower, and nontarget species will be absent or in low numbers; however, this incurs potential operational disadvantages including shorter daylength and more severe weather, reducing available flying time for bait drops, etc. Many factors such as island size, remoteness, target species, mitigation for nontarget species, approach (e.g. aerial or ground baiting, shooting, trapping, etc.), local capacity and bureaucracy, and environmental compliance all influence the economics (Donlan and Wilcox 2007). This makes it difficult to accurately estimate costs, particularly as contingency may be required to cope with inclement weather, equipment failure, planning delays and other unexpected difficulties.

How best to eradicate invasive mammals from islands?

Fortunately, the capacity to remove introduced vertebrates has increased enormously in recent decades because of improvement in GPS technology to assist bait distribution, the development of more effective poisons and bait delivery systems, the use of helicopters, trained dogs and Judas animals (an individual fitted with a transmitter and released that leads hunters to a remaining wild herd), improved risk management, and modelling of optimal strategies for eliminating the last few animals (Towns and Broome 2003; Morrison *et al*. 2007). The largest islands cleared to date of the most injurious of the various introduced mammals are indicated in Table 2. The eradication on Macquarie Island (12 870 ha) is even more ambitious, with a total cost estimated (before the recent setback) of AU$25 million over 7 years.

Risks for nontarget species should be identified, documented and managed, particularly possible primary and secondary poisoning of predators and scavengers (e.g. raptors, skuas (*Catharacta* spp.), gulls (Laridae) and giant petrels (*Macronectes* spp.)), and other endemic fauna. These may also be at risk from attacks by detection or hunting dogs used during an eradication programme. Although native fauna such as reptiles, amphibians, bats and invertebrates are considered at low risk of anticoagulant poisoning and not routinely included in risk assessments, ectothermic vertebrates and invertebrates may act as vectors, increasing the chances of secondary poisoning of native birds (Eason and Spurr 1995; Hoare and Hare 2006). Vulnerable nontargets may need to be translocated, taken into temporary captivity or later re-introduced from a suitable reservoir population (Towns and Broome 2003). If these are not options, alternative poisons may be used e.g. Diphacinone (although this is less toxic to mice), or active mitigation, for example removing baits in the vicinity of nests, or post-exposure treatment including administration of drugs to reverse the effects of ingestion (Donlan *et al*. 2003*b*; Murray and Tseng 2008). Biosecurity policy and practises should be re-evaluated before an eradication programme. Clearly, strict quarantine measures need to be in place to prevent reinvasion, particularly by rodents, with responsibility and resources provided to designated authorities to monitor and ensure compliance.

Ecosystem-level effects that might unintentionally have detrimental effects on threatened species also have to be considered. These include changes to the food web such as prey switching, or potential mesopredator release, especially of rabbits and rodents when cats are removed, or of mice when rats are removed (Caut *et al*. 2007; Rayner *et al*. 2007; Witmer *et al*. 2007; Bergstrom *et al*. 2009). A recent study indicates that it is not just numbers but (predation) behaviour of meso-predators that may have been suppressed when cats or rats were present (Hughes *et al*. 2008). Post-eradication rodent irruptions may be a major problem, particularly for small burrow or ground-nesting species that are often very vulnerable to predation. The removal of herbivorous mammals can also lead to dramatic changes in vegetation cover and structure, including the proliferation of exotic plants (Zavaleta *et al*. 2001). Although funding and feasibility constraints may result in a staged rather than a holistic approach (Bergstrom *et al*. 2009; Dowding *et al*. 2009), ideally all introduced vertebrates should be eliminated at once.

The advantages and disadvantages of different eradication methods are reviewed in Courchamp *et al*. (2003).Those used for targeting of rodents are poisoning, of rabbits are poisoning, shooting and detection by dogs, of ungulates are shooting, and of cats are trapping, shooting, poisoning and detection by dogs. A multi-year follow up phase is critical after poisoning of rabbits and cats, particularly as it is unlikely that aerial broadcast of baits will kill all target individuals. Except for rats and mice, the best strategy will usually involve a combination of techniques. Campaigns with a primary or secondary hunting or trapping phase require a strategy for detecting animals at very low density and ensuring their removal (Morrison *et al*. 2007; Ramsey *et al*. 2009). Preceding an eradication programme with a control phase might be counter-productive, as it could induce bait aversion or otherwise change behaviour. A clear exception to this was the introduction of the feline panleucopenia virus onto Marion Island (46°54′S, 37°45′E) which greatly reduced the cat population and ensured the feasibility of the subsequent hunting campaign (van Rensburg *et al*. 1987). The most effective poison and bait-delivery system must be determined for one or multiple targets.

Table 2. The largest islands cleared to date of the most widespread and harmful introduced mammals (Nogales *et al*. 2004; Lorvelec and Pascal 2005; Donlan and Wilcox 2008)

Introduced species	Largest island cleared
Norway Rat (*Rattus norvegicus*)	11 300 ha (Campbell, New Zealand)
Black Rat (*Rattus rattus*)	1022 ha (Hermite, Australia)
Pacific Rat (*Rattus exulans*)	3083 ha (Little Barrier, New Zealand)
Rabbit (*Oryctolagus cuniculus*)	800 ha (St Paul, France)
House Mouse (*Mus musculus*)	710 ha (Enderby, Auckland Islands, New Zealand)[A]
Goat (*Capra hircus*)	458 812 ha (Isabela, Ecuador)
Pig (*Sus scrofa*)	58 465 ha (Santiago, Ecuador)
Cat (*Felis catus*)	29 800 ha (Marion, South Africa)

[A]This may not be the largest cleared island for much longer; monitoring to date indicates that an aerial bait drop in 2008 on the 1163-ha Coal Island in Fiordland National Park, New Zealand, targeting House Mouse looks to have been successful.

This can be a combination of approaches including bait stations, hand and aerial broadcast. Use of bait stations has several advantages as it minimises exposure to nontargets, prevents general release of toxins into the environment, allows monitoring of bait uptake, and can be incorporated into a detection system using nontoxic baits or tracking boards. However, bait stations require continued effort for long periods, and are unlikely to be practical for large, rugged and remote islands: the largest island to date on which the successful eradication of rats was achieved by ground-based baiting was on the 3100-ha Langara Island (54°15′N, 133°01′W), Canada (Taylor *et al*. 2000).

What next in eradication research?

The dearth of widely-available, peer-reviewed papers on eradication noted by Donlan *et al*. (2003*a*), remains a major issue. This is despite the compelling evidence of major impacts of invasive mammals, and therefore the clear need to understand the advantages and disadvantages of different approaches to their removal. Among the many opportunities for research include studies to: determine bait encounter rates, avoidance and uptake (related to size of bait, placement and palatability), and hence appropriate broadcasting regimes for mice, rabbits and multiple targets within a single campaign; examine bait competition with terrestrial invertebrates, including crabs on tropical islands (Rodriguez *et al*. 2006); assess factors leading to mesopredator release; test new eradication methodologies, particularly for more intractable species including mice, mongooses and mustelids; identify species-specific toxins where minimising or eliminating nontarget impacts is imperative; better understand bait uptake and transfer by reptiles, amphibians and other native fauna that may act as vectors, increasing probability of secondary poisoning of native birds (Hoare and Hare 2006); understand factors leading to survival of some targets in aerial baiting campaigns; improve strategies for detecting invasive species, especially at very low densities in the latter stages of eradication campaigns (Morrison *et al*. 2007; Ramsey *et al*. 2009); improve biosecurity systems and practices, including in the design and deployment of bait station networks and other surveillance systems for detection of, and potentially defence against, re-invasion (Russell *et al*. 2008); examine the social context and illustrate the (typically minimal) risk to public health and economic benefits (e.g. enhanced agriculture or tourism) to encourage greater stakeholder participation on inhabited islands (White *et al*. 2008).

The lack of published studies along the above lines is an unnecessary barrier to progress, as thorough monitoring of the eradication process and outcomes is critical for determining issues leading to success and failure, and for building support elsewhere. Properly determining baseline (pre-eradication) levels and monitoring the response (post-eradication) of the ecosystem in general, and threatened species in particular, should not be regarded as a luxury to be dispensed with when funding is tight. Robust studies of the level of nontarget mortality, and monitoring of sub-lethal impacts on top predators, for example by analysis of poison residue or health indicators are also rare, but highly desirable (Howald *et al*. 1999). Similarly, where reinvasion is possible, more effort should be made to obtain blood or other tissue samples from introduced mammals before and, if unsuccessful, after the programme to try and determine through genetic analysis whether some targets survived or there was further immigration (Abdelkrim *et al*. 2007). It is a telling statistic that despite more than 800 successful invasive mammal eradications worldwide, less than 20% of studies directly quantified the benefits to birds, and many of these were in the grey literature (Lavers *et al*. 2010). This is particularly disappointing not just because of the potential for improving eradication methodologies and publicising its advantages, but also because eradications are large-scale ecological experiments, and paying close attention to the aftermath can reveal fundamental insights into the key regulators of bird populations.

Conclusions

Given the clear evidence for impacts of invasive species on birds, and the focus on mitigating and reversing biodiversity loss generated by the International Year of Biodiversity, the time is now ripe for conservation managers and researchers to make a difference at the grass-roots level. There is sufficient information available that with good planning and advice from an eradication expert, campaigns to eliminate invasive mammals from small islands (<500 ha) can be achieved with relatively modest budgets and small teams (5–10 people). It is important to caution that despite many recent successes, the effort needed to eradicate introduced mammals should not be underestimated, as indicated by the failure of several well-resourced programmes for a variety of reasons, including inadequate baiting regimes, competition for bait from terrestrial invertebrates, deviation from agreed protocols, problems with nontarget poisoning leading to cancellation, lack of funding and public support (Lorvelec and Pascal 2005; Howald *et al*. 2007). Nevertheless, by widening awareness of the available technology and expertise, learning lessons from past campaigns, and considering ecosystem-wide implications, both the political will and opportunities for eradications and the associated research are currently unprecedented.

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