Wildlife Services

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National Wildlife Research Center

FY 2010

Seeking Solutions Through Research

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Wildlife Services On-going Research & Development

Table of Contents

USDA APHIS
United States Department of Agriculture
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National Wildlife Research Center & Field Sites
Web site: www.aphis.usda.gov/wildlife_damage/nwrc/

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Reducing Wildlife Hazards to Aircraft

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Major Cooperators

- Federal Aviation Administration
- Airports across the United States
- Airline Pilots Association
- Port Authority of New York and New Jersey
- National Park Service
- U.S. Air Force Bird Air Strike Hazard (BASH) Team at Kirtland Air Force Base
- U.S. Air Force
- U.S. Army
- U.S. Marine Corp
- U.S. Dept. of Navy
- National Association of State Aviation Officials
- North Carolina Division of Aviation
- Auburn University
- North Carolina State University
- Michigan State University
- Indiana State University
- Purdue University
- Mississippi State University
- Oklahoma State University
- National Center for Atmospheric Research

Groups Affected by These Problems

- Airline passengers
- Airline pilots
- Airline administrators
- Aircraft and engine manufacturers
- Insurance underwriters
- Military pilots and aircrews
- Residents near airports

National Wildlife Research Center Scientists Study Wildlife Hazards On and Near Airports

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques. The NWRC field station in Sandusky, OH, is dedicated to providing a scientific foundation for WS and Federal Aviation Administration (FAA) programs that reduce wildlife collisions with aircraft. Consequently, the scientists work closely with the FAA and WS airport programs throughout the nation.

To be certified for commercial passenger traffic by the FAA, many U.S. airports are required to develop and implement a wildlife hazard management plan. The FAA strongly discourages any management practice that might create an attractant to wildlife in the vicinity of an airport. NWRC scientists conduct research to provide guidance to the FAA regarding mitigation of wildlife-aircraft strike hazards. NWRC research is focused on understanding the nature of wildlife hazards on and near airports, developing management tools to reduce those hazards, and providing WS, airport personnel, and the FAA with information on the latest strategies for controlling wildlife hazards.

Applying Science and Expertise to Wildlife Challenges

Wildlife Habitat Management and Other Land-Use Studies— Habitat management is fundamental in reducing wildlife use of airfields. NWRC scientists have studied vegetation types and vegetation management practices to identify strategies for making areas on and near airports less attractive to wildlife. For example, researchers examined the foraging preferences of Canada geese among commercially available turfgrasses and are providing recommendations to airport officials across the United States about vegetation types that do not attract grazing geese. NWRC scientists also are evaluating wildlife use of various agricultural crops to determine whether some may be safe for planting on and near airports.

Safe management of stormwater runoff on and near airports is another focus of research. NWRC scientists and WS biologists have developed models of bird use of stormwater-detention ponds and identified factors that discourage birds from using these facilities, particularly within airport approach/departure zones. Researchers suggest that stormwater ponds be located as far away as possible from other water resources, but recommend a minimum of one kilometer of separation between a planned stormwater facility and other water resources. Currently, NWRC scientists and university colleagues are modeling bird use of stormwater ponds that are characteristic of facilities found near certificated airports. This research will aid in the design of new airport facilities.

Bird Movements On and Near Airports— Biologists quantify bird movements in relation to airport locations and aircraft flight patterns to better understand wildlife strike risks. Researchers studying neck-collared Canada geese near John F. Kennedy International Airport in New York found that individual birds remained within five kilometers of their original marking location more than 90 percent of the time. In addition, 78 percent of locations used by the marked geese were within eight kilometers of the airport, indicating that site-specific management of Canada geese within eight kilometers of the airport will likely reduce the risk of goose strikes. NWRC scientists are also studying the movements of raptors such as bald eagles, osprey, red-tailed hawks, and vultures around commercial and military airports. These studies provide detailed information on daily and seasonal bird movements, the timing of bird activities, and altitudes at which birds fly. By analyzing the airspace used by both birds and aircraft, researchers are able to quantify the risk birds pose to civil and military flight operations.

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Exploiting Wildlife Anti-Predation Behaviors and Visual Ecology to Reduce Hazards to Aviation— By understanding factors that control wildlife responses to predation events, scientists can better discern the mechanisms that underlie responses of wildlife to different types of human activities, such as aviation. For example, variations in animal visual capabilities and other sensory systems may shed light on how animals detect and avoid threats from approaching aircraft, other vehicles, wind turbines and communication towers. NWRC scientists, along with university and private partners, are working to enhance animal detection and avoidance behaviors related to vehicle approach using vehicle-based lighting treatments. Studies show that vehicle lighting (varied by pulse frequency) can be used to enhance a bird's abilities to detect and avoid approaching ground-based vehicles and aircraft. Researchers also found that the response of a species to an approaching vehicle depends not only on its visual capacity but also on its innate response to predators. For example, with a reduced ability to visually track an object, brown-headed cowbirds were especially alert to an approaching vehicle under specific vehicle-lighting treatments, which might also cause them to flush earlier to reduce the risk of predation, according to researchers. In contrast, mourning doves—with wider fields of vision and an ability to detect more-distant objects—maintained position, possibly relying on cover for safety.

Evaluating Avian Radar— Recently, the Federal Aviation Administration (FAA) provided NWRC researchers with funding to evaluate the effectiveness of avian radars at airports. The effort brings together experts in wildlife biology, ornithology, radar engineering, and system integration from government, industry, and academia to evaluate the MERLIN Avian Radar System by DeTect, Inc.—one of several radar systems used to detect birds at and near airports. The assessment effort is part of the FAA's overall investigation into the effectiveness of commercially available avian radar detection systems at U.S. civil airports when used in conjunction with other known wildlife management and control techniques. Though it is well established that radar can detect wild birds, there is little published information concerning the accuracy and detection capabilities related to range, altitude, target size, and effects of weather for avian radar systems. NWRC researchers are leading the effort involving experts from the National Center for Atmospheric Research and several universities. Efforts involve 1) a technical evaluation of the candidate radar system, including sensor components and associated data delivery systems, 2) field evaluations of system accuracy using remote controlled aircraft and wild birds, 3) an assessment of the integration of radar technology with other, more traditional aspects of wildlife hazard management at airports, and 4) a behavioral study on the potential effects of radar energy on bird behavior. Information gathered from these studies might contribute to the development of future wildlife hazard mitigation guidelines as part of an integrated wildlife hazard management approach at civilian and military airports across the country.

Selected Publications:

BERNHARDT, G. E., B. F. BLACKWELL, T. L. DEVAULT, AND L. KUTSCHBACH-BROHL. 2010. Fatal injuries to birds from collisions with aircraft reveal anti-predator behaviours. Ibis 152:830-834.

BERNHARDT, G. E., L. KUTSCHBACH-BROHL, B. E. WASHBURN, R. B. CHIPMAN, and L. C. FRANCOEUR. 2010. Temporal variation in terrestrial invertebrate consumption by laughing gulls in New York. American Midland Naturalist 163:442-454.

BLACKWELL, B. F., T. L. DEVAULT, AND E. FERNANDEZ-JURICIC. 2009. Wildlife collisions with aircraft: a missing component of land-use planning for airports. Landscape and Urban Planning 93:1-9.

BLACKWELL, B. F., E. FERNANDEZ-JURICIC, T. W. SEAMANS, AND T. DOLAN. 2009. Avian visual system configuration and behavioural response to object approach. Animal Behaviour 77:673-684.

BLACKWELL, B. F., AND T. W. SEAMANS. 2009. Enhancing the perceived threat of vehicle approach to deer. Journal of Wildlife Management 73:128-135.

DEVAULT, T. L., J. E. KUBEL, O. E. RHODES JR., AND R. A. DOLBEER. 2009. Habitat and bird communities at small airports in the midwestern USA. Proceedings of the Wildlife Damage Management Conference 13:137-145.

GLISTA, D. J., T. L. DEVAULT, AND J. A. DEWOODY. 2009. A review of mitigation measures for reducing wildlife mortality on roadways. Landscape and Urban Planning 91:1-7.

KEIRN, G., J. CEPEK, B.F. BLACKWELL, AND T.L. DEVAULT. 2010. On a quest for safer skies. The Wildlife Professional Summer 2010:52-55.

KUTSCHBACH-BROHL, L., B. E. WASHBURN, G. E. BERNHARDT, R. B. CHIPMAN, AND L. C. FRANCOEUR. 2010. Arthropods of a semi-natural grassland in an urban environment: the John F. Kennedy International Airport, New York. Journal of Insect Conservation 14:347-358.

SEAMANS, T. W., S. E. CLEMONS, AND A. L. GOSSER. 2009. Observations of neck-collared Canada geese near John F. Kennedy International Airport, New York. Human-Wildlife

Major Research Accomplishments:

- WS established the efficacy of an endophyte-infected tall fescue variety and Zoysiagrass (warm season grasses native to China, Japan and other parts of Southeast Asia) in reducing foraging by Canada geese.
- WS and academic colleagues partnered in an on-going research effort to develop new guidance on the design of stormwater-management facilities on and near airports to reduce use by wildlife.
- WS studied the movement patterns of birds, such as bald eagles, osprey, and Canada geese. Researchers studying radio-collared and neck-collared Canada geese found that individual birds remained within five kilometers of their original marking location more than 90 percent of the time.
- WS partnered with colleagues in academia and private industry to develop and patent devices that enhance wildlife avoidance behaviors in response to approaching vehicles (e.g., aircraft).
- WS and partners are evaluating the effectiveness of commercially available avian radar detection systems at U.S. civil airports when used in conjunction with other known wildlife management and control techniques.

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Reducing Avian Predation in Aquaculture Systems

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Major Cooperators

- Catfish Farmers of America
- Canadian Wildlife Service
- Cornell University
- Michigan Department of Natural Resources
- Mississippi State University, College of Veterinary Medicine
- Mississippi State University, Department of Wildlife and
- Fisheries, and Aquaculture
- Mississippi Agricultural and Forestry Experiment Station
- Delta Research and Extension Center, Thad Cochran National Warmwater Aquaculture Center
- New York Department of Environmental Conservation
- Ontario Ministry of Natural Resources
- Ontario Parks
- Southern Regional Aquaculture Center
- Vermont Fish and Game Department

Groups Affected by These Problems

- Aquaculture producers, distributors and retailers
- Sportfish guides and outfitters
- Wildlife managers

National Wildlife Research Center Scientists Address Aquaculture Losses

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective and environmentally and socially responsible methods, tools, and techniques. The NWRC's field station in Starkville, MS, is located in the heart of the primary aquaculture producing area of the southeastern United States and was established to develop methods to reduce the impacts of fish-eating birds on aquaculture stocks.

In the past 35 years, populations of fish-eating birds have increased dramatically and caused substantial economic impacts to aquaculture production. Aquaculture industry costs associated with bird damage and damage prevention are estimated to exceed $25 million annually. The goal of NWRC's research is to determine the impact of fish-eating birds on aquaculture production and natural resources and to develop methods to reduce depredation impacts on southeastern catfish, baitfish, and crawfish industries. Current research is aimed at gaining information about the abundance, distribution, and foraging behavior of fish-eating birds, economic impacts associated with their foraging activities, and diseases they transmit at aquaculture facilities. Information gathered as a consequence of this research provides new strategies, techniques, and tools for reducing damage.

Applying Science and Expertise to Wildlife Challenges

Population Trends— NWRC scientists are studying population trends, demographics, and movement patterns of double-crested cormorants and American white pelicans by tracking large-scale movements through the use of telemetry and banding techniques. Satellite telemetry data reveal significant migratory connectivity in cormorants, and indicate a migratory divide across the Great Lakes, with western populations wintering mainly in the lower Mississippi alluvial valley, and eastern populations in the US Atlantic States. This research clarifies population trends and movements of fish-eating birds and will be used to evaluate various alternatives for managing impacts of these birds on commercial and natural resources.

Cormorant Damage to Catfish Aquaculture— The catfish industry in the United States is valued at more than $650 million per year in processed product sales, with nearly 65% of catfish production originating from Mississippi. NWRC biologists recently completed a decade-long field study that utilized data on cormorant food habits, bioenergetics, distribution and abundance to evaluate cormorant impacts on catfish aquaculture. Cormorants used catfish ponds extensively from January through April, with the greatest economic damage occurring in February and March. During this study, between 1,347 and 1,775 metric tons of catfish were consumed by cormorants in the Delta region of Mississippi. This depredation translated into a loss to the industry of $10.3 to $13.7 million annually or approximately 4-5% of farm level value.

Cormorant Movements— NWRC scientists used satellite telemetry to evaluate movements and migration patterns of double-crested cormorants captured near southeastern catfish aquaculture ponds. Results demonstrated that cormorants migrated along the Mississippi, Missouri, and Ohio River Valleys. The average duration of spring migration was 12 days, traveling 43 miles/70 km per day. These data indicate that cormorants tend to stay in one general region throughout winter if adequate food resources are available and their roosting sites are undisturbed; the data also provide further evidence that aquaculture is utilized extensively by wintering cormorants. Aquaculturists and resource managers are using these data to refine cormorant management strategies.

Cormorant Breeding Colony Dynamics— NWRC scientists and partners conducted a long-term study of cormorant breeding colony dynamics in the Great Lakes. This research

was a cooperative effort, involving Mississippi State University, the Canadian Wildlife Service, Ontario Ministry of Natural Resources, Ontario Parks, and Trent University. Survival estimates indicate approximately 80 percent mortality for first year birds, decreasing to over 20 percent thereafter. The data indicate some regional differences in reproductive parameters and suggest that management decisions should be based on local or regional population information. Population models reveal that a combination of adult culling and egg oiling would have the greatest efficacy for reducing population growth.

Aging Cormorants— NWRC scientists and collaborators at West Virginia University have identified a biomarker in the skin that is a linear ($R^2 = 0.93$) predictor of age in double-crested cormorants. This information may lead to a rapid technique for identifying the age of cormorants and many other species of birds without the need for more costly and logistically difficult methods. This technique will help quantify the demographics of cormorant populations, allowing for the optimization of management strategies for maintaining population viability while minimizing damage.

Cormorant Diet— NWRC scientists used fatty acid profiles to distinguish between game fish and farm-raised channel catfish in the fatty tissue of double-crested cormorants. Results indicated that it may be possible not only to distinguish between farm-raised channel catfish and game fish in the diet of cormorants, but also to identify the sources of the farm-raised channel catfish. Biologists and chemists are continuing to investigate the possibility of using fatty acid profiles to assess the actual impact of fish-eating birds on catfish aquaculture and recreational fisheries.

Harassment of Cormorants— NWRC scientists evaluated the utility of harassment programs involving spring migrating cormorants for reducing predation on vulnerable spawning stocks of walleye and yellow perch at two locations in Michigan. Overall, harassment deterred 90 percent of cormorant foraging attempts, with an average of less than 6 percent of the cormorants taken lethally at each site. Both walleye and yellow perch abundance increased significantly at each location. These results support the hypotheses that cormorant predation on spawning aggregations of sportfish is a significant mortality factor and that cormorant management can reduce sportfish mortality and increase fish abundance. Continuation of cormorant harassment programs and fishery assessments will determine whether improvement of targeted sport fisheries is sustained.

American White Pelican Disease Ecology— In collaboration with parasitologists at Mississippi State University College of Veterinary Medicine, the Thad Cochran Warmwater Aquaculture Center, and the Southern Regional Aquaculture Center, NWRC scientists described the life cycle for a virulent species of trematode infecting catfish in the southeastern United States and confirmed that American white pelicans serve as a host for this parasite. Results indicated that American white pelicans can transmit this parasite among catfish ponds. Double-crested cormorants, great blue herons, and great egrets did not appear to serve as hosts for these trematodes. Parasite life-cycle studies indicate that even a low infection of trematodes in pelicans can result in large numbers of trematode eggs deposited into catfish ponds. In addition, NWRC scientists confirmed that an introduced species of snail can serve as an intermediate host to the parasite. These studies underscore the importance of preventing pelican use of aquaculture facilities and understanding the biology and epidemiology of the disease organism.

Management Activites on Nesting Cormorants— Large colonies of double-crested cormorants breed in the Les Cheneaux Islands region of Lake Huron, Michigan. NWRC scientists and colloborators evaluated the effectiveness of Wildlife Services cormorant management as a means of improving the local yellow perch fishery. Management activities included egg-oiling and lethal control. Research documented an 83 percent decline in the number of cormorant foraging attempts and an increase in yellow perch and walleye abundance at locations where these management activities were in place. Management also resulted in reductions of over 90 and 70 percent in the annual numbers of young cormorants produced and total comorants, respectively.

Feeding Behavior and Diet of Black-Crowned Night Herons— Little is known about the effects of black-crowned night herons on catfish production in the southeastern United States. Because these fish-eating birds inhabit important catfish production areas and, opportunistically, exploit abundant food resources, NWRC researchers monitored the movements of free-ranging night herons to document their nocturnal use of catfish ponds in Mississippi and assess their potential impacts on catfish aquaculture facilities. Bird observations showed selective or clumped use of aquaculture ponds and stomach content analysis revealed catfish fingerlings in 72 percent of night herons sampled. Birds arrived and used the area during the summer and early fall of each year and were gone by January. More research is needed to document the birds' economic impact.

Selected Publications:

DOFFITT, C. M., L. M. POTE, AND D. T. KING. 2009. Experimental *Bolphorus damnificus* (Digenea: Bolbophoridae) infections in piscivorous birds. Journal of Wildlife Diseases 45:684-691.

DORR, B. S., T. ADERMAN, P. H. BUTCHKO, AND S. C. BARRAS. 2010. Management effects on breeding and foraging numbers and movements of double-crested cormorants in the Les Cheneaux Islands, Lake Huron, Michigan. Journal of Great Lakes Research 36:224-231.

DORR, B. S., A. MOERKE, M. BUR, C. BASSETT, T. ADERMAN, D. TRAYNOR, R. D. SINGLETON, P. H. BUTCHKO, AND J. D. TAYLOR II. 2010. Evaluation of harassment of migrating double-crested cormorants to limit depredation on selected sport fisheries in Michigan. Journal of Great Lakes Research 36:215-223.

FIKE, J. A., T. L. DEVAULT, AND O. E. RHODES. 2009. Identification of 24 polymorphic microsatellite markers for the double-crested cormorant (*Phalacrocorax auritus*). Molecular Ecology Resources 9:1183-1185.

KING, D. T., B. F. BLACKWELL, B. S. DORR, AND J. L. BELANT. 2010. Effects of aquaculture on migration and movement patterns of double-crested cormorants. Human-Wildlife Interactions 4:77-86.

KING, T., J.BELANT, B.HARREL, and J.GLAHN. 2010. Superabundant food improves body condition in American White Pelicans. Waterbirds 33:221-227.

SOVADA, M.A., P.J. PEITZ, K.A. CONVERSE, D.T.KING, E.K. HOFMEISTER, P. SCHERR, and H.S. Ip. 2008. Impact of West Nile virus and other mortality factors on American white pelicans at breeding colonies in the northern plains of North America. Biological Conservation 141:1021-1031.

YOST, M. C., L. M. POTE, D. J. WISE, B. S. DORR, and T. D. RICHARDSON. 2009. *Biomphalaria havanensis* identified as a potential intermediate host for the digenetic trematode *Bolbophorus damnificus*. North American Journal of Aquaculture 71:10-15.

Major Research Accomplishments:

- WS research showed double-crested cormorants tend to stay in one general region throughout winter if adequate food resources are available and their roosting sites are undisturbed. These data provide further evidence that aquaculture provides an ideal environment for wintering cormorants.
- WS and collaborators identified a biomarker in the skin of double-crested cormorants that is a linear predictor of age.
- WS research showed fatty acid profiles developed from cormorant fatty tissues can distinguish between game fish and farm-raised channel catfish in the diet of cormorants.
- WS and their cooperators demonstrated that American white pelicans are a host of the *Bolbophorus* trematode, which can be devastating to the catfish aquaculture industry.
- WS research documented a large decline in numbers of double-crested cormorant foraging attempts, and an increase in walleye populations at lakes in Michigan as a result of an ongoing cormorant management program.

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Avian and Invasive Species Population Management

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Major Cooperators

- Florida Power and Light Company
- Innolytics, LLC
- National Park Service
- U.S. Navy
- U.S. Geological Survey
- U.S. Fish and Wildlife Service

Groups Affected By These Problems

- Airports
- Airlines
- Air travelers
- Homeowners
- Business owners
- City managers
- Military installations
- Electric utility companies
- Broadcast and communication tower owners and operators

National Wildlife Research Center Scientists Address Problems Associated with Invasive Species and Overabundant Bird Populations

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques.

Scientists at NWRC's field station in Gainesville, FL, conduct research to resolve problems caused by invasive species, such as Burmese pythons and monk parakeets, and overabundant native bird species, such as vultures and crows. This research facility is a uniquely designed 26-acre site with large outdoor test pens and aviaries which allow research to be conducted under natural environmental conditions.

As land-use patterns change and urban populations surge into previously uninhabited areas, wildlife conflicts, inevitably, increase. Of growing concern are problems associated with some abundant native bird species that have shown the capacity to readily adapt to residential settings. Additionally, populations of invasive or non-native species, such as feral pigeons, monk parakeets, Burmese pythons and Nile monitors, continue to grow with increasing detrimental impacts to native ecosystems and human health and safety.

Applying Science & Expertise to Wildlife Challenges

Reduction of an Invasive Sacred Ibis Population in South Florida— The "sacred ibis" is a non-native bird from Africa that is seen as a threat to many species native to Florida. This bird is also present in Europe, where it has demonstrated an ability to adapt to human altered environments and spread into natural areas, competing with and preying upon native species. In south Florida, a burgeoning sacred ibis population has developed in recent years. Because of its documented negative impacts in other countries, the sacred ibis population in Florida was identified by agency partners of the Everglades Cooperative Invasive Species Management Area (ECISMA) for rapid response and removal. In 2009, NWRC biologists worked with WS staff in Florida, along with other Federal and State officials, to locate and recover free-flying ibis. Part of this operation involved outfitting ibis with satellite transmitters to help determine the birds' roosting and feeding locations. Recovery efforts resulted in the removal of 73 birds from south Florida, and there have been no subsequent ibis sightings in the area. Monitoring efforts continue to verify that all birds have been found and removed.

Monitoring Vulture Movements With Satellite Telemetry and Avian Radar— Many wildlife management efforts require researchers to monitor the location and movements of animals in situations where it is difficult to detect and monitor individuals visually. Radar and satellite Global Positioning System-Platform Transmitter Terminal (GPS-PTT) transmitters may be useful in these situations, as they provide complementary information on the movements and behaviors of individual animals. The newest GPS-PTT technology can report altitude, speed, and heading in addition to position (latitude and longitude). By updating the data at hourly intervals, a researcher can sample an animal's behavior and location. Digital avian radars, on the other hand, can detect and track birds on a more continuous basis (e.g., every 2.5 seconds, depending on the antenna rotation speed). However, the technology has limitations; radar cannot be used to identify birds by species, let alone distinguish individual birds from one another. Scientists must use other approaches to obtain this information.

NWRC researchers integrated data from both radar and GPS-PTT to continuously monitor the behavior and movements of tagged vultures. Radar detected 40 percent of the locations of vultures carrying GPS-PTT tags that were within 3 miles/5 kilometers of the radar. Approximately 75 percent of the undetected locations were calculated to be above

or below the radar's antenna beam. Speed and direction values recorded by the GPS-PTT tags and the radar were poorly correlated because the vultures were soaring and circling, which produced rapid changes in their azimuth (angular measurement/direction) and ground speed. Nevertheless, findings show that combining these two techniques allows for the monitoring of species when it is otherwise difficult to follow identified individual birds.

Assessing Allowable Take of Migratory Birds— Black vulture populations are expanding throughout the eastern United States, causing an increase in associated problems involving livestock predation, property damage, and aviation strike hazards. Wildlife managers need more reliable methods to determine how many birds can be removed for damage management purposes without endangering the future sustainability of the population. To help address this issue, NWRC scientists and biologists from U.S. Geological Survey and U.S. Fish and Wildlife Service collaborated to develop a method for determining allowable take. Their analysis indicates that greater numbers of birds could be culled than what is currently permitted without adversely affecting population levels. Called "Prescribed Take Level," the method developed in this study includes an estimate of the minimum size of the animal population, its maximum growth rate, and a variable determined by wildlife managers, based on the specific management objective and acceptable risk. Precisely estimating local vulture populations is difficult, due to uncertainties about the birds' lifespan and breeding habits. The researchers relied on annual bird-count data from the Breeding Bird Survey and studies of radio-tagged vultures. This method has great potential value for wildlife management efforts, as it can be adapted for use with other species and situations, such as the incidental take of depleted species, sport harvest, or nuisance control.

Burmese Python and Nile Monitor Lizard Bait Preferences— The pet industry legally sells Burmese pythons and Nile monitor lizards in the continental United States; however, these reptiles have become established invasive species in Florida. Most likely, they were introduced into the environment by escaping from captivity or through intentional release by their owners or by pet traders to establish populations that could be culled and sold. Invasive populations of Burmese pythons and Nile monitor lizards need to be controlled and eradicated because both species can survive in ecologically sensitive habitats where they pose serious threats to native wildlife. While there are no established, systematic, operational control techniques for these reptiles, Florida State and Federal agencies have initiated inquiries and meetings for developing control strategies. Acetaminophen, currently used in an integrated program for controlling brown tree snakes on Guam, could have a role in controlling pythons and lizards. In 2009, NWRC investigators found that acetaminophen-treated dead neonatal mouse baits are lethal to both small pythons and lizards. In anticipation of the development of acetaminophen as an oral toxicant for these two species, NWRC researchers also conducted bait evaluations to determine bait preference for pythons and lizards. Only two of the nine baits tested—a dead neonatal mouse and quail chick—were accepted by both pythons and lizards.

Effects of Cold Weather on Burmese Pythons— The Burmese python has invaded and become established in Everglades National Park and neighboring areas in south Florida. Beyond its substantial ecological impacts to native fauna in south Florida, there have been concerns about its potential to occupy other parts of the United States, even areas as far north as Washington, D.C. During a period of cold weather, seven of nine captive Burmese pythons held in outdoor pens at the NWRC field station in Gainesville, FL, died or would have died in the absence of intervention. This cold-induced mortality occurred despite the presence of refugia with heat sources. These serendipitous findings cast doubt on the ability of free-ranging Burmese pythons to establish and persist beyond the subtropical environment of south Florida.

Selected Publications:

AVERY, M. L., R. M. ENGEMAN, K. L. KEACHER, J. S. HUMPHREY, W. E. BRUCE, T. C. MATHIES, AND R. E. MAULDIN. 2010. Cold weather and the potential range of invasive Burmese pythons. Biological Invasions 12:3649-3652.

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ENGEMAN, R., B. U. CONSTANTIN, S. HARDIN, H. SMITH, AND JR. W. E. MESHAKA. 2009. "Species pollution" in Florida: a cross-section of invasive vertebrate issues and management responses. Pages 179-197 *in* C. P. Wilcox and R. B. Turpin, editors. Invasive species: detection, impact, and control. Nova Science Publishers, Hauppauge, New York.

GONCALVES DA SILVA, A., J. R. EBERHARD, T. F. WRIGHT, M. L. AVERY, AND M. A. RUSSELLO. 2010. Genetic evidence for high propagule pressure and long-distance dispersal in monk parakeet (*Myiopsitta monachus*) invasive populations. Molecular Ecology 19:3336-3350.

MOULTON, M. P., W. P. CROPPER JR., M. L. AVERY, AND L. E. MOULTON. 2010. The earliest house sparrow introductions to North America. Biological Invasions 12:2955-2958.

RUNGE, M. C., J. R. SAUER, M. L. AVERY, B. F. BLACKWELL, AND M. D. KONEFF. 2009. Assessing allowable take of migratory birds. Journal of Wildlife Management 73:556-565.

Major Research Accomplishments:

- WS developed crucial information for a black vulture management model that provides a scientific basis for evaluating impacts of lethal control on sustainability of populations.
- WS provided key research findings for the development and registration of acetaminophen to reduce populations of nonnative Burmese pythons and Nile monitor lizards.
- WS observed cold-induced mortality to Burmese pythons casting doubt on the ability of free-ranging Burmese pythons to establish and persist beyond the subtropical environment of south Florida.

Wildlife Services

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National Wildlife Research Center

FY 2010

Reducing Blackbird and Starling Conflicts

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Major Cooperators

- Louisiana Rice Research Board
- Louisiana Rice Producers Association
- Louisiana Blackbird Committee
- USA Rice Federation
- Louisiana Rice Research Station (LSU)
- Delta Research Station (MU)
- Missouri Rice Research and Merchandising Council
- Gowan Company
- Syngenta Crop Protection
- National Sunflower Association
- North Dakota State University
- North Dakota Department of Agriculture
- Kansas Feedlot Association
- Indianapolis Downtowners Association
- Ohio Dairy Association

Groups Affected By These Problems

- Rice, sunflower, and corn producers
- South Dakota Oilseed Council
- North Dakota Department of Agriculture
- South Dakota Department of Agriculture
- Feedlot Owners Association
- Consumers of sunflower, rice, corn and other products
- Processors, manufacturers, suppliers, and sellers of sunflower, rice, and corn products
- Utility companies

National Wildlife Research Center Scientists Address the Concerns of Farmers, and Feedlot, Dairy and Urban Area Managers

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques. NWRC's field station in Bismarck, ND, evaluates and develops methods for managing national blackbird damage to sunflower, rice, and corn in the Great Plains. The field station also assists with national problems involving European starling damage and diseases in urban areas, feedlots, and dairies as well as woodpecker damage to utility structures and buildings.

Blackbirds and starlings damage grain crops and eat livestock feed, resulting in significant economic losses for agricultural producers. NWRC scientists are studying ways to refine current damage abatement methods and develop new methods for reducing damage. Additionally, researchers are looking for methods to expand capabilities for targeting specific problem-causing birds. Red-winged blackbirds, common grackles, yellow-headed blackbirds and brown-headed cowbirds cause an estimated $20 million worth of damage to newly planted and ripening rice in Arkansas, California, Louisiana, Missouri and Texas, $15 million worth of sunflower damage in North Dakota and South Dakota, and $35 million worth of damage to ripening and newly planted corn nationally. Some individual rice and sunflower growers report 100 percent in losses due to bird depredation.

NWRC scientists routinely work with producers, commodity groups, research boards, universities, and local, State and Federal agencies to develop safer and more effective methods to reduce bird depredation on seeded and ripening sunflower, corn and rice and improve profitability for growers. To develop new methods and tools, NWRC scientists conduct multifaceted research studies involving the use of both captive and free-ranging birds to determine the status of blackbird populations in the sunflower-, corn- and rice-growing States, estimate the economic impacts of birds on the crops, evaluate and develop nonlethal repellants for deterring birds and improve the effectiveness and safety of avicides for reducing depredating populations.

Applying Science and Expertise to Wildlife Challenges

Conservation Sunflower Plots Benefit Birds and Farmers— Large flocks of blackbirds congregate in the northern Great Plains from August to October in preparation for a strenuous migration to southern wintering areas. Blackbirds acquire energy for migration by eating agricultural crops, especially sunflower. Red-winged blackbirds, common grackles and yellow-headed blackbirds cause most of the damage. Sunflower producers in North Dakota and South Dakota lose $15 million to blackbirds annually. Approximately 988,000 acres of sunflower are planted annually in North Dakota, more than any other state.

NWRC and North Dakota State University (NDSU) researchers examined migratory bird use of croplands in North Dakota and found species diversity and densities to be highest in wildlife conservation sunflower plots (WCSP) compared to commercial sunflower or other non-sunflower row-crops such as corn, soybeans and wheat. The research findings aid in the development of guidelines for future WCSP placement and management to improve migratory bird habitat while retaining productive agricultural practices.

WCSP (or "lure" crops) are a nonlethal wildlife damage management method used to reduce blackbird damage to ripening commercial sunflower crops. The goal is to keep birds in the WCSP as long as possible, thereby reducing the time they spend feeding in nearby commercial sunflower fields. The most successful WCSP for reducing blackbird damage are those planted between wetlands and commercial fields. NWRC scientists

and NDSU collaborators observed more dense communities of fall migratory birds in WCSP and commercial sunflower fields compared to other non-sunflower crops.
The cost-benefits associated with WSCP are still being evaluated; however, scientists are hopeful that the proper placement and management of WCSP will provide sunflower producers with an economically viable nonlethal blackbird damage management option that also improves wildlife habitat for other migratory birds.

Starling Population Management Modeling— Urban areas, feedlots and dairies are major gathering sites of European starlings in the winter. Starlings eat valuable livestock feed, defecate on livestock, facility superstructures, feeder troughs and feed and are a potential reservoir of diseases transmissible to livestock and humans. WS personnel manage starling numbers with an avicide, but, previously, lacked a standardized methodology to estimate mortality at feedlots and dairies. NWRC scientists developed a bioenergetics model for estimating bird mortality during baiting operations using DRC-1339. The information is used to document the avicide's effectiveness and impact on target species as part of the National Environmental Policy Act.

Chemical Repellents for Sunflower— NWRC scientists continue to develop the use of 9,10- anthraquinone (AQ) for repelling birds from newly planted seeds and ripening crops. Ring-necked pheasants can cause localized damage to newly planted sunflower. Ring-necked pheasants avoided emergent seedlings treated with 15800 ppm AQ seed treatments during a caged preference test. Researchers conducted laboratory and field efficacy studies with common grackles and AQ-treated confectionary sunflower. Captive common grackles reliably discriminated between untreated sunflower and seeds treated with 1300-ppm AQ. During a field efficacy study for ripening confectionary sunflower, NWRC scientists observed 18 percent damage among AQ-treated enclosures and 64 percent damage among untreated enclosures populated with common grackles. Supplemental field efficacy studies are still needed for the development of AQ-based repellents for managing avian depredation of ripening agricultural crops, including oilseed sunflower. Information from this and other studies will be used in the registration of future repellents with the U.S. Environmental Protection Agency.

Radio-telemetry to Monitor European Starling Movements— To learn more about the movements of invasive European starlings, NWRC scientist attached small radio transmitters to starlings in downtown Indianapolis, Indiana and Omaha, Nebraska; at five dairy farms in Ohio; three feedlots in Kansas; and in central New Jersey. Scientists found that starlings move readily among farms, feedlots and cities. Birds captured in central New Jersey were less consistent in their daily use of areas and were less cohesive in their roosting aggregations compared to similar populations in Midwest landscapes with a higher percentage of agricultural habitats. These results are significant because starlings can carry transmissible gastroenteritis (TGE), *E. Coli*, *Salmonella* spp., and Johne's disease. These pathogens can result in death and illness in pigs and cattle, costing nearly $1 billion in losses annually.

Anthraquinone To Alleviate Non-Target Take From Rodenticides— Rodenticides are a key component for crop protection, and reducing non-target exposure to rodenticides is an important consideration in the maintenance of existing pesticide labels and the development of new rodent control methods. In an effort to reduce the non-target risk associated with rodenticides, NWRC scientists explored the possibility of adapting currently registered bird repellents (i.e., anthraquinone) for incorporation into these materials. NWRC studies showed that adding an anthraquinone repellent prevents the consumption of rodenticide baits by Canada geese and ring-necked pheasants. Captive geese avoided baits treated with 2-percent zinc phosphide (typical concentration level used in rodenticide applications) and 2- to 2.5-percent anthraquinone (Arkion® Life Sciences). Although some geese and pheasants initially sampled treated baits, all birds subsequently avoided treated baits. No mortality or signs of zinc phosphide poisoning were observed among 10 geese and 40 pheasants that were offered the repellent-treated zinc phosphide baits.
Additional NWRC studies are underway to evaluate the efficacy of the new anthraquinone-zinc phosphide bait for target rodent species. NWRC researchers also plan to investigate the possible uses of this new bait in reducing non-target hazards with other pesticides, to compare costs relative to expected damage at unmanaged sites, and to assess the bait's environmental impacts.

Woodpecker Deterrent for Utility Pole Crossarms— Woodpeckers cause millions of dollars in damage to wooden utility pole structures around the world by pecking or drumming at the structures when searching for insects, announcing their territory, or excavating nesting or roosting cavities. The resulting damage presents a safety hazard to utility workers, promotes decay (due to water entrapped in the holes), necessitates premature replacement, and can lead to collapse under adverse conditions. In the United States, pileated woodpeckers *(Dryocopus pileatus)* cause some of the most severe damage to poles.

In captive studies at the NWRC, researchers evaluated the effectiveness of a polyurea elastomer coating material being applied in a process developed by Brooks Manufacturing Company (Bellingham, WA) to eliminate or reduce damage to crossarms by pileated woodpeckers. Pileated woodpeckers captured and later returned to national forests in Missouri and Arkansas were presented with coated and non-coated crossarms. Fully coated crossarms received no measurable damage, whereas woodpeckers severely damaged non-coated crossarms. More studies are needed to determine whether coated wood crossarms are more cost effective than other materials over the lifetime of the utility structure.

Selected Publications:

BYRD, R. W., J. L. CUMMINGS, S. K. TUPPER, and J. D. EISEMANN. 2009. Evaluation of sodium lauryl sulfate as a blackbird wetting agent. Proceedings of the Wildlife Damage Management Conference 13:191-196.

HAGY, H. M., G. M. LINZ, and W. J. BLEIER. 2010. Wildlife conservation sunflower plots and croplands as fall habitat for migratory birds. American Midland Naturalist 164:119-135.

GALLE, A. M., G. M. LINZ, H. J. HOMAN, and W. J. BLEIER. 2009. Avian use of harvested crop fields in North Dakota during spring migration. Western North American Naturalist 69:491-500.

GAUKLER, S. M., G. M. LINZ, J. S. SHERWOOD, N. W. DYER, W. J. BLEIER, Y. M. WANNEMUEHLER, L. K. NOLAN, and C. M. LOGUE. 2009. *Escherichia coli, Salmonella,* and *Mycobacterium avium* subsp. *paratuberculosis i*n wild European starlings at a Kansas feedlot. Avian Diseases 53:544-551.

HAGY, H. M., G. M. LINZ, and W. J. BLEIER. 2010. Wildlife conservation sunflower plots and croplands as fall habitat for migratory birds. American Midland Naturalist 164:119-135.

HOMAN, H. J., G. M. LINZ, S. BECKERMAN, A. G. DUFFINEY, and T. D. HALSTEAD. 2010. European starling preferences for bait substrates used in DRC-1339 applications. Human-Wildlife Interactions 4:25-31.

KLOSTERMAN, M., G. M. LINZ, A. A. SLOWIK, and W. BLEIER. 2010. Assessment of bird damage to sunflower and corn in North Dakota. Online: National Sunflower Association Research Forum (http://www. sunflowernsa. com).

SCHAAF, D. A., G. M. LINZ, C. DOETKOTT, M. W. LUTMAN, and W. J. BLEIER. 2010. Non-blackbird avian occurrence and abundance in North Dakota sunflower fields. Prairie Naturalist 40:73-86.

TUPPER, S. K., W. F. ANDELT, J. L. CUMMINGS, C. WEISNER, and R. E. HARNESS. 2010. Polyurea elastomer protects utility pole crossarms from damage by pileated woodpeckers. Journal of Wildlife Management 74:605-608.

WERNER, S. J., J. C. CARLSON, S. K. TUPPER, M. M. SANTER, and G. M. LINZ. 2009. Threshold concentrations of an anthraquinone-based repellent for Canada geese, red-winged blackbirds, and ring-necked pheasants. Applied Animal Behaviour Science 121:190-196.

WERNER, S. J., G. M. LINZ, S. K. TUPPER, and J. C. CARLSON. 2010. Laboratory efficacy of chemical repellents for reducing blackbird damage in rice and sunflower crops. Journal of Wildlife Management 74:1400-1404.

Major Research Accomplishments:

- WS developed a strategy to plant Wildlife Conservation Sunflower Plots to reduce damage to commercial sunflower fields and provide habitat for other animals.
- WS developed a model to estimate the avicide DRC-1339's effectiveness and impact on starling populations.
- WS evaluated the efficacy of 9, 10 anthraquione as a potential blackbird repellent for use on newly planted sunflower, corn, and rice seed to repel feeding pheasants and blackbirds and to reduce blackbird damage to ripening sunflower and rice.
- WS determined that combining anthraquinone with rodenticide baits helps to prevent the consumption of baits by non-target bird species, such as Canada geese and ring-necked pheasants.
- WS evaluated the effectiveness of a polyurea elastomer coating material for eliminating or reducing woodpecker damage to utility pole crossarms.

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Ecology of Emerging Viral and Bacterial Diseases in Wildlife

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Major Cooperators

- USDA/APHIS/Veterinary Services
- DOI/USGS/Biological Resources Division
- DOD/Global Emerging Infections Surveillance and Response System
- Colorado State University
- Iowa State University
- State Departments of Public Health
- Mississippi State University
- Berryman Institute

Groups Affected By These Problems

- U.S. citizens
- U.S. military
- Livestock and poultry producers
- Consumers
- Public health organizations and hospitals
- Wildlife and natural resource managers
- Federal, State and Local governments

National Wildlife Research Center Scientists Examine the Roles of Wildlife in the Transmission and Spread of Emerging Infectious Pathogens

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques.

Considerable concern exists around the world about recent emerging infectious diseases, of which 75 percent are zoonotic, meaning the pathogens causing the disease can be transmitted between animals and humans. Wildlife plays a critical role in both the emergence and increased incidence of diseases transmittable to livestock and humans. In the last two decades, approximately 72 percent of emerging infectious diseases originated in wildlife, such as highly-pathogenic H5N1 avian influenza. Thus, wildlife populations often play a key role in diseases that directly impact humans and agriculture. NWRC is at the forefront of research and surveillance for many of these pathogens.

Avian influenza virus (AIV) is found naturally in waterfowl and other wild bird species. There are 144 known subtypes of AIV but few of these subtypes cause serious diseases in birds. However, mutation of the virus can lead to infection of new wildlife species, domestic livestock, primarily poultry and humans. These mutations can result in AIV strains that are highly pathogenic. For example, the highly pathogenic strain of H5N1 AIV originated from a low pathogenic strain of AIV in wild waterfowl and mutated into a highly pathogenic strain in Asia. This strain, subsequently, spread from Asia across the Eastern Hemisphere and caused considerable economic loss and mortality in domestic poultry, as well as human deaths. Thus, understanding the ecology of low pathogenic strains of AIV in the wild is critical for the prevention of future influenza epidemics and global pandemics that affect both livestock and humans.

Applying Science and Expertise to Wildlife Challenges

Mallards Shed Light on Avian Influenza Viral Shedding and Transmission Through Water— NWRC scientists studied (1) how long, and at what levels mallard ducks shed avian influenza virus, (2) the best sampling methods (i.e., oral-pharyngeal swabs, cloacal swabs, and fecal swabs) for detecting the virus associated with mallards and (3) whether the virus can be transmitted through a water source shared by infected and uninfected mallards. Researchers experimentally inoculated 3-month-old and 6-month-old mallards with a subtype of low pathogenic avian influenza virus commonly found in wild duck populations. Fecal samples had significantly higher virus concentrations than oral-pharyngeal or cloacal swabs, and the older ducks shed significantly more virus than younger ducks regardless of the sample type tested. Uninfected mallards became infected after swimming in a water source that infected ducks had previously used. These results are important for surveillance purposes and suggest that water samples and fecal samples may be excellent alternatives to traditional cloacal and oralpharyngeal swabbing of live-captured waterfowl. Furthermore, duck age may be important when interpreting viral shedding results from experimental infections or surveillance. Differential, age-related shedding could affect prevalence estimates, modeling of virus spread, and subsequent risk assessments.

Development of a New Laboratory Assay To Detect Influenza A Antibodies in Domestic and Wildlife Species— In response to a need for a rapid, reliable, and inexpensive technique for large-scale surveillance of influenza A virus exposure in wildlife, NWRC and Iowa State University (ISU) scientists developed an epitope-blocking, enzyme-linked immunosorbent assay (bELISA) that rapidly detects antibodies to influenza A virus in taxonomically diverse domestic and wild vertebrate species. The researchers compared the efficacy of the bELISA as a serum screening assay to the agar gel immunodiffusion (AGID) assay that is currently used as a screening tool for large-scale influenza surveillance in

poultry. The concordance between the AGID assay and bELISA was 94 percent for experimentally challenged raccoons, but only 71 percent for experimentally challenged mallards. The bELISA was more sensitive than the AGID assay for both species, as demonstrated by the detection of antibodies to influenza A virus in more samples, at earlier time points in experimental infection studies and at higher serial dilutions. In summary, NWRC and ISU succeeded in developing a sensitive, inexpensive, objective, species-independent bELISA platform that can be performed in most laboratories and can screen for a variety of influenza A virus specific subtypes.

Monitoring Highly-Pathogenic H5N1 Avian Influenza in the United States— One potential route for introduction of Asian strain highly pathogenic AIV H5N1 into the United States includes migration of infected wild birds, including ducks, geese and shorebirds from Asia and Europe. Some waterfowl species may be only mildly affected by this AIV strain, and thus, these species may be ideal dispersers of the virus over long distances. As part of the U.S. Interagency Strategic Plan for the Early Detection of Highly Pathogenic H5N1 Avian Influenza in Wild Migratory Birds, the NWRC was responsible for analyzing 101,452 fecal samples collected from wild birds from 2006 through 2009.
NWRC scientists convened a committee of scientists to design a nation-wide monitoring program for the collection of environmental samples (both fecal and water), developed field sampling methods and guidelines, tested and evaluated various methods for collecting water samples from areas actively used by waterfowl, developed laboratory assays to detect AIV in fecal samples and analyzed the fecal samples for the presence of AIV. The expertise developed during this effort was, subsequently, expanded to other countries. For example, in collaboration with the U.S. Department of Defense, NWRC scientists helped develop and implement a surveillance program to detect highly pathogenic H5N1 AIV in Kenya using fecal samples from waterbirds migrating from areas that have experienced H5N1 outbreaks, such as Europe, Asia, and northern Africa. Kenyan nationals were trained in laboratory and field techniques to establish this national surveillance program. AIV was first detected in Kenya during this effort and, based on genetic analysis, was most closely related to AIV from Mongolia.

Potential Transmission and Spread of Avian Influenza from Waterfowl to Agriculture and Human Populations— NWRC and other scientists developed risk assessment models to identify potential routes of introduction and subsequent spread of AIV by waterfowl in the United States. These models coupled spatially explicit risk assessment models with field and laboratory data from AIV samples collected from wild birds, band recovery data from waterfowl, the distribution of poultry operations, and genetic sequencing of detected AIV subtypes in collected samples.
AIV data collected from the U.S. national surveillance program were combined with a novel application of bird banding/recovery data using statistical modeling approaches. The spatial and temporal distribution of AIV in wild birds across the U.S. was best explained by waterfowl migratory movements, waterfowl demography, and environmental temperature. Greatest risks to the U.S. poultry industry are likely in the Pacific Northwest and Great Lakes regions. These results suggest that surveillance plans and risk assessments should consider migratory patterns while remaining adaptable to potential climate change, which may impact both temperature and waterfowl migration.
Based on genetic analysis of AIV from these samples, 14 of the 16 H subtypes and all 9 N subtypes of AIV in the U.S. wild bird population were documented. Previously unknown lineages of H subtypes circulating in U.S. wild bird populations were identified and, in general, the AIV found in the U.S. is largely endemic with rare events of exchange between Europe/Asia and the U.S. Some AIV were determined to have shared common ancestors with swine H1N1, suggesting historical exchange between wild birds and swine.
In addition to examining risks across the nation, NWRC scientists are also developing risk assessments at the local and state level through a variety of field and laboratory studies. These risk assessments will help individual farms develop more targeted measures to prevent contamination of poultry by AIV carried by wildlife species and will assist networks of farms in preventing AIV spread from neighboring outbreaks.

Role of Feral Swine and Wildlife in the Transmission and Spread of Avian Influenza— NWRC scientists are examining whether feral swine, in association with natural wildlife reservoirs, such as waterfowl, pose risks for the development of virulent AIV strains. Other avian and mammalian wildlife species, such as raccoons, may also carry and transmit AIV from wildlife systems to agricultural and human systems. Because little is known about AIV in most wildlife species, NWRC scientists have initiated studies to determine whether a suite of candidate wildlife species act as hosts for AIV, whether they can be infected from water sources contaminated with AIV by infected waterfowl, and whether they can transmit the virus to other wildlife species, livestock or poultry. For example, NWRC scientists, in collaboration with Colorado State University, found that collared peccaries were exposed to influenza viral subtypes H1N1 and H3N1 and had both avian and human influenza virus receptors throughout the trachea and lung areas. Thus, peccaries may play the same role as swine, serving as potential mixing vessels for influenza virus from birds and humans. Collared peccaries range from South America to the southwestern United States and comingle with feral swine, which suggests that peccaries may be able to move influenza virus across international borders and transmit the virus to feral swine. This could lead to further spread of influenza virus by feral swine throughout the United States.

Potential of European Starlings To Transmit Pathogens in Feedlots— NWRC scientists studied the local movements of European starlings and their potential role in carrying diseases among feedlots. Scientists sampled European starlings, cattle feed, cattle water troughs, and cattle feces from 10 cattle feedlots for *Salmonella enteric* and Coccidia to determine if there is a relationship between European starlings and the occurrence of these pathogens. Results suggested that European starlings may be a source for *S. enterica*, but not Coccidia, in cattle feed and water, which likely contributes to infections throughout the herd. This finding suggests that European starlings could not only be an important source for *S. enterica* infections in cattle but may move pathogens within and among cattle feedlots.

Genetic Investigation of Influenza H1N1— NWRC scientists worked with the American Museum of Natural History to provide a rapid response to the April 2009 H1N1 outbreak in human populations. The scientists sequenced wild bird fecal samples that had already been collected and characterized as part of USDA's national surveillance effort for highly pathogenic H5N1 avian influenza to study the genetic relatedness of the avian, swine, and human H1 and N1 subtypes. Results indicated that the 2009 H1N1 human outbreak had evolutionary origins in both swine and wild bird influenzas, but that the origin of the human outbreak subtype of influenza virus was not recently derived from wild birds. In terms of evolution, the human outbreak H1 subtype arose out of a swine-derived lineage that is closely related to predominantly human H1. Evolution of the H1N1 influenza includes common exchanges among hosts such as birds, both wild and domestic, swine,

and humans. Ongoing research across host species will contribute to an understanding of the contemporaneous and evolutionary circulation of influenza viruses.

Selected Publications:

BLITVITCH, B. J., L. A. IBARA-JUAREZ, A. J. CORTES-GUZMAN, J. J. ROOT, A. B. FRANKLIN, H. J. SULLIVAN, AND I. FERNANDEZ-SALAS. 2010. Seroprevalence of equine influenza virus in northeast and southern Mexico. Veterinary Record 166:565-566.

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LORONO-PINO, M. A., J. A. FARFAN-ALE, J. E. GARCIA-REJON, M. LIN, E. ROSADO-PAREDES, F. I. PUERTO, A. BATES, J. J. ROOT, A. B. FRANKLIN, H. J. SULLIVAN, AND B. J. BLITVICH. 2009. Antibodies to influenza and West Nile viruses in horses in Mexico. Veterinary Record 166:22-23.

MCCLINTOCK, B. T., J. D. NICHOLS, L. L. BAILEY, D. I. MACKENZIE, W. L. KENDALL, AND A. B. FRANKLIN. 2010. Seeking a second opinion: uncertainty in disease ecology. Ecology Letters 13:659-674.

PIAGGIO, A. J., L. CLARK, A. B. FRANKLIN, AND S.O. KOLOKOTRONIS. 2009. Wild bird's-eye view of influenza virus A (H1N1) phylogenetic evolution. EcoHealth 6:346-350.

REYNOLDS, M. G., D. S. CARROLL, V. A. OLSON, C. HUGHES, J. GALLEY, A. LIKOS, J. M. MONTGOMERY, R. SUU-IRE, M. O. KWASI, J. J. ROOT, Z. BRADEN, J. ABEL, C. CLEMMONS, R. REGNERY, K. KAREM, AND I. K. DAMON. 2010. A silent enzootic of an Orthopoxvirus in Ghana, West Africa: evidence for multi-species involvement in the absence of widespread human disease. American Journal of Tropical Medicine and Hygiene 82:746-754.

ROOT, J.J., K.T. BENTLER, H.J. SULLIVAN, B.J. BLITVICH, R.G. MCLEAN, and A.B. FRANKLIN. 2010. Antibody responses of raccoons naturally exposed to influenza A virus Vector-Borne and Zoonotic Diseases 10:821-823.

SULLIVAN, H. J., B. J. BLITVICH, K. K. VANDALEN, K. T. BENTLER, A. B. FRANKLIN, AND J. J. ROOT. 2009. Evaluation of an epitope-blocking enzyme-linked immunosorbent assay for the detection of antibodies to influenza A virus in domestic and wild avian and mammalian species. Journal of Virological Methods 161:141-146.

VAN DALEN, K. K., S. A. SHRINER, H. J. SULLIVAN, J. J. ROOT, AND A. B. FRANKLIN. 2009. Monitoring exposure to avian influenza viruses in wild mammals. Mammal Review 39:167-177.

VAN DALEN, K. K., A. B. FRANKLIN, N. L. MOOERS, H. J. SULLIVAN, AND S. A. SHRINER. 2010. Shedding light on avian influenza H4N6 infection in mallards: modes of transmission and implications for surveillance. PLOS One 5:e12851.

Major Research Accomplishments:

- WS developed sampling and laboratory methodologies and processed more than 100,000 environmental samples in support of the national avian influenza monitoring effort.
- WS conducted research on the roles of wildlife in harboring and transmitting avian influenza virus to domestic animals and humans.
- WS developed large-scale spatial risk assessment models to predict routes of introduction and spread of avian influenza in the United States.
- WS is evaluating the role of wildlife as transmitters of bacterial pathogens to and among livestock facilities.
- WS sequenced wild bird fecal samples to study the genetic relatedness of the avian, swine, and human H1 and N1 subtypes.

Wildlife Services

Protecting People
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National Wildlife Research Center

FY 2010

Contraceptive Technologies for Use in Wildlife Population and Disease Management

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Major Cooperators

- Pennsylvania State University
- University of Florida
- University of Pittsburg
- Colorado State University
- Innolytics, LLC
- Iowa State University
- Florida Department of Agriculture and Consumer Services
- Florida Power and Light Company
- U.S. Air Force, Avon Park Florida.
- National Park Service

Groups Affected by These Problems

- Urban and suburban residents
- Airports, airlines, airline passengers
- Motorists, pedestrians
- Farmers
- Ranchers/Livestock producers
- Natural resource managers
- Landscapers
- Pet Owners
- Electric utility companies

National Wildlife Research Center Scientists Study Wildlife Contraception
Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques.

Research on the reproductive management of various avian and mammalian species that cause damage or threaten public health and safety is a high priority for WS. The severity of human-wildlife conflicts often is directly related to wildlife population density. Many problems are exacerbated as wildlife populations become larger. In many urban and suburban settings, for example, overabundant deer create safety hazards for motorists, consume ornamental shrubs, harbor and transmit diseases and parasites (e.g., Lyme-disease-bearing ticks), and degrade habitat quality in public parks and other locations. Rodents carry a variety of diseases (e.g., plague, hantavirus) and damage rangelands and crops, resulting in the loss of millions of dollars in agricultural production. Overabundant feral horses in several western states degrade the quality of the habitat and create ecological and political problems. Stray dogs in many countries pose a potential public health risk, primarily due to bite injuries and the spread of rabies.

The goal of NWRC's wildlife contraceptive research is to develop and field test economical and effective agents to suppress reproductive fertility in local populations of selected wildlife species that cause conflicts. Wildlife contraceptives can be used in conjunction with other tools in an integrated program to manage local, overabundant wildlife species.

Applying Science and Expertise to Wildlife Challenges

First Immunocontraceptive Vaccine Registered by EPA— In 2009, NWRC researchers successfully registered with the U.S. Environmental Protection Agency the first single-shot, multi-year immunocontraceptive vaccine for use in female white-tailed deer. Called GonaCon™ Immunocontraceptive Vaccine (GonaCon), this new tool promises to be useful for managing not only urban white-tailed deer where traditional options are limited, but also populations of other species, such as companion animals and wildlife that transmit diseases. Research has shown GonaCon to be an effective reproductive inhibitor in elk, feral horses, bison, prairie dogs, ground squirrels, and feral dogs and cats. NWRC and its collaborators are investigating the use of GonaCon for reducing the spread of rabies in feral dogs and raccoons, preventing reproduction by companion animals, controlling adrenocortical disease in pet ferrets, and preventing the spread of brucellosis in bison. The vaccine is being used for research purposes in the United States, Mexico, Europe, New Zealand and Australia. Future NWRC research with GonaCon likely will involve studies to support expanded registration to other species, to develop oral delivery systems, and to prevent transmission of wildlife diseases. On October 25, 2010, NWRC received the 2010 Colorado Governor's Award for High-Impact Research for its development of GonaCon.

Elk Fertility Control in Rocky Mountain National Park— Overabundant elk populations are dramatically altering native plant communities and may be limiting the abundance and diversity of other wildlife species at Rocky Mountain National Park in Colorado. After extensive agency and public review of five management alternatives, the U.S. Department of the Interior's National Park Service (NPS) decided to implement a carefully regulated plan to lethally remove some of the elk. This plan provided an opportunity for NWRC scientists and collaborators to evaluate GonaCon for reducing reproduction of adult female elk that are targeted for eventual lethal removal. The 3-year study was initiated in January 2009. NPS and Colorado State University researchers will recapture and euthanize some of the treated elk each winter, collect blood samples, and conduct necropsies to determine the reproductive and general health status of the animals and the contraceptive efficacy of GonaCon. They are also examining the injection site to document

any reactions to the injections. None of the 10 GonaCon-treated elk recaptured in January 2009 were pregnant, compared to a 90-percent pregnancy rate in non-treated animals. However, all 10 GonaCon-treated animals had pyogranulomatous inflammatory lesions in the muscle at the injection sites. NWRC scientists are working to reduce these granuloma effects. The field study at Rocky Mountain National Park will continue through 2011, enabling scientists to evaluate the efficacy and safety of GonaCon as a multi-year, single-injection contraception agent for elk.

Combined Rabies-Contraceptive Vaccines for Management of Disease in Feral Dogs and Raccoons— NWRC scientists conducted preliminary tests to evaluate the feasibility of a combined rabies-GonaCon vaccine for use in feral dogs and raccoons. WS operation biologists vaccinate hundreds of raccoons and other medium-sized predators annually in response to localized rabies outbreaks. However, in areas where raccoon populations are high, the risk remains high that rabies will continue due to the production of susceptible young. NWRC scientists investigated whether immunocontraception is feasible for controlling raccoon population densities while sustaining a high immune status within adult populations in urban areas where the risk of rabies is high. Thirty-two raccoons were inoculated with either the GonaCon, the rabies vaccine IMRAB® or both vaccines to simulate trap-vaccinate-release procedures used by the WS Oral Rabies Vaccination Program. Results show GonaCon prevents pregnancy in raccoons without interferring with the development of rabies antibodies stimulated by IMRAB®. To comply with registration requirements, NWRC scientists are conducting a breeding experiment as a second method to evaluate the contraceptive. They also plan to evaluate if GonaCon is as effective in young-of-the-year raccoons as it appears to be in adult raccoons.

Use of Contraceptive Vaccines To Manage Feral Horses— Overpopulation of wild horses is a significant concern in the western United States, as these animals can overgraze indigenous plant species and compete with livestock and local wildlife for food and habitat. The current management strategy of removal and adoption is expensive. Given legislative constraints on management options, wildlife officials need nonlethal methods to manage populations of wild horses. Administering immunocontraceptive vaccines to control the fertility of free-ranging horses is a potential option to manage overabundant local populations. NWRC scientists completed a 3-year study that investigated the effects of contraception, including the GonaCon Immunoncontraceptive Vaccine, on the behavior of feral horses. Although there was individual variability in the responses to the vaccine, contraception in the horses that responded well to the vaccine lasted for several years. Contraceptive treatments did not alter male-female relationships, sexual behaviors, or band fidelity.

Diazacon Use in Rose-Ringed Parakeets— NWRC scientists currently are evaluating diazacon for reducing fertility in birds and mammals. Diazacon (20,25 diazacholesterol) is a cholesterol mimic that inhibits cholesterol production and blocks steroid hormone formation. Rose-ringed parakeets, also known as ring-necked parakeets, are native to central Africa and Asia, but through accidental and deliberate release, populations are now established in Europe, Japan, and the United States. As an invasive, non-native species, the rose-ringed parakeet has raised conservation concerns, because of its early breeding season and preference for established nest cavities places it in potential conflict with native cavity-nesting birds. Potential economic impacts on agriculture, conservation concerns, and mixed public opinion regarding the species have prompted the development of alternative management options. NWRC and researchers at the United Kingdom's Food and Environment Research Agency orally dosed captive rose-ringed parakeets with 18 mg/kg of diazacon for up to 10 days. Egg fertility rates were reduced by 54.2 percent for the first clutch and 66.5 percent for the second clutch, compared to birds that were not dosed. Based on these results, researchers conclude that diazacon has potential for controlling fertility in rose-ringed parakeets if a suitable formulation and delivery system is developed for free-living populations.

Selected Publications:

BARRELL, G. K., S. C. T. SCHAAFSMA, M. J. RIDGWAY, M. WELLBY, AND L. A. MILLER. 2009. Effects of a synthetic gonadotropin releasing hormone agonist, leuprolide, on rut-associated events in male deer. Animal Production Science 49:1120-1124.

BENDER, S. C., D. L. BERGMAN, K. M. WENNING, L. A. MILLER, D. SLATE, F. R. JACKSON, AND C. E. RUPPRECHT. 2009. No adverse effects of simultaneous vaccination with the immunocontraceptive GonaCon ™and a commercial rabies vaccine on rabies virus neutralizing antibody production in dogs. Vaccine 27:7210-7213.

CAMPBELL, T. A., M. R. GARCIA, L. A. MILLER, M. A. RAMIREZ, D. B. LONG, J.-B. MARCHAND, AND F. HILL. 2010. Immunocontraception in male feral swine treated with a recombinant gonadotropin-releasing hormone vaccine. Journal of Swine Health and Production 18:118-124.

FAGERSTONE, K. A., L. A. MILLER, G. KILLIAN, AND C. A. YODER. 2010. Review of issues concerning the use of reproductive inhibitors, with particular emphasis on resolving human-wildlife conflicts in North America. Integrative Zoology 1:15-30.

GIONFRIDDO, J. P., J. D. EISEMANN, K. J. SULLIVAN, R. S. HEALEY, L. A. MILLER, K. A. FAGERSTONE, R. M. ENGEMAN, AND C. A. YODER. 2009. Field test of a single-injection gonadotrophin-releasing hormone immunocontraceptive vaccine in female white-tailed deer. Wildlife Research 36:177-184.

GIONFRIDDO, J. P., J. D. EISEMANN, K. J. SULLIVAN, R. S. HEALEY, L. A. MILLER, K. A. FAGERSTONE, R. M. ENGEMAN, AND C. A. YODER. 2009. Field test of a single-injection gonadotrophin-releasing hormone immunocontraceptive vaccine in female white-tailed deer. Wildlife Research 36:177-184.

KILLIAN, G., T. J. KREEGER, J. RHYAN, K. FAGERSTONE, AND L. MILLER. 2009. Observations on the use of Gonacon™ in captive female elk (Cervus elaphus). Journal of Wildlife Diseases 45:184-188.

LAMBERT, M. S., G. MASSEI, C. A. YODER, AND D. P. COWAN. 2010. An evaluation of diazacon as a potential contraceptive in non-native rose-ringed parakeets. Journal of Wildlife Management 74:573-581.

MASSEI, G., L. A. MILLER, AND G. J. KILLIAN. 2010. Immunocontraception to control rabies in dog populations. Human-Wildlife Interactions 4:155-157.

MILLER, L. A., K. A. FAGERSTONE, D. C. WAGNER, AND G. J. KILLIAN. 2009. Factors contributing to the success of a single-shot, multiyear PZP immunocontraceptive vaccine for white-tailed deer. Human-Wildlife Conflicts 3:103-115.

Major Research Accomplishments:

- WS successfully registered the GonaCon™ Immunocontraceptive Vaccine for use with female white-tailed deer with the EPA in 2009. WS continues to conduct research to expand the vaccine's registration to other species.
- WS is investigating the use of GonaCon™ in conjunction with the rabies vaccine on raccoons and feral or stray dogs. The immunocontraceptive could reduce populations of these animals in certain areas, thus, decreasing the potential spread of the disease.
- WS is conducting studies to support the registration of diazacon as an avian contraceptive for invasive bird species.

Wildlife Services

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FY 2010

Predator Damage Management

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Major Cooperators

- Utah State University
- The Berryman Institute
- U.S. Army
- U.S. Forest Service
- Utah Division of Wildlife Resources
- Wildlife Conservation Society
- Wyoming Department of Agriculture
- Wyoming Animal Damage Management Board
- Wyoming Department of Game and Fish
- Montana Fish, Wildlife and Parks
- Welder Wildlife Foundation

Groups Affected By These Problems

- Livestock producers
- Wildlife managers
- Environmental organizations
- Land management agencies

National Wildlife Research Center Scientists Study Predation and New Ways to Protect Livestock

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques.

Data on predator population dynamics, ecology, and behavior are necessary to understand predation patterns on livestock, game species, and threatened and endangered species. These data are also needed for effective depredation management, but significant gaps of knowledge exist with regard to predator-prey, predator-livestock, and predator-predator relationships. NWRC is adopting a multi-disciplinary approach to study interactions among predators, and the impact of predators and predator removal on ecosystems, wildlife population dynamics, and livestock predation.

The development of new predator management tools to reduce livestock losses and protect public safety is also a high priority for NWRC. Livestock predation costs producers approximately $138 million each year. For the sheep and lamb industry alone, predators account for approximately 39% of the total losses from all causes. Concerns for public health and safety, as well as animal welfare, have also pressured wildlife managers to seek immediate solutions when predators cause conflicts. Research conducted by scientists at NWRC's field station in Logan, UT, is focused on finding new tools and techniques to reduce conflicts with predators. In addition, NWRC researchers are developing improved methods for capturing predators and monitoring their behaviors and movements.

Applying Science and Expertise to Wildlife Challenges

Coyote Sterilization to Reduce Predation on Pronghorns— Coyote predation accounts for the majority of neonatal pronghorn mortality in many areas and may influence local population declines. Current techniques used to manage coyote predation on wildlife species generally focus on lethal control methods, as there are few effective nonlethal methods available. However, NWRC scientists have demonstrated that coyote sterilization can be effective in reducing sheep predation. Sterilization reduces the energetic need for parents to provision coyote pups, which may decrease predation on fawns by sterile coyotes.

In a recent study, NWRC and Utah State University researchers further examined the potential value of this management method. The researchers used tubal ligation and vasectomy to sterilize 15 coyotes. Seven additional coyotes were captured and sham sterilized. The researchers also monitored 71 pronghorn fawns by radio telemetry for a one year pre-treatment and coyotes and pronghorn fawns for a one year post-treatment. In addition, the researchers examined the effects of sterilization on coyote survival and their maintenance of territories. Survival of fawns was higher in home ranges of sterile coyotes than in home ranges of non-sterilized coyotes. The results support the hypothesis that sterilization, while keeping hormonal systems intact, did not change coyote social or territorial behaviors. Packs of sterile coyotes were the same size as packs of non-sterilized coyotes, and sterile and non-sterile coyote packs maintained similar home range sizes in all seasons tested. Based on this research, coyote sterilization appears to be a useful tool to boost pronghorn fawn survival in areas where fawn survival is a critical factor in pronghorn population persistence and where lethal control is not a viable management option.

Reducing Human-Black Bear Conflicts in Colorado— Increasing human-wildlife conflicts in urban environments throughout the U.S. impacts species conservation,

jeopardizes human livelihoods and safety and requires increased resources from managers. Ongoing research by NWRC scientists is studying black bear ecology and management in urban areas of Colorado to discover patterns of bear conflict, how conflict is influenced by availability of both human food sources and natural food sources, and management strategies to reduce conflict. The goal of the study is to provide citizens and managers with more understanding of why bears enter towns and tools for reducing conflicts.

Because availability of garbage has been identified as a key driver in human-bear conflicts, this research is focusing efforts on reducing garbage availability by altering human behavior. Since the inception of the study in 2005, production of natural foods available for bears has fluctuated dramatically over the years. A key discovery of this research is that bears use urban environments during poor production years but often keep away from town during good food years, dispelling the notion that once a garbage bear, always a garbage bear. Other results indicate that education and law enforcement, as implemented in the study, do very little to change human behavior. Wildlife managers are using this knowledge to develop new strategies for reducing human-bear conflicts.

Electrified and Standard Fladry for Protecting Livestock from Wolves— Wolf predation on livestock causes economic and emotional hardships for livestock producers and complicates the balance of wolf conservation with other human interests. New management tools that decrease the risk of predation may offer additional flexibility and/or efficiency for both livestock producers and wildlife management agencies. Scientists at the NWRC field station in Logan, UT, examined (1) the efficacy of electrified fladry compared to fladry alone for protecting a food source from wolves in captivity, (2) the efficacy of electrified fladry for reducing wolf use of pastures and preventing depredations, and (3) the applicability of electrified fladry to different situations. Fladry is a string of flags or other similar material, typically tied to a fence line, used to contain or exclude wild animals from a specific area. Both fladry and electrified fladry were effective in excluding wolves from a food resource for 1 to 14 days, with electried fladry excluding wolves for slightly longer periods of time. Knowing wolf activity at the ranches in the wild was insufficient information for determining if electrified fladry successfully prevented livestock depredations. However, researchers found that the operational use of electrified fladry by ranchers and livestock growers may be limited by costs associated with its purchase and that the application and effectiveness of electrified fladry may limit its overall usefulness for addressing wolf-livestock conflict.

Evaluation of Cable Foot Restraints— Negative public perceptions of the use of foot-hold traps have led to restrictions or all-out bans on these traps in several States. However, traps can be selective and effective tools for wildlife managers. To compensate for the loss of this tool, wildlife managers in some areas, use cable foot-restraints to capture coyotes. In a continued effort to improve the selectivity of traps and the welfare of trapped animals, NWRC researchers evaluated animal injuries associated with three types of cable foot-restraints: standard cable restraint, sleeved cable restraint and chain cable restraint.

NWRC researchers used International Standardization for Organization (ISO) injury scores to evaluate the cables. There were no significant differences in injury scores between the standard restraint and the other two cable restraints. However, injury scores for coyotes captured in sleeved restraints were higher than those for coyotes captured in chain restraints. The sleeve may have prevented the cable from tightening snugly on the coyote's foot, allowing the leg to move against the lock and causing more lacerations, abrasions, and other injuries. The chain restraint had the lowest injury score. Researchers believe this could be the result of (1) the links within the chain providing a greater, rounded surface area, thus distributing the pressure of the device's grip or (2) the lengths of chain acting similar to teeth or buttons on some jawed devices, which are thought to reduce movement and, thereby, injury. All three restraints tested had lower injury scores than unpadded steel-jaw traps but only the chain cable restraint had a lower mean injury score (though only slightly) than the padded steel-jaw trap. Scientists note that the padded foot-hold trap may cause less injury to the coyotes when captured than either the standard or chain cable restraints, serving as a more humane method for capturing coyotes. The results of this study provide valuable information to help wildlife managers evaluate the appropriateness of different types of capture devices for managing coyotes.

Jaguar Foraging Ecology in Brazil— The jaguar is a large carnivore of Central and South America. To date, kill rates and predation patterns by jaguars have not been well documented. However, over the past decade, NWRC biologists studied the foraging ecology of jaguars in Brazil in an area with both livestock and native prey. The study documented kill rates, characteristics of prey killed, patterns of predation and the influence of prey size on the duration at kill sites and the time interval between kills.

Kills were composed of cattle, caiman, peccaries, feral swine, marsh deer, giant anteaters, capybaras, brocket deer, and other avian, mammalian and reptilian species. Individual jaguars differed in the proportion of each species they killed, as well as the proportion of native prey versus cattle they killed. Although all 10 radio-collared cats killed cattle, only half (5) killed a high proportion of cattle (>35 percent of kills were cattle). Males and females killed cattle in similar proportions. The time interval to the next subsequent kill by jaguars increased with increasing prey size. Jaguars also increased the length of time at a carcass as prey size increased. Jaguar kill rates on peccaries steadily increased over the four-year study. In contrast, kill rates on cattle decreased during the same period. Rainfall and subsequent water levels on the Pantanal were the main driver of seasonal kill rates by jaguars on cattle and caiman; when water levels increased, predation on caiman increased as caiman became more dispersed on the landscape. Conversely, as water levels fell, caiman became less plentiful and cattle were moved out into the pastures, thereby increasing their availability to more jaguars. Ranchers in Brazil are using this information to reduce predation on cattle through improved husbandry techniques.

Interactions among Wolves, Coyotes, and Pronghorn— High coyote predation rates on pronghorn fawns are common throughout the western United States. NWRC scientists conducted a three-year study that provided strong evidence that wolf recovery in the Greater Yellowstone Ecosystem is decreasing the abundance of coyotes and, subsequently, increasing pronghorn fawn survival due to reduced coyote predation. Scientists documented a more than a five-fold increase in pronghorn fawn survival at sites used by wolves during summer and a nearly six-fold increase in fawn survival at sites used by wolves year-round. Results indicate a negative relationship between coyote and wolf densities, suggesting that competition facilitated the increase in observed fawn survival. Scientists also noted the abundance of transient coyotes was lower in areas used by wolves.

The effects of wolves on solitary coyotes may be an important mechanism by which wolves limit coyote populations. Furthermore, results suggest that the extirpation of wolves throughout much of North American may contribute to high rates of coyote predation on pronghorn fawns.

Selected Publications:

ATWOOD, T. C., E. M. GESE, AND K. E. KUNKEL. 2009. Spatial partitioning of predation risk in a multiple predator-multiple prey system. Journal of Wildlife Management 73:876-884.

ATWOOD, T. C., AND E. M. GESE. 2010. Importance of resource selection and social behavior to partitioning of hostile space by sympatric canids. Journal of Mammalogy 91:490-499.

BARUCH-MORDO, S., S. W. BRECK, K. R. WILSON, AND J. BRODERICK. 2009. A tool box half full: how social science can help solve human-wildlife conflict. Human Dimensions of Wildlife 14:219-223.

BERGMAN, D. L., S. W. BRECK, AND S. C. BENDER. 2009. Dogs gone wild: feral dog damage in the United States. Proceedings of the Wildlife Damage Management Conference 13:177-183.

BRUMMER, S. P., E. M. GESE, AND J. A. SHIVIK. 2010. The effect of enclosure type on the behavior and heart rate of captive coyotes. Applied Animal Behaviour Science 125:171-180.

CARLSON, D. A., AND E. M. GESE. 2010. Integrity of mating behaviors and seasonal reproduction in coyotes (*Canis latrans*) following treatment with estradiol benzoate. Animal Reproduction Science 117:322-330.

CARLSON, D. A., AND E. M. GESE. 2009. Influence of exogenous gonadotropin-releasing hormone on seasonal reproductive behavior of the coyote (*Canis latrans*). Theriogenology 72:773-783.

CAVALCANTI, S. M., AND E. M. GESE. 2009. Spatial ecology and social interactions of jaguars (*Panthera onca*) in the southern Panatal, Brazil. Journal of Mammalogy 90:935-945.

CAVALCANTI, S. M., AND E. M. GESE. 2010. Kill rates and predation patterns of jaguars (*Panthera onca)* in the southern Panatal, Brazil. Journal of Mammalogy 91:722-736.

CAVALCANTI, S. M. C., S. MARCHINI, A. ZIMMERMAN, E. M. GESE, AND D. W. MACDONALD. 2010. Jaguars, livestock, and people in Brazil: realities and perceptions behind the conflict. Pages 383-402 *in* D. Macdonald and A. Loveridge, editors. The biology and conservation of wild felids. Oxford University Press, Oxford, United Kingdom.

DARROW, P. A., R. T. SKIRPSTUNAS, S. W. CARLSON, AND J. A. SHIVIK. 2009. Comparison of injuries to coyote from 3 types of cable foot restraints. Journal of Wildlife Management 73:1441-1444.

MUNOZ-IGUALADA, J., J. A. SHIVIK, F. G. DOMINGUEZ, L. M. GONZALEZ, A. A. MORENO, AND M. F. OLALLA. 2010. Traditional and new cable restraint systems to capture fox in central Spain. Journal of Wildlife Management 74:181-187.

RANGLACK, D. H., K. D. SIGNOR, K. BUNNELL, AND J. SHIVIK. 2009. Black bear activity and visitation patterns at human food resources in Utah. Proceedings of the Wildlife Damage Management Conference 13:172-176.

SHIVIK, J. A., G. L. PALMER, E. M. GESE, AND B. OSTHAUS. 2009. Captive coyotes compared to their counterparts in the wild: does environmental enrichment help? Journal of Applied Animal Welfare Science 12:223-225.

WILSON, R. R., M. B. HOOTEN, B. N. STROBEL, AND J. A. SHIVIK. 2010. Accounting for individuals, uncertainty, and multiscale clustering in core area estimation. Journal of Wildlife Management 74:1343-1352.

WILSON, R. R., T. L.BLANKENSHIP, M. B. HOOTEN, AND J. A. SHIVIK. 2010. Prey-mediated avoidance of an intraguild predator by its intraguld prey. Oecologia 164:921-929.

Major Research Accomplishments:

- WS examined the impacts not only of predators on livestock, but of predators on other predators and native prey.
- WS reported that coyote sterilization increased pronghorn fawn survival.
- WS found fladry and electrified fladry were effective in excluding wolves from a food resource for short periods of time (1 to 14 days).
- WS evaluated coyote injuries related to the use of three types of cable foot restraints.
- WS determined black bear movements into urban areas are often in response to poor production of natural food sources in nearby habitats.

Wildlife Services

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FY 2010

Reducing Mammalian Damage in Forested and Riparian Ecosystems

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Major Cooperators

- British Columbia Ministry of Forest and Range
- Mississippi State University
- Oregon Forest Industries Council
- Oregon Department of Forestry
- Oregon Department of Fisheries and Wildlife
- Oregon State University
- The Jack Berryman Institute
- USDA Forest Service
- Washington Forest Protection Association
- Washington Department of Fisheries and Wildlife
- Washington Department of Natural Resources

Groups Affected By These Problems

- Commercial timber producers
- Gardeners/Landscapers
- Homeowners
- Natural resource managers
- Noncommercial forest land owners
- Orchard managers
- State departments of transportation

National Wildlife Research Center Scientists Develop Methods to Reduce Timber Damage

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques. NWRC's expertise in Corvallis, OR, focuses primarily on wildlife damage to forest resources.

Wildlife impacts on regenerating forests following wildfire or harvesting can be extensive. Cutting and gnawing on seedlings by deer, elk, mice, mountain beavers, pocket gophers, rabbits, and voles during the first five years of tree growth greatly hinder reforestation efforts. Other mammals such as bears and porcupines damage mature trees. North American beavers and nutria alter riparian vegetation, which limits streamside restoration efforts, erodes roads and railways and can endanger human health and safety. NWRC scientists are developing nonlethal tools and methods (e.g., repellents and habitat and behavior modification) to manage wildlife damage to forest resources.

Applying Science and Expertise to Wildlife Challenges

Developing and Testing Repellents to Protect Forest Resources— Use of commercial repellents for protecting trees can be cost prohibitive and, generally, provide only short-term protection. Cost-effective and longer lasting repellents are needed for application in forest management. NWRC scientists evaluated the effects of protein-based repellents for reducing damage by rodents and ungulates. Results demonstrated that a simple repellent made from glue and hydrolyzed casein may offer considerable browse protection from deer when alternative forage is available. NWRC scientists also concluded that avoidance of foods treated with animal-based proteins, such as hydrolyzed casein, was mediated by changes in palatability, not fear of predation. Additional studies evaluated the degree to which motivation impacts effectiveness of repellents differing in mechanisms of avoidance: fear, irritation, conditioned aversion, and flavor modification. Results suggested that habituation to odor limits the effectiveness of repellents that are not applied directly to food, while topically-applied irritants and animal-based products produce significant avoidance. Other studies are underway to identify genetically controlled chemical characteristics that promote herbivore avoidance of select tree species.

Understanding Tree Chemistry and Dietary Behaviors— Most problems associated with wildlife occur because of the foraging activities of animals. NWRC researchers are working to determine how select wildlife species respond to chemical components in the plants they eat. Initial results suggest that when given a choice, deer prefer to eat conifer seedlings with low terpene levels. Further research demonstrated that seedling age also can influence foraging behavior. Future efforts will evaluate the efficacy of selecting for these heritable traits and deploying them in an integrated management design to reduce deer browse in reforestation efforts.

Mountain Beaver Genetics— Mountain beavers (*Aplodontia rufa rufa)* are endemic to the Pacific Coast of California, Oregon, Washington, British Columbia, Canada and to the Sierra Nevada Mountains of California and Nevada. There are seven subspecies of mountain beaver. The U.S. Department of the Interior's Fish and Wildlife Service has classified one of these subspecies, *A. r. nigra*, as endangered and several other mountain beaver subspecies as populations of concern under the Endangered Species Act. However, in some portions of its range, mountain beaver cause significant damage to forestry interests and are managed as a pest species. Studies of mountain beaver populations are critical for understanding their status and for developing wildlife damage

management practices. In particular, molecular genetics techniques are useful for explaining population demographics.

To aid research efforts related to mountain beavers, NWRC scientists developed and characterized 10 microsatellite markers from the *A. r. rufa* genome. The addition of these 10 markers to previously published ones provides a powerful tool for studying *A. r. rufa* populations. For instance, researchers are using deoxyribonucleic acid (DNA) analyses to test whether mountain beaver populations are closed systems or if individuals move across forested landscapes to new areas. Researchers are also studying the relatedness and connectivity among the last two remaining populations of the endangered *A. r. nigra.*

Composition of Beaver Colonies— Natural resource managers faced with reducing beaver damage often make decisions based on classic scientific literature that suggests three basic factors: (1) beavers are monogamous breeders that live in colonies; (2) colonies are composed of a breeding pair of adults, their offspring, and occasionally, the offspring from the previous year; and (3) beavers typically breed during the winter and have their offspring in the spring. However, these assumptions are not always correct. NWRC scientists recently analyzed the composition of beaver colonies at 89 chronic damage sites in seven southeastern States and found several deviations from this conventional knowledge.

In this study, colony size ranged from 2 to 18 beavers. Eleven colonies contained one male and one female only, and only five of these were breeding pairs. Colonies contained anywhere from 1 to 11 males, while the number of females among colonies ranged from 0 to 8. The youngest age of reproductively active females was two, and the oldest was 18 years of age. Lactating and/or pregnant females were captured in every month except September, October, and November, suggesting a flexible or extended breeding season in southeastern colonies.

Issues such as female site fidelity, the reproductive potential of beavers, and the tendencies of juveniles to disperse to less optimal habitats or remain in their natal colonies indicate that the dynamics of beaver colonies are more complex than previously thought. For instance, managers working in areas of long-term damage may underestimate the number of beavers that need to be removed to protect an area's resources. In this regard, the results of the study have serious implications for wildlife managers when determining whether to use lethal or nonlethal approaches to control beaver populations.

Selected Publications:

CARRILLO, C. D., D. L. BERGMAN, J. TAYLOR, D. NOLTE, P. VIEHOEVER, AND M. DISNEY. 2009. An overview of historical beaver management in Arizona. Proceedings of the Wildlife Damage Management Conference 13:216-224.

FIELD, K. L., A. A. BACHMANOV, J. A. MENNELLA, G. K. BEAUCHAMP, AND B. A. KIMBALL. 2009. Protein hydrolysates are avoided by herbivores but not by omnivores in two-choice preference tests. PLoS ONE Jan 2009. (www.plosone.org) *doi:20.1371/journal.pone.0004126*.

KIMBALL, B. A., AND K. R. PERRY. 2009. Evaluating new protein sources for development of a deer repellent product. Crop Protection 28:364-366.

KIMBALL, B. A., J. TAYLOR, K. R. PERRY, AND C. CAPELLI. 2009. Deer responses to repellent stimuli. Journal of Chemical Ecology 35:1461-1470.

KIMBALL, B. A., AND J. D. TAYLOR II. 2010. Mammalian herbivore repellents: tools for altering plant palatability. Outlooks on Pest Management 21:181-187.

PIAGGIO, A. J., M. A. NEUBAUM, H. YUEH, C. E. RITLAND, J. J. JOHNSTON, AND S. L. PERKINS. 2009. Development of 10 polymorphic microsatellite loci isolated from the mountain beaver, *Aplodontia rufa rufa* (Rafinesque). Molecular Ecology Resources 9:323-325

TAYLOR II, J. D., D. L. BERGMAN, AND D. L. NOLTE. 2009. An overview of the International Beaver Ecology and Management Workshop. Proceedings of the Wildlife Damage Management Conference 13:225-234.

Major Research Accomplishments:

- WS evaluated the efficacy of hydrolyzed casein as a new repellent for rodents and ungulates.
- WS is working to determine how select wildlife species respond to chemical components in the plants they eat.
- WS developed and characterized 10 microsatellite markers from the mountain beaver genome to aid in explaining population demographics.
- WS analyzed the composition of beaver colonies and found several deviations from conventional knowledge about beaver.

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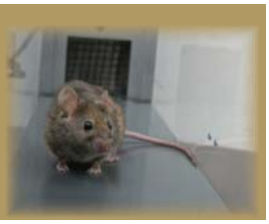
Controlling Rodent Populations and Damage with an Emphasis on Invasive House Mice and Native Voles



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Major Cooperators
- U.S. Fish and Wildlife Service
- U.S. National Park Service
- U.S. Department of Defense
- Florida Wildlife Commission
- California Department of Food and Agriculture
- Island Conservation, Inc.

Groups Affected By These Problems
- Urban citizens
- Farmers
- Livestock producers
- Natural resource managers
- Conservationists
- Military bases

National Wildlife Research Center Scientists Assess and Develop Methods to Manage Native Rodents or Eradicate Introduced, Invasive Rodents

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques.

Rodents occur worldwide and have adapted to most types of ecosystems. Rodents provide many important ecosystem functions. Although most rodent species do not cause serious damage problems, a small number of species do. Rodents damage ripening crops, forestry and nursery trees, rangelands, ornamental plants, property, cables and irrigation pipes. They also consume and contaminate stored food, transmit diseases and contribute to the decline of native flora and fauna on islands. Many tools are used to reduce rodent populations and mitigate damage. NWRC researchers develop and evaluate rodenticides, barriers and other tools to eliminate or reduce the damage caused by native and invasive rodents.

Applying Science and Expertise to Wildlife Challenges

Identifying Effective Attractants and Rodenticide Baits for Gambian Rats— Native to Africa, Gambian giant pouched rats are currently in Grassy Key, Florida and threaten to invade mainland Florida. Because of their large size, they pose a serious threat to native species and agricultural crops. Gambian giant pouched rats were implicated in a monkeypox outbreak in humans in the Midwestern U.S. in 2003, and are potential vectors of other diseases. To assist with WS initiated eradication and detection efforts in the Florida Keys, NWRC biologists tested 15 attractants for use in traps for capturing or detecting Gambian rats. The biologists found that similar scents (i.e., feces and urine) from other Gambian rats were the best attractant, but peanut butter, anise, ginger, and fatty acid scents could also be useful. In another study, NWRC evaluated several rodenticide baits with captive Gambian rats from Florida in multiple choice food trials: two formulations of diphacinone baits, and one formulation each of brodifacoum, chlorophacinone, zinc phosphide, and bromethalin bait. Only the brodifacoum and zinc phosphide baits were highly effective. In future Gambian rat control efforts, NWRC recommends the use of acute rodenticide zinc phosphide, or the second-generation anticoagulant, brodifacoum.

Behavior of Invasive Rats in an Unfamiliar Environment— Invasive rats pose a threat to native flora and fauna, especially on islands where native species have evolved in the absence of terrestrial predators. Effective detection and eradication is essential to preserve the integrity of island ecosystems. A better understanding of the behavior of rats when they first arrive in a new setting could lead to the development of more effective methods for detecting and eradicating rats from insular ecosystems.

NWRC biologists studied the behavior of three commensal rat species in a novel environment with various familiar and unfamiliar stimuli. While there were some differences in responses by species and sex, most rats sought out and spent considerable time in the den box, suggesting an immediate need for security when in an unfamiliar setting. Rats also sought out the feces of other rats, suggesting the need for social contact or reproduction. The management implications of the study results are two-fold. First, the detection of newly arriving rats on islands may be aided by the strategic placement of den boxes that are highly acceptable to rats. Wildlife managers could inspect the den boxes periodically for evidence of rats. Secondly, placing rat feces in the den boxes might enhance attraction of invading rats to the den boxes and slow their dispersion.

United States Department of Agriculture
Animal and Plant Health Inspection Service

Eradication of Roof Rats on Egmont Key, FL— Roof rats were accidently introduced to Egmont Key, a U.S. Fish and Wildlife Service National Wildlife Refuge near Tampa Bay, Florida, during a shoreline stabilization program in 2000. The rats pose a threat to all ground-nesting native species and could also damage historic structures in the area. NWRC biologists conducted a study to determine if two proposed rodenticide formulations (Ramik® Green pellets and Ramik Mini-Bars, both 0.005 percent diphacinone) would be palatable to, and effectively kill, roof rats from Egmont Key. Although both rodenticides resulted in high mortality, the scientists recommended the use of Ramik Mini-Bars on Egmont Key because their large size reduces potential hazards to the island's gopher tortoises compared to the smaller Ramik Green pellets. Based on these recommendations, in 2009, WS operations biologists designed and conducted a successful eradication program for these rats using an island-wide grid of bait stations and Ramik Mini-Bars. WS is also involved in several other island invasive rodent eradications.

Rodenticide Resistance in Meadow Voles— Meadow voles cause significant damage to agricultural crops. The anticoagulant rodenticide chlorophacinone has been used in artichoke fields in northern California for nearly 2 decades to control vole populations and reduce damage. Although initially efficacious, anecdotal evidence indicates that voles have developed resistance to chlorophacinone and are increasingly difficult to manage. NWRC researchers isolated liver microsomes from voles captured from areas with populations identified by farmers to be resistant to chlorophacinone and from areas that had never been baited with chlorophacinone to investigate possible metabolic differences between the two populations. The study found that microsome preparations from resistant populations of voles metabolized significantly more chlorophacinone than did non-resistant voles resulting in increased resistance to the rodenticide. NWRC researchers currently are investigating ways to improve the efficacy of the rodenticide in these resistant populations.

Determining Non-Target Risks of Rodenticides— Diphacinone is a first generation anticoagulant rodenticide used to manage pests such as rats, mice, and other rodents. Non-target species are potentially exposed to anticoagulant rodenticides through a variety of pathways, including through consumption of animals that ingested anticoagulant bait. Thus, determining tissue concentrations of diphacinone in target animals is an integral component of assessing secondary risks. NWRC researchers determined the concentrations of diphacinone in the liver, kidneys, lungs, muscle, whole blood, and whole body remainder of treated Wistar rats to develop physiologically based pharmacokinetic models (PBPK) to estimate diphacinone tissue concentrations and improve risk assessment strategies.

Selected Publications:

WITMER, G. W., N. P. SNOW, AND P. W. BURKE. 2010. Evaluating commercially available rodenticide baits for invasive Gambian giant pouched rats (*Cricetomys gambianus*). Crop Protection 29:1011-1014.

WITMER, G. W., N. P. SNOW, AND P. W. BURKE. 2010. Potential attractants for detecting and removing invading Gambian giant pouched rats (*Cricetomys gambianus*). Pest Management Science 66:412-416.

WITMER, G. W., and G. R. Singleton. 2010. Sustained agriculture: the need to manage rodent damage. Pp. 1-52 in: F. Wagar, ed. Agricultural Production. Nova Science Publishers, Inc., New York, NY.

WITMER, G. W., J. D. EISEMAN, T. M. PRIMUS, J. R. O'HARE, K. R. PERRY, R. M. ELSEY, AND P. L. TROSCLAIR III. 2010. Assessing potential risk to alligators, *Alligator mississippiensis*, from nutria control with zinc phosphide rodenticide baits. Bulletin of Environmental Contamination and Toxicology 84:698-702.

WITMER, G., A. E. FINE, J. GIONFRIDDO, M. PIPAS, K. SHIVELY, K. PICCOLO, AND P. BURKE. 2010. Epizootiologic survey of *Mycobacterium bovis* in wildlife and farm environments in northern Michigan. Journal of Wildlife Diseases 46:368-378.

JOJOLA, S. M., G. W. WITMER, AND P. W. BURKE. 2009. Evaluation of attractants to improve trapping success of nutria on Louisiana coastal marsh. Journal of Wildlife Management 73:1414-1419.

WITMER, G. W., AND P. W. BURKE. 2009. Influence of vitamin K-rich plant foods on anticoagulant baiting efficacy in wild house mice, Norway rats and wild black rats. Pacific Conservation Biology 15:87-91.

WITMER, G. W., G. M. KEIRN, N. HAWLEY, C. MARTIN, AND J. K. REASER. 2009. Human dimensions of invasive vertebrate species management. Proceedings of the Wildlife Damage Management Conference 13:100-105.

WITMER, G. W., N. P. SNOW, L. HUMBERG, AND T. SALMON. 2009. Vole problems, management options, and research needs in the United States. Proceedings of the Wildlife Damage Management Conference 13:235-249.

Major Research Accomplishments:

- WS identified effective attractants and rodenticides for Gambian giant pouched rat management.
- WS helped to successfully eradicated roof rats from Egmont Key, Florida.
- WS determined tissue concentrations of the rodenticide diphacinone in target species and used the data to improve risk assessment strategies for non-target species.

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Managing Invasive Species Impacts to Agriculture, Natural Resources, and Human Health and Safety

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Major Cooperators

- Hawaii Agriculture Research Center
- US Fish and Wildlife Service
- US Department of Defense
- Hawaii Department of Land and Natural Resources
- Hawaii Department of Agriculture
- University of Hawaii
- Kamehameha Schools (Bishop Estate)
- Nature Conservancy
- Tropical Fruit Growers of Hawaii
- Monsanto Corporation
- Syngenta Corporation
- Pioneers Seed
- MacFarms of Hawaii
- Mauna Loa Mac Nut
- Hawaii Macadamia Nut Growers Association
- Hawaiian Commercial and Sugar
- Island of Guam
- Hilo International Airport

Groups Affected By These Problems

- Farmers/Homeowners
- Horticulture industry
- Natural resource managers
- Tropical fruit and nut producers
- Seed crop industry
- Wildlife and refuge managers
- Commercial transportation industry

National Wildlife Research Center Scientists Develop Methods to Reduce Damage Caused by Invasive Species

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques. NWRC's field station in Hilo, HI, is ideally located to allow research biologists to develop methods needed to control invasive species damage to agricultural crops and native ecosystems on islands.

Oceanic islands like the Hawaiian archipelago are more susceptible to the impacts of invasive species than mainland areas because remote islands evolved in ecological isolation and have few predators or competitors, have a lot of air and sea traffic, and, typically, provide a favorable habitat and climate for many introduced species. Further, native species on the islands have evolved in the absence of many introduced threats and usually respond poorly to invasive animals or disease.

Invasive species are the single greatest threat to Hawaii's agricultural economy, natural environment, and the health and lifestyle of Hawaii's people. Invasive vertebrate species cause millions of dollars worth of crop losses, the extinction of native species, the destruction of native forests, the spread of disease, and threats to the health and safety of residents. NWRC scientists at the Hilo, HI, field station are investigating a variety of methods to reduce damage caused by invasive species such as rodents, coqui frogs, brown treesnakes, invasive birds, mongooses, and feral ungulates in Hawaii as well as throughout Pacific islands linked to Hawaii through transport and trade.

Applying Science and Expertise to Wildlife Challenges

Rodent Management and Eradication— To better manage rodent damage to Hawaii's agricultural resources, NWRC scientists are identifying and evaluating various rodenticide baits. As part of this process, NWRC scientists compiled the necessary data to obtain federal registration for these baits. Field tests were conducted on roof rats, a species that decimates native ecosystems as well as agricultural crops throughout the Pacific region. Results indicate that only certain rodenticides are effective on Hawaiian mice and rats. To date, two products have been registered by the Hawaii Department of Agriculture for use in tropical fruits and seed crops in Hawaii. Prior to this, no rodenticides were registered for use in these Hawaiian crops. In addition, several projects were completed which resulted in the registration of three products for the aerial broadcast of rodenticides. Much of the supporting documentation and many of the studies for these labels were completed at the Hilo, Hawaii field station. Collaborative studies will continue to evaluate aerial broadcast application of rodenticides in conservation areas throughout the Pacific region to protect native fauna and flora with emphasis on reducing the potential for exposure to non-target animals such as feral swine, native raptors, and land crabs.

Introduced Invasive Species— The negative impacts of introduced species on island ecosystems are severe. In Guam, brown treesnakes continue to impact the local economy, power grids, native plants and animals and military operations. NWRC scientists are attempting to reduce the opportunity for snakes to spread to new areas, such as Hawaii, and to reduce the impact of snakes on Guam. Alternative baits, such as beef treated with extracts of dead mice, also have been evaluated to help reduce the cost of operational baiting programs and improve baiting effectiveness. For wide area suppression of snake populations in remote areas, scientists are evaluating helicopter aerial delivery of mouse bait attached to paper streamers. The bait lands in the canopy where it is accessible to brown tree snakes, but inaccessible to non-target species. To help prevent snakes from stowing away in outbound cargo from Guam, NWRC scientists are evaluating repellencies of formulations containing essential oils, natural compounds, and other chemicals, with

the goal of providing a safe, ready-for-use product for military, commercial and private users. Furthermore, a major study was initiated in the beginning of this year to evaluate the risk of introducing invasive vertebrates throughout the Pacific as a result of the planned restructuring of military forces in the Pacific, specifically the introduction and spread of the brown tree snake. A risk analysis and biosecurity plan of the move has been prepared to assist in the development of an Environmental Impact Statement.

In Hawaii, a species of tree frog (coqui frog) was introduced from the Caribbean. In addition to its propensity for reproducing quickly and its piercing loud nighttime call, the species eats the insects and snails that many native forest birds rely on for survival and may have significant effects on forest dynamics. During the last five years, the development and evaluation of frog toxicants has been supported by several key cooperators. NWRC scientists have identified several effective frog toxicants (citric acid, hydrated lime, endosulfan sodium bicarbonate, potassium bicarbonate) for registration and evaluated the potential environmental effects of frog toxicants(citric acid, caffeine, hydrated lime, and sodium bicarbonate). Although, citric acid is, currently, the only frog toxicant that is being used, NWRC scientists are generating data for the registration of bicarbonate products for the state of Hawaii.

There is a serious concern about the introduction of Indian mongooses to new locations in the Pacific area that have so far remained free of this alien pest. NWRC scientists are identifying candidate bait substrates, lures, and/or attractants that elicit a strong attraction response from mongooses in the field. Preliminary results show that food-based baits are more effective than animal or food scents, and that fish-based food baits are the most effective. Findings could aid in optimizing current detection and capture strategies for mongooses and facilitate the development of toxicant baits specific for mongooses. More recently, NWRC scientists completed an intensive field study that explored mongoose behavior and evaluated the effectiveness of baits in attracting mongooses. Overall, it was found that mongooses cover much larger areas than previously reported with some home ranges exceeding 124 acres (50 hectares). Fish, coconut, and eggs were all effective baits in attracting mongooses to stations but distance traveled by mongooses were highest for fish baits.

Introduced predators such as cats can cause significant reductions in native bird species in Hawaii. Due to high food availability and their mobility, feral cats are often extremely difficult to manage in tropical climates. NWRC scientists completed an initial field evaluation of non-food based lures and scents for use as feral cat attractants. Food based lures, such as fish, are effective at times for cats but they are also effective on non-target animals, such as mongooses. Thus, trapping programs may be saturated with non-target captures and few cat captures. Non-food based lures that are effective for cats and not as effective for non-target animals will be assessed further for application onto feral cat trapping.

Lastly, NWRC scientists have initiated a new study to evaluate the diet of non-native feral sheep on Mauna Kea and assess the impacts of browsing by these sheep on the endangered native mamane tree. Mamane seeds are critical for the survival of the endangered honeycreeper, palila. NWRC scientists are investigating the relative preference of sheep based on rumen contents. Rumen analysis is continuing and future plans include conducting vegetation surveys in the locations where ungulate samples were collected to compare stomach contents with availability of the various herbaceous foods consumed.

Seed Crop Protection— Growing plants for seeds has emerged as one of Hawaii's biggest industries. Hawaii's climate enables three to four growing seasons per year, which allows companies to produce up to four generations of seed crops per year, enabling crops to move more quickly to market.

With this new industry comes a new interest in protecting seeds from foraging birds. Approximately 40 percent of the bird species in Hawaii are invasive. In addition to the damage they cause to native birds through disease and competition, invasive bird species cause millions of dollars in crop losses annually. For example, pigeons, doves, francolins, turkeys and skylarks feast on a variety of seeds and sprouting crops.

NWRC scientists are developing methods to minimize the damage caused by invasive birds. Scientists developed an integrated management plan to alter farm operations and reduce invasive bird populations on one farm. Birds were killing more than 76 percent of planted soybeans. Nine months after the program was initiated, bird damage was absent. During the past two years, NWRC has partnered with the Hawaii WS operational program to develop a bird management program for seed corn and soybeans. NWRC scientists evaluated the extent of the bird problem and developed an operational program; they, periodically, returned to evaluate the effectiveness of the operational program. The program continues to be successful in reducing the threat of seed predation and in reducing the threat from avian diseases. NWRC has also partnered with the Hawaii Department of Land and Natural Resources to evaluate crop depredation threats from feral parrots and to provide a management strategy to minimize the potential effects (e.g., fruit crop depredation) of these birds. The state partnered with the operational program to manage the feral parrot population, particularly the large population on Kauai.

Rodent-Proof Nest Boxes for Endangered Birds in Hawaii— The puaiohi, or small Kauai thrush, is an endangered bird endemic to the island of Kauai, HI. The sole population of about 500 birds is currently restricted to remote, higher elevation areas of the Alakai Plateau. Puaiohi nest primarily on steep stream-side cliffs, and their distribution and abundance are limited partly by the availability of suitable nest sites. Invasive black rats cause nest failure and mortality of nesting females, and ground-based rodent control has not been effective at reducing nest predation. NWRC researchers investigated whether artificial nest structures might be a viable alternative to rodent control by testing nest box designs to find one that is resistant to rats. In laboratory trials, the researchers evaluated three designs that were currently being deployed as artificial nest boxes for puaiohi and found that these structures are not rat resistant. From these initial results, researchers developed and tested an improved nest box design, producing a rodent-proof nest box for endangered birds and a bait station that protects non-target animals from accessing the baits.

Human Health and Safety— Due to the threat to human safety by bird strikes at airports, a program has been developed to evaluate the operational management of bird hazards at airports. The number of bird aircraft collisions continues to be high at Hawaii's airports. WS and NWRC personnel are evaluating the effects of current hazing techniques on one native species, the Pacific golden plover, at the Hilo International Airport. These hazing techniques include vehicular and pyrotechnic harassment by WS personnel, as well as harass-

ment by trained canines. The efficacy of the two methods will be compared by assessing the value of the introduction of a canine unit in the second year of the study. Additionally, the deployment of decoys to assist relocating territorial plovers to alternative habitats will be considered.

Selected Publications:

BEARD, K. H., E. A. PRICE, AND W. C. PITT. 2009. Biology and impacts of Pacific Island invasive species: *Eleutherodactylus coqui*, the Coqui frog (Anura: Leptodactylidae). Pacific Science 63:297-316.

TUTTLE, N. C., K. H. BEARD, AND W. C. PITT. 2009. Invasive litter, not an invasive insectivore, determines invertebrate communities in Hawaiian forests. Biological Invasions 11:845-855.

MATHIES, T., J. A. CRUZ, V. A. LANCE, AND J. A. SAVIDGE. 2010. Reproductive biology of the male brown treesnakes (*Boiga irregularis*) on Guam. Journal of Herpetology 44:209-221.

MATHIES, T, SCARPINO, R, LEVINE, B. A., CLARK, C., and SAVIDGE, J. A. 2011. Excluding Nontarget Species from Brown Tree Snake, *Boiga irregularis* (Reptilia: Colubridae), Bait Stations: Experimental Tests of Station Design and Placement. Pacific Science 65:41–57.

MATHIES, T. 2010. Reproductive cycles of tropical snakes. Book chapter in: *Reproductive Biology and Phylogeny of Snakes*. Eds: D.M. Sever and R.D. Aldridge.

PITT, W. C., L. C. DRISCOLL, AND R. T. SUGIHARA. 2010. Efficacy of rodenticide baits for the control of black rats, Polynesian rats, and mice. Archives of Environmental Contaminination and Toxicology.

PITT, W. C., L. C. DRISCOLL, AND E. A. VANDERWERF. 2010. A rat-resistant artificial nest box for cavity-nesting birds. Human Wildlife Interactions.

PITT, W. C. R. STAHL, AND C. YODER. 2010. Emerging Challenges of Managing Island Invasive Species: Potential invasive species unintentionally spread from military restructuring. Vertebrate Pest Conference.

EISEMANN, J.D. K. SWIFT, PETER DUNLEVY, W. C. PITT AND G. WITMER. 2010. Regulatory and Policy Issues Around Non-Target Mortality and Environmental Fate of Rodenticides – Panel Discussion. Vertebrate Pest Conference.

Major Research Accomplishments:

- WS supports rodenticide registrations for use in island conservation and the protection of seed crops and tropical fruits.
- WS research is evaluating the effectiveness of sex pheromones as attractants for invasive brown treesnakes on Guam.
- WS continued to develop tools to manage invasive tree frogs. Research efforts have led to collection of registration data for the use of sodium and potassium bicarbonate to reduce invasive tree frog populations.
- WS investigated ways to reduce rodent and bird damage to valuable seed crops.
- WS designed a rodent-proof nest box to help protect the endangered small Kauai thrush from predation by invasive rats.
- WS evaluates aerial delivery of acetaminophen-treated dead neonatal mice for wide area population suppression of brown tree snakes.
- WS evaluated lures, baits, and baiting strategies, and continues collaborations with local, national and international cooperators on impacts and control strategies for invasive mesopredators (mongooses, feral cats).
- WS is conducting rumen dietary examinations of non-native feral sheep to determine the browse preference of a native tree/shrub (mamane), the seeds and pods of which are critical for the survival of the endangered Hawaiian honeycreeper, palila.
- WS is evaluating the effects of current hazing techniques on native and non-native avian species that pose bird-aircraft collision hazards at the Hilo International Airport.
- WS and Hawaii natural resources agencies are assessing the ecological and economical threat from feral parrots, whose populations have dramatically increased in the wild.

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Feral Swine Damage Control Strategies in Texas

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Major Cooperators

- Caesar Kleberg Wildlife Research Institute
- King Ranch, Inc.
- Texas A&M AgriLIFE
- Texas A&M University-Kingsville
- Texas Animal Health Commission
- Texas Parks and Wildlife Department
- USDA/Agricultural Research Service
- USDA/APHIS/Veterinary Services
- Welder Wildlife Foundation

Groups Affected By These Problems

- Wildlife and natural resource managers
- U.S. citizens and landowners
- Livestock producers and farmers
- Sporting organizations
- Consumers
- Meat processors

National Wildlife Research Center Scientists Provide Basic Ecological Information to Develop Feral Swine Damage Control Strategies.

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques.

As increased urbanization leads to a loss of traditional wildlife habitat, the potential for conflicts between people and wildlife increases. Such conflicts can take many forms, but, recently, the potential for the transmission of diseases among wildlife, livestock, and humans has received greater attention.

The high reproductive rate and adaptability of feral swine has resulted in populations that have dramatically increased in size and distribution. This invasive animal can now be found across much of the United States, where it causes a range of agricultural and environmental damage through depredation, rooting, and wallowing activities. Furthermore, feral swine compete with native wildlife and livestock for habitats, are carriers of exotic and endemic diseases, and transmit parasites to livestock and humans.

One disease of particular concern to the commercial swine industry is pseudorabies virus, an infectious, often acute, herpesviral disease that infects the nervous system of livestock and wildlife. The disease poses a potential hazard to humans and a major hazard to the swine industry. Adult swine that recover from pseudorabies can develop latent infections and shed the virus indefinitely. Complicating eradication efforts, feral swine have been found seropositive for pseudorabies in 11 states where they are believed to be a free-ranging reservoir for the disease.

Applying Science and Expertise to Wildlife Challenges

Feral Swine Damage to Cottonseed and Evidence of Poisoning— Whole cottonseed is a high-quality food supplement used for cattle and white-tailed deer. Previous studies have found that feral swine and other non-target animals reduce their visitation to deer feeders and avoid consumption of feed when whole cottonseed is used. Unfortunately, recent NWRC research showed a high percentage (58%) of radio–collared feral swine regularly traveling long distances (≤3.2 km) to visit cottonseed storage sites. Complementing the visitation data, blood samples of local feral swine indicated that the animals were consuming cottonseed from these sites. Findings indicate that substituting whole cottonseed for grain or pelleted supplemental feed in deer feeders does not deter feral swine from raiding feeders and consuming whole cottonseed.

Contraceptives for Feral Swine— In recent years, scientists have made advances in immunocontraceptive vaccines involving gonadotrophin-releasing hormone or GnRH (e.g.,GonaCon™) to control feral swine populations. One major obstacle to the use of GonaCon for free ranging feral swine is the lack of an oral delivery mechanism. Another challenge with the GonaCon vaccine is the high cost of formulation. NWRC scientists initiated a study to seek low cost alternatives. aXent, a division of the Imaxio Company, has developed an adjuvant-free immunization technology for veterinary vaccine applications that is inexpensive to produce in large quantities and may be small enough to enable absorption in the gut. This proprietary technology has dramatically improved the immunogenicity of antigens. However, because this technology has not been evaluated within a GnRH vaccine for swine, it is unknown whether this is a cost effective alternative. NWRC scientists evaluated the effectiveness of a third generation GnRH vaccine that incorporated the new adjuvant-free immunization technology. Results revealed reduced testosterone production in feral swine that were given one and two doses of the third generation GnRH vaccine. Similarly, there was impaired sperm development in feral swine given the third generation

GnRH vaccine. These initial findings suggest the third generation GnRH vaccine may be effective at sterilizing male feral swine.

Feral Swine Activity Patterns— Free-ranging, feral swine are increasing in abundance and geographic distribution throughout North America. Information on their natural history, such as daily and seasonal activity patterns, is not available for much of the Southwest; also, there is evidence that these patterns may vary by region. NWRC researchers studied feral swine activity patterns and the impact of temperature on those patterns in southern Texas. Radio-collared feral swine displayed highly nocturnal activity patterns, and during the dormant and early growing season (January through March), activity increased with rising temperatures. However, data for summer (May through July) suggest no influence of temperature on activity patterns. These data are counter to observed reductions in the success of feral swine trapping during summer months. The researchers believe that reductions in summer trapping success may be due to the availability of alternative forage associated with the growing season and, therefore, are not directly related to temperature. These findings provide useful information for wildlife managers, as they can better focus their work depending on the season and environment. For example, during summer droughts, trapping success may increase by targeting trapping efforts near sources of water.

Feral Swine Behavior Relative to Aerial Gunning— Feral swine threaten natural and agricultural resources through their destructive feeding behavior, competition with native wildlife, and impacts on domestic animal agriculture. NWRC evaluated aerial gunning on feral swine to determine if this management method altered the home range and core area sizes of feral swine populations, distances between home range centers and distances moved by surviving animals. Researchers collected data before, during and after aerial gunning efforts in southern Texas using GPS collars deployed on 25 adult feral swine at 2 study sites. Data showed that home range and core area sizes did not differ between pre- and post-aerial gunning, although feral swine moved at a greater rate during the aerial gunning phase than during the pre- and post-periods. Feral swine returned to their original home ranges, thus making them unlikely to spread pathogens widely in response to aerial gunning. The researchers concluded that aerial gunning had only minor effects on the behavior of surviving swine, making this removal method a viable option during foreign animal disease outbreaks.

Evaluation of Boar-Operated-System (BOS™) Feeder— Emerging technologies to reduce risks associated with the transmission of diseases by feral swine include fertility control, vaccination, and toxicants. However, for these technologies to be appropriate for field application, a feral swine-specific oral delivery system is needed. In a recent study, NWRC researchers tested the effectiveness of the BOS, an oral delivery system designed to provide bait access only to feral swine. The researchers evaluated and monitored 10 BOS units for wildlife visitation, bait removal, and ingestion using motion-activated photography and baits containing the bait marker tetracycline hydrochloride (TH). Three of five pre-baited BOS units were used exclusively by feral swine. Additionally, five BOS units that were not pre-baited were not used by either feral swine or non-target wildlife. BOS units effectively reduced bait removal by non-target wildlife, while still allowing bait access to feral swine. Of the 81 feral swine and 23 raccoons captured in the study area, 90 percent and 13 percent, respectively, had TH-marked teeth. These results indicate that, with minor modifications, the BOS could be a valuable tool for use in managing feral swine diseases through delivery of oral vaccines or toxicants.

Promiscuous Mating in Feral Swine— Information on the behavioral ecology of feral swine might increase the efficiency and effectiveness of management strategies. NWRC researchers assessed the frequency of promiscuous mating in feral swine from southern Texas. Results showed evidence of multiple paternity in 21 of 64 litters (33%) from seven of nine sites sampled. Synchrony of estrous did not influence promiscuous mating, as researchers found multiple paternity at sites with synchronous and asynchronous estrous. Feral swine in Texas appear to be promiscuous under a range of demographic conditions, unlike wild boar and feral swine in other regions. The ecological and behavioral factors affecting multiple paternity are not clear, but may include male-male competition, harassment avoidance, genetic benefits for offspring, response to macro-habitat conditions, or selection. A high incidence of sexual contact among individuals may increase the opportunity for diseases transmitted by oral or venereal routes, such as swine brucellosis and pseudorabies. In addition, fertility control methods targeting males only are likely to be inefficient if female promiscuity is high; methods targeting females or both sexes jointly may be more effective.

Fencing for Use During Disease Outbreaks— Feral swine are susceptible to many diseases that are transmissible to cattle (e.g., foot-and-mouth disease, bovine tuberculosis, brucellosis) and domestic swine (e.g., classical swine fever, African swine fever). Animal health officials and wildlife managers need ways to effectively and quickly contain feral swine during disease outbreaks. In collaborations with researchers at the University of Nebraska, NWRC scientists evaluated five candidate fences and, based on efficacy, selected traditional 0.86-meter-high hog panels to test rigorously for containing feral swine with increasing levels of motivation. During a four-day trials, the fences proved 97 percent successful when feral swine were least motivated (relatively undisturbed by humans), 83 percent effective when motivated by humans with paintball projectors, and 100 percent successful when pursued by gunners in a helicopter. The researchers also conducted two longer, 14-day trials where swine were left undisturbed. Only one of twelve feral swine escaped during those trials. In addition to being effective in containing motivated feral swine, enclosures constructed of hog panels were easy to erect and inexpensive ($5.73 per meter, excluding labor) relative to other fencing options. Hog-panel fence structures therefore offer a valuable tool for use in managing feral swine populations.

Selected Publications:

CAMPBELL, T.A., S.L. BULLOCK, D.B. LONG, D.G. HEWITT, M.K. DOWD. 2010. Visitation to cottonseed storage sites by feral swine and evidence of toxicosis. Human-Wildlife Interactions 4:145–151.

CAMPBELL, T.A., M.R. Garcia, L.A. MILLER, M.A. RAMIREZ, D.B. LONG, J. MARCHAND, and F. HILL. 2010. Immunocontraception of male feral swine with a recombinant GnRH vaccine. Journal of Swine Health and Production 18:118–124.

CAMPBELL, T.A., and D.B. LONG. 2010. Activity patterns of wild boar in southern Texas. Southwestern Naturalist 55:564–567.

CAMPBELL, T.A., D.B. LONG, and B.R. LELAND. 2010. Feral swine behavior relative to aerial gunning is southern Texas. Journal of Wildlife Management 74:337–341.

DELGADO-ACEVEDO, J., A. ZAMORANO, R.W. DEYOUNG, T.A. CAMPBELL, D.G. HEWITT, and D.B. LONG. 2010. Promiscuous mating in feral swine (*Sus scrofa*) from Texas, USA. Wildlife Research 37:in press.

LONG, D.B., T.A. CAMPBELL, and G. MASSEI. 2010. Evalution of feral swine-specific feeder systems. Rangelands 32(2):8–13.

RATTAN, J.M., B.J. HIGGINBOTHAM, D.B. LONG, and T.A. CAMPBELL. 2010. Exclusion fencing for feral hogs at white-tailed deer feeders. Texas Journal of Agriculture and Natural Resources 23:in press.

Major Research Accomplishments:

- WS documented that substituting whole cottonseed for grain or pelleted supplemental feed in deer feeders does not deter feral swine from raiding feeders and consuming whole cottonseed.
- WS determined a recombinant GnRH vaccine reduced testosterone production and sperm development in male feral swine.
- WS studied feral swine daily and weekly activity patterns and noted reductions in summer trapping success may be due to the availability of alternative forage associated with the growing season and not directly related to temperature.
- WS concluded that aerial gunning has only minor effects on the behavior of surviving swine and is a viable management option during foreign animal disease outbreaks.
- WS developed feral swine-specific feeder systems for oral delivery of pharmaceuticals.
- WS studied feral swine breeding behavior and reproductive parameters and noted a high incidence of promiscuity among individuals. A high incidence of sexual contact among individuals may increase the opportunity for diseases transmitted by oral or venereal routes, such as swine brucellosis and pseudorabies.
- WS developed relatively inexpensive and quick-to-erect exclusion fencing for use with feral swine during disease outbreaks.

Wildlife Services

Protecting People
Protecting Agriculture
Protecting Wildlife

National Wildlife Research Center

FY 2010

Ecology, Control, and Prevention of Terrestrial Rabies in Free-Ranging Wildlife

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Major Cooperators

- Kansas State University
- Centers for Disease Control and Prevention
- New Mexico State University
- FoodSource (private bait company)
- MERIAL, Inc. (private vaccine development company)
- Purdue University
- Texas A&M University
- Texas State Department of Health Services
- Cleveland Metroparks

Groups Affected By These Problems

- U.S. citizens
- Wildlife and natural resource managers
- Veterinarians
- Livestock producers and farmers
- Sporting organizations
- Consumers

National Wildlife Research Center Scientists Develop New Methods, Strategies to Reduce Rabies Transmission from Infected Wildlife to Humans, Domestic Animals, and Wildlife

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques.

Increased urbanization, greater acceptance of and desire for living closer to free-ranging wildlife, and burgeoning wildlife numbers have led to increased conflict between people and wildlife. Such conflict can take many forms, including the transmission of diseases among wildlife, livestock, and humans. Indeed, many of the pathogens that cause animal disease also are capable of causing disease in humans. Appropriately, there is a great need to understand the processes mediating disease transmission between wildlife, livestock, and humans.

Rabies is an acute, fatal viral disease, most often transmitted through the bite of a rabid mammal, which can infect people as well as animals. Impacts to society from this and other wildlife diseases can be great. For instance, the cost of detection, prevention, and control of rabies in the United States is exceeding $300 million annually.

In 2000, the Secretary of Agriculture enacted a Declaration of Emergency for rabies, citing threats to livestock and to public health and safety. In 2001, NWRC initiated research to help reduce the transmission of this disease.

In the United States, terrestrial rabies can be found in many wild animals, including raccoons, skunks, gray foxes, arctic foxes, bobcats, and coyotes. In an effort to halt the spread and, eventually, eliminate terrestrial rabies in the United States, NWRC scientists are researching the behavior, ecology, movement, and population structure of raccoons and other wildlife hosts. They also are evaluating methods and techniques used to vaccinate wildlife against rabies to decrease the risk of transmission and maintenance of the disease in the wild.

Applying Science & Expertise to Wildlife Challenges

Coyotes and Bobcats as Potential Vectors of the Gray Fox Rabies Variant— Although all mammals are susceptible to rabies, only a few species are important reservoirs and/or vectors of the disease. The Texas gray fox variant of rabies is a strain adapted to and maintained by gray foxes in Texas since 1946. In 2007, the Texas fox-variant was detected in gray foxes, coyotes, and bobcats in west Texas, sparking concern that the variant may also be propagated through contact between the latter two species. If true, the ability of coyotes and bobcats to transmit fox-variant rabies will represent new health risks to humans, companion animals, and livestock. NWRC scientists and collaborators have determined that bobcats infected with rabies accumulate enough of the virus to potentially infect other animals through a bite. In addition, a field study in west Texas has identified habitat types that facilitate interaction, and possible rabies transmission between the three species. This information will be vital for informing bait distribution operations conducted by the WS and the Department of Health Services to control rabies in Texas.

Screening Rabid Animals with Infrared Thermography— NWRC researchers are investigating the use of infrared thermography (IRT) as a field tool to non-invasively detect rabies in raccoons captured during trap-vaccinate-release (TVR) efforts. NWRC

and WS personnel evaluated IRT on 311 animals captured during TVR efforts in Ohio. The ability of IRT to correctly identify rabies-negative raccoons ranged from 85 to 98 percent, depending upon the operator. Thirty-two of the trapped animals showed possible signs of being rabid, but were later determined to be negative for rabies. Researchers are now preparing to test IRT in areas of higher rabies prevalence, and under varying environmental conditions to identify factors that may influence the occurrence of false positive and negative results.

Raccoon Movements and Dispersal in Urban Enviroments— In 2004, raccoon variant rabies moved westward from Pennsylvania into eastern Ohio. In an effort to prevent further spread across Ohio, WS expanded the oral rabies vaccination (ORV) boundary west toward Cleveland. NWRC researchers conducted a study to better understand how raccoon-vectored rabies might move through urban areas of Cleveland and to help develop a vaccination strategy to stop this spread. Researchers found that radio-collared raccoons restricted their space use to small green spaces when available, but also occasionally inhabited abandoned houses. Restricted movements by raccoons in urban areas suggest that rabies may spread more slowly in these locations than in surrounding areas with higher levels of habitat connectivity. However, this finding does not suggest that urban areas should be disregarded when conducting ORV baiting operations. Small, tree-covered habitat patches-particularly those that border urban housing areas—should be hand-baited in an effort to prevent rabies spread within and between raccoons, domestic animals and humans.

Using Contraceptives to Curtail the Spread of Rabies— NWRC researchers are evaluating the use of the Gonacon™ vaccine, an immunocontraceptive, as a tool for the National Oral Rabies Vaccination (ORV) Program. The GonaCon™ vaccine stimulates the production of antibodies that bind to gonadotropin-releasing-hormone (GnRH), which signals the production of sex hormones. The antibodies reduce GnRH's ability to stimulate the release of sex hormones, and inhibit sexual activity and reproduction within individuals for up to two years**.** Researchers have treated raccoons with Gonacon™, the rabies vaccine, and a combination of the two vaccines to simulate trap vaccinate release (TVR) procedures used by the ORV Program to control rabies outbreaks. Results suggest that the Gonacon™ vaccine inhibits reproduction in raccoons for at least one breeding season and does not compromise the integrity of the rabies vaccine. Gonacon™, in concert with the rabies vaccine, may help control the spread of rabies through reducing the size of raccoon populations while increasing vaccination coverage.

Improving Rabies Vaccine Uptake in Wildlife— Devising ways to increase rabies vaccination rates is a primary goal for the rabies research team at NWRC. Researchers are working with Merial, Ltd. (Athens, Georgia), to investigate ways to improve RABORAL V-RG through the addition of adjuvants and thickeners. Raccoons, gray foxes, coyotes, and possibly other terrestrial mammals are vaccinated by ingesting the liquid vaccine which is held in a plastic sachet and surrounded by a palatable bait. Because the vaccine is in a liquid state, it is vulnerable to spillage following puncture of the sachet. Spillage, in turn, results in an animal receiving a lower than desired dose of the vaccine, which often necessitates the need for an animal to consume multiple vaccine baits to become immunized. To address this problem, researchers are evaluating the efficacy of using natural additives to increase the viscosity of the liquid vaccine and to act as adjuvants to enhance the immune response. This work will improve the effectiveness of the oral rabies vaccine, decrease the need for an animal to consume multiple vaccine baits, and potentially result in cost-savings to the ORV program.

Selected Publications:

FRY, T. L., T. C. ATWOOD, AND M. R. DUNBAR. 2010. Evaluation of rhodamine B as a biomarker for raccoons. Human-Wildlife Interactions 4:275-282.

DEYOUNG, R. W., A. ZAMORANO, B. T. MESENBRINK, T. A. CAMPBELL, B. R. LELAND, G. M. MOORE, R. L. HONEYCUTT, AND J. J. ROOT. 2009. Landscape-genetic analysis of population structure in the Texas gray fox oral rabies vaccination zone. Journal of Wildlife Management 73:1292-1299.

JOHNSON, S. R., A. J. PIAGGIO, M. A. NEUBAUM, AND M. R. DUNBAR. 2009. Using genetics to assess differentiation among raccoons in an area with variable rabies status in Alabama. Proceedings of the Wildlife Damage Management Conference 13:40-48.

PUSKAS, R. B., J. W. FISCHER, C. B. SWOPE, M. R. DUNBAR, R. G. MCLEAN, AND J. J. ROOT. 2010. Raccoon (*Procyon lotor*) movements and dispersal associated with ridges and valleys of Pennsylvania: implications for rabies management. Vector-Borne and Zoonotic Diseases 10.

ROOT, J. J., R. B. PUSKAS, J. W. FISCHER, C. B. SWOPE, M. A. NEUBAUM, S. A. REEDER, AND A. J. PIAGGIO. 2009. Landscape genetics of raccoons (Procyon lotor) associated with ridges and valleys of Pennsylvania: implications for oral rabies vaccination programs. Vector-borne and Zoonotic Diseases 9:583-588.

Major Research Accomplishments:

- WS studies on the gray fox variant of rabies in bobcats revealed that sufficient amounts of the virus are present in infected animals to cause infection in other mammals if bitten by bobcats. However, because only mild clinical signs of aggressive behavior were observed in bobcats, more research is needed to determine whether bobcats infected with the gray fox variant of rabies can develop sufficient aggression to bite others and transmit the virus.
- WS studies tested the use of infrared thermography as a field tool to detect rabies in trapped raccoons.
- WS field studies showed restricted movements by raccoons in urban areas suggesting that rabies may spread more slowly in these locations than in surrounding areas with higher levels of habitat connectivity.
- WS used a method called vitrification to help WS' ORV program increase rabies vaccination rates for wild, free-ranging wildlife. Vitrification of the Raboral V-RG® vaccine provides protection from a loss of viability at elevated temperatures. Results suggest that the vaccine virus would remain stable for longer periods of time in a vitrified format.

Wildlife Services

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National Wildlife Research Center

FY 2010

Management of Ungulate Disease and Damage

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Major Cooperators

- USDA/APHIS/Veterinary Services
- USDA/Agricultural Research Service
- DOI/National Park Service
- United States Geological Survey
- Canadian Food Inspection Agency
- University of Nebraska
- Colorado State University
- State Departments of Public Health
- Wisconsin Department of Natural Resources
- Colorado Division of Wildlife
- Michigan Department of Natural Resources
- University of Wisconsin
- Private elk and deer farmers

Groups Affected By These Problems

- Wildlife and natural resource managers
- U.S. citizens
- Livestock producers and farmers
- Captive cervid industry
- Sporting organizations
- Consumers
- Meat processors
- Rural communities
- State and federal agriculture and wildlife agencies

National Wildlife Research Center Scientists Study Chronic Wasting Disease, Bovine Tuberculosis and Other Diseases in Wild and Domestic Ungulates

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques.

As increased urbanization leads to a loss of traditional wildlife habitat, the potential for conflicts between people and wildlife increases. Such conflicts can take many forms, but potential for transmission of diseases among wildlife, livestock, and humans has, recently, received greater attention. Two diseases in particular ─ chronic wasting disease (CWD) and bovine tuberculosis bTB ─ can be found in wild and captive ungulates.

The spread of CWD is of nationwide concern and additional research is required to fill information gaps about CWD transmission at the interface between wild and domestic cervids. CWD infects elk, white-tailed deer, mule deer, and moose, but is not known to naturally infect other species of wildlife (including predators and scavengers), livestock, or humans. There is no treatment for CWD, and it is typically fatal in cervids. Realized and perceived CWD threats have significant implications for Federal and State wildlife management agencies, domestic cervid farmers, hunters, and businesses and economies reliant on deer and elk. In addition, these groups need additional and improved tools and management techniques to reduce the transmission, prevalence, and persistence of CWD in wild and captive cervids.

Tuberculosis is a contagious, bacterial disease of both animals and humans. Bovine TB can be transmitted from livestock to humans and to other animals. The significance of the disease is reflected in APHIS' efforts to eradicate bTB from the United States. The eradication program, which began in 1917, has made significant progress over the years. By the mid-1990's, only a few known infected cattle herds remained, suggesting that the eradication of the disease in the United States was forthcoming. However, cervids in Michigan, as well as a few other states, remains infected. Between 1975 and 1998, bovine TB was documented in Michigan's white-tailed deer with increasing prevalence, and scientific evidence revealed that infected deer transmitted the disease to some of Michigan's cattle.

In 2000, the Secretary of Agriculture enacted a Declaration of Emergency for bovine TB, citing threats to livestock, and public health and safety. In 2001, NWRC initiated research that could assist in reducing or eliminating the transmission of this disease to cattle and humans. This research is especially critical in light of new bovine TB cases recently documented in New Mexico, Minnesota, and California.

Applying Science and Expertise to Wildlife Challenges

Degrading CWD Prions in Soil— Prions, the infectious agent of CWD, bind to a wide range of soils and minerals potentially forming environmental reservoirs for infection. NWRC scientists assisted colleagues from the University of Nebraska-Lincoln and Creighton University to test the ability of the commercially available enzyme, Prionzyme™, to degrade CWD prions in soil. Investigators concluded the enzyme, produced by soil bacterium, successfully degraded CWD prions bound to contaminated soil. Although it may be impossible to totally eliminate prions in the environment, a topical enzyme treatment could help limit indirect disease transmission to cervids in some areas.

Influence of Magnesium and Manganese to CWD Risk— Certain trace minerals may affect CWD risk in cervids. Scientists from the NWRC, USDA Agricultural Research Service, Washington State University, and Colorado State University compared levels of copper, manganese, magnesium, zinc, selenium, and molybdenum in the brains of CWD positive and negative captive Rocky Mountain elk with differing prion genotypes. Brain tissue samples were collected from the cerebrum, parietal lobe, or optic lobe at necropsy. Results indicated that magnesium levels were significantly lower in CWD-positive elk than in control elk. Researchers conclude that mineral levels in elk brain tissues may help to predict CWD infection.

Live Test for CWD— Rectal lymphoid tissue can be used to detect CWD in live Rocky Mountain elk. NWRC researchers took 1,361 rectal biopsies from captive elk to quantify sex and age-related variance in numbers of rectal lymphoid follicles in order to determine the influence of elk sex and age on the diagnosis of CWD. Results showed that the number of lymphoid follicles obtained from typical biopsy tissues decreased with the age of the animal. The acceptable number of lymphoid follicles for detection of CWD was not considered to be a problem for elk up to 8.5 years of age, but for elk over 8.5 years of age, the follicle count was considered to be low. The sex of the animal had no affect on the number of lymphoid follicles observed in each age group. Based on these results, the researchers conclude that rectal biopsies are an accurate test for diagnosing preclinical stages of CWD in elk, especially for elk less than 8.5 years of age.

Predicting CWD Progression in Elk— NWRC researchers examined sections of brain stem, lymph node, and tonsil from approximately 300 free-ranging and 15,000 ranch-raised adult Rocky Mountain elk for the presence of the abnormal isoform of the prion protein (PrP^{CWD}) that has been associated with CWD. Researchers then assisted colleagues from Colorado State University, DOI's National Park Service, USDA's Agricultural Research Service, the U.S. Geological Survey (USGS), and the Canadian Food Inspection Agency to develop a technique, called the "obex score," to predict in elk which structure or regions of the brain, spinal cord, and extra neural tissues contain PrP^{CWD}.

PrP^{CWD} spreads throughout the obex of the brain stem at a rate similar to the movement of PrP^{CWD} throughout the central nervous system and extra neural tissues. Therefore, the obex score has potential usefulness as a basis for evaluating the presence of PrP^{CWD} in peripheral tissues and brain. Current studies are evaluating approximately 100 peripheral tissues and 75 neuro-anatomical locations of the brain and spinal cord in 36 free-ranging and ranch-raised elk with naturally occurring CWD and known incubation times. These results will be compared with corresponding obex scores.

Concurrent work with live animals is relating the level of CWD infection with changes in behavior. Cumulative results could lead to strategies for detecting infected animals before they show clinical signs, which could be useful in the treatment of infected individuals and management of CWD.

Protecting Fenced Resources from Deer Damage— As white-tailed deer populations continue to increase across the United States, so do deer-human conflicts. Fences are a common and effective tool used to exclude deer from valuable agricultural resources, but the weakest link in this system is often human-operated gates. NWRC scientists examined the efficacy of two gate alternatives: a modified cattle guard and a commercially available gate kit for mechanically opening and closing gates. The gate kits prevented deer from entering exclosures; however, supplemental testing revealed high mechanical failure rates. Modified cattle guards initially proved effective, but efficacy declined with time. Given some refinements, gate kits and modified cattle guards may be useful components of an integrated biosecurity strategy.

bTB Transmission Between Raccoons and Livestock— *Mycobacterium bovis*, the causative agent of bovine tuberculosis (bTB), is endemic to white-tailed deer in north-central Michigan, and is capable of causing disease in both cattle and humans. Recently, an extensive surveillance program conducted by the Michigan Department of Natural Resources identified raccoons as a host for *M. bovis*. NWRC scientists examined the potential for disease transmission between raccoons and livestock in the bTB endemic region of Michigan. Results showed raccoons used anthropogenic features, such as loafing sheds, barns, and feed storage facilities when they were located adjacent to forested habitat. Additionally, while simultaneous use of resources by raccoons and cattle was documented, it was determined that pathogen transmission was most likely to occur through indirect means, such as consumption of infected feed or water. Based on these findings, the best way to reduce the likelihood of disease transmission between cattle and raccoons is to place feeding and watering facilities away from forested patches.

Deer Visitation to Cattle Farm Yards— NWRC scientists investigated farm yard visitation by white-tailed deer in order to evaluate the extent to which deer and livestock intermingle and potentially spread disease. Global positioning system radio collars were placed on 25 deer captured on cattle farms in Michigan. Movement data showed deer visited 80 percent of farm yards within their annual home ranges, although only 13 percent of deer accounted for 80 percent of all farm yard visits. A higher proportion of visits occurred at night and multiple visits of farm yards during the same day were common. Visitation increased through spring and peaked during the fawning season. These findings suggest that frequency and timing of deer visitation should be incorporated into mitigation and control efforts to guard against potential transmission of bTB between cattle and deer. In particular, mitigation efforts targeted toward individual deer that are most likely to visit farm yards may reduce potential bTB transmission to cattle and between farms.

Using Coyotes to Detect Bovine Tuberculosis— Bovine tuberculosis (bTB) has been documented in a variety of wildlife species, including coyotes. Localized prevalence of bTB in coyotes can be as high as 30 percent, versus 1.8 percent in deer. Thus, sampling coyotes may be an efficient method of early detection of bTB in an area. To explore this concept, NWRC scientists collected biological samples from 171 coyotes in bTB positive and negative counties in northeastern Michigan. Seventeen coyotes were positive for *Mycobacterium bovis*, the causative agent of bTB. Sixteen of the coyotes were from known bTB-infected counties and one was found in a county with no previous documentation of bTB. The use of coyotes as sentinels may allow wildlife managers to detect the spread of bTB into uninfected counties before it reaches prevalence levels sufficient to be detected in deer. With earlier detection, managers may be able to take proactive surveillance and management measures to reduce the potential risk to domestic livestock and captive deer herds.

Selected Publications:

ATWOOD, T. C., T. J. DELIBERTO, H. J. SMITH, J. S. STEVENSON, AND K. C. VERCAUTEREN. 2009. Spatial ecology of raccoons related to cattle and bovine tuberculosis in northeastern Michigan. Journal of Wildlife Management 73:647-654.

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WALTER, W. D., K. C. VERCAUTEREN, J. M. GILSDORF, AND S. E. HYGNSTROM. 2009. Crop, native vegetation, and biofuels: response of white-tailed deer to changing management priorities. Journal of Wildlife Management 73:339-344.

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WHITE, S. N., K. I. O'ROURKE, T. GIDLEWSKI, K. C. VERCAUTEREN, M. R. MOUSEL, G. E. PHILLIPS, AND T. R. SPRAKER. 2010. Increased risk of chronic wasting disease in Rocky Mountain elk associated with decreased magnesium and increased manganese in brain tissue. Canadian Journal of Veterinary Research 74:50-53.

Major Research Accomplishments:

- WS determined Prionzyme™, a commercially available an enzyme, successfully degraded CWD prions bound to contaminated soil.
- WS concluded that mineral levels in elk brain tissues may help to predict CWD infection.
- WS concluded that rectal biopsies are an accurate test for diagnosing preclinical stages of CWD in elk, especially for elk less than 8.5 years of age.
- WS and partners developed a technique, called the “obex score,” to predict in elk which structure or regions of the brain, spinal cord, and extra neural tissues contain the CWD prion protein.
- WS evaluated gate kits and modified cattle guards to exclude deer from valuable agricultural resources.
- WS examined the potential for disease transmission between raccoons and livestock in the bTB endemic region of Michigan. Results showed raccoons used anthropogenic features, such as loafing sheds, barns, and feed storage facilities when they were located adjacent to forested habitat.
- WS investigated farm yard visitation by white-tailed deer in order to evaluate the extent to which deer and livestock intermingle and potentially spread disease.
- WS used coyotes as sentinels to detect the spread of bTB into uninfected counties in northeast Michigan. Localized prevalence of bTB in coyotes can be as high as 30 percent, versus 1.8 percent in deer. Thus, sampling coyotes is an efficient method of early detection of bTB in an area.

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Chemical and Metabolic Approaches for Minimizing Human-Wildlife Conflicts

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Major Cooperators

- Colorado State University
- Monell Chemical Senses Center
- University of Florida
- University of California
- U.S. Food and Drug Administration
- U.S. Environmental Protection Agency
- U.S. Department of Defense
- U.S. Fish and Wildlife Service
- California Department of Food and Agriculture
- Hawaii Department of Natural Resources
- LiphaTech, Inc.
- Kolfolk, Inc.
- Berryman Institute, Utah State University
- Wildlife Conservation Society
- ENSR Environmental Consultants
- Department of the Environment, Food and Rural Affairs, UK
- CIIT Institute for Health Research
- USDA/APHIS International Services
- Nevada Division of Wildlife
- Oregon Department of Fish and Wildlife
- University of Arizona
- Idaho State University
- Texas Tech University
- Wisconsin Department of Natural Resources
- The Nature Conservancy
- Island Conservation
- USGS Patuxent Wildlife Research Center

Groups Affected By These Problems

- U.S. citizens
- Agricultural producers
- Consumers of Agricultural products
- Industry groups
- State wildlife and natural resource managers

National Wildlife Research Center Scientists Use Chemistry to Resolve Wildlife Damage

Wildlife Services' (WS) National Wildlife Research Center (NWRC) is the only Federal research facility devoted exclusively to resolving conflicts between people and wildlife through the development of effective, selective, and socially responsible methods, tools, and techniques.

To help meet the increasing need for new, Federally-approved chemical tools for use in wildlife damage management, NWRC scientists design and test methodologies to identify, analyze and develop new drugs, repellents, toxicants, and other chemically-based wildlife damage management tools. These methodologies are used to support U.S. Environmental Protection Agency (EPA) and U.S. Food and Drug Administration (FDA) registration requirements. NWRC scientists are experienced in a variety of scientific disciplines, including pharmacology, environmental fate, chemical synthesis, toxicology, chemical ecology, computer modeling and formulation chemistry.

Studies include, but are not limited to the following:

1. Developing alternative chemical tools (toxicants, repellents, contraceptives, and attractants) to reduce rodent damage to crops and deer damage to forest resources.
2. Identifying existing products or naturally-occurring chemicals in plants and animals that could be used as agents to protect against wildlife damage.
3. Developing formulations for increasing the effectiveness of wildlife damage management chemicals already in use.
4. Developing computer models to evaluate the efficacy and safety of pesticides to target and non-target wildlife.

Applying Science and Expertise to Wildlife Challenges

Radio-Tracer Techniques— Scientists are using NWRC's state-of-the-art radioisotope laboratory to develop techniques for better understanding the metabolism, residues, degradation pathways, and mode of action for various chemicals (fertility agents, immobilizing agents, toxicants) of interest to APHIS. Current radio-tracer studies with alpha-chloralose (an immobilizing agent) may be used to support changes in use restrictions that would increase the value of this tool to the WS program and stakeholders.

Identification of Compounds— To develop effective repellents for pest birds and mammals, NWRC scientists are conducting experiments with inexpensive proteins and other natural products. These studies indicate that animal-derived protein sources, such as gelatin and casein, may serve as non-lethal repellents for a variety of herbivores, such as deer and rabbits.

Analytical Methods for Risk Assessment— NWRC chemists are developing new and improved methods for determining the risk to non target animals posed by chemicals developed to reduce wildlife damage. Data on chemical residues found in treated wildlife are critical for assuring that the proposed uses of these tools are accompanied by minimal risk to non target animals, humans and the environment. For example, NWRC chemists are assess secondary hazards of the rodenticide diphacinone to non target bird species. Findings show the oral toxicity of diphacinone is about 20 times greater to American kestrels than to northern bobwhite quail. Similar analytical approaches are being used to assess the safety of acetaminophen to control brown tree snakes in Guam, using anthraquinone to reduce bird damage to lettuce and rice and using diphacinone and brodifacoum to control pest rodents on Hawaii, Alaska and islands located in the Pacific and Caribbean. The residue data are used to develop computer models to estimate risk to target and nontarget wildlife. The computer models are also used to identify pesticide formulation and application strategies.

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Chemistry Support for NWRC Scientists— NWRC's Analytical Chemistry Laboratory provides support for all research projects being conducted at the Center's headquarters in Fort Collins, CO, and the Center's field stations located throughout the United States. This chemistry assistance supports a variety of research topics, including avian infertility, bovine tuberculosis, rabies, wildlife hazards to aviation, wildlife damage to forest resources, waterfowl disease, and bird damage to rice, sunflowers and aquaculture.

Selected Publications:

FIELD, K. L., A. A. BACHMANOV, J. A. MENNELLA, G. K. BEAUCHAMP, AND B. A. KIMBALL. 2009. Protein hydrolysates are avoided by herbivores but not by omnivores in two-choice preference tests. PLoS ONE Jan 2009. (www.plosone.org) *doi:20.1371/journal.pone.0004126*.

FIGUEROA, J.A., B.A. KIMBALL, AND K.R. PERRY. 2008. Lagomorph and Rodent Responses to Two Protein Hydrolysates. Crop Protection 27:851-854.

HORAK,K.E., C. WERMAGER, AND T.M. PRIMUS. 2010. The use of liver microsome *in-vitro* methods to study toxicant metabolism and predict species efficacy. Proceedings of the 24th Vertebrate Pest Conference.

JOHNSTON, J.J., R. BUNNING, N. TAYLOR, AND D. GRIFFIN. 2008. Benzoate adjuvant to increase the utility of methylxanthine pesticides: identification of a potential rodenticide formulation for organic food production. Proceedings of the Vertebrate Pest Conference 23:166-169.

KIMBALL, B. A., AND K. R. PERRY. 2009. Evaluating new protein sources for development of a deer repellent product. Crop Protection 28:364-366.

KIMBALL, B. A., J. TAYLOR, K. R. PERRY, AND C. CAPELLI. 2009. Deer responses to repellent stimuli. Journal of Chemical Ecology 35:1461-1470.

KIMBALL, B. A., AND J. D. TAYLOR II. 2010. Mammalian herbivore repellents: tools for altering plant palatability. Outlooks on Pest Management 21:181-187.

RATTNER, B.A., K.E. HORAK, S.E. WERNER, AND J.J. JOHNSTON. 2010. Acute Toxicity of Diphacinone in Northern Bobwhite: Effects on Survival and Blood Clotting. Ecotoxicology and Environmental Safety 73:1159-1164.

RATTNER, B.A., K.E. HORAK, S.E. WARNER, D.D. DAY, AND J.J. JOHNSTON J.J. 2010. Comparative toxicity of diphacinone to northern bobwhite (*Colinus virginianus*) and American kestrels (*Falco sparverius*). Proceedings of the 24th Vertebrate Pest Conference.

SCHMIT, B.S., T.M. PRIMUS, J.C. HURLEY, D.J. KOHLER, AND S.F. GRAVES. 2010. Response of captive skunks to microencapsulated tetracycline. Journal of Wildlife Management 46:1024-1028.

STAHL, R.S., S.J. WERNER, J.L. CUMMINGS, J.J. JOHNSTON. Computer Simulations of Baiting Efficacy for Raven Management using DRC-1339 Egg-Baits. Proceedings of the Vertebrate Pest Conference 23: 94-97.

THIEMANN, G.W., R.S. STAHL, S. BARUCH-MORDO, S. W. BRECK. 2008. *Trans* fatty acids provide evidence of anthropogenic feeding by black bears. Human Wildlife Conflicts 2:183-193.

WERNER, S.J., J.L. CUMMINGS, S.K. TUPPER, D.A. GOLDADE, AND D. BEIGHLEY. 2008. Blackbird Repellency of Selected Registered Pesticides. Journal of Wildlife Management 72:1007-1011.

WERNER, S.J., B.A. KIMBALL, AND F.D. PROVENZA. 2008. Color, Flavor, and Conditioned Avoidance among Red-Winged Blackbirds. Physiology and Behavior 93:110-117.

WITMER, G.W., J.D. EISEMAN, T.M. PRIMUS, J.R. O'HARE, K.R. PERRY, R.M. ELSEY, AND P.L. TROSCLAIR III. 2010. Assessing potential risk to alligators, *Alligator mississippiensis*, from nutria control with zinc phosphide rodenticide baits. Bulletin of Environmental Contamination and Toxicology 84:698-702.

Major Research Accomplishments:

- WS research indicates that habituation to odor limits the effectiveness of repellents that are not applied directly to food, while topically-applied irritants and animal-based products produce significant avoidance behavior in deer.
- WS developed analytical chemistry methods and analyzed numerous samples to support the development of tools to interfere with reproduction in pest bird species and to evaluate primary and secondary hazards of rodenticides used to eradicate invasive rats on islands.
- WS gathered data for the development of a physiologically based pharmacokinetic model to assess and predict rodenticide toxicity to a variety of non-target mammalian and avian species.

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Economic Research of Human-Wildlife Conflicts: Methods and Applications

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Major Cooperators

- California Department of Agriculture
- Departments of Economics and Ecology, University of Hawaii
- Economics Department, Colorado State University
- National Rabies Coordinator
- Ontario Ministry of Natural Resources, Canada
- Texas A&M University
- Texas Department of State Health Services
- Vertebrate Pest Control Research and Advisory Committee (California)

Groups Affected By These Problems

- Agricultural producers
- International wildlife conservation organizations
- State county agricultural commissioners
- State game and fish agencies
- State natural resource agencies
- State public health agencies
- Wildlife Services managers
- U.S. citizens

National Wildlife Research Center Economists Use Benefit-Cost Analyses to Quantify Economic Impacts of Human-Wildlife Conflicts

The Wildlife Service's (WS) National Wildlife Research Center (NWRC) is the only Federal research organization devoted to resolving human-wildlife conflicts through the development of effective, selective, and socially responsible methods, tools and techniques.

The 2006 Research Needs Assessment of USDA/APHIS/WS ranked economic assessments of diverse management techniques, products and programs third among the 13 most frequently cited data requirements by WS programs and staff. Economics research at NWRC seeks to meet this need and to satisfy The Government Performance and Results Act of 1993 by acquiring accounting-type, outcome-based data of program efficiency.

NWRC economists conduct research to determine the potential benefits (savings) and costs involved in reducing the impacts of introduced invasive species, emerging wildlife-transmitted diseases, and traditional wildlife-caused damages to agriculture, and property, natural resources, as well as wildlife-posed risks to public health and safety.

Applying Economic Expertise to the Challenges of Wildlife Damage Management

Economic Impact of Double-Crested Cormorants— Over the last 30 years, the population of double-crested cormorants—a large, fish-eating, colonial-nesting waterbird—has increased dramatically in the Great Lakes region. Recreational fishing is an important socio-economic activity in upstate New York, including Oneida Lake. Current research suggests that predation by cormorants has caused declines in the sport fish populations at Oneida Lake and potentially a decrease in the number of anglers visiting the Lake. To assess the economic effectiveness of the cormorant management program, NWRC scientists assessed cormorant damage to Oneida Lake. The methodological approach was to value both the direct and indirect economic impacts of reduced non-resident angler tourism in the region and to assess the monetary benefits and costs associated with WS' cormorant management program. The total estimated tourism revenue lost in the Oneida Lake Region due to cormorant damage over a 15-year period ranged from $100 to $500 million, and the total estimated number of jobs lost ranged from 3,000 to 12,000. A benefit-cost comparison provided ratios to evaluate the overall program efficiency and determine the return per dollar invested. The benefit-cost ratios calculated over the study period (1998 to 2005) ranged from 14 to 48 across the different levels of estimated benefit. In other words, for every $1 spent on the cormorant management program, $14 to $48 in benefits were realized. Additionally, the results indicated that the cormorant control program saved between 1,446 and 5,014 jobs in the Oneida Lake Region during the eight years following implementation.

Economic Assessment of Beaver Damage in Mississippi— Beaver populations in Mississippi have fluctuated significantly over the last 150 years, as their status has changed from a game species to a protected species to a nuisance species. To determine the overall value of Mississippi's Beaver Control Assistance Program (BCAP), NWRC economists assessed beaver-caused economic impacts to Mississippi's timber industry and estimated the damages avoided due to BCAP activities from 2005 to 2009. The total BCAP costs averaged $1.1 million annually over the study period. Six combinations of possible direct timber savings were estimated, ranging from $25 million to $57 million annually, which makes up between about four and seven percent of the total annual delivered value of timber in Mississippi. To estimate the potential secondary impact to the regional economy from this protected timber, the economists utilized an input-output model. The additional annual savings in regional economic activity ranged from $19 million

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to $42 million. Using these estimated values of prevented beaver damage, estimated that every dollar spent on BCAP saved between $39.67 and $88.52 in potential beaver damage to timber and the State economy.

Economic Analysis of Rabies Vaccination Program in Canada— Ontario, Canada, has had a red fox oral rabies vaccination (ORV) program in place since 1989. To determine if the program is cost effective, economists from the NWRC, the Ontario Ministry of Natural Resources, and Texas A&M University conducted a benefit-cost analysis. Between 1979 and 1989, prior to ORV baiting, there were annual averages of 2,248 human post-exposure treatments, 1,861 positive red fox rabies diagnostic tests and $246,809 in indemnity payments for livestock lost to rabies. After baiting, from 1990 to 2000, there were 35- , 66- and 41-percent decreases in post-exposure treatments, animal rabies tests, and indemnity payments, respectively. Researchers viewed these reductions as benefits of the ORV program, whereas total costs were those associated with ORV baiting. Using several statistical techniques, the researchers estimated that total benefits ranged from approximately $35 to $98 million. The annual mean ORV program cost was approximately $6 million, with total program costs of $77 million. The average benefit-cost ratios over the analysis period were 0.49, 1.06, 1.27 and 1.36, indicating overall program efficiency in three of the four conservative scenarios.

Cost Effectiveness of Oral Contraceptive for Managing Nuisance Canada Geese— OvoControl-G is an oral contraceptive bait for Canada geese. When fed to geese during their breeding season, the bait's active ingredient, nicarbazin, reduces the hatching success of eggs. When it is withdrawn from the diet, egg production and hatchability return to normal within a few days.

An NWRC economist modeled the cost effectiveness of using OvoControl-G versus egg addling, oiling, or other nest-destruction techniques to manage nuisance Canada geese. The model also evaluated the effects of the presence of non targets, alternative foods, and public support on cost efficacy. Results showed that, at low goose densities (less than 35 pairs of geese), labor was a significant portion of the cost. As goose densities increased, OvoControl-G became more cost effective than other methods, such as egg oiling or addling. The analysis provides information that can help wildlife managers determine whether OvoControl-G will provide a successful and cost-effective tool for controlling populations of Canada geese in specific management areas.

Selected Publications:

CAUDELL, J. N., S. A. SHWIFF, AND M. T. SLATER. 2010. Using a cost-effectiveness model to determine the applicability of OvoControl G to manage nuisance Canada geese. Journal of Wildlife Management 74:843-848.

ENGEMAN, R. M., J. E. LABORDE, B. U. CONSTANTIN, S. A. SHWIFF, P. HALL, A. DUFFINEY, AND F. LUCIANO. 2010. Economic impacts to commercial farms from invasive monkeys in Puerto Rico. Crop Protection 29:401-405.

GEBHARDT, K., S. A. SHWIFF, B. R. LELAND, D. R. HATCHETT, AND M. J. BODENCHUK. 2009. Methodology to estimate cost savings associated with the use of trap monitor systems by Wildlife Services. Proceedings of the Wildlife Damage Management Conference 13:132-136.

SHWIFF, S. A., R. T. STERNER, R. HALE, M. T. JAY, B. SUN, AND D. SLATE. 2009. Benefit cost scenarios of potential oral rabies vaccination for skunks in California. Journal of Wildlife Diseases 45:227-233.

SHWIFF, S. A., K. GEBHARDT, K. N. KIRKPATRICK, AND S. S. SHWIFF. 2010. Potential economic damage from introduction of brown tree snakes, *Boiga irregularis* (Reptilia: Colubridae) to the islands of Hawaii. Pacific Science 64:1-10.

STERNER, R. T., M. I. MELTZER, S. A. SHWIFF, AND D. SLATE. 2009. Tactics and economics of wildlife oral rabies vaccination, Canada and the United States. Emerging Infectious Diseases 15:1176-1184.

Major Research Accomplishments:

- WS economic studies showed that for every $1 spent on the double-crested cormorant management program in the Oneida Lake Region of New York, $14 to $48 in benefits was realized.
- WS economists assessed beaver-caused economic impacts to Mississippi's timber industry and estimated the damages avoided by beaver management ranged from $25 million to $57 million on average annually.
- WS economists and partners determined the red fox oral rabies vaccination (ORV) program in Canada is cost-effective in the majority of scenarios analyzed.
- WS economists determined the use of the oral contraceptive bait (OvoControl) for Canada geese becomes more cost effective than other control methods, such as egg addling or oiling, when goose densities are greater than 35 breeding pairs in a treated location.

Wildlife Services

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Product Registration: Providing Tools for Wildlife Services

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Major Cooperators

- Wildlife Services Operations
- U.S. Fish and Wildlife Service
- Private pesticide and repellent registrants
- Association of Fish and Wildlife Agencies
- State Wildlife Management Agencies
- State Pesticide Regulatory Agencies
- International pesticide product developers

Groups Affected By These Problems

- Urban and suburban residents
- Farmers, ranchers, and livestock producers
- Federal, State and private natural resource managers

National Wildlife Research Center Maintains Chemical Tools for Wildlife Damage Management

The NWRC Registration Unit is responsible for ensuring WS registrations of chemical-based management tools are current and meet State and Federal regulations. The primary mission of the Registration Unit is to provide regulatory guidance to NWRC management and scientists on product development and to assist Wildlife Services (WS) Operations personnel with their regulatory needs for using chemical control methods when managing problem wildlife. As a member of the WS Pesticide Coordinating Committee (PCC), the Registration Unit works closely with other committee members including APHIS' Policy and Program Development, Environmental and Risk Analysis Services office, WS Operational Support Staff, and the Pocatello Supply Depot in product registration activities. As part of the PCC, NWRC's Registration Unit assists with the development of standard guidelines for selling APHIS pesticide products to foreign parties and provides recommendations to WS management on all foreign sales.

APHIS continues to hold registrations with the U.S. Environmental Protection Agency (EPA) for rodenticides, predacides, avicides, repellents, a snake toxicant, an avian repellent and a contraceptive vaccine. APHIS also holds Investigational New Animal Drug (INAD) applications with the U.S. Food and Drug Administration (FDA) for immobilizing agents used in animal damage management. To maintain or expand authorized use of these products, the Registration Unit works closely with NWRC scientists to ensure that studies conducted for regulatory purposes meet EPA and FDA guidelines.

The Registration Unit also provides technical and regulatory assistance and information to state WS programs, Federal and State agricultural and conservation agencies, academic institutions, non-governmental groups, and private industry. Many of the requests for assistance come from WS Operations personnel seeking new products or improvements to existing products, or looking for help interpreting product labels to ensure proposed applications are legal.

Applying Science and Expertise to Wildlife Challenges

APHIS Pesticide Product Registrations— APHIS currently holds registrations through the EPA for eleven active ingredients formulated into 23 federally registered vertebrate pesticide products. These products meet the needs of bird management (five avicide products and one avian repellent), rodent management (11 rodenticide products), predator management for livestock and threatened and endangered species protection (four predacide products), a toxicant for managing brown tree snakes in Guam and a contraceptive vaccine for reducing fertility in white-tailed deer.

Rodenticides— The Registration Unit continues to serve as a primary contact for WS efforts in eradicating rodents from islands for the protection of threatened and endangered species and critical habitats. Since securing three registrations in 2007 for this purpose, the Registration Unit has provided guidance or regulatory assistance on five rodent eradication projects in the Pacific region to protect nesting seabirds. WS personnel conducted eradication projects on 100- and 700-acre islands in Guam and Hawaii, respectively. Additionally, the U.S. Fish and Wildlife Service successfully eradicated rats from a 7,000-acre island in the Alaska Maritime National Wildlife Refuge and is planning a future effort on Palmyra Atoll. The U.S. Air Force also plans to eradicate rats on Wake Atoll in the Pacific Ocean. These projects could not have proceeded without assistance from the Registration Unit.

The Registration Unit continues to coordinate a consortium of private companies who register zinc phosphide-based rodenticide products. Collectively, this consortium gathers data to maintain EPA registrations of zinc phosphide rodenticides and works with EPA to develop appropriate precautionary language on product labels. The consortium has saved WS hundreds of thousands of dollars and saved consortium members millions of dollars.

Bird Management Tools— DRC-1339 continues to be a valuable tool for managing damage caused by birds. Since 1996, APHIS has held EPA registrations for five DRC-1339 based products. These products are used to manage damage caused by blackbirds in feedlots and roost staging areas, gulls at landfills, pigeons roosting on structures, and crows and ravens preying on livestock and threatened and endangered species. The NWRC Registration Unit is working to expand DRC-1339 registrations for use with crow and raven management. The staff also worked cooperatively with the U.S. Fish and Wildlife Service and WS to obtain EPA approval of an amendment to the DRC-1339 Gull label allowing the use of DRC-1339 in certain New England States for the protection of threatened and endangered species against laughing gull predation. Additionally, U.S. territories and foreign governments, including the governments of American Samoa, Australia, South Africa, and Israel, have asked for assistance in managing bird damage.

NWRC's Registration Unit also provides significant guidance to Center scientists and private industry on the development of anthraquinone and currently registered fungicides for avian repellent uses. Current projects are aimed at developing chemical repellents for seed treatment and foliar applications in corn, sunflower, rice and, potentially, some soft fruit crops.

Wildlife Contraceptives— The NWRC is a world leader in the development of effective wildlife contraceptives. In 2009, NWRC researchers successfully registered with the U.S. Environmental Protection Agency the first single-shot, multi-year immunocontraceptive vaccine for use in female white-tailed deer. Called GonaCon™ Immunocontraceptive Vaccine (GonaCon), this new tool promises to be useful for managing not only urban white-tailed deer where traditional options are limited, but also populations of other species, such as companion animals and wildlife that transmit diseases. Research has shown GonaCon to be an effective reproductive inhibitor in elk, feral horses, bison, prairie dogs, ground squirrels, and feral dogs and cats. NWRC and its collaborators are investigating the use of GonaCon for reducing the spread of rabies in feral dogs and raccoons, preventing reproduction by companion animals, controlling adrenocortical disease in pet ferrets, and preventing the spread of brucellosis in bison. The vaccine is being used for research purposes in the United States, Mexico, Europe, New Zealand and Australia. Future NWRC research with GonaCon likely will involve studies to support expanded registration to other species, to develop oral delivery systems, and to prevent transmission of wildlife diseases. On October 25, 2010, NWRC received the 2010 Colorado Governor's Award for High-Impact Research for its development of GonaCon.

Registration of Predacides— In response to a 2007 petition calling for the cancellation of sodium cyanide and compound 1080, EPA requested that APHIS provide information for the agency's evaluation of these products. APHIS holds four registrations for these materials as predacides and uses these products at the request of ranchers who are losing sheep and goats to coyote predation. Working in conjunction with WS field operations staff in FY 2009, the NWRC Registration Unit helped write an 84-page informational packet for EPA on the use of sodium cyanide and compound 1080 as predacides. The packet contained data summaries for previous years, including the amount of chemical used, the number of target and non-target animals taken, full descriptions of events related to the accidental exposure of these products to humans, threatened and endangered species, and companion animals, the economics of predation management and background on APHIS' decision-making process for the use of chemical control measures. APHIS also provided EPA with a description of accountability procedures for WS' use of these measures. EPA denied the petition that called for cancellation of the registrations and allowed WS to continue using these materials, with only minor changes to regulatory use restrictions.

In 2004, the NWRC began developing a new predacide based on theobromine and caffeine, materials extracted from cocoa, coffee and tea. The effort demonstrated that these materials can be formulated into an effective product for managing coyote depredation. In 2009, the NWRC Registration Unit began developing the EPA-required registration data for this product. Efforts are now underway to develop product chemistry, toxicity, and efficacy data that will support an application to conduct a large-scale field efficacy study. This effort involves developing more than 60 data submissions, a product label, and a protocol for the field efficacy study. Current plans are to submit an Experimental Use Permit application to EPA in 2011 and begin the field efficacy study in 2012.

Development of a Feral Swine Toxicant— WS is pursuing an EPA registration of sodium nitrite for use as a feral swine toxicant. Sodium nitrite is a preservative for pork and other meats that happens to be toxic to live swine. NWRC signed a Cooperative Research and Development Agreement (CRADA) with the Invasive Species Cooperative Research Centre in Australia to share registration data already developed in Australia that may be appropriate to support an EPA product registration. Additionally, NWRC will conduct laboratory studies with sodium nitrite to gather acute oral avian toxicology, avian dietary toxicology, and end-product toxicology data. Field studies on various delivery systems will be conducted in Texas, Mississippi, Florida, Michigan and Missouri. This partnership will save APHIS hundreds of thousands of dollars in EPA registration data development costs. A private Australian company has also partnered with NWRC to provide funding to investigate sodium nitrite as a rodenticide.

Information Sharing: Environmental Risk Assessment and New Management Tools— The Registration Unit led development of an online searchable NWRC Chemical Effects Database containing historical data for approximately 7,000 chemicals analyzed and evaluated for repellency, toxicity, reproductive inhibition and immobilization on a variety of plants, birds, mammals, and amphibians. The database is useful to researchers worldwide who are involved in environmental risk assessments and the development of new damage management tools.

Selected Publications:

BYRD, R. W., J. L. CUMMINGS, S. K. TUPPER, AND J. D. EISEMANN. 2009. Evaluation of sodium lauryl sulfate as a blackbird wetting agent. Proceedings of the Wildlife Damage Management Conference 13:191-196.

EASON, C. T., K. A. FAGERSTONE, J. T. EISEMAN, S. HUMPHRYS, J. R. O'HARE, AND S. J. LAPIDGE. 2010. A review of existing and potential New World and Australasian vertebrate pesticides with a rationale for linking use patterns to registration patterns. International Journal of Pest Management 56:109-125.

GIONFRIDDO, J. P., J. D. EISEMANN, K. J. SULLIVAN, R. S. HEALEY, L. A. MILLER, K. A. FAGERSTONE, R. M. ENGEMAN, AND C. A. YODER. 2009. Field test of a single-injection gonadotrophin-releasing hormone immunocontraceptive vaccine in female white-tailed deer. Wildlife Research 36:177-184.

WITMER, G. W., J. D. EISEMAN, T. M. PRIMUS, J. R. O'HARE, K. R. PERRY, R. M. ELSEY, AND P. L. TROSCLAIR III. 2010. Assessing potential risk to alligators, *Alligator mississippiensis*, from nutria control with zinc phosphide rodenticide baits. Bulletin of Environmental Contamination and Toxicology 84:698-702.

Major Registration Accomplishments:

- APHIS successfully registered the GonaCon™ Immunocontraceptive Vaccine with the EPA in 2009. The vaccine reduces reproduction in female white-tailed deer. On October 25, 2010, NWRC received the 2010 Colorado Governor's Award for High-Impact Research for its development of GonaCon. WS continues to conduct research to expand the vaccine's registration to other species.
- WS developed a searchable Chemical Effects database containing historical data for approximately 7,000 chemicals analyzed and evaluated for repellency, toxicity, reproductive inhibition and immobilization on a variety of plants, birds, mammals, and amphibians. The database provides useful data to researchers worldwide who are involved in environmental risk assessments and the development of new damage management tools.
- WS signed a Cooperative Research and Development Agreement (CRADA) with the Invasive Animals Cooperative Research Centre (an Australian partner) to develop sodium nitrite as a feral swine toxicant for use in the United States.

Vertebrate Control Products Currently Registered or Approved for Use by USDA APHIS				
Taxa	**APHIS Products**	**Mode of Action**	**Species**	**Uses Unique to APHIS**
RODENTS	Zinc Phosphide (3 products)	Lethal	Voles, mice, rats, hares, woodchucks, ground squirrels, muskrats, nutria, prairie dogs	Some
	Strychnine (4 products)	Lethal	Pocket gophers	No
	Gas Cartridge (1 product)	Lethal	Prairie dogs, ground squirrels, woodchucks, marmots	No
	Diphacinone (1 product)	Lethal	Invasive rodents on islands	Yes
	Brodifacoum (2 products)	Lethal	Invasive rodents on islands	Yes
CANINE PREDATORS	Large Gas Cartridge (1 product)	Lethal	Coyotes, red foxes, striped skunks	Yes
	M-44 Cyanide Capsules (2 products)	Lethal	Coyotes, red foxes, gray foxes, arctic foxes, feral dogs	Some
	Livestock Protection Collar Compound 1080	Lethal	Coyotes	Yes
	Tranquilizer Trap Device	Non-lethal Immobilizing Agent	Wolves, coyotes, feral dogs	Yes
CERVIDS	GonaCon Immunocontraceptive Vaccine	Non-lethal Contraceptive	White-tailed deer	Yes
BIRDS	Compound DRC-1339 Concentrate (4 labels)	Lethal	Gulls, pigeons, ravens, crows, magpies, starlings, blackbirds	Yes
	Compound DRC-1339 Concentrate—Feedlots	Lethal	Blackbirds, starlings, grackles, cowbirds	Some
	Mesurol Aversive Conditioning Egg Treatment	Non-lethal	Crows, ravens	Yes
	Alpha-chloralose	Non-lethal	Geese, ducks, coots, pigeons, ravens	Yes
	Corn Oil	Non-Lethal (Egg Oil)	Canada geese	No
SNAKES	Acetaminophen	Lethal	Brown treesnakes	Yes
	Cinnamon, Clove and Anise Oil	Non-lethal Repellent	Snakes	No
** Registration review by EPA in progress*				