Wildlife Services

Protecting People
Protecting Agriculture
Protecting Wildlife

National Wildlife Research Center

FY 2008

Seeking Solutions Through Research

Contact Information:
Dr. Larry Clark, Center Director
NWRC Headquarters
4101 LaPorte Avenue
Fort Collins, CO 80521
Phone: (970) 266-6036
FAX: (970) 266-6040
larry.clark@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Wildlife Services On-going Research & Development

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USDA APHIS
United States Department of Agriculture
Animal and Plant Health Inspection Service

National Wildlife Research Center & Field Stations
Web site: www.aphis.usda.gov/wildlife_damage/nwrc

NWRC Contact Information:
Dr. Larry Clark, Center Director
NWRC Headquarters
4101 Laporte Avenue
Fort Collins, CO 80521
Phone: (970) 266-6036 FAX: (970) 266-6040
E-mail: larry.clark@aphis.usda.gov

Field Stations

Bismark, ND Field Station
Contact Information:
Dr. George Linz, WS Research Wildlife Biologist
North Dakota Field Station
2110 Miriam Circle, Suite B.
Bismarck, ND 58105
Phone: (701) 250-4469 FAX: (701) 250-4408
E-mail: george.m.linz@aphis.usda.gov

Gainesville, FL Field Station
Contact Information:
Dr. Michael Avery, WS Research Wildlife Biologist
Florida Field Station
2820 East University Avenue
Gainesville, FL 32641
Phone: (352) 375-2229 FAX: (352) 377-5559
E-mail: michael.l.avery@aphis.usda.gov

HI Field Station
Contact Information:
Dr. William Pitt, WS Research Wildlife Biologist
Hawaii Field Station
P.O. Box 10880
Hilo, HI 96721
Phone: (808) 961-4482 FAX (808) 961-4776
E-mail: will.pitt@aphis.usda.gov

Kingsville, TX Field Station
Contact Information:
Dr. Tyler A. Campbell, WS Research Wildlife Biologist
Texas Field Station
Texas A&M University-Kingsville
MSC 218, 700 University Blvd.
Kingsville, TX 78363
Phone: (361) 593-2426 FAX: (361) 593-4311
Email: tyler.a.campbell@aphis.usda.gov

Logan, UT Field Station
Contact Information:
Dr. John Shivik, WS Supervisory Research Wildlife Biologist
Utah Field Station
Utah State University
Logan, UT 84322-5295
Phone: (435) 797-1348 FAX: (435) 797-0288
E-mail: john.shivik@aphis.usda.gov

Olympia, WA Field Station
Contact Information:
Dr. Jimmy Taylor, Supervisory Research Wildlife Biologist
NWRC Olympia Field Station
9730-B Lathrop Industrial Drive SW
Olympia, WA 98512
Phone: (360) 956-3925 FAX: (360) 534-9755
E-mail: jimmy.d.taylor@aphis.usda.gov

Sandusky, OH Field Station
Contact Information:
Dr. Travis L. DeVault,
Supervisory Research Wildlife Biologist
Ohio Field Station
6100 Columbus Avenue
Sandusky, OH 44870
Phone: (419) 625-0242 FAX: (419) 625-8465
Email: Travis.L.DeVault@aphis.usda.gov

Starkville, MS Field Station
Contact Information:
Dr. Brian S. Dorr, WS Research Wildlife Biologist
Mississippi Field Station
P.O. Box 6099
Mississippi State, MS 39762-6099
Phone: (662) 325-8216 FAX: (662) 325-2474
E-mail: brian.s.dorr@aphis.usda.gov

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New Technologies to Deter Wildlife from Airports and Aircraft

Contact Information:
Dr. Travis L. DeVault, Supervisory Research Wildlife Biologist
Ohio Field Station
6100 Columbus Avenue
Sandusky, OH 44870
Phone: (419) 625-0242
FAX: (419) 625-8465
travis.l.devault@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

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. Marine Corp
- U.S. Dept. of Navy
- National Association of State Aviation Officials
- North Carolina Division of Aviation
- California State University at Long Beach
- Auburn University
- North Carolina State University
- Michigan State University
- Indiana State University
- Purdue University

Groups Affected by This Problem

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

NWRC 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 acceptable 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 hazards at airports. Subsequently, the scientists work closely with WS airport programs throughout that nation and the FAA.

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 serve as an attractant to wildlife in the vicinity of an airport. NWRC scientists conduct research to provide guidance to the FAA regarding mitigating bird-aircraft strike hazards. NWRC research is focused on understanding the nature of wildlife hazards at 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 & Expertise to Wildlife Challenges

Wildlife Habitat Management and Other Land-Use Studies On and Near Airports—Habitat management is fundamental to reducing wildlife use of airfields. NWRC scientists have studied vegetation types and vegetation management practices at airports 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.

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. This research will aid in the design of new airport facilities.

NWRC scientists also are studying waste management facilities and trash-transfer stations near airports to determine which features of these facilities make them attractive to wildlife. Proper design and management of waste-management facilities could reduce their attractiveness to wildlife and thus decrease potential hazards to aviation.

Wildlife Deterrents and Repellents—NWRC scientists investigated the use of gull effigies (e.g., replicas or taxidermic specimens) for dispersing gulls from landfills and other locations near airfields. Gulls were successfully repelled by effigies at loafing areas, but not at feeding and nesting locations. When other bird management techniques, such as pyrotechnics, were used in conjunction with effigies, gulls were successfully repelled from all areas. Scientists conclude that effigies can serve as an additional non-lethal tool for dispersing gulls from airfields, landfills, and other locations where large congregations of gulls are not desirable.

Further efforts are underway to evaluate the effectiveness of overhead grids, shock strips, and other scare devices as non-lethal bird deterrents. Early results are promising, and data are being collected regarding flock responses to these management tools.

Bird Movements On and Near Airports—Using traditional marking techniques and satellite telemetry technologies, NWRC scientists are studying the movements of large birds like bald eagles, osprey, and Canada geese 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. In one study involving 300 marked Canada geese (10 with satellite transmitters), NWRC scientists observed that 1) resident Canada geese pose a hazard to safe aircraft operations, 2) harassment programs can move geese within a large area but do not necessarily reduce the hazard, and 3) a goose removal program eliminated problematic geese and reduced goose-aircraft collisions. This research provides essential information to the development of management strategies for effective wildlife hazard management on and near airports.

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 vision 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 avoidance behaviors related to vehicle approach and vehicle-based lighting treatments.

Keeping Earthworms Off Runways— Earthworms are an attractant to birds, such as gulls, blackbirds, and starlings. These birds, in turn, can pose a severe threat to aviation safety. When worms emerge from underground after heavy rains, they often crawl onto airport runways where they attract foraging flocks of birds. In September 2004 at Calgary International Airport, two large passenger aircraft incurred significant damage when they struck gulls during takeoff. Investigations showed the gulls had been attracted to the airport to feed on earthworms that had crawled onto the runways. Furthermore, the earthworms themselves can create slippery conditions for aircraft rolling over them on runways.

NWRC scientists are evaluating the use of physical and chemical barriers to prevent earthworms from moving onto runways where they would be attractive to foraging birds. Preliminary results indicate that a combination of chemical and physical irritants might be most effective in keeping earthworms off runways.

Selected Publications:

Blackwell, B. F., L. M. Schafer, D. A. Helon, and M. A. Linnell. 2008. Bird use of stormwater-management ponds: decreasing avian attractants on airports. Landscape and Urban Planning 86:162–170.

Blackwell, B. F., and S. E. Wright. 2006. Collisions of red-tailed hawks (Buteo jamaicensis), turkey (Cathartes aura), and black vultures (Coragyps atratus) with aircraft: implications for bird strike reduction. Journal of Raptor Research 40:76-80.

DeVault, T. L., J. E. Kubel, D. G. Glista, and O. E. Rhodes, Jr. 2008. Mammalian hazards at small airports in Indiana: impact of perimeter fencing. Human-Wildlife Conflicts 2:240-247.

Schafer, L. M., B. F. Blackwell, and M. A. Linnell. 2007. Quantifying risk associated with potential bird-aircraft collisions. In Proceedings of the International Conference on Ecology and Transportation. Eds. C. L. Irwin, D. Nelson, and K.P. McDermott. Center for Transportation and the Environment, North Carolina State University, Raleigh, NC. Pp. 56–63.

Seamans, T. W. and K. C. VerCauteren. 2006. Evaluation of ElectroBraid fencing as a white-tailed deer barrier. Wildlife Society Bulletin 34:8-15.

Seamans, T. W., S. C. Barras, G. E. Bernhardt, B. F. Blackwell, and J. D. Cepek. 2007. Comparison of 2 vegetation-height management practices for wildlife control at airports. Human-Wildlife Conflicts 1:97–105.

Seamans, T. W., S. C. Barras, and G. E. Bernhardt. 2007. Evaluation of two perch deterrents for starlings, blackbirds and pigeons. International Journal of Pest Management 53:45–51.

Seamans, T. W., and D. A. Helon. 2008. Evaluation of an electric mat as a white-tailed deer (Odocoileus virginianus) barrier. International Journal of Pest Management 54:89–94.

Washburn, B. E., S. C. Barras, and T. W. Seamans. 2007. Foraging preferences of captive Canada geese related to turfgrass mixtures. Human-Wildlife Conflicts 1:214-223.

Washburn, B. E., and T. W. Seamans. 2007. Wildlife responses to vegetation height management in cool-season grasslands. Rangeland Ecology and Management 60:319–323.

Washburn, B. E., R. B. Chipman, and L. C. Franceour. 2006. Evaluation of bird response to propane exploders in an airport environment. Proceedings of Vertebrate Pest Conference 22:212–215.

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 validated the use of gull effigies to disperse gulls from areas around landfills and other locations near airfields.
- WS studied the bird-aircraft strike risk posed by breeding and migrating birds, such as bald eagles, osprey, and Canada geese.
- 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 evaluated the use of physical and chemical barriers to prevent earthworms from moving onto runways where they would be attractive to foraging birds.

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Defining Economic Impacts and Developing Strategies for Reducing Avian Predation in Aquaculture Systems

Contact Information:
Dr. Brian S. Dorr,
Research Wildlife Biologist
Mississippi Field Station
P.O. Box 6099
Mississippi State, MS 39762-6099
Phone: (662) 325-8216
FAX: (662) 325-2474
brian.s.dorr@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

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
- 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
- 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

NWRC 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, selective, and acceptable methods, tools, and techniques. 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 30 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 of southeastern catfish, baitfish, and crawfish industries. Current research is aimed at gaining information about the abundance, distribution, and foraging behavior of fish-eating birds, the economic impacts associated with their foraging activities, and the diseases they transmit at aquaculture facilities. This information will help to develop new techniques for reducing damage.

Applying Science & 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. This research will provide a better understanding of population trends and bird movements and will be used to evaluate various alternatives for managing impacts of these birds on southeastern aquaculture 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 completed a field study that evaluated the distribution and numbers of cormorants on catfish aquaculture tying together almost a decade of research on cormorant food habits, bioenergetics and abundance data. Cormorants used catfish ponds extensively during the period January through April, with the greatest economic damage occurring in February and March. During the 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 evaluated movements and migration patterns of double-crested cormorants captured near southeastern catfish aquaculture ponds. Results demonstrated that satellite transmitter-equipped cormorants migrated along the Mississippi, Missouri, and Ohio River Valleys. The average duration of spring migration was 12 days traveling 70 km per day. These data show that 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 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 completed 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% mortality for first year birds, decreasing to over 20% thereafter. The data show some regional differences in reproductive parameters suggesting that management decisions should be based on local or regional population

information. Population models indicate 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 (R2 = 0.93) predictor of age in double-crested cormorants. This information may lead to a rapid technique for identifying age of cormorants and many other species of birds without the need for more costly and logistically difficult methods. This technique will help provide a better understanding of the demographics of cormorant populations allowing for development of optimal management strategies for maintaining population viability while minimizing damage.

Pelican Diet and Aquaculture—A study of diet of American white pelicans in the southeastern United States reflect opportunistic foraging across locations. The diet of pelicans collected near catfish aquaculture was comprised of almost 90% commercial catfish. Pelicans collected near non-aquaculture areas included prey such as shad and sunfish. The body condition of pelicans foraging near aquaculture was improved compared to other pelicans possibly causing increased survival and reproductive success. This research demonstrated that the superabundant, large-sized, and vulnerable food source (i.e., catfish in aquaculture ponds) are used extensively by pelicans frequenting aquaculture producing areas.

American White Pelican Disease Ecology—In collaboration with parasitologists at two state universities, the Thad Cochran Warmwater Aquaculture Center, and the Southern Regional Aquaculture Center, NWRC scientists described the life cycle and confirmed that American white pelicans serve as host for the species of trematode infecting catfish in the southeastern United States. Results showed American white pelicans can transmit this disease 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 low infection of trematodes in pelicans can result in large numbers of trematode eggs deposited into catfish ponds. In addition NWRC scientists found 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 Activities on Nesting Cormorants—Large colonies of double-crested cormorants breed in the Les Cheneaux Islands region of Lake Huron, Michigan. NWRC Scientists have collaborated with the Michigan Department of Natural Resources, USGS, and Lake Superior State University to evaluate the effectiveness of Wildlife Services cormorant management as a means of improving the local yellow perch fishery. Management activities include egg-oiling and lethal control. Results showed management efforts reduced the number of young cormorants by more than 90% annually and overall cormorant numbers by 60%. Results also indicated cormorants from the colonies were feeding extensively in the specific areas of perch decline, and that perch numbers and harvest following the first four years of management have increased substantially.

Evaluating Cormorant Management Programs—WS and the U.S. Forest Service in Michigan have been working to reduce predation of sportfish by double-crested cormorants during spring migration. The management program enlists wildlife damage management specialists to protect fishery resources through an integrated program of non-lethal harassment supplemented by limited lethal take of cormorants. The designated specialists receive training, supervision, and supplies from WS. In return the specialists volunteer their time to conduct harassment operations. NWRC research documented a large decline in numbers of cormorant foraging attempts, and an increase in walleye populations at Brevoort Lake, Michigan a location where management and research have been conducted.

Selected Publications:

Chastant, J. E. 2008. Population characteristics of interior double-crested cormorants breeding across the southern border of Ontario. Thesis. Mississippi State University, Mississippi.

Dorr, B.S., L.W. Burger, and S.C. Barras. 2008. Evaluation of Aerial cluster sampling of double-crested cormorants on aquaculture in Mississippi. The Journal of Wildlife Management,
72 (1634:1640).

Fallon, J. A., R. L. Cochran, B. Dorr, and H. Klandorf. 2006. Interspecies comparison of Pentosodine accumulation in birds. Auk 123: 870-876.

Pearse, A. T., B. S. Dorr, S. J. Dinsmore, and R. M. Kaminski. 2007. Comparison of sampling strategies to estimate abundance of double-crested cormorants in western Mississippi. Human-Wildlife Conflicts 1:27-34.

Pote, L. M., and 18 other authors. 2008. A team approach in the study and control of the digenetic trematode Bolbophorus damnificus in commercial catfish. In Press. In Proceedings of the 7th International Symposium on Fish Parasites. Sept. 24-28, Viterbo, Italy.

Stahl, R. S., B. S. Dorr, S. C. Barras, and J. J. Johnston. 2006. Use of fatty acid profiles to distinguish between selected game fish and farm-raised channel catfish. Proceedings of the Vertebrate Pest Conference 22:389-392.

Werner, S. J., and B. S. Dorr. 2006. Influence of fish stocking density on the foraging behavior of double-crested cormorants Phalacrocorax auritus. Journal of the World Aquaculture Society 37: 121-125.

Yost, M. C, L. M. Pote, D. J. Wise and B. S. Dorr. 2008. Biompholaria havensis identified as a potential intermediate snail host for the digenetic trematode, Bolbophorus damnificus. In Press. North American Journal of Aquaculture.

Major Research Accomplishmnets:

- 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 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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Management of Blackbirds and Starlings in Sunflower, Rice, and Corn Fields, Feed Lots and Dairies

Contact Information:
Dr. George Linz,
Research Wildlife Biologist
North Dakota Field Station
2110 Miriam Circle, Suite B.
Bismarck, ND 58105
Phone: (701) 250-4469
FAX: (701) 250-4408
george.m.linz@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

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 This Problem

- Rice, sunflower, and corn producers
- Consumers of rice products
- Sunflower 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

NWRC Scientists Address the Concerns of Sunflower, Rice, and Corn Producers, Urban Areas, and Feedlot 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 acceptable methods, tools, and techniques. NWRC's field station in Bismarck, ND, studies 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 and at feedlots and dairies.

Blackbirds and starlings damage grain crops and eat livestock feed, causing significant economic losses to agricultural producers. NWRC scientists are studying ways to refine current damage abatement methods and develop new methods for reducing damage. Additionally, researchers are looking to expand capabilities to target specific problem-causing birds. Red-winged blackbirds, common grackles, 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 in North Dakota and South Dakota, and $35 million worth of ripening and newly planted corn. Some individual rice and sunflower growers report 100% 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 on both local and regional scales with predictable results.

Applying Science & Expertise to Wildlife Challenges

Conservation Sunflower Plots—During the last decade new farm programs have placed more emphasis on wildlife conservation. From 2004 to 2006, NWRC and North Dakota State University scientists collaborated to evaluate decoy sunflower plots, called Wildlife Conservation Sunflower Plots (WCSP). The objective of WCSP is to reduce damage to commercial fields by providing blackbirds an attractive nearby alternative food source. A secondary benefit is provision of a safe-haven for other wildlife that use shelterbelts and wetlands along the edges of sunflower fields. The majority of birds recorded using WCSP during a recent study were blackbirds, but 43 non-blackbird species also were recorded. Use of WCSP resulted in significantly lower damage in nearby commercial sunflower fields. In 2004, 2005, and 2006, bird damage to sunflowers in the WCSP was 39%, 32%, and 60%, respectively, compared to 5%, 4%, and 18%, respectively, in nearby commercial fields. These results indicate that WCSP can reduce bird damage in nearby commercial fields.

Ongoing studies are evaluating the use of geographical information systems for improving placement of WCSP and maximizing the benefits of this environmentally-friendly wildlife damage management concept.

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—NWRC scientists conducted a series of laboratory and field tests to identify, formulate, and evaluate potential nonlethal repellents for reducing bird damage to newly-planted and ripening rice, corn, and sunflower. Of the chemicals tested, six have shown promising results. In fact, one collaborator has since received a U.S. patent for a chemical tested as an avian repellent. Development and registration of a chemical repellent for seeded or ripening rice, sunflower and corn could have a major impact on reducing damage losses and environmental hazards and increasing efficiency and profitability of production. Information from this and other studies will be used in the registration of future repellents with the U.S. Environmental Protection Agency.

DRC-1339 Baiting—DRC-1339 is an avicide used in the management of blackbirds and starlings on staging areas prior to rice planting and on evaluated bait trays during sunflower and corn ripening. To support the registration of this management tool and improve current baiting methodologies, NWRC scientists conducted tests with caged blackbirds to identify DRC-1339 dose-response curves and determine dietary toxicity of DRC-1339. They also evaluated non-target hazards of DRC-1339 in North Dakota, Louisiana, Missouri and Texas and completed a DRC-1339 confined rotational rice study. This and other studies indicate that hazards to non-target birds are minimal during DRC-1339 baiting operations whether on staging areas or on evaluated bait trays. Research continues on developing new and improved DRC-1339 bait formulations and delivery methods that improve baiting effectiveness and comply with regulatory issues.

Use of Day-Glo® Fluorescent Marker and Radio-telemetry to Monitor Blackbirds and European Starling Movements—NWRC scientists used a Day-Glo® paint pigment to aerially mass-mark more than 3.2 million blackbirds causing damage to rice in Missouri. Three different rice-field roosts containing from 700,000 to 2.2 million birds were sprayed with different Day-Glo® colors on consecutive nights. Birds subsequently were collected during winter 2006 in Louisiana, Arkansas, and Missouri to determine the regional and migratory movements of birds after the rice-growing season. Collections continued during the following spring to determine the distribution of breeding male red-winged blackbirds in respect to the marking sites. This technique shows promise as an effective way of determining blackbird roost turnover, roost interchange, movement patterns, and distribution.

Scientist also attached small radio transmitters to European starlings in downtown Indianapolis and Omaha, at five dairy farms in Ohio, and three feedlots in Kansas. Scientists found that starlings move readily among farms and feedlots and cities. These results are significant because starlings can carry transmissible gastroenteritis (TGE), E. Coli, Salmonella spp., and Johne's disease. Theses pathogens can result in death and illness in pigs and cattle, costing nearly $1 billion in losses annually.

Selected Publications:

Hagy, H. M., G. M. Linz, and W. J. Bleier. 2008. Optimizing the use of decoy plots for blackbird control in commercial sunflower. Crop Protection. 27:1442-1447.

Forcey, G. M., G. M. Linz, W. E. Thogmartin, and W. J. Bleier. 2008. Modeling wetland blackbird populations as a function of waterfowl abundance in the prairie pothole region of the United States and Canada. Environmental Bioindicators1. 3:124–135.

Safratowich, B. D., G. M. Linz, W. J. Bleier, and H. J. Homan. 2008. Avian use of rural roadsides with cattail. Am Midl. Naturalist. 159:162-171.

Werner, S. J., B.A. Kimball, and F. D. Provenza. 2008. Food color, flavor, and conditioned avoidance among red-winged blackbirds. Physiology & Behavior 93: 110-117.

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.

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 Lorsban, Cobalt, Avitec, Aza-Direct, GG-orange terpene, caffeine, GWN-4770, GWN 4140, and Tilt EC as potential blackbird repellents for use on rice seed and ripening sunflower, rice, and corn to reduce blackbird damage.
- WS evaluated alternative baiting strategies for the effective and safe delivery of DRC-1339, a toxicant for the control of depredating blackbird populations.
- WS determined DRC-1339 dietary effects on several species of non-target birds.
- WS determined blackbird response to several concentrations of DRC-1339.
- WS determined residue levels of DRC-1339 in soil and plants following applications of the bait for blackbird control.
- WS determined the potential hazards of DRC-1339 to non-target bird species.
- WS developed and validated an empirical model and bioenergetics model to estimate the take of blackbirds from WS' blackbird/DRC-1339 baiting program and in Louisiana, Missouri, and Texas and starling baiting programs in feedlots and dairies, respectively.
- WS determined the movements and distribution of blackbird populations causing damage to rice crops in Missouri, Arkansas and Louisiana and sunflower in North Dakota.

Wildlife Services

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FY 2008

Resource Protection Through Avian Population Management

Contact Information:
Dr. Michael Avery,
Research Wildlife Biologist
Florida Field Station
2820 East University Avenue
Gainesville, FL 32641
Phone: (352) 375-2229
FAX: (352) 377-5559
michael.l.avery@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators

- Wildlife Services Operations in Florida, South Carolina, Pennsylvania, Virginia
- Florida Power and Light Company
- Innolytics, LLC
- Pennsylvania State University
- 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

NWRC Scientists Address Problems of 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 acceptable methods, tools, and techniques.

Researchers at NWRC's field station in Gainesville, FL, conduct research to resolve problems caused by vultures, crows, and other species of overabundant birds. This research facility is a uniquely designed 26-acre site with large outdoor flight pens and aviaries which allow bird research to be conducted throughout the year 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 vultures and crows, species that have shown the capacity to readily adapt to residential settings. Additionally, populations of non-native species such as feral pigeons and monk parakeets continue to grow with increasing detrimental impacts to human health and safety.

Applying Science & Expertise to Wildlife Challenges

Vulture Management at Military Air Bases—NWRC scientists documented vulture movements and resource use at military installations in order to reduce hazards to aircraft. At a site in South Carolina, 16 vultures were trapped and equipped with satellite transmitters that provide hourly updates on the birds' location, altitude, and speed. Dozens of other vultures were trapped and equipped with wing tags for visual identification. Key roost sites were identified for dispersal, and the birds' activities subsequent to dispersal are being monitored to determine effectiveness of the action. At an Air Force site in south Florida, vulture roosts and feeding sites were identified and a vulture management plan was developed to increase air traffic safety. Similar actions will be taken for the site in South Carolina.

Evaluation of Impacts of Lethal Control on Vulture Populations—As part of a cooperative effort with biologists from the U.S. Geological Survey and U.S. Fish and Wildlife Service (USFWS), NWRC scientists contributed demographic and behavioral data to assess the impacts of lethal take on black vulture populations. The data was included in a model used to set limits on lethal take of nuisance bird species through the USFWS permitting process. The model can be updated as new information becomes available and adapted to changes in bird population management objectives.

Management Methods for Urban Crow Roosts—NWRC scientists collaborated with WS operational staff and University researchers to develop strategies for managing large crow roosts in urban areas throughout the United States. One such roost of approximately 30,000 crows in the Lancaster, PA, area was the focus of investigations. NWRC scientists documented responses of crows to artificial effigies as a means of roost dispersal. The artificial effigies were incorporated into successful community-based efforts to rid areas of nuisance winter crow roosts. Researchers observed a shift from roost sites with effigies to sites where the crows were not harassed and were no longer causing problems for residents and business.

USDA APHIS
United States Department of Agriculture
Animal and Plant Health Inspection Service

Reproductive Control of Nonnative Avian Species—Monk parakeet populations are growing exponentially in certain areas of the United States. The species, which is native to South America, builds large stick nests that are often located in electric utility facilities. As a result, frequent short circuits and costly power outages occur.

To help retard the growth of parakeet populations, NWRC scientists are collaborating with utility companies to develop a contraceptive bait. The active ingredient is a cholesterol-inhibiting compound called diazacon. To date, nesting studies with captive parakeets and a field trial in south Florida have confirmed the potential utility of diazacon for parakeet reproductive control. Additional field studies are evaluating special feeders to limit access of the contraceptive bait to monk parakeets. The feeders prevent nontarget species, such as mourning doves, from eating the bait.

Through collaborations with private industry, NWRC scientists also developed a chemical reproductive inhibitor for feral pigeons. Information developed by NWRC scientists through feeding trials and captive nesting studies with pigeons was submitted to the U.S. Environmental Protection Agency in support of a Federal registration for a bait containing nicarbazin as the active ingredient. The product is now registered in 49 States.

Selected Publications:

Avery, M. L., K. L. Keacher, and E. A. Tillman. 2008. Nicarbazin bait reduces reproduction by pigeons (Columba livia). Wildlife Research 35:80-85.

Avery, M. L., C. A. Yoder, and E. A. Tillman. 2008. Diazacon inhibits reproduction in invasive monk parakeet populations. Journal of Wildlife Management. 72:1449-1452.

Blackwell, B. F., M. L. Avery, B. D. Watts, and M. S. Lowney. 2007. Demographics of black vultures in North Carolina. Journal of Wildlife Management 71:1976-1979.

Russello, M. A., M. L. Avery, and T. F. Wright. 2008. Genetic evidence links invasive monk parakeet populations in the United States to the international pet trade. BMC Evolutionary Biology 8:217.

Major Assistance Activities:

- WS initiated a satellite telemetry study to collect information on flight patterns and altitudes of vultures. The information was used to develop management strategies for reducing hazards to aircraft at military air bases.
- WS provided key research findings for the development and registration of chemical reproductive inhibitors to reduce populations of nonnative feral pigeons and monk parakeets.
- WS demonstrated the utility of artificial crow effigies as components of integrated management strategies for dispersal of nuisance winter urban crow roosts.
- 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.

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Ecology of Emerging Viral and Bacterial Diseases in Wildlife

Contact Information:
Dr. Alan B. Franklin,
Research Wildlife Biologist
NWRC Headquarters
4101 LaPorte Avenue
Fort Collins, CO 80521
Phone: (970) 266-6137
FAX: (970) 266-6138
alan.b.franklin@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators

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

Groups Affected By These Problems

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

NWRC Scientists Monitor and Assess the Roles of Wildlife in the Transmission and Spread of Emerging Infectious Diseases

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 acceptable methods, tools, and techniques.

Considerable concern exists around the world about recent emerging infectious diseases. Seventy-five percent of these emerging infectious diseases are zoonotic, meaning they are naturally transmitted between wildlife species and humans. Some zoonotic diseases carried by wildlife also can be transmitted to economically important domestic animals, such as avian influenza (AI) virus to poultry and pathogenic bacteria to cattle. Thus, wildlife populations often play a key role in many diseases that directly impact humans and agriculture. NWRC is at the forefront in the monitoring, surveillance and research of many of these diseases.

AI is found naturally in waterfowl and other wild bird species. There are 144 known subtypes of AI but few of these subtypes cause serious disease in birds. However, mutation of the virus can lead to infection of new wildlife species, domestic livestock (primarily poultry), and humans. These changes can result in AI strains that are highly pathogenic. Recently, highly pathogenic avian influenza (HPAI) H5N1 has spread from Asia across the Eastern Hemisphere and has caused considerable economic loss and mortality in domestic poultry, as well as some human deaths. The rapid geographic expansion of HPAI has prompted early detection and monitoring plans in the United States and increased research into how the virus may be spread through wildlife populations.

Applying Science & Expertise to Wildlife Challenges

Monitoring Highly-Pathogenic H5N1 Avian Influenza in the United States—One potential route for introduction of HPAI H5N1 into the United States includes migration of infected wild birds, including ducks, geese and shorebirds. Some waterfowl species may be only mildly affected by HPAI which makes them 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 more than 80,000 fecal samples collected from wild birds over the last 2.5 years. 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 AI in fecal samples, and analyzed approximately 80,000 fecal samples for the presence of AI. This effort is still ongoing and has expanded to other countries. For example, in collaboration with the U.S. Department of Defense, Kenyan nationals were recently trained in both laboratory and field techniques to establish a national surveillance program using environmental samples to detect HPAI H5N1 in waterbirds migrating from areas that have experienced HPAI H5N1 outbreaks, such as Europe, Asia, and northern Africa.

Potential Transmission and Spread of Avian Influenza from Waterfowl to Agriculture and Human Populations—In collaboration with other scientists, NWRC scientists are developing risk assessment models to identify potential routes of introduction and subsequent spread of AI by waterfowl in the United States. These models couple spatially explicit risk assessment models with field and laboratory data from AI samples collected from wild birds, band recovery data from waterfowl, the distribution of poultry operations, and genetic sequencing of detected AI subtypes in collected samples. Coupling the genetic information with band recovery data provides information about migratory patterns and gives insight on where birds exposed to specific AI virus genotypes originated, where they

moved to, and how they may further spread AI by mixing with other migratory populations. This allows scientists to identify areas where highly pathogenic strains of AI may be introduced into the United States and where they may subsequently spread in relation to domestic poultry operations and human populations. 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 AI carried by wildlife species and also assist networks of farms in preventing AI spread from neighboring outbreaks.

Role of Feral Pigs and Wildlife in the Transmission and Spread of Avian Influenza—Although AI can survive for extended periods in water (30-200 days), dilution of the virus in water beyond detectable limits may prevent the detection of the virus using current sampling methods. One alternative for sampling water is to use aquatic organisms, such as freshwater mollusks (mussels and clams), that naturally concentrate virus from the surrounding water. Mollusks accumulate a variety of viruses and can concentrate some viruses in their tissues 100 times greater than the surrounding water. NWRC scientists found that freshwater mollusks can concentrate AI from surrounding water and could be a useful tool for monitoring the presence of AI in water. In addition, NWRC scientists have developed more sensitive laboratory assays to detect AI in water, fecal samples, and tissues. These efforts could significantly reduce field surveillance costs and allow for more accurate and thorough risk assessments.

Development of Rapid Laboratory Tests for Avian Influenza Virus and Histoplasma—NWRC and its partners are working to develop rapid, reliable laboratory tests for detecting exposure of wildlife to various pathogens, such as AI and Histoplasma. Such tools are crucial to aid in the identification of wildlife species involved in the transmission and spread of these pathogens. As part of their larger research program on AI in wildlife, NWRC and Iowa State University scientists have developed a rapid and reliable method for detecting whether an animal has been exposed to AI. Another infection of concern is infection of humans with the soil-born fungus, Histoplasma capsulatum. As many as 200,000 people are infected annually in the United States with Histoplasma, which causes respiratory and systemic symptoms. Histoplasma is common in bird roosting areas because their feces promote the growth of Histoplasma in the soil. NWRC scientists recently completed a rapid laboratory test to detect Histoplasma in the soil and bird feces. This test has already been used by the City of Omaha, Nebraska to test soil samples for the presence of Histoplasma under large starling roosts before renovating park landscapes in order to protect public health.

Selected Publications:

Clark, L.; and J. S. Hall. 2006. Avian influenza in wild birds: status as reservoirs and risks posed to humans and agriculture. Ornithological Monographs 60:3-29.

Hall, J. S., K. T. Bentler, G. Landolt, S. A. Elmore, R. B. Minnis, T. A. Campbell, S. C. Barras, J. J. Root, J. Pilon, K. Pabilonia, C. Driscoll, D. Slate, H. Sullivan, and R. G. McLean. 2008. Influenza infection in wild raccoons. Emerging Infectious Diseases [Epub ahead of print].

Hall, J. S., R. Minnis, T. A. Campbell, S. Barras, R. W. DeYoung, K. Pabilonia, M. L. Avery, H. Sullivan, L. Clark, and R. McLean. 2008. Influenza exposure in United States feral swine populations. Journal of Wildlife Diseases 44:362-368

McLean, R. G., J. S. Hall, A. B. Franklin, H. Sullivan, K. VanDalen, S. Shriner, M. Farnsworth, P. Oesterle, G. Young, J. Carlson, K. Cobble, T. Deliberto, S. Swafford, S. Elmore, T. Anderson, S. Hauser, K. Bentler, N. Mooers, and K. Huyvaert. 2007 Avian influenza in wild birds: environmental sampling strategy for the rapid detection of avian influenza viruses. Pages 87-93 In: D. L. Nolte, W. M. Arjo, and D. H. Stalman, editors. Proceedings of the 12th Wildlife Damage Management Conference, Corpus Christi, Texas.

Major Assistance Activities:

- WS developed sampling and laboratory methodologies and processed approximately 80,000 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 to domestic animals and humans.
- WS is developing 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 is developing rapid laboratory tests to detect pathogens of concern to livestock and human health, such as avian influenza virus and Histoplasma.

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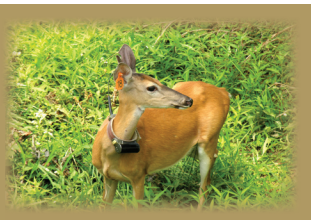
Development of Reproductive Control Methods for Overabundant Mammals and Birds



Contact Information:
Dr. Lowell Miller,
Research Physiologist (Immunology)
NWRC Headquarters
4101 LaPorte Avenue
Fort Collins, CO 80521
Phone: (970) 266-6163
FAX: (970) 266-6157
lowell.a.miller@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

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.
- USDA/APHIS/Wildlife Services Operations
- Navajo Nation

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

NWRC 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 acceptable 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 also carry a variety of diseases (e.g., plague, hantavirus), and they damage rangelands and crops, causing the loss of millions of dollars in agricultural production. More than four million feral hogs now occur in at least 28 states, where they cause serious ecological damage as well as serving as a reservoir for pseudorabies and brucellosis. Overabundant feral horses in several western states continue to create ecological and political problems.

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 species that are causing conflicts. Wildlife contraceptives can be used in conjunction with other tools in an integrated program to manage local, overabundant wildlife species.

Applying Science & Expertise to Wildlife Challenges

Immunocontraceptive Vaccine—NWRC researchers have successfully tested a single-injection, GnRH (gonadotropin-releasing hormone), immunocontraceptive vaccine (called GonaCon™) on free-ranging California ground squirrels, black-tailed prairie dogs, captive Norway rats, feral cats and dogs, domestic and feral swine, wild horses, elk and white-tailed deer. Temporary infertility was achieved in all species tested. Field studies testing the GonaCon™ contraceptive in white-tailed deer have been conducted in Maryland and New Jersey to determine the safety and efficacy of the product, as required by and for registration with the U.S. Environmental Protection Agency (EPA). NWRC is working closely with the Association of Fish and Wildlife Agencies to provide information on the benefits and limitations of GonaCon™ to natural resource managers, sportsmen, and other interested groups.

Development of the single-injection form of the GonaCon™ vaccine was made possible by the creation at NWRC of a new adjuvant called AdjuVac™. An adjuvant is an immunological agent that is added to a vaccine to improve the immune response. The GonaCon™ vaccine, which incorporates the AdjuVac™ adjuvant, could prove useful as an additional method as part of an integrated management plan for overabundant wildlife species.

Oral Contraceptives—Over the past eight years, scientists from the NWRC and their partner Innolytics, LLC developed new oral contraceptive baits to help reduce overabundant populations of resident Canada geese and feral pigeons. The products, called OvoControl®-G and -P, respectively, reduce the hatchability of eggs. Final regulatory approval and registration of the baits were granted in 2005 for Canada geese (registration # 80224-5) and 2007 for pigeons (registration # 80224-1) by the EPA. OvoControl® contains the veterinary drug nicarbazin, which is traditionally given to broiler chickens to prevent coccidiosis, one of the more common and costly diseases in poultry. A side effect of nicarbazin is decreased egg production and hatching rates. Nicarbazin affects the viability of eggs by causing disruption of the yolk membrane and creating

conditions under which the embryo cannot develop. When fed to Canada geese, ducks, and pigeons during their breeding season, OvoControl® effectively reduces the hatching success of eggs. When it is withdrawn from the diet, egg production and hatchability return to normal within a few days. OvoControl® is not harmful to geese, pigeons, other birds or people.

NWRC scientists continue to test the stability and viability of several other oral vaccines in a variety of formulations to improve their delivery to other free-ranging animals, such as feral swine.

Other Contraceptives—NWRC scientists currently are evaluating other contraceptive agents, including diazacon, in birds and mammals. Diazacon (20,25 diazacholesterol) is a cholesterol mimic that inhibits cholesterol production and blocks steroid hormone formation.

Diazacon has been tested on invasive monk parakeets. In collaboration with a south Florida utility company, NWRC biologists established bait stations at several electrical substations where monk parakeets were nesting. Nest examinations revealed that average productivity at treated sites was 0.65 nestlings per nest, compared to 3.07 nestlings per nest at untreated sites. These numbers indicate a 79% reduction. In 2008, NWRC scientists conducted a small study to test whether diazacon is effective in black-tailed prairie dogs. Though the study was delayed and treatment occurred later in the breeding season, scientists still observed positive results with the average number of young at treated sites being reduced by about 59%.

These results suggest that diazacon has potential for use as a fertility control agent in animals with a single breeding season.

Selected Publications:

Curtis, P.D., M.E. Richmond, L.A. Miller, F.W. Quimby. 2008. Pathophysiology of white-tailed deer vaccinated with gonadotropin-releasing hormone immunocontraceptive. Human-Wildlife Conflicts 2(1):68-79.

Fagerstone K.A., L.A. Miller, J.D. Eisemann, J.R. O'Hare, and J.P. Gionfriddo. 2008. Registration of wildlife contraceptives in the United States of America with OvoControl and GonaCon immunocontraceptive vaccines as examples. Wildlife Research 35:586-592.

Killian, G.J., D. Thain, N.K. Diehl, J.C. Rhyan, and L.A. Miller. 2008. Four-year contraception rates of mares treated with single-injection porcine zona pellucida and GnRH vaccines and intrauterine devices. Wildlife Research 35:531-539.

Massei, G., D.P. Cowan, J. Coats, F. Gladwell, J.E. Lane and L.A. Miller. 2008. Effect of the GnRH vaccine GonaCon on the fertility, physiology and behavior of wild boar. Wildlife Research 35:540-547.

Miller, L.A., K.A. Fagerstone, J. Gionfriddo, J. Rhyan, and G. Killian. 2008. The single-shot GnRH immunocontraceptive vaccine (GonaConTM) in white-tailed deer: comparison of several GnRH preparations. American Journal of Reproductive Immunology 60:214-223.

Miller, L.A. J.P. Gionfriddo, J.C. Rhyan, K.A. Fagerstone, D.C. Wagner and G.J. Killian. 2008. GnRH immunocontraception of male and female white-tailed deer fawns. Human Wildlife Conflicts 2(1):93-101.

Bynum, K.S., J.D. Eisemann, G.C. Weaver, C.A. Yoder, K.A. Fagerstone, and L.A. Miller. 2007. Nicarbazin OvaControl G bait reduces hatchability of eggs laid by resident Canada geese in Oregon. Journal of Wildlife Management 71(1):135-143.

Nash, P., C.A. Furcolow, K.S. Bynum, C.A. Yoder, L.A. Miller and J.J. Johnston. 2007. 20-25-Diazacholesterol as an oral contraceptive for black-tailed prairie dog population management. Human-Wildlife Conflicts 1(1):53-59.

Killian, G., K. Fagerstone, T. Kreeger, L. Miller, J. Rhyan. 2007 Management Strategies for Addressing Wildlife Disease Transmission: The Case for Fertility Control. Proceedings 12th of the Wildlife Damage Management Conference April 12, Corpus Cristi, TX.

Major Assistance Activities:

- WS and partners obtained EPA registration in 2005 and 2007 for the use of nicarbazin as an avian contraceptive for Canada geese and feral pigeons, respectively.
- WS submitted a GnRH immunocontraceptive (GonaConTM) registration package to the EPA in early 2009.
- WS is conducting studies to support the registration of DiazaCon as an avian contraceptive for invasive monk parakeets.
- WS is investigating the use of GonaConTM in conjunction with the rabies vaccine on feral or stray dogs. The immunocontraceptive could reduce feral and stray dog populations, thus, decreasing the potential spread of the disease.

Wildlife Services

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National Wildlife Research Center

FY 2008

Ecology, Behavior, and Management Methods for Predators to Protect Livestock and Wildlife

Contact Information:
Dr. Eric M. Gese,
Research Wildlife Biologist
Utah Field Station
Utah State University
Room 163, BNR Building,
Logan, UT 84322-5295
Phone: (435) 797-2542
FAX: (435) 797-0288
eric.w.gese@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc

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

Groups Affected By These Problems

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

NWRC Scientists Study Predation Behavior and Ecology

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 acceptable methods, tools, and techniques. NWRC's field station in Logan, UT, is the leading coyote ecology research complex in the world.

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 and wildlife population dynamics. Current studies include investigating if sterilization of coyotes reduces predation on pronghorn fawns; determining the population ecology and evaluating survey methods for coyotes for large-scale monitoring; investigating the behavioral ecology of coyotes; determining interactions among cougars, wolves, coyotes, and mule deer and their influence in the abundances of these species; examining the interactions among coyotes, lynx and snowshoe hares; investigating the effects of prey cycles and nutrition on coyote population regulation; understanding the abilities of coyotes to avoid capture and other management techniques; documenting the effects of forest structure on snowshoe hare distribution and abundance; and investigating the predation patterns of jaguars on livestock and native prey species. Results from studies are fundamental to selective predator management. The information gathered will also be used to guide WS' operational programs, and to provide necessary information in the National Environmental Policy Act (NEPA) process.

Applying Science & Expertise to Wildlife Challenges

Wolves' Impacts on Coyote Distribution and Abundance—Scientists at the NWRC Logan, UT field station investigated whether competition from wolves limits the distribution and abundance of coyotes, and whether the elimination of wolves from certain areas results in the expansion in coyote range throughout much of North America. Researchers gathered data on mortality and survival rates of coyotes captured at wolf-free and wolf-abundant sites in Wyoming, to determine whether mortality due to wolves is sufficient to reduce coyote densities. They also examined whether spatial segregation limits the local distribution of coyotes and determined whether coyotes are less abundant where wolves were common.

Although the number of coyotes was greater across the ecosystem, mean coyote densities were 33 percent lower where wolves were abundant, and densities declined 39 percent in some areas following wolf reintroduction. Overall, mortality of coyotes resulting from wolf predation was low, but wolves were responsible for 56 percent of transient coyote deaths. In addition, dispersal rates of transient coyotes were 117 percent higher where wolves were abundant. Scientists conclude that coyote abundance is limited by competition with wolves, and that differential effects on survival and dispersal rates of transient coyotes are important mechanisms by which wolves reduce coyote densities.

Coyote Scavenging Ecology and Wolves—Wolf recolonization of the Greater Yellowstone Ecosystem provides a rare opportunity for scientists to identify new behaviors facilitating coexistence between wolves and coyotes. NWRC scientists investigated behavioral interactions between coyotes and recolonizing wolves at ungulate carcasses in Montana's Madison Range. Socially dominant coyotes (alphas and betas) responded to actual and simulated wolf presence by increasing the proportion of time spent being

watchful while scavenging. Watchful behavior was more pronounced when scavenging closer to protective cover, where visual obstacles inhibited the ability of coyotes to scan for, and possibly escape from, returning wolves. Despite greater time being vigilant, alpha coyotes still consumed the greatest amount of carrion. Coyotes aggressively confronted wolves. The number of coyotes and stage of carcass consumption impacted whether coyotes were able to displace wolves from carcasses.

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 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.

Effects of Coyote Population Reduction on Swift Fox—The distribution and abundance of swift foxes has declined from historic levels. Causes for the decline include habitat loss and fragmentation, incidental poisoning, changing land use practices, trapping, and predation by other carnivores. Coyotes overlap the geographical distribution of swift foxes, compete for similar resources, and are a significant source of mortality in many swift fox populations.

Scientists at the NWRC Logan, UT field station evaluated whether controlling coyote populations decreases predation on declining or recovering fox populations. The scientists monitored 141 radio-collared swift foxes to compare swift fox population demographics (survival rates, dispersal rates, reproduction, density) between areas with and without coyote population reduction. Coyote predation was the main cause of juvenile and adult swift fox mortality in both areas, and juvenile survival increased where coyotes were removed. However, swift fox density remained similar between the areas. NWRC scientists concluded that in spite of increased swift fox survival, their population in the area was saturated, so additional animals had to disperse from the area.

Influence of Landscape, Predators, and Prey on Swift Foxes— NWRC researchers documented survival and density of swift foxes in a variety of landscapes and compared to prey availability, higher order predator abundance, and vegetation structure. The research found that predation by coyotes was responsible for the majority of swift fox mortalities, but concluded that the ultimate mechanism behind the mortalities was exposure to predation due to lack of adequate shrub cover and density.

Landscape Use and Movements of Wolves in Relation to Livestock—With the recolonization of wolves into agricultural areas, there is increasing concern of wolf-livestock conflicts. To assess the risk wolves may pose to livestock, NWRC researchers are investigating the activity patterns, movements, habitat use, visitation to livestock pastures by wolves, and the occurrence of depredation events in agricultural-wildland areas in northwestern Minnesota.

Researchers captured, radio-collared, and monitored sixteen wolves. Movement of wolves showed that while they visited livestock pastures, they apparently were passing through these pastures with cattle and not preying on livestock. When compared to random simulations of movements, wolves appeared to randomly encounter livestock pastures. Wolves were more active at night than during the day. Visitation of livestock pastures was not related to any discernible characteristics of the pastures (i.e., pasture size, cattle density, distance to human habitation, percent forest cover, index of deer abundance). However, pastures in which livestock were killed by wolves often contained more cattle than pastures without depredations. While the risk of wolf predation on livestock was potentially high, few livestock were actually killed. During the 3-year study, only 8 animals (all young or vulnerable livestock) were depredated by wolves.

Maintaining healthy wild prey populations, removing offending wolves that kill livestock, and encouraging effective and proper husbandry practices (e.g., disposal of carcasses) among livestock producers, should allow for the persistence of wolves in northwestern Minnesota while minimizing their impact to farmers.

Habitat Influence on Cougar and Wolf Predation—Numerous studies have documented how animals use specific anti-predator strategies to mitigate risk of predation from a single predator. However, when a recolonizing predator enters an already complex predator-prey system, the avoidance of one predator can enhance vulnerability to another.

In Montana, NWRC researchers studied the patterns of prey selection by recolonizing wolves and cougars in response to changes in prey habitat preferences. Elk were the primary prey for wolves, and mule deer were the primary prey for cougars, but elk made up an increasingly greater proportion of yearly cougar kills. While both predators preyed disproportionately on bull elk, wolves were most likely to prey on bulls in poor physical condition. Scientists concluded that habitat shifts in prey (from open landscapes to more wooded areas) were attempts by formerly naïve prey to lessen predation risk from wolves. However, shifting to more structurally complex habitats might have made prey more vulnerable to cougars. Habitat shifts may represent a compromise to minimize overall risk, following a change in predator exposure.

Selected Publications:

Arjo, W. M., E. M. Gese, T. J. Bennett, and A. J. Kozlowski. 2007. Changes in kit fox-coyote-prey relationships in the Great Basin Desert, Utah. Western North American Naturalist 67:389-401.

Atwood, T. C., E. M. Gese, and K. E. Kunkel. 2007. Comparative patterns of predation by cougars and recolonizing wolves. Journal of Wildlife Management 71:1098-1106.

Atwood, T. C., and E. M. Gese. 2008. Coyotes and recolonizing wolves: social rank mediates risk-conditional behaviour at ungulate carcasses. Animal Behaviour 75:753-762.

Berger, K. M., and E. M. Gese. 2007. Does interference competition with wolves limit the distribution and abundance of coyotes? Journal of Animal Ecology 76:1075-1085.

Berger, K. M., E. M. Gese, and J. Berger. 2008. Indirect effects and traditional trophic cascades: a test involving wolves, coyotes, and pronghorn. Ecology 89:818-828.

Carlson, D. A., and E. M. Gese. 2007. Relaxin as a diagnostic tool for pregnancy in the coyote (Canis latrans). Animal Reproduction Science 101:304-312.

Carlson, D. A., and E. M. Gese. 2008. Reproductive biology of the coyote (Canis latrans): integration of mating behavior, reproductive hormones, and vaginal cytology. Journal of Mammalogy 89:654-664.

Karki, S. M., E. M. Gese, and M. L. Klavetter. 2007. Effects of coyote population reduction on swift fox demographics in southeastern Colorado. Journal of Wildlife Management 71:2707-2718.

Kozlowski, A. J., E. M. Gese, and W. M. Arjo. 2008. Niche overlap and resource partitioning between sympatric kit foxes and coyotes in the Great Basin Desert of western Utah. American Midland Naturalist 160:191-208.

Larrucea-Sequin, E. S., P. F. Brussard, M. M. Jaeger, and R. H. Barrett. 2007. Cameras, coyotes, and the assumption of equal detectability. Journal of Wildlife Management 71:1682-1689.

Morey, P. S., E. M. Gese, and S. Gehrt. 2007. Spatial and temporal variation in the diet of coyotes in the Chicago metropolitan area. American Midland Naturalist 158:147-161.

Thompson, C. M., and E. M. Gese. 2007. Food webs and intraguild predation: community interactions of a native mesocarnivore. Ecology 88:334-346.

Major Research Accomplishments:

- WS demonstrated that coyotes can exert significant negative impacts on swift fox and may limit populations under appropriate conditions.
- WS examined the impacts not only of predators on livestock, but of predators on other predators and native prey.
- WS reported that wolves limited coyotes which were beneficial to increasing pronghorn fawn survival.

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Improved Technologies and Nonlethal Techniques for Managing Predation

Contact Information:
Dr. John Shivik,
Supervisory Research Wildlife Biologist
Utah Field Station
Utah State University
Logan, UT 84322-5295
Phone: (435) 797-1348
FAX: (435) 797-0288
john.shivik@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators
- Utah Division of Wildlife Resources
- Montana Fish, Wildlife, and Parks
- Utah State University
- Welder Wildlife Foundation

Groups Affected by This Problem
- Livestock producers
- Private citizens

NWRC Scientists Explore Innovative Ways to Protect Livestock from Predators

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 acceptable methods, tools, and techniques.

The development of new predator management tools to reduce livestock losses and protect public safety is a high priority for WS. Livestock predation costs producers approximately $93 million each year. In fact, for the sheep and lamb industry alone, predators account for approximately 36% 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 alternative, nonlethal tools and techniques to prevent predatory behavior through the use of disruptive (frightening) and aversive (behaviorally conditioning) stimuli. In addition, NWRC researchers are developing improved methods for capturing predators and monitoring their behaviors and movements.

Applying Science & Expertise to Wildlife Challenges

Capture Devices—Current capture technology consists largely of tools and materials that were developed hundreds of years ago. While effective, some of these capture methods have raised concerns about operating efficiency and animal welfare. In response, NWRC scientists have developed and tested new devices and attractants to more selectively and efficiently capture specific species. For instance, a recent study examined new designs for foot snares, which are often used to manage damage caused by coyotes (Canis latrans). Rating the effectiveness and injury caused by different cable foot-restraint devices is important for management and welfare, but data are lacking that show how modifications to the cable restraint affect injuries suffered by a captured coyote. The purpose of the study was to compare injury rates between a standard cable, and chain-loop, and a cable loop modified with a rubber sleeve. Results showed differences in the injury rates of coyotes caught in the three snare types. Chain-loop snares produced the lowest injury rate and sleeved cables caused the highest injury rate. The results suggest that adding a cushioning sleeve to a cable restraint may actually increase injury, and that injuries to coyotes caught in cable foot-restraints are similar to those of coyotes caught in padded steel jaw traps.

As world leaders in animal capture technology, NWRC scientists are also working closely with state fish and wildlife agencies, as well as with countries in the European Union, to develop and test new attractants and capture devices for canids, such as wolves, coyotes, and foxes.

Impacts of Wolves on Beef Calves—NWRC scientists monitored the fate of beef calves on three farms in Minnesota and Wisconsin over a two year period to identify the impacts of wolf kills to local farms. The presence/absence of predators was also studied as an indicator of potential depredations. During this time, four calves were killed by wolves on the study farms. Contrary to expectations, wolves did not appear to be selecting the youngest calves. Researchers also compared the effectiveness of two technologies used to monitor livestock. Radio telemetry collars and ear tags were applied to 511 beef calves. Radio collars and radio ear tags were very helpful for monitoring the calves in wooded areas and rough terrain.

Aversive Conditioning Devices—NWRC researchers are developing and evaluating new aversive conditioning devices, such as fladry, to keep predators away from livestock. Fladry is a method where strips of fabric are hung from cords and strung to encircle

pastures or areas that need protection from wolves and coyotes. NWRC researchers compared the reactions of 15 groups of captive wolves to barriers made of fladry, electrified fladry, or no fladry. Both fladry and electrified fladry were effective for excluding wolves from a food resource for short durations of time (1-14 days). Electrified fladry was more effective for protecting a food resource from captive wolves. A field study, conducted in cooperation with Montana Fish, Wildlife and Parks and WS Operations, built upon these findings. Nine livestock operations were equipped with either electrified fladry or no fladry. Wolf activity at the ranches was insufficient to determine the effectiveness of electrified fladry for preventing livestock depredations, but anecdotal evidence suggested a potential benefit. Survey information and interviews with ranchers further indicated the complexities of employing such methods, and many elements need to be considered before deciding to deploy (or not to deploy) electrified fladry.

Bear Damage in Urban Areas—NWRC scientists are studying black bear-human interactions in urban environments. In particular, scientists are determining how bear damage is influenced by human actions, bear population trends, and natural and anthropogenic food source dynamics. Forty black bears have been collared and monitored in Colorado near the communities of Aspen, Glenwood Springs, and Vail. Scientists collared 13 conflict bears to evaluate the success of their translocations, and one conflict bear to evaluate the success of on-site aversive conditioning release. GPS collars on bears allowed for the gathering of valuable data about bear resource selection in towns. By backtracking bear movements and over 1,200 GPS locations, scientists obtained confirmed feeding information on over 90 locations. The information will help wildlife managers evaluate current management efforts and identify those that are the most effective at both reducing conflicts and balancing the needs of humans and bears.

Selected Publications:

Baruch-Mordo, S., S. W. Breck, K. R. Wilson, and D. M. Theobald. 2008. Spatiotemporal distribution of black bear-human conflicts in Colorado. Journal of Wildlife Management 72:1853-1862.

Darrow, P. A. and J. A. Shivik. 2009. Variable coyote response to behavior contingent stimuli. Applied Animal Behavior Science 116:82-87.

Young, J. K., S. N. Glasscock, and J. A. Shivik. 2008. The influence of food abundance and distribution on coyote space use and diet. Journal of Mammalogy 89:1094—1104.

Muñoz-Igualada, J., J. Shivik, F. García-Domínguez, J. Lara-Zabía, and L. M. González-García. 2008. Evaluation of cage-traps and cable restraint devices to capture red foxes in Spain. Journal of Wildlife Management 72:830—836.

Shivik, J. A., and K. A. Fagerstone. 2007. A broad perspective on current and future research on urban coyotes. Proceedings of the Wildlife Damage Management Conference 12:418-420.

Mettler, A. E., and J. A. Shivik. 2007. Dominance and Neophobia in Coyote (Canis latrans) Breeding Pairs. Applied Animal Behaviour Science 102:85-94.

Heffernan, D. J., W. F. Andelt, and J. A. Shivik. 2007. Coyote exploratory behavior following removal of novel stimuli. Journal of Wildlife Management 71:587—593.

Major Research Accomplishments:

- WS designed, fabricated, and evaluated unique electronic animal repellent systems (e.g., fladry) to prevent carnivore predation on livestock.
- WS examined wolf presence at farms in Wisconsin and Minnesota.
- WS developed and tested new capture systems for wildlife.
- WS identified characteristics of bear damage and activity in urban areas

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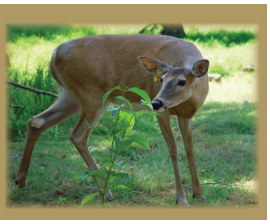
Reducing Wildlife Damage to Forest and Riparian Ecosystems



Contact Information:
Dr. Jimmy Taylor, Supervisory Research Wildlife Biologist
Washington Field Station
9730-B Lathrop Industrial Drive SW
Olympia, WA 98512
Phone: (360) 956-3925
FAX: (360) 534-9755
jimmy.d.taylor@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators

- Oregon Forest Industries Council
- Oregon Department of Forestry
- Oregon Department of Fisheries and Wildlife
- Tres Rios, City of Phoenix
- Washington Forest Protection Association
- Washington Department of Fisheries and Wildlife
- Washington Department of Natural Resources
- USDA Forest Service

Groups Affected By These Problems

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

NWRC 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 acceptable methods, tools, and techniques. NWRC's field station in Olympia, WA, has the capacity to conduct research on most animals associated with forest resource damage. Damage to timber resources at the human-wildlife interface often occurs in a variety of environments, ranging from bottomland hardwood forests to upland conifer farms.

Wildlife impacts on forest resources can be extensive. For example, attempts to replace trees after a harvest or a fire can be complete failures because of foraging wildlife. Reforestation efforts are greatly hindered by deer, elk, mice, mountain beavers, pocket gophers, and voles cutting and gnawing on seedlings during the first five years of tree growth. Other mammals such as bears, North American beavers, and porcupines damage established trees after canopy closure. Mountain beaver (Aplodontia rufa) are an example of a species that directly damage trees during (1-5 years) and after stand establishment (10-15 years).

Select species cause multiple impacts by their behavior and habits. For example, North American beavers are found in upland, lowland, and riparian habitats and they directly destroy trees by their foraging habits. Impounded water created by beaver damming activity floods and kills additional trees. Furthermore, altered water patterns caused by beaver damming erode roads and railways causing danger for human health and safety.

Developing nonlethal methods to manage wildlife damage is a priority in the ongoing research conducted at NWRC's Olympia field station. However, research to improve lethal control methods also is necessary. Scientists are currently conducting research to develop alternatives to lethal control, including repellents, and habitat and behavior modification.

NWRC scientists are working with a variety of natural resource managers to address the most significant wildlife damage problems in forested and riparian areas. The goal is to develop methods to reduce this wildlife damage while promoting ecosystem function. The research that NWRC is conducting is specifically targeted to find solutions to problems found in the Northwestern and Southeastern forests of the United States.

Applying Science & Expertise to Wildlife Challenges

Developing and Testing Repellents to Protect Forest Resources—Use of repellents for protecting trees can be cost prohibitive and results are generally short term. Thus, the need exists for a cost effective and long lasting repellent for application in forest management. NWRC studies evaluated the effects of hydrolyzed casein as a repellent for rodents and ungulates. Initial results showed 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. Other studies are working to identify genetically-controlled chemical characteristics which promote herbivore avoidance of select tree species.

Understanding Dietary Behaviors—Most problems associated with wildlife occur because of their foraging activities. NWRC researchers are working to determine how select wildlife species respond to chemical components in the plants they eat. Ongoing collaborative efforts will determine which traits can be selected to produce less palatable trees. Concurrently, ongoing studies suggest that when given a choice deer prefer to eat conifer seedlings with low terpene levels. Furthermore, tree breeding programs can be used to produce seedlings with elevated terpenes. Understanding these and other mechanisms that control dietary behaviors aid in the development of management

strategies for decreasing damage and help create models for predicting where damage is most likely to occur.

Manipulating Feeding Responses—Overgrazing of native trees can promote invasion of non-native woody species, thus altering ecosystem function and local diversity. An example of this is where North American beaver (Castor canadensis), native riparian trees (e.g., Salix spp. and Populus spp.), and invasive salt cedar (Tamarix spp.) coexist. Salt cedar is generally avoided due to high content of tannins and sodium chloride. NWRC researchers are working on methods to increase consumption of tamarisk plants while decreasing consumption of native plants. Initial results suggested that deterrent treatment of desirable plant species in wetland areas will facilitate foraging of invasive plants by beavers, including salt cedar.

A New Tool for Managing Mountain Beavers—The mountain beaver (Aplodontia rufa) is a rodent species endemic to the Pacific Northwest and northern coastal California. Unlike a true beaver, it has a short tail and is not well adapted to aquatic life but lives underground and is seldom seen. This herbivore is managed as a pest species because of the impact it has on newly planted Douglas-fir (Pseudotsuga menziesii) seedlings and Douglas-fir trees 10-15 years old. Attempts to manage mountain beavers through repellents, barriers, and trapping are costly and not effective. Results from a series of studies over a five year period at the Olympia field station concluded that chlorophacinone was an efficacious and environmentally safe toxicant with potential as a tool to control mountain beavers. Consequently, special local needs (SLN) labels were approved in Washington and Oregon for the use of Rozol™ (active ingredient chlorophacinone) as an additional tool to manage mountain beavers. Results from additional studies recommend integrating this tool with traditional trapping to increase forest health and reduce economic impacts.

A New Transmitter Design for Monitoring Beavers—Dispersal and long-term monitoring of North American beaver (Castor canadensis) populations has been hampered by the inability to retain external transmitters on the animals and the limited range of internal transmitters. Scientists at the NWRC field station in Olympia, Washington tested several transmitter designs to develop an effective and reliable external transmitter for beaver. A modified ear-tag transmitter fitted with a plastic sleeve and attached to the tail was found efficacious in pen trials. A subsequent field study conducted in Phoenix, AZ found the retention of the sleeve transmitter averaged 343 days, more than triple the time previously reported. This technique will be used to gain new knowledge of beaver behavior and movement in areas where beaver cause damage to roads, agriculture, and forest resources.

Selected Publications:

Arjo, W.M., C.O. Kochanny, J.L. Harper, R. Joos, D. L. Nolte, and D. Bergman. 2008. Assessment of transmitter models to monitor urban beaver populations. Wildlife Biology 14:309-317.

Arjo, W.M. 2007. Mountain Beaver: A Primitive Fossorial Rodent. Pages 309-321 in Subterranean rodents: News from underground (S. Begall, H. Burda, and C.E. Schliech, eds.). Springer-Verlag, Berlin.

Arjo, W.M., R.E. Huenefeld, D.L. Nolte. 2007. Mountain beaver home ranges, habitat use, and population dynamics in recently harvested units. Canadian Journal of Zoology 85:328-337.

Arjo, W.M. and D.L. Nolte. 2006. Boomer or bust: managing a Pacific Northwest pest species. Vertebrate Pest Conference 22:181-186

Arjo, W.M., K.K. Wagner, D.L. Nolte, R. Stahl, and J.J. Johnston. 2006. Potential non-target risks from strychnine-containing rodent carcasses. Crop Protection 25:182-187.

Figueroa, J.A., B.A. Kimball, and K.R. Perry. 2008. Lagomorph and Rodent Responses to Two Protein Hydrolysates. Crop Protection 27:851-854.

Kimball, B.A. and K.R. Perry. 2008. Evaluating New Protein Sources for Development of a Deer Repellent Product. Crop Protection 27:xxx-xxx (In press).

Kimball, B.A. and K.R. Perry. 2008. Manipulating Beaver (Castor canadensis) Feeding Responses to Invasive Tamarisk (Tamarix spp.). Journal of Chemical Ecology 34:1050-1056.

Kimball, B.A., J.H. Russell, J.P. DeGraan, and K.R. Perry. 2008. Screening Hydrolyzed Casein as a Deer Repellent for Reforestation Applications. Western Journal of Applied Forestry 23:172-176.

Kimball, B.A. and V. Billings. 2007. Do Herbivores Associate Flavours with Specific Consequences in Flavour Aversion Learning? Applied Animal Behavioral Science 107:252-261.

Kimball, B.A. and D.L. Nolte. 2006. Development of a New Deer Repellent for the Protection of Forest Resources. Western Journal of Applied Forestry. 21:108-111.

Kimball, B.A. and D.L. Nolte. 2006. Animal Tissue-based Repellents: Scary Odours or Altered Palatability? Advances in Vertebrate Pest Management. IV: 59-72.

Perry, K. R., L. A. Miller, and J. D. Taylor II. 2008. M. avium Bacterium: Is it an Essential Ingredient for a Single-injection GnRH Immunocontraceptive Vaccine? Vertebrate Pest Conference 23:253-256.

Perry, K., W.M. Arjo, K.S. Bynum, and L.A. Miller. 2006. GnRH single-injection immunocontraception of black-tailed deer. Vertebrate Pest Conference 22:72-77.

Rizor, S.E., W.M. Arjo, S. Bulkin, and D.L. Nolte. 2006. Long-term impacts on non-targets vertebrates following a cholecalciferol application to control pocket gophers. Vertebrate Pest Conference 22:166-170.

Runde, D. E, D.L. Nolte, W.M. Arjo, and W.C. Pitt. 2008. Efficacy of individual barriers to prevent damage to Douglas-fir seedlings by captive mountain beavers. Western Journal of Applied Forestry 23:99-105.

Taylor, J. D., D. Bergman, and D. Nolte. 2008. If you build it, they will come – management planning for a suburban beaver population in Arizona. Vertebrate Pest Conference 23:43-46.

Major Assistance Activities:

- WS evaluated efficacy of chlorophacinone as a toxicant for managing mountain beavers.
- WS evaluated the efficacy of hydrolyzed casein as a new repellent for rodents and ungulates.
- WS evaluated flavor aversion learning (FAL) for deterring ungulates from select tree species.
- WS evaluated methods for promoting consumption of invasive Tamarix species by North American beaver.
- WS developed an improved radio transmitter design for North American beaver.

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Methods and Strategies to Monitor and Manage Mammalian Invasive Species with Special Emphasis on Rodents

Contact Information:
Dr. Gary Witmer,
Research Wildlife Biologist
NWRC Headquarters
4101 LaPorte Avenue
Fort Collins, CO 80521
Phone: (970) 266-6335
FAX: (970) 266-6089
gary.w.witmer@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators
- U.S. Fish and Wildlife Service
- U.S. National Park Service
- U.S. Department of Defense
- Florida Wildlife Commission
- Louisiana Department of Wildlife and Fisheries
- Island Conservation, Inc.
- Global Materials Technology, Inc.

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

NWRC Scientists Assess and Develop Methods to Manage or Eradicate Introduced and Invasive Mammals

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 acceptable methods, tools, and techniques.

The National Invasive Species Council has documented the serious threat to agriculture, property, natural resources, and human health and safety in the United States posed by invasive or introduced plants, invertebrates, disease agents, and vertebrates. Pimentel and others (2000) estimated that invasive species result in at least $120 billion per year in losses, damage, and control in the United States. About 300 species of invasive vertebrates have been accidentally or purposefully introduced into the United States, including about 20 species of mammals. These include omnivores (rats, feral pigs), predators (mongoose, foxes, feral dogs and cats), and herbivores (feral livestock, non-native deer).

WS has a long history of involvement in invasive species management, not only on the mainland United States, but in Hawaii, the Caribbean, South America, Africa, Indonesia, and the Philippines. Research continues to improve methods and strategies to 1) prevent introductions, 2) detect new introductions, 3) eradicate introductions, and 4) support sustained suppression of well-established invasive species where eradication is not feasible.

Applying Science & Expertise to Wildlife Challenges

Developing Methods to Eradicate Gambian Giant Pouched Rats—Introduced Gambian giant pouched rats have become established on Grassy Key, an island in the Florida Keys. If they reach the mainland, they could cause significant damage to agriculture and natural resources. Studies have been conducted to identify effective rodenticides for use in eradicating the rats. In pen studies at the NWRC in Fort Collins, CO, brodifacoum (a second generation anticoagulant) and zinc phosphide (an acute toxicant) were found to be effective rodenticides for use on Gambian rats. Diphacinone (a first generation anticoagulant) was not as effective. Trials were also conducted to identify attractants for use in Gambian rat eradication efforts. Of 15 materials tested, only Gambian rat urine and fecal material served as effective attractants.

Effects of High Vitamin K-containing Plants on Anticoagulant Rodenticides—Resource managers involved in invasive rodent control have wondered whether or not the presence of vegetation foods on islands that contain high amounts of Vitamin K (the antidote to anticoagulant poisoning) can reduce the effectiveness of rodenticides used for eradication of invasive rodents. To test this hypothesis, NWRC researchers fed Brussels sprouts or collards, both green leafy vegetables containing high levels of Vitamin K, to captive wild Norway and roof rats and wild house mice before and during exposure to the anticoagulant rodenticides brodifacoum or diphacinone. High levels of mortality occurred in all groups. Hence, it appears that resource managers do not have to worry about reduced effectiveness of anticoagulant rodenticides because of the presence of vitamin K-rich plant foods where rodent control is being conducted.

Developing a Multiple Capture Live Trap for Nutria—NWRC scientists designed and tested a large cage trap with a one-way door for use on invasive nutria in coastal Louisiana marshes. The traps were baited with food materials (corn, carrots, and sweet potatoes) or with fertilized marsh plants raised in a plant nursery. Both baits were very effective lures; as many as three nutria were captured overnight in a single trap. Importantly, very few non-target animals were captured. The traps are now being used in the Pacific Northwest as part of nutria control programs.

USDA APHIS
United States Department of Agriculture
Animal and Plant Health Inspection Service

Developing Effective Rodent Barriers for Commensal Rodents—NWRC researchers tested the effectiveness of geo-textile (metal fiber) materials provided by a commercial company as barriers to openings used by wild Norway rats and wild house mice. When the material was tightly compacted and inserted into rat and mice holes, the barrier material was very effective in preventing access. When the material was used to cover a larger, square opening to a food box, however, it was not effective in preventing access by rats and mice. The company is now selling the material on the commercial market.

Selected Publications:

Witmer, G., J. Gionfriddo, and M. Pipas. 2008. Evaluation of physical barriers to prevent prairie dog colony expansion. Human-Wildlife Conflicts 2:206-211.

Witmer, G., R. Sayler, D. Huggins, and J. Capelli. 2007. Ecology and management of rodents in no-till agriculture in Washington, USA. Integrative Zoology 2:154-164.

Witmer, G., and M. Lowney. 2007. Population biology and monitoring of the Cuban hutia at Guantanamo Bay, Cuba. Mammalia 71:115-121.

Caut, S., J. Casanova, E. Virgos, J. Lozano, G. Witmer, and F. Courchamp. 2007. Rats dying for mice: modeling the competitor release effect. Austral Ecology 32:858-862.

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Witmer, G., F. Boyd, and Z. Hillis-Starr. 2007. The successful eradication of introduced rats from Buck Island using diphacinone, followed by an irruption of house mice. Wildlife Research 34:108-115.

Witmer, G. and R. Engeman. 2007. Fossorial rodents as pests: the case of the pocket gopher. Pp. 287-299 in: Subterranean Rodents---News from the Underground, S. Begall, ed. Springer-Verlag, Berlin.

Pitt, W., and G. Witmer. 2007. Invasive predators: a synthesis of the past, present, and future. Invited book chapter. Pp. 265-293 in: Predation in organisms: a distinct phenomenon, A. Elewa, ed. Springer-Verlag, Berlin.

Major Assistance Activities:

- WS organized and hosted an international invasive vertebrate management symposium in Fort Collins, CO, in August 2007. The Symposium drew 160 attendees from seven countries. Approximately 60 oral presentations and posters were presented and published in the symposium's proceedings.
- WS identified effective attractants and rodenticides for Gambian giant pouched rat management.
- WS designed and tested a multiple-capture live cage trap for nutria control in Louisiana.
- WS evaluated a geo-textile barrier material to prevent rodent access to protected areas.

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Methods and Strategies to Manage Invasive Species Impacts to Agriculture in Hawaii

Contact Information:
Dr. William Pitt,
Research Wildlife Biologist
Hawaii Field Station
P.O. Box 10880
Hilo, HI 96721
Phone: (808) 961-4482
FAX (808) 961-4776
will.pitt@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

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

Groups Affected By These Problems

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

NWRC Scientists Develop Methods to Reduce Damage Caused by Invasive Species to Agriculture, Natural Resources, and Human Health and Safety

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 acceptable 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 Hawaiian agricultural crops and native ecosystems, as well as other areas throughout the Pacific.

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 the reduction of 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.

Applying Science & 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 are compiling 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 show that only certain rodenticides are effective on Hawaiian mice and rats. The first rodenticide for tropical fruits and seed crops in Hawaii, Rozol Mini Blocks containing chlorophacinone, was approved for use by the EPA in 2008. In addition, the State of Hawaii granted a state registration for Diphacinone 50 Conservation in 2007, and WS and the U.S. Fish and Wildlife Service conducted a rodent eradication project on the 16-acre Mokapu Island for conservation purposes in February 2008. Rodent monitoring on the island will continue for two years to ensure the eradication was successful.

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 chance of snakes spreading to new areas such as Hawaii, and to reduce the impact of snakes on Guam. NWRC scientists are evaluating the use of female snake pheromones to attract more snakes to traps. Alternative baits, such as a treated beef mixture, have also been evaluated to help reduce the cost and improve trapping effectiveness. To reduce snake populations over large or remote areas and deliver baits to tree canopies, scientists successfully deployed mouse baits attached to paper streamers from helicopters. The streamers landed in the canopy layer of the forest 85% of the time, thus making the baits accessible to brown treesnakes but inaccessible to nontarget species.

In Hawaii, a species of tree 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. NWRC scientists are studying ways to manage frog

populations, determine the effects of frogs on native ecosystems, and minimize their effects on agriculture. Current efforts are focused on the development and testing of chemical agents, such as citric acid and sodium bicarbonate, that are lethal if sprayed on frogs. The effects of these pesticides on plants and non-target animals are also being studied.

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.

Seed Crop Protection—Growing plants for seed has emerged as one of Hawaii's biggest industries. In 2007, seed companies spent nearly $98 million in Hawaii on research and development of new crops. 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 and enables 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. Recently, 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 soybeans planted. Nine months after the program was initiated, bird damage was absent.

Selected Publications:

Koopman, M. E. and W. C. Pitt. 2007 Crop diversification leads to diverse bird problems in Hawaiian agriculture. Human Wildlife Conflicts. 1(2):235–243

Sin, H., K. H. Beard, and W. C. Pitt. 2008. An invasive frog, Eleutherodactylus coqui, increases new leaf production and leaf litter decomposition rates through nutrient cycling in Hawaii. Biological Invasions 10 (3):335-345.

Runde, D. E. and W. C. Pitt. 2008. Maui's Mitred Parakeets (Aratinga mitrata) Part 1. 'Elepaio 68(1):1-4, Maui's Mitred Parakeets (Aratinga mitrata) Part 2. 'Elepaio 68(2):1-2.

Major Assistance Activities:

- 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 caffeine, citric acid, hydrated lime, and sodium bicarbonate to reduce invasive tree frog populations.
- WS provided the data for two new rodenticide registrations in Hawaii. These rodenticide registrations are the first products to be registered for use on seed crops and tropical fruits in Hawaii.
- WS obtained the data for the registration of aerial broadcast of rodenticides for use in conservation areas and to protect native ecosystems.
- WS investigated ways to reduce damage to valuable seed crops.

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Surveillance Strategies/ Management Tools to Control Pseudorabies and Other Wildlife Diseases that Affect Humans and Livestock

Contact Information:
Dr. Tyler A. Campbell,
Research Wildlife Biologist
Texas Field Station
Texas A&M University-Kingsville
MSC 218, 700 University Blvd.
Kingsville, TX 78363
Phone: (361) 593-2426
FAX: (361) 593-4311
tyler.a.campbell@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators

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

NWRC Scientists Provide Basic Ecological Information to Develop Management Tools to Control Pseudorabies in Feral Swine, and Management of Other Wildlife Diseases that Affect Livestock and Humans

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 acceptable 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 the feral swine has resulted in populations that have dramatically increased in size and distribution. This invasive animal now occurs across 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 the 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 & Expertise to Wildlife Challenges

Feral Swine Exposure to Selected Pathogens in southern Texas—The pork industry spends millions of dollars each year to prevent and eradicate diseases from domestic swine. Many of these diseases are also present in feral swine populations. NWRC scientists conduct studies to determine the magnitude of disease prevalence in feral swine populations and ascertain whether feral swine pose a threat to domestic swine. Blood samples were obtained from 409 feral hswine in Texas to determine the prevalence of selected pathogens. Exposure rates were 35% for pseudorabies, 1% for brucellosis, and 1% for porcine reproductive and respiratory syndrome. Scientists believe simple modifications to enclosures may provide adequate biosecurity and prevent exposure of domestic swine in this region.

Distribution and Disease Prevalence of Feral Swine in Missouri—NWRC scientists determined the current distribution of feral swine in Missouri, as well as the prevalence and distribution of feral swine with antibodies against pseudorabies, swine brucellosis, tularemia, and classical swine fever. Feral swine sighting data from the public, Missouri Wildlife Services, and Missouri Department of Conservation wildlife biologists was collected and used to determine the distribution of feral swine in the state. From 2000–2005, a total of 115 swine sightings occurred statewide. Scientists also evaluated 321 feral swine blood samples for antibody presence from 1993–2005. Antibodies against pseudorabies and classical swine fever were not detected; however, one feral swine had antibodies against swine brucellosis (0.3% prevalence) and one feral swine had antibodies against tularemia (1.3% prevalence). Information from this and other disease surveillance is being used to help eliminate certain diseases before they become established in feral swine populations in Missouri.

Tetracycline as a Biological Marker for Feral Swine—Tetracycline hydrochloride (THC) is an ingestible antibiotic that produces a fluorescent mark on growing bone. NWRC scientists are investigating its usefulness as a biological marker for feral swine. Study results showed feral swine will consume THC when combined with palatable baits, more than 150 mg THC is necessary for adequate marking, and marks can be identified in teeth 7 days or less after ingestion. THC may be a useful tool for mark-recapture analysis, evaluation of large-scale feral swine movements, and determining the uptake of pharmaceuticals by feral swine.

Evaluation of Population Estimation Techniques—Population indices and density estimates are often used to measure the effectiveness of wildlife management actions. NWRC scientists evaluated the effectiveness of the following techniques for estimating the population and density of free-ranging feral swine populations: 1) a mark-recapture technique using THC; 2) traditional aerial surveys and spotlight surveys; and 3) motion sensitive cameras for passive (PTI) and active tracking indices (ATI). Two feral swine populations in Texas were estimated both prior to and immediately following lethal removal. In southern Texas, scientists estimated a reduction in feral swine populations of 44% for mark-recapture, 75% for spotlight surveys, 92% for the PTI, and 39% for ATI. In central Texas, scientists estimated a reduction of 35% for the mark-recapture. No feral swine were detected pre- or post-removal for the PTI; however, scientists did detect a 100% reduction in feral swine populations for the ATI. The THC was a suitable biomarker for mark-recapture analysis of feral swine. Traditional spotlight survey and aerial survey estimates appeared biased for feral swine populations. However, motion sensitive cameras showed promise in monitoring lethal control of feral swine.

Feral Swine Baits and Attractants—Few data exist regarding suitable feral swine attractants. To better understand feral swine and other mammalian species visitation and removal rates of fish- and vegetable-flavored baits, NWRC scientists conducted several field trials in Texas. Results showed cumulative bait removal rates after four nights ranged from 93–98%. Feral swine, raccoons, and collared peccaries showed similar removal rates. Coyotes removed more fish-flavored baits and white-tailed deer removed more vegetable-flavored baits than expected. Scientists conclude that feral swine are attracted to and readily consume baits; however, given the number of other species also attracted to the baits the development of a baiting system specific for feral swine will be more difficult.

In a follow-up study, scientists compared visitation and contact rates of mammals to 11 candidate feral swine attractants at scent stations using motion-sensing digital photography. Feral swine had greater visitation rates to apple and strawberry stations than to control stations. WS recommends managers consider using strawberry attractants for applications specific to feral swine. If, however, a less specific attractant is needed, then apple, berry, or caramel attractants may perform well.

Effectiveness of Localized Removal Events to Control Feral Swine Populations—Feral swine are one of the most aggressive and dangerous invasive species due to their impact to native plants and animals, damage to agriculture, and potential disease risks. Traditional control methods for feral swine include hunting, aerial shooting, poisoning, trapping, and fencing. To assess the effectiveness of localized removal events involving trapping and aerial shooting, NWRC scientists looked at the genetic makeup of feral swine populations before and after removal. Results showed that swine before and after removal events were genetically similar. This suggests that localized control methods have a minimal effect in controlling feral swine populations in southern Texas. The findings emphasize the need for more understanding of how landscape features facilitate feral swine movement and recolonization of available habitats.

Phylogeny of Feral Swine—Feral swine are widespread throughout the world as a result of human introductions. The large feral populations in the United States are thought to be a mixture of domestic swine, Eurasian wild boar, and the hybrids of these two forms. However, no detailed studies have evaluated the ancestry or relative contribution of domestic vs. “wild” swine to the current population of feral swine in the United States. NWRC scientists analyzed the phylogeny of feral swine in the continental United States, as well as Hawaii and Puerto Rico where feral swine have been isolated for several centuries and may represent the original founders from Spanish and other colonists. Muscle tissue was collected from 38 trapped or harvested swine and DNA analyzed. The DNA was compared with the sequences of domestic, feral, and wild swine archived at the National Center for Biotechnology Information (NCBI) database (http://www.ncbi.nlm. nih.gov/). The phylogenetic analysis revealed 4 major groups of swine. Southern Texas feral swine were most similar to domestic pigs and feral swine from Texas and elsewhere, with the exception of a wild boar from Spain. The results suggest that most South Texas feral swine probably descended from domestics that were released or escaped into the wild. The similarity to Spanish wild boar is intriguing and may suggest descendants of early releases.

Seasonal Home Ranges and Fidelity of Adult White-tailed Deer—Models predict that home range sizes of young (1 and 2 years old) and mature (5 and 6 years old) male white-tailed deer will be greater than middle-aged (3 and 4 years old) deer and that home range fidelity of young and mature deer will be less than middle-aged deer. NWRC scientists tested the predictions of these models by collecting home range sizes and fidelity of 96 radio-collared white-tailed adult male deer in southern Texas. Results showed annual home range sizes did not differ among age categories. Deer maintained smaller home ranges during spring than during other seasons, and old deer (≥7 years old) displayed smaller seasonal home ranges than young or mature deer. Deer exhibited greater home range fidelity during summer than during spring, prerut, and rut seasons. Researchers found limited evidence supporting the model predictions. The high annual home range fidelity observed suggests little shifting between years; however, annual home range sizes exceed the acreage of most private landholdings, which should be considered when formulating management and disease surveillance plans.

Survival and Movements of Translocated Deer— Managers commonly translocate white-tailed deer in south Texas, yet the effectiveness of this technique at enhancing deer populations is undocumented. NWRC researchers evaluated survival, movements, and body condition of 51 white-tailed deer from two translocations into a partially fenced property (2,000 ha) and an unfenced property (4,000 ha) in south Texas. Annual survival was lower in the partially fenced property (59%) compared to the unfenced property (74%), although more deer left the unfenced property (60%) than the partially fenced property (15%). Cumulatively, 39% of all deer survived and remained on the release area. Young (1.5-3.5 years old) translocated males had below average antler gain, body condition scores and rump fat measurements compared to

native males. Results of this study help managers evaluate the effectiveness of translocations as a management tool.

Selected Publications:

Campbell, T.A., R.W. DeYoung, E.M. Wehland, L.I. Grassman, D.B. Long, and J. Delgado-Acevedo. 2008. Feral swine exposure to selected viral and bacterial pathogens in southern Texas. Journal of Swine Health and Production 16:312-315.

Campbell, T.A., and D.B. Long. 2008. Mammalian visitation to candidate feral swine attractants. Journal of Wildlife Management 72:305–309.

Campbell, T.A., and D.B. Long. 2007. Species-specific visitation and removal of baits for delivery of pharmaceuticals to feral swine. Journal of Wildlife Diseases 43:485–491.

Hartin, R.E., M.R. Ryan, and T.A. Campbell. 2007. Distribution and disease prevalence of feral swine in Missouri. Human-Wildlife Conflicts 1:186–191.

Hellickson, M.W., T.A. Campbell, K.V. Miller, R.L. Marchinton, and C.A. DeYoung. 2008. Seasonal ranges and fidelity of adult male white-tailed deer in southern Texas. Southwestern Naturalist 53:1–8.

Reidy, M.M., T.A. Campbell, and D.G. Hewitt. 2008. Evaluation of electric fencing to inhibit feral swine movements. Journal of Wildlife Management 72:1012–1018.

Major Research Accomplishments:

- WS developed surveillance strategies that evaluated the potential or actual risk that pseudorabies and other diseases in feral swine pose to Texas livestock.
- WS developed baiting strategies for delivery of pharmaceuticals to control wildlife diseases, including pseudorabies.
- WS developed physical methods to minimize the transmission of pseudorabies and other diseases between livestock and wildlife.
- WS developed surveillance strategies to evaluate the risks of other wildlife diseases important to humans and livestock.
- WS tested model predictions of home range size and fidelity by white-tailed deer.
- WS studied the survival and movements of translocated white-tailed deer.

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Investigating the Ecology, Control, and Prevention of Terrestrial Rabies in Free-ranging Wildlife

Contact Information:
Dr. Mike R. Dunbar,
Research Wildlife Biologist/Veterinarian
NWRC Headquarters
4101 LaPorte Avenue
Fort Collins, CO 80521
Phone: (970) 266-6360
FAX: (970) 266-6138
mike.r.dunbar@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators
- Auburn University
- Centers for Disease Control and Prevention
- Colorado State University
- FoodSource (private bait company)
- MERIAL, Inc. (private vaccine development company)
- Ohio Department of Health Services
- Pennsylvania State University
- State Departments of Public Health
- Texas A&M University
- Texas State Health Services Department
- The Ohio State University
- The University of Maryland
- University of Alaska, Fairbanks
- USDA/APHIS/Wildlife Services Operations
- Navajo Nation

Groups Affected By These Problems
- U.S. citizens
- Wildlife and natural resource managers
- Livestock producers and farmers
- Sporting organizations
- Consumers

NWRC 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 acceptable methods, tools, and techniques.

Increased urbanization, greater acceptance and desire of living closer to free-ranging wildlife, and increasing wildlife numbers have led to increased conflicts between people and wildlife. Such conflicts can take many forms, both direct and indirect. Recently, the potential for the transmission of diseases among wildlife, livestock, and humans has received greater attention.

Rabies is an acute, fatal viral disease most often transmitted through the bite of a rabid mammal. It 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 that could help reduce the transmission of this disease.

In the United States, terrestrial rabies can be found in many wild animals, including raccoons, skunks, gray fox, arctic fox, and coyotes. In an effort to halt the spread and eventually eliminate terrestrial rabies in the United States, NWRC scientists are conducting research on the behavior, ecology, movements and population structures of raccoons and gray fox. They are also evaluating methods and techniques used to vaccinate free-roaming wildlife against rabies that could help decrease the risks of transmission and maintenance of the disease in the wild.

Applying Science & Expertise to Wildlife Challenges

Ecological and Genetic Studies on Raccoons in Urban Areas—NWRC scientists are learning more about raccoon ecology and genetics in northern Ohio. The information gathered will help improve the effectiveness of the WS oral rabies vaccination (ORV) program in the state and help prevent the westward spread of rabies in raccoons.

By combining radio telemetry, global positioning systems (GPS) collars, geographic information systems (GIS) habitat layers and population genetics data, scientists hope to answer questions regarding how rabies could be spread across northern Ohio, especially the Cleveland metropolitan area. Scientists want to know if factors such as urban area, suburban area, major highways, or greenbelts in the city, or even rural farming areas east of the city may prevent or encourage the spread of rabies in raccoons.

Since the fall of 2006, WS scientists and field specialists have been live-trapping and radio-collaring raccoons in and around the Cleveland area. Approximately 60 raccoons have been trapped for the telemetry study and nearly 200 DNA samples have been collected from raccoons for the genetic analysis. Documented raccoon movements have shown that a small percentage of raccoons move great distances (> 2 km) and may breach ORV zones and facilitate the spread of rabies. Preliminary genetic analysis appears to show that the greater Cleveland area is a barrier to the spread of rabies. These data provide the WS National Rabies Management Program a basis for reliable strategies that facilitate the control of rabies in and near metropolitan urban and suburban areas.

USDA APHIS
United States Department of Agriculture
Animal and Plant Health Inspection Service

Rabies Vaccine Efficacy—In captive animal studies, NWRC scientists and collaborators showed the Raboral-VRG® vaccine to effectively prevent rabies in raccoons at least 18 months after a single or double dose of the vaccine. This knowledge aids in the development of risk assessments and possible modifications of WS baiting strategies designed to eradicate raccoon rabies in the United States.

Effects of Natural Orthopoxviruses on Vaccination with V-RG—The search for reasons of low rabies vaccination rates in raccoons has been at the forefront of the ORV program. Post ORV surveys have shown antibody prevalence to be as low as 30% in targeted raccoons. One reason for the low prevalence may be naturally occurring orthopoxviruses in raccoon. NWRC studies have shown that orthopoxviruses in raccoons prevent the production of antibodies in response to other pox viruses including the pox virus, vaccinia, which is used in the rabies V-RG vaccine. Results indicate that a new non-vaccinia vectored vaccine may be needed in order to increase antibody prevalence rates in vaccinated raccoons.

Rhodamine B as a Biomarker for Raccoons—NWRC researchers investigated the use of rhodamine B as an alternative biomarker to tetracycline in raccoons. Rhodamine B is a chemical dye that, when ingested, stains the oral cavity and is absorbed systemically in growing tissues such as hair and whiskers producing fluorescent orange bands under ultraviolet (UV) light.

In studies, rhodamine B marked all raccoons that consumed at least 100 mg of the dye. An average of 55% of whiskers sampled from each individual exhibited fluorescence for up to 13 weeks. Researchers used two methods to evaluate whiskers: a UV microscope and hand-held UV lights. Both methods were effective for detecting the fluorescence produced by rhodamine B dye and could aid in the field evaluation of whiskers. By including rhodamine B in vaccine-laden baits, WS can estimate the percentage of raccoons that consume baits. Armed with this knowledge, WS can better evaluate the overall effectiveness of the ORV program and make informed decisions concerning changes in baiting and vaccination strategies aimed at controlling the spread of rabies in raccoons.

Barrier to Prevent the Western Spread of Rabies—Current efforts to prevent the spread of rabies in the United States involves the distribution of ORV baits which target specific wildlife host species, principally raccoons and gray foxes. Understanding the spatial spread of rabies and of the host species is necessary for designing control strategies. The ORV program uses natural barriers such as mountains and large bodies of water to help delineate ORV zones and slow the westward movement of raccoon rabies.

In Alabama, NWRC scientists collaborated with researchers from Auburn University to determine if gene flow occurred between raccoon populations across the Alabama River and thus determine whether this river served as a barrier to movement. The scientists employed 11 raccoon-specific microsatellite markers to obtain individual genotypes of 70 individuals. The scientists examined if population differentiation among microsatellites was due primarily to distances between localities and found that gene flow occurred across the river, and thus both dispersal of animals across the river and possible subsequent rabies transmission can occur. The spread of rabies across Alabama has been hindered, but this research indicates that the river is not the sole hindrance to the spread of rabies and that other landscape features still need to be investigated.

Selected Publications:

Dunbar, M. R., R. T. Sterner, and S. R. Johnson. 2007 Impacts of wildlife disease (including rabies) in urban environments. Proceedings of the 12th Wildlife Damage Management Conference. D. Nolte, W. M. Arjo, D. H. Stalman, Eds. Pp 253-264.

Fry, T. L. and M. R. Dunbar. A review of biomarkers used for wildlife damage and disease management. 2007. Proceedings of the 12th Wildlife Damage Management Conference. D. Nolte, W. M. Arjo, and D. H. Stalman, Eds. Pp 217-222.

Root, J. J., R. G. McLean, D. Slate, K. A. MacCarthy and J. E. Osorio. 2008. Potential effect of prior raccoonpox virus infection in raccoons on vaccinia-based rabies immunization. BMC Immunology. http://www.biomedcentral.com/1471-2172/9/57.

Compton, J. A., G. J. San Julian, and R. H. Yahner. 2006. A final report on the zoogeography of common raccoon (Procyon lotor) in Western Pennsylvania as related to an Oral Rabies Vaccination Program. School of Forest Resources, The Pennsylvania State University publication, 66 pp.

Mesenbrink, B. T., B. Leland, M. R. Dunbar, G. Moore, R. DeYoung, A. Zamorano, R. G. Mclean, and J. J. Root. 2006. Gray fox research to support oral rabies vaccination programs in Texas: An overview. R. M. Timm and J. M. O'Brien, eds. Proceedings of the 22nd Vertebrate Pest Conference 22:354-355.

Dunbar, M. R. and K. A. MacCarthy. 2006. Use of infrared thermography to detect signs of rabies infection in raccoons (Procyon lotor). Journal of Zoo and Wildlife Medicine 37 (4): 518-523

Major Assistance Activities:

- WS investigated raccoon ecology and genetics in urban and suburban areas to better understand the spread of rabies in these environments.
- WS studies showed the Raboral-VRG® vaccine effectively prevented rabies for at least 18 months in captive raccoons.
- WS discovered naturally occurring orthopoxviruses in raccoons prevent the production of antibodies in response to other pox viruses including the pox virus, vaccinia, which is used in the rabies V-RG vaccine.
- WS determined rhodamine B is an effective biomarker for use in ORV baits.
- WS field studies identified natural barriers to help delineate ORV zones and slow the westward movement of raccoon rabies.

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FY 2008

Controlling Wildlife Vectors of Bovine Tuberculosis

Contact Information:
Dr. Mike R. Dunbar,
Research Wildlife Biologist/Veterinarian
NWRC Headquarters
4101 LaPorte Avenue
Fort Collins, CO 80521
Phone: (970) 266-6360
FAX: (970) 266-6138
E-mail: mike.r.dunbar@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators

- Michigan Department of Agriculture
- Michigan Department of Natural Resources
- USDA/APHIS/Veterinary Services
- USDA/APHIS/Wildlife Services Operations

Groups Affected By These Problems

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

NWRC Scientists Examine Risks of Bovine Tuberculosis Transmission from Wildlife to Domestic Animals

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 acceptable methods, tools, and techniques.

Increased urbanization, greater acceptance and desire of living closer to free-ranging wildlife, and increasing wildlife numbers have led to increased conflicts between people and wildlife. Such conflicts can take many forms, both direct and indirect. Recently, the potential for the transmission of diseases among wildlife, livestock, and humans has received greater attention.

Tuberculosis (TB) 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 TB 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, 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. Consequently, Michigan's Accredited-Free Status, which allows for unrestricted interstate movement of cattle, was suspended by APHIS on August 13, 1998.

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 & Expertise to Wildlife Challenges

Deer Movements in Relation to Cattle Farms in Michigan—From 2007–2008, 27 white-tailed deer were fitted with Global Positioning Systems (GPS) and radio collars on four beef cattle farms in northern Michigan. Location data for each deer was collected by the GPS every two hours. Data retrieved to date suggest that deer are active on farm property primarily at night, with 30% of deer locations in areas associated with cattle use. Approximately half of those locations occurred between March and May. This overlap of space use has implications for TB transmission between free ranging deer and domestic cattle. NWRC scientists, along with scientists from the USDA Centers for Epidemiology and Animal Health, are analyzing data from retrieved collars to evaluate livestock husbandry practices relative to deer movements. Landowners were interviewed to collect information on their livestock husbandry practices, such as feeding times and locations. This information will assist researchers in developing recommendations for landowners to reduce potential interactions between deer and cattle, thus reducing the risk of TB on their property and in their livestock.

Coyotes and Raccoons as Transmitters of TB—Little is known about the role coyotes, raccoons and other wildlife may play in the transmission of bovine TB to domestic livestock. To evaluate the potential for coyotes to transmit TB, NWRC scientists inoculated captive coyotes with Mycobacterium bovis, the causative agent of bovine TB. Tissue samples were analyzed, as well as oral/nasal secretions and fecal samples to determine whether known TB positive coyotes shed the bacterium, thereby spreading the disease. None of the study animals shed the bacterium. NWRC scientists have also collected

tissue samples from free ranging raccoons and coyotes in and around the TB outbreak area in northeastern Michigan. Two (0.13%) sampled raccoons were diagnosed with TB, whereas 8% of sampled coyotes were found to be infected. All coyotes were from two TB-infected counties. Results suggest neither coyotes nor raccoons shed M. bovis, although the sample size of raccoons was too small to be definitive. Results from this and previous NWRC studies suggest coyotes may be a good sentinel species to monitor the potential spread of TB.

Infrared Thermography Technology Used to Detect TB in Elk—Cervical tuberculin (CT) tests are often used to detect bovine TB in live cervids. NWRC scientists are investigating whether infrared thermography (IRT), which remotely measures heat from a surface, can be used to evaluate the results of CT tests. In addition to being more objective than current evaluation methods, IRT also reduces the number of times an animal must be captured and handled. The current evaluation method includes the recapture of an animal at 66-78 hours, palpating for increased thickness and, depending on the CT test, measuring skin thickness.

NWRC observed successful IRT evaluations for the comparative cervical tuberculin (CCT) test in domestic cattle and are currently evaluating IRT of the single cervical tuberculin (SCT) test and the CCT test in captive elk. Captive elk were treated with small injections of Mycobacterium bovis or M. avium derivatives to cause a response in the CT tests. The current SCT and CCT evaluations indicate the treated animals responded to the bacterium derivatives in their systems.

Selected Publications:

Atwood, T. C., K. C. Vercauteren, T. J. Deliberto, H. J. Smith, and J. S. Stevenson. 2007. Coyotes as sentinels for monitoring bovine tuberculosis prevalence in white-tailed deer. Journal of Wildlife Management 71: 1545-1554.

Berentsen, A. M. R. Dunbar, and R. McLean. 2007. Research strategies to reduce bovine tuberculosis transmission from wildlife to cattle. Proceedings of the 12th Wildlife Damage Management Conference. D. Nolte, ed. Corpus Christi, Texas. 12: 232-238.

Dunbar, M., R. Sterner, and S. Johnson. 2007. Impacts of wildlife diseases in urban environments (including bovine tuberculosis). Proceedings of the 12th Wildlife Damage Management Conference. D. Nolte, ed. Corpus Christi, Texas. 12: 253-264.

Major Research Accomplishments:

- WS studied deer use of cattle farms and nearby habitats in order to prevent deer from transmitting bovine tuberculosis to cattle.
- WS determined that coyotes do not appear to shed the causative agent of bovine tuberculosis, but are an acceptable sentinel species for monitoring the prevalence and spread of TB.
- WS used infrared technology to remotely read comparative cervical tuberculin (CCT) test in cattle and captive elk.

Wildlife Services

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National Wildlife Research Center

FY 2008

Evaluation and Management of Chronic Wasting Disease Transmission

Contact Information:
Dr. Kurt C. VerCauteren
Research Wildlife Biologist
NWRC Headquarters
4101 LaPorte Ave.
Fort Collins, CO 80521
Phone: (970) 266-6093
FAX: (970) 266-6089
kurt.c.vercauteren@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators

- USDA/APHIS/Wildlife Services
- USDA/APHIS/Veterinary Services
- 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

NWRC Scientists Assess the Potential for Chronic Wasting Disease (CWD) Transmission Between Wild and Domestic Cervids and Develop Methods to Reduce/Manage the Disease

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 acceptable 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.

Chronic wasting disease (CWD) is a fatal neurological disease that infects captive and wild native white-tailed deer (Odocoileus virginianus), mule deer (Odocoileus hemionus), elk (Cervus elaphus), and moose (Alces alces). Red deer (also Cervus elaphus), imported to North America from Europe for the production of venison, are also susceptible.
CWD is thought to be caused by abnormal proteins called prions. Over time, these abnormal proteins can accumulate in the central nervous and lymphatic systems causing a degenerative lack of control and a "wasting-away" death.

There is no known cure or vaccine for CWD. The origin of CWD is unknown. The disease may have existed in the wild or begun in captivity under abnormally high deer densities. CWD was first observed in 1967 by the Colorado Division of Wildlife where it was initially diagnosed as malnutrition. In 1977, CWD was determined to be a transmissible spongiform encephalopathy, and the first infected wild animal, an elk from Rocky Mountain National Park, was diagnosed in 1981. Since that time, the disease has been found in fifteen other states in the west and mid-west. NWRC scientists are working aggressively to develop methods to reduce the transmission and spread of CWD.

Applying Science & Expertise to Wildlife Challenges

Ability of White-tailed Deer to Jump Game-Farm Fences—Deer can breach fences by going over, through or under the structure. One concern is that wild deer will jump the fences into captive deer farms, thus exposing those deer to disease. Agencies and landowners need information on the ability of deer to breach fence systems. NWRC scientists determined the capacity of deer to breach fences. The results from these studies have been critical in setting standards for fence height for security and containment of captive deer herds.

Resource Selection and Dispersal Direction of Sympatric Deer—Sympatric species are those that occur in the same or overlapping geographical areas, white-tailed deer and mule deer are examples. Determining how these species interact and move across landscapes is important, especially in areas where CWD is endemic and cross-species transmission for the disease is a possibility. In 2004, NWRC researchers initiated a 3-year study in Morrill County, Nebraska (MC) to determine behavior, habitat and movement conditions conducive to transmission of CWD between mule deer and white-tailed deer. The degree of spatial overlap and habitat use will assist the development of models for predicting the spread of CWD.

Sanitation and Decontamination of CWD-infected Surfaces and Sites—The captive cervid industry, meat processors, hunters, farmers, and other constituents need effective methods and techniques for eliminating the spread of CWD and other transmissible spongiform encephalopathies (i.e., Bovine Spongiform Encephalopathy, scrapie, Crutzveld-Jacob Disease). NWRC scientists are developing an enzymatic product that breaks down prion proteins and renders them harmless. This product potentially could be used to

sanitize and decontaminate tools, surfaces, facilities, mineral licks, and other areas infected with transmissible spongiform encephalopathies.

Live Test for CWD—NWRC scientists and collaborators are developing more efficient methods for detecting CWD in both dead and live cervids. Current tests on dead animals are expensive and time-consuming, which limits the number of animals tested. Live tests are invasive, require anesthesia, and are effective only for deer. NWRC scientists, in collaboration with other scientists, developed the first rectal biopsy test for CWD that works on both living and dead cervids. The test is easy to perform, does not require anesthesia, and can be repeated on individuals over time. NWRC scientists are working with State and Federal agencies to further test and validate this new tool.

CWD Vaccine Development—NWRC scientists are evaluating an experimental CWD vaccine for deer. In a preliminary study with a mouse model, the vaccine lengthened the longevity of infected individuals. We are now evaluating the vaccine in mule deer, though promising the results are not yet in. At the same time, NWRC scientists are attempting to further optimize the candidate vaccines and improve their performance.

Determination of Focal Points for CWD Transmission in the Wild—Through research with animal-activated cameras, NWRC scientists quantified cervid visits to key resource sites, such as mineral licks and wallowing areas, and documented behaviors that could increase transmission of the disease. The investigators concluded that the common breeding activity of male white-tailed deer of establishing scrapes as signposts for communication are likely a means of disseminating and contracting the disease. Mineral licks are also likely focal sites for transmission of the disease among deer, elk, and moose. As modes for disease transmission become better understood and decontamination methods are developed, this information will help pinpoint specific areas for management activities.

Potential for Avian Scavengers to Transmit CWD—Mechanisms for the spread of CWD are still being discovered. Birds have been identified as potential vectors for a number of diseases, where infected material is ingested and the disease agent is later shed in new areas after flying substantial distances. NWRC scientists are investigating whether avian scavengers can disseminate prions associated with transmissible spongiform encephalopathies (TSEs), like CWD, by a similar process. As prions are resistant to destruction, it is reasonable that infectious material could pass through the digestive tract of scavenging birds. The investigators showed that TSE-positive brain material from mice (i.e., mouse-adapted scrapie) that passes through the digestive tract of American crows is still infectious to mice. Our results demonstrate that a common, migratory North American scavenger, the American crow, can pass infective prions in feces and, therefore, could play a role in the spatial dissemination of prion disease.

Emergency Response to Disease Outbreaks in Deer—In the event of catastrophic disease outbreak involving wildlife from a point source, first responders and wildlife managers need new tools for containing potentially infected animals. NWRC scientists evaluated the efficacy of a 2.1 meter tall polypropylene mesh fence for containing free-ranging white-tailed deer in eastern Nebraska. The fence provided nearly complete confinement. Pre-confinement breaches by deer totaled 259 compared to one documented breach following the completion of the experimental enclosure. Given that time is of the essence when responding to a disease outbreak, this simple, quick and inexpensive fencing technique may prove useful during such emergencies. Future studies will continue to evaluate this potential new tool for use in wildlife disease management.

Electric Fencing to Prevent Contact between Captive and Wild Elk—Interaction between wild and farmed cervids often occurs along perimeter fence-lines. Direct and indirect contact at farms with only a single perimeter fence may play a role in transmission of diseases like CWD and bovine tuberculosis. NWRC researchers tested the effectiveness of a baited electric fence, used in conjunction with a single woven-wire high fence, at reducing fence-line contact by elk. Video-surveillance camera systems were used to monitor the test fence at a captive elk ranch. Researchers varied motivation levels, between elk on either side of the test fence area. Motivation levels or animal groupings included separating rutting bulls from estrous cows, separating cows from calves, and spreading sweet feed along the woven-wire fence. Prior to the installation of the electric fence, researchers documented 700 contacts between elk and the fence. Following installation of the electric fence contacts dropped to zero. The simple, inexpensive, baited-electric fence strategy provides a practical tool for reducing the potential for disease transmission between captive and wild cervids.

Selected Publications:

VerCauteren, K. C., T. C. Atwood, T. J. DeLiberto, H. J. Smith, J. S. Stevenson, B. V. Thomsen, and T. Gidlewski. 2008. Sentinel-based surveillance of coyotes to detect bovine tuberculosis in Michigan. Emerging Infectious Diseases. 14:1862-1869.

VerCauteren, K. C., M. J. Lavelle, and G. E. Phillips. 2008. Livestock protection dogs for deterring deer from cattle and feed. Journal of Wildlife Management 72:1443-1448.

Pilon, J., C. Loiacono, D. Okeson, S. Lund, K. C. VerCauteren, J. Rhyan L. M. Miller. 2007. Anti-prion activity generated by a novel vaccine formulation. Neuroscience Letters 429:161-164.

VerCauteren, K. C., P. W. Burke, G. E. Phillips, J. W. Fischer, N. W. Seward, B. A. Wunder, and M. J. Lavelle. 2007. Elk use of wallows: Implications for disease transmission. Journal of Wildlife Disease 43:784-788.

Atwood, T. C., K. C. VerCauteren, T. J. DeLiberto, H. J. Smith, and J. S. Stevenson. 2007. Coyotes as sentinels for monitoring bovine tuberculosis prevalence in white-tailed deer. Journal of Wildlife Management 71:1545-1554.

VerCauteren, K. C., N. W. Seward, M. J. Lavelle, J. W. Fischer, and G. E. Phillips. 2007. A fence design for excluding elk without impeding other wildlife. Journal of Rangeland Ecology and Management 60:529-532.

VerCauteren, K. C., M. J. Lavelle, N. W. Seward, J. W. Fischer, and G. E. Phillips. 2007. Fence-line contact between wild and farmed cervids in Colorado: potential for disease transmission. Journal of Wildlife Management. 71:1594-1602

VerCauteren, K. C., M. J. Lavelle, N. W. Seward, J. W. Fischer, and G. E. Phillips. 2007. Fence-line contact between wild and farmed white-tailed deer in Michigan: potential for disease transmission. Journal of Wildlife Management 71:1603-1606.

Seward, N. W., G. E. Phillips, J. F. Duquette, and K. C. VerCauteren. 2007. A frightening device for deterring deer from cattle feed. Journal of Wildlife Management 71:271-276.

Beringer, J., J. J. Millspaugh, T. Meyer, and K. C. VerCauteren. 2006. Use of parotid lymph node tissues for chronic wasting disease surveillance in hunter-killed and live white-tailed deer. Transactions of the Missouri Academy of Sciences 40:12-21.

Spraker T. R., T. L. Gidlewski, A. Balachandran, K. C. VerCauteren, L. Creekmore and R. D. Munger. 2006. Detection of PrPCWD in postmortem rectal lymphoid follicles of Rocky Mountain elk (Cervus elaphus nelsoni) infected with chronic wasting disease. Journal of Veterinary Diagnostic Investigations 18:553-557.

VerCauteren, K. C., M. J. Lavelle, and S. E. Hygnstrom. 2006. Fences and deer-damage management: a review of designs and efficacy. Wildlife Society Bulletin 34:191-200.

VerCauteren, K. C., M. J. Lavelle, and S. E. Hygnstrom. 2006. A simulation model for determining cost-effectiveness of fences for reducing deer damage. Wildlife Society Bulletin 34:16-22.

Seamans, T. W., and K. C. VerCauteren. 2006. Evaluation of ElectroBraid™ fencing as a white-tailed deer barrier. Wildlife Society Bulletin 34:8-15.

Major Research Accomplishmnets:

- WS determined the risk associated with direct and indirect contact between farmed and wild cervids at fencelines relative to the potential for CWD transmission.
- WS evaluated white-tailed deer and mule deer ecology along riparian areas relative to the transmission and spread of CWD.
- WS developed new methods to test for the presence of CWD in live and dead animals.
- WS determined the minimum fence height that deer cannot breach.
- WS identified focal sites where CWD is likely spread in the wild.
- WS is working to develop a CWD vaccine.
- WS is developing products to disinfect surfaces and areas contaminated with CWD.
- WS is helping to determine the origin and transmission routes of CWD.
- WS developed a fencing strategy to eliminate contact between captive and wild cervids.

Wildlife Services

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FY 2008

Reducing Wildlife Damage with Chemistry, Biochemistry and Computer Modeling Research

Contact Information:
Dr. Tom Primus,
Research Chemist
NWRC Headquarters
4101 LaPorte Avenue
Fort Collins, CO 80521
Phone: (970) 266-6065
FAX: (970) 266-6063
thomas.m.primus@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators

- Colorado State University
- 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

Groups Affected By These Problems

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

NWRC 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 acceptable 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, DNA markers, and other chemistry-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 metabolism chemistry, environmental fate, chemical synthesis, toxicology, chemical ecology, molecular genetics, 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 bird damage to rice and sunflower crops, to control Canada geese in urban and suburban settings, and to facilitate selective removal of predatory canids.
2. Developing and implementing DNA methodology to census wildlife species and to identify individual pest animals.
3. Identifying existing products or naturally-occurring chemicals in plants and animals that could be used as agents to protect against wildlife damage.
4. Developing formulations for increasing the effectiveness of wildlife damage management chemicals already in use.
5. Developing computer models to evaluate the efficacy and safety of pesticides to target and non-target wildlife.

Applying Science & 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 which would increase the value of this tool to the WS program and stakeholders.

Identification of Compounds—In an effort 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 or 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 nontarget animals, humans, and the environment. For example, NWRC chemists are analyzing DRC-1339 (an avicide) residues in nontarget and target birds collected from DRC-1339-baited sunflower and rice fields. Findings show that birds feeding on DRC-1339-baited fields pose little risk to scavenging or predatory wildlife. Similar analytical approaches are being used to assess the safety of acetaminophen to control brown treesnakes on 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 being used to identify pesticide formulation and application strategies.

Genetic (DNA) Based Wildlife Management Tools—Genetic techniques have been developed to aid in the identification of species, sex, and individual genotype of various wildlife species. These techniques are being applied to census wildlife populations through the collection of hair, scat, saliva, and tissue. NWRC scientists have used genetic techniques to track Mexican wolves, identify wolf-dog hybrids in Wisconsin and Wyoming, identify and census coyotes, assess taxonomy of species of concern and endangered species, identify source populations of invasive beavers, and understand bat and raccoon population movements in areas of high rabies incidence. These techniques provide managers with information about the effectiveness of a variety of wildlife management activities related to predator control and wildlife disease issues.

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 number of research topics, including avian infertility; bovine tuberculosis; rabies; wildlife hazards to aviation; wildlife damage to forest resources; bird damage to rice, sunflowers, and aquaculture; and waterfowl disease.

Selected Publications:

Cariappa, C.A., W. Ballard, S. Breck, A.J. Piaggio, M Neubaum. 2008. Estimating Population Size of Mexican Wolves Noninvasively. Ecological Restoration 26:14-16.

Field, K.L., Kimball, B.A., Mennella, J.A., Beauchamp, G.K., and Bachmanov, A.A. 2008. Hydrolyzed Casein Reduces the Palatability of Food for Mice. Physiol. Behav. 93:189-199.

Figueroa, J.A., Kimball, B.A., and Perry, K.R. 2008. Lagomorph and Rodent Responses to Two Protein Hydrolysates. Crop Protect. 27:851-854.

Kimball, B.A. and Perry, K.R. 2008. Manipulating Beaver (Castor canadensis) Feeding Responses to Invasive Tamarisk (Tamarix spp.). J. Chem. Ecol. 34:1050-1056.

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Pelz-Serrano K., A. Munguia-Vega, A.J. Piaggio, M.A. Neubaum, P. Munclinger, C. van Riper III, Culver M (in press) Development of nine microsatellite loci for the American Beaver, Castor canadensis (Rodentia: Castoridae). Molecular Ecology Resources.

Piaggio, A.J., K.W Navo, C. Stihler. 2008. Intraspecific comparison of population structure, genetic diversity, and dispersal among three subspecies of Townsend's big-eared bats, Corynorhinus townsendii townsendii, C. t. pallescens, and the endangered C. t. virginianus. Conservation Genetics. Online early: http://dx.doi.org/10.1007/s10592-008-9542-0

Piaggio, A.J., J.J. Johnston, S.L. Perkins. 2008. Development of polymorphic microsatellite loci for the common vampire bat, Desmodus rotundus (Chiroptera: Phylostomidae). Molecular Ecology Resources 8:440-442.

Stahl, R. S., J. J. Johnston, and G. M. Linz. 2008. Estimating the efficacy of DRC-1339-treated rice bait in blackbird staging areas in North Dakota ujsing a bioenergetics simulation. 30th National Sunflower Association Sunflower Research Forum.

Thieman, G.W., R.S. Stahl, S. Baruch-Murdo, and S. Breck. 2008. Trans fatty acids provide evidence of anthropogenic feeding by black bears. Human-Wildlife Conflicts 2: 183-192.

VanDalen, K.K., M.L. Killian, T.D. Anderson, J.C. Pedersen, A.B. Franklin, A.J. Piaggio. 2008. Development of Influenza A H16 Specific Primers Following Increased Detection in the United States. Archives of Virology 153:1981-1983.

Werner, S.J., Kimball, B.A., and Provenza, F.D. 2008. Color, Flavor, and Conditioned Avoidance among Red-Winged Blackbirds. Physiol. Behav. 93:110-117.

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.

Horiuchi, J., Badri, D., Kimball, B.A., Negre, F., Dudareva, N, Paschke, M., and Vivanco, J. 2007. The Floral Volatile, Methyl Benzoate, from Snapdragon (Antirrhinum majus) Triggers Phytotoxic Effects in Arabidopsis thaliana. Planta 226:1-10.

Hurley, J. C., P. A. Pipas, S. K. Tupper, J. L. Cummings, and R. S. Stahl. 2007. Field method for analyzing birds for avicide 3-chloro-p-toluidine hydrochloride. Proceedings of the Wildlife Damage Management Conference 12:94-102.

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Linz, G. M., H. J. Homan, L. B. Penry, T. M. Primus, and M. J. Goodall. 2007. Evaluation of caffeine and garlic oil as bird repellents. National Sunflower Association Sunflower Research Forum.

Primus, T.M., Jojola S.M., Robinson, S.J., and Johnston, J.J. 2007. Determination of Sulfadimethoxine Residues in Skunk Serum by HPLC J. Liquid Chrom. Rel. Tech., 30, 2095-2102.

Werner, S.J., J.L. Cummings, S.K. Tupper, J.C. Hurley, R.S. Stahl, T. M. Primus. 2007. Caffeine formulation for avian repellency. J. Wildl. Manag. 71:1676-1681.

Major Research Accomplishments:

- WS research has shown hydrolyzed casein to have great potential as a repellent for mountain beaver to reduce damage to conifer seedlings.
- WS has used genetic markers to identify canids involved in predation cases. The same markers have been used to identify wolf-dog hybrids.
- WS developed a database of genetic markers for domestic dogs, coyotes, and wolves from various parts of the country to aid state departments of natural resources in livestock predation investigations.
- WS developed analytical chemistry methods and analyzed numerous samples to support the development of avian repellents (anthraquinone, caffeine) and fertility control agents (nicarbazin, diazacholesterol).
- WS developed a bioenergetics computer model that estimates exposure and mortality to select bird species baited with DRC-1339. This model has been adopted by WS Operations to estimate baiting efficacy.
- WS developed methods to track wildlife depredation of farm raised fish and select high value gamefish to estimate the impact of bird depredation on stocks.

Wildlife Services

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FY 2008

Economic Research of Human-Wildlife Conflicts: Methods and Applications

Contact Information:
Dr. Stephanie Shwiff
Research Economist
NWRC Headquarters
4101 LaPorte Avenue
Fort Collins, CO 80521
Phone: (970) 266-6150
Fax: (970) 266-6157
stephanie.a.shwiff@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators

- California Department of Agriculture
- Departments of Economics and Ecology, University of Hawaii
- Economics Department, Colorado State University
- National Rabies Coordinator
- Texas Department of State Health Services
- Vertebrate Pest Control Research and Advisory Committee (California)
- USDA/APHIS Wildlife Services Operations

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

NWRC Scientists 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 acceptable methods, tools and techniques.

The 2006 Research Needs Assessment of 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.

Quantification of economic factors involved in mitigating human-wildlife conflicts began at NWRC in 2000. Current studies seek 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, property, natural resources, as well as wildlife-posed risks to public health and safety.

Applying Economic Expertise to the Challenges of Wildlife Damage Management

Surveys and Impacts of Invasive Species—In 2007, NWRC scientists and collaborators conducted a survey to project the total annual damages likely to be associated with potential introduction of the invasive brown treesnake to the Hawaiian Islands. Estimated damages for medical-related incidents, power outages, and tourism ranged between $622 million and $2.2 billion dollars. Decreased tourism alone was estimated to cause between 1,339 and 13,000 lost jobs. Survey results indicated that 20% of visitors would select a different vacation spot if the brown treesnake was established in Hawaii.

This study is one of many recent collaborations between NWRC and other groups to obtain data on economic impacts. Previous studies have also addressed costs related to livestock losses from black vulture predation in several Eastern states, blackbird damage to rice in the Mississippi Delta, and wild turkey damage to ginseng crops in the mid-west.

Modeling Benefits and Costs of WS Programs—Current NWRC research studies are developing and using novel benefit-cost and modeling procedures to quantify savings by WS programs. Approaches integrate economic, biologic, and demographic data into profiles of local or regional (e.g., county-by-county) savings and costs attributed to WS activities. The approaches also involve (1) estimating "replacement" costs for WS (i.e., what will it cost to acquire/perform similar wildlife damage management services privately), (2) creating "projections" of hypothetical increases in damage in the absence of WS, and (3) defining "scenarios" to characterize best-worst case outcomes using WS or no WS programs. For example, Impact Analysis for Planning (IMPLAN) models are being used to estimate potential impacts of feral-swine-transmitted foot and mouth disease to livestock in several states. IMPLAN provides an input-output model which projects potential economic benefits of wildlife and disease management by estimating the economic value of disease-caused damages in certain sectors of local or state economies.

Wildlife-Transmitted Diseases and Savings of Oral Vaccination—NWRC scientists are also conducting benefit-cost analyses to quantify the potential savings and costs associated with selected wildlife-transmitted diseases and potential disease mitigation methods. Assessments of certain agricultural and public health impacts of wildlife rabies in raccoons, foxes, coyotes, skunks, and vampire bats throughout North America have been published. Collaboration with the WS Rabies Coordinator, Rabies Economic Team, and scientists at the Centers for Disease Control and Prevention has yielded improved

United States Department of Agriculture
Animal and Plant Health Inspection Service

methodologies for quantifying the impacts of wildlife rabies and its control via oral rabies vaccination (ORV) technologies.

Benefits and Costs of T&E Protection—NWRC scientists have quantified the potential savings or increased revenues associated with predator management agreements aimed at the protection of threatened and endangered (T&E) species. The Steller's eider (Polysticta stelleri) is federally listed as a threatened species. In Alaska, these birds are highly susceptible to predation during nesting season in late spring and early summer. Control of arctic fox (Alopex lagopus) on the Barrow Steller's Eider Conservation Planning Area began in 2005. Prior to fox control, the nesting success averaged 16%. Since fox control (2005-2007), nest success has increased to about 50% per year. The annual cost of control has been about $29,000. Detailed economic analyses of these results are in progress, but it is clear that monetary benefits alone in eider production will be orders of magnitude greater than the costs.

Bird and Rodent Economic Impacts to California Crops—California ranks first in the nation for the production of dozens of crops, such as avocados, grapes, and processing tomatoes, and is the sole producer of many U.S. crops, such as almonds, artichokes, figs, olives, and walnuts. In 2006, California's gross value of agriculture production was nearly $38.9 billion. The 20 top California crop and livestock commodities accounted for more than 80% of the State's cash farm receipts, and eight of these commodities grossed over $1 billion in receipts.

As part of a cooperative agreement with the California Vertebrate Pest Control Research and Advisory Committee, NWRC economists are evaluating the impacts of bird and rodent damage to selected county economies. Bird and rodent pests of California agriculture include crows, ground squirrels, house sparrows, and cottontail rabbits. To date, a 3–step process has been used to select ten of 58 counties for input-output (IO) modeling. Economists have identified counties that: (1) led the State in total agricultural production, (2) had the highest valued cash receipts from a set of 25 key crops, and (3) had the highest percentage or concentration of targeted crops as compared to total agricultural cash receipts. Based on this empirical scheme, the ten counties receiving the greatest cumulative ranks in order are Monterey, Fresno, Ventura, Riverside, Kern, Tulare, San Joaquin, San Diego, Stanislaus, and Napa Counties. Scenarios of rodent- and bird-caused damages to these counties and crops are under development. These will provide a range of likely impacts and benefits attributed to pest control activities in the counties.

Selected Publications:

Sterner, R. T. 2008. Reducing the uncertainty of IPM economics. Pages 163-181 in E. N. Burton and P. V. Williams, editors. Crop Protection Research Advances. Nova Science Publishers, Hauppauge, New York.

Shwiff, S. A., K. A. Kirkpatrick and R. T. Sterner. 2008. Economic evaluation of a Texas oral rabies vaccination program for control of a domestic dog-coyote rabies epizootic: 1995-2006. Journal of the American Veterinary Medical Association 233(11):1736-1741.

Engeman, R. M., B. U. Constantin, S. A. Shwiff, H. T. Smith, J. Woolard, J. Allen, and J. Dunlap. 2007. Adaptive and economic management methods for feral swine control in Florida. Human-wildlife Conflicts 1:178-185.

Major Assistance Activities:

- WS and collaborators conducted a survey to project the total annual damages likely to be associated with a hypothetical introduction of the invasive brown treesnake to the Hawaiian Islands. Estimated damages for medical incidents, power outages, and tourism ranged between $622 million and $2.2 billion dollars. Decreased tourism alone was estimated to cause between 1,339 and 13,000 in lost jobs in this and other sectors of the State's economy.
- WS economists performed retrospective studies of wildlife rabies impacts in California and Texas. The California data showed that the average suspected human rabies exposure cost $3,688, with indirect (out-of-pocket, non-reimbursable) expenses to patients accounting for $1,124(2006 USD). For Texas, benefit-cost analysis showed that the use of an oral rabies vaccination (ORV) program to control an outbreak of canine-variant rabies in coyotes between 1995 and 2006 was cost efficient. Total estimated benefits of the program ranged from approximately $98 to $354 million, with total program costs reported as $26 million for the study period. This yielded benefit-cost ratios ranging from 3.70 to 13.44 for varying projections of case frequency levels.
- WS studies documented the economic impact of the National Wildlife Research Center (NWRC) on the local economy. Construction expenditures at the NWRC created a temporary economic impact of $152 million throughout the State of Colorado. As this spending flowed through the economy, approximately 1,120 non-NWRC jobs were created. Non-construction expenditures added $9.6 million to the local economy and NWRC's annual budget alone created 88 non-NWRC jobs.

Wildlife Services

Protecting People
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National Wildlife Research Center

FY 2008

Product Registration: Providing Tools for Wildlife Services

Contact Information:
Mr. John D. Eisemann
Registration Manager
NWRC Headquarters
4101 LaPorte Avenue
Fort Collins, CO 80521
Phone: (970) 266-6158
FAX: (970) 266-6157
john.d.eisemann@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

Major Cooperators
- USDA/APHIS Wildlife Services Operations
- U.S. Fish and Wildlife Service
- Private rodenticide registrants
- Association of Fish and Wildlife Agencies
- State Wildlife Management Agencies

Groups Affected By These Problems
- Urban and suburban residents
- Farmers, ranchers, and livestock producers
- Federal, State and private natural resource managers

NWRC 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 NWRC Registration Unit works closely with APHIS's Policy and Program Development, Environmental Services office in all product registration activities. APHIS continues to hold registrations with the U.S. Environmental Protection Agency (EPA) for rodenticides, predacides, avicides, repellents, snake toxicants, and an avian repellent. 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. In addition, the Registration Unit is working on product registrations through the EPA for contraceptives to be used on wild and feral animals. 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 assistance and information to state WS programs, Federal and State agricultural and conservation agencies, academic institutions, non-governmental groups, and private industry. Assistance often includes responding to requests for regulatory assistance from Federal and State agencies, in addition to WS. 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 & 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 avicides and one avian repellent), rodent management (11 rodenticides and one burrow fumigant), predator management for livestock protection (two predacides and one fumigant), and a toxicant for managing brown treesnakes on Guam.

Rodenticides—Three new rodenticide products were registered by APHIS through the EPA in 2007 with the assistance of the U.S. Fish and Wildlife Service (FWS) and a non-governmental organization. These products are used for the eradication of invasive rodents on islands and unmanned derelict ships for conservation purposes. The State of Hawaii granted a state registration for Diphacinone 50 Conservation in 2007 and WS and the FWS conducted an eradication project on the 16-acre Mokapu Island in February 2008. Rodent monitoring on the island will continue for 2 years to ensure the eradication was successful. The State of Alaska approved Brodifacoum 25W Conservation to conduct a rat eradication project on the 7,000-acre Rat Island in the Aleutian Islands in September 2008. These new tools are vital in the efforts to protect native wildlife on islands from invasive rodents.

In addition to the new conservation labels for rodent eradication using anticoagulant rodenticides, the Registration Unit also obtained an EPA Emergency Use Permit to use a zinc phosphide rodenticide for the eradication of Gambian giant pouched rats from Grassy Key, Florida. This project was unique in that it was the first eradication effort against the Gambian giant pouched rat in the United States.

The California Department of Food and Agriculture (CDFA) requested APHIS modify the "Zinc Phosphide Concentrate label (EPA Reg. 56228-6)" to help control California voles in artichoke fields. In a cooperative effort, the CDFA provided all the data needed to ensure product efficacy and worker safety, and APHIS submitted a label amendment request to EPA in 2007 that was approved in March 2008. In addition to this label modification, APHIS also submitted a request to EPA to allow the use of this product in food and feed crops, including alfalfa, barley, dry beans, sugar beets and wheat.

Wildlife Contraceptives—The NWRC is a world leader in the development of effective wildlife contraceptives. GonaCon™, an immunocontraceptive vaccine, is the first product of its type to provide multiple years of infertility to a variety of mammal species following a single injection. A registration application for the use of GonaCon with white-tailed deer was submitted to the EPA in early 2009. WS worked closely with the Association of Fish and Wildlife Agencies to develop guidelines for the effective use of GonaCon.

NWRC is currently testing the effectiveness of GonaCon in two other cervid species—fallow deer and elk. An EPA Experimental Use Permit (EUP) was obtained in July 2007 for a study being conducted on invasive fallow deer in cooperation with the U.S. National Park Service at Point Reyes National Seashore in California. Another EUP was approved in November 2007 to test GonaCon in overabundant elk populations in Rocky Mountain National Park (RMNP). This is part of a larger effort to study and manage the health and abundance of elk in the Park. It is a cooperative effort among the National Park Service, Colorado State University, the Colorado Division of Wildlife, and the NWRC.

Small scale field studies have demonstrated the effectiveness of GonaCon on rodents, such as prairie dogs and tree squirrels. Consequently, registrations are being considered for these species.

Predacides—In November 2007, the EPA sought public comment on a petition received by the EPA Administrator to cancel predacide registrations for sodium cyanide and sodium fluoroacetate. In reply to the petition, an inter-program APHIS task force was assembled to prepare a comprehensive APHIS response. The response submitted to EPA detailed the WS Program use of these compounds in the M-44 and Livestock Protection Collar (LPC), compliance and record-keeping, the economics of predator management, and human and pet health and safety of M-44 and LPC use over a period of 5 years.

After a two-year review, the EPA found M-44 and LPC use has a significant benefit in reducing predation on livestock without making an impact on coyote, other target or nontarget species, or the environment. The EPA and the Department of Homeland Security agreed that WS use of the predacides did not pose a potential bioterrorism threat that would warrant cancellation or suspension of the tools. WS remains committed to the partnership and consultation with other agencies, including the EPA, the U.S. Fish and Wildlife Services, and other land management agencies, which includes continued communications among agencies that will enable the program to serve its constituents' needs and wildlife populations.

Selected Publications:

Bergman, D. L., T. B. Veenendaal, B. F. Wakeling, and J. D. Eiseman. 2007. Current and historical use of alpha-chloralose on wild turkeys. Proceedings of the National Wild Turkey Symposium 9:51-57.

Bynum, K. S., J. D. Eiseman, G. C. Weaver, C. A. Yoder, K. A. Fagersone, and L. Miller. 2007. Nicarbazin OvoControl G bait reduces hatchability of eggs laid by resident Canada geese in Oregon. Journal of Wildlife Management 71:135-143.

Fagerstone, K. A., L. A. Miller, J. D. Eisemann, J. R. O'Hare, And J. P. Gionfriddo. 2008. Registration of wildlife contraceptives in the United States of America with OvoControl and GonaCon immunocontraceptive vaccines as examples. Wildlife Research 35:586-592.

Johnston, J. J. 2007. Assessing rodenticide hazards: improving the art and science of risk assessment. Proceedings of the Wildlife Damage Management Conference 12:170-174.

Johnston, J. J., R. S. Stahl, H. J. Homan, G. M. Linz, and W. C. Pitt. 2007. Probabilistic bioenergetic/toxicity modeling approach for estimating toxicant induced mortality to target invasive species and non-target wildlife. Pages 393-397 in G. W. Witmer, W. C. Pitt, and K. A. Fagerstone, editors. Managing invasive vertebrate species: proceedings of an international symposium. USDA/APHIS/National Wildlife Research Center, Fort Collins, Colorado, USA.

Killian, G., K. Fagerstone, T. Kreeger, L. Miller, AND J. Rhyan. 2007. Management strategies for addressing wildlife disease transmission: the case for fertility control. Proceedings of the Wildlife Damage Management Conference 12:265-271.

Miller, L. A., J.Gionfriddo, K. A. Fagerstone, J. Rhyan, and G. Killian. 2008. The single-shot GnRH imunocontraceptive vaccine (GonaConTM) in white-tailed deer: comparison of several GnRH preparations. American Journal of Reproductive Immunology 60:214-223.

Pilon, J., C. Loiacono, D. Okeson, S. Lund, K. Vercauteren, J. Rhyan, and L. Miller. 2007. Anti-prion activity generated by a novel vaccine formulation. Neuroscience Letters 429:161-164.

Major Research Accomplishments:

- APHIS submitted a registration application to the U.S. Environmental Protection Agency for the use of GonaCon™ Immunocontraceptive Vaccine for controlling white-tailed deer. Wildlife Services worked very closely with the Association of Fish and Wildlife Agencies on this product development.
- APHIS received three new rodenticide product registrations in the last two years. The development of these registrations was a cooperative effort with the U.S. Fish and Wildlife Service and two private rodenticide manufacturers. The products are for use by government conservation agencies to eradicate invasive rodents for islands solely for conservation purposes. These products were used in 2007 to eradicate rodents from a 16 acre island in Hawaii and a 7,000 acre island in Alaska.
- NWRC worked cooperatively with APHIS Legislative and Public Affairs and Wildlife Services Operations to produce a summary of Wildlife Services use of the M-44 (sodium cyanide) and Compound 1080 (sodium fluoroacetate) during the last 5 years. This report was submitted to the U.S. EPA in response to a petition they received from a coalition of environmental groups to cancel predacide uses of these materials.

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	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*				

Wildlife Services

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FY 2008

Expanding Research Capabilities Through New Construction

Contact Information:
Dr. Larry Clark, Center Director
NWRC Headquarters
4101 Laporte Avenue
Fort Collins, CO 80521
Phone: (970) 266-6036
FAX: (970) 266-6040
larry.clark@aphis.usda.gov
www.aphis.usda.gov/wildlife_damage/nwrc/

NWRC Builds New Research Facilities

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 acceptable methods, tools, and techniques.

APHIS WS is committed to completing its Site Master Plan to build research facilities that will permit NWRC to continue its mission and role as a world leader in providing science-based solutions to the complex issue of wildlife damage management.

Applying Science & Expertise to Wildlife Challenges

NWRC Security Center—In 2008, NWRC completed construction of a new security center for its headquarters site on the Foothills Research Campus of Colorado State University in Fort Collins, CO. The new security center is located just outside the main entrance to the NWRC site and provides facilities for the NWRC guard service to better provide surveillance and monitoring of all vehicular traffic entering and exiting the 43-acre site. This enhanced security addresses higher level security requirements mandated by the Department of Homeland Security. The security center was developed through a lease/construct agreement with the General Service Administration.

ISRB Building Exhaust Acoustical Attenuation Project—NWRC completed a building exhaust acoustical attenuation construction project on the existing Invasive Species Research Building in 2008. The construction reduced noise pollution from the air exhaust stacks located on top of the building. The building is designed to simulate temperature and humidity ranges from temperate to tropical ecosystems. There is no re-circulated air in the building which leads to a tremendous amount of exhaust air continuously being eliminated through the roof top exhaust stacks. New acoustic attenuators in lengthened exhaust stacks reduced the noise generated by the exhaust air from 66 to 54 decibels -- a more acceptable level for the community, employees, and animals.

Wildlife Disease Research Building—The Wildlife Disease Research Building (WDRB) will be the last major building to be completed in the original NWRC Site Master Plan approved by USDA in 1990. The building will be a biosafety level 3 Ag (BSL-3 Ag) biocontainment disease research facility with approximately 21,000 square feet of user space. The user space will include research, laboratory, animal holding and testing, office space and will greatly expand WS' capabilities to respond to wildlife disease emergencies and resolve important disease issues that involve livestock- and human-wildlife interactions.

In addition to basic wildlife disease research, the WDRB will also support the surveillance, rapid response, and vaccine assessment for emerging wildlife disease issues. Legislation mandates that USDA provide assistance upon request to State governments, private individuals, and other Federal agencies to control and prevent damage and disease caused or carried by wildlife. This future building will greatly enhance the ability of APHIS to provide this assistance. It will also provide important "surge" space for disease epidemic emergencies in the United States. In such emergencies, the NWRC facilities will be available for conducting BSL-3 laboratory work to address national concerns.

The WDRB will expand NWRC's existing BSL-3 wildlife disease research capabilities, as well as increase opportunities for collaborative research with Colorado State University and other organizations. The "Ag" designation in the description "BSL-3 Ag" indicates that each animal room is designed so that diseased animals can roam free in the rooms and/or be contained in open cages in the rooms. Neither of these situations is allowed in standard BSL-3 containment structures and the "Ag" capability is a critical need for disease studies in wildlife.

The WDRB will be owned by a private developer and leased through GSA to NWRC. Initial design of the WDRB was completed and discussions were held with potential private developers in 2008. Final design of the WDRB, in partnership with GSA, and a formal solicitation for offers from private developers is planned for 2009. The economic climate for financing a complex lease/construct building in late 2008 and into 2009 is a difficult one and may require additional planning on the part of GSA and NWRC before an award to a developer can be made. Development of construction documents and construction/commissioning of the WDRB building will take approximately two to three years after an award is made to a private developer. The estimated completion date at this time is FY 2012.