AN OVERVIEW OF THE 2ND NATIONAL INVASIVE RODENT SUMMIT

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***Abstract*:** On October 19-21, 2004, the USDA, APHIS, Wildlife Services, National Wildlife Research Center (NWRC) in Fort Collins, CO, hosted the 2nd National Invasive Rodent Summit. The conference was jointly sponsored by the NWRC, the U.S. Fish and Wildlife Service (FWS) and The Wildlife Society's Wildlife Damage Management Working Group. The conference was a follow-up to the 2001 "Rat Summit" held in San Francisco, CA. Like the "Rat Summit," this conference emphasized the management of rodents to conserve plants, other wildlife and habitats. The scope of the problem, concerns, species involved, and lands affected were all considered. The conference began with talks covering invasive species management on a national level by personnel from the National Invasive Species Council, the FWS, and the U.S. Armed Forces Pest Management Board. Numerous examples of rodent eradications on islands were presented. Mainland rodent control efforts were presented and noted to be quite different from island eradications, differing in size of area, duration of effort, landownership, hazards and non-target issues, and residue accumulation. A session addressed rodents and disease because many human and livestock diseases are transmitted by rodents or their ecto-parasites. Nutria, an invasive aquatic rodent, presents problems of marsh degradation in Maryland and Louisiana; control efforts and research needs were considered in a special session. While many of the basic methods of rodent control were developed for commensal rodent control in and around buildings and for agricultural situations, new approaches, being investigated and implemented, were discussed. These included IPM/community efforts, trap-barrier-systems, and fertility control. Issues of methods development and registration costs and various constraints remain. There was considerable discussion of assessing the risks of rodenticide use, including primary and secondary hazards, and residue accumulations. Modeling efforts and worst-case scenario investigations have contributed to the understanding and reduction of hazards and have aided in toxicant selection. While many challenges remain, much progress has been made in the control and eradication of introduced, invasive rodents. The conference was well attended with 105 registrants representing 10 countries and territories and 23 states.

***Key words*:** eradication, house mouse, island conservation, invasive species, *Mus musculus*, *Myocastor coypus*, Norway rat, *Rattus norvegicus*, *Rattus rattus*, rodenticide, roof rat

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INTRODUCTION

Organisms that have been moved (accidentally or purposely by humans, or by natural range expansion) and have become established are variously referred to as "alien," non-indigenous," or "non-native" in

the new setting where they occur. In general, only a small portion of these will become serious pests in the new environment and are collectively referred to as "invasive species" (NISC 2001, Burdick 2005). A list of the 100 "worst' invasive species has been compiled (Lowe et al. 2004). Invasive species may harm the economy, the environment, and, at times, human and animal health. They are one of the leading causes of endangered native species of plants and animals (NISC 2001). While they cause damage throughout the world, it has been estimated that in the U.S. alone, invasive species cost the economy about $137 billion per year (Pimental et al. 2000).

The National Invasive Species Council (NISC) was established in 1999, in response to the U.S. Presidential Executive Order 13112. The NISC is co-chaired by the U.S. Secretaries of Agriculture, Interior, and Commerce, but also includes representation from most other federal agencies. The NISC helps ensure that federal invasive species activities are coordinated and complementary. In 2001, they released the national management plan, "Meeting the Invasive Species Challenge" (NISC 2001). In this action plan for the nation, they addressed the areas of leadership and coordination, prevention, early detection and rapid response, control and management, restoration, international cooperation, research, information management, and education and public awareness (see their website at: www.invasivespecies.gov/).

Among the vertebrates, rodents comprise a major invasive species group. Chief among these species are the "commensal" rodent species, Norway rats, (*Rattus norvegicus)*, roof rats, (*Rattus rattus)*, and house mice, (*Mus musculus*) that live in close association with human habitations and developments. We note, however, that many other species of rodents have been accidentally or purposely introduced to various parts of the world (e.g., Long 2003). Intensive efforts to control these species for the protection of crops, stored foods, property, and human and livestock health go back many centuries. There is a long history of development and testing of methods for rodent control, including sanitation and exclusion, traps, toxicants, and delivery systems (Witmer et al. 1995). While many tools and techniques are available, changing social dynamics and the emergence of the animal rights movement have led to increasing restriction or elimination of many of the traditional strategies or materials used (Fall and Jackson 2002). More recently, a large emphasis has been placed on invasive rodent control or eradication for conservation purposes, especially on public lands (Witmer et al. 1998). Several recent symposia, books, and special journal issues have documented the challenges and efforts associated with invasive rodents (Caughley et al. 1998, King 2003, Mundy 1996, Singleton et al. 1999, Singleton et al. 2003, Veitch and Clout 2002). Clearly, wildlife biologists and resource managers will continue to be challenged to provide data to maintain a broad array of appropriate, science-based techniques and management options while fostering the improvement of existing methods and the development of new methods and strategies.

On October 19-21, 2004, the USDA, APHIS, Wildlife Services, National Wildlife Research Center (NWRC) in Fort Collins, CO, hosted the 2nd National Invasive Rodent Summit. The conference was jointly sponsored by the NWRC, the U.S. Fish and Wildlife Service (FWS) and The Wildlife Society's Wildlife Damage Management Working Group. The conference was a follow-up to the 2001 "Rat Summit" held in San Francisco, CA. Like the "Rat Summit,"

this conference emphasized the management of rodents to conserve plants, other wildlife and habitats. The scope of the problem, concerns, species involved, and lands affected were all considered. The conference was well attended with 105 registrants from 10 countries and territories and 23 states. Hence, while the Conference was titled a "national" event, it was truly international in scope. In this paper, we summarize the key points of the presentations and discussions for each of the sessions of the Conference. The abstracts of the Conference are available on the NWRC website: www.aphis.usda.gov/ws/nwrc/symposia/rodents/index.html .

ISLAND ERADICATIONS

Rodents have managed to reach, and become established on, a very large number of islands around the world. Their effects on native biota have been severe in many cases, in part because insular animals evolved without significant predation pressure. Much of the concern with invasive rodents has focused on impacts to nesting seabird populations as well as endangered species such as sea turtles. Several speakers presented overviews of successful rodent eradications on islands in the Caribbean, the North Atlantic and the North Pacific; the first two being conducted with bait stations and the latter with an aerial broadcast bait application. Additional information on island rodent eradications can be obtained from the references given in the introduction above and in the database maintained on the Island Conservation, Inc., website: www.islandconservation.org/islanderad.html

Accomplishing a successful eradication of invasive rodents on an island involves extensive effort, and involves consideration of environmental regulations compliance, choice of methods, rodenticide registrations, inventory and monitoring of rodents and natural resources, non-target hazard assessment and mitigation, logistical planning and support, garnering adequate funds and personnel resources, and the gaining of agency and public support (USDI 2000). It is very important to realize that every island situation is somewhat different and there are no generic approaches or "cookbooks" for rodent eradication. Many things can go wrong, so contingency planning is essential. Historically, many rodent eradication efforts have failed. It is important to expect the unexpected when planning rodent eradications. Removal of invasive rats can lead to an irruption of the house mouse population or predatory species (such as brown tree snakes, *Boiga irregularis*, or feral cats, *Felis catus*) shifting their predation from rats to native birds. In addition to detailed planning, baseline studies may be needed to better understand the site-specific situation and to test proposed methods and rodenticides. Such an effort is underway by the FWS in the Aleutian Islands to develop a program to eliminate introduced rodents from islands of the Alaska Maritime National Wildlife Refuge (Ebbert and Byrd 2003). Another important consideration in rodent management planning is the prevention of introductions to rodent-free islands and re-introductions to islands that have been cleared of rodents. Very good examples of prevention programs are underway by the FWS, Alaska Maritime National Wildlife Refuge. Their rodent management plan included extensive outreach activities on the Pribilof Islands to maintain their rat-free status and a "Shipwreck Response Plan" to rapidly respond to a shipwreck or derelict vessel to avoid rodent introductions.

A key to successful eradications of invasive rodents on islands has been the judicious and effective use of rodenticides. These pesticides are carefully regulated in the U.S. by the U.S. Environmental Protection Agency (EPA) through the

Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the pesticide registration process; several types of registration options are available (e.g., Jacobs 1994). This is a contentious and shifting arena with losses of many registrations and elaborate efforts to gain re-registrations (Jacobs 2002). The cost of registering a new active ingredient is in the millions of dollars and may require many years of effort. Therefore, most eradications or control efforts rely on modified uses of existing products. Acquisition of EPA experimental or emergency use permits can be relatively easy for one-time projects in relation to obtaining a new product registration which would be available for a wide variety of eradication or control efforts. Efforts are underway to gain U.S. national registrations for two rodenticides (diphacinone and brodifacoum) for island conservation purposes. As proposed, use directions on the label would allow enough flexibility in bait application techniques to have the greatest probability of success. This follows approaches successfully used in other parts of the world and the recent, successful eradication of invasive rats on Anapaca Island off of the California coast.

Several speakers presented material on insular situations involving invasive rodents other than the basic, commensal species: Gambian pouched rats (*Cricetomys gambianus*) on islands in the Florida Keys and arctic ground squirrels (*Spermophilus parryii*) on Aleutian Islands. The first situation is complex because of development and human activity, private land ownership, and the potential presence of the endangered Key Largo woodrat (*Neotoma floridana smalli*). In the latter situation, it needs to be determined whether or not the rodents got to the islands on their own or were purposefully introduced by humans to provide a food base for introduced foxes (*Alopex lagopus*, *Vulpes vulpes*) used for the fur trade; both cases may exist. In both of these invasive rodent situations, effective methods will need to be developed to resolve the problem.

MAINLAND/LARGE ISLAND CONTROL

Early invasive rodent eradication efforts focused on small- to medium-sized islands, but as successes accumulated and methodologies were improved, some larger islands were taken on with some success stories. Mainland situations and very large islands pose significant challenges for rodent control or eradication. The size of the area, alone, increases logistical and budget needs and demands a long-term, sustained effort, in part because of risks of re-invasion from surrounding areas. There often are landownership and public access/use issues. There are usually more non-target hazard issues and the sustained use of rodenticides (versus a short-term effort for eradications on smaller islands) can lead to residue accumulations and genetic resistance. It was also noted that complex predator-prey assemblages occur and, while the rodents are causing damage themselves, they are also providing a prey base for introduced predators (e.g., mustelids [*Mustela* spp.], feral cats, and brown tree snakes). Nonetheless, examples were presented of recent efforts to control rats for conservation purposes on mainland United Kingdom, New Zealand, and the United States (California and Arizona). To help improve efficiency and effectiveness while reducing resource needs, control is often applied at a brief, critical period, such as just before bird nesting begins (e.g., Whisson et al. 2004). While there have been some small-scale successes, the challenges that remain include increasing the scale of coverage and providing year-round protection to more vulnerable species of the native flora and fauna. Lovegrove et al. (2003) published a good overview of the challenges of protecting a small, mainland,

regional park in New Zealand from invasive species.

RODENTS AND DISEASE

It has long been known that rodents play a role in the maintenance and transmission of numerous diseases. Some of these diseases (e.g., plague, typhus) have ravaged the human population of the world on various occasions (Witmer 2004). As such, introduced rodents pose a health and safety hazard to humans and their livestock and companion animals. In North America, these diseases include long-standing "endemic" diseases such as plague, tularemia, and leptospirosis, but also some "newly emerged" diseases such as lyme disease, hantavirus, and monkeypox virus. In some cases, the role that rodents may play in the epidemiology of a disease (e.g., West Nile Virus) is not yet known and further research and surveillance is necessary. Additionally, there has been a growing concern that one or more of these diseases could be used as a weapon of bio-terrorism (Borchert 2004). Detailed examples of the role of rodents in several diseases were presented at the Conference.

In most cases, sanitation, disease surveillance, and rodent population reduction are considered essential to the reduction of disease risk and to the prevention of outbreaks. In any given situation, there is a need for a good understanding of the epidemiology of the disease and the role of rodents; transmission cycles (which often include invertebrate vectors); effective detection, treatment, control, and prevention strategies; improvements in sanitation, farm practices and animal husbandry; and improvements in infrastructure (especially in remote or developing parts of the world) for prompt and effective action (Witmer et al. 2004). Continued research is needed to find new ways to disrupt disease transmission cycles. For example, one speaker suggested that systemic insecticides could be incorporated into rodent baits to control fleas of rodents.

NUTRIA: THE INVASIVE AQUATIC RODENT

Nutria or coypu (*Myocastor coypus*), a semi-aquatic rodent native to southern South America, are an invasive species of concern mainly in the southern and eastern United States as well as in several other parts of the world (Long 2003). Nutria were introduced into the U.S. in 1899 for fur farming and became established in several states. Nutria dispersals primarily occurred when the fur market declined in the early 1980s causing farmers to release animals, as escapees during hurricanes or rising floodwaters, or as releases to establish "weed eaters." The ravenous appetite of these herbivores can cause damage to agricultural crops and aquatic vegetation to the point of significantly altering aquatic ecosystem functions (Bounds et al. 2003). Their burrowing habits can weaken irrigation structures and create hazards for cattle, and they are a host for some diseases. Nutria are a classic example of a friend or foe relationship of humans with wildlife. Louisiana continues to recognize nutria as a beneficial natural resource (for food, fur and as a prey base for alligators) and manages for a low population (to prevent marsh damage), whereas the FWS recognizes the overall impacts of this invasive species and has implemented an eradication strategy at the Blackwater National Wildlife Refuge in Maryland.

Eradication can be desirable in areas such as national wildlife refuges, but can be difficult due to the nutria's extensive suitable range of habitat, the logistical challenges associated with these habitats, their efficiency in dispersal, and their high, year-round reproductive ability (Carter and Leonard 2002). However, eradication is

being attempted by the USDA/APHIS/Wildlife Services at the Blackwater National Wildlife Refuge, where systematic intensive control, using trapping and shooting, was conducted across a "nutria exclusion zone."

Control is more practical in some areas and is facilitated by periods of cold temperatures and sustained lethal control. An example of long-term nutria management was implemented by the Louisiana Department of Wildlife and Fisheries where an incentive payment is distributed to registered trappers/hunters on a per nutria basis. Research efforts continue to develop efficient methods for nutria control, including barriers and repellents to minimize damage, attractants for bait delivery of toxicants or fertility control materials, lures for improved capture rates, improved capture devices, the use of dogs to find and capture nutria, and improved methods of detection and monitoring (Jojola et al., 2005).

CONTROL TECHNIQUES

Many of the basic methods, tools, and rodenticides baits used in invasive rodent management and eradication were developed for commensal rodent control in urban/developed settings (Corrigan 2001) or for rodent control in agriculture settings (Marsh 1994). Control, rather than eradication, is usually the goal in those situations and management action is driven by benefit-cost analyses. In those settings, unlike conservation settings, there are clear tangible, monetary benefits to rodent control in terms of food and property protection and human and livestock health protection. Benefit-cost analyses can also be applied to conservation management activities and greater use of this approach may help make invasive rodent control and eradication more efficient and can be used to help prioritize efforts (Shwiff 2004).

Another strategy taken out of the agriculture industry that can be applied to invasive species management for conservation purposes is integrated pest management (IPM). Most state, provincial, territorial, and federal agencies have incorporated IPM into their pest management plans and include concepts such as preventative methods, pest monitoring, thresholds that trigger action, and the use of multiple, diverse methods. Gaining public support and generating community involvement also can be very valuable.

Research continues to develop efficient and effective methods to monitor invasive rodent populations. While the presence and abundance of rodents at high densities is easily determined, it is much more difficult to detect them when numbers are very low such as soon after a new invasion occurs or after an eradication effort is impemented. Nonetheless, the ability to detect rodent presence in these situations is critical to keeping islands rodent-free. Research continues to improve the use of track stations, chew blocks/cards, trap-lines, and remote cameras for population monitoring (Engeman and Witmer 2000).

Bait stations are often used, and at times are required, in order to protect baits and to reduce access to baits by non-target animals. The exclusion of non-target animals (such as other rodents, crabs, and ants) is also very important so that adequate amounts of bait are available to attract the target rodent population. Unfortunately, traditional bait stations, designed for commensal rodent control in and around buildings, do not meet these needs in most conservation land situations. Efforts are underway to design and develop new bait stations that meet these criteria and yet allow full access to all sizes and both sexes of the target rodent species.

New approaches are being investigated that could greatly add to the toolbox for invasive rodent control and eradication. These include methods such as trap-barrier-systems and other multiple-capture devices, and fertility control. While many persons agree that fertility control could play an important role in wildlife damage management, there are many technical, legal, environmental, and socio-political issues that need to be resolved (Fagerstone et al. 2002). Many of the issues for developing and using fertility control agents are similar to those for toxic baits: having an adequate oral delivery system, species specificity, protecting baits from weather and non-target animals, obtaining registrations, making the approach economically feasible, and gaining public support.

RODENTICIDE RISK ASSESSMENT

Rodenticides are heavily relied on for invasive rodent control and eradication. The benefits of removing invasive rodents from sensitive habitats like islands have been shown many times over. To date, there have been at least 255 attempts to eradicate rodents from islands worldwide, most of which have been successful (Island Conservation, Inc., unpublished database). However, there remains considerable discussion over potential primary and secondary risks of a poisoning project and how to best assess the risks prior to project initiation. Traditional deterministic risk assessment methods (Urban and Cook 1986) are slowly being replaced by probabilistic methods which tend to better characterize potential risk (Johnston et al. 2005) and comparative analysis models are being used to compare attributes of active ingredients and products (Erickson and Urban 2004).

Second generation anticoagulant rodenticides, primarily brodifacoum, are the usual choice for an eradication effort. These compounds have more acute toxicity than the first generation anticoagulants and eradication projects can be successful with only a single bait application. However, their high acute toxicity and propensity to accumulate in tissues also raise the level of concern for non-target hazards. First generation anticoagulants, such as diphacinone, present less initial hazard, however, they must be applied for a longer period of time, raising project costs, and they are less proven for eradication projects. It was noted on several occasions during the Conference that, while brodifacoum has been effectively used in many rodent eradications, several agencies are considering a shift to using more diphacinone or other materials because of their more favorable hazard profile. Acute toxicants, such as zinc phosphide and bromethalin, can be effective alternatives in some situations where previous use of anticoagulants has lead to genetic resistance to anticoagulants. Although zinc phosphide can present high primary toxicity concerns, this compound does not accumulate in tissues and presents little to no concern for secondary hazards (Erickson and Urban 2004)

Probabilistic risk assessment methods allow the incorporation of the likelihood and frequency of an event occurring (such as: baiting parameters, variability around toxicity profiles, temporal variability in species presence or probability of exposure), worst-case analysis, and impact uncertainties. However, there is scientific debate over the quality and relevance of the data being used to conduct the assessments. For example, in urban areas in particular, is it correct to assume natural populations are actually naive to rodenticides? Since most eco-toxicological work is geared toward lethality, do we really understand the impacts sub-lethal exposure can have on individuals, populations, or

food webs? Expert opinion and well thought out assumptions are the basis of ecological risk assessments, but is our data adequate?

WHERE FROM HERE?

While much progress has been made in the control and eradication of invasive rodents, it is clear that many challenges remain. Many of those have been presented in the sections above, but we conclude with a list that was compiled on the last day of the Conference. These were considered key points that need to be addressed to gain a better understanding of how to successfully carry out eradication efforts while minimizing the ecological impacts.

1. More effort should be placed on the development and evaluation of diphacinone as an eradication tool.
2. How do we determine the cut-off on when we have adequate techniques and knowledge of the specific situation to proceed with control or eradication versus needing additional field trials or research studies?
3. How can non-toxicant-based techniques be used in effective ways to reduce use of toxicants?
4. How do we increase public education, involvement, and support?
5. How can we improve long-term monitoring and how do we respond when a rodent is detected?
6. More contact with the National Invasive Species Council and other stakeholders should be made to promote invasive rodent management at the national level for increased action and support.
7. How do we effectively use maintenance baiting in high-risk areas?
8. More publication of successes, responses to control efforts, and the economics of control and eradication programs is needed.
9. We need more synthesizing of what we know: what's been tried? What works and doesn't work? What are the major issues that remain and potential solutions? What can be applied to other species and settings?

Finally, because rodent control for conservation purposes is such a shifting arena with frequent new developments in approaches and changes in the regulatory environment, attendees concluded that it would be useful for the Invasive Rodent Summit to be repeated every two or three years.

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