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National Wildlife Research Center Accomplishments, 2006

U.S. Department of Agriculture
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Wildlife Services

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Cover photo credit: U.S. Department of the Interior, U.S. Fish and Wildlife Service photo of a double-crested cormorant.

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Contents

Introduction

Nilgai antelope with a radio collar is released in Texas. (APHIS photo by Tyler Campbell.)

National Wildlife Research Center

Mission—The mission of the U.S. Department of Agriculture's (USDA) Wildlife Services (WS) Program is to provide Federal leadership in managing problems caused by wildlife. The National Wildlife Research Center (NWRC) functions as the research arm of WS by applying scientific expertise to the development of information and practical methods to resolve problems caused by the interaction of people and wildlife. 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 150 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 for ensics, and veterinary medicine. NWRC's research is organized under four programs:

- The **Bird Research Program** focuses on reducing bird damage to crops and aquaculture facilities; reducing bird–aircraft collisions; developing new bird repellants; and reducing predation losses and property damage caused by vultures.

- The **Mammal Research Program** examines the ecology, behavior, and management of mammalian predators in relation to livestock, game animals, and threatened and endangered species; develops methods for reducing invasive species damage on islands; and provides solutions to problems associated with foraging mammals.

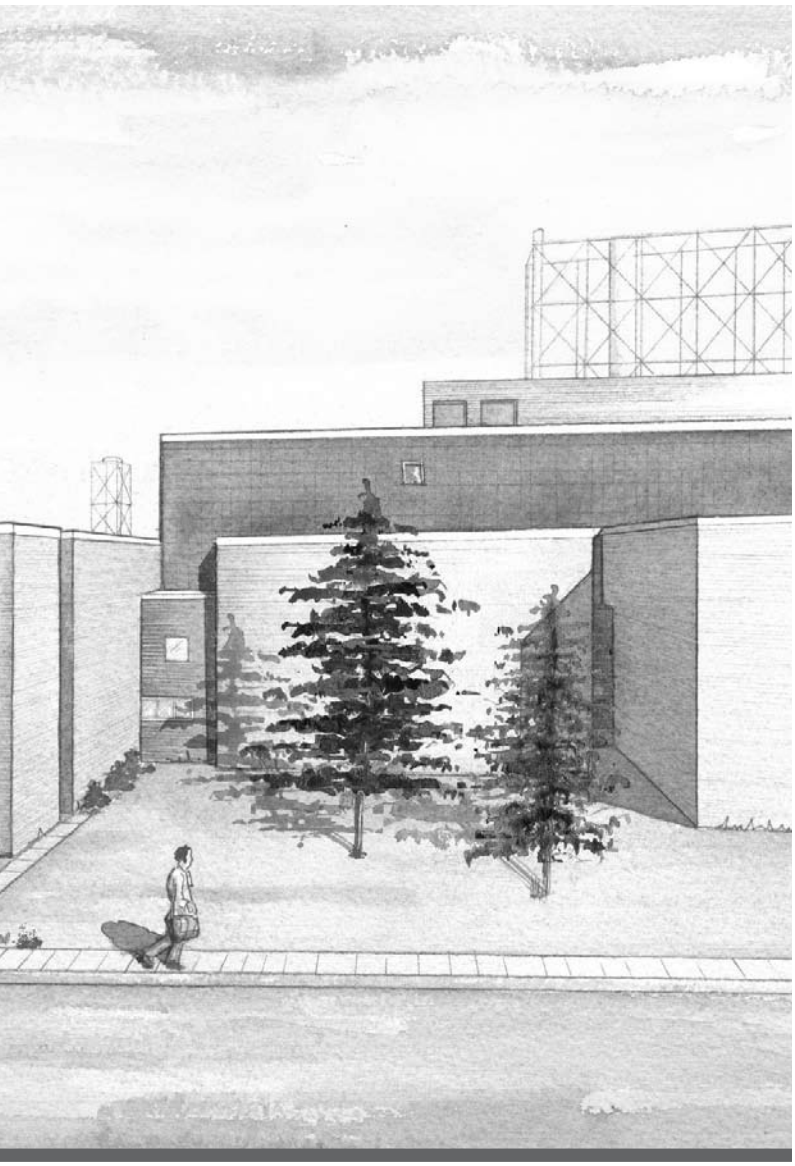
- The **Wildlife Disease Research Program** explores ways to reduce the spread and transmission of diseases from wildlife to humans and domestic animals; monitor wildlife for pathogens; provide risk assessments for agriculture and human health and safety; and assist WS operations for surveillance and monitoring efforts.

- The **Product Development Research Program** encompasses studies for pesticide registration, formulation chemistry, chemical analysis, benefit–cost analysis, and wildlife contraceptive development.

Construction Update—The NWRC headquarters is located on 43 acres on the Foothills Research Campus of Colorado State University (CSU) in Fort Collins. During fiscal year 2006, several planning and construction activities took place, related to completing the Master Plan for the NWRC site.

Renovation was completed on a portion of the existing Animal Research Building to create Biosafety Level 3 (BSL–3) laboratory space and animal holding and testing space for ongoing wildlife disease research and diagnostics.

BSL–3 level facilities have safeguards that are designed to prevent the spread of agents that may be transmitted through respiration. The renovation created a BSL–3-enhanced laboratory plus two standard animal rooms and six animal cubicles that can be used for BSL–3 animal disease research. This renovated space will be used beginning in the spring of 2007 for BSL–3 research studies, after a break-in period under BSL–2 conditions.



Artist's rendering of the NWRC Invasive Species Research Building. (Ben Robbins, BurkettDesign, Denver, CO; reproduced by permission.)

Construction of the Invasive Species Research Building (ISRB) was completed in November 2006. The 25,000-ft^2 ISRB will provide NWRC with indoor animal research space specifically designed to hold wild animal species that are not native to the United States. The building will be capable of maintaining tropical climates with high humidity and high temperatures and will contain a diagnostic imaging laboratory. This laboratory will provide digital radiography and ultrasound capabilities for all research and animal-care needs on the entire NWRC site.

The last building to be constructed as part of the NWRC Headquarters Master Plan is a new Wildlife Disease Research Building (WDRB). The WDRB will house most of NWRC's BSL–3 disease research and will be constructed to BSL–3-Ag standards. During 2006, the environmental assessment, a written Program of Requirements, and the "30-percent design" of this anticipated 25,000-ft^2 WDRB were completed. Final design and construction will take place in 2007 and 2008 with a planned completion date of December 31, 2008.

Developing Methods

GOAL: Increase effective methods available for wildlife damage management.

The management of starling populations in feedlots and dairies is a difficult problem for agricultural producers. (APHIS file photo.)

Bird Research Program

TITLE: New Technologies To Deter Wildlife from Airports and Aircraft

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

To be certified for commercial passenger traffic by the U.S. Federal Aviation Administration (FAA), most U.S. airports are required to have wildlife hazard-management plans in place. In addition, the FAA has strict standards regarding bird-strike preventive capabilities of aircraft engines and the placement of wildlife attractants, such as waste-management facilities, near airports.

An interagency agreement between NWRC and the FAA, renewed in 2003, provides the FAA with scientific support for its recommendations to aviation policymakers for guidance on controlling wildlife hazards.

Federally protected bird species cause most of these hazards, although other wildlife such as deer and coyotes also can be a problem.

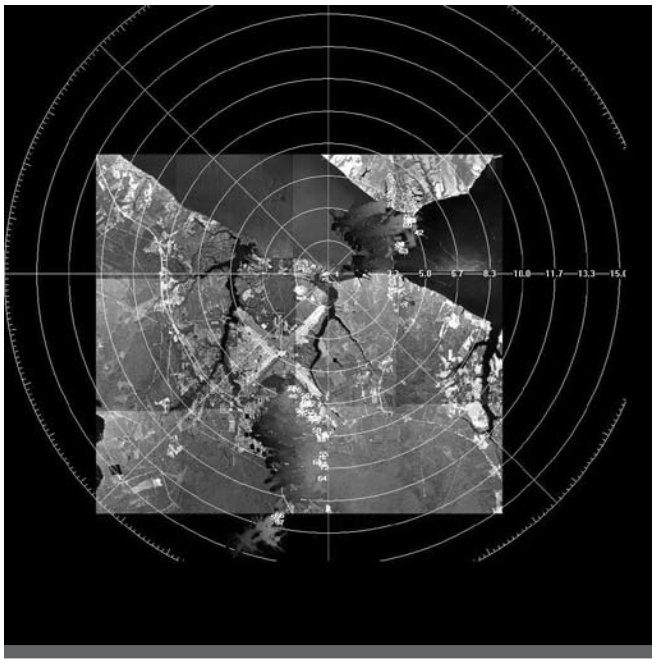
Research and information needs cover a broad spectrum of topics related to understanding the nature of wildlife hazards at airports, developing management tools that will reduce these hazards, and providing airport personnel with information on the latest strategies for controlling wildlife hazards.

Evaluation of Effigies To Disperse Gulls From Landfills—Biologists from the NWRC Ohio field station evaluated the use of herring and ring-billed gull effigies (taxidermy mounts) in dispersing gulls from roosts, breeding colonies, and areas where the birds present a hazard to aviation. The technique provides a nonlethal means of dispersing gulls from

Gulls are a significant problem at landfills.
(APHIS photo by Robert Beason.)

a variety of areas where they threaten human health and safety, adversely impact other waterbirds, or are a nuisance. Effigies have been used successfully to keep gulls from loafing areas near landfills and dredge spoil sites.

Use of Maritime Radars To Evaluate Potential Wildlife Hazards to Aircraft—NWRC Ohio field station scientists, in collaboration with the Cherry Point Marine Corps Air Station in North Carolina, are evaluating whether small (< 50 KW) radar equipment designed for use on ships can be adapted to monitor the activity of birds on and near airfields where they present a hazard to aircraft. The new radar systems can operate unattended to collect data on bird movements which can be monitored remotely in real time or analyzed later. Results indicate that radar can provide information to supplement visual observations by wildlife biologists on the airfield. The greater range of a radar compared to visual observations and its ability to detect birds at night provide information that would not be available otherwise. Analyses of data over an extended period will allow wildlife managers to determine the times of day or night and locations that birds are most abundant around the airfield. Knowing the

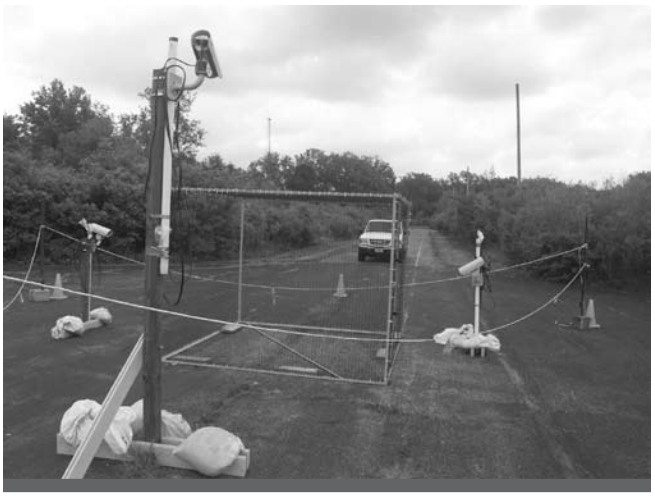


Small radars developed for monitoring bird activities can detect avian hazards such as these flocks of waterfowl passing over a coastal airfield. The radars have the advantage over visual observers in that they can detect birds at night and when human observers are not present. The red tracks indicate the path taken by individual flocks of waterbirds; the dark shade represents the oldest part of the track and the white number, the most recent location. The southern group is passing over the southwest end of a runway.
(APHIS photo by Robert Beason.)

locations used by hazardous birds, wildlife managers can mitigate the attractants and airfield managers can schedule activities to avoid hazardous periods.

Development of Lighting To Reduce Bird-Strike Hazards to Aircraft—Given avian responses to signal colors and the importance of motion detection to birds, there is potential for the integration of light-based techniques (i.e., via specific wavelengths or colors, pulse rates, or combinations thereof) in reducing bird collisions with aircraft. In an experiment to study avian avoidance behavior, biologists at the NWRC Ohio field station monitored avian responses to specific lighting treatments and an approaching ground-based vehicle by using a complex video surveillance system. The system was composed of three video cameras at the flight cage and a fourth, wireless camera mounted on the vehicle to monitor the approach. The images were captured by a digital video recorder, and an observer monitored each experimental group on a quad split-screen flat panel display. The recorded images were played back to determine the time and distance over which individual birds reacted to specific lighting treatments.

Evaluating Trash-Transfer Facilities as Bird Attractants—Traditional household-waste landfills are very attractive to many species of birds, especially gulls. Thus, landfills located near airports create a hazard to aircraft when birds cross airfields to get to feeding grounds. The FAA currently recommends municipal solid-waste landfills and trash-transfer facilities not be sited within 5 statute miles of an airport. Recently, there has been an increase in the number of trash-transfer facilities with interest in locating near airports and airfields. Consequently, aviation authorities are concerned about the attractiveness of these facilities to bird species hazardous to aviation. Little information is available regarding the attractiveness of specific kinds of trash-transfer facilities to birds.



Three cameras are used to monitor the reaction of birds to the lighting system of an approaching vehicle. A fourth camera mounted on the vehicle monitors the birds' reactions from the perspective of the vehicle. The data from the four cameras are recorded simultaneously onto a digital video recorder for subsequent analysis. (APHIS photo by Robert Beason.)

An example of a trash-transfer facility that is very attractive to birds. If such facilities are sited near airports, the risk of bird–aircraft collisions could increase significantly.
(APHIS photo by Robert Beason.)

During 2004–05, researchers at NWRC's Ohio field station, in cooperation with WS operations in Arizona, California, Connecticut, Massachusetts, Missouri, Ohio, and Washington, conducted a yearlong study to determine whether trash-transfer facilities of various designs (e.g., open-sided, fully enclosed) are attractive to avian species hazardous to aviation. The objectives of the study were to: (1) document wildlife use of trash-transfer facilities and (2) determine if building design or onsite management characteristics of trash-transfer facilities influence their attractiveness to wildlife species.

Bird species hazardous to aviation commonly observed using trash-transfer facilities (e.g., feeding on refuse) included gulls, crows, and European starlings. However, patterns of wildlife use at facilities varied by geographic location, building design, and onsite management characteristics. Facilities with fully enclosed trash systems had fewer bird problems.

This study suggests that some trash-transfer facilities can be compatible with safe aircraft operations if designed and operated in a manner that reduces their attractiveness to hazardous wildlife.

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 patters 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. 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 to 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—NWRC scientists conducted tests with both captive and free-ranging blackbirds to identify and develop nonlethal repellants for reducing bird depredation on seeded and ripening rice. Of many chemicals tested, GWN–4770, GWN–4140, caffeine, and Tilt® EC have shown the most promising results.

In small-scale field-enclosure tests, NWRC scientists worked with cooperators from Southeast Missouri

Rice field. (Istockphoto.)

State University to evaluate GWN–4770 as a seed treatment to reduce blackbird damage to drill-planted rice seed. Scientists observed 50 percent fewer unprotected seedlings than seedlings treated with 10,000 ppm GWN-4770 in a drill-seeded rice field in southeastern Missouri.

NWRC scientists also evaluated GWN–4140 (liquid GWN–4770) as a blackbird repellant within ripening rice fields at the Southeast Missouri State University Rice Research Farm near Malden, MO. Researchers observed no difference in average rice harvested among treated (GWN–4140) and untreated plots. An average of 5.6 µg/g GWN–4140 (active ingredient) was recovered on the day following pesticide application, and <5.0 µg/g GWN–4140 was recovered on treated subplots through the remainder of the study. Thus, the pesticide treatment did not reduce blackbird consumption of ripening rice, and residues may have been insufficient for repellent efficacy.

Caffeine has also shown promise as a potential repellant for newly planted rice and ripening rice. However, the repellant was phytotoxic when applied to presoaked rice with a seed-treater at a 1-percent concentration. NWRC scientists conducted generation tests to determine whether caffeine or other products in the formulation caused seed phytotoxicity. The results showed that a 1-percent treatment of caffeine and sodium benzoate by themselves or in combination resulted in 0 percent germination of presoaked rice after
5 days compared to control rice, which had 95-percent germination. Reduced treatments of caffeine in elevated amounts of water allowed for germination at the same level as controls, but the excess amounts of water prevented the caffeine and sodium benzoate from adhering to the rice grains.

In addition, NWRC scientists cooperated with personnel at the Louisiana State University Rice Experiment Station near Crowley, LA, to evaluate the phytotoxicity effects of application rates of 1 and 2 kg/ha of caffeine and sodium benzoate applied to ripening rice at milk stage. Caffeine residues for 1 and 2 kg/ha ranged from 111 to 285 µg/g on day 1 after treatment to <MLOD and 11.5 µg/g on day 28 after treatment. There was no documented phytotoxicity to rice plants following either application. Harvest yields from control plots associated with 1 kg/ha application averaged 9,526 kg/ha; yields from treated plots averaged 9,601 kg/ha. Harvest yields from control plots associated with 2 kg/ha application averaged 10,192 kg/ha; yields from treated plots averaged 9,980 kg/ha. Data indicate that formulations of caffeine and sodium benzoate applied at 1 or 2 kg/ha to ripening

rice did not show any plant phytotoxicity or cause significant yield loss.

Choice and no-choice tests with red-winged blackbirds were conducted to evaluate the repellancy of Tilt® EC as a potential bird repellant for rice. In the choice test, birds discriminated between untreated rice and rice treated with the label rate. In the no-choice test, birds were tested at 25 percent to 200 percent of the label rate. At 100 percent, consumption of treated rice was reduced 32 percent.

DRC–1339 Metering Device Tested—Current procedures for mixing, bagging, and storing DRC–1339 baits used in the blackbird baiting program affect the chemical concentration on baits, cause degradation due to exposure, and reduce the acceptance of treated baits by blackbirds. NWRC scientists designed a prototype metering device for eliminating the existing problems with premixing, bagging and storing DRC–1339-treated brown rice baits and for dispersing DRC–1339 evenly at a dilution rate of 1 treated kernel : 25 untreated kernels. However, collection of moisture and rusting of steel used to make the metering device impeded the flow of treated rice.

During 2005, subsequent modifications were evaluated, including making the device out of stainless steel to prevent rust, increasing the hopper to hold a greater capacity, increasing the exit tube from 1.1 cm to 1.5 cm, and decreasing the hopper bottom angle from 370 to 200 degrees. DRC–1339-treated brown rice alone did not flow uniformly from the prototype, but a more uniform flow was achieved by diluting the treated rice in the metering device's hopper with equal amounts of untreated brown rice.

NWRC researchers prepare DayGlo paint pigment materials for aerially mass-marking blackbirds in Missouri rice fields. (APHIS photo by Jeff Homan.)

Predictive Model To Estimate DRC–1339 Mortality in Blackbirds—NWRC scientists collected data and developed an input management program based on a model to estimate the mortality of blackbirds during DRC–1339 baiting operations. This program was designed to be used by field managers. The model incorporated a combination of parameters that included bait concentration, toxicity, bait consumption, bait dilution rate, and species composition. From 2002 to 2005, NWRC scientists determined the number of rice grains in the esophagus and gizzard of 2,982 blackbirds collected as they departed sites baited with DRC–1339 at sites in Louisiana, Texas, and Missouri.

Acute oral toxicity tests that meet the Environmental Protection Agency's (EPA) current standards based on 10 birds per dose level with at least 5 levels were conducted to determine DRC–1339 toxicity for all blackbird target species observed on bait sites. Laboratory lavage trials were also conducted with a 2-percent DRC–1339-treated rice grain bait using 30 bird groups. The resulting data were incorporated into a model that was used by WS personnel in Louisiana, Texas, and Missouri during 2005 and 2006 to estimate blackbird mortality. The model was menu driven to direct the user to enter only the gender and species composition of the blackbirds using DRC–1339 bait sites on the day of baiting and the amount of DRC–1339-treated bait applied and consumed. The model then generated an estimated number of blackbirds by gender and species taken by bait site.

Longevity of Day-Glo® Fluorescent Marker—NWRC scientists have been evaluating the longevity of Day-Glo™ Fluorescent particle markers used to aerially mass-mark red-winged blackbirds. Under simulated field conditions in the NWRC Outdoor Animal Research Facility flight pen, blackbirds were hand-marked with a method that simulated aerial spraying. Retained marks lasted for 254 days (8.5 months), at which time the study was terminated because the birds started to molt. At the end of the study, all 52 birds still retained at least some marker material on all four body parts analyzed. The wings of birds retained the marker longer than the body, head, or tail. This technique shows promise as an effective way of determining blackbird roost turnover, roost interchange, movement patterns, and distribution.

NWRC scientists evaluate the longevity of the DayGlo marker particle formulation under field conditions for possible use in long-term studies. (APHIS photo by Jeff Homan.)

Blackbirds Winter in Missouri, Arkansas, and Louisiana Rice—During October 2005, NWRC scientists used a Day-glo paint pigment to aerially mass-mark more than 3.2 million blackbirds causing damage to rice in Missouri. Three different ricefield roosts containing from 700,000 to 2.2 million birds were sprayed with different Day-glo colors on consecutive nights. Birds subsequently were collected during January and February 2006 in various rice-producing counties in Louisiana, Arkansas, and Missouri to determine the regional and migratory movements of birds after the rice-growing season. Ten percent of 3,282 blackbirds collected were marked. Collections continued during May 2006 to determine the distribution of breeding male redwinged blackbirds in respect to the marking sites.

Electronic Deterrent Device Ineffective on Pileated Woodpeckers—Pileated woodpeckers cause extensive damage to utility poles, resulting in significant annual economic losses to utility companies. NWRC scientists cooperated with EDM, Inc., Fort Collins, CO and New York State Electric and Gas, Hammondsport, NY to evaluate the effective-

ness of electronic deterrent devices that are mounted on poles and are designed to detect vibrations caused by woodpeckers pecking on the pole. The active deterrent devices emitted sounds to frighten away pileated woodpeckers; control deterrent devices did not emit any sounds.

The scientists monitored eight active and seven control devices for 4 months. Poles were inspected for damage prior to installation of the devices, during monitoring, and after removal of the devices. In addition, the scientists observed the H-structures for 192 hours for pileated woodpecker activity. No differences in number of birds on the poles or damage to the H-structures were observed between active and control units. More research is needed to more thoroughly evaluate the potential of electronic deterrent devices.

Application of Effigies Aids Urban Crow Roost Dispersal—Large roosts of crows are becoming more common in urban areas, especially during winter months. Such large aggregations of crows often result in property damage, crop losses, and health risks. Because the currently available means to manage such urban roosts are insufficient or ineffective, biologists at NWRC's Florida field station worked with Pennsylvania WS personnel to evaluate alternative roost-dispersal methods.

The roost in Lancaster, PA, contained 30,000 to 40,000 birds, a mix of fish crows and American crows. In a series of trials, researchers installed taxidermic crow effigies and decorative artificial crow statuettes in trees and on the ground in staging areas and roost sites favored by crows. In some cases, birds abandoned the sites immediately; in other cases they shifted their location when harassment was augmented with recorded distress calls and laser lights. Throughout the winter, the overall size of the Lancaster crow population did not vary, but the location did in response to harassment. This experiment demonstrated that artificial effigies, alone or in combination with other methods, can cause crows to shift staging and roosting sites. Effigies offer management options previously unknown for urban nuisance problems.

Pileated woodpeckers can cause substantial damage to utility poles. (USDA Forest Service photo by Mike Ostry.)

This urban crow roost in Lancaster, PA, adversely affects residences, businesses, and schools. (APHIS photo by Michael Avery.)

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.

In the United States, blackbirds and starlings are abundant and widely distributed, with their winter population believed to be between 750 million and 1 billion. The estimated annual damage to grain, fruit, and berry crops from blackbirds and starlings exceeds $150 million in direct costs. Additional costs, not estimated, include those spent to prevent health and safety hazards and those from damage-abatement efforts. Blackbirds cause significant damage to sunflower and grain crops and eat livestock feed as well.

Red-Winged Blackbird Reproductive Physiology— The red-winged blackbird, one of the most abundant birds in North America, causes substantial damage to agricultural crops in the northern Great Plains. Considerable effort has been directed at reducing breeding densities of depredating birds; however, no data are available to examine the effects that reduced densities have on the reproductive performance of red-winged blackbirds. Maternally derived yolk steroids present in eggs have been shown to increase with increasing breeding densities in some species, suggesting a potential compensatory mechanism by which adult social interactions can affect reproductive success.

NWRC scientists, in collaboration with North Dakota State University, examined the effects of increased density and associated social interactions on aggressive behavior of breeding adults, on maternally derived yolk steroids, and on reproductive performance. The scientists simulated intrusions by placing caged female red-winged blackbirds in the territories of free-ranging (wild) nesting female red-winged blackbirds. Experimental groups consisted of breeding female birds presented with one of two treatments: Treatment (cage with 1 bird), Control (empty cage—no bird).

A North Dakota State University graduate student funded by NWRC is estimating blackbird damage in wildlife conservation sunflower plots. (APHIS photo by George Linz.)

Females in the treatment group exhibited the greatest aggressive behavior, but there was little difference in reproductive output or egg constituents (yolk, albumen, maternally-derived yolk steroids) among experimental groups. These results suggest that interaction among red-winged blackbird females results in increased aggressive behavior but does not affect yolk testosterone levels. Additional research is needed to determine if reproductive recruitment in red-winged blackbird populations is density dependent. The results of these experiments will better focus efforts to manage blackbird damage to sunflower.

Wildlife Conservation Sunflower Plots—Blackbirds cause an estimated $4–$10 million worth of damage annually in North Dakota, South Dakota, and Minnesota. In 2004 and 2005, WS sponsored the research of a graduate student from North Dakota State University to evaluate wildlife conservation sunflower plots (WCSPs) for reducing blackbird depredation in commercial sunflower fields as well as providing stopover habitat for migratory nonblackbird species. The student estimated avian abundance and richness in 23 8-ha plantings of oilseed sunflower by conducting point counts and mist-netting birds from August through October during each of the 2 years. Avian use of nearby commercial sunflower and small-grain fields was also surveyed. Local land-use and vegetation characteristics were compared with increased avian use of each field type. WCSPs were evaluated for both blackbird and nonblackbird response to local habitat characteristics. Blackbird and nonblackbird density was greater in WCSPs than in commercial sunflower or small-grain fields, including both control groups in 2005. Wetlands were positively related to blackbird density, while shelterbelts and some weed plants were positively related to nonblackbirds. Producers seeking to maximize WCSP use by blackbirds should keep weeds to a minimum in decoy plots and place WCSPs near wetlands.

A North Dakota State University graduate student funded by NWRC is using radio-telemetry to track the movements of fledgeling red-winged blackbirds. (APHIS photo by George Linz.)

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.

Fish-eating birds can have a substantial economic impact on aquacultural production. Annual costs associated with bird damage and damage prevention for aquaculture industries are estimated to exceed $17 million. Double-crested cormorants, American white pelicans, and several wading birds are the predominant species associated with these conflicts. In addition to conflicts with aquaculture, double-crested cormorants have also been associated with habitat changes throughout North America and the potential spread of parasites and fish diseases. Current NWRC aquaculture research is aimed at acquiring information regarding the abundance, foraging behavior, economic impacts, and damage-management techniques associated with fish-eating birds near aquaculture facilities in the Southeast. Because these birds annually migrate from northern breeding areas to southeastern wintering grounds, the Center's research efforts should provide the information necessary to develop and evaluate management alternatives for fish-eating birds throughout their range.

WS Researchers Partner To Identify Vectors of Whirling Disease—Whirling disease debilitates trout and can contribute to severe declines in trout populations in the Intermountain West, where angling is extremely important to local and State economies. Biologists from the NWRC's Bird Research Program partnered with the National Park Service and Montana State University to determine if fish-eating birds are viable vectors of *Myxobolus cerebralis*, the parasite that causes whirling

Commercial catfish production is a vital industry in the Southeastern United States worth over $400 million a year. NWRC scientists studying the economic impacts of double-crested cormorants to this industry found that these birds cost catfish farmers up to $13 million annually in Mississippi alone. (USDA Agricultural Research Service photo.)

disease in wild trout. Fish-eating birds may vector the disease among different trout populations by passing viable spores through their digestive tract. This mechanism represents a significant threat to trout populations because of the great distances that these birds may travel in a short time. Although viable myxospores are known to pass through the digestive tract of some predators, such as northern pike and mallards, other NWRC studies have shown that species-specific differences in environmental conditions in the digestive tract of different bird species can limit which species are viable vectors. Therefore, NWRC biologists conducted experiments to assess whether or not viable myxospores can be passed through the digestive tract of four fish-eating bird species (American white pelicans, double-crested cormorants, great blue herons, and night herons) to determine if these species are possible vectors of this disease. The data are now being analyzed by National Park Service scientists.

NWRC Scientists Determine the Scope of Cormorant Damage to Mississippi Catfish Production—The catfish industry as a whole is valued at more than $400 million per year in the United States, with nearly 65 percent of catfish production in Mississippi alone. NWRC biologists completed a study of the distribution and abundance of double-crested cormorants in the delta region of Mississippi to determine the impacts of foraging by cormorants on this important industry. To estimate the abundance of cormorants on these ponds during winter and get reliable estimates of damage, NWRC biologists conducted aerial surveys of representative catfish ponds across the region. Study results demonstrate that cormorants used these ponds extensively during the period 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

NWRC researchers determined that double-crested cormorants were responsible for catfish depredation worth $9.8 million and $13.2 million in two recent winters. (APHIS file photo.)

were consumed by cormorants in the delta region of Mississippi. These losses translated into a cost of $13.2 million and $9.8 million. Future studies will aim to develop efficient methods for monitoring cormorant abundance and distribution for purposes of damage estimation and cormorant management.

NWRC Scientists Identify Cormorant Migration Patterns—NWRC biologists attached satellite telemetry transmitters to double-crested cormorants captured at roosts near aquaculture facilities in Alabama, Arkansas, Louisiana, and Mississippi to develop a better understanding of migration patterns for cormorants using aquaculture farms in the Southeastern United States. During spring, cormorants captured in Alabama migrated east of the Mississippi River and primarily west of the Appalachian Mountains. Cormorants from Arkansas, Louisiana, and Mississippi migrated north along the Mississippi River valley, the Missouri River valley, and/or the Ohio River valley. These studies verified that cormorants using aquaculture facilities in the Southeastern United States are from the same population as those that are thought to impact natural resources in the Great Lakes region.

Departure for spring migration ranged from March 26 through May 12, 2006. Interestingly, adult cormorants departed for spring migration earlier than immature cormorants, and four immature cormorants and one adult did not migrate at all, but stayed in the southeastern United States throughout the year. In fall, the date of departure for the wintering grounds ranged from August 17 through October 25. Cormorants required an average of 12 days to complete migration and traveled an average of 70 km per day.

This information will assist aquaculture producers with the timing of preparations for cormorant management on their farms. The results of this study will also benefit wildlife managers, who need to define population boundaries for regional management approaches.

Mammal Research Program

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 to 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. Further, native species on the islands have evolved in the absence of many introduced threats and usually respond poorly to invasive animals or disease.

Invasive species are the single greatest threat to Hawaii's agricultural economy and natural environment and to the health and lifestyle of Hawaii's 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 wide variety of methods to resolve small mammal damage to agriculture, reforestation, and structures and equipment.

Optimizing Detection and Control Strategies for Mongoose in Hawaii—The small Indian mongoose is firmly established in all the major Hawaiian Islands except Kauai and is a major predator of ground-nesting native birds. There have been frequent sightings of these invasive mammals on Kauai; however, extensive trapping has not been successful in capturing any mongooses. There is serious concern about the introduction of this exotic animal to other mongoose-free locations in the Pacific area. NWRC's Hawaii field station has

Small Indian mongooses forage over large areas in search of food. Whole fish baits were more effective at attracting mongooses over long distances. Effective baits are critical in capturing incipient mongoose populations on the Pacific islands. (APHIS photo by Robert Sugihara.)

conducted research into identifying candidate bait substrates, lures, and/or attractants that would elicit a strong attraction response from mongooses in the field. Food baits (frozen fish, uncooked beef scraps, processed meat [hot dogs]) elicited the highest visitation rate and capture success of mongooses in the six different locations where the trials were conducted. Whole chicken eggs were effective in luring locally foraging mongooses, but the attractiveness of eggs decreased significantly in subsequent days of trapping, suggesting that visual rather than olfactory cues were more important for this bait type.

On the island of Kauai or in other sites of recent introductions, the ideal bait would have to be sufficiently attractive to lure in mongooses from a distance. Using radio-telemetry and passive integrated transponder (PIT)-tagged mongooses, NWRC scientists are determining home range and the spatial (foraging distance) and temporal (time and frequency of visitation) responses of 26 microchip-tagged mongooses (13 with transmitters) to the food baits. An automatic microchip reader/datalogger documents the identity and time of visitation to a bait station. Mongoose visitations to bait stations were examined for clues on mongoose foraging ecology. Evaluation of the importance of several factors was considered: solitary or group foraging behavior, peak foraging time of day, effect of previous exposure on subsequent visitation, and the potential development of site fidelity where mongoose would return to known food sources. Preliminary evaluation suggests that mongooses have large home ranges (males 26.7 ha, females 14 ha) in a resource-rich environment. They forage widely, moving long distances (males 700 m, females 440 m) daily. Whole-fish baits were the most effective based on the fact that mongoose move longer distances (300 m) to reach them than they will move to find other food baits. Results also 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. These findings could aid in optimizing current detection and capture strategies for established and incipient mongoose populations or be used in the development of toxicant baits specific for mongooses.

Evaluation of Nontarget Species Exclusionary Modifications to Bait Stations Accessible to Rats and Mice—Rodenticides have been a cost-effective and efficacious technique to control or eradicate rodents worldwide. In many locations, bait stations must be used due to concerns about nontarget bait-take by native terrestrial foraging species. Designed primarily for use by rats and mice, the entry opening and ground placement of many

Norway rats are commonly found in and adjacent to nature conservation areas in Hawaii and the Pacific region. (APHIS file photo.)

commercially available bait stations may also permit access by opportunistic feeders (e.g., birds, reptiles, amphibians, terrestrial crabs, and other small nontarget animals). Using common bait stations can thus result in bait exposure risks to rare native species and excessive bait removal by nuisance animals.

Some operators have made creative modifications such as reducing the entry opening and placing stations above ground level to exclude bait take by nontarget feeders. However, the accessibility of such modified stations to target rodent species has not been fully assessed. Using captive animals and remote camera observations, scientists from NWRC's Hawaii field station determined the minimum hole size and maximum platform height that could be accessed by the Polynesian rat, Norway rat, roof rat, and house mouse, all of which are commonly found in and adjacent to native-species conservation areas in Hawaii and the Pacific region.

PVC pipes, capped at both ends with holes of varying diameter, and baited with coconut, were used to assess bait-station entry accessibility. The minimum entry hole size was 13 mm for mice, 30 mm for Polynesian rats, 35 mm for black rats, and 40 mm for Norway rats. A small platform (baited with coconut and suspended from the roof of an enclosure at varying heights above the floor) was used for the jumping trials. Although rodents are adept climbers, jumping heights were fairly low—25 cm for mice, 30 cm for Polynesian rats, 40 cm for black rats, and 50 cm for Norway rats. These data suggest that the opening of many bait stations could be reduced to exclude nontarget organisms, but raising bait stations off the ground may exclude some rodents if climbing access is not provided.

TITLE: Development and Assessment of Methods and Strategies To Monitor and Manage Invasive Mammalian 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.

Large numbers of invasive (nonnative) animals have become established in the continental United States, its territories, and nearby countries and islands. These include fish (grass carp, tilapia, walking catfish), reptiles and amphibians (brown treesnake [BTS], cane toad, Caribbean tree frog), birds (myna, monk parakeet, mute swan, starling, pigeon), and mammals (feral livestock, feral dogs and cats, mongooses, rats, and nutria). Invasive vertebrate species cause substantial damage to crops and livestock, property, and natural resources (including threatened and endangered species, biodiversity, and ecosystem health) and pose a disease hazard to humans and livestock.

Nutria Lures Found To Increase Trap Success in Louisiana—At high densities, introduced, invasive nutria (an aquatic herbivorous rodent) are known to damage Louisiana marshes. Because traditional hunting and trapping methods can be inadequate to control nutria populations, they often need to be managed by other means. One possible tool for increasing efficiency of nutria harvest is the use of attractants. Effective attractants could be used for drawing nutria into a specific area, where they could then be removed via shooting or the placement of traps or rodenticide bait stations. Earlier pen studies at NWRC established that four lures—nutria urine, nutria fur extract, synthetic anal-gland secretion, and a commercially available apple-based lure—are attractive to nutria. In 2006, NWRC

Nutria at a trap station. (APHIS file photo.)

The potential impact of rodenticide use to the American alligator was evaluated by NWRC scientists. (APHIS photo by Scott Barras.)

scientists examined the effectiveness of these lures under field conditions to see if traps with lures caught more nutria than untreated traps. All 4 lures tested increased trapping success from 42 percent to 120 percent over untreated traps, with nutria fur extract yielding the biggest increase. Traps treated with the fur extract captured 220 percent more nutria then untreated traps. These lures will provide an additional tool to maintain nutria populations at levels that will not damage marshes.

Rodenticide Poses Little Hazard to Alligators— To lessen the damage that nutria cause to coastal marshlands in Louisiana, nutria populations must be reduced in some areas. This can be accomplished in various ways, including the use of the rodenticide zinc phosphide (ZP). However, the potential impacts of this rodenticide on American alligators, a valuable natural resource in Louisiana, must be assessed. NWRC scientists conducted a nontarget hazard assessment by (1) determining the levels of ZP in nutria that had succumbed to ZP rodenticide bait, (2) completing a risk assessment to determine the level of ZP exposure alligators were likely to experience from consuming poisoned nutria, and (3) determining the sensitivity of alligators to ZP by dosing them with various amounts of ZP in two different seasons. The mean amount of ZP found in each nutria carcass was 50 mg. The risk assessment determined that a conservative estimate for maximum exposure would be 173 mg ZP for a 28-kg alligator, or 6.2 mg/kg.

Results of this study show that the lethal dose where 50 percent of alligators die (LD_{50}) is about 15 mg/kg of ZP, and alligators are not affected by lower dosages. Therefore, the use of ZP rodenticide baits to manage nutria populations would pose only a small risk to alligators.

Efficacy of Commercial Rodenticides Used for Control of Wild Norway Rats and House Mice— Rodenticides are an essential tool in the control of introduced, invasive rat and mice populations. Researchers and managers need to know which of the many rodenticides commercially available will perform effectively against wild populations of rats and mice that have alternative foods to eat besides the rodenticide bait. NWRC scientists conducted two-choice trials with wild-caught Norway rats and house mice, using an array of commercial baits containing first- or second-generation anticoagulants or acute toxicants as the active ingredients.

All but 1 of the 12 rodenticides tested were 80- to 100-percent effective against wild Norway rats. With the wild house mice, however, only 5 of the 12 rodenticides were 80- to 100-percent effective. These were 3-day exposure trials; the trials will be repeated for mice using the 7-day exposure. These results indicate which rodenticides (such as brodifacoum and diphacinone) should be used for island eradications of introduced, invasive rodents. Furthermore, the study confirms that house mice are less susceptible to rodenticides than Norway rats.

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.

Information about predator population dynamics, ecology, and behavior in relation to predation on livestock, game species, and threatened and endangered species is needed for effective depredation management. This information also can be used as a basis for developing accurate methodologies for indexing predator abundance and for monitoring programs. Such programs are increasingly important because they provide evidence of regulatory compliance. While many data exist, significant gaps remain, especially in regard to predator–prey, predator–predator, and predator–livestock relationships. In addition, despite increasing interest in selective attractants for the delivery of pharmaceutical materials, repellants, and deterrent strategies that can reduce depredation, few practical alternatives to lethal control methods exist. By focusing on ecological and behavioral issues, this project addresses high-priority needs identified in WS research needs assessments.

Food Web Interactions and Intraguild Predation: Influence of Landscape, Predators, and Prey on a Native Mesocarnivore—Interactions between predators who compete for the same prey source create complex relationships such as intraguild predation where one predator preys on another. Theoretical research has predicted two possible paths to stability in intraguild systems: intermediate predators either out-compete higher order predators for shared resources or select habitat based on security. The effects of intraguild predation on

Swift foxes compete with coyotes on the prairies of the United States. Landscape features appear to be important for this small mesocarnivore. (APHIS photo by Eric Gese.)

intermediate mammalian predators, such as the swift fox, are not well understood. Researchers from NWRC's Logan, UT, field station examined the relationships between swift foxes and both their predators and prey, as well the effect of vegetation structure on swift fox–coyote interactions over a 3-year period. Observations at the Pinon Canyon Maneuver Site in southeastern Colorado were used to compare swift fox survival and density in a variety of landscapes to prey availability, higher order predator abundance, and vegetation structure.

Swift fox density varied between study sites, while survival did not. Coyote abundance was positively related to the basal prey species and vegetation structure, while swift fox density was negatively related to coyote abundance, basic prey species, and vegetation structure. The results support the prediction that under intraguild predation in terrestrial systems, top-predator distribution matches resource availability, while intermediate-predator distribution inversely matches predation risk. While predation by coyotes may be the proximate cause of swift fox mortality, the ultimate mechanism appears to be exposure to predation moderated by shrub density.

Landscape Use and Movements of Wolves in Relation to Livestock in a Wildland–Agriculture Matrix—Wolves have expanded their distribution into areas of the U.S. Midwest that have not had wolves for several decades. With recolonization of wolves into agricultural areas, there is increasing concern about wolf–livestock conflicts. To assess the risk wolves may pose to livestock, NWRC

Researchers studied the patterns of prey selection by recolonizing wolves and cougars in response to prey habitat shifts in Montana. (U.S. Fish and Wildlife Service photo.)

(U.S. Fish and Wildlife Service photo by Claire Dobert.)

researchers initiated a 3–year study investigating the activity patterns, movements, habitat use, and visitation to livestock pastures by wolves and the occurrence of depredation events in an agricultural–wildland matrix in northwestern Minnesota.

From June 1997 through November 1999, researchers captured 23 wolves, including pups, from 3 packs; 16 of these wolves were radio-collared. The collared wolves were tracked on a 24-hr basis during the spring, summer, and fall of 1998 and 1999. Observers found that wolves passed directly through a pasture containing cattle on 28 percent of the nights of tracking. Fifty-eight and 95 percent of the wolf locations were <1 km and <5 km from a pasture, respectively. Data on how wolves use space showed that, while they visited livestock pastures during the 24-hr tracking sessions, they apparently were passing through these pastures with cattle and not preying on livestock. Researchers concluded that the wolves were moving randomly, not trying to encounter livestock. Thirty percent of random movements passed directly through a pasture; 65 percent and 95 percent of random movements were within 1 km and 5 km of a pasture, respectively.

Wolves were more active at night than during the day. Wolves avoided pastures during the day and visited them at night, when depredations were most likely (i.e., human presence was low).

Visitation was not related to any discernible characteristics of the pastures (i.e., pasture size, cattle density, distance to human habitation, percent forest cover, index of deer abundance). Pastures in which livestock were killed by wolves contained more cattle than pastures without depredations, but that was true in 1998 only. While the risk of wolf predation on livestock was potentially high (i.e., predation occurred within 1 km of a pasture on 58 percent of nights), few livestock were actually killed. During the 3-year study, only 8 animals (all young or vulnerable livestock) were depredated by wolves. Maintaining healthy wild prey populations, removing offending wolves that kill livestock, and encouraging effective and proper husbandry practices (e.g., disposal of carcasses) among livestock producers may minimize the impact of wolves on farmers in this agriculture–wildland matrix.

Relative Contributions of Habitat Complexity and Prey Physical Condition to Predation by Cougars and Recolonizing Wolves—Numerous studies have documented how prey may use specific antipredator strategies to mitigate risk of predation from a single predator. However, when a recolonizing

predator enters an already complex predator–prey system, specific antipredator behaviors can conflict, and avoidance of one predator can enhance vulnerability to another. Researchers studied the patterns of prey selection by recolonizing wolves and cougars in response to prey habitat shifts in the northern Madison Range of Montana. Although the study revealed that the predators partitioned hunting habitats, the structural complexity at wolf kill-sites increased over time, whereas the complexity of cougar kill-sites remained static. Elk were the primary prey for wolves, and mule deer the primary prey for cougars, but elk made up an increasingly greater proportion of yearly cougar kills over the life of the study. While both predators preyed disproportionately on bull elk, wolves were most likely to prey on bulls in poor physical condition.

NWRC scientists concluded that habitat shifts in prey were attempts by formerly naïve prey to lessen predation risk from wolves. However, shifting to more structurally complex habitats might have made prey more vulnerable to cougars. Habitat shifts may represent a compromise to minimize overall risk, following a change in predator exposure.

Resource Selection and Social Behavior Modulates the Partitioning of Hostile Space by Sympatric Canids—Investigations into mechanisms of competition are particularly suited to systems where interactive behaviors are emergent. Wolf recolonization of the Greater Yellowstone Ecosystem (GYE) provided NWRC researchers with such a system, and they were able to identify developing behaviors influencing the outcome of competitive interactions between coyotes and wolves.

Scientists observed coyote–wolf interactions immediately after wolf recolonization, when emergent behaviors mediating the outcome of competitive interaction were detectable and mechanisms of spatial avoidance were identifiable. Coyotes made adaptive changes in resource selection that reduced the likelihood of their encountering wolves. However, carrion located in predictable areas—the foci of intense competition—provided inducement for coyotes to travel through areas of significant wolf activity.

Coyotes interact with wolves in the northern Rockies and are adapting to the return of this top carnivore. (APHIS photo by Eric Gese.)

Researchers concluded that coyotes do not perceive wolves as a threat requiring generalized spatial avoidance. Rather, the threat of aggressive interactions with wolves is spatially discrete and primarily confined to areas immediate to carrion resources. In most cases, wolves excluded coyotes from carcasses and monopolized access until they decided to forgo further feeding. However, occasionally, numerically superior aggressive coyotes were successful in supplanting wolves from carcasses. Thus despite the disadvantage of smaller body size, numerically superior coyotes demonstrated resource holding potential. Coyotes relied on subtle behaviors to avoid spatial interaction with wolves and on conspicuous behaviors to mitigate the outcome of temporal interactions.

TITLE: Improved Technologies and Nonlethal Techniques for Managing Predation

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

Predator attacks on livestock cost the industry millions of dollars annually. As a result, efficient, socially acceptable tools are needed to minimize livestock depredations. Scientific studies are underway at NWRC to identify predator traits that can be exploited to create more effective means to capture problem animals or to exclude them from areas with livestock. Scientists are also developing approaches to resolve problems associated with bears residing near people in parks or in urban and suburban areas. This project targets the development and evaluation of innovative nonlethal techniques and the efficacy of existing frightening devices or aversive stimuli to deter these predators.

Because no one management technique exists that can be 100-percent successful in all situations, scientists in this project employ advanced engineering and thorough knowledge of animal behavior to research all possible avenues for producing state-of-the-art nonlethal predator-management tools.

New Programmable Predator Frightening and Calling Device and Tests of Fladry for Repelling Coyotes—The Scare-Call, a new remotely activated, multisensory, programmable device that can be used either to frighten or call predators, has been developed by NWRC's Logan field station and ML Designs of Goleta, CA. The initial concept for the tool came from consultations with WS Operations in several States, but additional research added significant capabilities to the device. Currently, the device can be programmed weeks in advance and left in the field. It can also be triggered or remotely programmed from hundreds of yards away. Scare-Call uses high-quality digital audio files and can respond to inputs, such as motion detectors, or use external outputs, such as lights and external speakers.

The Scare-Call can be programmed to call predators to capture sites or, alternatively, configured to repel them from pastures. (APHIS photo by John Shivik.)

The devices were deployed in a study that examined the variability of boldness and shyness of coyotes. One observational study examined the variation in the response of captive coyotes to the behavior-contingent scare device. Two pairs of coyotes ate the food on the first night, 2 pairs of coyotes persisted in trying to eat the food every night of the trial without success, and 10 pairs of coyotes gave up attempting to obtain the food.

Another experiment examined the effects of individual stimuli or a combination of stimuli on coyote habituation using 15 pairs of captive coyotes. Coyotes did not activate the scare device with different stimuli at significantly different rates. Results showed that coyotes habituated to the three stimuli differentially, with a larger proportion of coyotes specifically habituating to the sound-only treatment.

Researchers then used variables of gender, age, social status, rearing, and distance from another pen with a scare device to find predictors of boldness or shyness in coyotes. Social status was

the only variable that predicted boldness, with subordinate coyotes being the most likely to attempt to eat the novel food and to eventually habituate to the scare device.

In studies of the use of fladry—ropes adorned with interspersed flags traditionally used in Eastern Europe to hunt wolves—previous research suggested that within social animals, subordinate individuals are less neophobic than dominant individuals. NWRC scientists studied the effect of social status on neophobic responses using 10 captive coyote breeding pairs. Social status was determined from observations of feeding behavior and agonistic interactions during a series of reference trials. Once dominance was established, biologists used fladry to create a novel context around a familiar food source.

Dominant coyotes were first to feed during fladry trials and showed much more interest toward fladry (sniffing flags, approaching the fladry area) than subordinate coyotes did. Subordinate coyotes never crossed fladry barriers and showed strong avoidance of fladry areas.

Results suggest that dominant coyotes are less neophobic of novel settings that contain familiar food than subordinates are. Because a reduction in neophobia can be interpreted as an increase in risk taking, our results support field observations that dominant (alpha) coyotes take more risks than subordinates to obtain familiar, yet potentially dangerous resources, e.g., by hunting large prey and livestock.

Coyote Cage Trap Tests—The need for alternative capture techniques for predators is increasing because of concerns about the efficiency, selectivity, and injury-causing characteristics of currently available capture methods. There is also a need for comparative data evaluating new or seldom-used methods.

In an initial evaluation, researchers first surveyed wildlife managers for information on cage-trapping; using these data, NWRC conducted a field study of four coyote capture systems for animal damage management. The SoftCatch®, Collarum®, WS–Turman (WS–T), and Tomahawk® systems were tested in Arizona and South Texas during 2001 and 2002. Scientists determined capture efficiency and selectivity and performed whole-body necropsies to identify trap-related injuries.

Surveys indicated that coyotes were usually captured in large (> 1.6 m long) cage traps baited with meat or carcasses. In the field evaluation, capture efficiency (percentage of coyote captures per capture opportunity) was estimated at 0 percent for the Tomahawk cage-trap, 87 percent for the Collarum, 88 percent for the WS–T throw arm, and 100 percent for the SoftCatch.

Tomahawks were the least selective, capturing 34 noncoyote animals, and Collarums were the most selective, capturing only coyotes. The WS–T and Soft Catch devices showed intermediate selectivity of 50 percent and 69 percent, respectively.

Compared to previously tested jawed devices, the traps tested in 2006 caused fewer injuries to coyotes. Of the animals caught in the Collarum and Soft Catch traps, 92 percent showed no signs of poor welfare. The figure was 57 percent for coyotes caught in the WS–T trap.

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.

Foraging wildlife impacts forest resources in numerous ways. Damage can result in reduced productivity, delayed harvest cycles, failure to establish replacement trees after a harvest or fire, and failure to establish native plants. This damage may hinder the increase in forest diversity, improvement of riparian areas, revegetation of disturbed sites, restoration of endangered or threatened plants, or the creation or improvement of wildlife habitat.

Managing resources to resolve these problems is becoming increasingly difficult. The land base to produce timber is shrinking. This declining base restricts options, while increasing the necessity to protect remaining resources. Historical approaches to reducing forest damage problems are under increasing scrutiny as the public demands more humane means to resolve wildlife conflicts. Additionally, conflicting management objectives frequently impede attempts to resolve problems. One manager may be attempting to reduce damage on a timber stand while an adjacent landowner is working to increase wildlife populations. The combined result highlights the critical need for increased and enhanced research and outreach programs. New nonlethal approaches need to be identified and existing approaches improved.

Support for Registration of Chlorophacinone for Mountain Beaver Control—In the Pacific Northwest, mountain beaver cause more damage to tree seedlings and 10- to 15-year-old trees than any other mammal. Attempts to manage mountain beaver through use of existing technologies, (e.g., repellants, barriers, and trapping) are costly and not always productive. In addition, the most reliable method to control mountain beaver populations, trapping, is becoming less politically and socially acceptable. Therefore, improvements and alternative methods for control of mountain beaver populations are desirable.

Through a series of studies, NWRC's Olympia field station screened four selected toxicants and determined that chlorophacinone is a likely toxicant for mountain beaver control. Initial field trials with chlorophacinone were conducted to determine efficacy in three recently harvested parcels in Oregon.

Removal of at least 1 bag of bait per burrow system was high across units (78–93 percent), although only two units incurred significant mountain beaver mortality (67–68 percent). Mortality was spread out through the study period, and additional mortalities were documented during the secondary monitoring period, 3 months after baiting. Delayed mortalities were likely due to the caching behavior exhibited in mountain beaver.

An NWRC technician and a forest-industry cooperator recover mountain beaver. (APHIS photo by Wendy Arjo.)

Whole-body chlorophacinone residual concentrations averaged 0.176 µ/g (± 0.02 SE) with a range of 0 to 0.31µ/g, well below environmental risk concerns. In a few cases, the hoarding observed likely reduced bait availability for other animals. Availability of vegetation, surrounding population sources, and previously established beaver populations, all contributed to the observed mortality differences between the units.

A followup study was conducted in Washington to examine the effects of bait hoarding and reinvasion on the efficacy of baiting. Efficacy during this study was lower than previously documented, most likely due to early availability of forage within the unit. Bait hoarding was documented with one animal obtaining 7 bait bags from 3 other mountain beavers. Reinvasion into the unit after removal of the residents occurred in 6 weeks.

A combination of simultaneous baiting and trapping, applied the first year after seedlings are planted, can offer managers a more efficacious and cost-effective tool than currently in use by protecting a window of time for seedlings to establish. If EPA approves use of chlorophacinone as a toxicant for mountain beaver control, future studies will address the economic impacts associated with the operational use of this new tool.

Flavor Aversion Learning (FAL) in Herbivores— Results from numerous studies suggest that FAL is well suited for applied wildlife-damage management. However, in practice FAL frequently fails as a management tool. This failure results, in part, from a lack of awareness of the many factors that contribute to the learning process. At the same time, it is recognized that herbivore avoidance of toxic plants is a direct result of FAL. Although these naturally occurring aversions can sometimes fail, they are typically more robust than those produced for applied management situations. A series of studies was conducted at the Olympia field station with model herbivores to gain greater insight into herbivore foraging behavior and applied FAL.

Using goats as surrogates in flavor aversion learning trials. (APHIS file photo.)

One recent study was designed to address flavor-consequence specificity. In this study scientists asked, "Do herbivores discriminate among different toxins, or do they generalize their responses?" This research was achieved by administering two different toxins that produce different physiological consequences and monitoring extinction (cessation of avoidance behavior), prior illness (reacquisition of an aversion based on reexposure to the toxin), and spontaneous recovery (postextinction reacquisition of an aversion in the absence of toxicosis). These processes are central to FAL and may have significant implications for successful application of FAL for the protection of agricultural resources.

Results demonstrated that herbivores did not associate unique physiological effects of toxicosis with specific flavors. Additionally, presence of a novel food during exposure diminished aversion to a food associated with prior illness because the familiar diet was intermittently toxic.

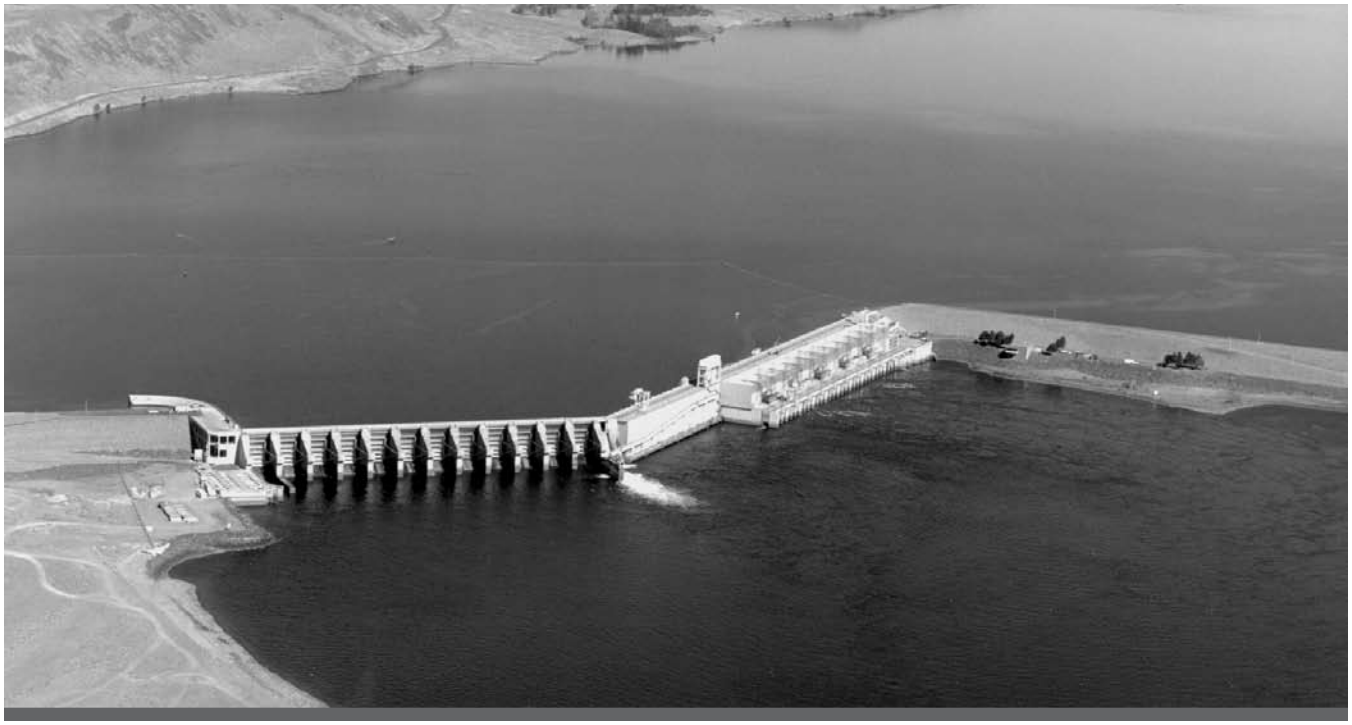
These results suggest that persistent aversions are unlikely when foods are intermittently paired with toxins. In practice, preferable results in applied FAL (i.e., protection of an agricultural resource from damage caused by foraging herbivores) will come from frequent exposure to multiple toxins. Ultimately, persistent aversions to specific foods will result only when the toxin is inescapably paired with the food.

Evaluation of Nonlethal and Lethal Control Measures To Reduce Avian Predation on Salmonid Smolts—At the request of Washington WS, investigators from NWRC's field stations in Olympia, WA, and Starkville, MS, collaborated in evaluating control measures at the Wanapum and Priest Rapids dams on the Columbia River during 2005. Several anadromous salmonid species in the Columbia River Basin are listed under the Endangered Species Act of 1973. Accordingly, the responsibility to protect or enhance survival of migrating salmon lies with several entities, including the public utility districts operating hydroelectric dams along the Columbia River. Dams pose a problem to juvenile salmonids on their outmigration: as the salmonids pass through the turbines of the hydroelectric facility, they become disoriented and sometimes die.

Aggregations of piscivorous birds, primarily gulls, concentrate and feed at the tailraces of dams during the smolt outmigration period and appear to be the dominant avian predator on juvenile salmonids in the Columbia River Basin. NWRC scientists conducted a preliminary systematic evaluation of the effectiveness of the avian predator-control program at Priest Rapids and Wanapum Dams for 2005, including the need for and effectiveness of lethal control. Specific goals include (1) reduce damage or loss to downstream juvenile, migrant salmonids caused by piscivorous birds, (2) determine efficacy of nonlethal and lethal control methods, and (3) determine the potential effects of avian predation on salmon smolt numbers.

Smolt numbers peaked at Rock Island through early May and tapered to less than 1,000 smolts per day the beginning of June. At Wanapum Dam, gull numbers tracked smolt abundance, and there was a significant positive association between the number of observed gulls and the number of salmonid smolts. Northern pikeminnows less than 9 inches are also considered to be a possible available prey item for piscivious birds. There was no correlation

Flocks of fish-eating birds, primarily gulls, concentrate and feed at the tailraces of dams during the outmigration of juvenile salmonids along the Columbia River. (U.S. Department of Energy file photo.)



found between gull numbers at Wanapum Dam and available pikeminnows.

Wire arrays were established at each dam to deter or at least minimize bird predation. Few birds were observed under the wires at Wanapum Dam. However, at Priest Rapids Dam, more birds were under the wires in May and then also late in the season, when bird populations increased. A relatively low percentage of birds was removed from Priest Rapids Dam (1.9 percent) and Wanapum Dam (4.3 percent). There was a significant difference in the number of birds present 5 minutes after the arrays were installed at Wanapum Dam with month and control varying significantly. The number of birds returning after nonlethal control was significantly greater than the numbers returning after lethal and nonlethal/lethal combination of control. There was no difference observed in bird returns under the different control measures at Priest Rapids Dam.

More than 70 percent of the birds removed at Wanapum had fish present in their gut, and of these, 21.8 percent had PIT tags. Most fish parts were not identifiable, but of those that could be identified at the Wanapum site, 125 of the 206 recovered birds had salmon remains. The numbers at Priest Rapids were lower, with 40.1 percent of the recovered birds containing fish in their stomach and only 7 percent containing pit tags. The majority of the recovered pit tags were from steelhead (84 percent), followed by Chinook (11 percent) and coho (5 percent).

Product Development Research Program

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.

The approach to developing chemistry-based tools is based on increasing the understanding of the chemical and biochemical aspects of wildlife damage. Analytical chemistry is an integral part of much of the research conducted at NWRC. Project scientists have experience in related scientific disciplines, such as metabolism chemistry, environmental fate, chemical synthesis, toxicology, chemical ecology, wildlife genetics, and chemical formulation.

Development of an Improved Bait Matrix for Rabies Vaccine Baits—Biomarkers such as tetracycline are commonly included in baits intended for wildlife. Last year, USDA distributed more than 10 million tetracycline-containing rabies vaccine baits to control the spread of wildlife-vectored rabies to humans, pets, and livestock. To estimate the percent of target species consuming the baits, field crews collected raccoons and skunks in baited

In 2005, USDA distributed more than 10 million tetracycline-containing rabies vaccine baits. (U.S. Fish and Wildlife Service photo by Dave Menke.)

areas, and researchers analyzed the animals' teeth for the presence of the biomarker.

Several incidents of low biomarker detection rates prompted an investigation of the stability of the biomarker in the baits. Results indicated that a portion of the tetracycline was converted to epitetracycline, a compound with lower biomarker activity. Additionally, significant quantities of both compounds were trapped in the polymer that is homogeneously distributed throughout the bait. The results of this study suggest that approximately 40 percent of the target quantity of tetracycline was unavailable for absorption. This situation likely causes the low biomarker detection rates noted in the field studies.

A prototype bait formulation was developed using an acid-soluble, low-melting-point polymer. Using such a polymer minimized the conversion of tetracycline to epitetracycline. (table 1). The acid solubility of the polymer increases bait degradation in the stomach, thereby increasing release of the biomarker. Additionally, bicarbonate was added to the bait formulation. In the acidic stomach environment, bicarbonate liberates carbon dioxide, which further increases the physical breakdown of the bait matrix and subsequent release of the biomarker. At neutral pH, the new bait formulation exhibited the required stability to prevent biomarker release under environmental conditions.

Table 1—Tetracycline recovery and epitetracycline formation in netural and acidic solutions

	Mean recovery			
	Total tetracycline recovery		Epitetracycline formation	
	pH 7	pH 2	pH 7	pH 2
	(Percent)			
Current bait	< 1	37.6	< 1	12.4
New bait	< 1	90.9	< 1	3.6

An NWRC scientist examines a sedated raccoon during the rabies vaccine study. (APHIS file photo.)

Identification of Fatty-Acid Dietary Indicators in Wildlife Tissue—NWRC chemists have developed methods to quantify fatty acids in agricultural crops and fish and wildlife tissues in hopes of developing approaches to identify wildlife populations that are responsible for agricultural losses. For example, in collaboration with the Bird Research Program, chemistry research has demonstrated that the fatty-acid profiles of rice, corn, and sunflower are significantly different. Subsequent studies using caged birds indicate that fatty-acid analysis of bird tissues can be used to distinguish between birds fed these different food sources.

Investigators determined, by analyzing field-collected blackbirds from NWRC's Bismarck, ND, field station, that fatty-acid profiles in birds change as they migrate along the flyway from North Dakota to Nebraska, likely reflecting changes in diet as the birds migrate.

Chemistry researchers have also developed analytical methods to determine fatty acid profiles in farm raised and wild fish. Statistical analyses of the resulting fatty-acid profiles indicate that it is possible to distinguish between the species and source (wild v. commercial) of fish. Further collaborative studies with the Starkville, MS, field station are planned

to apply this methodology to identify the contents of fish harvested from cormorant gastrointestinal tracts. Application of this approach to birds should enable researchers and operational personnel to determine the contribution of wild v. commercial fish in the diet of cormorant populations. Furthermore, it may be possible to establish the source of the farm-raised fish based on differences in the fatty-acid profiles of fish tissues.

Fatty-acid analyses are also being applied to mammalian pests. In a collaborative study with NWRC's Mammals Research Program and Colorado State University (CSU), these fatty-acid analysis approaches are being developed to identify nuisance bears that consume manmade foods. In a controlled feeding study, bears fed anthropogenic foods had fatty-acid profiles in tissues reflecting the presence of fatty acids found only in those foods.

Research findings indicate that fatty-acid analyses can link wildlife to damaged agricultural resources. This approach has the potential to identify problem wildlife populations and depredating individuals. Application of this approach can facilitate selective and effective wildlife damage management.

Development of Deer Repellants—Browsing deer inflict damage to crops and ornamentals and impede reforestation efforts. There are no indications that this serious economic problem is subsiding. A series of experiments conducted by a scientist in the Analytical Chemistry Project in Fort Collins and staff at the Olympia field station determined that certain food-grade materials, such as milk casein and egg albumen, have great potential as repellants to reduce deer consumption of desirable resources. Chemical analyses further demonstrated that proteins which deter browsing deer share the attribute of containing the amino acid methionine in their structures. A study evaluated several methionine-containing proteins by applying them to desirable plants and offering them to captive deer.

The results of these experiments suggest that a repellant formulated with purified hydrolyzed casein used for nutritional and health applications effectively reduces browsing damage and is a promising tool for protecting seedlings in reforested areas.

Assessment of Fertilization as a Strategy for Reducing Deer Browsing—During fall 2005, two members of the Analytical Chemistry Project collected the final samples in a multiyear collaborative study to assess the effects of fertilization on the phytochemistry of western redcedar. In cooperation with the timber industry in Oregon, investigators subject test trees to treatments with fertilizer applied to the soil and elemental sulfur applied to the foliage to determine if these treatments promote chemical changes to deter deer browsing.

To date, chemical analyses of the foliage have demonstrated that site and temporal variability in the chemical constituents of redcedar foliage far exceed in their influence on browsing any treatment effects. These data from the first 2 years of the study indicate that fertilization is not an effective strategy for producing browse resistance in redcedar in a timely fashion.

Development of Bird Repellants—The Analytical Chemistry Project began developing methods in July 2005 to determine how much caffeine remains on ripening sunflower seeds after applications made early in the gowing season. The researchers are currently developing a method to determine caffeine residues on rice seed panicles treated during the milk phase. Additionally, the team is developing methods to determine flutolanil (Moncut®) residues in ripening rice to aid in assessing (1) the efficacy of this bird repellant and (2) its environmental impact in rice-paddy water. These methods along with others already developed for caffeine in rice-paddy water and in ripening rice, will be used to provide residue data in support of up to five field studies conducted in the fall of 2006 by various scientists in the Bird Program.

Ground squirrels cause damage to crops and rangeland grasses in California. (U.S. Fish and Wildlife Service photo by John and Karen Hollingsworth.)

Providing More Effective Ground Squirrel Baits— Broadcast application of 0.005-percent chlorophacinone and 0.005-percent diphacinone steamrolled oat (SRO) bait for ground squirrel control is essential to supress damage to crops and rangeland grasses in California. A major concern, however, is the potential for secondary hazards to nontarget species that may scavenge on the carcasses of target species. There is a synergistic effect between antibiotics, such as tetracycline and erythromycin, and anticoagulants, such as diphacinone. Therefore, NWRC researchers assessed the effectiveness of tetracycline combined with lower levels of diphacinone than in registered baits for its potential for rodent control. The animal portion of the study was conducted during 2004, and residue analysis for diphacinone and tetracycline was completed in 2005.

In the study SRO baits at 0.005-percent diphacinone (no tetracycline), 0.0025-percent and 0.001-percent diphacinone bait with 1 percent tetracycline, and a control bait without diphacinone but with 1 percent tetracycline hydrochloride were fed to Wistar Norway rats in a controlled environment. The scientists assessed mortality and determined diphacinone and tetracycline residues for whole-body and liver tissues.

Mortality was 10 out of 10 for each treatment group and 0 of 10 for the control groups. Table 2 lists residue results for carcass and liver tissues.

Table 2—Mean diphacinone residues in rodent carcasses and liver at two dosage levels, with and without tetracycline, in ppm

	Diphacinone rate		
	Without tetracycline	With 1% tetracycline	
	0.005%	0.0025%	0.001%
Carcass	1.05	0.434	0.263
Liver	3.88	1.260	0.988

Mean residues in the animals treated with the registered bait are approximately four times greater than in the 0.001-percent diphacinone experimental bait containing the synergist. No diphacinone residues were detected in the control groups. Tetracycline residues ranged from 35 to 360 ppm in whole-body tissue samples for the treatment groups, which represents 3 to 9 percent of the total amount of tetracycline that the rats consumed.

These results show that using tetracycline along with the anticoagulants could be an effective method of reducing residues in target animals and in those animals that eat them.

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 such as monk parakeets and crows and in mammalian species such as California ground squirrels and prairie dogs.

The WS program has given high priority to research on reproductive control of various species of mammals and birds involved in human–wildlife conflicts. Results of the research can then be used to develop alternative management tools.

Immunocontraception To Control Deer Populations and Reduce Human–Deer Conflicts—Many white-tailed deer herds that inhabit urban and suburban environments are overabundant and are causing numerous problems for their human neighbors. The most serious problems include damage to vegetation and increases in deer–motor vehicle collisions. Regulated sport hunting, which is typically used to control deer population levels, generally is highly restricted or not permitted in these settings due to concerns for human safety. Safe and effective contraceptives to maintain deer populations at levels achieved by hunting and as part of an integrated population management strategy are needed.

NWRC has developed and tested many types of wildlife contraceptives, including GonaCon™ immunocontraceptive vaccine, which has been 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 brown rats. GonaCon is now available as a one-injection formulation that is more practical for field delivery to free-ranging wildlife than earlier, two-injection contraceptive agents.

Biologists attaching a radio-telemetry collar to a vaccinated deer. (APHIS file photo.)

Two field studies of the efficacy of GonaCon as a contraceptive for deer are underway in the Eastern United States. The first study was initiated in Silver Spring, MD, during July 2004 on a fully fenced, forested site that is managed by the U.S. General Services Administration. Overabundant deer were creating numerous conflicts with humans there, and WS was asked to resolve the problems. NWRC scientists worked with Maryland 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.

In year 1 of the study, only 14.4 percent of the vaccinated deer reproduced. GonaCon vaccination carried over to year 2 in some animals: about 53 percent of previously treated does had fawns during 2006.

A second 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 very similar in design and scope to the Maryland deer study. Twenty-eight adult does were captured and injected with GonaCon, and 14 other does that will serve as control animals were captured and given sham injections before being released.

Field observations during the summer of 2006 indicated that only 32 percent of treated does had fawns during the first year after treatment. As in Maryland, the reproductive success of free-ranging treated and control deer will be monitored and compared for 2 years to measure the efficacy of GonaCon as a deer contraceptive under field conditions.

Study of the Safety of GonaConImmunocontraceptive Vaccine in Target Animal—A pivotal GonaCon safety study in target species, conducted in collaboration with The Pennsylvania State University, began in late July 2005 with the study phase completed in December 2005. The Food and Drug Administration (FDA) requires these data to access the safety of new animal drugs to the intended target species. The study was designed to better understand the entire physiological response of deer to GonCon and to establish if contraindications were associated with its use.

Seven does were given a single injection of vaccine containing GnRH and keyhole limpet hematocyanin and compared to six does given a single control injection of saline and six does given three injections of GonaCon at 2-week intervals per dose (to simulate reinjection). Blood samples were drawn immediately before vaccination and at 5, 10, 15, and 20 weeks after immunization to evaluate any changes in blood chemistry and hematology of treated deer when compared to control deer. Blood was assayed for luteinizing hormone, testosterone, and progesterone and anti-GnRH titers as well as hematology and blood chemistry. At each sampling period, the general health of the doe was observed, and the injection site was inspected for the possible formation of abscesses.

At week 20, all deer were euthanized and veterinary pathologists evaluated the carcasses at necropsy, taking samples of lymph nodes, reproductive organs, lung, liver, heart, kidney, spleen, and brain for histology. The study deer were generally in good health at the conclusion of the study, and no abnormal hematology, blood chemistry, or histopathology attributable to the vaccination was observed. Aside from the formation of granulomas at the injection site, such as frequently occur with vaccinations, there were no significant contraindications or toxic effects associated with GonaCon.

Diazacon™ Reduces Monk Parakeet Reproduction at Electric Utility Substations—Populations of the exotic monk parakeet, native to South America, have been growing at exponential rates throughout the USA, especially in south Florida. The parakeets construct large nests of sticks and branches and often select electric utility structures as nest sites. As a result, power outages occur as the nest material, or the birds themselves, create short circuits. As part of an effort to develop an integrated management approach to reduce the parakeet problem, NWRC biologists have been researching means for slowing the population growth of the parakeets. One promising method is the compound 20,25–diazacholesterol HCl (sold commercially as Diazacon). Trials with captive birds demonstrated that this compound can eliminate reproduction under controlled conditions. To obtain a registration for this chemical, however, demonstration of efficacy in the field is needed.

In cooperation with a south Florida utility company, biologists at the NWRC Florida field station established bait stations at four electrical substations and presented parakeets with Diazacon-treated sunflower seeds for 10 days at two sites. The other two sites received no treated bait. Field

Monk parakeets feeding on Diazacon-treated sunflower seeds. Consumption of the bait resulted in greater than 50-percent reduction in reproductive success at the test sites. (APHIS file photo.)

Monk parakeet nests built in electrical substations often cause power outages that result in loss of service and expensive repairs. (APHIS file photo.)

crews measured consumption daily, and video cameras monitored visits to the bait stations. After 5 weeks, crews removed accessible nests at all four substations and recorded the numbers of eggs and nestlings.

Results of the nest examinations revealed that average productivity at the two sites with treated seed was 2.04 nestlings/nest, compared to 4.89 nestlings/nest at two sites with untreated seed. This represents a 58 percent reduction in reproductive success and suggests that Diazacon for parakeet management warrants further development.

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

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

The scope of wildlife damage-management activities continues to expand as conflicts with humans and wildlife increase. New wildlife diseases (e.g., hantavirus, bovine tuberculosis, and chronic wasting disease) may cause risks to human health, livestock production, and wildlife populations. Increased populations of urban, resident Canada geese pose nuisance and contamination problems in many municipalities throughout the United States. Predators can deter recovery efforts for certain endangered and threatened species such as the California least tern. NWRC's economics research seeks to quantify benefits and costs of new and traditional wildlife-management activities. NWRC's economist is working to learn what the "real" costs and benefits are for intervening with repellants, relocations, removals, rodenticides, etc., to limit the effects of certain wildlife upon agriculture, natural resources, or public health.

Potential Oral Rabies Vaccination of Skunks in California—Since the 1950s, the epidemiology of rabies has changed dramatically in the United States. While total cases of animal rabies have declined due mainly to dog-vaccination programs, cases of wildlife rabies have increased and attenuated the overall case decline. Data for 2004 showed that, in the 49 States (excluding Hawaii) plus Puerto Rico, canine rabies accounted for only 1.4 percent of disease incidence while wildlife accounted for about 92 percent (94 cases *v.* 6,836).

In 2005, Economics Project staff continued to collaborate with the California Department Health

Skunks are a potential carrier of rabies. (Corel photo.)

Services (CDHS) to perform a benefit–cost analysis of the potential use of skunk oral rabies vaccination (ORV) baits in that State. Although no oral vaccine for skunks is currently registered, research and development have yielded much progress toward this goal.

Areas of historical skunk rabies were identified using geographic information system (GIS) plots of positive skunk rabies cases confirmed by the CDHS between 1993 and 2003. Key areas of skunk rabies involved the Sacramento Valley (Amador, Butte, Calaveras, Sacramento, Sutter, and Yuba Counties), the eastern San Francisco Bay Area (Contra Costa, Alameda and Santa Clara Counties), and the area of San Luis Obispo and Santa Barbara Counties.

Using these skunk rabies "hot spots," the study assessed the potential accrued benefits of rabies prevention and the costs of distributing the ORV baits. Benefits were viewed as the expected savings from reduced societal costs associated with the disease, such as minimized exposure from rabid animal encounters and therefore a decreased number of postexposure prophylaxis (PEP) treatments.

To estimate potential benefits, two scenarios were devised: (1) researchers baited all skunk rabies areas, effectively preventing the spread of rabies as had been seen historically, and (2) the same area as scenario 1 with additional protection assumed for the Greater Los Angeles Basin. Additionally, each scenario factored in multiple levels of rabies prevention (50 percent, 75 percent, and 100 percent). Annual benefits were found to be $548,344 under scenario 1 and $1,199,328 under scenario 2. Baiting costs were derived for multiple bait-densities (37.5, 75, and 150/km^2), bait campaigns (1, 2 or 3 annual programs), a bait cost of $1.24, and costs for distributing the baits from the air or on the ground. Cost estimates ranged from $2,260,668 at the lowest bait density to $7,016,668 at the highest bait density. Benefit–cost ratios (BCRs) were determined for all possible combinations of prevention, bait density, and bait campaigns.

BCRs ranged from 0.16 to 2.91 under scenario 1 and 0.34 to 6.35 under scenario 2. Additional contingency costs to stop possible outbreaks in previously baited areas reduced these BCRs to between 0.10 and 1.82 under scenario 1 and to between 0.21 and 3.97 under scenario 2. A BCR of <1 indicates that the costs outweigh the benefits and the combination of bait-density, bait campaigns, bait cost, and distribution is not economically inefficient.

Economic Assessment of California WS Operations Activities—The NWRC economist completed an economic assessment of the California WS program in 2005. Detailed analyses quantified WS' economic benefits to each of the 38 counties that contributed cooperative funds in 2004, with an aggregate report of county results used to form an overall statewide estimate of the program's value. The general categories of wildlife damage-management activities included agriculture, health and human safety, natural resources, and property. Researchers used replacement-cost and damage-avoided methods to determine economic valuation.

Protection of livestock (particularly sheep, cattle, and goats) from predation was the main activity of California WS personnel in each of the cooperating counties. Researchers estimated that, in years 1 and 2 of the study (which approximated the Federal

Government's fiscal years 2003 and 2004), the 38 California counties would have spent $6,605,234 and $8,602,590, respectively, to achieve the levels of damage protection that WS operations provided in those years. On a per-county basis, mean replacement figures were estimated at $173,822 and $226,373 for the same years. Although WS work was worth that much money, the 38 counties contributed, on average, just $51,798 in cost-sharing assessments. If they had hired alternative wildlife-damage-management firms to do the same work, the counties would have had to spend $122,024 and $174,575 more to get the job done.

This type of economic analysis is also being used by NWRC to examine the benefits and costs associated with other California counties not currently using WS. Kings and Fresno Counties were eager to evaluate their programs by the same methods used in this report, and the California Department of Food and Agriculture's (CDFA) Vertebrate Pest Research Advisory Council contracted with the Economics Project to complete a similar study.

Economics of Puget Sound Goose Management—During the 1990s, urban Canada geese populations grew throughout the eastern Puget Sound. Although a valuable viewing resource for the public, these abundant geese posed nuisance and contamination problems for park, beach, and golf-course managers in many municipalities along the Sound. Park and beach usage declined due to contamination.

Canada geese posed nuisance and contamination problems for park, beach, and golf-course managers in many municipalities along the Puget Sound area. Park and beach attendance declined due to contamination. (Istockphoto.)

The NWRC Economics Project completed a 2-year study with the CSU economics department that provided an econometric assessment of urban goose damage and control efforts in the Puget Sound area. The assessment looked at 12 years (1993–2004) of goose-related damage and control data collected and provided by Washington WS biologists. Damage declined dramatically following a peak in goose management actions during 2000.

The model for these analyses assumed that damage by resident geese triggered a policy or management response; if effective, the response in turn would affect the size of the problem. This two-way effect creates a "negative feedback loop." That is, from a starting point of high damage, goose management entails a high level of response, which leads to decreased damage, then to a decreased control requirement, until the cycle of damage and management damps down to equilibrium. In the balanced state, damage levels are low enough that very modest management efforts will maintain low goose numbers and damage. This model of urban goose and damage management fits diverse wildlife-caused problems, and it needs to be pursued in describing other wildlife-damage scenarios.

Econometric analyses showed that lethal removal and egg addling were cost-effective methods of reducing goose-related damage, but hazing of geese was not. Benefits exceeded costs whenever goose-caused damage exceeded $200 per incident, and removal or addling cost less than $20 per goose or less than $3.00 per egg, respectively.

NWRC Impact Analysis—NWRC provides numerous benefits to the field of wildlife damage management that can be difficult to quantify. NWRC scientists undertook to the quantification of

the direct economic effects of NWRC headquarters' spending and employment on the economy in the State of Colorado. In other words, if NWRC's headquarters did not exist, what would be the impact to the Colorado economy? This report did not attempt to quantify the intangible benefits of NWRC or the products it creates, nor did it quantify the economic impacts on a national level. Therefore, results of this study underestimated the overall value of NWRC.

To estimate NWRC's contribution to Colorado's economy, Center scientists ran impact analyses for three different geographic regions: (1) Larimer County, (2) Larimer County plus the four contiguous counties (Weld, Jackson, Boulder, and Grand), and (3) the State of Colorado, here referred to as local, regional, and State. Data for the analyses were based on NWRC's yearly expenditures for construction, salaries, operations, and meetings. All data were reported on an annual basis except for construction expenditures, which occurred over a 15-year period (1991–2005) but for the purpose of analysis, were assumed to occur all in 1 year. All expenditure data were allocated to the proper industry sectors traditionally associated with each type of economic spending. The economic modeling software IMPLAN® then calculated and analyzed NWRC's economic contributions at the local, regional, and State levels.

The key finding of this analysis is that NWRC construction expenditures generated the greatest economic impact of all NWRC expenditures. Construction created a temporary economic impact of $152 million throughout Colorado. As this spending flowed through the economy, approximately 1,120 temporary non-NWRC jobs were created.

The largest incremental annual effect of NWRC was generated in region 1 (Larimer County). Nonconstruction expenditures added $8.5 million to the local economy, and NWRC's annual budget alone created 79 non-NWRC jobs.

The second-largest incremental annual effect of NWRC was generated in region 2 (Larimer County plus four contiguous counties). Nonconstruction expenditures added $9.8 million to the regional economy and created 92 non-NWRC jobs (13 beyond the 79 created within Larimer County).

At the State level, nonconstruction expenditures added $17 million to the economy and created a total of 103 non-NWRC jobs (11 outside the 5-county area). NWRC employs about 125 people at its headquarters office and creates almost that many outside jobs within the State. Total employment generated by NWRC was 228. For every $10 million spent by NWRC, 92 jobs were created annually.

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.

Native bird populations were absent from all but the northern third of Guam by 1970. Today, of the 12 native species of forest birds on Guam, only the Mariana crow, the island swiftlet, and the Micronesian starling survive in the wild, with the crow population on the verge of extinction. Other birds have been taken into captive breeding programs. Bat populations on Guam have declined along with the bird populations. In fact, most of the island's native terrestrial vertebrates have been extirpated.

A major cause of the decline of these species is an introduced predator—the BTS. Native to Australia,

NWRC is developing methods to manage BTSs on Guam. (U.S. Fish and Wildlife Service photo.)

the Solomon Islands, New Guinea, and Indonesia, the BTS was most likely accidentally introduced to Guam through post-World War II cargo shipments.

Since 1995, NWRC has received funding from the U.S. Department of Defense (DoD) Legacy Resource Management Program to research methods to manage the BTS. The DoD is the steward of about 25 million acres of land in the United States. This acreage is varied and often rich in threatened and endangered species, critical habitats, and sensitive ecosystems. The Legacy Program, established in 1990, provides funding for the DoD's efforts to "enhance stewardship on military lands while supporting the military mission." NWRC has also received funding from the U.S. Department of the Interior's Office of Insular Affairs.

Management of the BTS, through the development of integrated strategies, is aimed at preventing its dispersal in cargo, containing any incoming snakes at destinations, reclaiming areas on Guam for reintroduction of native wildlife, protecting endangered species and other wildlife, improving public health, and protecting power stations and other sensitive locations from intrusion. To achieve these aims, BTS research efforts at NWRC encompass development of repellants, attractants, toxicants, fumigants, reproductive inhibitors, and improved trapping methods.

Development of an Aerial Bait-Delivery System for the BTS—Previous investigations have demonstrated that aerial broadcast is an application technique for delivering dead neonatal mouse (DNM) baits to BTSs in remote, inaccessible forest areas on Guam. The major reason for placing baits in the forest canopy is to keep them from being taken by terrestrial scavengers, such as feral pigs, monitor lizards, crabs, and toads. But a practical, inexpensive aerial-delivery system (e.g., a system that includes flotation material attached to dead mouse bait, helicopter or fixed-wing aircraft, and a dispenser for flotation material) has not been fully developed.

The latest effort in developing an aerial delivery system on Guam used small, biodegradable parachutes deployed by hand from a helicopter. Two types of material were evaluated: polylactic acid plastic polymer derived from corn (Ecofilm®, 20.3 × 20.3 cm) and common paper hand towels (23.8 × 27.3 cm). Thread was attached to the four corners of each type of material, which was secured to the rear legs of dead mice. Over each of 2 forested sites, 20 mice with radio transmitters were deployed (10 with Ecofilm and 10 with paper towels), and canopy or ground locations were recorded. The percentage of Ecofilm and paper-towel parachutes that landed in the canopy was 75 percent and 85 percent, respectively.

Paper-towel parachutes are preferred because they are easier to handle and do not slip as easily as the Ecofilm chutes when stacked. However, a drawback of each type of parachute is the time-consuming process for hand assembly of the threads and tying on of mice. NWRC's Product Development scientists continue their research to improve the delivery system.

Field Evaluations of Bait Matrices To Replace DNMs for Oral Delivery of Toxicants to BTSs on Guam—DNM treated with acetaminophen are effective bait matrices for BTS. However, DNMs are expensive ($0.70–$0.80 each), and there are logistic problems of shipping frozen mice from the U.S. mainland to Guam and maintaining them frozen until used in the field. Furthermore, mice not consumed from bait stations are retrieved after 2–4 days for disposal, but the resulting putrid stench from the decomposing mice is offensive to field personnel. Bait acceptance also declines during the later stages of putrefaction. For these reasons a bait matrix that is equally acceptable as dead mice to snakes, does not putrefy, and has a longer field life would be very desirable.

Using DNMs as the positive reference, researchers evaluated several candidate bait matrices including both untreated and treated molded PVC,

molded konjac (a soluble dietary fiber), cotton roll formulated with New Zealand rat lure (0.2 percent pyrazine, 0.3-percent 2–ethyl pyrazine, 0.5-percent 2–ethyl–3–methyl pyrazine, 0.3-percent m-cresol), deer skin, and pig skin. The evaluations were done in transects with random placement of baits on Guam. In these tests, bait acceptance for DNMs ranged from 65 to 70 percent and 0 to 20 percent for all other bait matrices.

In another study, researchers evaluated bait acceptance of unadulterated DNMs, freeze-dried DNMs, and dehydrated DNMs on 5 transects of 10 randomly placed baits per transect. Baits devoured by ants, as evidenced by a skeleton in the bait station, were not included in the tabulation of bait acceptance. Bait acceptance was 87 percent for unadulterated and freeze-dried DNMs and 77 percent for dehydrated DNMs.

Preliminary data indicate that freeze-dried and dehydrated DNMs, in contrast to unadulterated mice, can be stored in vacuum-sealed bags at ambient temperature without spoiling, and their useful field-life for bait acceptance is at least 4 days. Future studies with freeze-dried and dehydrated DNMs will include storage stability under ambient and field conditions, bait acceptance, and as lures for the capture of BTSs in live traps.

Immunocontraception as a Tool for Controlling the BTS on Guam—NWRC scientists have been investigating methods for vaccinating BTSs against GnRH, the endogenously produced hormone in vertebrates that controls the release of gonadotropins (luteinizing hormone [LH] and follicle-stimulating hormone [FSH] and thereby reproduction. At least 13 GnRH subtypes have been identified, and these can be reduced to 4 main forms: GnRH–I, GnRH–II, GnRH–III, and GnRH–IV. Although all four forms participate in some aspect of reproduction, NWRC scientists have focused on vaccination against GnRH–I because it is the only form yet identified in snakes and it is widely known to play a critical role in LH synthesis and secretion. LH is the gonadotropin that controls spermatogenesis and testosterone production in all male vertebrates.

Accordingly, a vaccine for GnRH–I was developed, and 24 adult male BTSs were vaccinated. Another 24 adult males serving as controls were given the vaccine carrier only. Spermatogenic activity in both groups was histologically assessed at 56 and 112 days after vaccination.

A previous study by NWRC scientists using GnRH–I-vaccinated females found that females produced high antibody titers to GnRH–I after comparable time intervals, demonstrating that the vaccine elicits a satisfactory immune response. However, GnRH–I-vaccinated males showed no evidence of inhibition of spermatogenesis—all males in both groups at both sample times exhibited normal sperm development. These findings raise the possibility that testicular function in snakes is mediated by a form of GnRH other than GnRH–I.

Program Support

Registration Highlights

The NWRC Registration Unit is responsible for providing data and information toward regulatory approval of new or existing products needed by WS Operations so they may more efficiently address wildlife damage issues and protect agriculture, human health, and endangered species or critical habitats. To meet this responsibility, the Registration Unit works closely with APHIS headquarters staff in Riverdale, MD, and with NWRC scientists to ensure that regulatory studies meet Environmental Protection Agency (EPA) and FDA regulatory guidelines.

APHIS currently holds registrations through the EPA for 8 active ingredients formulated into 19 federally registered vertebrate pesticide products. These products meet the needs of bird management (five

avicides and one avian repellant), rodent management (seven rodenticides and one fumigant), predator management for livestock protection (two predacides and one fumigant), and a toxicant for managing BTSs on Guam. At the request of Federal conservation agencies, APHIS recently applied for the registration of an anticoagulant rodenticide for eradication of rodents on critical island habitats.

APHIS also holds five Investigational New Animal Drug (INAD) authorizations from FDA to continue the development of three wildlife contraceptives and to permit WS use of two immobilizing agents. During 2005, EPA and FDA agreed that wildlife contraceptives would now be regulated by the EPA. As a result, APHIS will begin the process of transferring our wildlife contraceptives to the EPA.

Pesticides

Bird Management—Human health and safety concerns, agricultural damage, and threats to endangered species caused by birds are ongoing problems throughout the United States. For example, gulls settling near landfills pose a hazard to nearby aircraft. Starlings, blackbirds, and pigeons can damage crops in the field and at agricultural facilities and become health or nuisance pests in urban areas. And corvids may become agricultural and urban pests and harm threatened and endangered species as well. The NWRC Registration Unit maintains APHIS' avicide products, ensuring the labels are in compliance with EPA regulations. This process includes working with State WS offices to meet regulatory requirements, which allows new uses of our avicide products to meet the local needs of individual States.

The management of crows at urban and agricultural roost sites has become a major concern over the past several years. If nonlethal techniques prove ineffective, only one EPA registered pesticide product—DRC–1339—is available for lethal removal of crows. The increasing and diverse variety of corvid problems has shown that current DRC–1339 labels are not sufficient to meet WS' needs. The Registration Unit, in cooperation with APHIS' Policy and Program Development Unit and WS State offices, is developing a DRC–1339 label revision specifically addressing management of crow roosts.

The management of starling populations in feedlots and dairies is a difficult problem for agricultural producers. (APHIS file photo.)

Management of starling populations in feedlots and dairies is a difficult problem for agricultural producers. California WS identified the need for a management tool, and the NWRC Registration Unit sought a State registration for Compound DRC–1339 Concentrate—Feedlots from the CDFA. It granted a conditional registration for Compound DRC–1339 Concentrate—Feedlots in 2005 pending submission of a storage stability study on the product. The Registration Unit, in cooperation with the Pocatello Supply Depot, began the 1-year storage-stability study in 2005. The experimental phase of the study is complete, and results will be submitted to CDFA in 2006. Contingent upon a satisfactory CDFA review of the data, a full registration of the product in California is expected by the end of 2006.

Anthranquinone (currently registered as a goose repellant) is one of several compounds under investigation as a bird repellant for crops. The Registration Unit has provided regulatory guidance to help identify and register avian repellants to protect rice, corn, and other crops from bird

damage. Interregional Research Project #4 (IR–4) funding was obtained to conduct a residue study of anthraquinone for use as a seed-corn treatment to repel sandhill cranes. The cranes can methodically feed on the seed along newly planted corn rows. Anthraquinone provides a nonlethal tool to discourage this feeding behavior. The IR–4 study provided data to support an emergency exemption in Wisconsin, allowing the use of anthraquinone on seed corn to repel sandhill canes.

Rodent Management—WS has traditionally been involved in managing field rodents for agricultural protection. APHIS continues to maintain the registration of seven grain-based rodent baits (with strychnine or zinc phosphide as the active ingredients) and one incendiary cartridge for fumigating rodent burrows. The Registration Unit submitted an application to EPA for the registration of "Diphacinone–50: Conservation." This registration would allow delivery of this preformulated rodenticide by means of helicopter, hand broadcasting, burrow and canopy baiting, or depositing in bait stations. The product is designed specifically to facilitate eradication of invasive rodents on island ecosystems. A decision on this registration is expected from EPA in late 2007.

The Registration Unit is working on a similar registration for the active ingredient brodifacoum and hopes to submit that registration data package to EPA by the end of 2006. These labels will be a valuable tool for providing predator-free nesting habitat for hundreds of species of seabirds, especially in tropical islands and in the Aleutian Islands of the Alaska Maritime National Wildlife Refuge.

Until full registration of these rodenticides for conservation is obtained from EPA, the Registration Unit has pursued other regulatory options through EPA to allow limited use of specific products. EPA granted an emergency exemption to Florida for the use of zinc phosphide on Grassy Key to eradicate the Gambian pouched rat. These large (9-pound) exotic rodents are native to Africa. Biologists are concerned that the spread of these invasive animals could severely damage sensitive ecosystems in the Florida Keys, and the Everglades should the rats reach the mainland. The Registration Unit also facilitated an emergency exemption to use brodifacoum to eradicate roof rats on Congo Cay, U.S. Virgin Islands. The rats are a threat to brown pelicans and other nesting birds on this small island.

In cooperation with forestry companies private rodenticide manufacturers in the Pacific Northwest, NWRC's Olympia field station completed a multiyear project evaluating the laboratory and field efficacy of rodenticides on the mountain beaver. A pelleted chlorophacinone bait was found to be the most effective. In 2005, all of the data generated in this study were provided to LiphaTech, Inc., to support adding the mountain beaver to their existing product label. LiphaTech submitted to EPA a registration application for chlorophacinone use in California and Washington State in 2006.

NWRC continues to coordinate and provide technical and administrative assistance to the Zinc Phosphide Consortium. This consortium was established to help meet EPA's reregistration requirements for technical zinc phosphide. In 1998, EPA issued the Reregistration Eligibility Decision for that compound. In response, the consortium compiled and submitted data to support the continued registration of technical zinc phosphide. In addition, product-specific data were required for each individual end-use product, including the three APHIS zinc phosphide products.

EPA is currently in the process of finalizing the reregistration for both technical zinc phosphide and APHIS' products. New labels for APHIS zinc phosphide are expected to become available in 2006. The consortium also agreed to furnish partial funding for a residue tolerance study for zinc phosphide on grass grown for seed. This study, begun in early 2006, is being conducted by IR–4.

Predator Management Tools

APHIS maintains the registrations for four predacide products based on sodium cyanide and compound 1080 and one incendiary device for fumigating dens and burrows. These products are used primarily for the protection of livestock but also may be used to protect threatened or endangered species from canine predators or to protect human health from communicable diseases spread by canines (e.g., rabies).

In 2003, APHIS submitted an Experimental Use Permit request to the EPA for a study designed to evaluate the effectiveness of the M–44 (a spring-activated sodium cyanide ejector) for protecting ground-nesting birds from canine predators. EPA did not approve this study as proposed. In response, WS queried field offices as to the interest in this registration change. Only a few States favored this change. As a result of the survey, NWRC withdrew the Experimental Use Permit application.

Wildlife Drugs and Vaccines

APHIS has five INAD authorizations with FDA that allow interstate transport of the compounds for experimental purposes. Three of the compounds—GnRH, PZP, and Diazacon are being tested as wildlife contraceptives. The other two compounds for which APHIS has INADs are alpha–chloralose and propiopromazine hydrochloride (PPZH), both immobilizing agents. All of these products are for use by USDA personnel or persons under their direct supervision.

During 2005, the EPA and FDA agreed that wildlife contraceptives would be regulated by EPA. Therefore, APHIS is in the process of transferring registration work on our wildlife contraceptives to EPA.

Immobilizing Drugs—NWRC continues to investigate the use of two immobilizing agents under FDA INAD permits. PPZH is used in the tranquilizer trap device for sedating predators captured in leghold traps. PPZH-sedated animals suffer from significantly less trap-related stress and are more approachable by biologists. As a result, PPZH-sedated animals experience less injury to the leg prior to being released. NWRC is currently conducting one laboratory product stability study and three field evaluations where PPZH is used to facilitate marking study animals.

The use of the immobilizing agent alpha–chloralose is currently allowed for the capture of waterfowl, Canada geese, American coots, common ravens, and sandhill cranes under an FDA INAD. Any use on other species requires obtaining authorization from FDA for a single-time use. The NWRC Registration Unit typically receives 2–3 requests each year from WS Operations seeking additional uses of alpha–chloralose.

Thanks to conservation efforts of many State wildlife-management agencies, wild turkey populations are expanding at unprecedented rates. WS is being

Vaccinated deer with eartags. (APHIS file photo.)

contacted to remove problem birds in some urban centers. Alpha–chloralose is an appropriate and effective tool in many of these situations.

In 2005, the Registration Unit submitted data to support a request that FDA add wild turkeys to the list of species under this INAD. It is expected FDA will approve this request by the end of 2006.

Contraceptives—Efforts continue to fulfill data requirements for regulatory authorization of GonaCon Immunocontraceptive Vaccine for white-tailed deer. Three FDA required studies were initiated in FY 04 and FY 2005. A target-animal safety study conducted in cooperation with The Pennsylvania State University showed that the vaccine affects only the reproductive hormones in the deer and had little effect on other physiological functions.

Two efficacy studies are currently underway. NWRC scientists began a 2-year field-efficacy study in July 2004 at the White Oak Federal Facility in cooperation with the Maryland WS program. The field phase of the study was completed in the summer of 2006. A second 2-year field study near Morristown, NJ, began in 2005 in collaboration with White Buffalo, Inc. In addition to these three studies, the Registration Unit prepared a data submission to FDA in 2004, beginning the process of evaluating the safety to humans who consume GonaCon-vaccinated deer. FDA responded in November 2005 with a favorable review of the human food safety of GonaCon.

The path to regulatory authorization of GonaCon took a new route in 2005. In 1997, the Registration Unit initiated the drug approval process through FDA by opening an INAD file for GonaCon. Since that time, the Registration Unit has been working to meet FDA drug-approval requirements. As the process continued, it was realized that the typical GonaCon use patterns common in wildlife applications were inconsistent with FDA's regulatory framework. Discussions between FDA and EPA resulted in the transfer of regulatory oversight of contraceptive vaccines for use in wildlife and feral animals to EPA. However, FDA will maintain authority of contraceptive vaccines for use on captive animals, including all domestic and zoo animals.

NWRC continues cooperative research with a Dutch veterinary drug manufacturer to develop GonaCon as a tool to reduce boar taint in domestic swine. Boar taint is the unpleasant odor released during the cooking of pork and pork products made from the meat of uncastrated male pigs. It is caused by high levels of sex hormones absorbed in the pig's fat. This product is of interest to the European pork industry due to European Union legislation prohibiting castration of swine without anesthesia. Additional studies are underway to determine the usefulness of GonaCon to control fertility in other wildlife and feral mammal species.

The Registration Unit is proud to have been a partner with Innolytics, LLC, in the successful registration of the Canada goose contraceptive, OvoControl G™. OvoControl G is based on the active ingredient nicarbazin, an anticoccidial compound used in the poultry industry for more than 50 years. The combination of the nontoxic compound, bait formulation, and directions for use result in a product that presents very little risk to nontarget species. However, when fed to geese on a daily basis, the birds lay and incubate eggs that will not hatch.

As a result of this collaborative effort, Innolytics obtained a registration for OvoControl G from the EPA in November 2005. NWRC received an "Outstanding Technology Development" award from the Federal Laboratory Consortium for its role in the development of this new technology.

Regulatory Assistance Provided to Federal, State, and Nongovernmental Organizations

The Registration Unit routinely responds to information requests from WS program personnel

and other Government and nongovernmental cooperators during the preparation of environmental assessments, environmental impact statements, and Section 7 consultations with the U.S. Department of Interior's U.S. Fish and Wildlife Service (FWS). These inquiries typically involve preparing tailored summaries and interpretations of NWRC research or risk assessments to address unique pesticide use scenarios. Additionally, the Registration Unit is frequently asked to consult on pesticide registration and use questions from sources within WS and from outside agencies and private entities.

NWRC personnel provided technical assistance to a consortium of State, Federal, and nongovernmental organizations in Hawaii by developing a registration package and risk assessment for EPA registration of "Diphacinone–50: Conservation" as an aerially delivered anticoagulant rodenticide to control rats in conservation areas. In addition, biologists from the Alaska Maritime National Wildlife Refuge have enlisted help from NWRC in drafting a refugewide management plan for eradicating rats and other nonnative rodents on the Aleutian Islands.

Information Transfer Activities—In addition to one-on-one communication with government and nongovernmental parties, Registration Unit personnel disseminate information through involvement in professional conferences. During the past year, Registration staff participated in the Vertebrate Pest Conference and the Western Extension and Research Administrative Committee (WERA–95) formerly WCC–95. Staff contributed to 10 presentations at these meetings as authors and coauthors. Personnel of the Registration Unit also hold elected offices in WERA–95 as the committee vice-chair and the secretary. More information about NWRC's regulatory efforts and copies of APHIS vertebrate pesticide labels can be found at the Registration Unit's web site <http://www.aphis.usda.gov/ws/nwrc/research/registration.html>.

Wildlife Disease Research Program

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

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

This research is attempting to quantify benefits and costs of both traditional and new wildlife-management activities (e.g., as intervening with repellants, relocations, removals, and rodenticides) to limit the adverse effects of wildlife on agriculture, natural resources, and human health and safety.

Evaluation of the Ability of White-Tailed Deer To Jump Fences—Research on the control and management of CWD—a debilitating and lethal neuronal disease of cervids—and bovine tuberculosis (BTB) is a high priority for APHIS. Wild deer are competent hosts for CWD and BTB. One concern is that wild deer will jump the fences into captive deer farms, thus exposing those deer to disease. Officials in APHIS' Veterinary Services (VS) program are

NWRC conducted field tests on the efficiency of fence systems to exclude wild deer from captive herds. (APHIS photo by Kirk VerCauteren.)

currently developing fencing recommendations that will be required for captive cervid operations to be in compliance with the VS program to control CWD. In Michigan, the State Department of Agriculture and Department of Natural Resources are developing fencing guidelines and recommendations related to means to manage BTB. Agencies need information on the ability of deer to breach fence systems.

As an initial step in determining the minimum fence height that deer cannot breach, NWRC scientists reviewed the literature and anecdotal evidence and conducted field tests on the containment efficiency of fence systems under different motivation scenarios for deer. Human drivers and humans plus dogs were used to motivate deer to breach fence systems. All deer successfully cleared the test fences when fence height was set at 3, 4, or 5 feet. When fence height was set at 6 feet, 91 percent of deer cleared the fence. At a height of 7 feet only 10 percent of the deer jumped the fence, and no deer cleared the fence at 8 feet. These results will be useful in setting standards for fence height for security and containment of captive deer herds.

Cervid Use of Mineral Licks and Wallows: Implications for Disease Transmission—Mineral licks and wallows are aggregation points for wild cervids. One possible consequence of high cervid densities is increased risk of transmission of disease, such as CWD and BTB. Motion-activated cameras were used to capture behavior of elk at 28 wallows and 4 licks. Telemetry was used to estimate proximity of elk and by inference, the risk of interaction and potential for disease transmission. Interacting telemetry collars are collars that record the date and duration when two or more collars are within a 5-m distance of one another. With this new technology, NWRC researchers obtained information on direct and indirect interactions at wallows and licks as well as away from those areas.

During the first field season (August through October 2005), motion-activated cameras were set up within Rocky Mountain National Park. Most wallows were used a few times by a few individual bull elk during the rut, and some were merely created and not visited thereafter. Thus, the infrequent use (0.10 elk visit/day) of wallows by elk during the rut may not play a substantial role in the transmission of disease.

In contrast, routine use of licks by elk and deer of both sexes and all age classes was documented during the entire study period. Though documented less often, moose also used licks (0.01 moose visit/day). Interestingly, all three of these species can contract CWD.

Behaviors of interest commonly observed at licks included consumption of soil (potential ingestion of disease agents) and defecation (potential shedding of disease agents). Related to CWD, as modes of transmission become better understood and decontamination methods are developed, there may be merit in focusing management efforts on focal areas, such as mineral licks.

CWD Vaccine Development—NWRC researchers are using mouse models to test candidate vaccines to prevent CWD infection. The mouse–scrapie model relies on a mouse-adapted scrapie strain of a pathogenic prion derived from sheep and then serially passaged in mice as the infectious agent. Prior to administering intraperitoneal challenge with this prion strain, NWRC scientists vaccinated study mice with peptides derived from amino acid sequences of the prion protein that have been conjugated to a carrier protein and formulated in an emulsion of Adjuvac™ to stimulate an immune response.

While the study is still ongoing, interesting trends are beginning to emerge. NWRC's active vaccination approach has yielded two candidate vaccines. Of five vaccines candidates tested, to date only one appears to have failed to provide any protection. In addition to these in vivo results, NWRC scientists have made progress in development of an in vitro assay of western blotting and electroimmunosorbent assay (ELISA) for diagnosing the progression of the disease.

These early collaborations between the Wildlife Disease and the Product Development Research Programs provide promise for the development of a vaccine strategy to prevent prionosis, an infectious neurodegenerative disease. Future research directions will be to continue to refine prion–peptides and vaccine formulations, test other modes of disease challenge, and most importantly, expand the vaccine test trails out of the mouse model and into cervids and/or ovids.

Decontamination of CWD Prions—NWRC scientists have been testing potential CWD inactivating enzymes in collaboration with two private sector partners, PrionTech, Ltd., and Novozymes Biotech, Inc. A study using a mouse model of prion disease was conducted to determine whether treatments that eliminate detectable prions using in vitro diagnostics also eliminate infective potential. Two of the enzymes tested were capable of destroying the infectivity of abnormal prions. Survivorship (up to 84 weeks) of mice treated with enzymes increased by 25 percent relative to infected controls.

Much work remains to be done in the development of enzymatic deactivation of prions; however, the research has led to some promising avenues for improvement. Developing an enzyme-based method for prion inactivation will provide a versatile tool for decontamination that may be useful for environmental, laboratory, animal-facility, food-processing, and medical situations.

Development of a Live-Animal Test for Detecting CWD in Elk—Until recently, there was no practical live-animal test for detecting CWD in elk. Collaborations among CSU, APHIS VS, the Agricultural Research Service, the Canadian Food Inspection Agency, several private elk ranchers, and NWRC scientists have yielded a rectal biopsy method for detecting CWD in infected elk that have not yet displayed CWD symptoms. The test is beginning to be used operationally by VS and private elk ranchers.

Elk herd. (U.S. National Park Service photo.)

A Fence Design for Excluding Elk Without Impeding Other Wildlife—High densities of elk can degrade natural and human-developed environments such as golf courses, lawns, and gardens. Traditional means to exclude elk and alleviate damage often impede other wildlife. NWRC biologists have designed a simple fence that excluded elk without restricting access to other wildlife. A 1-ha stand of quaking aspen traditionally used by high numbers of elk was enclosed with our fence design. The efficacy of the fence was determined by monitoring wildlife use inside and outside the exclosure with trackplots, animal-activated cameras, and changes in aspen sprout recruitment and height. The fence successfully excluded all elk while allowing other wildlife access. Wildlife that used the exclosure included beaver, black bear, bobcat, coyote, deer, mountain lion, raccoon, red fox, and rabbits. After 1 year of protection, the number of sprouts in the exclosure slightly increased (64 in 2004 to 70 in 2005) with mean aspen sprout height being greater inside the exclosure than outside. This fence design effectively excludes elk, facilitates aspen regeneration, and may be applicable in other areas for protecting additional resources. The National Park Service will be using this design to erect exclosures to protect aspen and willow stands from overabundant elk.

TITLE: Investigating BTB at the Wildlife–Livestock Interface

GOAL: Study the ecology of wildlife at the livestock interface for the purpose of evaluating risk factors that may be involved with transmission of BTB among wildlife and from wildlife to domestic animals and to develop and evaluate methods and strategies that may reduce or eliminate such transmission.

Tuberculosis is a contagious bacterial disease of both animals and humans. BTB (caused by *Mycobacterium bovis)* can be transmitted from livestock to humans and to other animals. Bovine TB is a chronic disease, seldom becoming apparent until it has reached an advanced stage in animals. The significance of the disease is reflected in the efforts to eradicate TB from the United States since 1917. By the mid-1990s, only a few known infected cattle herds remained, and it looked like the disease would soon be eradicated in the United States. However, between 1975 and 1998, TB was documented in Michigan white-tailed deer, with increasing evidence suggesting that deer had transmitted the disease back to cattle. Large economic costs are incurred by a State and the livestock industry when the State loses its Accredited-Free TB status. It has been estimated that Michigan will incur losses of $22 million to $74 million over a 5-year period.

A Frightening Device for Deterring Deer Use of Cattle Feed—In Michigan, wild white-tailed deer continue to be a reservoir for reinfecting cattle herds with BTB. Although direct interaction between deer and cattle is rare, deer with tuberculosis may contaminate cattle feed and indirectly infect cattle.

NWRC researchers designed and evaluated a new frightening device for deterring deer from cattle feeders. The deer-resistant cattle feeder (DRCF) specifically attempted to condition deer to avoid cattle feeders through delivery of negative physical stimuli. At a high-density captive white-tailed deer operation in northeastern lower Michigan, we conducted a comparative change experiment using pretreatment and treatment periods and random allocation of DRCF-protection to three of six feeders during the treatment period. Animal-activated cameras were used to collect data on deer use of feeders.

Frightening device for deterring deer from cattle feeders. (APHIS photo by Kirk VerCauteren.)

It was found that deer use was equal at protected and unprotected feeders during the pretreatment period but was lower at protected feeders during the treatment period. DRCFs were 100-percent effective during the first 2 treatment weeks and averaged 94 percent during the first 5 weeks but then dropped to an average of 61 percent during the final week.

Excluding problems associated with low battery power and infrared sensors, DRCFs were ≥ 99 percent effective at deterring deer.

We also tested our DRCF on a cattle farm to assess its durability and affect on cattle. Results suggest that DRCFs can effectively limit deer use of cattle feed, potentially with minimal impact on feeding behavior of cattle, thus reducing potential transmission of BTB through contaminated feed.

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—always fatal if left untreated—is an acute viral encephalomyelitis of mammals most often transmitted through the bite of a rabid animal. While human deaths from rabies are rare in the United States, the disease remains a public and animal health problem that results in 50,000 to 70,000 human deaths worldwide, annually. Over the past 100 years, rabies in the United States has changed dramatically.

Prior to 1960, most rabies cases here were reported in domestic dogs. Today, however, more than 90 percent of all animal cases reported to the Centers for Disease Control and Prevention occur in wildlife, with the principal rabies hosts being wild carnivores (raccoons, skunks, foxes, coyotes, and bats). The estimated public-health costs associated with rabies detection, prevention, and control have risen to more than $300 million annually. If rabies strains such as those transmitted by raccoons, gray foxes, and coyotes are not prevented from spreading to new areas of the United States, the health risks and costs associated with the disease will increase substantially as broader geographic areas of the country are affected.

Oral Rabies Vaccination Program in Texas—Beginning in early 2005, NWRC staff, in cooperation with Texas WS and the Texas Department of State Health Services, initiated ecological studies of gray fox to support oral rabies vaccination (ORV) activities in west-central Texas. A major objective of the study is to document the movements and the potential of long-distance movements of gray fox near a 2004 ORV zone break. At present, telemetry data suggest that at least one male fox has moved over 13 km in a straight-line distance. This finding is significant because it indicates that male gray fox will move considerable distances in this area, and long movements could potentially breach the ORV zone.

Grey fox movements were monitored in west-central Texas as part of the oral rabies vaccination project. (APHIS photo by Jeff Root.)

Biologists examine a sedated grey fox as part of the oral rabies vaccination project. (APHIS file photo.)

An additional major objective of this project involves a landscape-genetics approach to assist gray-fox ORV strategies in Texas. Specific objectives include

(1) identification of landscape features influencing dispersal and gene flow, (2) estimation of dispersal rates, and (3) examination of sex bias in dispersal. Preliminary data indicate a high degree of genetic variation among the gray fox sampled. It is anticipated that this type of information will provide key insights into gray-fox ecology as it pertains to ORV strategies.

Oral Rabies Pen Study—A pen study was conducted at the NWRC in Fort Collins, to determine the longevity of the oral V–RG (Merial, Ltd.) rabies vaccine that is currently being used by WS to combat rabies in raccoons and prevent the westward spread of this virus variant. In this study, V-RG was given in varying doses to six different groups of raccoons, and the groups were then challenged with the raccoon variant of the rabies virus at different time points of 6, 12, and 18 months to determine the long-term efficacy of the vaccine and how the antibodies produced from the vaccination correlate with the raccoons' susceptibility to the rabies virus. The 6-, 12-, and 18-month challenges have been completed; sample and data analysis are ongoing.

The results of the completed challenges show that if raccoons become vaccinated, the antibody titers produced across a single group of animals vary. To date, this study has shown that most of the raccoons that were able to develop an antibody titer from vaccination were able to survive a rabies viral infection up to 18 months after vaccination.

Raccoon Movements in Alabama and the Effects of Natural Barriers on Preventing the Western Spread of Rabies—Raccoons have been extensively studied in a variety of habitats across much of their North American range. Although canine distemper is thought to play a major role in regulating raccoon populations, raccoon rabies can be an important mortality factor in the Southeastern United States. In 1999, 2,872 reported cases of raccoon rabies occurred in the United States. Rabies spread into Alabama more than 30 years ago but has not continued to spread westward at a rate commensurate with northward spread up the Atlantic seaboard and subsequent westward spread through States in the north. Understanding survival, movements, home range size and distribution, use or avoidance of natural barriers like rivers and mountains, as well as habitat use, may help explain this phenomenon.

This Alabama raccoon has been fitted with a GPS collar. (APHIS photo by Wendy Arjo.)

Researchers from the Olympia field station radio-collared 115 raccoons on 4 study sites in western and central Alabama from 2004 through 2005. Study sites differed in habitat types: agricultural, forested, riverine, and managed. Density estimates of raccoons were similar in the agriculture and riverine habitats in central Alabama with 8 raccoons/km^2. Densities were lower in the forested habitat at 5 raccoons/km^2. The bottomland deciduous habitat located around the riverine in Lowndes County contained a higher density of raccoons (8 animals/km^2) than the forested habitat in west-central Alabama. Home ranges and core use areas did not differ between the habitats but did between the sexes, with males having larger home ranges. Two males were documented to have used both sides of the Alabama River in their home ranges, proving that rivers are not necessarily a geographic barrier to the movement of raccoons. These data have implications for vaccine baiting programs.

Blood samples for distemper were analyzed from 97 raccoons in all 4 habitat types: from 38 forested, 16 agricultural, 12 managed, and 31 riverine. Two habitats in closer contact with humans had a higher proportion of canine distemper virus (CDV)-positive

An NWRC technician holding a radio-collared raccoon in Alabama. (APHIS photo by Wendy Arjo.)

titers (agriculture, 44 percent; managed, 50 percent); the riverine area, 24 percent, and the forested area (least frequented by humans), 23 percent. The forested area, a less dense raccoon population, contained proportionally fewer animals with seropositive results for distemper than the denser raccoon site in the agricultural habitat. The agricultural and riverine habitats were close spatially, and both were in close proximity to human habitation; the agricultural habitat had almost twice as many positive animals as the riverine habitat.

Laboratory analysis for rabies antibodies was completed on serum samples from 43 raccoons in the 4 habitats: 6 agricultural, 11 managed, 8 riverine, and 18 forested. The central portion of Alabama is considered the rabies enzootic area and contains the agricultural and riverine habitat south of the Alabama River and the managed habitat north of the river. The proportion of positive rabies titers (>0.5) was higher in the managed and riverine habitat, where 57 percent and 60 percent of the animals tested positive, respectively. In both the forested and agricultural habitats only 20 percent of the animals showed positive titers. Of the three habitats within the central Alabama rabies enzootic area (agricultural, riverine, and managed), only two had significant positive titers (> 50 percent of the animals tested). The agricultural habitat located on the south side of the Alabama River near the riverine habitat contained a third fewer positive cases, yet the densities between the agricultural and riverine sites were similar.

The high density in the agricultural habitat does not appear to have assisted in the spread of rabies. Although the forested habitat is currently managed outside the rabies enzootic area, it appears that rabies is spreading westward in the state with 20 percent of the raccoons testing positive. Density of raccoons in central Alabama appears to be higher in those preferred habitats (bottomland hardwoods and aquatic areas as well as areas with supplemental food), even with the presence of both rabies and distemper.

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 developing management tools to control pseudorabies in feral pigs, and management of other wildlife diseases (in particular, Texas cattle fever, and heartwater) that affect livestock.

Pseudorabies (PRV, also known as Aujesky's disease) is an infectious, often acute, disease that affects the nervous system of livestock, as well as many species of wildlife. The disease poses a potential hazard to humans (although documented cases are rare) and a major hazard to the swine industry. Mortality occurs within infected swine populations, and those that recover from PRV can develop latent infections and shed the virus, contributing to its spread.

One of the principal obstacles to eradication of PRV is the widespread and growing population of feral hogs throughout the United States. Free-ranging feral hogs have been present for many decades in the Southern States but more recently have spread as far north as Oregon. PRV-infected feral hogs have been identified in Texas, Alabama, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, and South Carolina.

Project scientists study the movement patterns and behavior of free-ranging and captive feral hogs and look at relative exposure to diseases. Studies also examine how the disease is transmitted and the likelihood of transmission to domestic swine.

Serologic Survey of Feral Hogs in Eastern and Southern Texas—The pork industry has spent millions to eradicate significant diseases from domestic swine annually. PRV, brucellosis, and classical swine fever (CSF) were eradicated from the domestic swine industry; however, PRV and brucellosis are both present in feral populations. CSF was successfully eradicated from both domestic and wild populations in the late 1970s. A fourth disease, porcine respiratory and reproductive syndrome (PRRS), is an emerging disease in domestic swine (since the late 1980s) and has only recently been found in feral swine populations. The purpose of this study was to determine the prevalence of these diseases in feral hog populations to see if feral hogs could pose a disease threat to domestic swine. Feral swine from eastern and southern Texas were trapped and tested for economically significant diseases.

In collaboration with Caesar Kleberg Wildlife Research Institute (CKWRI) and scientists at Texas A&M University–Kingsville (TAMK), NWRC scientists at the Kingsville field station collected and analyzed blood from 344 feral hogs for the presence of antibodies to PRV, brucellosis, and CSF. Of the 148 blood samples analyzed by serologic prevalence for exposure to PRV, brucellosis, CSF, and PRRS was 28, 13, 0, and 1 percent, respectively. Prevalence rates for PRV and brucellosis were similar to rates found in other serologic surveys conducted on feral hog populations around the Nation. CSF remains in eradicated status, and PRRS appears to be a newly emerging disease in feral populations, potentially demonstrating the transmission relationship between domestic animals and wildlife in general.

Biologists collect blood from feral swine as part of disease surveillance. (APHIS file photo.)

Genetic Appraisal of Feral Pigs—A collaborative effort between NWRC and CKWRI was begun in May 2005 to quantify the frequency and extent of multiple paternity in free-ranging pigs. Tissue samples are being collected with assistance from Texas WS, and field and laboratory assistance is being provided by NWRC and CKWRI personnel. The goal of this study is to obtain insights into the mating behavior of feral pigs.

Tissue samples were obtained from free-ranging pregnant sows, DNA was extracted, and multilocus genotypes were constructed based on a panel of 12 DNA microsatellite markers. Researchers have found evidence for multiple paternity (siring of offspring by >1 male) in two of seven feral pig litters (~30 percent). This information allows estimates of mating contact among breeding pigs, during which diseases can be transmitted. With the suggested high rate of multiple paternity, the transmission rates of diseases that are spread by direct contact (e.g., PRV and brucellosis) are increased.

A TAMK Ph.D. student is now expanding the study to examine the genetic characterization of feral pigs throughout Texas. The overall goals of that study are to discover how landscape features influence movements and dispersal and to provide basic ecological information that will increase the effectiveness of feral pig management and control efforts.

Development of Baiting Strategies for Pharmaceutical Delivery to Feral Pigs—NWRC scientists at the Kingsville field station collaborated with scientists from the Invasive Animals Cooperative Research Centre in Australia in two field trials involving Pigout® Feral Pig Baits. Few studies have evaluated oral delivery systems for biological agents (e.g., vaccines, fertility control agents, and toxicants) in feral pigs in the United States.

Biologist examining blood samples collected during a feral-swine disease project. (APHIS photo by Tyler Campbell.)

Trial 1 evaluated the percentage of feral pigs and nontarget animals that remove and consume PIGOUT fish-flavored baits intended to transport pharmaceuticals to feral pigs in south Texas. Researchers hand-placed 1,178 iophenoxic acid (IA)-marked baits over a 4,253-acre property in Texas and monitored species-specific bait removal and consumption using track stations, automated camera systems, and serum IA values from captured animals.

After 72 hours, 90 of baits had been removed. Of the baits where investigators could identify the species responsible for specific removal, 51 percent were taken by raccoons, 22 percent by feral pigs, and 20 percent by collared peccaries. Elevated serum IA values were found in 74 percent of the trapped feral pigs, 89 percent of the raccoons, and 43 percent of the opossums. PIGOUT baits were successful in marking a substantial proportion of feral pigs; however, observed removal rates suggest that the majority of the baits were taken by nontarget species and are therefore unsuitable for many pharmaceutical applications in their current form.

The objective of trial 2 was to assess wildlife and livestock visitation and removal rates of four baits intended to deliver pharmaceuticals to feral swine. Baits consisted of PIGOUT fish-flavored (A), PIGOUT vegetable-flavored (B), PIGOUT fish-flavored plus Get Away repellant (C), and PIGOUT vegetable-flavored plus Get Away (D). From February 7 through March 13, 2006, biologists hand-placed 80 baits of each type and monitored visitation and removal by wildlife and livestock with automated camera systems for four or more nights.

Cumulative bait-removal rates for baits A–D were 93, 97, 98, and 97 percent, respectively. A total of 3,434 photographic observations were made. Species visiting and removing baits included feral swine, raccoons, cattle, collared peccaries, coyotes, white-tailed deer, eastern cottontail rabbits, rodents, and striped skunks. Photographic data suggest overall removal rates of 46 percent by feral swine, 21 percent by raccoons, 17 percent by cattle, 8 percent by collared peccaries, 2 percent by coyotes, and 6 percent by "other." Cattle removed more of Bait D than expected. Coyotes removed more of Bait A than expected. No among-bait differences for feral swine, raccoons, and collared peccaries occurred. Limited evidence was found that Get Away deterred nontarget bait removal.

When targeting feral swine, fish-flavored baits may be most appropriate when nontargets include herbivores. Vegetable-flavored baits may be most appropriate when nontargets include omnivores and carnivores.

Remote camera photo of a feral hog along an electrified fence. (APHIS file photo.)

Evaluation of Electric Fencing To Inhibit Feral Pig Movements—Introduced feral-pig populations occur throughout the Southern United States and have become a widespread nuisance and pest. Feral pigs are implicated in erosion damage, destruction of agricultural crops, and transmission of disease to domestic livestock. Development of a cost-effective barrier system to restrict-feral pig movement will help alleviate and prevent these problems.

NWRC investigators evaluated the effectiveness of three different electric fence arrangements in a captive setting with naïve, wild-caught feral pigs. The effectiveness of the most promising fence design was then evaluated in a field setting with wild, free-ranging feral pigs. In both trials, sour corn was used as a motivating factor to get pigs to cross the barrier. Voltages for both trials averaged 7,000 volts and were maintained by solar- and battery-powered chargers.

In the captive trial researchers found that a 1-strand electric fence at 8 inches above the ground reduced feral-pig movement by 5 percent, a 2-strand fence at 8 and 18 inches reduced movement by 71 percent, and a 3-strand fence at 8, 18, and 28 inches reduced movement by 69 percent. In the field trial, the most promising fence (2 strands at 8 and 18 inches) reduced movement of adult feral pigs by 88 percent and all feral pigs, including piglets, by 64 percent.

Electric fencing has the potential to reduce problems associated with feral pigs. However, it is not a fool-proof method, and integrated management techniques incorporating sustained hunting, trapping, and fencing should be used.

Feral Hog Interaction With Domestic Female Swine in Southern Texas—The population of feral hogs in Texas is estimated between 1.5 million and 2 million animals, and their distribution and abundance within the State are expanding. Feral hogs are known carriers of many diseases, and their presence near domestic swine may pose a disease transmission threat, though this relationship has not been documented in the literature. To determine the potential frequency of interaction events between feral hogs and neighboring domestic swine, biologists at the Kingsville, TX field station built six pens in areas known to be frequented by feral hogs. Within each of three of the pens one domestic sow was placed and given food and water daily. Within each of the other three pens (control pens), only food and water were placed and replenished daily. Each pen was monitored daily for feral-hog visitation by quantifying feral-hog tracks around the pen and through photographic observation using motion-sensing cameras. Pens were monitored for 60 days.

Feral hogs visited pens with domestic sows during 49 percent of the nights but visited the control pens only 5 percent of the nights. Photos from motion-sensing cameras showed that feral hogs occasionally attempted to climb the pens to gain access.

This experiment demonstrates that feral hogs are attracted to domestic swine and regularly interact with them in close proximity. We conclude that feral hogs are a significant threat for transmission and reintroduction of diseases to domestic swine in South Texas.

Roundworm in Raccoons from Duval County, Texas—Raccoon roundworm *(Baylisascaris procyonis)* is a relatively large parasitic nematode occurring throughout Texas in areas with high rainfall and high raccoon densities. Many mammals (including humans) can become seriously ill with a neurological disease when larvated eggs are ingested, develop, and migrate to the brain. Presently it is believed that B. procyonis does not occur in semiarid, hot environments and is probably limited by soil types and raccoon densities.

A study on the zoonotic nematode *B. procyonis* in raccoons was initiated in 2006 by NWRC researchers in Duval County, TX. Raccoons were captured using 20 Tomahawk® live-traps baited with potted meat products and whole-kernel corn. A total of 19 raccoons were captured over 180 trap-nights.

Tests found eight species of helminthes (five nematodes, one acanthocephalan, and two cestodes) and only one raccoon, an adult female, was free of intestinal parasites. *B. procyonis* was found in three individuals (one adult male, one adult female, and one juvenile male). Most likely the presence of *B. procyonis* was due to the high raccoon densities that were probably associated with supplemental feed on the study site. To reduce the risk of raccoon roundworm range expansion and transmission to other species (including humans) in semiarid regions of Texas, it may be necessary to limit supplemental feeding activities and/or restrict feed consumption by raccoons.

Movements and Habitat Use of Nilgai Antelope in Southern Texas—The nilgai antelope was successfully introduced into South Texas in 1941 in an effort to occupy an ecological role intermediate between native wildlife and livestock. Nilgai now range freely throughout much of coastal south Texas, and current statewide estimates exceed 30,000 individuals. Nilgai are beneficial because they are hunted recreationally and harvested commercially for venison. Negative aspects of nilgai populations are damage to fences and competition for forage with deer and cattle. Anecdotal reports from landowners suggested that nilgai move long distances and that their home ranges may encompass properties of multiple landowners. Such movement patterns could make nilgai difficult to manage.

To address these issues, a research project was initiated with the following objectives: (1) determine nilgai home-range size, (2) determine movement patterns of nilgai in relation to habitat characteristics, and (3) document nilgai movements in relation to hunting and grazing pressure. Research is being conducted near Norias and Raymondville, TX.

To date, 32 nilgai (18 females and 14 males) have been captured and radio-collared. The nilgai will be tracked on a regular basis for 2 years from the ground as well as from small aircraft. In the first 2 months of the study, scientists have already documented nilgai moving 10–15 miles from their capture location.

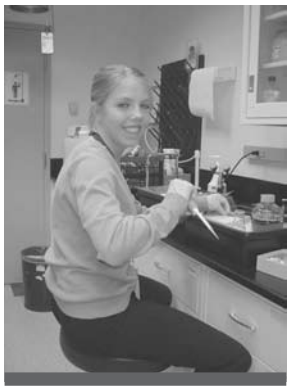
TITLE: Surveillance, Monitoring Research, and Response for Wildlife Diseases

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

Many types of micro-organisms are carried by wildlife. Some of these organisms cause human disease. Some impact agricultural animal health and agricultural biosecurity. Both types are of considerable concern to USDA. Risks from these pathogens must be identified and management plans developed to limit risks. Scientists with this project will develop ways to estimate how much of a threat individual disease organisms pose to humans and agricultural animals (e.g. cattle, chickens).

These risk assessments will involve coordination with WS' national and State operational programs, State agricultural and health agencies, and other stakeholders. The assessments will include a summary report on the economic impact of the pathogen, zoonotic (transmission from animal to human) potential of the pathogen, the role of wildlife as a host or reservoir for the pathogen, a determination of laboratory and field support needed for a passive or active surveillance effort, the potential for various management options, and the effort needed for surveillance to develop a risk assessment or management plan.

NWRC Continues Surveillance Studies for West Nile Virus (WNV) Activity in a Variety of Hosts—Collaborative studies on the host range and exposure rates of WNV are ongoing in a variety



NWRC technicians process hundreds of samples as part of the avian influenza surveillance project. (APHIS photo by Alan Franklin.)

of species across the United States. A 4-year mark–recapture study completed in Pennsylvania provided historical data on WNV activity in that area. Results suggest the possible utility of gray catbirds as sentinels for detecting the presence of WNV. This species had WNV antibody prevalences >10 percent for all 4 years. The exposure rates over 4 years in white-tailed deer from Iowa were examined by NWRC scientists in collaboration with researchers from the University of Iowa. NWRC researchers also examined WNV exposure in mesopredators (raccoons, opossum, skunks) from five States as well as continuing a study on the potential impact of WNV on northern spotted owl populations in California. Although WNV was not found within spotted owl populations, high prevalence rates in the mesopredator study were observed in raccoons (45.6 percent) and striped skunks (62.9 percent). Recent studies on fox squirrels suggest that they may be important wildlife hosts for WNV, as well as indicators of local prevalence of WNV.

Cliff-Swallow Ecosystems as Early Season Indicators of WNV Activity and as an Overwintering Mechanism—Identifying the intensity of WNV activity for specific geographic areas is a high priority for vector-control managers and public health officials who require early identification of viral activity each year to plan disease-control activities. Current surveillance systems have not achieved this level of precise predictive power. NWRC researchers have identified a promising surveillance system in nesting cliff swallows. Scientists have found that overwintering WNV-positive ectoparasites in swallow nests indicate an early season amplification mechanism of the virus and WNV infection in nestlings 5 weeks prior to the first human infections in the area. These results indicate that WNV may have an efficient head start within the cliff-swallow ecosystem each year prior to general amplification in the overall avian community.

Cliff swallow approaching its nest. (U.S. Fish and Wildlife Service photo by Donna Dewhurst.)

Since 2003, NWRC has collected a total of 10,038 samples from 5,790 individual birds at swallow colonies. To date, 6,105 samples have been tested of which 110 nestlings tested positive for WNV RNA. The highest rate of exposure in nestlings was in 2003 with 22 percent of the nestling testing positive,

in 2004 and 2005 the prevalence was much lower 1.38 percent and 1.23 percent, respectively. In addition, 39.5 percent of the adults swallows captured in 2004 were WNV antibody positive.

NWRC is currently conducting surveillance studies for the fourth year using this system in order to characterize WNV activity in both swallows and their ectoparasites, such as swallow bugs. The role of swallow bugs in the transmission cycle of WNV is currently being examined more closely in laboratory and field studies. West Nile virus prevalence in bugs is not as well documented. In 2003, 19 percent of the nests tested had bugs that were positive for WNV RNA. The positive nests came from the same sites that had positive nestlings. The bugs collected since then (~800 nests) are being tested in 2006 to look for further correlation between positive bugs and positive swallows within sites.

Using this system, NWRC continues to provide surveillance data to public health officials in Fort Collins, CO. This surveillance method has profound implications for the efficient management of this zoonotic disease of public health and domestic animal health importance.

Providing Wildlife Services

GOAL: Provide high-quality wildlife damage-management services for our customers that result in the protection of agriculture, wildlife and other natural resources, property, and human health and safety.

Biologists take samples from waterfowl during avian influenza screening in Alaska. (APHIS file photo.)

National Support

NWRC Plays Integral Part in National Early Detection System for Highly Pathogenic (H5N1) Avian Influenza—The occurrence of highly pathogenic avian influenza (HPAI) subtype H5N1 has raised considerable concern regarding its 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 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 is responsible for developing field sampling methods, directing collection of field samples, and analyzing 50,000 environmental (water and avian fecal) samples from all 50 States.

By mid-August 2006, NWRC had analyzed 1,043 pools from 4,979 fecal samples collected by WS State personnel; 4.7 percent of these pools tested positive for avian influenza but none were positive for any HPAI subtypes.

As part of the national strategy, NWRC also 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 began diagnostics analysis of the initial samples collected in Alaska. The committee formed to design a nationwide monitoring program developed a preliminary strategy based on band-recovery data to provide additional guidance to WS State personnel on promising locations for collecting additional samples during the migratory season.

Gambian Giant Pouched Rats in the Florida Keys—The Gambian giant pouched rat (GGPR) has become an invasive species of concern for the State of Florida. An NWRC researcher worked with Florida WS in 2006 to develop information for planning the species' eradication from Grassy and Crawl Keys, where it is currently established. A pilot eradication campaign on Crawl Key, employing population monitoring methods developed by NWRC, was carried out in spring of 2006.

The Gambian giant pouched rat has become an invasive species of concern in Florida. (APHIS photo by John Woolard.)

Recent camera surveys indicated no GGPR survival on Crawl Key following Hurricane Wilma and the pilot eradication effort. As a result, eradication efforts will now focus on the primary population on Grassy Key. The first step in the eradication process will be to monitor Grassy Key using a camera-indexing methodology cooperatively developed by NWRC and WS Operations personnel. This setup will determine current GGPR distributions and relative abundances throughout the island. Subsequent steps this fall will include the construction and deployment of bait stations especially designed to exclude native species. Bait-station density will be based on the results of the camera survey, with a higher density of bait stations in areas where GGPRs are found. Prebaiting will

be done at all bait stations with nontoxic bait to acclimate GGPRs prior to using toxic bait.

The researcher has also been working with economists from the U.S. Department of Interior's U.S. Geological Survey who are attempting to model this invasive species' impacts should it escape the Keys and become established on the mainland. Work has focused on developing methods to place monetary values on imperiled natural resources, such as rare species and habitats. GGPRs likely would negatively impact agriculture through direct crop losses, contamination of harvested crops, reduced marketability of damaged produce, and contamination and consumption of livestock feed. GGPRs also could negatively impact populations of some threatened and endangered species, especially the endangered Key Largo woodrat, the Key Largo cotton mouse, and the Lower Keys marsh rabbit. GGPRs also have been associated with a variety of pathogenic diseases that could be spread to humans, livestock, or other wildlife.

Dramatic Reduction in Swine Damage to an Imperiled Habitat in Florida—An NWRC researcher collaborated with Florida WS and Eglin Air Force Base (EAFB) Natural Resources staff on studies to assess the amount and value of damage to imperiled habitats, and the efficacy of control measures beginning in 2003 through 2005. Only 1 percent of Florida's seepage slopes remain, with EAFB containing some of the largest tracts. Feral swine damage is among the greatest threats to this wetland habitat.

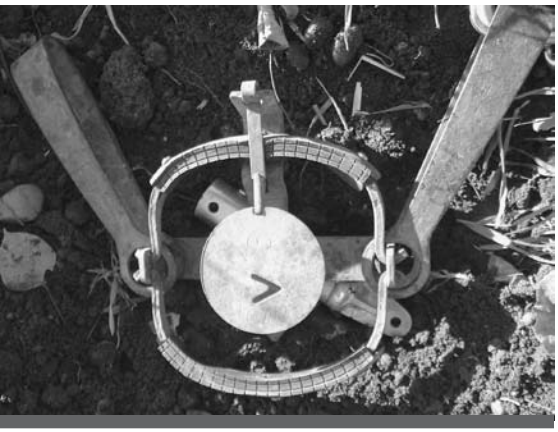
Feral swine damage is a serious threat to wetland habitat in several States. (NASA photo.)

Before they initiated swine control, the research team found that areas open to hunting had a lower percent of seepage-slope area damaged (10.9 percent) than areas closed to hunting (25 percent). However, after only 8 months of control in only the unhunted areas, damage dropped to just 7.2 percent. Control in closed areas also impacted the open hunting areas not receiving control (5.6 percent) to such an extent that damage levels in the open and closed areas could not be distinguished statistically.

Another year of control brought damage in the closed area down to 5.6 percent, while the control-free open hunting area dropped to 4.3 percent, again indistinguishable from the controlled portion. Although it was applied only to the closed hunting area, control also reduced damage in the open hunting area, as swine move freely among areas. Precontrol, the combined value of swine damage to seepage slopes in open and closed hunting areas was $5.3 million. After 1.7 years of control, losses were reduced by nearly $4 million. The benefit–cost ratio over those 1.7 years of control was a noteworthy 27.5, meaning that every $1 invested yielded $27.50 worth of benefits. The economic benefits of control exceeded costs 55.2-fold the first year, when control's greatest impact would be expected.

The work at EAFB concluded with a training session provided by a Georgia WS wildlife disease biologist on tissue-sampling methods for testing swine for brucellosis, PRV, and CSF.

Trap Monitors for WS—In an effort to increase the efficiency of trap checks, WS Operations and NWRC have been evaluating the use of remote trap monitors. Working closely with the operational program,



An ATS trap monitor in the trap bed beneath a Victor #3 long spring trap. Trap monitors can be used in a wide variety of trapping situations. (APHIS photo by John Shivik.)

NWRC produced a research summary of the use of trap monitors in 7 States. The specialists that used these monitors showed much ingenuity in trap-setting and made many useful observations about trap monitors.

When the monitor was hung aboveground on a hillside, it was detectable in the valley below from 8 miles away. One Oregon WS specialist reported hearing the trap monitor from 12 miles away. However, if the trap monitor is completely buried or used in areas with rolling hills, the effective distance may be only ½ mile. The Wisconsin specialists noted that they would be willing to use a larger trap monitor if it were able to be heard from a greater distance.

In Oklahoma, distance limitations prevented using monitors for coyotes, but trap monitors were used for beaver to decrease the hazard and time of specialists' wading through beaver sloughs to check conibear traps. Many specialists commented that the monitors had saved them hiking or driving time. The Oregon WS specialist mentioned that the trap monitor saved him 2 hours of drive-time on logging roads when checking some of his foot snares for bears. The Minnesota WS specialist suggested that he needed to build up his confidence in the trap monitors before he could fully trust them.

Most specialists agreed that they would like the monitors to cost less. The specialists also mentioned that the trap monitors could be improved by making the antenna replaceable so when one antenna was chewed, a new antenna could be attached. Currently, scientists are working with WS personnel in 18 States on this issue.

Biologists Band Cormorants To Study Productivity—In July 2006, biologists and students from the NWRC Starkville, MS, field station, the Berryman Institute, the Canadian Wildlife Service, Mississippi State University, the Ontario Ministry of Natural Resources, the U.S. Department of the Interior's U.S. Fish and Wildlife Service (FWS), and the World Wildlife Trust banded double-crested cormorants as part of a continuing study of cormorant reproduction and colony dynamics. Birds still in the nest were banded in five colonies in Blind River, ON, and four colonies in Kenora, ON. Biologists also observed cormorants previously marked with alpha-coded color and metal legbands at these colonies and additional sites near Brighton, ON, to determine survival, productivity, and nest characteristics.

Data from this study will help determine cormorant population characteristics, provide information to develop models predicting population changes under different management scenarios, evaluate management actions, and develop management strategies for cormorants affecting commercial and natural resources.

Rat Eradication on Congo Island, Virgin Islands—During the first week of June 2006, Alabama WS biologists and an NWRC scientist removed brown rats from Congo Island in the U.S. Virgin Islands under an Emergency Use Permit from EPA. This project was undertaken at the request of the U.S. Virgin Islands' Division of Fish and Wildlife for the protection of brown pelicans and other nesting seabird populations. The biologists systematically hand-broadcast brodifacoum over the entire 26-acre island with the goal of totally eradicating the rats. Followup monitoring of rodent populations will be conducted jointly by WS and the Virgin Islands office of the U.S. Fish and Wildlife Service.

NWRC Biologists Track and Relocate Ospreys— In June 2006, biologists from the NWRC Starkville, MS, and Sandusky, OH, field stations, the Virginia WS program, the Indiana Department of Natural Resources (DNR), and the United States Air Force 1st Fighter Wing at Langley Air Force Base (AFB), VA, initiated a collaborative research project. The project will evaluate management efforts to reduce bird-strike risks from migrating and breeding ospreys at Langley AFB and the mid-Atlantic Chesapeake Bay region. NWRC biologists captured and outfitted four osprey fledglings in the Langley area with new, lightweight satellite transmitters that will allow their movements to be tracked for up to 3 years. The biologists also assisted with the capture and relocation to Indiana of 14 additional osprey fledglings as part of Indiana DNR's osprey restoration efforts. The project will ultimately provide regional information on managing ospreys to military aviation and flight safety personnel and professional wildlife management agencies.

Adult osprey on nest. (APHIS photo by Tom Olexa.)

NWRC and WS Operations Biologists Consult on Wind Turbines—On July 10, 2006, biologists from the Sandusky field station and Ohio WS operations were invited to attend the presentation by U.S. Congresswoman Marcy Kaptur of a $1 million wind energy award to Bowling Green State University (BGSU) for the Coastal Ohio Wind Project. Two NWRC field station biologists worked with the BGSU dean and a local wind-energy business for 10 months to provide guidance on assessing and mitigating potential negative effects on birds by an experimental wind turbine under consideration for the university campus. The NWRC biologists and Ohio WS biologists also helped BGSU draft documentation for the U.S. Department of Energy concerning bird habitat use near the turbine site and potential tools to reduce bird collisions with turbine blades. Furthermore, the biologists anticipate direct involvement in drafting and implementing a wildlife hazard assessment for the BGSU wind turbine. Key involvement by WS in providing guidance on wildlife issues to BGSU relative to the experimental wind turbine is precedent setting for the agency and for this relatively new industry in the United States.

An NWRC biologist holds an osprey fitted with a radio-telemetry device. (APHIS file photo.)

Wind turbines may pose a hazard to birds. (U.S. Department of Energy photo.)

Scientists Complete Analysis for Rocky Mountain Arsenal—Between January and May 2006, NWRC scientists completed the analysis of 217 samples for organochlorine pesticide residues. This work was completed in collaboration with the DoD and the U.S. FWS. The DoD and FWS are conducting an organochlorine residue-monitoring program at the Rocky Mountain Arsenal in Colorado. Bird, mammal, fish, and insect samples were received, processed, and analyzed and the results delivered an average of 2 weeks ahead of schedule.

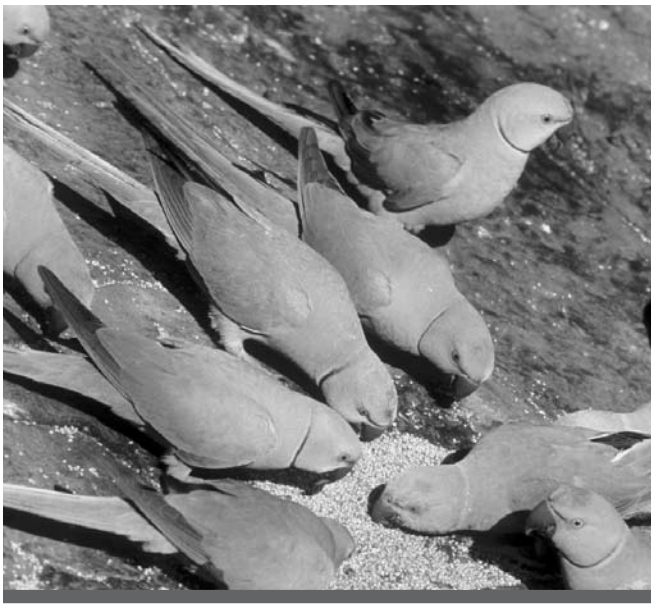
NWRC Biologists Assess House Mouse Situation on the Farallon Islands—The Farallon Islands National Wildlife Refuge is a group of islands about 30 miles offshore from San Francisco. The refuge is home to the largest seabird colony on the Pacific coast, south of Alaska. Many thousands of nesting seabirds summer there each year and are being impacted by invasive house mice, which have become established on Southeast Farallon Island, the southern part of the island chain. NWRC biologists joined personnel from EPA and Island Conservation, Inc., in March 2006 on a 1-day trip to the island hosted by the FWS. The group discussed the situation and potential eradication strategies.

It was agreed that two aerial-broadcast rodenticide bait drops, 2 weeks apart, would clear the island of mice. The drops would be in the fall when the migratory birds have left the island. Other mitigation plans will minimize potential impacts to the resident arboreal salamander and the few land birds that use the island. The two houses used by the Island caretakers and bird researchers will need to be fumigated to assure removal of all mice dwelling therein. NWRC personnel will continue to assist in planning the eradication.

Farallon Islands National Wildlife Refuge. (National Oceanic and Atmospheric Administration photo.)

International Cooperation

Cooperative Research with Central Science Laboratory—In the spring of 2006, the NWRC's Reproductive Control project began a cooperative research program with the Central Science Laboratory in York, England, to develop contraceptives for the rose-ringed parakeet and grey squirrel. The rose-ringed parakeet is native to central and western Africa and India, and feral colonies have been established in England at least since the 1970s. Feral populations are a result of intentional and accidental releases of captive birds. In their native range, rose-ringed parakeets can cause considerable damage to fruit and grain crops. Contraceptive efforts will focus on preventing egg hatchability or preventing egg laying.



In their native range, rose-ringed parakeets can cause considerable damage to fruit and grain crops. (Istockphoto.)

The grey squirrel was introduced to Britain from North America in the late 1800s and to northern Italy during the mid to late 1900s. Grey squirrels in Britain and Italy compete with native red squirrels and could potentially cause serious population declines. Reproductive and juvenile recruitment rates for red squirrels are lower in areas where grey squirrels are present. In addition, grey squirrels are thought to be carriers of the squirrel pox virus. Although the virus has little effect on grey squirrels, it is most often lethal to red squirrels. Grey squirrels also cause bark stripping damage to trees, and that can have serious economic impacts as well as influencing woodland composition. A competitive cholesterol inhibitor is being tested as a potential contraceptive agent.

The Saiga antelope is an endangered subspecies in Mongolia. (U.S. Fish and Wildlife Service file photo.)

APHIS Scientist Assists in Successfully Capturing Saiga Antelope in Mongolia—During early September 2006 an NWRC research scientist/wildlife veterinarian assisted scientists with the Wildlife Conservation Society and local Mongolians in the field capture and radio-collaring of Saiga antelope in remote southwestern Mongolia. Eight antelope were captured with the aide of "tangle" nets. Partially as a result of capture and handling techniques modified for Saiga by the NWRC scientist, no animals died or were injured. This is the first successful capture of adults of this rare and endangered subspecies in Mongolia. If GPS radio tracking over the next year is successful, data will aide the government of Mongolia in developing a better management strategy aimed at preventing the extinction of this unique antelope.

Chinese Scientists Visit NWRC—On July 27, 2006, NWRC hosted scientists from the Chinese Ministry of Agriculture. This six-person team is touring the United States to exchange information on agriculture protection and production. They visited NWRC to discuss methods and strategies to protect crops from damage by rodents, birds, and other wildlife. NWRC scientists presented information on the status and prevention of damage to natural resources, diseases associated with rodents, management of bird impacts to rice fields, and use and registration of toxicants in the United States. Ministry of Agriculture personnel, in turn, presented their primary concerns and current strategies for protecting croplands. Areas for future collaborations and potential joint research projects will be discussed. The visitors were also given a tour of NWRC laboratories and animal-holding facilities used to develop new techniques for protecting agricultural resources.

NWRC hosted Chinese visitors in September 2006. (APHIS photo by Laurie Paulik.)

Economic Benchmarking for Wildlife Damage Management Studies in Australia—An NWRC scientist traveled to Adelaide, Australia, in July 2006, to give a workshop entitled, "Economic Benchmarking for Wildlife Damage Management." The trip was sponsored by the Invasive Animals Cooperative Research Centre. This Centre has numerous demonstration (study) sites throughout Australia to test management techniques and assess their efficacy for reducing damage by invasive species. The workshop provided Centre scientists and site leaders with an introduction to economic benchmarking and exercises for adapting these economic methods into planned studies.

Spanish Environmental Ministry Scientists Visit NWRC—From August 30 through September 8, four scientists and managers from Spain's Ministerio de Medio Ambiente and Consejería de Medio Ambiente, Junta de Castilla y León visited with scientists from NWRC's Logan, UT, field station and the Utah WS State Director. The scientists discussed Spanish research studies on fox and lynx behavior. The Ministry is assisting regional governments with predator control methods that may be used to protect endangered species. Scientists there have recently become involved in research to test attractants and capture devices for foxes on the Iberian Peninsula. Research on these tools should be useful not only in Spain but also for species in the United States.

International Workshop on Asian H5N1 Surveillance in Wild Birds—NWRC biologists participated in a 3-day workshop March 7–10, 2006, in Phnom Penh, Cambodia, on surveillance techniques for the detection of avian influenza virus Asian H5N1 in wild birds. Avian influenza is a disease of wild and domesticated birds. Each year, there is an influenza season for wild birds just as there is for humans, and, as with people, some forms of the virus are worse than others. Asian H5N1 is a highly pathogenic strain of avian influenza that has been detected in parts of Asia, Europe, and Africa. The Asian H5N1 strain is of high concern because of the potential impacts it can have on agriculture, wildlife, and human health.

The goal of the workshop was to increase the understanding of avian influenza and help develop a framework for a Cambodian national surveillance

system for wild birds. In addition to learning capture, handling, and sampling techniques for gathering avian influenza samples in wild birds, participants were also trained in laboratory diagnostics and data management.

The workshop, which was hosted by WS and USDA's Foreign Agricultural Service and sponsored by the U.S Agency for International Development, featured wildlife and veterinary experts from Cambodia's National Animal Health and Production Investigation Centre, the Chinese Institute of Zoology, the Wildlife Conservation Society, the United Nations' Food and Agriculture Organization, along with the U.S. Departments of Agriculture and the Interior.

Scientists around the world are working to better understand the nature of the Asian H5N1 virus and how it is transmitted. Wild birds serve as an early warning system for detecting avian influenza. By collecting samples from both dead and live wild birds, wildlife specialists in Cambodia can proactively monitor for avian influenza viruses, including Asian H5N1, in bird populations. They can also minimize the potential for human exposure to infected birds.

Assistance for Indexing Kalahari Carnivores— During July 2006, an NWRC scientist met in Potsdam, Germany, with a researcher from the University of Potsdam who has been a coordinator of multinational ecological research in the Kalahari Desert in southern Africa. The German scientist's research has involved the use of tracking plots to monitor 10 species of carnivores. Development of field and quantitative methodologies for indexing animal populations has been a major research focus for the NWRC researcher, and he was able to provide advice on analytical methods for the carnivore data. He also demonstrated how those data fit well into a general indexing paradigm developed at NWRC and advised on how to distribute this low-labor, low-tech methodology for successfully monitoring the populations for the 10 carnivores.

Vampire Bat Studies in Mexico—NWRC scientists traveled to the state of San Luis Potosí, Mexico, in July 2006 to work with WS Operations personnel, the WS Disease Coordinator, APHIS–International Services personnel, and Mexican government scientists. This trip was an exploratory phase of a potential collaborative effort to gather information about vampire bat populations in an area where bat rabies in cattle is prevalent. The goal of the trip was to assist with a vampire bat capture/control campaign and collect tissue samples for genetic analysis of vampire bat populations at NWRC. Genetic studies of the bats may permit scientists to evaluate gene flow, population movements, and population size. This knowledge could be important in developing effective management strategies for vampire bat populations.

Scientists From the U.K. Central Science Laboratory Visit NWRC—Scientists from the Central Science Laboratory, York, United Kingdom, visited NWRC's Sandusky, OH, field station and the WS National Coordinator for Airport Safety and Assistance during June 2006. The scientists discussed research programs and studies in the United Kingdom directed toward reducing the risk of bird collisions with aircraft. The Laboratory is responsible for research on bird–aircraft strike hazards in the United Kingdom as well as developing wildlife management programs for airports. Recently they have become involved in research to reduce avian and bat mortality at wind turbines. Research on visual deterrents to reduce bird collisions with aircraft should be useful to reduce bird collisions with wind turbines.

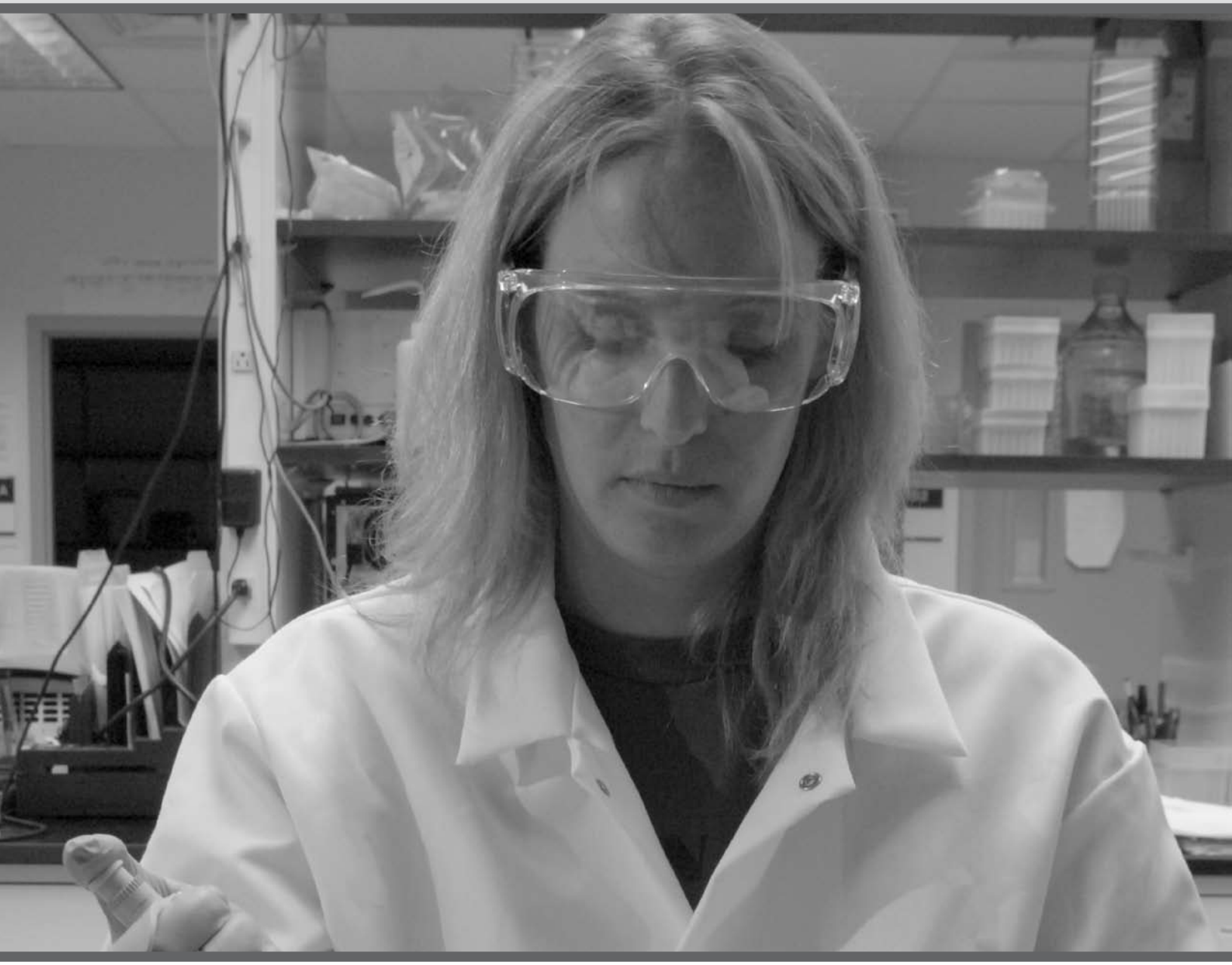
Collaboration With CIIT Centers for Health Research—During August 2006, an NWRC scientist visited the Chemical Industry Institute of Toxicology (CIIT) Centers for Health Research in Research Triangle Park, NC. The scientist's collaborative sabbatical work will center on the development of models for wildlife management chemicals. Model outputs will include the estimation of effects and

Vampire bat.
(APHIS file photo.)

chemical residues in target and nontarget species. Data will help to focus regulatory registration activities as well as to develop and identify the best methods for applying damage management products.

Valuing and Investing in People

GOAL: Promote an organizational culture that values and invests in our people to support their professionalism, competency, and innovation as Federal leaders of wildlife management.



NWRC scientists are analyzing close to 50,000 environmental samples as part of the national avian influenza surveillance effort. (USDA photo by Bob Nichol.)

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 (ANAWG). In that capacity, Susan has facilitated potential efforts and information exchange between APHIS and Native Americans on topics such as avian influenza surveillance, emergency response and preparedness procedures, and surveillance for CWD in deer and elk. Susan has also served as a mentor providing career guidance to a Native American high-school student in Fort Collins.

The ANAWG strives to enhance APHIS program delivery and accessibility to tribes, intertribal committees, and related organizations. Working Group members meet every other year to discuss their involvement with tribes and how to improve their efforts. Hot topics at the ANAWG's May 2006 meeting included coordinated efforts with tribes in surveillance and sample collection of HPAI, in emergency response and preparedness procedures, and in surveillance and monitoring of CWD in deer and elk.

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

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, Jr.; McLean, R. G.; Clark, L. Cliff swallows as a sentinel in West Nile virus surveillance.

Caesar Kleberg Foundation Award—Dr. Bob McLean, NWRC's Wildlife Disease Program Manager, received the Caesar Kleberg Foundation Award medallion during the 25th anniversary symposium of the Caesar Kleberg Wildlife Research Institute in Corpus Christi, TX, in April. McLean was one of eight scientists from around the world who received a special medallion for this prestigious award. During the symposium, the award recipients were asked to present on their area of expertise. Dr. McLean's talk was titled "The Introduction and Emergence of Major Wildlife Diseases in North America." The presentations by the recipients will be published in a book, "Wildlife Science: Linking Ecological Theory and Management Applications."

Scientist Elected ACS Program Chair—In May 2006, John J. Johnston, research chemist at NWRC, was elected Program Chair of the American Chemical Society (ACS) Agrochemicals Division for 2007 and Chair-Elect (President) for 2008. The division has 1,200 members from government, industry, and academia. In 2007, Dr. Johnston will be responsible for organizing the Agrochemical Division symposia at national ACS meetings in Chicago and Boston. Symposia topics will include biofuels, glyphosate resistance, GIS for environmental risk assessment, drought and sustainable agriculture, urban and forest pest management, veterinary pharmaceuticals in the environment, nutrient and contaminant analyses in soils, and rodenticides for protection of agriculture and public health.

2005 Publication Awards

The NWRC Publications Awards Committee is pleased to recognize Ann Kitchen and Eric Gese for their work on the NWRC publication judged best for 2005:

Kitchen, A. M.; gese, E. M.; Waits, L. P.; Karki, S. M.; Schauster, E. R. 2005. Genetic and spatial structure within a swift fox population. Journal of Animal Ecology 74: 1173–1181.

This article fills an important niche in our understanding of social structure in canids by examining one of the smaller members of the family in detail. In addition, the Kitchen and Gese study combined both genetic and field observational data to understand kin selection and evolutionary strategies in the swift fox.

Supporting Student Research

Coyote Space-Use and Supplemental Feeding—A Utah State University graduate student supported by the Logan field station completed a dissertation that examined coyote space-use in Texas. Several studies have focused on short-term spatial patterns in coyotes, but little information is available regarding long-term patterns. The main objective of NWRC's study was to compare historical and current spatial structures of coyote home-ranges. The spatial overlap of coyote home-ranges at the Welder Wildlife Refuge in south Texas was compared over two study periods, one in 1978–79 and the second in 2003–04. Researchers also compared coyote diet, age, and activity patterns between the two study periods.

Mean percent overlap of home-ranges observed was 71.73 ± 6.79 percent in 2003 with 1979 and 55.60 ± 10.72 percent for 1979 with 2003. Core areas showed little overlap. Overall dietary trends were similar between 1979 and 2003, but some differences in the type of prey items did occur. Activity patterns were similar between the two study periods, with peaks in movement occurring around sunrise and sunset.

Study findings suggest that large-scale trends, like territory location, will exhibit long-term stability in coyotes. Fine-scale trends, like type of prey item and distribution of locations within a territory, however, are dynamic, reflecting changes in the local environment. Coyotes were also extremely resistant to changing their diet and territory-use even during periods of intense supplemental feeding. Thus, supplemental feeding in itself may not be enough to draw coyotes away from areas containing human resources that need protection.

Graduate Student Successfully Defends Dissertation on Indirect Transmission of BTB—An NWRC scientist, as an invited graduate committee member, participated in the dissertation defense of Amanda Fine, a Ph.D. candidate at Michigan State University, in March 2006. Ms. Fine successfully defended her dissertation, entitled "The Role of Indirect Transmission in the Epidemiology of Bovine Tuberculosis in White-Tailed Deer and Cattle in Michigan." She developed a laboratory technique for "cleaning up" environmental samples so that they could then be cultured for the acid-fast *Mycobacterium* organism.

In collaboration with studies conducted by NWRC scientists, extensive collecting and processing of environmental samples (soil, water, cattle and deer feces, and cattle feed) from the BTB-endemic area in northern Michigan found no culture-positive results, although other acid-fast organisms were found. This illustrates how difficult it is to locate BTB in the environment.

Fine also conducted an outdoor study to assess the persistence of bovine TB in the environment on water, soil, corn, and hay. Viable bacteria were found to persist up to 88 days on soil in the environment, especially in the cooler, wetter seasons.

This study confirms the need to clean up the environment of infected farms after cattle are removed and to wait an adequate period of time before new cattle are brought back to the farm. Also, keeping cattle feed from being contaminated by infected deer is very important because the BTB can persist on that feed for a lengthy period.

Environmental Education on Pacific Northwest Wildlife—On May 18, 2006, an NWRC scientist from the Olympia field station participated in an environmental education program for a local high school. The pilot program, sponsored by Weyerhaeuser, was initiated to provide students with information on forest resources, timber management, and wildlife resources. Each participating scientist was invited to present information on forest mammalian species and their identification. In addition, students were able to obtain hands-on experience in learning telemetry techniques for monitoring wildlife.

Vulture Capture and Tagging Methods Demonstrated at Teaching Zoo—On June 19, 2006, a team of researchers from the NWRC Florida field station provided practical experience in capturing and marking vultures to students at the Santa Fe Community College Teaching Zoo in Gainesville. Students from the zoo program participated in attaching numbered patagial tags to the birds for identification. Students also received training in safe handling of vultures and in proper techniques for obtaining body measurements. For many of the participants, this was their first experience in capturing and handling wild raptorlike birds, and it provided them with valuable insights in dealing with a real-world wildlife-management situation.

Leptospirosis Genetic Diversity and Distribution Under Study—In August 2006, NWRC's Hilo, HI, field station hosted Mayee Wong, a University of Hawaii Ph.D. candidate. Ms. Wong's project objective is to characterize the genetic diversity and molecular phylogenetics of the *Leptospira* pathogen and determine host use and parasite specificity among rodent and mongoose populations in an urban forest/stream environment on Oahu. Field station biologists demonstrated rodent identification, trapping and tagging techniques, and collection of morphological data. Field station personnel also provided Ms. Wong with experience in capturing and handling rats, mice, and mongooses; sedating captured animals; and collecting blood serum samples for pathogen DNA analysis.

Leptospirosis is one of the most widespread of the diseases transmissible to humans from animals in tropical regions and is many times more common (approximately 30-fold) in Hawaii than in other parts of the Nation. A more complete characterization of the genetic diversity of *Leptospira* and their distribution in nature will lead to a better understanding of the mechanisms of disease transmission in Hawaii's watersheds and ultimately to the prevention of what has become today a significant zoonotic disease threat to human health.

Students Learn About Research and Job Opportunities at NWRC— On September 14, 2006, a researcher from the NWRC Hawaii field station gave a presentation to a senior seminar of 45 students at the University of Hawaii. The presentation covered Center history, current research conducted at NWRC, NWRC's position as a leading international institution researching human–wildlife conflicts, and potential future research opportunities. The seminar also exposed students to future job possibilities in biological sciences and potential paths to these careers.

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.

Cliff swallow. (APHIS file photo.)

Information Services

Managing Vertebrate Invasive Species Symposium—NWRC personnel began planning the 4th NWRC international symposium, which will be held August 7–9, 2007, in Fort Collins, CO. The symposium will highlight research, management, and public education associated with vertebrate invasive species, such as mammals, birds, reptiles, and amphibians. Some of the sessions include early detection and rapid response, invasions and impacts, resource recovery, economics, and global initiatives. Information about the symposium can be found on the NWRC web site at <http://www.aphis.usda.gov/ws/nwrc>.

NWRC Web Site—Content on the NWRC Web site has been updated to include current and new project activities and research findings. The NWRC 2005 Annual Publication List is complete and links to the full text of all 2005 publications. A video clip showing a newly designed air cannon net-launcher is available on Bird Research Program pages. A March 2006 factsheet on OvoControl, a contraceptive for Canada geese, has been uploaded to the Product Development pages. All Program and Project pages were reviewed and yearly highlights added. Also, a new online statistical package now compiles information on NWRC Website users.

Most Web work was directed toward preparing the NWRC site for migration to the new standardized USDA design. All URLs were cataloged, subject- and audience-tagged, and prioritized for transfer. Initial WS Web "looks" and headings were presented to APHIS Webmasters for comment. USDA draft Web guidelines were followed in constructing a preliminary, more subject-oriented navigation and design for NWRC. An NWRC librarian made presentations to Program employees regarding forthcoming changes and solicited comments regarding new content and design.

Digital Commons—NWRC has been collaborating with the University of Nebraska, Lincoln Library, and the Internet Center for Wildlife Damage Management (ICWDM) on two projects—a Digital Commons archive of NWRC-authored publications and an image collection of wildlife damage photographs. The articles and other publications on wildlife damage management may be found at <http://digitalcommons.unl.edu/icwdm_usdanwrc/>. The photo collection will be launched in early 2007.

Library—A more integrated online catalog has improved services for requesters by providing Internet access to NWRC library holdings. Serial records have now been moved from the old GLAS stand-alone software to the new Sirsi/Dynix Horizon system. All online journal entries now reflect the last issue received—an added benefit for users. Catalog holdings increased by 231 items in 2006, including NWRC reprints, unpublished reports and new books. Library brochures have been updated, and a new scanning project has been implemented. Back years of NWRC papers (prior to 1998) will gradually be made available electronically for easier distribution.

A new display has also been added to the library. Visitors can now view a pileated woodpecker and damaged telephone pole in addition to a black vulture, nutria, mountain beaver, and a monk parakeet nest.

The AgNIC Wildlife Damage Management Web site, a collaborative effort between the NWRC library staff and CSU staff, was enlarged and updated. Information on wildlife diseases, invasive species, nonlethal predator control, and improvements in management tools is now available. New photographs of invasive BTSs and coqui frogs were added to the site.

Information Services Unit staff borrowed, photocopied, or downloaded more than 1,500 items from other libraries in response to information requests from the WS program and lent 170 items in return.

Visitors examine exhibits during the NWRC Archives' open house. (APHIS photo by Barbara Messineo.)

Additionally, staff photocopied nearly 2,730 inhouse journal articles, reports, and NWRC-authored reprints for distribution to researchers and WS Operations staff. More than 9,600 other NWRC or WS information products were distributed, including children's activity sheets and information packets. Overall reference information requests totaled nearly 400, with more than a third of the requests arriving via e-mail from the NWRC Web site.

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 Fifth Annual NWRC Archives Week, October 17–21, 2005, was a time to publicize NWRC archival records internally. An open house on October 19 featured exhibits that detailed the Center's International Program Unit, which was in existence from 1965 through 1995. Two NWRC

retirees, Dan Thompson and Sam Linhart, gave a panel presentation on October 20 regarding their research on vampire bats in the 1960s and 1970s. Part of the presentation included watching a film clip from the National Geographic movie "Strange Creatures in the Night," which highlighted the Center's research.

A hallway exhibit case provides NWRC the opportunity to show visitors and staff current and past research. In April 2006, an exhibit on NWRC's wildlife disease research was installed. This exhibit focuses on the Center's past and present wildlife disease research. It highlights various diseases as well as our newest field station in Kingsville, TX.

Seminars

The NWRC seminar program offers a valuable forum for the exchange of ideas among Center staff, field station personnel, visiting scientists, and WS staff. During 2006, NWRC hosted 18 seminars, including presentations by speakers from various universities and foreign wildlife organizations, NWRC headquarters and field station staff, and potential candidates for employment. Topics included chronic wasting disease, West Nile virus, BTS research, invasive mammals, and research on repellants. The following table lists the 2006 presentations.

Table 3—Presentations by NWRC Scientists and Visitors During 2006

Bob McLean	NWRC, Fort Collins	BSL–3 Research
Kim Burnett	University of Hawaii	BTS Economic Impacts to Hawaii
Tommy King	NWRC, Starkville, MS	Management Implications of Double-Crested Cormorant Migration Patterns
Diana Dwyer	NWRC, Fort Collins	Google and Beyond: Electronic Resources at NWRC
John Pilon	APHIS Science Fellow	Vaccine Development for Chronic Wasting Disease
Heather Keough	Utah State University	Factors Influencing Ferruginous Hawk Breeding Site Selection and Reproductive Success in the Uintah Basin, Utah
Jim Gionfriddo	NWRC, Fort Collins	Pivotal Field Studies of GonaCon Immunocontraceptive Vaccine for Use in the Contraception of Female White-tailed Deer: Maryland and New Jersey
Heather Sullivan	NWRC, Fort Collins	West Nile Virus in Blackbirds
Stephanie Shwiff	NWRC, Fort Collins	NWRC's Dollars at Work: What Are Our Impacts on the Local Economy?
Jerry Hurley	NWRC, Fort Collins	Chemistry Expertise at NWRC
Vaughan Langman	APHIS, Animal Care	Biophysics of the Thermal Neutral Zone
Dale Nolte	NWRC, Fort Collins	USDA Wildlife Services in Southeast Asia: Assisting Foreign Countries With Avian Influenza Surveillance in Wild Birds
Pauline Nol	APHIS Science Fellow	Oral Bacille Calmette-Guerin Vaccination of White-Tailed Deer Against BTB
Tom Mathies, Rick Mauldin	NWRC, Fort Collins	Blood Chemistry and Acetaminophin Toxicity in BTS
Gary Witmer, Susan Jojola	NWRC, Fort Collins	An Overview of the Invasive Mammals Research Project
Dany Chheang	Cambodia Wildlife Protection Office	Wildlife Management in Cambodia—Wildlife Protection Office
Scott Werner	NWRC, Fort Collins	Caffeine Formulation for Avian Repellancy
Kristin Field	Monell Chemical Senses Center	Milk Protein Avoidance: Toward Understanding a New Deer Repellant

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 following:

- 62d annual Northeast Fish and Wildlife Conference
- 8th annual USDA Rabies Management Team Meeting
- Annual meeting of the Organization of Fish and Wildlife Information Managers
- Association of Fish and Wildlife Agencies' annual meeting
- Brown Treesnake Working Group technical meeting
- Crop Improvement Association meeting
- Ecological Society of America annual meeting
- Electric Power Research Institute stakeholders' meeting
- Florida chapter of The Wildlife Society
- Hawaii Conservation Conference
- John F. Kennedy International Airport Bird Hazard Task Force
- Mexican wolf management workshop
- Missouri Rice Producers' conference
- Monell Chemical Senses Center scientific membership meeting
- National Conference on Wild Pigs
- National Sunflower Association's summer seminar
- New York Nonlethal Canada Goose Management Steering Committee meeting
- North American Prairie Conference
- Northern Plains Biological Symposium
- Oregon Northwest chapter of the American Society of Foresters
- Rice Research Field Day
- Science and Policy of Wildlife and Salmon conference
- Sunflower research workshop
- Toward Wildlife Friendly Wind Power
- USDA–Agricultural Research Service Eastern Regional Research Center meeting
- Wildlife Disease Association meeting

Publications

[**Boldface** type indicates an NWRC author.]

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