United States Department of Agriculture
Animal and Plant Health Inspection Service
Miscellaneous Publication No. ____

Innovative Solutions to Human–Wildlife Conflicts

National Wildlife Research Center Accomplishments, 2007

United States Department of Agriculture
Animal and Plant Health Inspection Service
Wildlife Services

National Wildlife Research Center
4101 LaPorte Ave.
Fort Collins, CO 80521–2154
http://www.aphis.usda.gov/ws/nwrc

Main telephone number
(970) 266–6000
FAX: (970) 266–6032

Information Services
(970) 266–6015
FAX: (970) 266–6010
email: nwrc@usda.gov

Animal Care
(970) 266–6204

Research Programs

Agriculture and Resource Protection: (970) 266–6133
Invasive Species and Technology Development: (970) 266–6159
Wildlife Diseases: (970) 266–6133

NWRC Field Stations:

Bismarck, ND
(701) 250–4468
FAX: (701) 250–4408

Gainesville, FL
(352) 375–2229
FAX: (352) 377–5559

Hilo, HI
(808) 961–4482
FAX: (808) 961–4776

Kingsville, TX
(361) 593–2426
FAX: (361) 593–4311

Logan, UT
(435) 797–2505
FAX: (435) 797–0288
Millville, UT, Office
(435) 245–6091
FAX: (435) 245–3156

Olympia, WA
(360) 956–3925
FAX: (360) 534–9755

Sandusky, OH
(419) 625–0242
FAX: (419) 625–8465

Starkville, MS
(662) 325–8215
FAX: (662) 325–8704

Issued January 2008

Contents

Introduction

National Wildlife Research Center

The National Wildlife Research Center (NWRC) is a world leader in providing science-based solutions to complex issues of wildlife damage management. As the research arm of the Wildlife Services (WS) program within the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service, NWRC works with WS operational staff to provide Federal leadership and expertise to resolve wildlife conflicts related to agriculture, livestock, human health and safety (including wildlife diseases), invasive species, and threatened and endangered species. NWRC is committed to finding nonlethal solutions to reduce wildlife damage to agricultural crops, aquaculture, and natural resources. As part of WS' strategic plan to improve the coexistence of people and wildlife, NWRC has identified four strategic program goals: (1) developing methods, (2) providing wildlife services, (3) valuing and investing in people, and (4) enhancing information and communication. WS is dedicated to helping meet the wildlife-damage management needs of the United States by building on NWRC's strengths in these four key areas. This annual research highlights report is structured around these program goals.

Expertise

NWRC employs more than 160 scientists, technicians, and support personnel at its Fort Collins, CO, headquarters and at field stations in several other States. NWRC scientists have expertise in a wide range of disciplines, including animal behavior, wildlife biology, wildlife sensory biology, epidemiology, chemistry, wildlife diseases, immunology, reproductive physiology, statistics, toxicology, wildlife genetic forensics, and veterinary medicine.

In August 2007, NWRC realigned its organizational structure and related project-management system to better address WS program, agency, and departmental priorities. This new project alignment permits NWRC to continue to effectively address both the current and rapidly emerging new priorities of APHIS, the WS program, and the Center in the area of human–wildlife conflict mitigation.

Although agricultural and plant health are still highlighted in the vision and goals of the new APHIS Strategic Plan for 2007–12, they also encourage a stronger emphasis on invasive species; emerging wildlife diseases, such as avian influenza; and emergency response. These APHIS goals are consistent with USDA's 2005–10 Strategic Plan priorities—particularly "Enhance Protection and Safety of the Nation's Agricultural and Food Supply" and "Reduce the Number and Severity of Agricultural Pests and Disease Outbreaks."

As a result of this new emphasis, the Center's current research projects have been realigned under three new Research Programs:

- **Agriculture and Resource Protection—**Focuses on reducing wildlife damage to crops, aquaculture facilities, and timber resources; developing new repellants; reducing predation losses to livestock and property damage; and examining the ecology, behavior, and management of mammalian predators.

- **Invasive Species and Technology Development—**Develops methods for reducing invasive species damage to native wildlife and ecosystems and encompasses studies for pesticide registration, formulation chemistry, chemical analysis, benefit–cost analysis, and wildlife contraceptive development.

- **Wildlife Disease—**Explores ways to reduce the spread and transmission of diseases from wildlife to humans and domestic animals; develops disease diagnostic methods; develops methods and strategies to monitor wildlife pathogens; provides risk assessments for agriculture and human health and safety; and assists WS operations for surveillance and monitoring efforts.

Construction Update

NWRC's 43–acre headquarters campus is located on Colorado State University (CSU) land in Fort Collins, CO. During fiscal year 2007, several planning and construction activities took place, related to completing the Master Plan for the NWRC site.

Invasive Species Research Building—On December 6, 2006, WS celebrated the opening of its new 25,000-ft^2 Invasive Species Research Building (ISRB). More than 100 people attended the opening ceremony, including representatives from USDA, the builders (a Federal–private sector partnership), and CSU.

The facility, built by the General Services Administration (GSA) and Everitt/Keenan Associates (a private developer), expands upon NWRC's existing capabilities to conduct wildlife research by providing a state-of-the-art complex where invasive wildlife can be properly cared for and studied. The ISRB also enhances NWRC's ability to study the ecology, biology, behavior, and physiology of invasive wildlife species and to develop management tools and strategies for mitigating their damage and controlling their spread. The building is designed to simulate temperature and humidity ranges from temperate to tropical ecosystems. The flexibility of these environmental controls allows for the year-round study of invasive wildlife species. Examples of invasive species NWRC will study in the facility include nutria; Norway, roof, and Gambian giant pouched rats; European starlings; brown treesnakes (BTSs); nile monitors; Burmese pythons; and Caribbean tree frogs.

Biosafety Level–3 Suite—In early 2007, the Biosafety Level–3 (BSL–3) laboratory suite opened at the NWRC Fort Collins campus. The new 2,500–ft^2 suite, located in the existing Animal Research Building (ARB), includes two large animal-research rooms, six smaller animal rooms, a virology laboratory, and showers and autoclave rooms for decontamination of staff and clothing. The suite contains four levels of protection for the safety of the surrounding community and staff, as well as air locks and separate HEPA (high-efficiency particulate air)-filtered air ventilation systems.

NWRC's Master Plan includes the development of a larger Wildlife Disease Research Building (WDRB). Until the completion of that building in 2010, the smaller BSL–3 suite in the ARB provides an intermediate solution to WS BSL-3 research needs. Wildlife disease biologists are able to (1) study the ecology and epidemiology of endemic, emerging, and foreign animal diseases in wildlife; (2) carry out research concerning management of wildlife diseases impacting U.S. agriculture and human health and safety; (3) determine species susceptibility to pathogens; and (4) carry out vaccine efficacy and challenge studies. Anticipated future animal and laboratory studies will be conducted using BSL–3 agents such as histoplasma; the viruses that cause Saint Louis encephalitis, highly pathogenic avian influenza (HPAI), and Rift Valley fever; and the bacterium that causes bovine tuberculosis (bTB).

More Details on the Planned Wildlife Disease Research Building—The new 28,500-ft^2 facility will greatly expand WS' ability to respond to wildlife disease emergencies and resolve important disease issues that involve livestock–wildlife and human–wildlife interactions.

To support both experimental and field investigations, a complete laboratory infrastructure and animal testing capability will be included in the new BSL–3 Ag research facility to provide support for diagnostics methods development, vaccine development, risk assessments, and wildlife-disease surveillance and monitoring activities. (The "Ag" designation in the BSL–3 description of the WDRB indicates that each animal room is being designed as primary containment for diseased animals, meaning the animals can roam freely in the rooms.) Diagnostic methods development will include rapid diagnostics for wildlife diseases, such as avian influenza (AI), rabies, bTB, and West Nile virus.

In addition, activities will focus on development of diagnostic and screening assays for multiple diseases from single samples. The ability to process large numbers of samples for multiple diseases in any surveillance effort requires expanded capabilities for high-throughput testing (robotic processing) of samples. It also requires controlled biosafety environments for development and validation of multiplex diagnostic methods for zoonotic and animal pathogens. ("Zoonotic" refers to pathogens or diseases that are naturally transmitted between wildlife species and humans.) The infrastructure of the new WDRB will include diagnostic capabilities in the areas of mycology, virology, and bacteriology.

The new BSL–3 Ag WDRB will expand NWRC's existing BSL–3 wildlife disease research capabilities and increase opportunities for collaborative research with CSU. The WDRB will include offices, a BSL–3 laboratory, BSL–3 Ag animal holding and testing quarters, and other support spaces for wildlife disease-research purposes. Final design and construction will take place in 2008 with a planned completion date of 2010.

Developing Methods

Agriculture and Resource Protection Research Program

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

GOAL: Develop an understanding of the economic impacts of damage inflicted on aquaculture production systems by cormorants, pelicans, wading birds, and waterfowl and develop tools and techniques for reducing that damage.

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 for double-crested cormorants (DCCOs) alone. 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 depredations of catfish, baitfish, and crawfish industries in the Southeast. 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.

NWRC Scientists Study the Reproductive Status of DCCOs in the Eastern United States—The recent abundance and foraging habits of DCCOs have thrust this species into conflict with the aquaculture industry and fisheries interests over both perceived and documented impacts to natural and commercial resources. Consequently, resource managers are aggressively employing control measures on DCCOs' breeding, migratory, and wintering areas to alleviate damage. Unfortunately, the breeding biology of cormorants is poorly understood, and without this basic knowledge, scientists cannot accurately predict the effects of management on cormorant populations nor attribute observed changes in reproductive success and population size to management actions. To better understand the breeding biology of cormorants, NWRC scientists began a study in 2007 to determine their reproductive status in the Northeastern, Midwestern, and Southern United States. This study will allow researchers to determine the proportion of nonbreeding individuals associated with breeding assemblages of cormorants and use this knowledge to improve population estimates of cormorants across the breeding range.

The Role of American White Pelicans in the Life Cycle and Spread of the Bolbophorus Catfish Trematode—The bolbophorus catfish trematode *(Bolbophorus damnificus)* is associated with high mortality rates in catfish fingerlings and the formation of cysts in the fillets of mature catfish. NWRC scientists collaborated with parasitologists from the Mississippi State University College of Veterinary Medicine to determine the role American white pelicans play in the life cycle and spread of *B. damnificus* in catfish. NWRC scientists confirmed the life cycle of this trematode and compared it to the known life cycle of a similar species. The research provided further evidence that *B. damnificus* is a distinct species and the causative agent for trematode-associated deaths in catfish. The research also showed that the American white pelican is the definitive avian host.

Additional studies were conducted to identify other potential intermediate hosts for the infectious trematode. Results confirmed that the *Planorbella trivolvis* (a freshwater snail) population native to the Mississippi Delta is a first intermediate host for *B. damnificus.* The studies also demonstrated that the *P. trivolvis* population found in North Dakota may also serve as intermediate hosts. Populations of these snails are present in both the breeding and wintering ranges of the American white pelican and are susceptible to *B. damnificus* infection, which may serve to perpetuate the *B. damnificus* life cycle in the North-Central United States.

Cormorant Movement Patterns Identified—NWRC scientists attached satellite telemetry transmitters to DCCOs captured at roosts near aquaculture facilities in Alabama, Arkansas, Louisiana, and Mississippi to develop a better understanding of the winter and summer movements of cormorants using aquaculture farms in the Southeastern United States. The winter home ranges for all cormorants averaged 37,384

km^2, with 3,467 km^2 in the core use area. In summer, cormorants occupy a smaller territory—29,300 km^2 on average—and 2,889 km^2 in the core use area. There were no differences in the ranges of adult *v.* immature birds or between capture regions (e.g., the Mississippi River flood plain of Arkansas, Louisiana, and Mississippi or eastern Mississippi and western Alabama).

This study verified that cormorants using aquaculture facilities in the Southeast are from the same population as those that are thought to impact natural resources in the Great Lakes region. Data from this study may be used to provide information necessary for regional and/or flyway-based DCCO population management strategies.

Scope of Cormorant Damage to Mississippi Catfish Production—The U.S. catfish industry is valued at more than $650 million, with nearly 65 percent of catfish production originating from Mississippi. Biologists at NWRC's Mississippi field station completed a study that evaluates the distribution and numbers of DCCOs on catfish aquaculture facilities, tying together almost a decade of research on cormorant food habits, bioenergetics, and abundance data.

A significant finding is that most depredation occurs on food-fish production ponds, where economic losses are high. Study results demonstrate that cormorants used these ponds extensively during January through April, with the greatest economic damage occurring in February and March. During the years of this study (winter 2000–01 and 2003–04), an estimated 1,775 and 1,347 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 million to $13.2 million annually.

Future studies will aim to develop efficient methods for monitoring cormorant abundance and distribution for purposes of damage estimation and cormorant management.

Development of New Aging Techniques for Birds—With collaborators at West Virginia University, NWRC scientists have found pentosidine concentrations in the skin of DCCOs to be a linear predictor of age. This information may lead to a rapid, more cost-effective technique for identifying the age of cormorants and many other species of birds. Pentosidine concentration analysis will provide scientists a better understanding of the demographics of cormorants that are impacting catfish production in the Southeast. In addition, NWRC scientists are developing aging techniques for other bird species of concern, including monk parakeets and black vultures.

Cormorant Distribution and Abundance on Catfish Ponds in the Delta Region of Mississippi—Biologists evaluated the efficiency of aerial and ground surveys conducted twice monthly for detecting changes in cormorant abundance on aquaculture facilities. Results showed that the sampling effort would need to be increased by approximately 40 percent in order to meet the desired level of detection (a 15-percent change in population levels). Habitat modeling efforts evaluated the factors that affect cormorant use of catfish facilities. Results suggest that cormorants are most likely to be present at food-fish ponds *v.* fingerling and broodfish ponds. Additionally, bird use of catfish pond clusters was related to season of the year, distance of ponds from cormorant roosts, distance from roads, and the number of cormorants in nearby roosts.

Response of DCCOs to Management Activities on the Breeding Grounds in the Les Cheneaux Islands of Lake Huron, Michigan—Scientists from NWRC's Mississippi field station collaborated with the WS Operational Program in Michigan and the Michigan Department of Natural Resources to use DCCO management as a means of improving the local yellow-perch fishery. Several studies addressed different aspects of the damage attributed to cormorants or the management approach for dealing with the damage.

Management efforts resulted in more than a 90-percent reduction in the number of young cormorants produced annually and more than a 60-percent reduction in cormorant numbers overall. Research results indicate that cormorants from the colonies in question are feeding extensively in the specific areas where perch populations have declined, and that perch numbers following the first 3 years of management have improved.

TITLE: New Technologies To Deter Wildlife Away From Airports and Aircraft

GOAL: Develop and evaluate methods and technologies for reducing the risks of wildlife strikes to civil aviation and provide scientifically valid methods and techniques to be used on airfields to manage hazardous wildlife.

In order to be certified for commercial passenger traffic by the U.S. Federal Aviation Administration (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 increase wildlife in the vicinity of an airport. NWRC's research is focused on understanding the nature of wildlife hazards at airports, developing management tools to reduce those hazards, and providing WS and airport personnel with information on the latest strategies for controlling wildlife hazards.

Validation of Avian Radar To Detect and Track Birds—In a multiagency effort, researchers from NWRC's Ohio field station, WS Operations, the FAA, the U.S. Department of the Navy, academia, and industry joined together to validate the ability of digital avian radar systems to accurately detect and track birds hazardous to aviation on three U.S. military airfields. Their results confirm that these new radar systems provide an accurate and valuable tool to monitor bird movements on and near airfields. Knowledge of avian movements allows biologists to alter environmental attractants that bring birds into the proximity of aircraft. A second objective of the research is to develop an integrated representation of networked radar systems. This effort will allow wildlife biologists to view a composite representation of multiple radar systems positioned at various locations on an airfield, rather than viewing the individual displays of each radar.

Assessing Potential Risks That Ospreys Pose for Bird–Aircraft Strikes—Osprey populations in North America have shown a dramatic recovery in the past decade, with breeding populations continuing to expand along the Atlantic coast. From 1973 to 1996, the Chesapeake Bay population increased from 1,400 breeding pairs to more than 3,500. These factors suggest that ospreys can be a serious safety and economic concern to military flight operations. A multiagency research project was initiated in 2006 to quantify the risk of osprey–military aircraft collisions. Risk levels were derived from satellite tracking of breeding and migratory movements of ospreys in relation to military flight operations in the mid-Atlantic Chesapeake Bay region. NWRC scientists captured and attached global positioning system (GPS) satellite telemetry transmitters to six adult ospreys on their nesting territories near Langley Air Force Base, Virginia. Satellite-tagged ospreys were monitored daily during the breeding (summer), fall migration, and wintering periods of 2006. Intensive monitoring of the birds during the breeding season suggested that adult ospreys are active (i.e., flying) about the same amount of time during daylight hours.

Four ospreys completed their fall migration to their wintering grounds in the Caribbean or South America, traveling an average distance of 4,828 km; contact with the other two ospreys was lost during migration over open ocean. All six adult ospreys traveled similar migration routes along the eastern coast of the United States. Females began their fall migrations in August; males departed in September. Adults migrated during daylight hours and roosted at night. Migratory routes and flight characteristics (e.g., altitude) of ospreys will be evaluated to assess the risk that migrating ospreys pose to military aircraft operations along the eastern seaboard.

During May 2007, an additional seven adult ospreys were fitted with satellite telemetry transmitters near Langley Air Force Base. Information obtained from this study will be used to measure the effectiveness of osprey management practices, develop long-term risk management strategies, and support legal requirements that would allow ospreys and military aircraft to coexist in a safer flying environment.

Movements of Resident Canada Geese in New York City—Canada geese are one of the most hazardous species to aviation because of their large body size and flocking behavior. Among all birds responsible for economic losses to the aviation industry in North America between 1990 and 2005, Canada geese caused the most damage. In a collaborative effort with the WS program in New York and the FAA, NWRC scientists fitted 200 Canada geese with neck collars in New York City parks near John F.

Kennedy International Airport (JFKIA). The movements of these geese are being monitored and recorded to determine how far and in which directions they travel from their banding sites.

Knowledge of goose movements will allow airport biologists to make more efficient use of time and money to control geese that might threaten safety of aircraft in the New York City area. An added benefit of the study is that, by understanding movement patterns of geese, biologists can avoid harassing geese in a manner that creates a safety hazard. During the molt (June–July), more than half of the geese were resighted in the parks where they were banded. Since they were banded and fitted with neck-collars, the geese have been sighted in four Northeastern States and at JFKIA. In addition, several of the geese are known to have been shot by hunters during the hunting season. The appearance of neck-collared geese at JFKIA indicates that the geese in at least some of the New York City parks frequent the airport.

Enhancing the Perceived Threat of Vehicle Approach to Deer—In North America and Europe, the cost of deer–vehicle collisions exceeds $1 billion in association with human injury and property damage, as well as injury and death to the animals involved. Given that the majority of such collisions occur during the twilight hours of dawn and dusk, scientists at the NWRC Ohio field station investigated whether the perceived threat to deer posed by vehicle approach could be enhanced. The investigators hypothesized that a vehicle-based lighting system that produces an emission spectrum covering peak visual capabilities of deer, as well as being brighter than standard tungsten–halogen (TH) lighting alone, would elicit a greater flight-initiation distance (FID) by free-ranging white-tailed deer.

The lighting system comprised two TH lamps and a single Xenarc high-intensity discharge (HID) lamp. Deer exposed to the combination of TH lamps and constant illumination of the HID lamp exhibited the greatest mean FID of 136 m (446 ft). In contrast, deer exposed to only TH lamps initiated flight on average at 116 m (380 ft), and those exposed to the combination of TH lamps and the HID lamp exhibited a mean FID of 89 m (292 ft). The combination of TH lamps and constant illumination of the HID lamp contributed significantly to the probability of a FID ≥ 94 m (308 ft).

Given the results, scientists concluded that vehicle-based lighting is the main object of a deer's focus, not necessarily the vehicle itself. Therefore, vehicle-based lighting can be designed to enhance the perceived threat to deer posed by an approaching vehicle and yield greater FIDs.

TITLE: **Evaluation of Wildlife Food Plots, Repellants, and DRC–1339 "Take Models" for the Management of Blackbirds and Starlings in Sunflower Fields, Feedlots, and Dairies**

GOAL: Develop new and scientifically valid methods to reduce blackbird and starling damage to ripening sunflower crops, feedlots, and dairies.

Starling Take Model—DRC–1339 is a selective and effective avicide for reducing troublesome populations of blackbirds, starlings, pigeons, and other species of birds. However, the lack of standardized and reliable techniques to estimate mortality during baiting operations is a major concern of WS. Such estimates are needed to satisfy requirements of the National Environmental Policy Act (NEPA) and the Government Performance and Results Act.

NWRC scientists developed a bioenergetics model in 2007 that estimates bait consumption and mortality based on daily energy requirements of birds and species-specific toxicity of DRC–1339. The model was constructed for starlings and CU Bird Carrier (fat pellets) baits diluted 5:1 (untreated:treated), but it can be modified for use with other species, baits, and dilutions. The model is a user-friendly, Excel™ program that provides a bioenergetically based method of estimating mortality during DRC–1339 baiting operations.

Blackbird Repellants—NWRC scientists evaluated the repellancy of caffeine and garlic oil for reducing depredations by blackbirds on intact sunflower heads. Damage was significantly reduced on heads treated with caffeine (compared to untreated heads), but not on heads treated with garlic. Average consumption of sunflower by blackbirds was less for the caffeine-treated heads (2,826 µg/mL) than for those treated with garlic oil (0.02 g/mL). Overall, mean consumption (cm^2 of seeds per bird) was

significantly less for the birds fed 3 mL (4,747 µg/mL) of caffeine per head than for birds fed 2 mL (2,212 µg/mL) of caffeine per head.

Garlic oil had no apparent effect on sunflower consumption. In the tests conducted in 2005, when the entire seeds were coated with garlic oil at 2 percent, 1 percent, and 0.5 percent by weight, feeding was reduced 80 percent, 40 percent, and 22 percent, respectively, compared to consumption of untreated sunflower heads. This suggests that treating only the exposed portion of the seeds with garlic oil—as was done in the 2007 experiments—is not sufficient to deter feeding, particularly when the birds do not have access to alternate foods.

Additional studies are needed to determine whether free-ranging birds are deterred by low levels of garlic oil when alternative foods are available. During September 2006, three treatments of a water–caffeine solution applied by helicopter to sunflower did not provide a sufficient amount of repellant to the drooping seed heads. This study adds to the growing body of evidence indicating that caffeine can reduce feeding by blackbirds, *provided* that birds encounter the repellant. However, additional research is needed to develop methods of applying adequate spray coverage on developing seeds in ripening sunflower fields.

TITLE: **Development of Repellants and Other Techniques for Managing Blackbird Depredations to Rice**

GOAL: Develop a blackbird repellant for rice, improve the effectiveness of DRC–1339 for managing blackbird populations, determine local and regional movement patterns of blackbirds, and develop new or improved management strategies for reducing blackbird damage to rice.

Red-winged blackbirds, common grackles, and brown-headed cowbirds cause an estimated $11.5 million worth of damage to newly planted and ripening rice in Arkansas, California, Louisiana, Missouri, and Texas every year. Some individual growers report 100-percent losses due to bird depredation. NWRC scientists routinely work with rice producers, rice commodity groups, rice research boards, universities, and local, State, and Federal agencies to develop safer and more effective methods to reduce bird depredation on seeded and ripening rice and improve profitability for growers.

To develop new methods and tools, Center scientists conduct multifaceted research studies involving the use of both captive and free-ranging birds. These studies will determine the status of blackbird populations in the southern rice-growing States, estimate the economic impacts of birds on the rice crop, evaluate and develop nonlethal repellants for deterring birds, and improve the effectiveness and safety of avicides for reducing depredating populations.

Potential Blackbird Repellants for Rice—Tests were conducted at the NWRC outdoor animal facility in Fort Collins, CO, to identify potential nonlethal repellants for reducing bird depredation on newly planted rice seed and ripening rice. Based on a series of feeding trials with captive red-winged blackbirds, Tilt® and caffeine were identified as two promising repellants.

NWRC scientists, in cooperation with researchers at the University of Missouri Delta Center, Southeast Missouri State University, and Missouri WS, conducted controlled tests in large netted enclosures to evaluate the effectiveness of Tilt and caffeine as repellants for red-winged blackbirds in ripening rice fields. During these field trials, Tilt did not result in any differences in damage between the treated and untreated plots, probably because chemical residues of the repellant were far below the repellancy threshold. For caffeine, damage was slightly less (although not at statistically significant levels) at the conclusion of the test in treated plots than in untreated plots. Chemical analysis of the spray formulation indicated 2.67 percent caffeine. Caffeine residues on rice panicles immediately following the spray application averaged 407 µg/g and at the conclusion of the test (24 days after spray application) averaged 195 µg/g. The insignificant difference in repellancy between treated and untreated plots for both repellants could have been due either to low residue levels of the repellants on the rice panicles and/or to increased feeding pressure due to the high number of birds in each enclosure, thus overwhelming the treatment.

Chromaflair® "Crow Buster" Ineffective at Dispersing American Crows and Red-Winged Blackbirds—NWRC scientists evaluated the ChromaFlair Crow Buster, a device developed in Japan to repel Asian crows from garbage cans, fruit trees, and utility structures. The Crow Buster consists of an iridescent green-purple strip (1.5–3.5 cm wide) of stiff, shiny plastic cut into a spiral shape.

Scientists estimated the influence of the Crow Buster on the foraging distribution of red-winged blackbirds and American crows in the NWRC outdoor flight pen in Fort Collins. During the study, scientists monitored daily food consumption from feed dishes placed 5 m, 10 m, or 15 m from a vertical post used to suspend the Crow Buster.

The Crow Buster had no apparent effect on the foraging distribution of blackbirds. American crows were repelled only during the first day of the test, and even then only up to 10 m from the suspended device. Results show the Crow Buster is not likely to be effective at repelling red-winged blackbirds and American crows under field conditions, where most applications would require efficacy for at least several days and at distances greater than 10 m.

Viability and Potential Distribution of Crop Seeds Ingested by Birds—The expansion of genetically modified pharmaceutical and industrial crops to outdoor plantings has generated concerns that birds may ingest and disperse seeds from these crops to other areas, potentially resulting in the contamination of the human food supply. NWRC scientists, in cooperation with APHIS' Biotechnology Regulatory Services, conducted studies to determine digestion and physical transport of commercial agriculture seed corn, barley, safflower, and rice by captive mallards, ring-necked pheasants, red-winged blackbirds, and rock pigeons.

Corn, barley, safflower, and rice seeds that were either free fed or orally force-fed did not pass through the digestive tracts of mallards, pheasants, blackbirds, or pigeons. However, birds retained viable seeds in their esophagus, crop, and gizzard. For instance, mallards and ring-necked pheasants retained 228 and 192 barley seeds, respectively, in their esophagus/crop after foraging for 6 hours. Of the seeds recovered from the esophagus/crop of these two species, respectively, 93 percent and 50 percent subsequently germinated.

Birds transported seeds away from the feeding site, but there were only five instances of seeds attaching to the feet or legs of birds. The risk of corn, barley, safflower, or rice germinating offsite when transported by a bird either internally or externally will depend on environmental conditions, soil types, temperature, timing, seed quality, and location. Isolating planting locations away from commercial agricultural crops and migrating birds would reduce the probability of seeds' being transported and germinating in similar sites.

More research is needed to (1) determine the extent of seed removal by birds from experimental pharmaceutical and industrial crops sites, (2) determine germination rates of seeds recovered from birds after a year-long exposure to environmental conditions, (3) identify the species of birds most likely to visit experimental pharmaceutical and industrial crops sites, and (4) develop a risk model for pharmaceutical and industrial seeds transported and germinated offsite.

TITLE: **Defining Impacts and Developing Strategies To Reduce Mammalian Damage in Forested and Riparian Ecosystems**

GOAL: Develop an understanding of the economic and ecological impacts of damage inflicted on forested and riparian systems by herbivorous and omnivorous mammals and develop tools and techniques for reducing that damage.

Damage to timber resources by wildlife 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 compromised because of foraging wildlife. Reforestation efforts are greatly hindered by bears, beavers, deer, elk, mice, mountain beavers,

pocket gophers, porcupines, and voles cutting and gnawing on seedlings. Some of the same species that damage seedlings also damage and destroy established trees after canopy closure.

Developing nonlethal methods to manage wildlife damage is a priority in the ongoing research conducted at NWRC's Olympia, WA, field station. Scientists are conducting research to develop alternatives to lethal control, including physical deterrents, repellants, frightening devices, habitat and behavior modification, and improved capture methods.

NWRC Scientists Develop Integrated Approach for Managing Mountain Beavers—Trapping is currently the most common and effective method employed for controlling mountain beaver damage. However, research conducted by scientists at the NWRC Olympia field station demonstrated that the effects are short lived. Mountain beavers often reinvade newly harvested units in just a few weeks and are, therefore, present when new seedlings are most vulnerable to damage. Scientists at the field station have also conducted research to develop a baiting strategy for reducing seedling damage by mountain beavers in reforested areas.

The results demonstrated that using an integrated pest management (IPM) system of trapping and baiting with chlorophacinone, a rodenticide, may allow for additional seedling protection between trapping and the emergence of herbaceous vegetation, thus decreasing long-term costs of retrapping and replanting. Based on these results, the Washington and Oregon State departments of agriculture approved Special Local Need registrations for use of Rozol™ Pellets (active ingredient chlorophacinone) to control mountain beavers in forested lands west of the Cascade Crest.

Using Natural Tree Chemistry To Prevent Browsing by Ruminants—Browsing by deer and elk can cause significant ecological and economic impacts. Research has shown that area repellants are not effective at reducing deer/elk browsing and that exclusion devices (e.g., fences) are generally cost prohibitive. Thus, new, nonlethal approaches need to be identified.

Working in collaboration with the British Columbia Ministry of Forests, NWRC scientists studied deer diet selection by offering captive deer cloned copies of western redcedar seedlings of known monoterpene content. (Monoterpenes are a type of terpene or hydrocarbon produced by conifers and are a major component of resin. They are used by plants to deter herbivory.)

Results demonstrated that black-tailed deer made foraging decisions based on the monoterpene content of the seedlings. Because monoterpene content is a highly heritable trait, it is possible to breed seedlings with elevated monoterpene levels and thus potentially reduce deer/elk browsing in certain areas.

TITLE: **Documenting Impacts, Developing Control Strategies, and Applying Knowledge of Predator Behavior and Demographics To Protect Livestock and Natural Resources**

GOAL: Improve current knowledge of predator ecology, physiology, and behavior relative to depredations on species of human concern; assess predator responses to management practices; and develop control approaches that effectively target alpha coyotes.

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 scientists use a multidisciplinary approach to study interactions among predators and the impact of predators and predator removal on ecosystems and wildlife population dynamics. Results from these studies are fundamental to selective predator management, as well as to providing necessary information in the NEPA process.

Interactions Among Wolves, Coyotes, and Pronghorn Antelope: Does Wolf Recovery Help Pronghorns?—High coyote predation rates on pronghorn fawns are common throughout the Western

United States. Scientists at the NWRC Logan, UT, field station used a natural experiment created by wolf recolonization in the southern Greater Yellowstone Ecosystem to evaluate whether wolf recovery would decrease the abundance of coyotes and subsequently increase pronghorn fawn survival due to reduced coyote predation.

Results from a 3-year study involving spatial contrasts of wolf densities, coyote densities, and pronghorn fawn survival at control (wolf-free) and experimental (wolf-abundant) sites provided strong evidence of wolves' decreasing coyote numbers and increasing fawn survival. The scientists documented a more than fivefold increase in pronghorn fawn survival at sites used by wolves during summer and a nearly sixfold increase in fawn survival at sites used by wolves year 'round. Results indicated a negative relationship between coyote and wolf densities, suggesting that interspecific competition facilitated the increase in observed fawn survival. Whereas densities of resident coyotes were similar between control and experimental sites, the abundance of transient coyotes was markedly lower in areas used by wolves. Thus, differential effects of wolves on solitary coyotes may be an important mechanism by which wolves limit coyote populations.

These results suggest that widespread extirpation of wolves may contribute to high rates of coyote predation on pronghorn fawns. The results also support a growing body of evidence demonstrating the importance of top carnivores' influencing smaller predators and their prey in structuring the dynamics of terrestrial systems.

Effects of Coyote Population Reduction on Swift-Fox Demographics in Southeastern Colorado— The distribution and abundance of swift foxes have 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 geographic distribution of swift foxes, compete for similar resources, and are a significant source of mortality for swift-fox populations. Current swift-fox conservation and management plans to bolster declining or recovering fox populations may include coyote population reduction to decrease predation. However, the role of coyote predation in swift-fox population dynamics is not well understood.

To better understand the interactions of swift foxes and coyotes, scientists at the NWRC Logan, UT, field station compared swift-fox population demographics (survival rates, dispersal rates, reproduction, density) between areas with and without coyote population reduction. On the Piñon Canyon Maneuver Site in Colorado, NWRC scientists monitored 141 swift foxes for 65,226 radio-days from 1998 to 2000 with 18,035 total telemetry locations collected. In areas where coyotes were removed, the juvenile swift-fox survival rate increased and survival was temporarily prolonged. Survival patterns for adult foxes also were altered by coyote removal, but only following late-summer coyote removals, and again only temporarily. Coyote predation remained the main cause of juvenile and adult swift-fox mortality in both areas.

The increase in juvenile fox survival in the coyote removal area resulted in a compensatory increase in the juvenile dispersal rate and an earlier pulse in dispersal movements. The adult-fox dispersal rate was more consistent throughout the year in the coyote removal area. Coyote removal did not influence the reproductive parameters of the swift foxes. Even though juvenile survival increased, swift-fox density remained similar between the areas due to the compensatory dispersal rate among juvenile foxes. NWRC scientists concluded that the swift-fox population in the area was saturated because all suitable habitat was being used by foxes.

TITLE: Improved Technologies and Nonlethal Techniques for Managing Predation

GOAL: Identify, develop, and evaluate improved technologies and tools, especially nonlethal methods for managing predation.

Livestock predation costs U.S. producers approximately $93 million each year. Developing acceptable and effective predator-management tools to reduce these livestock losses is a high priority for WS. Concerns for public health and safety, as well as animal welfare, put wildlife managers under pressure to

seek immediate solutions when predators cause conflicts. Research conducted by scientists at NWRC's Utah field station 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.

Electrified Fladry as a New Approach for Protecting Livestock From Wolves—Scientists at the NWRC Utah field station conducted an experiment to test the effectiveness of electrified fladry for protecting food resources from 10 captive wolf groups (n = 36, range = 2–7 wolves/group). (Fladry is simply a line of flags hung along the perimeter of a pasture.) In this study, researchers combine an animal's fear of a novel stimulus (flags) with conditioning from an unpleasant electric shock.

An electrified fladry system (turbo-fladry) was used to partition an 18.6-m^2 area of wolves' pens and prevent access to food. A fresh carcass was available in the protected area for 5 days. On the sixth and seventh days, wolves were given a fresh carcass in the unprotected area in addition to having a carcass in the protected area. Trials continued for 2 weeks, or until the barrier failed (i.e., all wolves moved freely to the protected food resource).

Tracks and signs of scratching in front of the turbo-fladry indicated a high frequency of investigation without learning to cross the barrier. Several wolves that investigated the turbo-fladry barrier either bit or touched the electric wire with their nose and quickly retreated. Eighty percent of the wolves never crossed the turbo-fladry barriers during the 2-week trials.

Because of the promising preliminary results, NWRC scientists have expanded the research and currently are examining the effectiveness and ease of use of electrified fladry in pastures in Montana.

Trap Monitors for WS Operational Personnel—Public interest in capture devices and potential injuries to animals has resulted in changes in trapping regulations in various States and countries. In this country, some States have altered regulations to require that traps be checked every 24 hours. Such a reduction of trap-check intervals could seriously impact WS Operations and reduce their ability to provide timely and efficient services over wide areas. The capability to monitor traps remotely would enable WS specialists to respond to stakeholder requests and monitor traps more effectively.

Working in collaboration with WS biologists in several States, scientists at the NWRC Logan field station evaluated several types of trap monitors to alert wildlife specialists when an animal is captured in a trap. The devices, which can be used with any type of trap, consist of small radio transmitters that emit unique pulse rates when an animal is captured. WS personnel tested the device using conibear, foothold, and cage traps, as well as foot snares and bait stations. Species studied included coyote, black bear, mountain lion, wolf, feral pig, and beaver.

Results indicated that trap monitors, when used in appropriate situations, can save WS specialists time and resources. Furthermore, trap monitors allowed specialists to prioritize visual inspection of trap sites, to reduce the amount of disturbance at the sites, and to more easily find equipment and animals.

Wildlife Disease Research Program

TITLE: Controlling Wildlife Vectors of Bovine Tuberculosis

GOAL: Study the ecology of tuberculosis in wildlife; assess the risk of disease transmission among wildlife, domestic animals, and humans; and develop methods that reduce or eliminate such transmission.

Bovine tuberculosis (bTB) is a contagious disease affecting wildlife, livestock, and humans caused by the bacterium *Mycobacterium bovis*. The disease is transmitted through direct contact, inhalation of aerosolized bacilli, or indirect contact via shared feed. Although once common in the United States in cattle, bTB has been historically rare in wildlife. However, since 1994, cases of bTB have been found in Michigan white-tailed deer; and research indicates that the disease is transmitted from deer to other wildlife and cattle by shared feed.

The presence of a wildlife reservoir for bTB has implications for Michigan's livestock industry. Since 1997, cattle on 40 farms and 527 wild white-tailed deer have tested positive for bTB. The situation is exacerbated by the sharing of feed and resources between wild deer and domestic cattle, and most cattle farms have only limited fencing and other techniques suitable for preventing deer access.

Evaluation of Potential Shedding of *M. bovis* by Experimentally Infected Coyotes—In cooperation with CSU's departments of Biomedical Sciences and Microbiology, Immunology, and Pathology, NWRC scientists are evaluating the potential shedding of *Mycobacterium bovis* by coyotes. *M. bovis* causes bTB in domestic cattle and other animals. In some areas of Michigan, the prevalence of bTB infection in coyotes has been as high as 33 percent.

In BSL–3 facilities at CSU, four coyotes were inoculated with *M. bovis* isolates in order to identify whether coyotes are a potential transmission source for bTB. Oral swabs, nasal swabs, feces, and blood samples were taken every 2 weeks. In addition, coyote feces were mixed in the bedding litter of guinea pigs to determine if the feces contained enough viable organisms to infect the guinea pigs.

Preliminary culture results for coyotes have been negative for bTB, and no negative effects were observed in the guinea pigs. Information from this study will be used for APHIS' National Bovine Tuberculosis Eradication Program in the United States.

Using Coyotes as a Sentinel Species To Detect the Presence of bTB in Michigan—Between 12 and 33 percent of coyotes in the bTB-affected area in Michigan are positive for bTB. If they shed *M. bovis*, coyotes could be an important source of infection for cattle. In this field study, NWRC scientists are determining if coyotes are shedding *M. bovis.* Another objective is to determine whether the prevalence of bTB in coyotes in Michigan has changed from past years.

Researchers caught and euthanized 46 coyotes from 1 deer-infected county and performed necropsies on the animals. Nearly 160 carcasses remain to be sampled over the next 18 months. To date, seven coyotes have been found positive for bTB. Preliminary results from one county in Michigan show that bTB prevalence has not changed in the past 2 years and remains near 30 percent.

Evaluating Risk Factors Associated With Transmission of bTB From White-Tailed Deer to Cattle— In 2007, NWRC researchers began a study to evaluate risk factors associated with the transmission of bTB from white-tailed deer to cattle.

Eighteen adult deer were trapped and collared in bTB outbreak areas in the northeastern lower peninsula of Michigan from January through March 2007 with traps provided by Minnesota and Michigan departments of natural resources. Deer movements in relation to farming practices, feeding areas, barns, outbuildings, feed storage areas, water sources, etc., are currently being monitored.

Data from this study will aid in the development of new methods to decrease potential interaction between cattle and wild deer. Such measures may include moderate changes to livestock management and/or feeding practices and increased exclusionary techniques, such as additional fencing. Reducing the interaction between wild deer and domestic cattle via shared feed and other resources may be a key component in eliminating the transmission of bTB from deer to cattle.

TITLE: **Evaluation and Management of Chronic Wasting Disease (CWD) Transmission**

GOAL: Assess the potential for CWD transmission at the interface between wild and domestic cervids and develop methods to reduce transmission and spread.

The spread of CWD in wild and captive cervids is of great concern for the health of these species. While CWD infects elk, white-tailed deer, mule deer, and moose, it is not known to infect other species of wildlife naturally (including predators and scavengers). Nor does it infect livestock or humans. There is no treatment for CWD, and it is typically fatal in cervids. Realized and perceived threats of CWD have immense implications for Federal and State wildlife-management agencies, domestic cervid farmers, hunters, and businesses and economies reliant on deer and elk. As a consequence, more and better tools and techniques are needed to reduce the transmission, prevalence, and persistence of CWD in wild and captive cervids.

Automated Species Recognition System for Controlling Animal Access to Resources—Automated, species-specific access by animals to resources could be a powerful tool in wildlife disease management. Efficiency of delivering vaccines, pharmaceuticals, contraceptives, or toxins could be enhanced if target species were allowed access to treated baits but nontarget species were excluded. Researchers at the National Centre for Engineering in Agriculture at the University of Southern Queensland, the School of Animal Studies at the University of Queensland, and RPM Livestock in Australia have developed a prototype of a computerized video monitoring system to control gated access to resources enclosed within fenced areas automatically. NWRC researchers have initiated a collaborative study with these organizations to acquire video imagery of domestic and wildlife species required to adapt and test the prototype system for use in North America. Primary efforts have focused on cervids susceptible to CWD and on other domestic and wildlife species similar in body type to cervids that may “confuse” the computer system.

NWRC scientists acquired the prototype camera system and species recognition software in 2007 and have fabricated a filming lane similar to that used by Australian researchers. The filming lane is designed to encourage single-file passage of large animals to facilitate the clear lateral imagery required for species identification. To date (October 2007), the trial has resulted in high-quality imagery of 15 elk, 13 mule deer, and 15 white-tailed deer. The trials continued throughout 2007 so that scientists can evaluate the accuracy of the species recognition software and its potential uses.

CWD Vaccine—NWRC research into a CWD vaccine continues to move forward along several fronts. An experimental vaccine trial in the widely used RML mouse scrapie model system yielded two promising candidates for further study. Currently, the two CWD vaccine candidates have been resynthesized, formulated, and used to vaccinate mule deer, making this the first known application of a CWD vaccine in the target species. This pivotal CWD vaccine study is a model of cooperation between State and Federal agencies. With guidance from USDA–APHIS’ Veterinary Services, collaboration with the Colorado Division of Wildlife and CSU, and support from WS, scientists have already accumulated important efficacy data on the CWD vaccine.

Currently, prime and booster injections of the vaccine have been administered to mule deer housed at CSU’s Animal Population Health Institute paddocks, a CWD-free environment. The experimental animals were subsequently transferred to the Colorado Division of Wildlife’s CWD-infected paddocks at the Foothills Wildlife Research Facility in Fort Collins.

Preliminary results show that the mule deer are producing good antibody titers to peptides 4 and 6 in response to the vaccine. Data also show that these antibodies have high affinity to the prion protein. The

deer have already passed more than 120 days since their disease challenge in an environment that simulates natural CWD transmission routes. Conclusive results on how well the CWD vaccine works in mule deer will not be known for another year to 18 months. Additional vaccine work using a mouse model is being initiated, including the design of an oral CWD vaccine.

Testing of Hydrolysis and Rendering Effects on Prion Infectivity—Infectious prions are inherently resistant to destruction. With support from the beef industry, NWRC biologists are testing how effective hydrolysis and rendering procedures are at destroying infectious prion material to determine if these methods are viable carcass waste-disposal options.

Hydrolysis is a process of using lye under increased pressure and temperature to degrade biological material. Proteins are broken down into component amino acids during the process. Rendering is a process of cooking material in oil. NWRC biologists are testing the effects of hydrolysis and rendering using a mouse model of prion disease with infected mouse brain as the test material. Following hydrolysis and rendering, the material was injected into test mice.

Six months after inoculation, some of the mice are showing signs of developing the disease. Preliminary results showed none of the 23 mice injected with hydrolyzed material died, while 16 out of 23 mice injected with rendered material died within about 244 days of injection. These results demonstrate that hydrolysis is effective at destroying infectious prions. Rendering, on the other hand, is not as effective as hydrolysis and does not remove all of the infectious material.

Enzymatic Decontamination of Infectious Prion Material—In 2007, NWRC scientists completed an 18–month study testing the ability of two enzymes to destroy the infectivity of prion material. Enzyme 1 protected 57 percent of the mice tested from becoming infected and developing CWD and prolonged the time before the disease was noted in the rest. The level of infectious material destruction appears to be very high, almost to the point of complete removal of infectivity. Enzyme 2 also showed substantial reduction in disease material under even less favorable digestion conditions (i.e., lower temperatures). All negative control mice survived the entire study period and all positive controls developed the disease. With modifications to the treatment conditions, complete removal of infectious potential may be possible. It is clear that enzymes will be a useful tool for the decontamination of infectious prion material.

Validation of a Live Test for CWD—In 2006, a practical live test for CWD in elk was developed by NWRC scientists in cooperation with CSU and APHIS' Veterinary Services. Scientists are continuing to refine the methods and are now fully developing, evaluating, and validating a rectal biopsy method so it can be used as a tool for detecting CWD in cervids that have been infected but have not yet begun to show signs of disease. The technique is currently being used in pen studies to determine time to infection relative to transmission route.

CWD Blood Bank—Researchers from several Federal and State agencies and universities are developing diagnostic tests and other techniques to determine whether animals are infected with CWD or other transmissible spongiform encephalopathy (TSE) diseases. One limitation to the development of these methods is access to positive samples for evaluating the tests. To address this need, NWRC has initiated a CWD blood bank to store blood and other tissues that can be made available for research. As of October 2007, blood and tissue samples have been collected and stored from 7 and 56 CWD-positive deer, respectively.

TITLE: Surveillance, Monitoring, Research and Response for Wildlife Diseases

GOAL: Understand the role wildlife play as hosts and reservoirs for zoonotic diseases (e.g., AI, plague, West Nile virus) and diseases of agricultural importance (e.g., AI, salmonellosis).

Considerable concern exists around the world about emerging infectious diseases. Of these emerging diseases, 75 percent are zoonotic. Some zoonotic diseases carried by wildlife also can be transmitted to economically important domestic animals, such as West Nile virus to horses and AI to poultry. Thus, wildlife populations often play a key role in the transmission of diseases that directly impact humans and

agriculture. NWRC is actively involved in the monitoring and surveillance of and research on many of these diseases.

National Early Detection System for HPAI (H5N1 Subtype) in Wild Migratory Birds—The occurrence of HPAI subtype H5N1 continues to cause considerable concern regarding the potential impact on wild birds, domestic poultry, and human health should it be introduced into the United States. One potential route for introduction of the virus into the country is migration of infected wild birds. As part of the U.S. Interagency Strategic Early Detection System for Highly Pathogenic H5N1 Avian Influenza in Wild Migratory Birds, NWRC continues to be responsible for developing field sampling methods, directing collection of field samples, and analyzing environmental (water and avian fecal) samples in the United States. As part of this strategy, NWRC convened a committee to design a nationwide monitoring program for environmental samples, provided initial guidance for sampling, developed a field collection system, developed assays for both water and fecal samples, and performed diagnostics analysis of the initial samples collected in Alaska.

In 2006, NWRC staff analyzed 50,184 avian fecal samples from all 50 States and the Pacific Islands and detected low-pathogenic AI in 4.0 percent of the sample pools; 0.2 percent of the sample pools were positive for H5 and H7 subtypes. However, no HPAI H5N1 was detected.

In 2007, NWRC staff continued to assist the national surveillance program by analyzing an additional 25,000 avian fecal samples that were collected using a more targeted approach based on the sampling conducted in 2006.

Human Health Risks From Nesting Waterbirds on Alcatraz Island—Preliminary surveys were conducted on Alcatraz Island, CA, to identify and measure the frequency and intensity of wildlife diseases in western gulls that may threaten the health of human visitors to this National Park. In particular, research focused on AI, pathogenic intestinal bacteria, Lyme disease, and histoplasmosis.

All of the 238 fresh fecal samples collected tested negative for the virus that causes AI. Ticks known to transmit the bacteria that causes Lyme disease—*Borrelia burgdorferi*—were not detected. Thirty-one different intestinal bacterial types were identified from the representative 481 bacterial isolates taken from 243 fresh fecal, tracheal, and cloacal swabs and regurgitation swabs. *Escherichia coli* was the most abundant intestinal bacterium identified from "contact" sites (where visitors could contact gull feces) and "source" sites (where gulls bred in high densities). *Proteus mirabilis* was the second most abundant intestinal bacterium identified. While isolated less frequently, some bacteria identified (e.g., *Salmonella* spp. and *Shigella* spp.) are of interest because they can cause illness in humans.

Role of Backyard Poultry in the Transmission of AI—Backyard poultry are common in many areas of the United States but are not regulated or tracked by State or Federal agencies. Therefore, little is known about the density or spatial configuration of backyard farms. In cooperation with CSU, NWRC biologists established spatial adjacency matrices for backyard poultry and game-bird farms in Colorado and developed epidemiologic network models of AI virus on backyard farms. These models can be used to assess connectivity of backyard farms based on distance between farms, the number of neighboring farms, and landscape features that impact wildlife movement between farms.

An understanding of connectivity in farm networks can be used to predict patterns of the spread of AI virus and to prioritize sites for biosafety and control measures. Typically, control measures are applied to a circular buffer around an impacted farm. Identifying highly connected farms and landscape features conducive to wildlife movement will allow control measures to be applied to a more meaningful and efficient area.

TITLE: Investigating the Ecology, Control, and Prevention of Terrestrial Rabies in Free-Ranging Wildlife

GOAL: Study the ecology of wildlife and evaluate risk factors that may be involved with the transmission of rabies among wildlife and rabies virus trafficking across landscapes and develop methods and strategies that reduce or eliminate such transmission.

Rabies is an acute, fatal viral disease most often transmitted through the bite of a rabid mammal. The disease 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 about $300 million a year.

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 eradicate terrestrial rabies here, NWRC scientists are conducting research on the behavior, ecology, movements, and population structures of raccoons and gray foxes. The researchers are also evaluating methods and techniques used to vaccinate free-roaming wildlife against rabies.

Use of Rhodamine B as a New Biomarker for Raccoons—The Oral Rabies Vaccination (ORV) program, administered by WS, has long desired an effective, easy-to-use biomarker that would allow for noninvasive identification of animals that have been exposed to ORV baits. The ORV program currently uses tetracycline, an antibiotic deposited in growing bone and teeth. Tetracycline has proven to be reliable, but evaluating this biomarker is invasive and expensive. Research conducted at NWRC examined rhodamine B as a possible alternative biomarker for the ORV program.

Rhodamine B is a chemical dye that, when ingested, stains the oral cavity and is absorbed systemically into growing tissues such as hair and vibrissae (whiskers), producing fluorescent orange bands under ultraviolet (UV) light. Researchers fed 18 raccoons rhodamine B and monitored their whiskers and fur for fluorescence for 15 weeks.

All raccoons exhibited fluorescence in their whiskers. On any given sampling-day, an average of 55 percent of whiskers sampled from each individual fluoresced. Evaluations of whiskers using a UV-equipped microscope and hand-held UV lights were compared to determine if evaluation of whiskers can be done in the field. To a limited degree, field evaluations were successful.

At the conclusion of the study, researchers conducted necropsies on all raccoons to look at the systemic effects of the dye. Gross and histopathologic examination of tissues revealed only subtle lesions consistent with those previously reported in wild raccoons.

Rhodamine B appears to be a safe and effective biomarker that may reduce the need for invasive sampling techniques to assess the success of the ORV program. The next step will be to assess whether raccoons readily consume fishmeal polymer baits containing rhodamine B. Confirmation that raccoons do not exhibit a taste aversion to rhodamine B baits will allow scientists to make a recommendation for the use of rhodamine B as part of the national ORV program.

NWRC Researchers Evaluate Potential for the Spread of Raccoon Rabies Across Northern Ohio— Rabies in the United States occurs primarily in wildlife species. Genetically distinct rabies virus strains are maintained within a number of carnivore and bat species in distinct geographic areas. Until the early 1970s, rabies caused by the raccoon virus strain was predominantly found in Florida and Georgia. However, during that decade, rabies-infected raccoons were transported from Florida to the Virginia–West Virginia border, quickly spreading the disease to a large number of animals in the region. Since then, the disease has expanded throughout the Eastern United States, presenting a significant human health risk over a large geographic area.

Currently, eastern Ohio serves as one boundary to the westward spread of the raccoon variant of rabies. The primary means of controlling this variant of rabies in the United States is the ORV Program conducted by WS Operations. The ORV Program's vaccine-laden baits have been distributed throughout the Eastern and Southeastern United States since 1990 and on the current western edge of the raccoon rabies strain (the Ohio–Pennsylvania border) since 1997.

The goal of the ORV Program in Ohio is to contain raccoon rabies in the natural corridor consisting of the Allegheny Mountains in the north and the Ohio River in the southeast. With the spread of rabies into Lake, Geauga, and Cuyahoga Counties of northeastern Ohio, movements of raccoons there need to be examined. NWRC scientists are attempting to identify if there are barriers and/or corridors that may affect the spread of raccoon rabies in the area.

NWRC researchers have begun capturing and radio-collaring raccoons in both urban areas and rural–suburban interfaces. Raccoons are being located weekly using VHF (very high frequency) telemetry. Genetic sampling, which will be used to evaluate raccoon movements in northern Ohio over time, is being done on approximately 180 samples. The majority of genetic sampling occurred simultaneously during a raccoon density study in the late summer and early fall of 2007. The raccoon location information is being entered into a geographic information system (GIS) program in an effort to follow raccoon movements and evaluate any barriers to or corridors for movement (e.g., rivers, roads, greenbelts, etc.). Preliminary results show raccoons are not moving long distances.

Information gleaned from this study will be used to facilitate the ORV Program in planning strategies in an attempt to halt the westward spread of the raccoon variant across northern Ohio and possibly into other States to the west.

TITLE: **Development of Surveillance Strategies and Management Tools To Control Pseudorabies and Other Wildlife Diseases That Affect Humans and Livestock**

GOALS: Provide basic ecological information as related to (1) developing management tools to control pseudorabies in feral pigs and (2) managing other wildlife diseases (in particular, Texas cattle fever and heartwater) that affect livestock.

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.

Feral hogs' high reproductive rate and adaptability have dramatically increased their population size and distribution. This invasive animal now exists in 32 States, where it causes a range of agricultural and environmental damage through depredation, rooting, and wallowing activities. Furthermore, feral hogs compete with native wildlife and livestock for habitat, are carriers of exotic and endemic diseases, and transmit parasites to livestock and humans.

One disease of particular concern to the commercial swine industry is pseudorabies (PRV), also known as Aujeszky's disease. PRV is an infectious, often acute, herpesviral disease that affects the nervous system of livestock and wildlife. The disease poses a potential hazard to humans (although documented cases are rare) and a major hazard to the swine industry. Feral hogs have been found to be seropostive for pseudorabies in 11 States where they are believed to be a free-ranging reservoir for the disease.

A Landscape–Genetic Approach to the Management of Feral Pigs—The feral pig is considered an exotic invasive species in the United States. Feral pigs cause significant agricultural damage, and they are a public health risk because they can harbor numerous diseases, including brucellosis, pseudorabies, and foot-and-mouth disease. Currently, feral pig populations are controlled through trapping or shooting. However, these methods are labor intensive and inefficient because pigs from neighboring areas quickly recolonize managed areas. NWRC scientists and cooperators are using microsatellite DNA markers to assess the broad-scale population structure of feral pigs in South Texas and to evaluate recolonization after local removals.

Preliminary results indicate that pig populations display a moderate degree of population structuring at a large scale (~120 mi^2), suggesting that at broad geographic scales, populations are functionally independent of each other. However, genetic similarity was not a simple function of geographic distance, implying that movement and dispersal are not equal among populations. This may be due to the

presence of terrain features that promote dispersal (e.g., river systems) or inhibit it (e.g., urban areas, vast areas of farmland).

At a local scale, feral pig samples taken before and after removal were genetically different, indicating rapid recolonization into the controlled area. Overall, results indicate that knowledge of feral pig population structure in some areas of South Texas could be used to improve control efforts. But high rates of movement and dispersal would likely require control efforts over a very broad region, possibly an entire watershed. Attempts will be made to identify fine-scale genetic structure and landscape features that could be used to focus management efforts.

Surveillance for the Pathogenic H5N1 Strain of AI in Feral Hogs—An influenza pandemic is currently regarded by many health officials as a significant threat to global public health. The next influenza pandemic will likely be caused by a virus that possesses surface proteins to which humans have no immunity. Previous influenza pandemics occurred via genetic reassortment in an animal coinfected by avian and human influenza virus strains. One likely "mixing vessel" is the feral hog.

The invasive feral hog exists across North America, and large populations inhabit areas frequented by bird species that serve as influenza reservoirs. NWRC scientists conducted surveillance on feral hogs for the presence of avian-origin influenza viruses (including the highly pathogenic H5N1) in Texas, a State where millions of migratory and resident waterfowl and shorebirds winter among a large population of feral hogs.

Nasal swabs and blood serum from hunter-harvested animals and nuisance animals removed by Texas WS were obtained during 2006 and 2007. Samples were screened for all 16 hemagglutinin and 9 neuraminidase subtypes of the influenza virus. As of October 2007, more than 600 samples had been tested with no avian-origin influenza viruses detected.

Early detection is critical for disease management strategies to be successful. This study is an important step in understanding the dynamics of this highly publicized zoonotic disease and will aid in understanding potential routes of human exposure.

High Rates of Multiple Mating in Feral Pigs: Risk of Disease Transmission—Feral pigs are susceptible to diseases that affect wildlife, livestock, and humans—a fact that raises serious concerns about the role these animals play in the maintenance and transmission of disease. However, predictions of disease transmission by feral pigs are hampered by a lack of information on their ecology and behavior. As a result, estimates of contact rates and other vital information for disease risk models and management are tenuous at best.

NWRC scientists are developing a database of genetic information from free-ranging pregnant sows and embryos to provide a robust estimate of rates of multiple mating across South Texas. The goal of this ongoing study is to investigate the mating behavior of feral pigs using genetic methods. Because some diseases (e.g., pseudorabies and brucellosis) are transmitted by contact among individuals, including sexual contact, the frequency of multiple mating provides a means of estimating rates of contact among individuals.

As of October 2007, more than 30 litters have been obtained, and researchers have found evidence for multiple paternity (siring of offspring by more than one boar) in 48 percent of litters. That high rate of multiple mating suggests that the risk of transmitting diseases spread by direct contact is significant. Results demonstrate the value of genetic techniques to provide insight into difficult wildlife-management problems and supply timely information for predictions of disease transmission within feral pigs.

Evaluation of Population Estimation Techniques for Feral Pigs—For land managers, feral pigs are a concern because they cause environmental and economic damage. Population estimates for feral pigs are critical in determining efficient management strategies. However, density estimation techniques used for native ungulate species, such as white-tailed deer, are inaccurate and unreliable in determining feral pig populations. New techniques using motion-sensing cameras and ingestible biological markers help

reduce the cost, manpower, and time necessary to obtain population density estimates of free-ranging wildlife and may prove useful for feral pigs.

NWRC scientists and cooperators evaluated population-monitoring techniques at study sites located in southern and central Texas. They assessed (1) a mark–recapture technique using the biological marker tetracycline, which is an antibiotic that produces a fluorescent mark on growing bone; (2) traditional aerial surveys and spotlight surveys; and (3) passive and active tracking indices using motion-sensing cameras. Results showed that tetracycline is a suitable biological marker for feral pigs; aerial surveys and spotlight surveys did not provide reliable estimates for feral pig populations; and motion-sensing cameras showed promise in monitoring feral pig populations.

Mammalian Visitation to Candidate Feral-Hog Attractants—Few data exist regarding suitable feral-hog attractants in the United States. NWRC researchers compared species-specific visitation and contact rates of mammals to 11 candidate feral-hog attractants at scent stations using motion-sensing digital photography. Of the 720 scent stations monitored, scientists found feral hogs had greater visitation to stations featuring apple and strawberry scents than to control stations. Raccoons and collared peccaries were less likely to visit stations with strawberry versus other scents, such as berry or apple.

NWRC scientists recommend that natural-resource managers consider using strawberry attractants for feral-hog-specific applications. If, however, a general feral-hog attractant is needed, then apple, berry, or caramel attractants may perform well.

Potential for the Transmission of Diseases Between Feral Swine and Domestic Pigs—Swine diseases such as brucellosis, PRV, and classical swine fever (CSF) have been eradicated from domestic pig populations. But domestic pigs raised in traditional farm facilities or "backyard" settings are vulnerable to diseases harbored by feral swine. The objectives of this study were to determine (1) serum antibody levels to PRV, brucellosis, CSF, and porcine reproductive and respiratory syndrome (PRRS) in Texas feral swine populations; and (2) the frequency of feral swine contact with domestic swine.

Results showed the prevalence of antibodies to brucellosis, PRV, and CSF in feral swine was 11, 30, and 0 percent, respectively. Also, feral swine from southern Texas were 8 times more likely to have been exposed to PRV than to brucellosis; whereas, feral swine from eastern Texas were 1.3 times more likely to have been exposed to brucellosis than to PRV. Seven radio-collared feral swine (19 percent of the study group) came within 300 feet of domestic swine facilities, providing opportunities for disease transmission by fenceline contact, while 33 feral swine (89 percent) used habitats within 1 mile of domestic swine. (Contact closer than 1 mile is considered a threat to the health of domestic swine via aerosol transmission.)

Invasive Species and Technology Development Research Program

TITLE: **Development and Assessment of Methods and Strategies To Monitor and Manage Mammalian Invasive Species, With an Emphasis on Rodents**

GOAL: Review the current biological status of established and potential invasive mammalian species, with an emphasis on rodents in the United States and its territories, and investigate promising methods and strategies for surveillance, management, and eradication.

The National Invasive Species Council has documented the serious threat posed by invasive or introduced plants, invertebrates, disease agents, and vertebrates to agriculture, property, natural resources, and human health and safety in the United States. It is estimated that invasive species result in at least $138 million per year in losses, damage, and control costs. About 300 species of invasive vertebrates have been accidentally or purposefully introduced into the country, including about 20 species of mammals. These include omnivores (rats and feral pigs), predators (mongoose, foxes, and feral dogs and cats), and herbivores (feral livestock and nonnative deer).

WS has a long history of involvement in managing invasive species, not only on the U.S. mainland, 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 nonnative vertebrates already established, and (4) support sustained control for well-established invasive species where eradication is not feasible.

NWRC Biologists Develop and Test a Multiple-Capture Trap for Nutria—An invasive aquatic rodent from South America, nutria cause substantial damage to marsh vegetation in many parts of the United States. NWRC researchers designed and tested a multiple capture trap (MCT) at the Mandalay National Wildlife Refuge in coastal Louisiana. Six MCTs were baited with food (carrots, corn, and sweet potatoes), and six were baited with fertilized marsh plants.

During a 10-day trial, nutria were caught in both types of MCT sets: 10 in the food traps and 12 in plant lure traps. As many as three nutria were captured overnight in one trap. On two occasions, nutria escaped the traps when approached by a person. No nontarget animals were captured; however, investigators suspected that swamp rabbits were entering the MCTs to feed and then were able to escape through the traps' one-way door.

Using a FLIR (forward-looking infrared) unit at night and motion-activated cameras, observers saw several nutria around some of the traps, but the animals were never caught. Clearly, more-effective attractants for nutria need to be developed before the MCT will be highly effective in catching nutria. Additional field trials, perhaps using nutria auditory cues, are planned to be conducted in the Pacific Northwest.

NWRC Biologists Study Wild Norway Rat Behavior for Better Management Strategies—A better understanding of invasive rat behavior would allow for better detection of invading rats on islands and a greater likelihood of rapid and successful eradication. NWRC biologists used operant-conditioning behavior paradigms to study wild Norway rats' rate of learning certain behaviors (wheel spinning and lever pressing), using a food-pellet reward system. Rats required about 14 sessions to reach a steady-state performance in wheel trials but at least 21 sessions during the lever-pressing trials. Considerable variation in individual behavior was noted. Researchers concluded that individual activity levels may influence exploratory behavior, which may be correlated to the likelihood of rats' entering traps or bait stations used in detection and control efforts. It is possible that multiple detection devices will need to be employed to assure detection of newly arriving rats on an island.

TITLE: **Methods and Strategies To Manage Invasive Species Impacts to Agriculture in Hawaii**

GOAL: Develop safe and effective methods and strategies to manage the effects of invasive species on agriculture, natural resources, and human health and safety in Hawaii and other island ecosystems.

Oceanic islands like the Hawaiian chain are more susceptible to invasive species than mainland areas because islands have few predators or competitors, have a lot of air and sea traffic, and typically provide a favorable climate for many species. Furthermore, 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 and natural environment and to the health and lifestyle of its people. Invasive species cause millions of dollars' worth of crop losses, the extinction of native species, the destruction of native forests, and the spread of disease and also reduce the health and safety of residents. This project investigates a variety of methods to resolve small-mammal damage to agriculture, reforestation, and structures and equipment.

Rodenticide Development—The efficacy of many commercially available rodenticide products on wild black rats *(Rattus rattus),* Polynesian rats *(R. exulans),* and mice *(Mus musculus)* is unknown. The few successfully used products have not been systematically tested in a common laboratory environment or

compared to other available products. Products vary according to their toxicity to nontarget animals, speed and method of action, and bioaccumulation and biomagnification potential. Thus, a product appropriate for one application may not be appropriate for another, and limiting the pool of potential products restricts a manager's ability to mitigate the effects of an eradication effort. Two major data gaps are the effectiveness of these products on rats typically found on Pacific islands and a comparison of the effectiveness of the products available.

NWRC scientists have completed the initial testing of rodenticides on three rodent species (black rat, Polynesian rat, and mouse) and have evaluated their effectiveness over 3-day and 7-day exposure periods. As expected, the acute toxicants were more effective than the first-generation anticoagulants. However, there was a marked difference in the toxicity of some products to these rodent species. These differences in toxicity are partially explained by differences in the amount of bait consumed and the toxicity of the product. Rodent preference for bait compared to laboratory chow diet varied greatly by product and rodent species.

Development of Mongoose Lures—Introduced small Indian mongooses are major predators of birds in Hawaii. The eggs and nestlings of ground-nesting birds are especially vulnerable to these invasive mammals, which occupy diverse habitats on all the major islands except Kauai. Trapping and bait stations have been used to reduce high mongoose populations near and around native-bird nesting habitats. However, the method has been less successful in areas with low mongoose density or high alternate prey density. Recent sightings of mongooses on Kauai and the potential for accidental introductions on other mongoose-free islands in the Hawaiian chain or other Pacific locations highlight the need for improved index and capture techniques utilizing traps, scent-visitation stations, baits, lures, or attractants to quickly respond to reported sightings or incipient mongoose populations.

NWRC scientists at the Hilo, HI, field station identified several baits that were effective in trapping mongooses, but their effectiveness in attracting mongooses from a distance was unclear. Thus, scientists evaluated the distance that these lures were effective by using radio telemetry and automatic microchip readers to track mongooses.

Mongoose home ranges averaged 15–20 ha, and some covered more than 50 ha. Several baits were identified that encouraged mongooses to travel long distances (>1 km). Results suggest that trap spacing for mongooses should be increased, as all mongooses easily detected baits at distances over 100 m and covered large areas during daily activities. Furthermore, several of the baits identified could be used to trap incipient mongoose populations or for the development of toxicant baits specific for mongooses.

TITLE: **Resource Protection Through Avian Population Management**

GOAL: Develop methods for estimating avian populations for species of concern; develop and evaluate antifertility methods to reduce nuisance avian populations; evaluate the impacts of wildlife damage management methods on targeted avian populations.

As land-use patterns change and urban populations spread into previously uninhabited areas, human–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 nonnative species, such as feral pigeons and monk parakeets, continue to grow with increasing detrimental impacts to human health and safety.

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 that allow bird research to be conducted throughout the year under natural environmental conditions.

Diazacon Used To Reduce Monk Parakeet Reproduction—The monk parakeet, which is native to South America, constructs its nest of sticks and branches and maintains it throughout the year. Unfortunately, parakeets often build their bulky nests in electrical substations and other utility structures.

In close proximity to energized equipment, nest material or the birds can create short circuits and produce power outages. This problem has been troublesome for electric utility companies in Florida and other parts of the United States for more than 20 years. To help address this problem, NWRC biologists are investigating ways to slow the growth of the monk parakeet population. Reproductive control using the chemical diazacon, a cholinesterase-inhibiting compound, is one approach that shows promise.

In collaboration with a south Florida utility company, NWRC biologists established bait stations at several electrical substations where monk parakeets were nesting. At some sites, the bait stations contained diazacon-treated sunflower seeds; at other sites, no treated bait was offered. The treated bait was presented for 10 days, and visits to the bait stations by parakeets were documented with motion-activated digital cameras. Then, 7–8 weeks later, nests at treated and untreated substations were removed, and the numbers of eggs and nestlings were recorded.

Nest examinations revealed that average productivity at the treated sites was 0.65 nestlings/nest, compared to 3.07 nestlings/nest at untreated sites. These numbers indicate a 79-percent reduction due to the treatment and are consistent with results obtained in 2006.

Vulture Movements Tracked by Satellite—Black vultures and turkey vultures represent serious safety hazards for high-speed, low-flying military aircraft. Winter surveys indicate that vulture numbers in South Carolina are two to three times higher than national averages. In recognition of the potential danger to its pilots and aircraft, the U.S. Navy contracted with WS to investigate options for vulture management at the Marine Corps Air Station in Beaufort, SC. The goal of the study is to document vulture movements and activity in the area of the air base, and devise a management plan to alleviate potential hazards.

Working with wildlife biologists from the South Carolina WS office, NWRC researchers attached solar-powered GPS satellite transmitters to eight black vultures and eight turkey vultures. Hourly readings provided data on each vulture's location, altitude, and speed. The GPS locations were processed into a GIS database that permits analyses of daily and seasonal movements, night communal roost locations, and daytime activity centers. In addition to the 16 birds with transmitters, WS biologists also marked more than 120 vultures with conspicuous, white wing tags. Resightings of these birds within the study area provided important supplementary information on vulture movements and resource use.

As of October 2007, the longest movement by a "transmittered" bird was approximately 500 miles, from Beaufort, SC, to Homestead, FL. Most of the birds with transmitters have remained within 10 miles of Beaufort.

An unexpected benefit of the study was the collection of new information on daily vulture activity. Data showed that the majority of vulture activity occurs later in the day, whereas bird surveys are usually conducted within 4 hours of sunrise. Thus, most black vultures are not detected during these surveys; consequently, vulture population sizes may be underestimated. These findings are being incorporated into revised protocols for estimating the size of vulture populations.

TITLE: **Development of Chemistry-, Biochemistry-, and Computational-Based Tools for Wildlife Damage Management**

GOAL: Develop and apply chemistry-, biochemistry-, and computer-modeling-based techniques and tools for improved management of pest wildlife by WS and the wildlife damage-management community.

Due to the increasing need for new, federally approved chemical tools that can be used by wildlife damage-management professionals, NWRC scientists are investigating methodologies to identify, analyze, and develop new drugs, repellants, toxicants, DNA markers, and other chemistry-based products. These methodologies could potentially be used to support APHIS registration requirements through the U.S. Environmental Protection Agency (EPA) and U.S. Food and Drug Administration (FDA).

Development of a Model for Estimating Pesticide Efficacy and Nontarget Impacts—Chemistry Project staff developed a probabilistic model consisting of exposure and effects modules to improve the ability to estimate the effects of pesticides on both target and nontarget species. The exposure module is based on the energy requirements of animals potentially exposed to pesticides via consumption of pesticide baits or other species containing pesticide residues. The effects module utilizes the slope and LD_{50} (median lethal dose) of the dose *v.* response curve.

In collaboration with other government agencies, NWRC scientists have applied this model to a variety of scenarios pertinent to WS and APHIS, including:

- Estimation of target species "take" associated with DRC–1339 (an avicide) baiting,
- Estimation of nontarget mortality associated with DRC–1339 baiting,
- Prediction of the improved DRC–1339 formulation procedures to optimize the ratio of target:nontarget mortality,
- Estimation of acute and subacute effects to nontarget avian species potentially exposed to rodenticides in conjunction with control of invasive rodent species, and
- Estimation of the percentage of human population that would exceed EPA-recommended mercury exposure limits via the consumption of freshwater and saltwater fish.

TITLE: Development of Reproductive Control Methods for Overabundant Birds and Mammals

GOAL: Obtain FDA approval for use of porcine zona pellucida (PZP) and gonadotropin-releasing hormone (GnRH) immunocontraceptive vaccines for white-tailed deer and develop new oral contraceptive agents for use in controlling reproduction in overabundant avian species (e.g., monk parakeets and crows) and in mammalian species (e.g., California ground squirrels and prairie dogs).

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, and 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, and degrade habitat quality in public parks and other locations. Rodents also carry a variety of diseases and damage rangelands and crops, causing the loss of millions of dollars' worth of agriculture production. Overabundant feral hogs, horses, cats, and dogs also cause damage and create ecological and political problems.

Immunocontraception To Control Deer Populations and Reduce Human–Deer Conflicts—In several regions of the United States, white-tailed deer herds that inhabit urban and suburban environments have become overabundant and are creating conflicts with their human neighbors. Typical problems include damage to vegetation and increases in deer–motor vehicle collisions. Wildlife contraception may be one tool that can help manage overabundant deer herds in urban and residential areas where other management methods, such as hunting, are not an option.

NWRC has developed and tested many types of wildlife contraceptives, including GonaCon™ (an immunocontraceptive vaccine), which has been highly effective in producing safe and reversible infertility in captive white-tailed deer and in other mammalian species, such as bison, wild horses, domestic and feral swine, domestic cats, California ground squirrels, and rats. GonaCon is a one-injection formulation that is much more practical for field delivery to free-ranging wildlife than earlier, two-injection contraceptive agents. NWRC regularly receives inquiries from concerned citizens regarding the possibility of using GonaCon to address local problems with overabundant deer and other species of wildlife.

Two major field studies of the efficacy of GonaCon as a contraceptive for deer are underway in the United States. The first study was initiated in Silver Spring, MD, during July 2004, on a fully fenced, forested site

that is managed by GSA. Overabundant deer were creating numerous conflicts with humans, and WS was asked to resolve the problems. NWRC scientists worked with Maryland-based WS biologists to capture and vaccinate 28 adult does with GonaCon. An additional 15 does were captured, marked, and released without injections as untreated control animals.

After 1 year, 88 percent of the GonaCon-treated does did not produce fawns, as indicated by lactation. After two years, 47 percent of the treated does did not produce fawns. Necropsy observations and histological examination of selected reproductive and other relevant tissue samples taken from treated and control deer identified no adverse effects associated with the GonaCon vaccine except for localized, injection-site reactions in 29 percent of treated deer.

A second major field study of GonaCon as a deer management tool began in the Morristown, NJ, area during July 2005 on a completely enclosed, privately owned, corporate office campus where overabundant deer were damaging vegetation and creating traffic hazards. NWRC scientists are collaborating on this study with biologists from White Buffalo, Inc., a nonprofit deer-management organization based in Connecticut. This 2-year field study is similar in design and scope to the Maryland study. Twenty-eight adult does were captured and injected with GonaCon, and 14 other does that are serving as control animals were captured and given sham injections before being released. As in Maryland, the reproductive success of free-ranging treated and control deer is being monitored and compared for 2 years to measure the efficacy of GonaCon as a deer contraceptive under field conditions.

After 1 year, 67 percent of the GonaCon-treated does did not produce fawns, as indicated by lactation. The reproductive performance of study deer in New Jersey will be assessed again to determine the second-year contraceptive efficacy of GonaCon vaccine in free-ranging, white-tailed female deer.

Use of GonaCon To Control Black-Tailed Prairie Dogs—Many prairie dog colonies exist across the Western United States. In some areas, particularly suburban settings, prairie dog colonies have expanded to the point that they have denuded the landscape. Conflicts have arisen in urban areas between resource managers, who must manage natural areas to maintain native plant life, and residents who oppose lethal control of prairie dog colonies. In October 2006, a study was initiated in Larimer County, CO, to evaluate the feasibility of using GonaCon immunocontraceptive as a nonlethal management tool for black-tailed prairie dogs in urban and suburban settings.

Prairie dogs were captured on control and treatment sites, weighed, sexed, and marked with ear tags and fur dye. In addition, each captured prairie dog was vaccinated with either a sham vaccine or GonaCon. Beginning in May 2007, prairie dogs were recaptured at both sites to determine breeding status and to collect blood samples for analysis of anti-GnRH antibody titers. Pup counts were also conducted during May and June 2007.

Preliminary data show that none of the prairie dogs treated with the GonaCon vaccine produced litters, whereas 83 percent of those receiving the sham vaccine successfully reproduced.

TITLE: **Economic Research of Wildlife-Caused Agricultural, Public-Health, and Natural-Resource Impacts**

GOAL: Quantify the benefits and costs of WS products and activities that aim to mitigate the impacts of wildlife diseases, wildlife damage to agriculture and natural resources, and wildlife risks to public health or safety.

The scope of wildlife damage-management activities continues to expand as conflicts with humans and wildlife increase. NWRC's economists seek to quantify the potential savings (benefits) and costs derived from mitigating the impacts of wildlife diseases; wildlife damage to agriculture, property, and natural resources; and wildlife risks to public health and safety.

Economics of Oral Vaccination for Domestic-Dog–Coyote Rabies in Texas—In 1988, a domestic-dog–coyote (DDC) variant of rabies was identified in Texas. Coyotes served as the main reservoir of this

new variant. By 1995, DDC rabies was present in 20 counties of south Texas, and the disease was predicted to spread northward at approximately 72 km/year, potentially covering the whole of Texas by 2007. To control this outbreak, the Texas Department of State Health Services, in collaboration with the WS National Rabies Program, initiated in 1995 a series of oral rabies vaccination (ORV) baiting campaigns.

Annually between 1995 and 2006, ORV baits (19–27 baits/km^2) were dispensed over selected southern Texas counties. By 2002, this program had evolved into annual bait distributions within an ORV "maintenance" zone north of the Rio Grande to prevent future cases of DDC rabies in Texas.

In 2006, NWRC economists and scientists were asked to conduct an economic assessment of the Texas DDC ORV Program. The objective of the study was to provide a cost–benefit analysis of the program from 1995 to 2006. Costs were the total expenditures of the DDC ORV Program from 1995 to 2006 (i.e., salaries, aircraft operation, and baits). Benefits were the savings associated with the potential reduced number of human postexposure prophylaxis (PEP) treatments and animals tested (AT) for the DDC variant.

To estimate savings, the annual numbers of PEP and AT were averaged across the 20 original southern Texas counties to determine the case frequency prior to DDC ORV baiting. These frequencies were then extrapolated northward throughout the rest of the State, based on the human population in each county. It was assumed that, without an ORV baiting program, PEP and AT cases would have spread through the rest of the State at either the same rate as in the original 20 counties, three-fourths of that rate, or half of that rate. Benefits or savings were then calculated using the number of PEP and AT cases avoided and their estimated expense.

Total DDC ORV Program benefits from 1995 to 2006 were calculated for three case-frequency rates. Estimated benefits ranged from about $98 million to $354 million. Total costs of the DDC ORV program exceeded $26 million from 1995 to 2006. The estimated benefits were then compared to the total program costs for the 1995 to 2006 time period.

To determine the overall economic efficiency of the program, benefit–cost ratios were calculated. A benefit–cost ratio greater than 1 signified economic efficiency (i.e., savings exceeded program expenses). Benefit–cost ratios were calculated at between 3.7 and 13.4, depending upon the level of PEP and AT case frequency.

Currently, only an 80-km-wide zone is baited annually to deter translocation of rabid dogs across the border between the United States and Mexico. The analysis revealed that this level of continued baiting will be economically efficient from between 2016 to 2030, depending on the case frequency.

Estimating Economic Impacts to Hawaii From the Invasive BTS—In 2004, NWRC economists undertook a study to estimate the economic impacts likely to occur to the Hawaiian Islands by the hypothetical translocation of the BTS from the Territory of Guam. The approach of this study was to collect and compile data from Guam to glean an understanding of the snakes' impact to that island. There were three general categories of economic impact related to the BTS' invasion: medical treatments, electrical outages, and tourism losses. Data gathered on Guam for medical and electrical impacts were used to derive results for Hawaii. Impacts associated with the tourism sector of the economy were projected using an input–output model.

Results indicate that, at $351,706 annually, expenditures in Hawaii for medical treatments will be the smallest portion of the costs associated with the BTS. Electrical outages resulting from the presence of the BTS on Hawaii will likely cost residents, business, government, and tourists $335 million to $454 million annually.

Impacts to Hawaii's tourism from the BTS have never before been estimated. In this study, a hypothetical range of decreased tourist numbers (1 percent–10 percent) was used, resulting in an annual decrease in revenue to the Hawaiian economy of $137.5 million to $1.4 billion and 1,339 to 13,000 jobs lost in the

local economy. The total annual economic impacts of the translocation of the invasive BTS to Hawaii fall within the range of $473 million to $1.8 billion.

Estimating the Value of a Beef Cow for Wolf Predation Payments—The reintroduction of Mexican gray wolves into the Blue Range Wolf Reintroduction Area in southwestern New Mexico and southeastern Arizona has involved indemnity payments to ranchers for depredated livestock. Currently, ranchers are reimbursed for only the market value of a cow. In 2007, NWRC economists developed an economic model to better assess the value of a cow in New Mexico. Computations focused on the actual valuation of a range beef cow in New Mexico, with estimates of the impacts to cattle producers if the cow is killed at various life stages and replaced with a weanling heifer. Although no change in indemnity payment schemes has occurred, ranchers found the results more reflective of the "true" loss incurred from wolf predation. Results are consistent with calculated actual production and animal value loss incurred from wolf predation.

TITLE: Field Evaluation of Chemical Methods for BTS Management

GOAL: Develop techniques to help control the BTS on Guam and prevent its dispersal from that island.

The BTS is one of the most ecologically damaging invasive species. In just the half-century since the BTS was accidentally introduced to Guam, it has exterminated most of that island's native forest birds and greatly reduced its population of fruit bats and native lizards. While managing the BTS population on Guam, WS actively works to prevent its spread to other Pacific islands, especially Hawaii. In the past, NWRC has received funding from the Department of Defense (DoD) Legacy Resource Management Program to research methods to manage the BTS. NWRC currently receives funding from the U.S. Department of the Interior's Office of Insular Affairs. BTS research efforts at NWRC encompass development of repellants, attractants, toxicants, fumigants, reproductive inhibitors, and improved trapping methods.

Commercial Paper Products as Parachutes for Aerial Delivery of Baits to BTSs—NWRC continues to evaluate parachutes for the aerial delivery of baits to BTSs in inaccessible, remote, forested areas on Guam. In an attempt to provide practical, economical parachutes, investigators evaluated four commercial paper products: paper cups, paper plates, and two types of white marking flags—a "single-ender" white flag with a 10-foot paper streamer attached to a chipboard card and a "double-ender" flag with a 16-foot paper streamer attached to the standard chipboard card with a smaller chipboard card at the tail end of the streamer.

As a test of the efficacy of these parachutes for their ability to deliver baits to BTSs, untreated dead neonatal mice (DNM) with radio transmitters were attached to each of the four types of paper products and hand-dropped from a helicopter over a forested site. Twenty each of the single- and double-enders and 15 each of the cups and plates were dropped. Location (canopy or ground landing) for each of the mice was recorded by visual inspection or radio signal.

Canopy entanglements for the single-ender flags, double-ender flags, cups, and plates were 85 percent, 95 percent, 67 percent, and 80 percent, respectively. Single-ender flags are preferred because they are less expensive than double-ender flags. Also, baits can be more conveniently attached to the single-enders with glue while cups and plates require labor-intensive thread connections to attach baits.

The next step in the development of a single-ender product will be assessment of their aerial deployment from a helicopter by an automated electromechanical dispenser.

Alternative Baits and Trap Lures for the BTS—An alternative bait to replace DNMs for baiting BTSs is highly desirable because the mice are expensive, may become ant and maggot infested, and putrefy after 2 to 3 days of field exposure. Two baiting evaluations with unadulterated DNM (uDNM), freeze-dried DNM (fdDNM), and dehydrated DNM (dDNM) were conducted in January–February 2007 (dry season) and July–August (wet season) on Guam. Baits destroyed by ants and maggots (as evidenced by

skeletons or skulls) were not used in calculating cumulative consumption of baits (bait-take) in each of the two baiting periods.

During the dry season, the 4-day cumulative bait-take was 86 percent, 84 percent, and 73 percent for uDNM, fdDNM, and dDNM, respectively. During the wet season, the 6-day cumulative bait-take was 96 percent, 55 percent, and 48 percent for uDNM, fdDNM, and dDNM, respectively. Although the bait-take did not differ significantly among treatments, neither the fdDNM nor the dDNM offers benefits over the uDNM in terms of bait take; however, the former may provide a benefit in terms of ease of handling and longevity in the field.

Five live trap lure treatments (empty trap, live mouse, uDNM, fdDNM, dDNM), totaling 180 trap-nights for each treatment, were also evaluated for capturing snakes. Traps were checked daily for 6 days, and captured snakes were removed daily from each site. The empty traps captured no snakes; the fdDNM, 1; dDNM, 2; uDNM, 10; and traps baited with a live mouse, 95. Based on these results, the fdDNM and dDNM do not have potential as lures for live-trapping BTSs.

Evaluation of Mechanical Mice as Lures for BTS Live Traps—It is well known that both visual and olfactory cues are important in the foraging behavior of BTSs and that a live mouse is an excellent lure for capturing snakes in live traps. However, there are logistical and maintenance concerns with using live mice in traps. Inanimate lures similar to those used in mammalian predator-control programs would be highly desirable. Two types of mechanical mouse (MM) lures were evaluated for capturing snakes in live traps under field conditions on Guam. MMs were activated by either an electronic (MM1) or a quartz clock movement (MM2). Snake capture was evaluated in seven live-trap treatments: (1) no lure, (2) live mouse, (3) DNM [as the source of dead mouse odor], (4) MM1, (5) MM1 plus DNM, (6) MM2, and (7) MM2 plus DNM.

Thirty-two snakes were captured with the live mouse lure, nine with MM2 plus DNM, four with DNM, two with MM1 plus DNM, and one with no lure. No snakes were captured with either the MM1 or MM2 alone.

The primary value of this work is that it shows that mechanical mouse MM2 with a dead mouse odor is attractive for capturing snakes and raises the potential for investigating a mechanical mouse with other candidate odors as lures.

BTS Sex Pheromone Research—NWRC scientists investigated the potential use of female BTS sex pheromones and synthetic versions as a tool for detecting small, incipient populations of BTSs in locations on and off Guam. In an initial study, scientists assessed responses of adult males to substrate-borne skin secretions of adult females in an outdoor seminatural enclosure on Guam. It is thought that females produce the pheromone only when in estrus. Therefore, males were given a simultaneous choice of investigating poles to which the scent of either a vitellogenic (breeding) female or nonvitellogenic (nonbreeding) female had been applied or a no-scent control pole.

Males spent more time, and exhibited a greater frequency of investigative “nose-probes,” on poles contacted by vitellogenic females than by nonvitellogenic females or no-scent controls.

Registration Program Support

The NWRC Registration Unit is responsible for ensuring that the registrations for chemical-based vertebrate-management tools used in WS’ operational program are current and meet State and Federal regulations. The Unit works closely with APHIS’ Policy and Program Development, Environmental Services office in all product-registration activities.

APHIS continues to hold registrations with EPA for rodenticides, predacides, avicides, repellants, snake toxicants, and one avian repellant. In addition, APHIS holds Investigational New Animal Drug (INAD) applications with FDA for immobilizing and contraceptive agents used in animal damage management. To maintain or expand authorized use of these products, the Registration Unit works closely with NWRC scientists to ensure that studies conducted for regulatory purposes meet EPA and FDA

recommendations. In addition, the Registration Unit responds to requests from WS Operations personnel for new products or improvements to existing products. The Registration Unit also provides technical assistance and information to State WS programs, Federal and State agricultural and conservation agencies, academic institutions, nongovernmental groups, and private industry.

Regulatory Oversight of Contraceptives and Immobilizing Agents
The primary regulatory event impacting APHIS during the past year is a change in the regulatory oversight of the immobilizing and contraceptive agents. In early fiscal year (FY) 2007, FDA and EPA began negotiations to draft a Memorandum of Understanding (MOU) between themselves. The draft MOU specifies that the regulation of contraceptive materials for wildlife and feral animals deemed to be pests under the Federal Insecticide, Fungicide and Rodenticide Act's definition of pest species would be transferred to EPA, and that FDA would retain regulation of contraceptives used in companion animals, livestock, and zoo animals. In conjunction with this MOU, FDA notified APHIS that all of the INADs APHIS holds should be closed.

In response, APHIS has closed the INAD for DiazaCon, an oral contraceptive under development for monk parakeets and prairie dogs.

FDA will retain regulatory authority over immobilizing agents used for wildlife management. APHIS currently holds INADs for propiopromazine HCl used in the tranquilizer trap device, and alpha chloralose for nonlethal removal of problem birds. FDA is requesting APHIS close the INADs for these products also. Given the limited use of either of these products, it is unlikely that full new-animal drug authorizations will be obtained. Consequently, APHIS is evaluating alternatives through FDA and EPA that would allow continued use of alpha chloralose by WS.

Wildlife Contraceptives—One wildlife contraceptive likely to receive EPA registration is GonaCon, an immunocontraceptive vaccine based on GnRH. GonaCon is the first immunocontraceptive vaccine to provide multiple years of infertility following a single injection. The first product registration will be for use in female white-tailed deer. Data submission for EPA registration is expected during the winter of 2007–08. In preparation for this registration, NWRC and WS personnel are working closely with the Association of Fish and Wildlife Agencies to ensure the final label meets the needs of State game and fish management agencies.

GonaCon is currently being tested on a wide variety of wildlife species and may be registered for others in the future.

Rodenticide and Avicide Use for Island Conservation
The NWRC Registration Unit and APHIS have been integrally involved in national, interagency efforts to eradicate rodents on islands for the conservation of critical habitats and the preservation of native flora and fauna. Work done by WS; the U.S. Department of the Interior's U.S. Fish and Wildlife Service (FWS), National Park Service (NPS), and U.S. Geological Survey; and many other national and international organizations has demonstrated that removing introduced rodents from island ecosystems can have beneficial effects on native organisms and birds. These efforts have led APHIS to submit three registration applications to EPA and one application to the Hawaii Department of Agriculture for applying anticoagulant rodenticides (diphacinone and brodifacoum) for the eradication of introduced rodents. EPA granted the first registration, for a diphacinone-based rodenticide, in July 2007. Registrations for the remaining products are expected in 2007 and 2008.

As a supplement to the body of work on rodent eradication, the Registration Unit, in cooperation with FWS, published a risk assessment for aerial diphacinone applications to Hawaiian forests.

The Registration Unit worked closely with two rodent-eradication efforts conducted by WS Operations, one on a small island off St. Johns in the U.S. Virgin Islands and one on Grassy Key in Florida. Both of these efforts were conducted under Emergency Use Permits granted by EPA. The goal of the Virgin Islands effort was to prepare habitat for the reintroduction of the endangered Virgin Islands boa. The brodifacoum bait proposed for registration was hand broadcast at the maximum application rate. Rats

were not observed on the island for at least 6 months. However, trapping efforts 1 year after application revealed that rats were once again on the island. Failure of this eradication effort may have been due to the complexity of the physical structure of the island (e.g., numerous crevices and cliff faces where bait was not adequately distributed) or because of reinvasion from the neighboring island 260 yards offshore. Scientists are currently collecting DNA samples from rodents in the treated area as well as on nearby islands to identify possible sources of reinvading rodents.

The Registration Unit has also assisted with the eradication of the recently introduced Gambian giant pouched rat in Florida. Because of poor containment by the pet trade, this rat became established on Grassy Key. The FWS, Florida Fish and Wildlife Conservation Commission, and Florida Department of Agriculture and Consumer Services were fearful of the impacts that the Gambian giant pouched rat could have on southern Florida and the entire gulf coast region if it became established on the Florida mainland.

Working with these agencies, NWRC helped obtain a quarantine emergency exemption from EPA to conduct an eradication effort using specially formulated zinc phosphide bait. Bait application for this eradication effort began in June 2007 and continues.

Rodenticide and Avicide Use for Agricultural Protection

Rodenticides continue to be a critical tool for the protection of agricultural resources. During FY07, the Registration Unit responded to requests from EPA for additional data for zinc phosphide and strychnine. The Registration Unit also responded to numerous requests for regulatory assistance from State agencies and WS. Many of the requests for assistance came from WS Operations personnel looking for help interpreting product labels to ensure that proposed applications were legal. However, State agriculture and pesticide agencies also requested label modification to meet growers' needs and requested scientific review of registration application material for vertebrate pesticide products proposed for registration within their States.

All APHIS strychnine products are now officially reregistered with EPA. These strychnine products are restricted to subterranean baiting for pocket gophers. The final data requirement for reregistration, a product storage stability study, was completed and submitted to EPA in FY 2007 by the Registration Unit, in cooperation with the NWRC Analytical Chemistry Project and the Pocatello Supply Depot.

At the request of EPA, APHIS voluntarily cancelled its two inactive product labels that allowed aboveground baiting. With the exception of one Nevada State registration, all aboveground uses of strychnine have been terminated.

APHIS worked with the State of California on two agricultural protection studies involving an avicide (DRC–1339) and a rodenticide (zinc phosphide). To secure a registration for using DRC–1339 in feedlots, the California EPA asked APHIS to conduct a storage stability study. In cooperation with the NWRC Analytical Chemistry Project and the Pocatello Supply Depot, the Registration Unit completed and submitted this study to the California EPA. With this product approval, all five of the APHIS DRC–1339 products are now registered for use in California.

The California Department of Food and Agriculture (CDFA) requested an amendment to the APHIS zinc phosphide concentrate label to include use with artichokes. CDFA provided all the data needed to ensure product efficacy and worker safety. APHIS submitted a label amendment request to EPA in April 2007. Use of this product in artichokes is expected to be approved in late 2007. In addition to this label modification, APHIS also submitted a request to EPA to allow use of this product in food and feed crops, including alfalfa, barley, dry beans, sugar beets, and wheat.

In FY 2007, the NWRC Registration Unit finished a multiyear cooperative study with a private rodenticide registrant, the NWRC Olympia Field Station, and the forest-products industry in the Pacific Northwest to develop a rodenticide product containing chlorophacinone for controlling mountain beavers in reforestation areas. The Registration Unit's role in this project involved obtaining two Experimental Use Permits from EPA to conduct efficacy trials and trials looking at the economics of baiting techniques. In

addition, the Registration Unit worked closely with the private rodenticide registrant to ensure a successful product registration. Through these efforts, the product received State registrations in Oregon and Washington.

Providing Wildlife Services

National Support

NWRC Begins Gull Monitoring Program—In April and May 2007, NWRC biologists from the Sandusky, OH, field station and the Illinois WS program banded and wing-tagged 580 nesting ring-billed gulls. Prior to the banding and tagging, Illinois WS personnel oiled ring-billed gull eggs in two nesting colonies in Chicago. This work was done at the City of Chicago's request in response to beach closures, over the past few summers, attributed to high bacteria counts thought to be from ring-billed gulls loafing and feeding at the beaches. From the tagging, biologists hope to determine whether the nesting colonies are the source of gulls contaminating the beaches, and whether oiling the eggs of nesting gulls causes them to abandon the area at the conclusion of the nesting season. Beaches in Chicago were monitored throughout the summer to determine if marked gulls use the beaches and if there is a difference in beach use between gulls that had their eggs oiled and those that did not. The data are currently being evaluated and will be published in 2008.

Biologists Conduct Laughing Gull Nest Survey—In June 2007, biologists from the NWRC Sandusky field station, the New York WS program, the NPS, the Port Authority of New York and New Jersey, and other groups conducted a ground-truth census of the laughing-gull nesting colony in a 600-acre marsh complex in Jamaica Bay near New York City. The marshes, on NPS property, are adjacent to JFKIA, where gull–aircraft collisions have posed a serious bird-strike problem. All gull nests were counted in ten 100- x 100-foot ground-truthing plots established in the marsh. Aerial photographs will be taken of the entire marsh complex, and researchers will obtain a nest census of the marsh by counting all nests, including those in the ground-truth plots, on the enlarged aerial photographs. Counts on the photographs of the ground-truth plots will allow for determining the accuracy of the aerial census. Results of a previous census indicate that the colony contained about 2,500 nests in 2006, a decline of 66 percent from the 7,600 nests counted in 1990.

Management programs by WS at JFKIA from 1991 through 2006 have reduced laughing gull–aircraft collisions by 76 to 99 percent annually compared to 1988–90, when the airport averaged more than 150 strikes per year. Although the local population of laughing gulls next to JFKIA has declined as a result of these management actions, the regional population from Virginia to Maine has shown an increase during 1990 through 2006, based on analysis of North American Breeding Bird Survey data. This NWRC-developed census technique is a critical component of the gull management program at JFKIA and may be of use in other situations where colonial-nesting waterbirds conflict with human activities.

Exotic Wildlife Rapid Response Team Initiated in Florida—In August 2007, two biologists from the NWRC Gainesville field station and one biologist from Florida WS met with representatives from various State, Federal, and tribal entities to form a Rapid Response Task Force for invasive animal species that threaten the Everglades ecosystem. This meeting was a result of the Everglades Cooperative Invasive Species Management Area Summit held in Miami July 25–27, 2007, where groundwork was laid for cooperative education, research, and funding to address management of invasive animals. At the Rapid Response Team meeting, WS was nominated as the primary response agency for the eradication of newly detected invasive wildlife species.

Cooperative agreements are being developed to facilitate yearly funding of the necessary management and research activities. The long-term goal of the team is to extend coverage beyond south Florida to other areas of the State with invasive wildlife conflicts.

NWRC Scientists Consulted on Predator-Proof Fencing—In September 2006, two researchers from the NWRC Hilo, HI, field station were consulted by the FWS on plans to erect a 45-ha predator-proof fence. The researchers had previously provided technical assistance in constructing and testing various fence designs. The proposed placement of the fence is designed to protect endangered birds, including the Hawaiian crow. The researchers noted that placement of the fence on lava substrates may provide fissures that allow rodents to bypass the fence. Final plans for the fence are still being discussed.

International Cooperation

NWRC Scientists Consult With Mexican Scientists on Bat Control Program To Protect Cattle—In September 2006, scientists from APHIS' International Services Program in Mexico City and the Mexican National Campaign of Paralytic Rabies in Bovines (SAGARPA) visited NWRC in Fort Collins. The scientists are collaborating with NWRC researchers on methods to control bat rabies transmission to cattle in Mexico.

NWRC Scientists Participate in Avian Influenza Training in Cambodia—In January 2007, USDA conducted a cooperative workshop with the Cambodian Wildlife Protection Office (WPO) in Sihanoukville, Cambodia. The primary objective of the course was to train 24 WPO biologists to respond to wild bird morbidity or mortality events. Five WS personnel from NWRC and the WS National Wildlife Disease Program instructed participants on wild bird capture, necropsy, and AI sampling techniques using classroom and field exercises. The success of the training was well demonstrated during the last field exercise that required the newly trained staff to respond to a mock morbidity–mortality event. Staff accurately assessed the status of the event and then made an appropriate response, wearing protective equipment to gather birds and collect samples to test for potential AI.

NWRC Hosts Chinese International Visitor Leadership Program Scientists—This leadership program is funded by USDA and hosted by the U.S. Meat Export Federation for visiting scientists from the People's Republic of China. The program focuses on U.S. implementation of the World Trade Organization agreement on the application of sanitary and phytosanitary measures. This year's program addressed pathogens and residues in food exports. The Chinese scientists toured a variety of U.S. laboratories during the course of the summer program. NWRC headquarters in Fort Collins was identified by USDA as one of the laboratories to be included in the training program.

In July 2007, Chinese scientists visited NWRC. Fifteen Chinese scientists were given a tour of the NWRC headquarters facilities and an overview of NWRC research programs and activities. Of particular interest to the Chinese delegation was NWRC research relating to diagnostic methods development, environmental decontamination, and vaccine development for prions responsible for chronic wasting disease. The delegation was also interested in NWRC research relating to development of AI diagnostic methods for environmental samples and models for spatial sampling.

Earlier in February 2007, NWRC scientists hosted Mr. He Yubang, Deputy Director of the Qinghai Lake Nature Reserve in China. The reserve is a key migratory-bird nesting area and receives between 60,000 and 100,000 birds between the months of March and October each year. In May 2005, 6,000 birds at the lake died of H5N1 AI—the same strain of bird flu that was found in birds as far away as Russia, Turkey, and several other Western European countries. Mr. He visited NWRC to learn more about surveillance and monitoring of animals and wildlife diseases. He received an overview of NWRC research and later met with bird and wildlife-disease research scientists, who discussed bird research activities and NWRC's AI surveillance program.

In July 2007, NWRC Wildlife Disease Research Program scientists hosted Dr. Ma Guiping, Director of the Bovine Spongiform Encephalopathy (BSE) Test Laboratory and Technical Center, Beijing, China. Dr. Ma is a scientific advisor to the Chinese government on animal disease prevention and control. Dr. Ma visited NWRC to learn more about the Center's research on CWD, how he could use the Center's findings to prevent CWD introduction into China, and how NWRC's work could be useful to him as related to BSE. NWRC scientists discussed several of their studies with Dr. Ma and highlighted the capabilities of our facilities.

Collaboration in Australia To Evaluate Mark–Recapture Population Estimation—Mark–recapture is the most common method in wildlife research and management for estimating abundance of small-mammal populations. As part of an ongoing collaboration on mark–recapture estimation, government researchers with Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO) visited NWRC in November 2006 to discuss mark–recapture results from an intensive, multiyear rodent

study from Bribie Island, Australia. Mark–recapture requires much consideration in its application and interpretation of its results.

Collaboration on Indexing Dingoes and Coexisting Species in Queensland, Australia, To Examine Impacts of Baiting Programs—An NWRC scientist is collaborating with a researcher from the Queensland Department of Natural Resources and Mines to calculate passive tracking indices for dingoes and 19 other species from three shires in Queensland. Data have been collected in each of the three shires for 4 years. Passive tracking index values will be assessed for both baited and unbaited areas within each shire before and after baiting programs. The results will help discern the effects the bait programs have on dingo populations, the effects the bait programs have on other species, and the effects the dingo removal has on the other species.

Scientists Present AI Workshop in Laos—In March 2007, WS hosted a 3-day workshop in Vientiane, Laos, on surveillance techniques for the detection of HPAI virus in wild birds. The goal of the workshop was to increase the understanding of AI and help develop a framework for a Laos National Surveillance System for AI in wild birds. In addition to learning capture, handling, and sampling techniques for gathering AI samples in wild birds, participants were trained in laboratory diagnostics and data management. The workshop was similar to one conducted in Phnom Penh, Cambodia, in March 2006.

Valuing and Investing in People

NWRC values and invests in its people to support their professionalism, competency, and innovation as Federal leaders of wildlife damage management.

NWRC Biologist Receives APHIS Administrator's Civil Rights Award—Susan Jojola, a biologist with NWRC's Mammals Research Program, was honored on October 26, 2006, with the USDA–APHIS Civil Rights Award for her efforts as a Tribal Liaison for the APHIS Native American Working Group. In that role, Jojola has facilitated partnerships and information exchange between APHIS and Native Americans on topics such as AI surveillance, emergency response and preparedness procedures, and surveillance for chronic wasting disease in deer and elk. She has also served as a mentor providing career guidance to a Native American high school student in Fort Collins, CO.

NWRC Researchers Submit Winning Posters—Dennis Kohler and Paul Oesterle, both researchers at NWRC who are pursuing graduate degrees at CSU, received awards and recognition for their research at the 2006 Zoonotic Disease Colloquium at the university. The two winning posters:

Kohler, D.; Bowen, R.A.; Dunbar, M.R.; McLean, R. G. Duration of protective immunity in raccoons *(Procyon lotor)* immunized with oral rabies virus vaccine V-RG.

Oesterle, P.; Hall, J.; McLean, R. G.; Clark, L. Cliff swallows as a sentinel in West Nile virus surveillance.

Biologist Honored at Florida Wildlife Society Meeting—NWRC biologist John Humphrey was honored with an award in appreciation of his dedication, support, and promotion of the Florida Chapter of The Wildlife Society during its ninth annual spring conference in St. Petersburg, FL.

World Rabies Day Walk—On September 7, 2007, about 40 NWRC employees participated in a 4-km Fun Run/Walk in honor of World Rabies Day. Each participant received a commemorative T-shirt and information regarding the WS' National Rabies Management Program and NWRC rabies research.

The mission of World Rabies Day is to raise awareness about how human and animal rabies impact world health, how easy the disease is to prevent, and how its main global sources can be eliminated. Sponsored events occurred worldwide, including educational programs in Africa, dances in Brazil, special television programs in Asia, and races run competitively in Europe.

2006 Publication Awards

NWRC's Publication Awards Committee selected these two journal articles as outstanding research publications for 2006:

Blejwas, K. M.; **Williams, C. L.;** Shin, G. T.; McCullough, D. R.; **Jaeger, M. M.** Salivary DNA evidence convicts breeding male coyotes of killing sheep. Journal of Wildlife Management 70: 1087–1093.

Kitchen, A. M.; **Gese, E. M.;** Waits, L. P.; Karki, S. M.; Schauster, E. R. Multiple breeding strategies in the swift fox, *Vulpes velox.* Animal Behaviour 71: 1029–1038.

Both publications highlight the value of genetic testing as a new tool in wildlife damage research. Kitchen and coworkers used a combination of genetic analyses and observational data to closely examine the genetic relationships and social interactions within a population of free-ranging swift foxes. The authors documented, for the first time, extrapair paternity and mate switching in swift foxes. The paper by Blejwas and coworkers describes the use of a DNA analytical technique that permits the identification of livestock-killing predators and distinguishes between individual animals that killed wildlife and those that merely scavenged wildlife.

Supporting Student Research

Ecological Effects of Coqui Frogs—Utah State University graduate student Nathania Tuttle completed her master's thesis on the potential ecological effects of coqui frogs on Hawaiian invertebrates, plants, and forest nutrient dynamics. Her research was supported by NWRC. Coqui frogs, native to Puerto Rico, have rapidly spread across the Hawaiian islands in the 15 years since they were first documented there. Frog populations in Hawaii have exceeded 55,000 per hectare. Tuttle found that the frogs were affecting plant growth and that they may also affect insect communities. Typically, predators may affect plants by limiting herbivores. However, she found that frogs were recycling nutrients by eating a lot of insects, converting them into accessible nutrients, and then releasing the nutrients for plants to absorb. Her research is critical because nutrient availability for plants may influence the competitive balance among native and invasive plants.

Student Receives Award for Research on Coyote Lure Operative Devices—Julia Figueroa, a biological science technician at NWRC and a CSU Hughs Undergraduate Research Scholar, was awarded honors for her poster presentation entitled "Obtaining Genetic Data From Activated Coyote Lure Operative Devices" at the CSU College of Natural Sciences' "Celebrate Undergraduate Research and Creativity Showcase." Figueroa's poster highlights her work contributing to the development of methods for extracting DNA from coyote lure operative devices (CLODs) to identify individual coyotes or nontarget species.

CLODs are a management tool being investigated by NWRC. They orally deliver active compounds (e.g., contraceptives, vaccines, marking agents, and toxicants) to coyotes. Other uses include censusing and monitoring wild populations of coyotes from genetic data collected from activated (chewed) CLODs.

Staff Changes

Dr. Dale Nolte Accepts Position as WS International Liaison—In April 2007, Dale Nolte, NWRC's Mammal Research Program Manager, accepted a new position with the WS Wildlife Disease Coordinator's office to focus on WS' international training and outreach development. Nolte will be detailed to APHIS–International Services in Bangkok, Thailand, to assist in AI wildlife-surveillance training and capacity building for APHIS and WS. Bangkok is the regional office for International Services' AI activities in Southeast Asia.

Dr. Scott Barras Becomes Virginia WS State Director—In May 2007, Scott Barras became the new State Director for the Virginia WS program. Barras has served as the field station leader of the NWRC Starkville, MS, field station since 2002. In that capacity, he developed research projects related to understanding and reducing the conflicts between fish-eating birds and aquaculture producers. From 1999 to 2002, he served as a Research Wildlife Biologist at the Sandusky, OH, field station, where he developed and conducted research aimed at reducing the factors that contribute to wildlife–aircraft collisions. He is currently an Assistant Adjunct Professor with the Department of Wildlife and Fisheries Sciences at Mississippi State University and is a certified wildlife biologist with the Wildlife Society.

NWRC Research Chemist Stationed at Monell Chemical Senses Center—Dr. Bruce Kimball, a research chemist with NWRC, has been assigned to a duty station at the Monell Chemical Senses Center. Kimball will continue to report directly to the project leader for "Development of Chemistry, Biochemistry, and Computational-Based Tools for Wildlife Damage Management" project within NWRC's Invasive Species and Technology Development Research Program.

NWRC and the Monell Chemical Senses Center have a long history of working together, and Kimball's move allows NWRC to capitalize on the chemosensory expertise available at Monell. There are a number of potential research areas that could be investigated through this collaboration, including chemosensory evaluation of baits for vaccine delivery, tools to reduce urban deer browsing, evaluation of attractants, repellants, physiological responses to avoidance stimuli, and chemosensory evaluation of baits for invasive species eradication.

Retirements

Jean Bourassa retired from NWRC in August 2007, after 34 years with the Center and its predecessor organization, the Denver Wildlife Research Center. He worked in the electronics lab designing and producing electronic instrumentation for wildlife research, including telemetry designs and attachment techniques. In 1996, upon relocation to Fort Collins, he added duties working on GIS data.

Since **John Cummings** started working for WS in 1974, in his role as a Supervisory Research Wildlife Biologist, he has been instrumental in NWRC's efforts to develop new tools and techniques for reducing blackbird damage to rice and other crops. Mr. Cummings worked on methyl anthranilate as a goose repellant for turf; aerial mass-marking of blackbirds in rice fields to determine movements and distribution in southern rice-growing areas; a “take" model to estimate take of blackbirds with DRC-1339 on staging areas; Aqua-blok™ as a covering material for contaminants at Eagle River Flats in Alaska; and capture techniques such as mini-cannons and nets, the air cannon, the groove-cock, and the night-hawker to capture birds.

Since **Marge Goodall** joined NWRC in 1989, she has been the supervisor of the Analytical Services group (part of the Invasive Species and Technology Development Research Program). She persevered through the chemistry lab remodelling project at the Denver Wildlife Research Center and the move from Denver to two different Fort Collins locations. Marge retired in April 2007.

Paige Groninger began work in the fiscal office of the Denver Wildlife Research Center in 1964. She then obtained her degree in math and computer science under an upward mobility program and began working on a new career path as a computer programmer. She has helped numerous NWRC scientists through her expertise in SAS databases and programming. She retired in March 2007.

Joyce Jones has retired after 23 years of civilian Government service. She served as NWRC’s Administrative Officer since 2003. In this role, she had oversight responsibilities of administrative, facilities, Information Technology, and security sections of the Center. In retirement, Ms. Jones plans to travel overseas, spend more quality time with her grandchildren, and pursue her hobbies of birding, golfing, volunteering, reading, and relaxing.

Fred Knowlton worked for 43 years at NWRC focusing on predator behavior and ecology. He initially started at the Denver Wildlife Research Center, but was transferred to Utah in 1972. Dr. Knowlton was primarily responsible for the development and construction of the predator research facility and field station at Logan, UT. In retirement, he plans to continue working with the field station staff and Utah State University students.

Charlotte Miller-Charlotte retired from her position as WS’ Information Technology Project Leader and Training Coordinator in December 2007. She also served as the National Wildlife Services Equal Employment Opportunity Advisory Committee Chair working in the areas of employee recruitment, training, and outreach and was active on the Board of Directors for the Combined Federal Campaign of Larimer County. Dr. Miller plans to spend more time with her three children, five grandchildren, and one great grandchild.

Information and Communication

Information Services

TITLE: Enhancing Information and Communication

GOAL: Collect and analyze internal and external information to monitor and enhance program effectiveness. Communicate internally and externally to accomplish NWRC's mission and to build an understanding of the Federal role in wildlife damage management.

Managing Vertebrate Invasive Species Symposium—On August 7 through 9, 2007, NWRC hosted an international symposium in Fort Collins on managing invasive birds, mammals, reptiles, and amphibians. About 160 people attended. The goal of the symposium was to highlight research, management, and public education campaigns associated with invasive wildlife. Speakers at the plenary sessions provided national and international perspectives and summaries of invasive species problems. More than 50 additional speakers, from the United States and 8 foreign countries, presented information on economic and other impacts of invasive species; the regulatory environment; the need for coordination of efforts among agencies and nations; pathways and means-of-entry for invasives; and detection, prevention, eradication and monitoring of individual species. An additional 20 technical posters were displayed. Smaller gatherings, focusing on specialized topics, followed the conference. NWRC employees provided tours of the Center's headquarters, including the new ISRB.

Economics of Wildlife Damage Management Leaflet—NWRC's Economic Research Project and the use of economics in wildlife damage management are highlighted in a new leaflet entitled "Solutions Through Science: Economics of Wildlife Damage Management." The full-color publication is aimed at WS Operations and wildlife managers who are interested in conducting economic assessments.

Library—While the library's catalog holdings increased by 378 items in 2007, its journal print subscriptions were reduced by about 20 percent as serial online access increased through the USDA's Digital Desktop service. A library-materials inventory has been implemented to identify and locate items checked out by NWRC staff over the last 10 years.

Three new taxidermic displays have been added to the library. Visitors can now view male and female red-winged blackbirds in a cattail marsh arrangement, an invasive BTS, and an invasive Gambian giant pouched rat. The displays are used in tours and as educational tools by staff members.

Library staff contributed to several new NWRC outreach products. The library coordinated a Center-wide effort that resulted in production of 11 new wall posters explaining NWRC research programs and various invasive species problems. These posters were used as educational materials in the newly opened ISRB. The posters were updated later in the year to reflect organizational changes. Library staff also coordinated a new "Solutions Through Science" leaflet on wildlife damage management economics research at NWRC. This publication was released as a USDA Program Aid in August. Library staff redesigned the Annual Publication List, implementing new NWRC graphics.

Information Services Unit staff borrowed, photocopied, or downloaded more than 1,000 items from other libraries in response to information requests from the WS program and lent 142 items in return. Additionally, staff photocopied nearly 2,273 inhouse journal articles, reports, and NWRC-authored reprints for distribution to researchers and WS Operations staff. More than 1,000 copies each of the NWRC-produced annual accomplishments report, Research Update, and Publication List were mailed. More than 10,000 other NWRC or WS information products were distributed, including children's activity sheets, factsheets, and information packets.

NWRC Web Site—Extensive work was directed toward reformatting and organizing NWRC's Web-based information into the new USDA-required Web template. In addition to updating and reorganizing project and program content pages, the NWRC Webmaster renamed several hundred photos and resized them to meet new guidelines.

Archives—The mission of the NWRC Archives/Records Management Unit is to collect, preserve, and make available the research records and materials that document the history of NWRC. To that end, much of the Unit's work in the past year focused on tasks to organize and make accessible historical records. The Unit also highlighted, in exhibits and staff-outreach activities, materials that tell the story of NWRC's research.

The Sixth Annual NWRC Archives Week, from October 1 through 5, 2007, was a time to internally publicize NWRC archival records. An open house in October featured exhibits and a presentation on the Center's telemetry research.

Archives staff developed and displayed a hallway exhibit on NWRC's rodent research. The exhibit focused on the Center's past and present rodent research, including current work on the eradication of the Gambian giant pouched rat in Florida. The hallway exhibit provides an opportunity to highlight both current and past research to visitors and staff.

Trapping Oral History Initiative—This initiative, the brainchild of NWRC's Dr. John Shivik, began in 2005 as a WS collaborative effort between Operations and the NWRC. With its focus on interviewing retired and current WS employees, the initiative emphasizes the trapping and hunting aspects of the program. The idea of the interviews grew out of conversations between John and field personnel, who noted the loss of knowledge as people retired or passed on.

In 2005 and 2006, Nancy Freeman and Diana Dwyer, both members of NWRC's Information Services unit, conducted 24 interviews, mainly in the West. Additional interviews are planned for covering the eastern part of the United States in 2007–08 if funding becomes available. The transcribed interviews will become part of the NWRC Archives.

The overriding similarity in the interviews is that the current and retired employees loved their work. They may not have liked everything about it, but overwhelmingly, they say they'd have worked for no one else and would not have done any other type of work.

In the words of Dale Booth, current Utah WS employee, ". . . [I]t's been a good job. It's been my life, you know, I mean, that's what I've enjoyed. After working 38 and a half years, if I could be young again, I'd do the very same thing."

Media Relations—In 2007, NWRC and APHIS Legislative and Public Affairs staff responded to roughly 89 media and community requests for information regarding WS research activities. NWRC also hosted three reporters at its headquarters office in Fort Collins. Visits included tours of the facilities and interviews with experts on the topics of wildlife contraceptives, invasive species, and product registration.

Seminars

The NWRC seminar program offers a valuable forum for the exchange of ideas among Center staff, field station personnel, visiting scientists, and WS Operations staff. During 2007, NWRC hosted about 17 seminars, including presentations by speakers from various universities and foreign wildlife organizations, NWRC headquarters and field staff, and potential candidates for employment. Topics included economic assessments, bear–human conflicts, wildlife toxicology, and wildlife diseases. The following table lists the 2007 presentations.

Speaker	Affiliation	Title
Camilla Myers	Wildlife Research, CSIRO Publishing Co.	Wildlife Research: New Directions and Opportunities for Publication
Teresa Howes, Gail Keirn	APHIS Legislative and Public Affairs	Standing on Top of the World: Lessons Learned From an Interagency Media Event in Barrow, AK

Presentations by NWRC scientists and visitors during 2007

Teresa Howes, Gail Keirn	APHIS Legislative and Public Affairs	Standing on Top of the World: Lessons Learned From an Interagency Media Event in Barrow, AK
Charles R. Brown	University of Tulsa	Ecology of Buggy Creek Virus, an Arbovirus in the Western Equine Encephalomyelitis Virus Complex, in Western Nebraska
George Linz, Jeff Homan	NWRC, Bismarck, ND	Current Research Topics at the North Dakota Field Station and Starling Research in Urban Environments
Bob Kling	CSU	Economic Assessment of Canada Goose Management Efforts in the Puget Sound Area
John Johnston	NWRC, Fort Collins	NWRC Sabbatical Seminar: PBPK Modeling and Piedmont Blues
Darlene Blaney, Scott Peterson, Mike Moxcey	WS Information Technology Support Center	Using SQL Builder To Access MIS Data
Stewart Breck	NWRC, Fort Collins	The Emergence of Bear–Human Conflict: Understanding the Bear Necessities and Development of Carrots and Sticks
Jeff Root	NWRC, Fort Collins	Sabbatical Seminar: A Search for Rodent-Borne Viruses in East Africa
Gary Witmer, Rick Engeman	NWRC, Fort Collins	Big Effort To Rid Florida of Big Rats Before They Become a Big Problem
Geoffrey Wahungu	Moi University, Eldoret, Kenya	The Status of Human–Wildlife Conflict in Kenya
Erik Osnas	University of Wisconsin–Madison	Spatial Epidemiology of Chronic Wasting Disease in Wisconsin
Seth Britch	USDA Agricultural Research Service	Rift Valley Fever Virus, a Potential Emerging Threat to Wildlife, Livestock, and Humans in the U.S.–A Review of Issues and Concerns, and a GIS Early-Warning System for RVF Vectors
John Shivik	NWRC, Logan, UT	Logan, UT, Field Station Update, 2007
Susan Shriner	NWRC, Fort Collins	An Epidemiological Network Model for AI in Backyard Poultry in Colorado
Barnett Rattner	U.S. Geological Survey	Wildlife Toxicology Studies at the Patuxent Wildlife Research Center
Susan Wilzer, Tanya Tanner	National Agricultural Library	DigiTop Overview

Meetings, Workshops, and Conference Presentations

To help promote collaboration and the exchange of scientific information, NWRC scientists often present at, host, or attend national and international scientific meetings. Some of the meetings recently attended or hosted by NWRC scientists include the follwing:

American Association of Zoo Veterinarians Annual Conference
Society for Environmental Toxicology and Chemistry Meeting
National Tribal Invasive Species Conference
Engineering Safety and Maintenance for Overhead Lines Conference
American Chemical Society National Meeting
Annual Wyoming Weed and Pest Conference
Aquaculture American 2005
Association for Chemoreception Sciences Annual Meeting
Bird Strike Committee–U.S.A./Canada
Electric Power Research Institute
International Mammalogical Congress
International Rodent Symposium
International Society of Chemical Ecology
International Symposium on Zoo and Wildlife Disease
International Wildlife Fertility Control Workshop
Managing Invasive Vertebrate Species
Michigan Annual Bovine TB Conference
Midwest Fish and Wildlife Conference
National Reindeer Herders Conference
Oregon Forest Industries Council Annual Meeting
Prion 2006: Strategies, Advances, and Trends Toward Protection of Society
Society for Environmental Toxicology and Chemistry–Europe
Special Libraries Association Meeting
Sunflower Grower Meeting
Texas Cattle Fever Meeting
United States Animal Health Association
Washington Forest Protection Association
Western States and Provinces deer and elk workshops
Western States Nutria Workshop
Wildlife Damage Management Symposium
Wildlife Disease Association Meeting
Wildlife Society Meeting

Publications

Authors' names printed in **boldface** type are NWRC employees.

Arjo, W. M. 2007. Mountain beaver: a primitive fossorial rodent. In: Begall, S.; Burda, S.; Schleich, C. E., eds. Subterranean rodents: news from underground. Berlin, Germany: Springer–Verlag: 309–321.

Arjo, W. M.; Nolte, D. L. 2007. Mountain beaver home ranges, habitat use, and population dynamics in Washington. Canadian Journal of Zoology 85: 328–337.

Arjo, W. M.; Nolte, D. L. 2006. Boomer or bust: managing a Pacific Northwest pest species. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 181–186.

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

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

Atwood, T. C.; **Gese, E. M.**; Kunkel, K. E. 2007. Comparative patterns of predation by cougars and recolonizing wolves in Montana's Madison Range. Journal of Wildlife Management 71: 1098–106.

Atwood, T. C.; **VerCauteren, K. C.; DeLiberto, T. J.; Smith, H. J.; Stevenson, J. S.** 2007. Coyotes as sentinels for monitoring bovine tuberculosis prevalence in white-tailed deer. Journal of Wildlife Management 71: 1545–54.

Avery, M. L.; Humphrey, J. S.; Tillman, E. A.; **Milleson, M. P.** 2006. Responses of black vultures to roost dispersal in Radford, Virginia. In: Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 239–243.

Avery, M. L.; Keacher, K. L.; Tillman, E. A. 2006. Development of nicarbazin bait for managing rock pigeon populations. In: Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 116–120.

Balliette, J.; O'Brien, J. M.; **Eisemann, J. D.** 2006. Efficacy of strychnine and zinc phosphide cabbage baits in controlling ground squirrels in Diamond Valley, Nevada. In: Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 151–155.

Bangs, E.; Jiminez, M.; Niemeyer, C.; Fontaine, J.C.M.; Krischke, R.; Handegard, L.; **Shivik, J.**; Sime, C.; Nadeau, S.; Mack, C.; Smith, D. W.; Asher, V.; Stone, S. 2006. Non–lethal and lethal tools to manage wolf–livestock conflict in the northwestern United States. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 7–16.

Beasley, J. C.; **DeVault, T. L.**; Retomsa, M. L.; Rhodes, O. E., Jr. 2007. A hierarchical analysis of habitat selection by raccoons in northern Indiana. Journal of Wildlife Management 71(4): 1125–1133.

Bentler, K. T.; Hall, J. S.; Root, J. J.; Klenk, K.; **Schmit, B.; Blackwell, B. F.**; Ramey, P. C.; **Clark, L.** 2007. Serologic evidence of West Nile virus exposure in North American mesopredators. American Journal of Tropical Medicine and Hygiene 76: 179.

Berentsen, A. R.; Johnston, J. J.; Mauldin, R. E.; Schmidt, R. H. 2006. Using the CLOD to deliver pentachlorobenzene to coyotes *(Canis latrans).* In: Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 277–281.

Berger, K. M.; **Gese, E. M.** 2007. Does interference competition with wolves limit the distribution and abundance of coyotes? Journal of Animal Ecology 76:1075–85.

Blackwell, B. F.; Avery, M. L.; Watts, B. D.; Lowney, M. S. 2007. Demographics of black vultures in North Carolina. Journal of Wildlife Management 71(6): 1976–1979.

Blackwell, B. F.; Seamans, T. W.; Washburn, B. E. 2006. Use of infrared technology in wildlife surveys. In: Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 467–472.

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

Blejwas, K. M.; **Williams, C. L.**; Shin, G. T.; McCullough, D. R.; **Jaeger, M. M.** 2006. Salivary DNA evidence convicts breeding male coyotes of killing sheep. Journal of Wildlife Management 70: 1087–1093.

Breck, S. W. 2006. Sampling rare or elusive species: concepts, designs, and techniques for estimating population parameters: a review. Wildlife Society Bulletin 34: 897–898.

Breck, S. W.; Lance, N.; Callahan, P. 2006. A shocking device for protection of concentrated food sources from black bears. Wildlife Society Bulletin 34: 23–26.

Bucknall, J.; Suckow, J.; Miller, E.; **Seamans, T.**; Stern, C.; Trumbull, V. L. 2006. USDA APHIS Wildlife Services employs cooperative partnerships and use of alternative capture methods to retrieve flighted birds affected by oil on the Delaware River. In: The effects of oil on wildlife: proceedings of the 8th international conference; 3–5 August 2005; St. John's, Newfoundland, Canada. Newark, DE: Tri–State Bird Rescue & Research, Inc.: 29–36.

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

Campbell, T. A.; Long, D. B. 2007. Species–specific visitation and removal of baits for delivery of pharmaceuticals to feral swine. Journal of Wildlife Diseases 43(3): 485–491.

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

Caut, S.; Casanovas, J. G.; Virgos, E.; Lozano, J.; **Witmer, G. W.**; Courchamp, F. 2007. Rats dying for mice: modeling the competitor release effect. Australian Ecology 32: 858–868.

Clark, L.; Hall, J.; McLean, R.; Dunbar, M.; Klenk, K.; Bowen, R.; Smeraski, C. A. 2006. Susceptibility of greater sage–grouse to experimental infection with West Nile virus. Journal of Wildlife Diseases 42: 14–22.

Cummings, J. L.; York, D. L.; Primus, T. M.; Engeman, R. M.; Mauldin, R. E. 2006. Effectiveness of Flight Control™ to reduce damage to lettuce seedlings from horned larks. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 225–227.

Curtis, P. D.; Richmond, M. E.; **Miller, L. A.**; Quimby, F. W. 2007. Pathophysiology of white-tailed deer vaccinated with porcine zona pellucida immunocontraceptive. Vaccine 25: 4623–4630.

DeVault, T. 2007. Oneida Lake's cormorant harassment program frequently asked questions. Oneida Lake Bulletin Summer 2007: 3–4.

DeVault, T. L.; Beasley, J. C.; Humberg, L. A.; MacGown, B. J.; Retamosa, M. I.; Rhodes, O. E, Jr. 2007. Intrafield patterns of wildlife damage to corn and soybeans in northern Indiana. Human–Wildlife Conflicts 1(2): 205–213.

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

Eisemann, J. D.; Swift, C. E. 2006. Ecological and human health hazards from broadcast application of 0.005% diphacinone rodenticide baits in native Hawaiian ecosystems. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 413–433.

Eisemann, J. D.; Fagerstone, K. A.; O'Hare, J. R. 2006. Wildlife contraceptives: a regulatory hot potato. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 63–66.

Engeman, R. M. 2006. A surprising observation of spiny softshell climbing ability. Journal of Kansas Herpetology No. 19: 9–10.

Engeman, R. M.; Engeman, M. A. 2006. *Bufo woodhousii* (Woodhouse's toad) survival. Herpetological Review 37: 442–443.

Engeman, R. M.; Evangilista, P. 2006. Investigating the feasibility of a passive tracking index for monitoring wildlife in the Lower Omo Valley, Ethiopia. African Journal of Ecology 45: 184–188.

Engeman, R. M.; Constantin, B. U.; **Shwiff, S. A.**; Smith, H. T.; **Woolard, J.**; **Allen, J.; Dunlap, J.** 2007. Adaptive and economic management methods for feral hog control in Florida. Human–Wildlife Conflicts 1(2): 178–185.

Engeman, R. M.; Stevens, A.; **Allen, J.; Dunlap, J.**; Daniel, M.; Teague, D.; Constantin, B. 2007. Feral swine management for conservation of an imperiled wetland habitat: Florida's vanishing seepage slopes. Biological Conservation 134: 440–446.

Engeman, R. M.; Woolard, J.; Smith, H. T.; **Bourassa, J.**; Constantin, B. U.; Griffin, D. 2007. An extraordinary patch of feral hog damage in Florida before and after initiating hog removal. Human–Wildlife Conflicts 1(2): 271–275.

Engeman, R. M.; Stevens, A.; **Allen, J.; Dunlap, J.**; Daniel, M.; Teague, D.; Constantin, B. 2007. Feral swine management for conservation of an imperiled wetland habitat: Florida's vanishing seepage slopes. Biological Conservation 134: 440–6.

Engeman, R. M.; Smith, H. T.; Kaufmann, G. S. 2007. *Gopherus polyphemus* (Gopher tortoise) mortality. Herpetological Review 38: 331–2.

Fagerstone, K. A.; Miller, L. A.; Bynum, K. S.; Eisemann, J. D.; Yoder, C. 2006. When, where and for what wildlife species will contraception be a useful management approach? In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 45–54.

Forcey, G. M.; **Linz, G. M.**; Thogmartin, W. E.; Bleier, W. J. 2007. Influence of land use and climate on wetland breeding birds in the Prairie Pothole region of Canada. Canadian Journal of Zoology 85: 421–436.

Galligan, E. W.; **DeVault, T. L.**; Lina, S. L. 2006. Nesting success of grassland and savanna birds on reclaimed surface coal mines of the midwestern United States. Wilson Journal of Ornithology 118: 537–546.

Gantz, G. F.; Stoddart, L. C.; **Knowlton, F. F.** 2006. Accuracy of aerial telemetry locations in mountainous terrain. Journal of Wildlife Management 70: 1809–1812.

Gehring, T. M.; Hawley, J. E.; Davidson, S. J.; Rossler, S. T.; Cellar, A. C.; Schultz, R. N.; Wydeven, A. P.; **VerCauteren, K. C.** 2006. Are viable non-lethal management tools available for reducing wolf–human conflict? Preliminary results from field experiments. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 2–6.

Gese, E. M. 2006. Depredation management techniques for coyotes and wolves in North America: lessons learned and possible application to Brazilian carnivores. In: Morato, R. G.; Rodriques, E.; Eizirik, E.; Mangini, P. R.; Azevedo, F.C.C.; Marinho–Filho, J. Manejo e conservação de carnivoros neotropicais. Sao Paolo, Brazil: Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renovavis: 193–214.

Gionfriddo, J. P.; Eisemann, J. D.; Sullivan, K. J.; Healey, R. S.; **Miller, L. A.** 2006. Field test of GonaCon immunocontraceptive vaccine in free-ranging female white-tailed deer. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 78–81.

Green, M. C.; Waits, J. L.; **Avery, M. L.; Tobin, M. E.**; LeBerg, P. L. 2006. Microsatellite variation of double-crested cormorant populations in eastern North America. Journal of Wildlife Management 70: 579–583.

Gregg, M. A.; **Dunbar, M. R.**; Crawford, J. A. 2007. Use of implanted radiotransmitters to estimate survival of greater sage-grouse chicks. Journal of Wildlife Management 71(2): 646–51.

Griffing, S. M.; Kilpatrick, A. M.; **Clark, L.**; Marra, P. P. 2007. Mosquito landing rates on nesting American robins (*Turdus migratorius*). Vector Borne and Zoonotic Diseases 7: 437–43.

Hartin, R. E.; Ryan, M. R.; **Campbell, T. A.** 2007. Distribution and disease prevalence of feral hogs in Missouri. Human–Wildlife Conflicts 1(2): 186–191.

Harvey, J. W.; **Dunbar, M. R.**; Norton, T. M.; Yabsley, M. J. 2007. Laboratory findings in acute *Cytauxzoon felis* infection in cougars (*Puma concolor couguar)* in Florida. Journal of Zoo and Wildlife Medicine 38: 285–91.

Henke, S. E.; Fedynich, A. M.; **Campbell, T. A.** 2007. Wildlife disease management: an insurmountable challenge? In: Fulbright, T. E.; Hewitt, D. G., eds. Wildlife science: linking ecological theory and management applications. Boca Raton, FL: CRC Press: 279–294.

Jaeger, M. M.; Haque, E.; Suttana, P.; **Bruggers, R. L.** 2007. Daytime cover, diet and space-use of golden jackals *(Canis aureus)* in agro-ecosystems of Bangladesh. Mammalia 71(1/2):1–10.

Johnston, J. J.; Snow, J. L. 2007. Population-based fish consumption survey and probabilistic methylmercury risk assessment. Human and Ecological Risk Assessment 13: 1214–1227.

Johnston, J. J.; Cummings, J. L.; Kohler, D. J.; Stahl, R. 2006. Probabilistic model to optimize formulation and baiting strategies for the pesticide CPTH (3–chloro–4–methylaniline hydrochloride). In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 440–446.

Johnston, J. J.; Hurley, J. C.; Primus, T. M.; Schmidt, B. S.; DeLiberto, T. J. 2006. Improving rabies vaccine baits. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 344–345.

Jojola, S. M.; Robinson, S. J.; VerCauteren, K. C. 2007. Oral rabies vaccine (ORV) bait uptake by captive striped skunks. Journal of Wildlife Diseases 43: 97–106.

Jojola, S. M.; Witmer, G.; Nolte, D. L. 2006. Managing invasive nutria: the role of olfactory cues. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 192–194.

Karki, S. M.; **Gese, E. M.**; Klavetter, M. L. 2007. Effects of coyote population reduction on swift fox demographics in southeastern Colorado. Journal of Wildlife Management 71(8): 2702–2718.

Killian, G.; Diehl, N. K.; **Miller, L.**; Rhyan, J.; Thain, D. 2006. Long-term efficacy of three contraceptive approaches for population control of wild horses. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 67–71.

Killian, G.; **Eisemann, J. D.**; Wagner, D.; Werner, J.; Shaw, D.; **Engeman, R.; Miller, L.** 2006. Safety and toxicity evaluation of GonaCon immunocontraceptive vaccine in white-tailed deer. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 82–87.

Kimball, B. A.; Billings, V. 2007. Do herbivores associate flavours with specific consequences in flavour aversion learning? Applied Animal Behaviour Science 107: 252–261.

Kitchen, A. M.; Knowlton, F. F. 2006. Evaluation of cross–fostering among canids: a conservation and research tool. Biological Conservation 129: 221–225.

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

Larrucea, E. S.; Brussard, P. F.; **Jaeger, M. M.**; Barrett, R. H. 2007. Cameras, coyotes, and the assumption of equal detectibility. Journal of Wildlife Management 71(5): 1682–1689.

Linz, G. M.; Homan, H. J.; Penry, L. B. 2006. Evaluation of potential insect baits for red–winged blackbirds. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 256–257.

Linz, G. M.; Homan, H. J.; Penry, L. B.; Primus, T. M.; Goodall, M. J. 2007. Evaluation of caffeine and garlic oil as bird repellents. National Sunflower Association Sunflower Research Forum http://www.sunflowernsa.com/research/research–workshop/documents/Linz_etal_Caffeine_07.pdf.

Linz, G. M.; Raetzman, J. M.; Hagy, H. M.; **Homan, H. J.**; Bleier, W. J. 2007. Blackbird use of wildlife conservation sunflower plots. National Sunflower Association Sunflower Research Forum http://www.sunflowernsa.com/research/research–workshop/documents/Linz_etal_Blackbird_07.pdf

McLean R. G. 2007. Introduction and emergence of wildlife diseases in North America. In: Fulbright T. E; Hewitt D. G, eds. Wildlife science: linking ecological theory and management applications. Boca Raton, FL: CRC Press: 261–278.

McLean, R. G. 2006. West Nile virus in North American wildlife. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 311–317.

Mesenbrink, B. T.; Leland, B.; **Dunbar, M. R.**; Moore, G.; DeYoung, R.; Zamorano, A.; **McLean, R. G.; Root, J. J.** 2006. Gray fox research to support oral rabies vaccination programs in Texas: an overview. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 354–355.

Meshaka, W. E., Jr.; Smith, H. T.; Golden, E.; Moore, J. A.; Fitchett, S.; Cowan, E. M.; **Engeman, R. M.**; Sekscienski, S. R.; Cress, H. L. 2007. Green iguanas (*Iguana iguana):* the unintended consequence of sound wildlife management practices in a south Florida park. Herpetological Conservation and Biology 2(2): 149–56.

Mettler, A. E.; **Shivik, J. A.** 2007. Dominance and neophobia in coyote *(Canis latrans)* breeding pairs. Applied Animal Behaviour 102: 85–94.

Miller, L. A.; Bynum, K. S.; Zemlicka, D. 2006. PZP immunocontraceptive in coyotes: a multi-year study with three vaccine formulations. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 88–95.

Miller, L. A.; Talwar, G. P.; Killian, G. J. 2006. Contraceptive effect of recombinant GnRH vaccine in adult female pigs. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 106–109.

Milleson, M. P.; **Shwiff, S. A.; Avery, M. L.** 2006. Vulture–cattle interactions—a survey of Florida ranchers. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 231–238.

Millspaugh, J. J.; Burke, T.; Van Dyke, G.; Slotow, R.; **Washburn, B. E.**; Woods, R. J. 2007. Stress response of working African elephants to transportation and safari adventures. Journal of Wildlife Management 71: 1257–60.

Morey, P. S.; **Gese, E. M.**; Gehrt, S. 2007. Spatial and temporal variation in the diet of coyotes in the Chicago metropolitan area. American Midland Naturalist 158(1): 147–161.

Nash, P.; Furcolow, C. A.; Bynum, K. S.; Yoder, C. A.; Miller, L. A.; Johnston, J. J. 2007. 20,25–Diazacholesterol as an oral contraceptive for black-tailed prairie dog population management. Human–Wildlife Conflicts 1: 60–67.

O'Hare, J. R.; Eisemann, J. D.; Fagerstone, K. A. 2006. Changes in the taxonomic nomenclature and conservation status of ground squirrel species: implications for pesticide labeling and use of zinc phosphide. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 450–457.

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

Pedersen, K.; Clark, L. 2007. A review of Shiga toxin *Escherichia coli* and *Salmonella enterica* in cattle and free–ranging birds: potential association and epidemiological links. Human–Wildlife Conflicts 1: 68–77.

Perry, K. R.; Arjo, W. M.; Bynum, K. S. Miller, L. A. 2006. GnRH single–injection immunocontraception of black–tailed deer. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 72–77.

Pitt, W. C.; Witmer, G. W. 2007. Invasive predators: a synthesis of the past, present, and future. In: Elewa, Ashraf M. T., ed. Predation in organisms—a distinct phenomenon. Heidelberg, Germany: Springer Verlag: 265–293.

Powers, J. G.; **Nash, P. B.**; Rhyan, J. C.; **Yoder, C. A.**; **Miller, L. A.** 2007. Comparison of immune and adverse effects induced by AdjuVac and Freund's complete adjuvant in New Zealand white rabbits (*Oryctolagus cuniculus*). Lab Animal 36(9): 51–8.

Primus, T. M.; Jojola, S. M.; Robinson, S. J.; Johnston, J. J. 2007. Determination of sulfadimethoxine residues in skunk serum by HPLC. Journal of Liquid Chromatography & Related Technologies 30: 2095–102.

Pruett–Jones, S.; Newman, J. R.; Newman, C. M.; **Avery, M. L.**; Lindsay, J. R. 2007. Population viability analysis of monk parakeets in the United States and examination of alternative management strategies. Human–Wildlife Conflicts 1: 35–44.

Ralston, S. T.; **Linz, G. M.**; Bleier, W. J.; **Homan, H. J.** 2007. Cattail distribution and abundance in North Dakota. Journal of Aquatic Plant Management 45: 21–24.

Ramey, C. A.; Bourassa, J. B.; Furuta, M. S. 2006. Survival and movement ecology of ring–necked pheasants in northern California agricultural areas. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 492–499.

Reindl–Thompson, S. A.; **Shivik, J. A.**; Whitelaw, A.; Hurt, A.; Higgins, K. F. 2006. Efficacy of scent dogs in detecting black-footed ferrets at a reintroduction site in South Dakota. Wildlife Society Bulletin 34: 1435–1439.

Rizor, S. E.; Arjo, W. M.; Bulkin, S.; **Nolte, D. L.** 2006. Efficacy of cholecalciferol baits for pocket gopher control and possible effects on non-target rodents in Pacific Northwest forests. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 166–170.

Root, J. J.; Oesterle, P. T.; Nemeth, N. M.; Klenk, K.; Gould, D. H.; **McLean, R. G.; Hall, J. S.** 2006. Experimental infection of fox squirrels *(Sciurus niger)* with West Nile virus. American Journal of Tropical Medicine and Hygiene 75: 697–701.

Root, J. J.; Oesterle, P. T.; Sullivan, H. J.; Hall, J. S.; Marlenne, N. L.; **McLean, R. G.**; Montenieri, J. A.; **Clark, L.** 2007. Short report: fox squirrel *(Sciurus niger)* associations with West Nile virus. American Journal of Tropical Medicine and Hygiene 76: 782–784.

Savarie, P. J.; Clark, L. 2006. Evaluation of bait matrices and chemical lure attractants for brown tree snakes. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 483–488.

Sawin, R. S.; **Linz, G. M.; Bleier, W. J.; Homan, H. J.** 2006. Feeding habits of spring-migrating blackbirds in east-central South Dakota. Prairie Naturalist 38: 73–84.

Seamans, T. W.; Helon, D. A. 2006. Evaluation of ChromaFlair® Crow Buster as a starling repellent at nest sites. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 228–230.

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

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

Seward, N. W.; Phillips, G. E.; Duquette, J. F.; VerCauteren, K. C. 2007. A frightening device for deterring deer use of cattle feeders. Journal of Wildlife Management 71: 271–276.

Shwiff, S. A.; Smith, H. T.; **Engeman, R. M.**; Barry, R. M.; Rossmanith, R. J.; Nelson, M. 2007. Bioeconomic analysis of herpetofauna road-kills in a Florida state park. Ecological Economics 64: 181–185.

Shwiff, S. A.; Sterner, R. T.; Jay, M. T.; Parikh, S.; Bellomy, A.; Meltzer, M. I.; Rupprecht, C. E. 2007. Direct and indirect costs of rabies exposure: a retrospective study in southern California (1998–2002). Journal of Wildlife Diseases 43: 251–257.

Shwiff, S. A.; Sterner, R. T.; Kirkpatrick, K. N.; Engeman, R. M.; Coolahan, D. C. 2006. Benefits and costs associated with Wildlife Services activities in California. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 356–360.

Sin, H.; Beard, K. H.; **Pitt, W. C.** 2006. Invasive frogs' influence on lowland forest arthropod communities and ecological processes in Hawaii. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 534.

Smith, H. T.; Meshaka, W. E., Jr.; **Engeman, R. M.**; Crossett, S. M.; Foley, M. E.; Bush, G. 2006. Raccoon predation as a potential limiting factor in the success of the green iguana in southern Florida. Journal of Kansas Herpetology Number 20, 7–8.

Spraker, T. R.; Gidlewski, T. L.; Balachandran, A.; **VerCauteren, K. C.**; Creekmore, L.; Munger, R. D. 2006. Detection of PrP^{CWD} in postmortem rectal lymphoid tissues in Rocky Mountain elk *(Cervus elaphus nelsoni)* infected with chronic wasting disease. Journal of Veterinary Diagnostic Investigation 18: 553–557.

Stahl, R. S.; Johnston, J. J. 2006. The effect of time on the recovery of DRC–1339 residues from tissues collected from decomposing mourning dove carcasses. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 447–449.

Stahl, R. S.; Dorr, B. S.; Barras, S. C.; Johnston, J. J. 2006. Use of fatty acid profiles to distinguish between selected game fish and farm–raised channel catfish. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 389–392.

Sterner, R. T. 2006. Economic modeling of oral rabies vaccination: issues and concepts. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 339–343.

Thompson, C. M.; **Gese, E. M.** 2007. Food webs and intraguild predation: community interactions of a native mesocarnivore. Ecology 88: 334–46.

VerCauteren, K. C.; Lavelle, M. J.; Seward, N. W.; Fischer, J. W.; Phillips, G. E. 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.; Seward, N. W.; Lavelle, M. J.; Fischer, J. W.; Phillips, G. E. 2007. A fence design for excluding elk without impeding other wildlife. Rangeland Ecology & Management 60: 529–32.

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

Washburn, B. E.; Barras, S. C.; Seamans, T. W. 2007. Foraging preferences of captive Canada geese related to turfgrass mixtures. Human–Wildlife Conflicts 1(2): 214–223.

Washburn, B. E.; Chipman, R. B.; Francoeur, L. C. 2006. Evaluation of bird response to propane exploders in an airport environment. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 212–215.

Werner, S. J.; Cummings, J. L.; Tupper, S. K.; Hurley, J. C.; Stahl, R. S.; Primus, T. M. 2007. Caffeine formulation for avian repellency. Journal of Wildlife Management 71: 1676–1681.

Witmer G. W. 2007. The ecology of vertebrate pests and integrated pest management (IPM). In: Kogan M, Jepson P, editors. Perspectives in ecological theory and integrated pest management. Cambridge, UK: Cambridge University Press: 393–410.

Witmer, G. W.; Engeman, R. M. 2007. Subterranean rodents as pests: the case of the pocket gopher. In: Begall, S.; Burda, S.; Schleich, C. E., eds. Subterranean rodents: news from underground. Berlin, Germany: Springer–Verlag: 287–299.

Witmer, G.; Jojola, S. 2006. What's up with house mice?—a review. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 124–130.

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

Witmer, G.; O'Brien, J. 2006. Rodent management in alfalfa. In: Proceedings, 2006 Western Alfalfa & Forage Conference; 11–13 December 2006; Reno, NV. Davis, CA: University of California Cooperative Extension, Agronomy Research and Extension Center, Plant Sciences Department, University of California, Davis. Online at http://alfalfa.ucdavis.edu/symposium/proceedings/2006.–06–101.pdf. 11 p.

Witmer, G.; Pipas, M.; Linder, T. 2006. Animal use of black-tailed prairie dog burrows: preliminary findings. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 185–197.

Witmer, G.; Burke, P.; Jojola, S.; Dunlevy, P. 2006. The biology of introduced Norway rats on Kiska Island, Alaska, and an evaluation of an eradication approach. Northwest Science 80: 191–198.

Witmer, G. W.; Boyd, F.; Hillis–Starr, Z. 2007. The successful eradication of introduced roof rats *(Rattus rattus)* from Buck Island using diphacinone, followed by an irruption of house mice *(Mus musculus)*. Wildlife Research 34: 108–115.

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

Wyckoff, A. C.; Henke, S. E.; **Campbell, T.; VerCauteren, K. C.** 2006. Is trapping success of feral hogs dependent upon weather conditions? In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 370–372.

Yoder, C. A.; Avery, M. L.; Keacher, K. L.; Tillman, E. A. 2007. Use of DiazaCon™ as a reproductive inhibitor for monk parakeets *(Myiopsitta monachus)*. Wildlife Research 34: 8–13.

Yoder, C. A.; Graham, J. K.; **Miller, L. A.; Bynum, K. S.; Johnston, J. J.; Goodall, M. J.** 2006. Effect of method of delivering nicarbazin to mallards on plasma 4,4'–dinitrocarbanilide levels and reproduction. Poultry Science 85: 1442–1448.

Yoder, C. A.; Graham, J. K.; **Miller, L. A.; Bynum, K. S.; Johnston, J. J.; Goodall, M. J.** 2006. Evaluation of nicarbazin as a potential waterfowl contraceptive using mallards as a model. Poultry Science 85: 1275–1284.

Yoder, C. A.; Miller, L. A. 2006. Avian contraceptive tools: one size does not fit all. In: Timm, R. M.; O'Brien, J. M., eds. Proceedings of the 22d vertebrate pest conference; 6–9 March 2006; Berkeley, CA. Davis, CA: University of California, Davis: 110–115.

Yoder, C. A.; Graham, J. K.; **Miller, L. A.** 2006. Molecular effects of nicarbazin on avian reproduction. Poultry Science 85: 1285–1293.

Yoder, C. A.; Avery, M. L.; Keacher, K. L.; Tillman, E. A. 2007. Use of DiazaCon™ as a reproductive inhibitor for monk parakeets (*Myiopsitta monachus*). Wildlife Research 34: 8–13.

Young, J.; **Shivik, J. A.** 2006. What carnivore biologists can learn from bugs, birds, and beavers: a review of spatial theories. Canadian Journal of Zoology 84: 1703–1711.