THE USE OF RODENTICIDES FOR CONSERVATION EFFORTS

GARY WITMER, USDA, APHIS, Wildlife Services, National Wildlife Research Center, Fort Collins, CO, USA
JOHN D. EISEMANN, USDA, APHIS, Wildlife Services, National Wildlife Research Center, Fort Collins, CO, USA
GREGG HOWALD, Island Conservation, Kelowna, British Columbia, Canada

Abstract: Non-native rats (*Rattus spp*.) and mice have been introduced to more than 80% of the island groups around the world. They have caused ecosystem-wide impacts, including the extirpation and extinction of many native and endemic species which evolved in a mammalian predator-free environment. Fortunately, practitioners have developed techniques to eradicate introduced rodents, allowing ecosystems to recover. Rodenticides have proven an effective tool in eradications, having been used in over 300 successful eradications worldwide. Careful planning, adequate resources, and a sustained effort by competent field staff are needed to help ensure a successful eradication program. Island eradications are logistically complex and often quite expensive, requiring that once initiated, removal of 100% of rodents is paramount to facilitate support for future projects. However, efforts must be made to reduce potential rodenticide impacts to non-target animals, especially native birds and mammals. Standard considerations include confirming the species present, their behavioral characteristics and scale of risk, the legal status of species present, and population levels and distributions. To minimize risks, the type of rodenticide used, bait formulation, placement (stations or broadcast), timing of application, number of applications, and weather needs to be considered. It is important to recognize the great value of a successful invasive rodent eradication to island resources; recovery of native flora and fauna is usually rapid and remarkable.

Key words: eradication, house mice, island conservation, mitigation, *Mus musculus*, *Rattus*, rodent, rodenticide

Proceedings of the 12th Wildlife Damage Management Conference (D.L. Nolte, W.M. Arjo, D.H. Stalman, Eds). 2007

INTRODUCTION

It is important to address invasive species in the United States (US) because over 50,000 species of foreign animals, plants, and micro-organisms have entered the US. It has been estimated that invasive species cost the US at least $120 billion dollars per year (Pimentel et al. 2005). The great increase in worldwide trade and travel has greatly increased the risk of the introduction of invasive species. Once established, invasive species can have profound effects on ecosystems and economies. It has been estimated that about 42% of the species on the threatened and endangered species list are at risk from invasive species (Wilcove et al. 1998).

Efforts to address invasive species have increased in recent years. The US now has a National Invasive Species Council (NISC) which has produced a National Invasive Species Management Plan (NISC 2001). There have also been an increasing number of conferences on invasive species

(e.g., Veitch and Clout 2002, Witmer and Eisemann 2005) and books on the subject (e.g., Mooney et al. 2005, Ruiz and Carlton 2003, Wittenberg and Cock 2001).

To date, most efforts in the US have been directed towards invasive plants and insects, however, there is increasingly more attention being paid to invasive vertebrates (NPS 2004). Established invasive vertebrates in the US include at least 20 species of mammals, 97 of birds, 53 of amphibians/reptiles, and 138 of fish (Pimentel et al. 2005).

INVASIVE RODENTS

About 40% of all mammal species in the world (~4,400 species) are rodents (~1,600 species; Nowak 1999). All rodent species have ecological, scientific, social, and economic values; in particular, they provide an important prey base for many species of predatory animals. Rodents have adapted to various lifestyles on all continents and their use of habitats is extensive and varied. Most rodent species are relatively small, secretive, prolific, adaptable, and have continuously growing incisors which requires them to be constantly gnawing on materials. All these characteristics make many rodent species highly efficient and competitive invaders.

The main non-native, invasive species of rodents occurring in the US are the commensal rats (*Rattus* spp.), house mouse (*Mus musculus*), and the nutria, (*Myocastor coypus*). Other non-native species occur on a much more restricted basis, such as the Gambian giant pouched rat (*Cricetomys gambianus*) in the Florida Keys. In some cases, species native to North America have been transplanted by humans and have become established: ground squirrels (*Spermophilus* spp.) on some Aleutian Islands and fox squirrels (*Sciurus niger*) in western states.

A variety of economic and health problems result where invasive rodents have become established, including damage to growing crops, trees, seeds, pastures; damage and contamination of stored foods; damage to structures and property; and disease transmission (Witmer et al. 1995). It has been estimated that in the US alone, commensal rodents cause more that $19 billion dollars in damage each year (Pimentel et al. 2005) and this does not include the many millions of dollars spent on rodenticides and the pest control industry each year. Extensive marsh vegetation damage has occurred in Maryland (Kendrot 2004) and Louisiana (Evers et al. 1998) from the invasive nutria populations in those states.

Invasive rodents have caused the demise of many endemic species on islands (Atkinson 1985). In most cases, endemic island floral and fauna have not evolved with the pressures of herbivory and predation by terrestrial mammals. Many islands have no mammal species present or only a few species of bats. It has been estimated that about 42% of the species on the threatened and endangered species list are at risk from invasive species (Wilcove et al. 1998) with many of the culprits being invasive rodents (Atkinson 1985). Several species of rodents (house mouse, ship rat [*Rattus rattus*], gray squirrel [*Sciurus carolinensis*], and nutria) are on the “100 Worst Invasive Alien Species” list (Lowe et al. 2004). The risks and impacts to sea turtles (Witmer et al. 2007) and ground-nesting seabirds (Witmer et al. 2006) are particularly great.

METHODS TO MANAGEMENT AND ERADICATE INVASIVE RODENTS

A variety of methods are used around the world to manage rodent populations directly or to reduce the damage caused by rodents. These methods include

physical (e.g., traps, barriers), chemical (e.g., toxic baits, fumigants, repellents), biological/cultural (e.g., resistant plants, crop type, sanitation, habitat manipulation), and others such as bounties and compensation (Witmer et al. 1995). Other methods such as fertility control are still in the developmental stages (Nash et al. 2007). Each method has advantages and disadvantages and a site-specific assessment should be made before implementing a rodent damage management program.

Despite all the tools and methods developed for rodent population and damage management, rodenticides are the major tool in the management and eradication of invasive rodents. Rodenticides provide us with the tool that allows us the best chance of meeting the tenants of a successful eradication: 1) all individuals must be put at risk; 2) animals must be removed faster that they can reproduce; and 3) the risk of immigration must be zero (Parkes and Murphy 2003). To achieve this, a well-planned strategy with contingencies must be in place (Broome et al. 2005). There must also be adequate financial and staffing resources available and a sustained effort must be made to ensure every individual rodent is removed. Additionally, to be used successfully, the rodenticide bait must be highly efficacious and palatable to the target rodent species. The rodenticide bait must also be available over an adequate area and for an adequate period of time so that all target animals will be exposed to a lethal dose. Finally, long-term post-eradication monitoring is essential to determine that a successful eradication has been achieved, but also to give early warning should a re-invasion occur. Some practitioners believe that 2 years of relatively intense monitoring with no invasive rodents detected should occur before a "probably successful eradication" can be declared (Howald et al. 2007).

There has been a substantial effort to eradicate invasive rodents from various islands around the world with at least 332 successes (Howald et al. 2007). Not only has the number of island eradications increased dramatically since 1990, but so has the size of islands successfully eradicated of rodents; the largest being Campbell Island (11,300 ha) in New Zealand (Howald et al. 2007). The vast majority of the eradications used the second generation anticoagulant brodifacoum (Howald et al. 2007). The second most commonly used rodenticide was another second generation anticoagulant bromadiolone. In some cases, two different rodenticides were used (brodifacoum and pindone) and in a few cases, an acute toxicant was used (1080, strychnine, or cholecalciferol).

Bait stations and hand-broadcasting were the most commonly used bait delivery systems, although the number of islands cleared of invasive rodents by aerial broadcast-baiting has increased in recent years (Howald et al. 2007). Aerial broadcast-baiting can greatly increase the efficiency of the operation, reducing the time and labor requirements, and hence, the overall cost of the operation. Additionally, with a potent rodenticide such as brodifacoum that generally kills rodents after a single feeding, a single broadcast-baiting may accomplish the eradication. Aerial broadcast-baiting also reduces the risk of harm to field crews working on the rugged terrain and cliff areas of many islands in order to hand deliver baits.

In some cases, traps were also used as part of the eradication effort. We know of a few cases where traps alone were used in successful eradications. For example, live traps were used on small Green Cay (7.2 ha, US Virgin Islands) to remove all roof rats (James Rebholz, USFWS, personal communication). In this case snap traps and

rodenticides were not used for fear of harming the endangered St. Croix ground lizard (*Ameiva polops*) that occurs on the island.

Rodenticide use in the US is regulated by the US Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA; Jacobs 1994). Recently, EPA granted the registration of "Diphacinone 50: Conservation" (56228-35), the first nationally registered label specifically for eradicating invasive rodents on islands. Currently, registration packages are under review by the EPA for nationwide registrations for aerial broadcast baiting with brodifacoum (Witmer et al. 2007). These registrations would greatly increase our ability to eradicate invasive rodents from large numbers of islands, and larger islands, in the U.S. Other aspects of the registration and use of rodenticides in the U.S. were covered by Witmer and Eisemann (2007).

THE REDUCTION OF NON-TARGET HAZARDS OF RODENTICIDE USE IN CONSERVATION EFFORTS

Both primary (direct consumption) and secondary hazards (consuming a poisoned rodent) can occur from rodenticide use. In all cases, a significant effort should be made to minimize losses to non-target animals because these are the very resources that we are trying to protect from the invasive rodents. In many island situations, the risks to non-target mammals from rodenticide use are non-existent or very low because few, if any, native terrestrial mammal species occur on many of those islands. Bat species are the most common exception, but these are insectivorous or frugivorous and highly unlikely to consume baits or dead rodent carcasses. Bird species, in general, are less susceptible to some anticoagulant baits (e.g., diphacinone) than mammals which can add a safety margin in some cases (Tasheva 1995, Timm 1994). It is important to note that even when non-target species (e.g., ants, hermit crabs, most reptiles and amphibians) are not effected by the anticoagulant baits (Booth et al. 2003, Hoare and Hare 2006, Johnston et al. 2005, Spurr and Drew 1999), they may affect the success of the eradication effort by consuming baits put out for the invasive rodents or by swarming the baits to the extent that the baits are less available to the target rodents (Jacob et al. 2002, Witmer et al. 2007). Research on insect anti-feedants may ultimately help solve this problem (Spurr and McGregor 2003). Other non-target species (e.g., coconut crabs, feral pigs) may damage equipment such as bait stations used in the eradication effort.

The main safeguard for the safe use of rodenticides in conservation efforts is carefully following the EPA-approved label instructions for the product. Other basic considerations include the rodenticide product used; when, where, and how it is applied; cleaning up spills promptly; and not using rodenticides in some areas where highly valued or protected wildlife occur (determined by scouting the area before use).

Other mitigation measures are often used in island eradication efforts with these being selected on a case-by-case basis. The timing of bait application (especially with broadcast baiting) may be done after migratory birds have left the island to reduce their chance of direct or indirect exposure (Howald et al. 2005). However, it is important to realize that a "window" of good weather is also needed at the time of bait application so that the bait will not weather quickly and mold from water exposure and will not be blown into inaccessible areas (e.g., water or small crevasses) by storms before the rodents can consume adequate amounts of the bait, and to help assure aircraft crew safety. Conversely, the moist weather that sets in will quickly decompose

the baits so that unduly long presence of baits is not likely (Howald et al. 2005). Bait pellets can be large enough to help assure that they will not be consumed by small granivorous birds and dark-colored (dark green or blue) to reduce their visibility to birds (Howald et al. 2005) and lizards (Tershy and Breese 1994). Also, specially-designed bait stations can be used to restrict access by non-targets (Witmer et al. 2007), including endemic mice (Erickson et al. 1990).

In some cases, raptors are taken into captivity or temporarily relocated so that they are less likely to be exposed to animals consuming the bait (Howald et al. 2005, Merton et al. 2002). If a small, endemic rodent species occurs on the island, some can be held in captivity and a breeding colony can even be established (Howald et al. 2005, Merton et al. 2002). Collecting and removing (or burying) rodent carcasses can also be done (Meier and Varnham 2004), but often few carcasses are found (many die under ground). A quick response to an invasion may reduce the effort required as well as the amount of bait used and the length of time bait is available in the environment. As noted earlier, a single aerial broadcast baiting of brodifacoum pellets is often effective for rodent eradication and this approach reduces the time bait is available to non-target animals (Eason et al. 2001) versus repeated placement of bait by hand or in bait stations. Valued or protected animals on some islands may require that bait is not placed in some areas; in these cases, rodents are removed from the bait-protected areas (e.g., exclosures or pens) by the use of live-traps or other means (NPS 2000).

Efforts should also be made to make sure that the accumulate of anticoagulant residues in accessible rodent carcasses do not become an issue (Hoare and Hare 2006). Brodifacoum residues are known to accumulation in tissues of many animal species and to persist for many months (Eason and Spurr 1995, Ogilvie et al. 1997), however, this mainly becomes a concern with prolonged use such as in agricultural (Shore et al. 1999) or urban settings (Hosea 2000). A “one-off” island operation (i.e., a single broadcast baiting to eradicate invasive rodents) would not result in a serious residue situation (Eason et al. 2001). In some cases where a prolonged use of rodenticide is needed, it would be prudent to use diphacinone because residues are not likely to accumulate to significant levels (Eason et al. 2002). Additionally, one must be very careful with the use of brodifacoum where residues may accumulate in the tissues of animals that might be consumed by humans (e.g., feral pigs; Eason et al. 1999, 2001). It should be noted that in some cases anticoagulant baits used to eradicate invasive rodents have had a beneficial “spin-off” effect by also reducing or eradicating invasive predatory animals (e.g., stoats [*Mustela ermine*], Alterio and Moller 2000; feral cats [*Felis catus*], Nogales et al. 2004) that feed on those poisoned rodents.

In general, impacts to non-target species during the course of invasive rodent eradication efforts should be considered in terms of population-level effects, not effects to individuals, and in terms of the “greater good’ that is achieved from a successful eradication. While there will probably always be some non-target losses, if proper precautions are taken, these will be relatively few and those populations will quickly recover (Empson and Miskelly 1999, Howald et al. 2005). Many persons involved with successful invasive rodent eradications on islands are pleasantly surprised with how rapidly the island’s floral and faunal resources recover after the rodents are gone (Witmer et al. 2007).

CONCLUSIONS

Seabird populations, sea turtle populations, and other island resources warrant protection from invasive rodents. The significant impacts of introduced rodents on floral and faunal have been repeatedly demonstrated. Invasive rodents are very adaptable, can exploit a wide array of resources as food and cover, and can gear up reproduction very quickly when and where abundant resources exist (Macdonald et al. 1999). While invasive rodents will continue to pose challenges to land and resource managers, they can be controlled or even eradicated with a well-planned and adequately-supported effort using rodenticides. Appropriate measures should be taken to reduce non-target impacts in eradication projects. With proper planning, non-target losses will be minimal and populations, along with other island resources, will recover quickly after the rodents have been removed.

LITERATURE CITED

ALTERIO, N., AND H. MOLLER. 2000. Secondary poisoning of stoats in a South Island podocarp forest, New Zealand: implications for conservation. Wildlife Research 27:501-508.

ATKINSON, I. 1985. The spread of commensal species of *Rattus* to oceanic islands and their effects on island avifaunas. Pages 35-81 *in* P. Moors, editor. Conservation of island birds. International Council of Bird Preservation, Technical Bulletin No. 3, Cambridge, U.K.

BOOTH, L., P. FISHER, V. HEPPELTHWAITE, AND C. EASON. 2003. Toxicity and residues of brodifacoum in snails and earthworms. DOC Science Internal Series 143, New Zealand Department of Conservation, Wellington, NZ. 14 pp.

BROOME, K., P. CROMARTY, AND A. COX. 2005. Rat eradications - how to get it right without a recipe. Proceedings of the Australasian Vertebrate Pest Conference 13:152-157.

EASON, C., AND E. SPURR. 1995. Review of the toxicity and impacts of brodifacoum on non-target wildlife in New Zealand. New Zealand Journal of Zoology 22:371-379.

_____, L. MILNE, M. POTTIS, G. MORRISS, G. WRIGHT, AND O. SUTHERLAND. 1999. Secondary and tertiary poisoning risks associated with brodifacoum. New Zealand Journal of Ecology 23:219-224.

_____, E. MURPHY, G. WRIGHT, C. O'CONNOR, AND A. BUCKLE. 2001. Risk assessment of broad-scale toxicant application for rodent eradication on islands versus mainland use. Pages 45-58 *in*: H.J. Pelz, P. Cowan, and C. Feare, editors. Advances in vertebrate pest management II. Filander Verlag, Furth.

_____, G. WRIGHT, L. MILNE, AND G. MORRISS. 2001. Laboratory and field studies of brodifacoum residues in relation to risk of exposure to wildlife and people. Science for Conservation 177B:11-23. New Zealand Department of Conservation, Wellington, NZ.

_____, E. MURPHY, G. WRIGHT, AND E. SPURR. 2002. Assessment of risks of brodifacoum to non-target birds and mammals in New Zealand. Ecotoxicology 11:35-48.

EMPSON, R., AND C. MISKELLY. 1999. The risks, costs and benefits of using brodifacoum to eradicate rats from Kapiti Island, New Zealand. New Zealand Journal of Ecology 23:241-254.

ERICKSON, W., R. MARSH, AND W. HALVORSON. 1990. A roof rat bait station that excludes deer mice. Wildlife Society Bulletin 18:319-325.

EVERS, D.E., C.E. SASSER, J.G. GOSSELINK, D.A. FULLER, AND J.M. VISSER. 1998. The impact of vertebrate herbivores on wetland vegetation in Atchafalaya Bay, Louisiana. Estuaries 21:1-13.

HOARE, J., AND K. HARE. 2006. The impact of brodifacoum on non-target wildlife: gaps in knowledge. New Zealand Journal of Ecology 30:157-167.

HOSEA, R. 2000. Exposure of non-target wildlife to anticoagulant rodenticides in

California. Proceedings of the Vertebrate Pest Conference 19:236-244.

HOWALD, G., K. FAULKNER, B. TERSHY, B. KEITT, H. GELLERMAN, E. CREEL, M. GRINNELL, S. ORTEGA, AND D. CROLL. 2005. Eradication of black rats from Anacapa Island: biological and social considerations. Pages 299-312 *in* D. Garcelon and C. Schwemm, editors Proceedings of the 6th California Islands symposium. National Park Service Technical Publication CHIS-05-01, Institute for Wildlife Studies, Arcata, CA.

_____, C. DONLAN, J. GALVAN, J. RUSSEL, J. PARKES, A. SAMANIEGO, Y. WAND, D. VEITCH, P. GENOVESI, M. PASCAL, A. SAUNDERS, AND B. TERSHY. 2007. Invasive rodent eradication on islands. Conservation Biology: 21:121-124.

JACOB, J., H. YLONEN, J. PERRY, AND G. SINGLETON. 2002. Who eats first? Uptake of pellet bait by non-target species. International Biodeterioration and Biodegradation 49:121-124.

JACOBS. W.W. 1994. Pesticides federally registered for control of terrestrial vertebrate pests. Pages G-1 – G-22 *in* S. Hygnstrom, R. Timm, and G. Larson, editors, Prevention and control of wildlife damage. University of Nebraska Cooperative Extension Service, Lincoln, NE.

JOHNSTON, J., W. PITT, R. SUGIHARA, J. EISEMANN, T. PRIMUS, M. HOLMES, J. CROCKER, AND A. HART. 2005. Probabilistic risk assessment for snails, slugs, and endangered honeycreepers in diphacinone rodenticide baited areas on Hawaii, USA. Environmental Toxicology and Chemistry 24:1557-1567.

KENDROT, S. 2004. Eradication strategies for nutria in Chesapeake and Delaware Bay wetlands: Annual Report September 1, 2002-August 31, 2003. Nutria Project, U.S. Department of Agriculture, Wildlife Services, Annapolis, MD.

LOWE, S., M. BROWNE, AND S. BOUDJELAS. 2004. 100 of the world's worst invasive alien species. World Conservation Union (IUCN), Gland, Switzerland.

MACDONALD, D., F. MATHEWS, M. BERDOY, AND M. DEPORTER. 1999. The behavior and ecology of *Rattus norvegicus*: From opportunism to kamikaze tendencies. Pages 49-80 *in* G. Singleton, L. Hinds, H. Leirs, and Z. Zhang, editors. Ecologically-based management of rodent pests. Australian Centre for International Agricultural Research, Canberra, Australia.

MEIER, G., AND K. VARNHAM. 2004. Rat eradication as part of a green turtle conservation programme in Indonesia. Marine Turtle Newletter 106:11-12.

MERTON, D., G. CLIMO, V. LABOUDALLON, S. ROBERT, AND C. LANDER. 2002. Alien mammal eradication and quarantine on inhabited islands in the Seychelles. Pages 182-198 *in* C. Veitch and M. Clout, editors. Turning the tide: The eradication of invasive species. IUCN SSC Invasive Species Specialist Group, Gland, Switzerland.

MOONEY, H., R. MACK, J. MCNEELY, L. NEVEILLE, P. SCHEI, AND J. WAAGE. 2005. Invasive Alien Species: A New Synthesis. Island Press, Washington, D.C. 368 pp.

NASH, P., C. FURCOLOW, K. BYNUM, C. YODER, L. MILLER, AND J. JOHNSTON. 2002. 20, 25-diazacholesterol as an oral contraceptive for the black-tailed prairie dog population management. Human-Wildlife Conflicts 1:60-67.

NATIONAL INVASIVE SPECIES COUNCIL. 2001. Meeting the Invasive Species Challenge: Management Plan. National Invasive Species Council, Washington, D.C. 74 pp.

NATIONAL PARK SERVICE. 2000. Anacapa Restoration Project: Final Environmental Impact Statement. Channel Islands National Park, Ventura County, CA. 139 pp.

_____. 2004. Special issue: invasive species. Park Science 22:1-71.

NOGALES, M., A. MARTIN, B. TERSHY, C. DONLAN, D. VEITCH, N. PUERTA, B. WOOD, AND J. ALONSO. 2003. A

review of feral cat eradication on islands. Conservation Biology 18:310-319.

NOWAK, R.M. 1999. Mammals of the world. The Johns Hopkins University Press, Baltimore, MD. 1936 pp.

OGILVIE, S., R. PIERCE, G. WRIGHT, L. BOOTH, AND C. EASON. 1997. Brodifacoum residue analysis in water, soil, invertebrates, and birds after rat eradication on Lady Alice Island. New Zealand Journal of Ecology 21:195-197.

PARKES, J., AND E. MURPHY. 2003. Management of introduced mammals in New Zealand. New Zealand Journal of Zoology 30:335-359.

PIMENTEL, D., R. ZUNIGA, AND D. MORRISON. 2005. Update on the environmental and economic costs associated with alien-invasive species in the United States. Ecological Economics 52:273-288.

RUIZ, G., AND J. CARLTON. 2003. Invasive species: Vectors and management strategies. Island Press, Washington, D.C. 518 pp.

SHORE, R., J. BIRKS, AND P. FREESTONE. 1999. Exposure of non-target vertebrates to second-generation rodenticides in Britain, with particular reference to the polecat. New Zealand Journal of Ecology 23:199-206.

SPURR, E., AND K. DREW. 1999. Invertebrate feeding on baits used for vertebrate pest control in New Zealand. New Zealand Journal of Ecology 23:167-173.

_____, AND P. MCGREGOR. 2003. Potential invertebrate antifeedants for toxic baits used for vertebrate pest control. Science for Conservation 232. Department of Conservation, Wellington, New Zealand. 36 pp.

TASHEVA, M. 1995. Anticoagulant rodenticides. Environmental Health Criteria 175. World Health Organization, Geneva, Switzerland. 121 pp.

TERSHY, B., AND D. BREESE. 1994. Color preference of the island endemic lizard *Uta palmeri* in relation to rat eradication campaigns. The Southwestern Naturalist 39:295-297.

TIMM, R.M. 1994. Description of active ingredients. Pages G-23 – G-62 *in* S. Hygnstrom, R. Timm, and G. Larson, editors. Prevention and control of wildlife damage. University of Nebraska Cooperative Extension Service, Lincoln, NE.

VEITCH, C., AND M. CLOUT. 2002. Turning the Tide: The eradication of invasive species. IUCN SSC Invasive Species Specialist Group, Gland, Switzerland.

WILCOVE, D., D. ROTHSTEIN, J. DUBOW, A. PHILLIPS, AND E. LOSOS. 1998. Quantifying threats to imperiled species in the United States. BioScience 48:607-615.

WITMER, G., M. FALL, AND L. FIEDLER. 1995. Rodent control, research needs, and technology transfer. Pages 693-697 *in* J. Bissonette, editor. Integrating people and wildlife for a sustainable future. The Wildlife Society, Bethesda, MD.

_____, AND J. EISEMANN. 2005. An overview of the 2nd national invasive rodent summit. Proceedings of the Wildlife Damage Management Conference 11:102-111.

_____, AND _____. 2007. Rodenticide use in the United States: An overview. Proceedings of the Wildlife Damage Management Conference 12:114-118

_____, P. BURKE, S. JOJOLA, AND P. DUNLEVY. 2006. The biology of introduced Norway rats on Kiska Island, Alaska, and an evaluation of an eradication approach. Northwest Science 80:191-198.

_____, F. BOYD, AND Z. HILLOS-STARR. 2007. The successful eradication of introduced roof rats from Buck Island using diphacinone, followed by an irruption of house mice. Wildlife Research 34:108-115.

WITTENBERG, R., AND M. COCK. 2001. Invasive alien species: a toolkit of best prevention and management practices. CABI, Wallingford, U.K. 228 pp.