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Wildlife Services

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Introduction

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 providing scientific information on the development of socially acceptable methods for wildlife damage management. 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 disease, immunology, reproductive physiology, statistics, toxicology, wildlife genetic forensics, 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 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 animals.

- The **Wildlife Diseases 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 in Fort Collins. During fiscal year 2005, several planning and construction activities took place, related to completing the Master Plan for the NWRC site. A portion of the Animal Research Building was renovated to create Biosafety Level 3 (BSL–3) laboratory space and animal holding and testing space for ongoing wildlife disease research being conducted at NWRC. 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.

Groundbreaking took place in early November 2005 for the construction of the Invasive Species Research Building (ISRB). Anticipated completion is November of 2006. The 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.

The last building to be constructed as part of the NWRC's Headquarters Master Plan is the new Wildlife Disease Research Building (WDRB). The WDRB will house most of NWRC's BSL–3 disease research. The WDRB is currently being designed and undergoing an environmental assessment; it should be ready for occupancy in 2008.

New Assistant Director—In 2005, Dr. Larry Clark was named the new Assistant Director at NWRC. Larry brings unique qualifications and expertise to the position. He joined NWRC in 1991 after serving 8 years as a research scientist at the Monell Chemical Senses Center in Philadelphia, PA. Larry has been instrumental in establishing NWRC's new capabilities to address wildlife disease issues. As Assistant Director, he supervises the day-to-day operations of the Center. Larry received his Ph.D. degree in biology from the University of Pennsylvania.

New Mammal Research Program Manager— Dr. Dale Nolte was appointed as Mammal Research Program Manager. Previously Dale had served as the NWRC Olympia, WA, field station leader since 1992. Dale's research focused on understanding behavioral mechanisms behind wildlife damage to the timber industry and investigating and developing methods to resolve these problems. His research also focused on beaver impacts on riparian habitats and on nutria impact on coastal marsh lands. Prior to joining NWRC, Dale held professional positions at Franklin and Marshall University in Pennsylvania and the Monell Chemical Senses Center in Philadelphia. Dale completed his B.S. and M.S. degrees at Kansas State University and his Ph.D. at Utah State University, all in range science.

Developing Methods

GOAL: Increase effective methods available for wildlife damage management.

Bird Research Program

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

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

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. 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 southeastern aquaculture facilities. 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 Research and Operations Biologists Cooperate in Regional Studies of Cormorant Management— NWRC scientists initiated a suite of studies in Michigan, New York, and Vermont to determine the impacts of double-crested cormorants on natural resources and their response to management activities on breeding habitats in the Northern United States. Each study addresses a different aspect of the damage attributed to these birds or the management approach for dealing with this damage. In Michigan, biologists are in the second year of a study to determine the impacts of cormorants on a local yellow-perch fishery that experienced a rapid and unexplained decline. Preliminary results indicate that cormorants from the colonies in question are feeding extensively in the specific areas of perch decline, and that perch numbers following the first year of cormorant management have improved.

In a similar study conducted at Oneida Lake, NY, biologists used satellite transmitters to determine

the movement response of cormorants to nonlethal harassment techniques such as boat chases and pyrotechnics. Preliminary results showed that displaced cormorants ranged widely, visiting other known nesting sites. These results suggest that nonlethal harassment is effective for moving cormorants, but displaced birds may relocate to other nesting colonies and cause damage at other sites.

The issue of bird displacement following management was a primary concern to biologists working on Lake Champlain in New York and Vermont. In response to these concerns, scientists from NWRC initiated a collaborative effort with the WS operational programs in New York and Vermont to reduce damage to native vegetation caused by double-crested cormorants on Young Island. Collaborators include WS, The Nature Conservancy, New York State Department of Environmental Conservation, Vermont Fish and Game Department, and the University of Vermont. To reduce damage, WS is using lethal and nonlethal techniques to decrease colony size. NWRC biologists are monitoring the movement response of 60 radio-marked cormorants following management activities to determine if adults remain on managed sites or if they disperse and attempt to nest at peripheral locations. An unmanaged nesting colony located on the Four Brothers Islands in Lake Champlain will serve as a control to which movement characteristics from the managed plots will be compared. Results from this study will be used to help managers estimate the likelihood of spreading wildlife damage problems when certain management techniques are applied.

Cooperators from all of these sites contributed to a followup study where biologists marked nesting cormorants at five sites where management will occur and five sites where it will not occur to determine the colony abandonment rate of cormorants from managed versus unmanaged colonies.

The Role of Birds in Catfish Parasite Transmission—Scientists from the NWRC Mississippi field station collaborated with parasitologists from the Mississippi State University College of Veterinary Medicine to determine the role of American white pelicans in the life cycle and spread of the *Bolbophorus* catfish trematode. This trematode is associated with high mortality rates in catfish fingerlings and the formation of cysts in the fillets of mature catfish. The scientists infected pelicans with the trematode at the avian testing facility at the Mississippi field station and found that the pelicans shed thousands of trematode eggs per gram of feces within a week after infection. Preliminary results indicate that, among water birds, pelicans are the only one to host the trematode. Future studies will investigate the role pelicans play in moving the trematode from farm to farm.

TITLE: **Develop New or Improved Vulture-Management Methods To Reduce Property Damage and Livestock Predation and Disperse Nuisance Roosts**

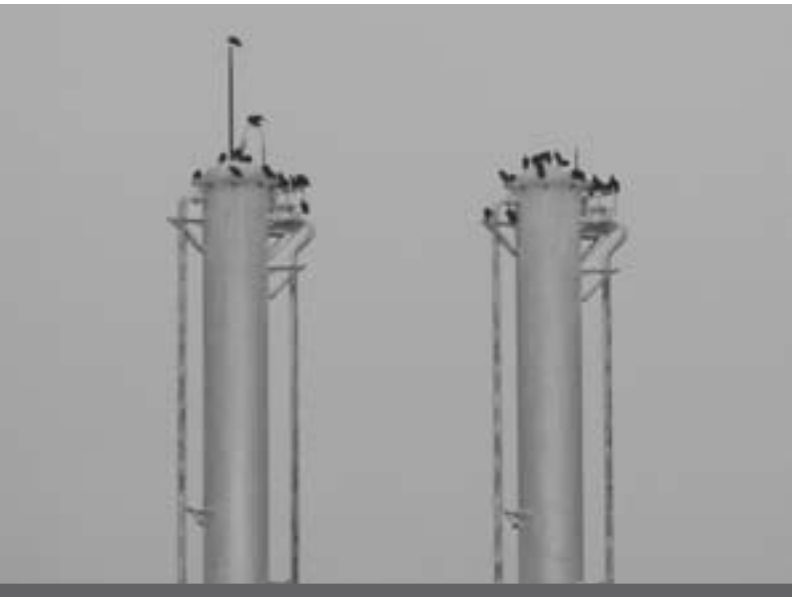
GOAL: Develop practical, effective uses of taxidermic and artificial effigies to manage predation, aviation safety, and property-damage problems caused by black and turkey vultures. Examine population genetics and modeling as means to evaluate vulture responses to lethal control.

Vulture populations are increasing nationwide, particularly in the southeastern United States. As vulture numbers increase, so do conflicts with human activities. Black vultures, for example, damage vinyl, plastic, and other synthetic construction and insulation material. Additionally, black vultures prey on newly born livestock and, in association with turkey vultures, form roosts that not only are nuisances but also contribute to human health and safety problems. Vultures often forage at landfills, which in turn are often located near airports. In their daily flights to and from landfills to feed, vultures constitute a major hazard to aircraft. Problems related to vulture management show no sign of diminishing, and the need for efficient, practical, and safe methods of managing vulture damage situations is acute.

Motion-Activated Sprinkler for Protecting Houses From Perching Vultures—Biologists at NWRC's Florida field station conducted a series of flight-pen trials and a field evaluation to document the efficacy of a commercially available motion-activated sprinkler device for deterring black vultures from perching on roofs. During 3-day pretreatment periods in the flight pen, vultures perched on the test roofs 72 percent of the time. Then the sprinkler device was activated for 3 days, and the birds used the roof 1.6 percent of the time. When the sprinkler was deactivated, birds resumed using the roof, usually within several hours. Thus to be effective, the device has to remain activated.

A field trial conducted at a residence near St. Petersburg with a history of vulture problems confirmed that the motion-activated sprinkler is an efficient vulture deterrent. Vulture perching on the roof of the house was eliminated by the installation of two of the units.

Dispersal of Vultures From a Gas Plant Using Artificial Effigies and Laser—In 2005, biologists with the Florida and Texas field stations and from Fort Collins successfully applied artificial vulture effigies and a hand-held laser to disperse black



vultures and turkey vultures that were roosting in a natural gas plant near Kingsville, TX. Daily counts of vultures on the structures before effigy installation averaged 204 birds. After several days of documenting vulture numbers on the towers at sunrise, three artificial effigies were installed at strategic locations throughout the site. The effigy used for this operation was a 38-cm-tall decorative bird. It had a hard foam body covered with glued-on feathers and a plastic, raptorlike head and feet.

Daily counts of birds declined 60 percent with the effigy in place for 3 days. Then the laser was used for 4 more days and birds were eliminated from the site entirely. Similar levels of success have been obtained previously in dispersing vultures from roosts on cell towers and from tree roosts in residential settings.

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

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

Red-winged blackbirds, common grackles, and brown-headed cowbirds cause extensive damage to newly planted rice and ripening rice. NWRC researchers are focused on reducing bird damage to rice and improving profitability to growers by developing new or improved management strategies and expanding partnerships between rice producers, rice commodity groups, rice research boards, universities, and local, State, and Federal agencies.

Potential Blackbird Repellants for Rice—NWRC scientists conducted tests with both captive and free-ranging birds to identify and develop nonlethal repellants for reducing bird depredations on seeded and ripening rice. In a series of feeding trials at the NWRC Outdoor Animal Research Facility in Fort Collins, CO, male red-winged blackbirds discriminated between untreated rice and rice treated with 1 percent GWN–4770 (weight to weight). During the 4-day treatment phase of the test, blackbirds consumed an average of 9.1 g of untreated rice and 0 g of rice treated with 1 percent GWN–4770. During one-choice tests, consumption by blackbirds offered rice treated with 0.25, 0.5, 0.75, 1, or 2 percent GWN–4770 declined with increasing concentration of the repellant. Relative to pretreatment rice consumption, blackbirds consumed 34 percent and 77 percent less rice treated with 1 percent and 2 percent GWN–4770, respectively.

Caffeine also showed promise as a potential repellant for newly planted rice and ripening rice. NWRC scientists in Fort Collins conducted tests with caged birds to evaluate the repellancy of caffeine formulated on rice seed with various concentrations of sodium benzoate. All red-winged blackbirds discriminated between untreated rice and rice treated with 1 percent caffeine and 1 percent sodium benzoate during 4-day preference test and a 4-day posttest. A positive dose–response relationship was observed among birds offered rice treated with 0.1 percent, 0.25 percent, 0.5 percent, 1 percent, or 2 percent caffeine. Consumption declined by 52 percent relative to the pretreatment during the no-choice tests with 0.1 percent caffeine. Repellancy was 88 percent to 100 percent, respectively, among birds offered rice treated with caffeine at 0.25 percent to 2 percent.

A small-scale field test was conducted near Kaplan, LA, to evaluate the repellancy of caffeine on newly water-seeded rice. Caffeine was applied with a seed-treater at a 1 percent concentration to presoaked rice before water planting on 2- and 2.5-ha test sites. After the water was drained from the test sites, bird numbers increased dramatically, with up to 1,500 blackbirds observed per day on 1 site. However, less than 2 percent of the rice seed was consumed during the first 5 days of the test.

On one field, the number of blackbirds decreased after this period, but on the other site, blackbirds consumed most of the rice over the next 5-day period. Germination, which is normally >95 percent, was only about 10 percent.

Residue levels on treated seeds varied from 0.64 percent at planting to 0.16 percent at the conclusion of the test, 10 days after planting. Thus, although caffeine showed good repellancy for blackbirds, modifications are needed to the formulation and/or concentration to eliminate phytotoxicity and increase germination.

Movement Patterns and Distribution of Blackbirds in Missouri—During October 2004, NWRC scientists used a Day-Glo™ paint pigment to aerially mass-mark more than 2.2 million red-winged blackbirds and brown-headed cowbirds in Missouri to determine roost turnover, roost interchange, movement patterns, and distribution. Roost sites were up to 40 km (25 mi) apart and were marked with individual colors.

Marking success among the three sites varied from 44 percent to 73 percent. When double-marked

birds were collected following spray marking, their presence indicated that daily interchange took place among the three roost sites.

During January, 8,389 blackbirds were collected in the southern rice-growing region of Missouri, Arkansas, and Louisiana; 173 of those were marked. Of the marked blackbirds, 121 were collected in Missouri, 27 in Arkansas, and 24 in Louisiana.

The durability and longevity of Day-Glo paint pigment used to mass-mark roosting blackbirds was evaluated in the NWRC's outdoor flight pen under natural environmental conditions. Using a hand-held sprayer, researchers marked 52 male red-winged blackbirds and released them into the flight pen. Birds were captured about every 3 weeks to examine the conditions of the marks. At 170 days after spraying, all birds showed marking to varying degrees. Most marking on the head and breast feathers has worn off; marks on the wings showed less wear.

Estimating DRC–1339 Blackbird Mortality With a Predictive Model—NWRC scientists have developed a model to estimate mortality during DRC–1339 baiting operations at blackbird staging areas. The model is menu driven and requires the user to enter only the species of birds observed at the bait site, the amount of DRC–1339-treated bait applied, and the amount of bait remaining after the birds have left the site. The model estimates the numbers and species of blackbirds taken at the bait site.

To gather data needed for the model, NWRC scientists collected 2,982 blackbirds as they departed DRC–1339 bait sites in Louisiana, Texas, and Missouri. In all, 2,171 red-winged blackbirds, 661 brown-headed cowbirds, and 131 grackles (common, boat-tailed and great-tailed) were collected.

On average, blackbirds visited DRC–1339 bait sites for less than 5 minutes, during which time blackbirds consumed an average of 25 rice grains (range 0–205), cowbirds consumed an average of 16 rice grains (range 0–204), and grackles consumed an average of 51 rice grains (range 0–265). Of the

2,171 red-winged blackbirds collected, 46 percent consumed more than 25 rice grains, 52 percent consumed between 1 and 25 rice grains, and 2 percent did not consume any rice grains. A similar distribution of consumption was calculated for the other species.

To refine the model and to meet the Environmental Protection Agency's (EPA) current standards requiring at least 5 levels and 10 birds per dose level, NWRC scientists conducted definitive acute oral toxicity tests with each of the major target species that were observed on DRC–1339 bait sites. Dose–response curves were calculated for brown-headed cowbirds, red-winged blackbirds, and common grackles. The LD_{50} (the estimated dose that kills 50 percent of exposed birds) for brown-headed cowbirds, red-winged blackbirds, and common grackles was 1.8, 2.5, and 0.7 mg/kg, and the LD_{99} for the same species was 3.1, 3.6, and 3.7 mg/kg, respectively.

Another key component of the model involves the toxicity of a single 2-percent DRC–1339 rice bait to each of the major species of blackbirds that visit bait sites. Three groups of individually caged birds (red-winged blackbirds, brown-headed cowbirds, and common grackles) were lavaged with a single grain of rice treated with 2-percent DRC–1339. Mortality and time to death for each species were 100 percent (5 to 72 hours) for red-winged blackbirds, 97 percent (7 to 144 hours) for brown-headed cowbirds, 90 percent (10 to 99 hours) for common grackles, and 83 percent (26 to 216 hours) for boat-tailed grackles.

New Metering Device Could Simplify DRC–1339 Baiting—Current procedures used by WS to mix, bag, and store DRC–1339 accelerates degradation of the bait and reduces blackbird acceptance of treated baits. NWRC biologists developed a metering device to more accurately add DRC–1339-treated brown rice to untreated brown rice at a dilution rate of 1:25 as the bait leaves the Herd Seeder™ bait hopper.

Various box sizes, drop angles, gate openings and application rates were assessed with untreated brown rice and DRC–1339-treated brown rice. The application rate of brown rice and the gate opening of the bait hopper were also assessed. After initial tests, a metering device with a 1.1-cm gate opening, 370 angled bottoms, and a capacity for 1 kg of DRC–1339-treated brown rice was selected for evaluation during a baiting program in Louisiana.

Overall, the metering device reduced problems normally encountered during premixing, bagging, and storing treated brown-rice baits prior to field baiting. In addition, the metering device more evenly dispersed DRC–1339 at the desired dilution rate. However, additional development is needed to reduce collection of moisture and rusting of the steel used to make the metering device.

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

Blackbirds and starlings are responsible for damaging grain crops and sunflowers and eating livestock feed. NWRC investigators are evaluating the efficacy and environmental impacts of using DRC–1339 to reduce blackbird and starling populations at feedlots. Scientists also are evaluating the efficacy of nonlethal repellants in reducing damage to ripening sunflowers. Population models on blackbird distribution and abundance and a database on the basic ecology and regional movements of blackbirds in relation to sunflower and livestock feed damage are also being developed.

Red-Winged Blackbird Migratory Patterns—NWRC scientists collaborated with WS biologists from North Dakota, South Dakota, and Kansas to determine dispersal of blackbirds migrating through the prairie pothole States during the fall. During September 2004, the researchers used fluorescent particles to aerially apply and color-mark about 73,000 red-winged blackbirds at 2 roosts within Stutsman County, ND. Every roost was sprayed seven times with 265 to 375 L of marker formulation per spray. From mid-October to late November, 5,833 red-winged blackbirds were collected in North Dakota, South Dakota, Nebraska and Kansas.

Overall, 11 of the collected birds bore color markings, yielding a 0.19 percent return rate. The highest return rate (0.24 percent) was for the 3,307 birds collected in central Kansas in the vicinity of Cheyenne Bottoms Wildlife Area. Two of the 1,283 birds (0.16 percent) collected in southeastern North Dakota were marked, and 1 of 1,199 birds (0.08 percent) collected in South Dakota was marked. About 30 percent of the red-winged blackbird population near Cheyenne Bottoms Wildlife Area in late November probably originated from North Dakota. This is a high number, considering the distance from the marking site (~1,000 km, or roughly 621 miles, due south) and the extensive geographic area available to the marked population.

Scientists speculate that the drop in sunflower production in southeastern portions of North Dakota and the concomitant westward expansion of the sunflower crop might have increased the use of Cheyenne Bottoms Wildlife Area by North Dakota's red-winged blackbirds.

Wildlife Conservation Sunflower Plots—In late summer and fall 2004, NWRC scientists, in collaboration with North Dakota State University and North Dakota and South Dakota WS, evaluated the use of wildlife conservation sunflower plots (WCSPs) for reducing blackbird depredations in nearby commercial sunflower fields. The scientists compared avian use of sunflower fields, grain crops, and experimental WCSPs planted near wetlands traditionally used by blackbirds. The study area was in the prairie pothole region of North Dakota, typified by a high density of sunflower and wetlands. The close proximity of blackbird roosts, cattail marshes, and large amounts sunflower make this region a major stopover location for blackbirds and other during fall migration. Blackbird depredation in this area is a major problem, causing some producers to abandon sunflower production.

Scientists surveyed 13 study sites for blackbird and other bird species and habitat preference. Each study site included one WCSP, one commercial sunflower field, and a grain crop field all located within 2.4 km (1.5 mi) of each other. Of the 43 species observed during the study, 26 were seen in WCSPs, 31 were recorded in commercial sunflower, and 21 were observed in other types of grain fields. Nonblackbird density in commercial sunflower was 0.74 bird/ha; WCSPs harbored 1.56 birds/ha. Of 20,000 blackbirds counted, 50 percent were in WCSPs and 50 percent were in commercial sunflower fields. Blackbird density was 10.4 birds/ha and 90.8 birds/ha in commercial sunflower fields and WCSP, respectively. Overall grain crop density was 0.47 bird/ha for blackbirds and 0.58 bird/ha for nonblackbirds. Red-winged blackbirds accounted for 69 percent of blackbirds observed, followed by common grackles (25 percent) and yellow-headed blackbirds (6 percent).

Birds ate 38.6 percent of sunflowers in the 13 WCSPs, compared to only 4.7 percent of sunflowers in the 23 commercial sunflower fields located within 2.4 km of the WCSPs. Damage among individual fields varied, but the overall damage increased noticeably around September 4 and then again near September 25, most likely because of an influx of migrating blackbirds at these times.

NWRC data indicate that WCSPs have the potential to be an important component for an integrated pest management plan to reduce blackbird damage to sunflower. Both blackbird and nonblackbird species made extensive use of WCSPs during their fall migration, resulting in reduced damage to nearby commercial sunflower fields.

TITLE: New Technologies To Deter Wildlife From Airports and Aircraft

GOAL: To 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 passenger traffic by the 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 the capabilities of aircraft engines to withstand bird strikes and the siting of wildlife

attractants, such as waste-management facilities, near airports. An interagency agreement between NWRC and the FAA was established in 1991 to provide the FAA with scientific support for recommendations and policies to control wildlife hazards to the aviation industry. These wildlife hazards are caused primarily by federally protected bird species, although certain mammals (e.g., deer) can also 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 for reducing these hazards, and providing airport personnel with information on the latest strategies for controlling wildlife hazards.

Evaluation of an Electrified Mat as a White-Tailed Deer Barrier—Due to their size and numbers, white-tailed deer pose a direct threat to public safety at airports. Properly using fencing around airfields successfully reduces intrusions by deer, but deer can still gain access to areas through open gates.

Cattle guards reduce deer entry but may be too expensive or may not allow some vehicles access to the airfield. Scientists tested an electronic mat on free ranging deer for 6 weeks during winter months in northern Ohio to determine if deer would cross the mat to reach a desirable food source.

Mean daily deer intrusions at treated sites decreased an average of 95 percent from pretreatment throughout the study. Intrusions at control sites decreased initially by 60 percent but returned to pretreatment levels. Food consumption at treated sites decreased for the first 4 weeks but then returned to pretreatment levels for the last 2 weeks. Rather than going over the electrified mat to reach the food source, deer jumped over or broke through the snow fencing that delineated each site. Food consumption at control sites decreased for the initial 2 weeks but returned to pretreatment levels for the last 4 weeks of the test. Deer avoided openings at sites with electrified mats but not similar openings at control sites. These results suggest that the electric mat, when used with suitable fencing, can reduce the number of deer passing through fence openings into areas that need protection from deer.

Bird Use of Stormwater Management Ponds: Design Considerations—Airport managers control the movement of stormwater away from runways, taxiways, and aprons into temporary holding ponds to ensure the safety of aircraft operations. However, such water-retention ponds frequently attract wildlife, especially birds. The FAA mandates that airports manage potential wildlife attractants like water-retention ponds. To quantify the primary factors that contribute to the attractiveness of detention

ponds to wildlife and to provide guidelines regarding the design of retention ponds on and around airports, biologists at the NWRC Ohio field station are collaborating with the FAA and WS biologists in Washington to test two hypotheses concerning avian use of stormwater-management ponds (which include detention ponds): (1) the number of bird species is most directly related to pond isolation (hectares of wetland resources within 1 km) and (2) the number of bird species is influenced most by the combination of the surface area of the pond or wetland complex, relative area of emergent vegetation, and pond isolation. The results of this study will help determine whether future stormwater-management facilities at airports should be designed to reduce attractiveness to birds and other wildlife, despite the effect on local resources, or whether the priority should be on decreasing the area of habitat available within each facility and on discouraging growth of emergent vegetation.

Efficacy of Aircraft-Mounted Lighting To Reduce Bird Strikes—From 1990 through 2003, collisions of birds with aircraft (bird strikes) cost the U.S. civil aviation industry approximately $500 million annually in direct monetary losses and associated expenses. One potential means of reducing bird strikes is to exploit avian response to light (color and pulse rate) as a potential technique to be incorporated into aircraft-mounted lighting. NWRC scientists are conducting studies to increase avian perception of approaching aircraft by using ecologically salient cues that induce quicker avian avoidance responses.

Recent work indicates that during daylight hours, captive brown-headed cowbirds exposed to an approaching ground-based vehicle exhibiting pulsing 250-W “white” aircraft landing lights initiated avoidance behavior more quickly than birds experiencing an oncoming vehicle with nonpulsing (steady) lights or no lights (control). Field application with a foreign civil air carrier has corroborated these experimental findings with captive birds.

In subsequent research, 91–99 percent of rock doves exposed to wavelength-specific light-emitting diodes exhibited alert behavior when exposed to 475-nm and 644-nm wavelength treatments pulsed at 24 Hz. In contrast, less than 60 percent of the control birds (no light treatment) exhibited alert behaviors.

Current research involves quantifying potential behavioral differences in captive groups of rock doves exposed to light treatments including full-spectrum and particular colors (peak transmission through filters at wavelengths of ~480, 520, and 640 nm), with light treatments presented at 2 and 16 Hz each. An experiment to quantify alert behavior to the aforementioned light treatments has been completed, but without the effect of an oncoming vehicle. In 2006, scientists at the NWRC Ohio field station will refine the experimental design based on results thus far and incorporate vehicle movement into the experiment.

Evaluating Trash-Transfer Facilities as Bird Attractants—Traditional household-waste landfills attract many species of birds, especially gulls. Thus, landfills create a hazard to aircraft if located near airports. The FAA currently recommends that municipal solid-waste landfills and trash-transfer facilities located within 5 miles of an airport. Recently, there has been an increase in the number of trash-transfer facilities with interest in locating them within 5 miles of airports. Consequently, there is a concern regarding the attractiveness of these facilities to bird species hazardous to aviation.

If trash-transfer facilities serve as attractants for gulls and other birds, the presence of these facilities near airports could increase the risk to aircraft operations. Little information is available regarding the attractiveness of various kinds of trash-transfer facilities to birds. In 2004, researchers at the Ohio field station, in cooperation with WS operational offices in six States, initiated a study to determine whether trash-transfer facilities of various designs (e.g., open-sided, fully enclosed) are attractive to avian species hazardous to aviation.

Trash-transfer facilities of various designs were selected in Arizona, California, Connecticut, Massachusetts, Missouri, Ohio, and Washington, representing different geographic regions of the United States. Trash-transfer facilities in each of three general categories—open-sided, partially exposed, or fully enclosed—are being studied. Control sites consist of buildings similar in size and shape to trash-transfer facilities buildings but without refuse (e.g., a grocery store). WS biologists are monitoring bird use of these facilities twice a week for 1 year. The information provided by this study will be useful for determining if and what type of trash-transfer facilities might be compatible with safe aircraft operations.

Evaluating the Attractiveness of Biosolids to Wildlife—Airports might exploit different land uses on their airfields to generate or to save funds. The application of biosolids is one such use. However, the response of wildlife to the application of biosolids is unknown. Although FAA regulations and technical guidance do not currently prohibit this practice, it is critical to safe aircraft operations to determine if wildlife hazardous to aviation are attracted to grassland areas receiving biosolids.

In 2004, scientists from the Ohio field station, in cooperation with North Carolina WS, initiated a study to evaluate wildlife use of airfield grassland habitats receiving applications of biosolids at Marine Corps Air Station Cherry Point in North Carolina. Over the past 13 years, biosolids were spread onto portions of the airfield at Cherry Point. The large size of the airfield allowed for five control and five biosolid-treated study plots. During 2004 and 2005, plant communities were quantified and bird and mammal use was monitored in each study plot.

Preliminary findings suggest that long-term application of biosolids has significantly altered plant communities on this airfield. Areas where biosolids were applied have little botanical diversity and are dominated by tall fescue. Lower botanical diversity (i.e., fewer kinds of plants) is good from a bird-strike perspective as there are fewer kinds of plants to provide food and cover for birds and other wildlife.

Although flora are less diverse on treated plots, small-mammal communities do not significantly differ between treated and control plots at Cherry Point. Bird use of control and biosolid-treated areas appears to be species specific, particularly for flocking species. European starlings were more abundant in the treatment plots during only 2 months (December and January). Few starlings were observed in either the control or treatment plots during the rest of the year.

Monell Chemical Senses Center Wildlife Repellant Update—NWRC has maintained a long-term research collaboration with the Monell Chemical Senses Center that has resulted in the discovery and development of repellants used to deter wildlife damage. An NWRC biologist and Monell researchers employed noninvasive hormonal assays using fecal samples to monitor hormonal responses of European starlings to repellent exposure and hazing techniques. An animal's arousal or stress level is a critical variable in determining how well an aversive experience is encoded into long-term memory. This modulatory effect of stress on learning and memory can be exploited to improve existing methods for managing wildlife. Hormonal responses are correlated with long-term learning; therefore, hormone measurements provide a means to estimate the likelihood that a specific repellant or hazing method will be effective for an extended period.

Long-term learning occurs most effectively when an animal is in a moderate state of alertness. The researchers validated the assay for the response of the stress hormone corticosterone for starlings and followed its time course after a challenge produced by ACTH injection. Following this validation, a set of repellants and stressors were evaluated to determine whether they could raise corticosterone levels in the birds. The failure of some of the stimuli (lasers, visual patterns, odors) to increase the level of the stress hormone in the birds indicates that not all purported repellants were stressful.

Mammal Research Program

TITLE: Developing Tools and Strategies To Reduce Mammalian Impacts on Forest Resources

GOAL: Provide feasible nonlethal solutions and improved rodenticides for forest managers to resolve problems encountered with selected wild mammals.

Wildlife impacts on forest resources can be extensive. Although damage is most often considered in terms of reduced productivity or delayed harvest cycles, attempts to replace trees after a harvest or a fire can be complete failures because of foraging wildlife. Further, wildlife often impede attempts to establish native plants to increase forest diversity, improve riparian areas, revegetate disturbed sites, restore endangered or threatened plants, or to create or improve habitat for wildlife. Foraging wildlife can be extremely detrimental to plant projects, particularly if animals make use of plants before seedlings are well established, or if foraging is continuous or particularly intense. Managing resources to resolve these problems is becoming increasingly difficult. The land base to produce timber is shrinking as efforts to provide habitat for wildlife, particularly for threatened or endangered species, have increased. This declining land base restricts options, while increasing the necessity to protect remaining resources. There is a critical need for increased and enhanced research and outreach programs geared to solving human–wildlife conflicts and improving wildlife damage management.

Mountain Beaver Biology and Ecology—In the Pacific Northwest, mountain beavers cause more damage to tree seedlings and 10- to 15-year-old trees than any other mammal species. Efforts to manage species are hindered by lack of or outdated information on the species' basic biology. The Olympia field station has designed and implemented several studies to increase our understanding of mountain beaver biology (i.e., reproduction, distribution, population characteristics, movements, and feeding behavior).

Information gathered from two studies with radiocollared mountain beavers has demonstrated that this species can move greater distances and use larger areas in its daily activities than previously recorded. In both pen trials and in the field, available forage has an effect on both seedling damage and the distance that animals move. In addition, researchers at the station have determined that, with adequate forage, mountain beavers are reproductively capable at 1 year of age.

Available forage appears to be linked not only with reproductive capability but also with seedling damage. Although data did not support that lactating females' damaging more seedlings, the availability of alternative forage during initial planting does affect the number of seedlings damaged. This information alone has profound effects on how foresters manage the mountain beaver in an area and on potential site preparation.

Development of a Deer Repellant From Food-Grade Materials—Certain purified proteins (complete milk protein, egg albumen, and soy) reduce browsing of conifers by black-tailed deer. Others (acid and base hydrolyzed porcine collagen) are ineffective. Analyses of protein hydrolysates by liquid chromatography and mass spectrometry together with the bioassay results indicate that repellancy may be predicted by methionine content of the protein.

NWRC investigators conducted a series of bioassays aimed at the development of a new deer repellant from methionine-containing proteins for protecting conifer seedlings in reforestation efforts. Using captive black-tailed deer, the researchers tested complete milk protein, edible acid casein, hydrolyzed casein, and free methionine as deer repellants by spraying conifer saplings with an agricultural sticker–spreader and dusting the trees with the test compounds. White-tailed deer were also offered casein and hydrolyzed casein-treated diets in two-choice tests to determine relative avoidance. These bioassays indicate that hydrolyzed casein is strongly avoided by deer.

Its ease of formulation and demonstrated repellancy make hydrolyzed casein a promising repellant for minimizing damage from browsing deer. A study identified 8-percent and 12-percent aqueous solutions of hydrolyzed casein as highly effective concentrations for reforestation applications. Studies showed that commercial nutrient and health supplements containing purified hydrolyzed casein effectively reduce browse damage. This method shows promise for protecting seedlings in reforested areas.

Nonlethal Approaches to Protecting Wetlands From Beavers—Wetland restoration projects often provide the resources necessary for dispersing beavers. Although they are a natural and desirable

component of a wetland ecosystem, beavers' foraging behaviors can be destructive. In conjunction with Arizona WS, NWRC scientists are conducting a series of studies to assess candidate tools for reducing damage by beavers in the Tres Rios riparian Restoration Project Area, near Phoenix.

Several different nonlethal methods were employed (e.g., frightening devices, textural repellants, fences) in an effort to reduce beaver damage. Fencing may be a feasible approach to reduce damage to small, targeted areas, and textural repellants may provide some utility to protect established trees.

Currently, in cooperation with Arizona WS, beaver populations are being monitored at Tres Rios with a newly designed transmitter system to determine dispersal and reinvasion. A mobile laboratory has been developed to be used onsite for beaver research at the Tres Rios facility.

Assessment of Toxicants—Attempts to manage the mountain beaver through repellants, barriers, and trapping can be costly and are not always productive. In addition, the most reliable method to control mountain beaver populations—trapping—is becoming less politically and socially acceptable. Therefore, alternative tools to control mountain beaver populations are desirable. At present there are no toxicants registered for mountain-beaver use; however, four toxicants are registered for underground control of other fossorial rodents. Through a series of studies, biologists have been able to screen these toxicants and determine that chlorophacinone is a likely toxicant for mountain-beaver control.

Two field trials to determine the efficacy of chlorophacinone were conducted to support EPA registration. These field studies demonstrated that efficacy could be achieved through baiting. These studies also provided insight into mountain-beaver biology. Secondary risks to nontarget species are reduced because most of the mountain beavers died within their burrow systems and nests. This research also documented that animals hoard baits and travel great distances to gather bait bags as a potential food source for their caches. Reinvasion into the units occurred much faster than previously thought possible, depending on the surrounding habitat types.

Although efficacy was not up to EPA standards after 45 days, several more mountain beavers died up to 3 months after baiting. Chlorophacinone has the potential to become an additional tool for forest managers to control mountain-beaver damage.

TITLE: **Documenting Impacts, Developing Control Strategies, and Applying Knowledge of Predator Behavior and Demographics for the Protection of Livestock and Natural Resources**

GOAL: Examine the ecology, behavior, and management methods of predators in relation to depredations on domestic livestock, game animals, predators, and threatened and endangered species and develop lethal and nonlethal control methods that effectively target alpha coyotes.

Interactions Between Wolves and Coyotes in Southwestern Montana—The results of competitive interactions between wolves and coyotes may be ambiguous, particularly in areas where coyotes have become habituated to the presence of wolves. Although they may kill coyotes, wolves also provide scavenging opportunities by killing large prey that may not be directly vulnerable to coyotes.

NWRC researchers observed competitive interactions between coyotes and wolves at wolf-killed and manually placed ungulate carcasses in southwestern Montana to determine whether coyotes optimized the tradeoff between a large but rare cost (injury or death) against a smaller but more frequent benefit (scavenging opportunities). Wolf activity (prior and current) and coyote social status influenced the proportion of time coyotes spent alert and on guard while scavenging. Alpha coyotes were nearly twice as vigilant as lower-ranking pack associates when exploiting wolf-killed carcasses. As a result, average biomass consumed at these carcasses (i.e., active consumption rate × time spent feeding) was much lower for alphas (638.86 g/bout, SE = 129.71) than for subordinates (1306.87 g/bout, SE = 295.94).

These results suggest that risk management by coyotes falls most heavily on dominant individuals who may be more experienced in assessing risk but who pay a price by consuming less biomass. Prey-kill sites have the potential to become focal areas of competitive interactions and present an opportunity to further clarify the factors that mediate the outcome of interactions between closely related carnivore species.

Spatial Ecology of Swift Foxes: The Influence of Genetic Relatedness—Spatial data on swift foxes were incorporated with genetic analysis to assess the influence of relatedness between individuals on their social and spatial ecology. The space-use patterns of 188 radio-collared swift foxes in southeastern Colorado were also recorded from January 1997 to

December 2000. In all, 167 foxes were also genotyped at 11 microsatellite DNA loci, allowing scientists to estimate the degree of relatedness between individuals. The genetic structure of the population was described by examining the relatedness of neighbors and the relationship between the spatial and genetic distance of all individuals.

Data revealed that close kin tend to cluster within the population, and female clusters were more extensive than male clusters. The evidence of kin clustering was useful in explaining the study's findings that neighbors exhibited considerable overlap in home range and did not spatially avoid each other. In fact, the more closely related neighbors were, the more home-range overlap they tolerated. In addition, neighbors occasionally shared dens at the same time. Relatedness also influenced the likelihood that an individual would inherit a newly vacated home range. Thus, for swift foxes, the genetic structure of the population and interactions between kin were interrelated to space-use patterns and social ecology.

TITLE: Improved Technologies and Nonlethal Techniques for Managing Predation

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

What's Scary to Predators?—In May 2005, a Utah State University graduate student supported by the NWRC Utah field station successfully defended his master's thesis titled, "Investigations into behavioral responses of predators to novel visual stimuli." His research examined behavioral responses of predators, in natural and captive environments, to various novel stimuli. The thesis documented the influence of stimulus size on avoidance behavior by coyotes; influence of object shape, especially the human form, on predator avoidance behavior; and the effectiveness of fladry and the relative susceptibility of dominant and subordinate coyotes to it. Fladry may be an effective temporary repellant for coyotes, with a mean time to habituation for captive coyotes of more than 2 days. Studies of wild coyotes are still needed to determine latency to habituation when fladry is used for protection of livestock.

Predictability of Coyote Food Resources—During the summer of 2004, the Logan, UT, field station's Predator Research Facility hosted the research of Lynne Gilbert–Norton from the University of Exeter in the United Kingdom. At the end of October, Gilbert-Norton filed her Master of Psychology thesis titled, "The predictability of food resources, and its effect on foraging and exploratory behaviour of captive coyotes *(Canis latrans)."* Her research will be instrumental in understanding coyote behavior relative to attractants and space use. Furthermore, the study will enable the improvement and use of naturalistic environments for coyotes at the Millville site, so that new capture devices and other management methods may be appropriately tested at the facility.

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

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

Oceanic islands like the Hawaiian Islands 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 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.

Bird Repellants Fail To Reduce Invasive Bird Consumption of Corn—NWRC biologists evaluated the relative efficacy of candidate bird repellants for protecting sprouting corn crops in Hawaii. Caffeine, methyl anthranilate, and anthraquinone at maximum label concentrations were tested to determine if they were effective bird repellants as both a sprout spray and a seed treatment. All chemicals showed little effectiveness as bird repellants in the sprout treatment (i.e., most of the corn was grazed). Anthraquinone was the most effective sprout treatment but did not reduce feeding to acceptable levels. Further, the use of anthraquinone likely will be restricted to consumer products. No chemicals were effective as seed treatments. The chemicals may have even allowed the birds to detect seeds and thus increased feeding. Consequently, caffeine, methyl anthranilate, and anthraquinone are not recommended as repellants for francolins feeding on sprouting corn in Hawaii. However, caffeine may have some repellancy, especially if combined with a lure crop.

Development of Mongoose Tracking Stations and Baits—The small Indian mongoose, initially introduced around the world to control rat populations, has been extremely detrimental to native birds and other animals and has become a priority for many countries to control or extirpate. To help in this effort, NWRC scientists developed an effective mongoose tracking station to detect incipient mongoose populations on Puerto Rico. Scientists also provided assistance to invasive species managers from

Kauai to deploy these monitoring stations to monitor any incipient mongoose populations on the mongoose-free island. These tracking stations are now used in Puerto Rico, Japan, and throughout Hawaii to detect and monitor mongoose. NWRC also evaluated and developed baits to ensure that mongoose could be trapped effectively in areas where food resources are plentiful.

The invasive mongoose has greatly expanded its range on Amami and Okinawa Islands and is considered the number one invasive predator, threatening the rare Okinawa rail, endangered rabbit, two species of rodents, the Ryukyu robin, a native woodpecker, a climbing lizard, and several species of indigenous amphibians. Control efforts in the Amani and Ryukyu Islands have focused on trapping and experimental testing of barrier fences. Toxicants are not used due to the presence of native rodents and other ground-foraging animals that share their habitat with the mongoose.

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 Sates 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. The United States has at least 221 nonnative terrestrial vertebrate species, of which about 20 species of invasive mammals have become established. These include fish (grass carp, tilapia, walking catfish), reptiles and amphibians (brown treesnake, cane toad, Caribbean tree frog), birds (myna, monk parakeet, mute swan, starling, pigeon) and mammals (feral livestock, dogs, 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.

Developing Norway Rat Control Methods for the Aleutian Islands— When they become established on islands, invasive rats cause substantial damage to native floral and faunal resources, including ground-nesting seabirds. NWRC scientists in

cooperation with the U.S. Department of Interior's U.S. Fish and Wildlife Service (FWS) attempted to control introduced Norway rats *(Rattus norvegicus)* on Kiska Island, AK, during April and May 2004, by hand-broadcasting rodenticide pellets (0.005-percent diaphacinone) over a 4-ha area at the rate of 28 kg/ha. Data were also gathered on aspects of rat ecology and distribution.

The rodenticide bait pellets were effective in reducing the Norway rat population on the island. The rats were observed mainly at low elevations, perhaps because of the harsh conditions and more limited resources over much of the year at higher elevations and the occurrence of a regular and diverse food supply near the shorelines. There were some detections, however, of small pockets of rats at higher elevations.

Rat stomach contents revealed that vegetation and seabirds were important components of the diet at the north end of Kiska Island, but stomach contents varied by location depending upon the type of food most readily available. For example, fish and kelp appeared in the stomachs of rats collected at Lake Christine. All females captured in early spring were pregnant. It appeared that juvenile rats were rare at that time of year.

While the control or eradication of rats at remote locations such as the Aleutian Islands is theoretically possible, there are many challenges posed to resource managers. This field study has provided insight into the ecology and management of Norway rats at Kiska Island but also points out some of the challenges that remain.

Developing Attractants for Nutria in Louisiana's Coastal Marshes—Nutria damage to Louisiana coastal marshes is a growing concern. A research priority in controlling nutria damage is to develop attractants that elicit consumption of baits or that enable nutria to locate and enter traps. Initial screening of potential attractants was conducted in a Y-maze with captive nutria in New Iberia, LA, in February and March 2005. Odors that nutria most responded to were a commercial nutria lure (Nutria #1™) and two materials developed by a Cornell University graduate student: synthetic fatty acid B and female fur extract.

Plants are also attractive to nutria. In April 2005, biologists examined plants grown under different fertilizer regimes as potential attractants. Nutria were video-recorded overnight inside an enclosure with the plants, and feeding activity was recorded for each plant. Fertilized plants were preferred over

unfertilized plants, but fertilizer alone was not attractive. There was a slight preference for *Panicum* grasses when offered with *Spartina*.

Nutria urine may also be an attractant for nutria. A trail of nutria urine was sprayed on the ground along a designated path. The goal was to find out if the nutria urine was sufficiently attractive to lead nutria into traps. Nutria did not follow the urine trail with any significant purpose. The next phase of the attractant study is to field test attractants that had the highest response from nutria in NWRC's pen studies.

Invasive Species Control in the U.S. Virgin Islands—Invasive, introduced animals are causing substantial damage to the natural resources of public lands and preventing the restoration of native species and ecosystems in the U.S. Virgin Islands (USVI). From April 7 to 18, 2005, two research biologists from NWRC, Fort Collins, joined three WS operations personnel from Alabama to control invasive mammals on St. John's and other small islands. The work was conducted for the U.S. National Park Service (NPS) and the territorial government of the USVI. Trapping and shooting were used to remove introduced mongoose, feral goats, and feral pigs from public lands. Meat from the goats and pigs was donated to local people.

The group also used snap traps to determine if rats had been successfully eradicated with rodenticides from three 12-ha (30-acre) islands. No rats were captured, suggesting that the eradications had been successful. The methods used for the rat eradications were based on the successful strategy developed and implemented in 1999 for Buck Island, USVI, by NWRC researchers.

The 2005 investigators also met with NPS personnel to discuss options for control of the growing feral burro population on public lands. In this case, fertility control may be one of the only methods potentially acceptable to all parties, including the general public. The control effort will continue during the summer of 2006.

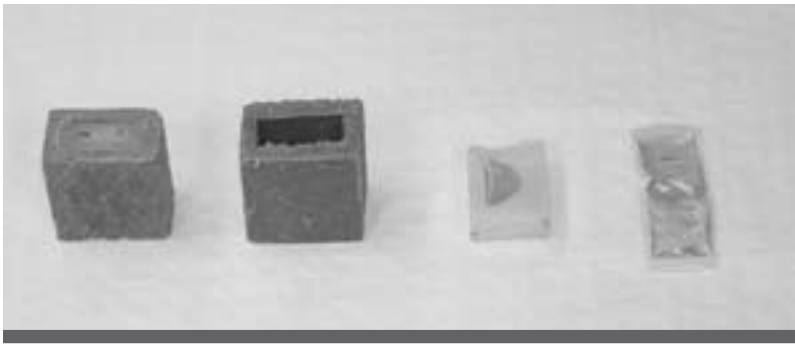
Product Development Research Program

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

GOAL: Develop and apply techniques based on chemistry, biochemistry and computer modeling 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 forms the foundation for much of the research conducted under this project. Project scientists have experience in related scientific disciplines, such as metabolism chemistry, environmental fate, chemical synthesis, toxicology, chemical ecology, wildlife genetics, and chemical formulation. Project personnel also initiate and/or collaborate with other NWRC scientists on a variety of studies that contribute to development of wildlife-management tools.

Evaluation and Significance of Tetracycline Stability in Rabies Vaccine Baits—Tetracycline, which is widely used as a biomarker for bait consumption by wildlife, is incorporated into bones and teeth and may be detected by fluorescence microscopy for several weeks after consumption. Last year, APHIS–WS 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, WS personnel collected raccoons and skunks in baited areas and analyzed teeth for the presence of the biomarker.



Several findings of low biomarker detection rates prompted an investigation of the stability of the biomarker in the baits. Baits collected at several points along the manufacturing and distribution chain were analyzed for free and polymer-bound tetracycline and the less active isomer epitetracycline. Results indicated that a portion of the tetracycline was converted to epitetracycline. Additionally, significant quantities of both compounds were trapped in the polymer, which is homogeneously distributed throughout the bait.

The results of this study show that approximately 40 percent of the target quantity of tetracycline was unavailable for absorption. This situation could contribute to low biomarker detection rates and suggests that the bait formulation should be modified. Future research aimed at identifying bait-preparation procedures for improving the stability and availability of the tetracycline biomarker in rabies vaccine baits is planned.

TITLE: **Economic Research on 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.

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

Economic Analyses of California Skunk Rabies— The incidence of rabies in wildlife has increased dramatically in the past 25 years, with >7,000 positive cases reported in the United States annually since 1999. Multiple variants of the rabies virus occur in this country: bat, canine, raccoon, and skunk. Skunk- and bat-variant rabies are the only types of wildlife rabies that occur in California. Between 1997 and 2001, an average of 156 and 163 positive cases of skunk- and bat-variant rabies were documented in that State, respectively.

Beginning in 2003, NWRC's Economics Project staff collaborated with the California Department of Health Services (CDHS) to determine the economic feasibility of using oral rabies vaccination (ORV) for controlling skunk rabies there. This research focused on two main topics: (1) surveying the direct and indirect costs of rabies in San Luis Obispo and Santa Barbara Counties and (2) conducting a benefit–cost analysis of the potential use of skunk ORV baits to reduce this disease in endemic areas and prevent its possible spread into the Los Angeles Basin.

Of 134 individuals believed to have been exposed to rabies, 51 volunteers (41 percent) were interviewed for medically related costs. Municipal records were also gleaned for animal control, case investigation, and other charges related to rabies cases. The average total cost of a suspected rabies exposure for this volunteer sample was $3,445 (range: $694 to $8,586), with average direct and indirect costs per case of $2,321 (range: $275 to $5,843) and $1,124 (range: $418 to $2,742), respectively. Indirect costs (e.g., lost wages, postexposure prophylaxis-related transportation costs) contributed about one-third to the total case expense and were not reimbursed to the patient. This study represented the first time that such indirect patient costs were assessed; it also showed that indirect costs of rabies can total a third more expense than medical or case-management costs alone.

Using these identified costs, NWRC investigators conducted a scenario-type study that assessed the potential benefits and costs of using ORV baiting to eliminate or prevent the spread of skunk rabies in parts of California. Although no ORV for skunks is currently available, research and development of this ORV product is underway. Areas of traditional skunk rabies were identified using geographic information system (GIS) plots of all positive skunk rabies cases identified using geospatial locations of all CDHS rabies cases between 1993 and 2003. Two scenarios were devised: (1) baiting major skunk-rabies areas and (2) baiting the southernmost skunk rabies area, with protection assumed for the Greater Los Angeles Basin. Potential costs were derived for multiple bait prices ($0.75, $1.00, and $1.25 each), bait densities (37.5, 75, and 150/km^2), bait campaigns (three or six annual programs), and empirical costs for air–ground baiting surveillance, project planning, and evaluation for prescribed topographical sites (net present values) derived from raccoon ORV. Cost estimates for scenario 1 ranged from $2,034,723 at the lowest bait price and density to $9,307,462 at the highest bait price and density. Scenario 2—which covers the least amount of area but offers protection of the most populated area—yielded costs between $389,476 and $1,779,405 and afforded benefit–cost ratios between 1.06 and 6.35 for baits distributed at 37.5/km^2 between one and three times with 50-percent and 100-percent assumed suppression of rabies, respectively. Benefits were viewed as due to the expected savings for reduced direct and indirect costs associated with the disease.

Economics of Urban Goose Management Near Puget Sound—Introduced urban Canada geese increased in numbers during the 1990s throughout eastern Puget Sound. This has become a common scenario nationwide. Complaints from some homeowners and municipal parks and recreation departments increased due to sod damage, beach closures, and dock cleanup expenses. Park attendance also declined due to fecal contamination. Both nonlethal "hazing," capture with relocation, and humane "roundup" methods (capture with euthanasia during the birds' annual spring molt) were tried for almost a decade. Today, complaints from homeowners and municipal officials have declined. What were the methodological and economic solutions to these human–goose conflicts?

In July 2004, a cooperative agreement was developed with the Colorado State University (CSU) Economics Department to conduct research of the benefits and costs related to urban Canada goose management efforts in the eastern part of Puget Sound. A meeting with local municipal officials from Seattle, Tacoma, and Tumwater was held in March 2005 in Seattle, in a genuinely cooperative atmosphere. Possible records and data sources for economic analyses were identified and discussed (e.g., data on park attendance, beach cleanup, and beach-closures).

Some initial analyses of the WS Management Information System (MIS) records revealed recent declines in damage and monetary costs due to geese. Complaints of urban goose damage peaked in the Seattle area in 2000 at 226, with only 28 in 2004. Similarly, estimates of monetary loss associated with geese peaked in 1998 at over $800,000,

but the 2004 figures totaled only about $120,000 in goose-caused damage (e.g., sod replacement and damage to grain crops). The next step will be to get dollar estimates for damage from municipal sources and analyze the relationships between management actions and those costs.

Benefit–Cost Analysis of WS in California—In 2003, the State of California experienced a fiscal crisis. Counties that contributed to WS operations for wildlife damage-management activities found it difficult to fund this service. The need to define the true value of WS was realized.

In July 2003, NWRC economists undertook a study to describe benefits and costs of WS operations in California. Detailed analyses and reports were created to quantify WS–CA economic benefits to each of the 38 counties that contributed cooperative funds to WS. Additionally, a California-wide report combined the county results to form an overall picture of the benefits to the State itself.

For any activity to be economically favorable, the benefit of that activity must outweigh its cost. The approach used here was to survey WS District Supervisors and to document the main activities in each of 38 counties where WS receives county funds. The four general categories in which resource protection was provided included agriculture, health and safety, natural resources, and property. Results showed that the protection of livestock (particularly sheep, cattle, and goats) from predation was a main activity of WS personnel in all of the counties.

Regarding agriculture, particularly livestock protection, one California county had initiated a predation-compensation program that served as an agricultural replacement program for WS livestock-protection activities. The costs of the compensation program were extrapolated to each of the 38 WS-served counties based upon known head of livestock and known predation rates. Additionally, a special economic analysis (IMPLAN) was used to capture the benefits of WS protection of livestock. This analysis captured the costs to the county economy if predation of animals were to increase in the absence of WS.

For activities protecting health and human safety, natural resources, and property, WS records were used to estimate replacement costs and increased damage that might be expected were the counties to discontinue WS' operations. The number of "incidents" in each category was multiplied by an average cost charged by private, nongovernmental operators. This calculation provided a minimal cost to have similar services provided by another entity. In real life, WS specialists often remove multiple animals and provide additional technical assistance whose total cost would not be reflected in the calculations above. To determine monetary increases in wildlife damage, estimates recorded in the MIS for each incident were increased within a range of 25 to 100 percent.

Results showed that, of the 38 counties currently contributing cooperative funds to WS, no county paid more for the WS program than what they received in benefits. Moreover, in only three

counties were the benefits less than double the costs (a 2:1 benefit-cost ratio. The total value of WS to California was calculated at between $12 million and $19 million. Given that counties spent approximately $2 million annually on the WS Program, the net benefit to the State was viewed to be between $10 million and $17 million.

How the Brown Treesnake (BT) Could Impact Hawaii's Economy—By now, most Americans have heard of the BT. This reptile was allegedly transported to Guam aboard cargo ships from the Solomon Islands after World War II. The snake has caused major declines and extinctions of native bird populations on Guam; it is a classic example of problems posed by the introduction of invasive species to new habitats.

Guam's dense BT population poses a threat to other Pacific Island ecosystems and economies. Of particular concern is the possible transportation of the snake to Hawaii.

In 2004, NWRC received funds to assess the potential economic impacts of the BT to the Hawaiian Islands. Significant effort has been expended on studying the biology, control and potential eradication of this species, but very little has been done to estimate its economic impact were it to be relocated to Hawaii. A theoretical estimate of these economic impacts has been placed at $1.7 billion annually. Experiences for Guam suggest that medical costs due to bites, increased costs associated with power outages, increased transportation costs due to cargo searches and fumigations, and the loss in value of bird species are probable sources of economic impacts.

Prior studies have not considered the potential impact of the BT on tourism. The NWRC study will estimate the potential decrease in tourism as a result of the snake and include the loss of jobs and revenue to the local economy. The study will provide novel approaches and analyses of these potential impacts. For example, increased transportation costs related to increased cargo inspections and delays will be key variables of the study. Look for details on the results of this work in the 2006 highlights report from NWRC.

Impact on Nest Predation When Predator Control Is Removed Midway Through Sea-Turtle Nesting—The beach at Hobe Sound National Wildlife Refuge in Florida is a high-density nesting beach serving three species of threatened and endangered sea turtles. Historically, up to 95 percent of turtle nests at the refuge were lost to predation by raccoons and armadillos. Predator control optimized by predator

WS activities on Grassy Key. Both a tracking-tile method using a large Styrofoam™-tile with a strip of ink placed diagonally and remotely triggered cameras were found to provide quality indexing data.

WS is planning a Gambian giant rat eradication program. These indexing procedures will provide low-labor means to detect the presence of Gambian giant rats, assess their distribution, optimize the timing and placement of control devices, and evaluate control efficacy.

Additionally, five trap designs used in New Zealand for capturing invasive brush-tailed possums, stoats, and ferrets were applied. These trap designs showed promise for capturing Gambian giant rats while excluding nontarget species. Efficacy tests for the traps are one of the first steps in eradication efforts.

Road-Kill Data Document Raccoon Migrations To Prey on Sea-Turtle Nests—An NWRC scientist has been working with WS operations in Florida and biologists with the Florida Department of Environmental Protection to reduce predation on sea-turtle nests, primarily by raccoons. Part of this effort has involved identification of raccoon activity patterns relative to turtle nesting. A passive tracking index has been successfully used to monitor raccoons on the beaches during turtle nesting, but it is equally important to understand the attraction of the raccoons to the beaches by turtle nesting. To this end, the scientist analyzed (1) monthly data on turtle nesting over 4 years from John D. MacArthur Beach State Park and over 10 years from Sebastion Inlet State Park, (2) raccoon road-kill data from adjacent roads, and (3) data on park attendance (as an index of local traffic) to make inferences about raccoon activity patterns relative to turtle nesting.

Raccoon road-kills were found to diminish substantially during turtle nesting, even though local traffic was constant or increasing. Opossums, the only other mammal consistently found as road-kills, did not show a decrease during turtle nesting season, but they are not known as a significant predator of turtle nests.

The researchers concluded that during the turtle nesting season, raccoons are drawn to the beach to prey on the abundant turtle eggs. And the raccoons do not leave the beach area until the end of turtle nesting season. High numbers of raccoon road-kills during the fall, followed by a decrease in the spring around the start of turtle nesting season, might be used by managers as indicators for implementing management actions to protect turtle nests.

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

GOAL: Obtain FDA approval for use of porcine zona pellucida (PZP) and gonadotropin-releasing hormone (GnRH) immunocontraceptive vaccines for white-tailed deer and develop new oral contraceptive agents for use in controlling reproduction in overabundant avian species (e.g., monk parakeets and crows) and in mammalian species (e.g., California ground squirrel 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—Locally overabundant deer herds, particularly those inhabiting fenced or other enclosed areas in urban or suburban settings, present serious problems for wildlife managers, landowners, and the general public. Problems associated with deer overabundance include increased numbers of collisions between deer and motor vehicles, increased frequencies of other deer–human conflicts (e.g., damage to gardens and ornamental plantings), aggressive behavior toward humans by bucks during the rut, greater potential for disease transmission among deer, reduced nutritional status of deer, and damage to local native vegetation due to overbrowsing. Traditional methods of population control, such as regulated harvest by licensed hunters, are impractical or illegal in urban and suburban settings. The development of safe and effective wildlife contraceptives is needed to control locally overabundant populations of deer and other wildlife in situations where traditional management tools cannot be employed.

NWRC researchers in Fort Collins have been active in the development and testing of wildlife contraceptive agents since 1992. Scientists there have developed a new immunocontraceptive vaccine (GonaCon™) that shows great promise as a wildlife infertility agent. GonaCon differs from many earlier infertility agents in two important ways. First, it incorporates a new adjuvant (called AdjuVac™), developed by NWRC scientists, that is more effective than the commonly used Freund's adjuvant and lacks the undesirable side effects of Freund's. Second, the GonaCon vaccine is available as a single-injection treatment that is much more practical than two-injection vaccines as a field-delivery system for use on free-ranging animals.

GonaCon causes infertility by stimulating the production and release of GnRH-specific antibody into the bloodstream. GnRH produced in the brain binds to the antibody and is prevented from activating the release of luteinizing hormone (LH) and follicle-stimulating hormone (FSH). Without LH and FSH to stimulate the synthesis of sex hormones in the reproductive organs, animals of both sexes remain in a nonreproductive state. All sexual activity is suspended as long as sufficient antibody is present to bind to all GnRH present in the bloodstream.

A pivotal field study of the efficacy of GonaCon as an infertility agent for deer is underway on a completely enclosed site near Silver Spring, MD. A locally overabundant herd of white-tailed deer has caused considerable ecological damage to the site, and land managers contracted NWRC to assist in the management of the deer via immunocontraception. In July 2004, NWRC scientists traveled to Silver Spring, where they provided training and technical assistance to personnel from the WS Maryland office. Twenty-eight does were captured, marked, vaccinated with GonaCon, and released. Fifteen additional does were captured, marked, and released without vaccination, as untreated control animals.

NWRC scientists returned to Silver Spring during July 2005 to help Maryland WS personnel locate fawns and identify their mothers. The reproductive success of untreated does was 83 percent while that of treated does was only 12 percent, showing that the GonaCon vaccine is an effective wildlife infertility agent. The Silver Spring study will continue through the summer of 2006 and will provide deer reproductive data for two breeding seasons after the does were vaccinated with GonaCon.

Control of American Crow Populations and Reduction of Human–Crow Conflicts Through Avian Contraception—Overabundant wintering crow populations have become a serious issue for many U.S. municipalities. In many regions, crows have increased greatly in numbers and have shifted the locations of their winter roost sites from rural to urban or suburban settings. Problems include unsanitary conditions caused by the deposition of fecal material and regurgitated pellets and unacceptably high vocalizations. These issues have led many local governments to direct substantial resources toward resolving crow roost situations.

Through funding provided by the California Department of Food and Agriculture (CDFA), NWRC is developing and field-testing DiazaCon™ as a contraceptive agent for American crows. DiazaCon is a cholesterol mimic that prevents the formation

of testosterone and progesterone. To be effective, DiazaCon must be fed to birds for several days just prior to breeding. Because DiazaCon persists in the body, its contraceptive effects can last for several months.

During February 2005, NWRC scientists traveled to Yuba City, CA, to conduct a feasibility study to develop methods for the use of DiazaCon in a future field-efficacy trial to control reproduction of American crows. Aggregations of wintering crows have increased dramatically in size in this area during recent decades, causing great concern. Early attempts to reduce crow numbers included a poisoning program, but that effort was abandoned. Subsequent, nonlethal crow-reduction methods implemented included various visual and sonic frightening devices, but these techniques succeeded only in moving the birds from one neighborhood to another within Yuba City.

During the monthlong field effort, the scientists successfully tested various methods of baiting, capturing, sexing, marking, and monitoring free-ranging crows. If funding becomes available, NWRC scientists plan to return to California to conduct a field-efficacy study of DiazaCon as a contraceptive for use in managing free-ranging populations of American crows.

Evaluation of an Oral Contraceptive for Monk Parakeets—The monk parakeet is an invasive species native to South America, where it is considered to be a major crop pest. Its population in the United States is increasing exponentially. The parakeet's habit of constructing large nests of sticks and branches on electric utility structures is causing increasing problems for power companies in Florida, Texas, New York, and elsewhere. One promising approach to reducing growth of the monk parakeet population is reproduction inhibition.

A study investigating the potential of DiazaCon as an oral contraceptive for monk parakeets began in spring 2003 by personnel in the Infertility Project in Fort Collins and at the NWRC's Florida field station in Gainesville. DiazaCon is a cholesterol inhibitor that blocks the conversion of desmosterol to cholesterol, resulting in lowered cholesterol levels. Because cholesterol is the precursor for reproductive hormones, lowered levels inhibit reproduction.

Based on the results from the initial oral gavage study, a 50-mg/kg dose was chosen for further testing. Another gavage study testing different lengths of treatment was conducted in fall 2003. Parakeets were orally gavaged daily for either 5 or 10 consecutive days. Based on this study, a free feeding study

was initiated in May 2004. Parakeets were fed DiazaCon-treated sunflower seeds for 5 days. Fecal samples were collected for analysis of fecal steroids, and reproductive success was monitored. Treated birds laid approximately half as many eggs as control birds. Parakeet nests were monitored for hatching until mid-August, the end of the reproductive season. None of the eggs from the DiazaCon group hatched.

Plans are underway to conduct a field evaluation of the efficacy of DiazaCon-treated bait for monk parakeet management in 2006.

TITLE: Development of Nicarbazin for Application as an Infertility Agent for Canada Goose Management

GOAL: Continue to develop nicarbazin for application in the field for the reproductive control of geese.

Expanding populations of resident Canada geese that remain in suburban and urban areas year-round often result in increased conflicts with humans. Nonlethal and humane means are needed for managing the size of Canada goose flocks residing near or on airports, golf courses, industrial parks, government sites, and city parks.

Nicarbazin Is an Effective Reproductive Inhibitor for Resident Canada Goose Flocks—Nicarbazin may offer a way to limit Canada goose populations. It is a compound traditionally used on broiler chickens to prevent the disease coccidiosis, but

decreased egg production and hatching rates occur as side effects. It appears that one mechanism by which nicarbazin exerts its effect on reduced viability of eggs is by causing disruption of the yolk membrane, allowing the yolk and albumin to flow together and creating conditions under which the embryo cannot develop.

Exploiting this side effect, NWRC investigators conducted studies of nicarbazin for reducing the hatchability of eggs from Canada geese. An initial study in Coturnix quail verified reduction in hatchability in a species other than chickens. Because plasma nicarbazin was not routinely measured, a study in chickens was conducted to determine the relationship between nicarbazin levels in plasma and eggs. A comparative study in chickens, mallards, and Canada geese showed that nicarbazin absorption was lowest in geese. Studies in both penned and wild Canada geese showed that reduction in hatchability was possible, but neither study used bait suitable for general field application. Bait development led to the OvoControl-G® (Innolytics LLC) bait, which was highly palatable in pen studies and was therefore taken forward for a field-efficacy study.

Nicarbazin Field-Effectiveness Study—The study was initiated in February 2004 at 10 sites in Oregon, with 2 control and 3 treated sites on each side of the Cascades. Following acclimation to untreated bait, the resident Canada geese were fed nicarbazin-laced bait for about 6 weeks. Field crews located and monitored nests until hatching or at least 5 days beyond the expected hatching date to determine hatchability. Data collection was completed in May 2004.

A total of 8,000 kg of bait was consumed, with 5,100 kg of newly developed OvoControl-G nicarbazin bait consumed across 6 treated sites and 2,900 kg of untreated bait consumed across 4 control sites. A total of 69 nests at treated sites and 46 nests from breeding pairs at control sites were monitored to determine hatching success of eggs.

Hatchability from treated sites was reduced by 36 percent compared to rates on control sites. When considering nests at sites rather than sites as a whole, the percentage of eggs hatching from clutches at treated sites was cut in half (reduced by 51 percent). Results from this study were submitted to support EPA registration of nicarbazin as a reproductive inhibitor for use in Canada geese.

TITLE: Field Evaluation of Chemical Methods for BT Management

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

The BT, a species accidentally introduced to Guam, has decimated that island's native fauna and poses a similar threat to other Pacific island ecosystems. NWRC scientists are field-testing chemical methods to control the BT, including toxicants, attractants, and reproductive inhibitors. The eventual goal of this research is to implement their use in an integrated program to control the BT on Guam, prevent

its dispersal from Guam, and control BT populations, when necessary, in other island situations. Control will be conducted by a variety of individuals and organizations, including WS, the Department of Defense, the Government of Guam, natural resource managers, military personnel, and others.

Aerial Delivery of BT Baits in Habitats With Low and High Crab Abundance—Aerial broadcast is a practical application technique for delivering baits to BTs in inaccessible, remote forest areas on Guam. A major reason for placing baits in the forest canopy is keep them from being taken by terrestrial scavengers, such as feral pigs, monitor lizards, crabs, and toads. Previous aerial-bait evaluations with parachute and flotation materials for entangling dead mice baits with radio transmitters in the forest canopy were conducted in areas known to have low crab populations. Results of those evaluations showed that 6–11 percent of baits were taken by crabs and marine toads, and monitor lizards took less than 1 percent of baits. Feral pigs took baits that had fallen from the tree canopy to the ground.

Researchers conducted a followup comparative study to evaluate bait-take by snakes and nontarget animals of baits that remained in the canopy and baits that fell to the ground. Aerially applied, untreated dead mice with radio transmitters were deployed by helicopter to two forest sites on Guam that had either low or high abundance of coconut and hermit crabs as determined from counts of crabs at lure stations. Forty mice with radio transmitters (20 with jute mesh flotation nets and 20 without nets) were dropped at each of the two sites, and location (canopy or ground landings) and bait-take of mice were recorded.

All mice without flotation nets landed on the ground. At the high crab site, 16 percent of mice with nets landed in the canopy. At the low crab site, 26 percent did so. Comparisons of bait-take between the low and high crab-abundance sites are documented in the following tabulation:

Species	Bait-take percentages, by crab density	
	High	Low
BTs	0	23
Crabs	64	23
Monitor lizards, toads, ants, and unknown animals	0–13	0–23
Baits not taken	3	26

It is evident from these data that crabs will remove mice, making them unavailable for snakes, and a flotation system that delivers the majority of mice to the canopy is needed where there is a high abundance of crabs.

Field Evaluations of Alternate Oral Baits to Dead Neonatal Mice for Oral Delivery of Toxicants to BTs on Guam—Dead neonatal mice treated with acetaminophen are readily consumed by BTs, and consumption (bait-take) as high as 70 to 100 percent is routinely observed with untreated mice. But costs and logistics of using dead mice as baits make it highly desirable to find alternative baits equally acceptable to snakes.

Field evaluations were conducted to entice snakes to consume untreated beef, cotton rolls, and commercial Snake Steak Sausages® treated with either (1) a "loud" attractive odor (live mice, or dead mice in a screened cage in various stages of decomposition) placed in close proximity to the test baits but not accessible to snakes, (2) two commercial lures (Mouse Maker™ and Strike-Um™) applied to the test baits, or (3) an inoculation with bacteria from dead mice that are known to produce the odors of decomposition that are attractive to snakes. Bait-take was compared to similarly treated and untreated dead mice.

Almost without exception, bait-take was highest for all dead mice treatments and ranged from 30 to 100 percent. The overall bait-take for untreated and treated beef, cotton roll, and snake sausage baits ranged from 0 to 45 percent. Treatment of test baits with commercial lures or inoculates of dead mouse bacteria did not increase bait-take. The most encouraging treatment for bait-take enhancement was with the live mouse, which increased consumption of beef from 25 to 45 percent and cotton roll from 0 to 35 percent.

It would not be advantageous to use live mice as lures for baits, but inanimate fake mice with a lure may be feasible. Future bait evaluations will be conducted with a moving mechanical mouse in combination with a mouse synthetic odor.

Immunocontraception as a Potential tool for Controlling the BTs on Guam—NWRC scientists are also evaluating reproductive inhibition as another technique to control the BTs on Guam. One line of research is investigating immunizing snakes against their own GnRH. In vertebrates, GnRH is the hormone that mediates testes function in males and ovarian growth in females.

An initial evaluation was conducted using females that were vaccinated with an antigen conjugate consisting of c–GnRH–I (a form of GnRH found in snakes) and keyhole limpet hemocyanin. High plasma titers of antibody against c–GnRH–I were observed 56 days and 112 days after the initial vaccination, indicating that females should be contracepted. The question of whether reproduction was inhibited was not addressed because the females in the study were not reproductive when vaccinated. Effects of the vaccine are presently under examination in males BTs, which unlike—females—are always reproductive.

Program Support

Registration Highlights

The NWRC Registration Unit is responsible for coordinating the development of data required for maintaining or modifying authorized uses of APHIS vertebrate control products to meet the varied demands involved in protecting agriculture, endangered species, and public health. To meet this responsibility, the Registration Unit works closely with APHIS headquarters staff in Riverdale, MD, and with NWRC scientists to ensure that research results will be acceptable for regulatory purposes and that study designs meet EPA and FDA regulatory guidelines. APHIS currently holds registrations through the EPA for 8 active ingredients formulated into 19 federally registered vertebrate pesticide products.

To meet the dynamic needs of WS field personnel, the Registration Unit routinely responds to requests for new products or changes to existing products that will improve their ability to manage problem wildlife. Technical assistance is also provided to Federal and State agricultural and conservation agencies, as well as to other nongovernmental groups and individuals.

APHIS vertebrate control agents are typically products that have little demand and, therefore, are not registered by private companies. But these agents are important tools for managing wildlife problems. Such 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 the BTs on Guam.

APHIS also holds five Investigational New Animal Drug (INAD) authorizations from the FDA to continue the development of two immobilizing agents and three wildlife contraceptives.

Pesticides

Bird Management—Concern for human health and safety, agricultural damage, and threats to endangered species caused by birds continue to increase throughout the United States. Bird species that present the greatest problem include gulls (landfills and airports); starlings, blackbirds, and pigeons (agricultural facilities, crops, and urban areas); and corvids (agriculture, urban areas, and threatened and endangered species conservation). In the past year, the Registration Unit has been heavily involved in ensuring that APHIS' avicide labels are in compliance with EPA regulations and, at the request of WS State offices, in expanding the use of APHIS' avicide products so they meet the needs of individual States.

Over the last 3 years, the management of crows at urban and agricultural roost sites has become a major concern. Often after employing all nonlethal alternatives, WS' customers ask for lethal control. DRC–1339 is the only pesticide product available for lethal removal of crows. It has become obvious that APHIS' current DRC–1339 labels are inadequate to manage crow populations. Consequently, in cooperation with APHIS' Policy and Program Development Unit and WS State offices, the Registration Unit has begun to draft a DRC–1339 label specifically addressing management of crow roosts. NWRC anticipates submitting this label to EPA for registration in early 2006.

California WS identified a need for DRC–1339 to manage starling populations in feedlots and dairy farms. In 2004, CDFA granted a Conditional Registration of Compound DRC–1339 Concentrate—Feedlots pending submission of a storage stability study on the product. In cooperation with the Pocatello Supply Depot, the Registration Unit began that study in 2005. It will be completed and submitted to CDFA in early 2006.

The Registration Unit continued to provide regulatory guidance to the NWRC project working to identify and register an avian repellant to protect rice from blackbird damage. Compounds under investigation include the goose repellant anthranquinone, caffeine, and fungicides with registrations for the use in rice production.

Rodent Management—WS has traditionally been involved in managing field rodents for agricultural protection. APHIS continues to maintain the registration of seven grain-based bait products (strychnine and zinc phosphide) for rodents and one incendiary cartridge for fumigating rodent burrows. In 2005, the Registration Unit responded to a variety of rodent management issues including agricultural commodities protection and environmental conservation.

In its review of APHIS' zinc phosphide labels, EPA asked APHIS to provide clarification of the American Society of Mammalogists' recent taxonomic reclassification of western ground squirrel species within the genus *Spermophilus,* specifically the Townsend's ground squirrel. As a result, the Registration Unit produced a data submission that clearly delineates the ranges of the *Spermophilus* species. The primary change in the geographic distribution of this genus is that, while previously widespread throughout the Western States, the Towsend's ground squirrel is now restricted to two small populations in southwestern Washington. The species with the largest distribution is now the Piute ground squirrel, which was formally classified as *S. townsendii*. This taxonomic change requires all rodenticide registrants with *S. townsendii* listed as a target species, including APHIS, to modify their labels to reflect the change.

In cooperation with the NWRC Washington field station, NWRC scientists at Fort Collins are continuing to evaluate the efficacy of a chlorophacinone-based rodenticide bait manufactured by LiphaTech for controlling mountain beavers in reforestation sites in the northwestern United States. Results from two field studies in Oregon and Washington indicate that a single application of this bait can reduce mountain beaver populations by as much as 70 percent. LiphaTech hopes to submit an application for registration of this new bait to EPA in 2006.

Since the early 1990s, NWRC has coordinated and provided technical and administrative assistance to the Strychnine and Zinc Phosphide Consortia. These consortia were established to help meet EPA reregistration requirements for these compounds. The Stychnine Consortium successfully met the requirements to reregister strychnine and was officially disbanded in 2005. The Zinc Phosphide Consortium, however, is still waiting for EPA's response to its latest round of data and label submissions. No more data requirements are expected, and zinc phosphide is expected to be successfully reregistered in 2006. APHIS'

coordination of and participation in these two consortia saved the Federal Government hundreds of thousands of dollars in data-development costs for rodenticide products used in WS operations nationwide.

In cooperation with the FWS, NWRC's Registration Unit continues to work on the development of three rodenticide products that would allow the control or eradication of rodents on islands for conservation purposes. One diphacinone-based product would be registered only in the State of Hawaii but would allow for the control of invasive rodents in habitats critical to the survival of many species of endangered forest birds and plants there. The other two products, one diphacinone and one brodifacoum based, would be available for nationwide use and are specifically designed for the eradication of invasive rodents on islands. Gaining approval for these products will be valuable for providing predator-free nesting habitat for hundreds of species of seabirds, especially in the tropical islands in the Pacific region and the Aleutian Islands of the Alaska Maritime National Wildlife Refuge.

Predator Management Tools

APHIS maintains the registration for four predacide products and one incendiary device. These products are used primarily for the protection of livestock but also can 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). During the last year, the use of Compound 1080 in the Livestock Protection Collar was expanded to include the States of Ohio and Pennsylvania. In 2003, APHIS submitted an Experimental Use Permit request to EPA for a multi-State study designed to evaluate the effectiveness of the M–44 device for protecting ground-nesting birds from canine predators. EPA did not approve this study. Subsequently, the study was modified to include only the State of Utah and was resubmitted to EPA for approval. NWRC hopes to obtain approval for this Utah-only study prior to the beginning of the 2006 nesting season.

NWRC also received funding in 2005 from the California Vertebrate Pest Control Research Advisory Committee through the CDFA to continue research on the development of an improved theobromine-and-caffeine-based toxicant for coyote management. Research will focus on the identification of formulation adjuvants to enhance the mode of action and improve the potency of theobromine and caffeine to coyotes. Additionally, EPA requirements to potentially register theobromine and caffeine will be determined.

Wildlife Drugs and Vaccines

APHIS has five INAD authorizations with FDA that allow interstate transport of certain compounds for experimental purposes. Three of the compounds—GnRH, PZP, and 20,25–diazacholestrol HCl (DiazaCon)—are being tested as wildlife contraceptives. The other two compounds for which APHIS has INADs are alpha–chloralose and propiopromazine hydrochloride, both immobilizing agents. All of these products are for use by USDA personnel or persons under their direct supervision.

Immobilizing Drugs—Two immobilizing agents are under investigation by NWRC to capture problem mammals and birds humanely. Propiopromazine hydrochloride is used in the tranquilizer trap device for sedating animals captured in leghold

traps. This compound significantly reduces the amount of potential damage to the leg of a captured animal prior to being released. The immobilizing agent alpha–chloralose is authorized for use to live-capture waterfowl, Canada geese, American coots, and common ravens. It is a very effective tool for capturing and removing small numbers of problem birds from nuisance situations.

In 2004, the Registration Unit submitted data to support a request that FDA add capture of sandhill cranes to the list of species under this INAD. This project was a cooperative effort between NWRC, Wisconsin WS, the International Crane Foundation, and USDA–APHIS' Policy and Program Development unit. FDA approved this request in 2005. In addition, APHIS obtained a time-limited approval to use alpha–chloralose on common crows in central California. NWRC plans on submitting a request to FDA to add wild turkeys to the list of species covered under the INAD.

Contraceptives—Progress continues toward fulfilling data requirements for an FDA authorization of GonaCon Immunocontraceptive Vaccine for white-tailed deer. Three FDA-required studies were either completed or initiated in fiscal year 2005. A target-animal safety study was completed in cooperation with The Pennsylvania State University. This study evaluated vaccinated deer for unintended physiological effects of the vaccine. Preliminary results indicate the vaccine affects only the reproductive hormones in deer and has little effect on other physiological functions.

In cooperation with the Maryland WS program, NWRC scientists began a field-efficacy study at Maryland's White Oak Federal Facility. Deer were vaccinated in July 2004 and were observed for fawning success during 2005 with repeat observations scheduled for 2006.

A study evaluating the storage stability of GonaCon also began in 2005. This study, conducted in Fort Collins, is designed to demonstrate the viability of the vaccine over an 18-month storage period.

Finally, the NWRC Registration Unit made a data submission to FDA to begin the process of evaluating the safety of people eating meat from deer vaccinated with GonaCon.

NWRC has begun preliminary discussions with a Dutch veterinary drug manufacturer to develop GonaCon as a tool to reduce boar taint in domestic swine. Boar taint is an unpleasant odor that is released during cooking of pork and pork products made from the meat of uncastrated male pigs. It is due to high levels of sex hormones absorbed in the pigs' fat. GonaCon is of interest to the European pork industry because the European Union recently passed a law prohibiting castration of swine unless under anesthesia. A partnership with this company could significantly speed up efforts to register GonaCon in the United States as a contraceptive for wild pigs.

Over the past 5 years, NWRC has played a pivotal role in the development of nicarbazin as a contraceptive for resident (i.e., nonmigrating) Canada geese. This project was a collaborative effort between NWRC and Innolytics, LLC, a private company that will eventually manufacture, register, and sell the bait. In 2004, the bait product—OvoControl-G—

was field-tested in Oregon and successfully reduced the number of hatching eggs by 50 percent. Innolytics received a registration for OvoControl-G from EPA in late 2005.

DiazaCon is currently under investigation as a chemical contraceptive for both birds and mammals. NWRC research has demonstrated that DiazaCon can inhibit reproduction in monk parakeets, mallards, quail, crows, and prairie dogs. Work on DiazaCon has been conducted under an INAD with FDA. In 2005, APHIS requested that EPA provide regulatory oversight of this compound. The Registration Unit expects to begin the process of registering DiazaCon in 2006.

Regulatory Assistance Provided to Federal, State, and Nongovernmental Organizations

The Registration Unit frequently responds to information requests from WS program personnel or other Government and nongovernmental cooperators during the preparation of Environmental Assessments, Environmental Impact Statements, and Section 7 consultations with the FWS. These inquiries typically involve preparing unique summaries and interpretations of NWRC research or the preparation of 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 are providing technical assistance to a consortium of State, Federal, and nongovernmental organizations in Hawaii by developing a registration package and risk assessment for registering diphacinone 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 scores of Aleutian Islands.

Information Transfer Activities

NWRC chemical toxicity data were published in 2004 as NWRC Research Report No. 04–01. The publication "Toxicity, Repellancy or Phytotoxicity of 979 Chemicals to Birds" presents a portion of the data collected by NWRC or its predecessor, the Denver Wildlife Research Center, during the 30-year period in which the facilities were actively involved in a chemical screening program designed to identify new compounds for vertebrate pest management. This publication includes the results of thousands of individual toxicity trials conducted under standardized testing protocols and includes data on 34 mammalian, 26 avian, and 15 plant species. It is a valuable addition to the global body of chemical toxicity information and should prove useful to modelers and scientists interested in identifying new compounds for further development.

With the cooperation of headquarters staff, the Registration Unit continues to expand the NWRC Web site (http://www.aphis.usda.gov/ws/nwrc/RegUnit.htm) to include sample copies of the current APHIS vertebrate pesticide labels as well as Wildlife Service Tech Notes. Tech Notes provide information on the proper use of APHIS pesticide products as well as other wildlife management tools or techniques developed at NWRC.

Wildlife Diseases Research Program

Increasing human populations means greater encroachment of people into wildlife habitats. That, in turn, leads to increased contact between wildlife and people and between wildlife and domestic animals. Elevated contact can escalate the potential invasiveness of new diseases threatening the health of people, domestic animals, and wildlife. Additionally, heightened worldwide mobility of people, animals, goods, services, and products can move new disease organisms and their hosts thousands of miles in as little as a single day. Recent zoonotic diseases such as West Nile virus (WNV), wildlife rabies, hantavirus, and Lyme disease have resulted in a growing disease risk to humans, while other diseases such as scours in dairy cattle, bovine tuberculosis, brucellosis, avian influenza, and pseudorabies negatively impact livestock.

NWRC is conducting research to develop applied methods to mitigate and manage wildlife diseases (e.g., raccoon and skunk rabies, bovine tuberculosis, and WNV) and identify bacteria found in urban geese and blackbirds associated with dairies and other pathogens that may cross from wildlife reservoirs to humans. Research is focused on development of surveillance and monitoring techniques, as well as effective, safe, and deliverable vaccines, barriers, and other methods to reduce or eliminate disease transmission.

TITLE: Surveillance, Monitoring, and Response

GOAL: Understand the role wildlife play as hosts and reservoirs for zoonotic diseases and diseases of agricultural importance, develop epidemiologic models for equine and human health risk assessment, develop spatially explicit (GIS) risk assessments for agricultural biosecurity, and develop management recommendations that will minimize wildlife impact on disease transmission.

Surveillance for WNV Activity in a Variety of Hosts—Collaborative studies on the host range and exposure rates of WNV were performed in a variety of species across the United States. A long-term

mark–recapture study was continued for a third year in Pennsylvania, providing historical data on WNV activity in that area. The exposure rates over 4 years in white-tailed deer from Iowa were examined in collaboration with researchers from the University of Iowa. NWRC investigators also examined WNV exposure in mesopredators (raccoons, opossum, and skunks from five States across the United States and continued a study in conjunction with CSU scientists on the potential of WNV to populations of the northern spotted owl in California.

Utility of Cliff Swallow Ecosystems as Early Season Indicators of WNV Activity—Identifying the intensity of WNV activity for specific geographic areas is a high priority for vector-control managers and public health officials. Current surveillance systems have not achieved this level of precise predictive power. NWRC researchers have identified a promising surveillance system for nesting cliff swallows. Overwintering WNV-positive ecotoparasites have been found in swallow nests. This finding is significant in that it may indicate an early season amplification mechanism of the virus, giving it an efficient jump start within the cliff-swallow ecosystem each year prior to general amplification in the overall avian community.

It was also found that infection in nestling cliff swallows preceded WNV activity in the human population by about 5 weeks. Early identification of viral activity is important for public health and vector control preparedness.

NWRC is currently conducting surveillance studies for the third year using this system in order to characterize WNV activity in both swallows and their ectoparasites. The Center continues to provide surveillance data to public health officials in Fort Collins. This surveillance method has profound implications for the efficient management of this zoonotic disease.

Developing Methods for Diagnosis and Monitoring of Wildlife Diseases—Recent NWRC accomplishments in monitoring wildlife disease feature the ability to genetically fingerprint isolates of bacteria from feces of birds and mammals, including livestock. This capability will enable researchers to track infection and movement of bacteria across the agricultural landscape and to assess the roles and impacts of peridomestic birds in the spread of potentially serious bacterial pathogens.

Molecular assays using polymerase chain reaction (PCR) technology to rapidly diagnose the presence of histoplasma and bovine tuberculosis in environmental samples are currently being developed at NWRC. A BSL–2 laboratory using PCR to detect and identify virus and serological assays to detect antibody is fully operational in support of WNV studies in birds. The development of a tissue-culture laboratory has enabled NWRC to perform virus isolation, titration, and neutralization assays to identify virus isolates and to verify results from other serological assays.

Research Tracking Peridomestic Bird Movements in Agricultural Landscapes—Research at NWRC on the movements of birds between agricultural operations has been initiated. Using dye markers and spray systems, field crews marked birds and later captured them and tracked their movements. Telemetry studies of pigeons are also being conducted documenting the movement of this species between dairy and feedlot operations. These are important data to acquire for the monitoring and control of bacterial pathogens.

CSU Master's Degree Awarded—NWRC biologist Heather Sullivan successfully defended her thesis for the master of science degree in the Department of Environmental Health at CSU. Sullivan's thesis topic was, "West Nile Virus Sero-Surveillance by Means of the Nobuto Whole Blood Filter Strip in Red-Winged Blackbirds *(Agelaius phoeniceus)* in North Dakota (2003–2004)."

Two scientific papers will result from this research. In the first, Sullivan compares two different electro-immunosorbent assay (ELISA) methods (epitope-blocking and indirect) for WNV antibody detection and two different sampling methods (serum versus Nobuto strip [i.e., filter paper blood blot]) to determine the best method for field sero-surveillance studies that optimize antibody detection and reduce sampling costs. The second paper will outline the population exposure of blackbirds to WNV and their possible importance for disseminating the pathogen across North America. Both papers will represent valuable contributions to disease monitoring efforts and disease ecology.

TITLE: Controlling Wildlife Vectors of Bovine Tuberculosis and Rabies

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

Bovine tuberculosis is a contagious bacterial disease of both animals and humans. It can be transmitted from livestock to humans and to other animals. 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 in the United States were reported in domestic dogs. Today, however, more than 90 percent of all animal cases reported to the Centers for Disease Control and Prevention (CDC) 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 are expected to increase substantially as broader geographic areas of the country are affected.

In 2000, the Secretary of Agriculture enacted Declarations of Emergency for bovine TB and rabies, citing threats to livestock and human health and safety. In an effort to eradicate TB and rabies, NWRC is conducting research that would lead to a reduction or elimination of the potential transmission of these diseases between wildlife and livestock.

Use Of Coyotes as a Sentinel Species for Detection of Bovine TB in Michigan—In 1975, bovine TB was isolated from a white-tailed deer from the Lower Peninsula of Michigan. No further cases were found until 1994. This change prompted a survey of deer in Michigan in 1995. Since then, 509 deer have been found positive out of 138,567 tested. In 1998, bovine TB was found in three cattle herds in the same area. To date, 32 cattle herds have been found with cattle positive for bovine TB. No infected cattle herds have been found in nearly a year.

In 1998, Michigan lost its TB-Free Status and is currently recognized as a Modified Accredited State by USDA–APHIS. As a result, personnel at the Michigan Department of Natural Resources began attempts to reduce, and possibly eradicate, the disease in deer. Presently, apparent prevalence of bovine TB infection in deer in Michigan's Lower Peninsula is 1.7 percent.

To determine if deer in an area are infected with bovine TB and to determine prevalence of infection normally necessitate capturing and testing large

numbers of deer. Because of that fact, NWRC researchers evaluated the feasibility of using coyotes, which feed on deer, as sentinel animals. NWRC researchers believed that, if there were other wildlife species infected at a higher prevalence than deer, and if those other species were more easily attainable for sample collection, they could serve as a sentinel species for deer that may be infected with bovine TB.

Biologists found that nearly 30 percent of coyotes within the bovine TB-infected zone in Michigan were infected. Because coyotes have a somewhat limited home range, they could then be used as a sentinel species to determine if deer, in areas outside the bovine TB zone, are infected with bovine TB. This method of surveillance should assist management agencies to more easily determine possible spread of bovine TB in Michigan.

Evaluation of Livestock Protection Dogs for Deterring Deer and Cattle Interaction—Bovine TB in northern Michigan has proven a dilemma requiring aggressive measures, including the depopulation of livestock operations, culling of wildlife, banning the feeding of wildlife, and fencing livestock feed. Bovine TB is believed to be transmitted from white-tailed deer to cattle through aerosol, saliva, and nasal secretions (direct transmission) and on contaminated feed (indirect transmission). Effective methods for excluding deer from cattle enclosures could minimize the potential for direct and indirect transmission of bovine TB between infected deer and cattle.

NWRC researchers combined a tool utilized in Europe to control predation on sheep with the concept of modern frightening devices. The use of livestock protection dogs (LPDs) seemed like a feasible solution for excluding white-tailed deer from areas occupied by cattle, thereby reducing the potential for bovine TB transmission between deer and cattle.

Researchers evaluated four LPDs over a 5-month period utilizing four data-collection methods (direct observations, motion-activated video, track plot indices, and trail monitors) on deer farms in Michigan. Pastures protected by dogs had fewer intrusions by deer, fewer "contacts" (within 5 m) between deer and cattle, and lower use of cattle feed by deer. Overall, LPDs decreased the potential for disease transmission, with 66 percent fewer intrusions by deer into protected pastures and 100 percent lower use of cattle feed by deer.

At the conclusion of the first phase of the study, the LPDs were placed with livestock producers that were willing to incorporate them into their operations. Researchers are conducting visual observations of the dogs in their working environment as well as encouraging responses through staged testing. Results from observations show 0 deer have approached to within 5 m of cattle or have used

concentrated cattle feed when LPDs are onsite. LPDs are proving to be an effective alternative to more intrusive (e.g., high fences) and less effective (e.g., frightening devices) means of minimizing deer contact with cattle.

A Frightening Device for Reducing Bovine TB Transmission From White-Tailed Deer to Cattle— NWRC research has shown that white-tailed deer can transmit TB to cattle through indirect routes such as infected feed (hay and silage) and respiratory aerosols, as well as by direct contact. Means to alleviate and prevent the contamination of cattle feed are needed. NWRC biologists are conducting research that reduces or eliminates the potential transmission of TB between white-tailed deer and cattle by using an innovative frightening device that is mounted to bale feeders.

The device is activated when infrared sensors detect the body heat and motion of a large animal. When activated, an overhead bar with dangling arms begins to spin. The arms swat any deer or cow that is within 1 m of the bale feeder.

The initial phase of the study was conducted on a captive deer farm with an extremely high deer density (305 deer/km^2) and the devices performed very well. The second phase is being conducted on a cattle farm where devices are turned on only during dawn and dusk periods and at night. To date, no deer have fed at protected sites and cattle are undeterred.

Use of Infrared Cameras To Detect Rabies in Experimentally Infected Raccoons—NWRC researchers recently completed trial studies using infrared thermography to detect rabies in experimentally infected raccoons. Thermography is a technique that detects and measures variations in the heat emitted by various regions of the body and transforms them into visible signals that can be recorded photographically. Coupled with the knowledge of diseases and their clinical signs, this technique could potentially be used to detect and measure increases in an animal's body surface temperature at specific areas of the body in relation to a particular disease.

In the case of rabies, heat associated with viral activity is most prevalent in the nose and rostrum area and shows up as white (hot) or bright red (very warm) on thermal images. In rabies, the pattern of infection using infrared thermography appears to be unique.

NWRC scientists plan to field-test the use of infrared thermography to detect rabies in wild raccoons in 2006. The use of infrared thermography in the initial screening, surveillance, and monitoring of foreign and domestic diseases could potentially save millions of dollars for animal industries, and public-health and wildlife-management agencies.

Manipulation and Consumption of ORV baits by Adult and Juvenile Raccoons—A pen study was conducted at NWRC in Fort Collins to determine the percentage of juvenile and adult raccoons that were able to effectively manipulate and consume three commercially available ORV baits in placebo form. The study was conducted to help explain monitoring discrepancies between biomarking with tetracycline and ORV vaccination rates in raccoons during ORV campaigns where vaccination rate differences sometimes were observed between adult and juvenile raccoons. The baits used were Ultralight bait (Artemis Technologies, Inc.) and fish meal polymer and coated sachet baits (both Merial Ltd.).

In this study, a significant discrepancy in biomarking and vaccination rates was seen only with the fish meal polymer bait. There was no evidence that juveniles are being vaccinated at a lower rate due to their inability to manipulate and consume the ORV baits. The less-than-perfect biomarking and mock-vaccination rates suggest that further improvements in bait design should be made in order to optimize ORV efforts in the field.

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.

CWD is a transmissible spongiform encephalopathy of deer and elk. To date, this disease has been found only in cervids (members of the deer family). CWD is a nervous system disease and is typified by chronic weight loss leading to death. Species that have been affected with CWD include Rocky Mountain elk, mule deer, white-tailed deer, and black-tailed deer.

Concerns over the spread of CWD among wild animals and its transmission to farm herds has increased as the disease has spread from northeastern Colorado and southeastern Wyoming to other States. NWRC research is focused on examining the transmission of CWD between wild and domestic cervids and developing methods to reduce these interactions.

Transmission of CWD in Nebraska: Influences of Deer Movements, Population Dynamics, Social Behavior, and Landscape Patterns—CWD was first observed in deer in Nebraska in 2000. To address several concerns about CWD, NWRC investigators developed a research project to determine the role that mule deer and white-tailed deer in riparian habitats play in the potential spread of CWD across the Great Plains. Data are being collected on essential parameters (habitat use, movements, population dynamics, social behavior, landscape patterns) and

epidemiologic models are being developed to predict the transmission of CWD.

Fieldwork begun in the Missouri River Valley in January 1991 and in the North Platte River Valley in February 2004 continues to the present. A helicopter survey of the Missouri River Valley study area was conducted in January 2005 and estimated 82 and 49 deer/mi^2 on the DeSoto and Boyer Chute National Wildlife Refuges, respectively. Fawn:doe and buck:doe ratios in the Missour River Valley were 1.22:1 and 0.46:1, respectively. Ratios in the North Platte River Valley were 0.60:1 and 0.30:1, respectively. Data on cause-specific mortality are being analyzed.

Chemical immobilization and drop-door traps were used to capture and radio-mark 118 deer in the 2 study areas during 2004 through 2005. The deer were located 7,452 times since January 2004. Scientists generated 222 annual home ranges on 73 deer from the MRV study area from the period of 1991 through 2004. The size of the average annual home range of 62 resident deer was 238 ha. Average proportion of habitat within the home ranges was 46 percent forest, 27 percent cropland, 14 percent grassland, and 13 percent aquatic.

Fifteen percent of the radio-marked deer were transient and exhibited bimodal annual home ranges. Migrants have traveled up to 32 km, and emigrants, up to 121 km from capture sites. In western Nebraska, radio-marked deer emigrated up to 112 km from capture sites. NWRC scientists have begun the development of individual-based simulation models that will describe the population dynamics and movements of deer and potentially of CWD across a heterogeneous landscape.

Computerized Species Recognition System for Controlling Animal Access to Resources—Automated, species-specific regulation of animal access to resources could be a powerful tool in wildlife disease management. Efficiency of delivering vaccines, pharmaceuticals, contraceptives, or toxins could be enhanced if target species were allowed access to treated baits but nontarget species were excluded. Researchers at the National Center for Engineering in Agriculture (NCEA) in Queensland, Australia, have developed a prototype for a computerized video-monitoring system to automatically control gated access to resources enclosed within fenced areas. NWRC researchers have initiated a collaborative study with NCEA to acquire video imagery of domestic and wildlife species, which is required to adapt the prototype system for use in North America (phase 1) and to test the efficacy of the prototype system (phase 2). Primary efforts will focus on cervids susceptible to CWD and on other domestic and wildlife species that might be confused with focal species.

CWD Vaccine Development—NWRC has embarked on a suite of studies to develop a CWD vaccine. Preliminary vaccine candidates—short peptides derived from portions of the primary amino acid sequence of the prion protein causing CWD—have been screened by intramuscular injection of rabbits.

These peptides have been conjugated to keyhole limpet hemocyanin (KLH) and formulated with AdjuVac to improve immune response. ELISA results have identified three promising peptides. The next phase will be to use a mouse model to predict in vivo efficacy of the vaccine candidates.

Evaluation of Fence-Line Interactions Among Farmed and Free-Ranging Cervids—Through the use of track plots and motion-activated video, NWRC scientists evaluated interactions occurring between farmed and wild cervids (mule deer, white-tailed deer, and Rocky Mountain elk) through game-ranch fences. The primary objective was to establish a level of disease transmission risk that exists along such fencelines. Six of the study sites were white-tailed deer ranches in Michigan; nine were elk ranches in Colorado. Researchers collected track-plot data biweekly and video data continuously. Track-plot data revealed where animals visited the same location during a 24-hour period, while video data showed if captive and wild cervid visitations occurred concurrently and disclosed the nature of those visitations.

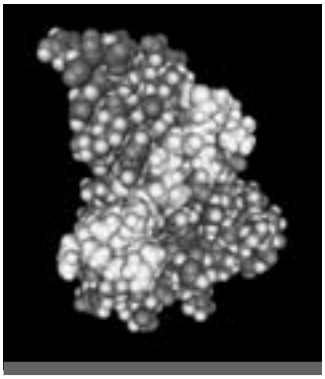
Colorado track-plot data revealed that most activity for captive elk was during the spring migration and calving season. Michigan track-plot data revealed that most activity for captive deer was during the fawning season. Camera data suggest that interactions are more frequent between farmed and wild elk than between farmed and wild white-tailed deer.

Considerable variation was found from site-to-site in the species, sex, age-class, and number of wild cervids frequenting game-ranch fencelines. Elevation, habitat type, and proximity to prime habitat

appeared to play a role in the time of year that the interactions took place. Game-ranch management practices (animal stocking rates, proximity of males to females, feeding practices, and fence construction) also had a strong effect on fenceline activity.

Decontamination of CWD Prions—Practical means to decontaminate surfaces and areas that may host CWD prions are needed. Infectious prions are resistant to most normal methods of disinfection and degradation. Enzyme digestion of prions may provide a more practical alternative disinfection method to use in certain situations. NWRC scientists are cooperating with others to test whether some enzymes might degrade prions.

Several enzymes have been identified that are capable of degrading prions to the point that they are undetectable in laboratory diagnostic tests. Testing was also done to establish some parameters for enzyme function on CWD material. Pretreatment temperature, incubation temperature, enzyme concentrations, incubation time, and pH conditions have been compared.



The next step is to begin animal studies to test whether the enzymes are capable of eliminating or reducing the potential for prion infection. If enzyme treatment is successful in preventing transmission, the method could be valuable for decontamination in the meat-processing industry, environmental and facility cleanup, and waste treatment.

Development of Live-Animal Tests for CWD— Currently there is no test available to determine if living elk have CWD and only one test available to determine if living deer have CWD. The disease can be detected in deer via a tonsilar biopsy procedure, which, though effective, is quite invasive. NWRC and cooperators have developed and evaluated a simpler biopsy method that has proven effective in elk. Additionally, researchers have evaluated the feasibility of employing parotid gland biopsies to detect CWD in living deer. The technique is showing promise.

Grants Awarded for Mule Deer Research—On September 15, 2005, the Boone and Crockett Club, a premier conservation organization founded by Theodore Roosevelt in 1887, published an article highlighting its 2005 conservation grant recipients. This year the focus of the competitive grants was mule deer, a species declining throughout its range. NWRC scientists will be primary investigators on two research projects selected by the Club. Results of one project, "Conditions Affecting Limiting Factors for Mule Deer in Southwestern Montana," will help managers to predict mule-deer population trends and employ appropriate management strategies. The other project, "Transmission of Chronic Wasting Disease in Riparian Areas," will employ data from more than 300 radio-marked deer to develop models to be used for predicting and managing the spread of CWD. Collaborators include Utah State University, Montana State University, the University of Nebraska, and the Nebraska Game and Parks Commission.

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

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

Feral Pig Study in Texas—Research continues on the movement ecology of feral pigs relative to domestic swine facilities in eastern and southern Texas. This research is being conducted in collaboration with Caesar Kleberg Wildlife Research Institute (CKWRI) and Texas A&M University–Kingsville (TAMU–K). Trapping efforts from the summers of 2004 and 2005 have resulted in 212 captured pigs, 18 of which were recaptures. Sex ratio (93 males:101 females) did not differ statistically from a 1:1 relationship. In this group, 80 pigs were young, 48 were juveniles, and 34 were adults.

Serum samples from 102 animals have been evaluated for the presence of antibodies to pseudorabies virus (PRV) and brucellosis. In the southern Texas region, pigs were more likely to have been exposed to PRV (38 percent prevalence) than brucellosis (10 percent prevalence). However, in the eastern Texas region, pigs were more likely to have been exposed to brucellosis (33 percent prevalence) than PRV (12 percent prevalence). Serology results for classical swine fever ("hog cholera") are pending.

Fifty-seven adult pigs have been fitted with GPS telemetry collars. Collars have been retrieved from 27 animals that either died or slipped their collars. Of these collars, 6 remained on live animals for >1 month (approximately 24 locations/week), thus providing sufficient locations to draw conclusions on their movements. Three pigs were frequently found near domestic livestock facilities, and three pigs did not interact at all with domestic pigs.

At present, there are >35 active collars on feral pigs. Movement data will continue to be collected through December 2006. Seasonal movements, home ranges, habitat use, and interaction with domestic livestock will be evaluated and compared by sex and region.

Complementing this study, an investigation into feral pig population-survey techniques is being initiated on State-owned land near Artesia Wells, TX. This work will be completed in collaboration with the CKWRI and the Texas Parks and Wildlife Department. The study director and CKWRI scientists are working with a master's degree student in developing the necessary field protocols to conduct this work. Study objectives will be to compare feral pig density estimates derived from spotlight distance sampling, helicopter surveys, and mark–recapture (marked with an orally administered biomarker and recaptured at hunter harvest) techniques.

Internal TAMU–K funding was secured by CKWRI scientists to complete a preliminary genetic appraisal of feral pigs. This collaborative effort,

which began in May 2005, seeks to quantify the frequency and extent of multiple paternity in free-ranging pigs. Tissue samples are being collected with assistance from Texas WS. Field and laboratory work are primarily being completed by an undergraduate research assistant, with help from NWRC and CKWRI personnel. Currently, DNA has been extracted and genotyped from >200 samples. Preliminary analyses suggest a high incidence of multiple paternity among littermates.

Evaluation of a Latex Agglutination Test Kit—A PRV antibody latex agglutination test kit (Viral Antigens, Inc., Memphis, TN) is being evaluated for use on feral-pig serum samples. The advantage of this procedure is that rapid results can be determined in the field. Of the >40 samples tested with the latex agglutination kits, all results have been consistent with samples analyzed by serum neutralization and ELISA.

Bait Evaluation—An investigation of Pigout® Feral Pig Baits (Animal Control Technologies, Somerton, Victoria, Australia) was initiated in collaboration with scientists from the Pest Animal Control Cooperative Research Centre (Canberra ACT, Australia). In late April 2005, about 1,150 baits injected with a serum iodine marker (iophenoxic acid) were distributed by hand on private land west of Premont, TX. Baits were dropped at an intensity of 69 baits/km^2.

After 72 hours, 90 percent of the baits had been removed. Motion-detecting photography and track stations revealed that feral pigs removed about 22 percent of the baits while nontarget animals removed the other 78 percent. These statistics were somewhat surprising given the species-specific characteristics of this bait in Australia (>90 percent removed by feral pigs). Serum samples indicate that 74 percent of feral pigs, 89 percent of raccoons, and 43 percent of opossums had consumed baits.

Additional field and captive studies comparing Pigout baits of different flavors (fishmeal and vegetable) and attractants (blood meal, urine, etc.) are planned during FY 2006. Furthermore, once a suitable delivery vehicle is identified, work with collaborators in Australia and New Zealand on a lipid-encapsulation matrix (which allows injectable vaccines to be delivered orally) will commence at the CKWRI's captive wildlife facilities.

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.

National Support

NWRC Biologists To Evaluate Cormorant Hazing Efficacy—During June 2005, satellite transmitters were attached to 25 double-crested cormorants to monitor their movements. Researchers from the NWRC Mississippi field station and New York WS are studying the effectiveness of hazing on movements of the cormorants at Oneida Lake, NY. Various stakeholders are concerned that an increasing cormorant population may have caused a decline in walleye and yellow perch fisheries on Oneida Lake.

New York WS has begun a hazing program to discourage nesting and disperse cormorants from the lake. Transmitters were put on the cormorants to better understand how they respond to this management technique. Wildlife scientists and managers hope that results from this study will reveal the effectiveness of hazing and what level of harassment is required to maintain an acceptable cormorant population size.

Noninvasive Monitoring of Canine Parvovirus and Distemper—Personnel at the NWRC Utah field station initiated a cooperative study in 2005 with personnel from the Veterinary School at North Carolina State University to assess the practicality of using noninvasive means of monitoring exposure of wild canids to parvovirus and distemper. The study involves periodically collecting fecal samples from a series of coyote pups for a period of 6 weeks starting immediately before being vaccinated with a commercial modified live vaccine routinely used in the coyote colony health-maintenance program. The feces will be subjected to a PCR assay to detect shedding of antibodies to the two diseases. Four methods of fecal preservation will be compared in the process. If effective, this vaccine will provide a useful new, noninvasive technique for wildlife disease surveillance.

Census of Laughing-Gull Colony Conducted—Biologists at the NWRC Ohio field station—with assistance from New York WS, the National Park Service (NPS), the Port Authority of New York and New Jersey, the City of New York Parks Department, The Littoral Society, and other groups—took a census of the laughing-gull nesting colony in a 81-ha (600-acre) marsh complex in Jamaica Bay, next to New York City. These marshes, on NPS property, are adjacent to John F. Kennedy International

Airport (JFKIA), where gull–aircraft collisions have been a serious problem. Nine ground plots were established in the marsh, and all gull nests in the plots were counted. Additionally, aerial photographs were taken of the entire marsh complex.

In the fall of 2005, biologists conducted a nest census of the entire marsh by counting all nests (including those in the nine previously counted plots) that are visible on enlarged copies of the aerial photographs. To determine the accuracy of the aerial census, scientists will match on-the-ground nest counts in the nine plots with counts from the photographs.

Results from a census conducted in 2004 indicated that the colony contained about 2,100 nests, a decline of 75 percent from the 7,600 nests counted in 1990. Management programs by WS at JFKIA during 1991 through 2004 have reduced laughing-gull–aircraft collisions by 76 to 99 percent annually compared to 1988 to 1990, when the airport averaged more than 150 strikes/year.

This NWRC-developed census technique (counting nests from aerial photographs and using ground-plot counts as a correction factor) is a critical component of the gull management program at JFKIA and may be of use in other situations where colonial-nesting waterbirds conflict with human activities.

Rodent Control at Army Training Area—A researcher from NWRC's Hawaii field station and Hawaii WS operational staff met with personnel from the U.S. Army's Pohakuloa Training Area (PTA) in July 2005 to discuss house mouse control in and around the facilities. PTA encompasses 108,000 acres, lying at 6,000 to 8,650 feet above sea level, between Mauna Kea and Mauna Loa mountains. The facilities include housing, airfield, and training areas for 15,000 to 18,000 military personnel. The area is also rich in flora and fauna, including a dozen endangered plant and animal species.

Recent higher-than-normal rainfall in the area has resulted in lush growth of many seed-bearing plants, prompting concerns of a pending serious mouse infestation such as had occurred 2 years ago under similar weather conditions. Drive-by inspections were made to identify sensitive areas (e.g., food storage and handling buildings, staff offices, warehouses) where serious infestations occurred in the past.

The NWRC scientist onsite recommended that surveys to monitor rodent populations be implemented immediately so that control measures could be put

in place prior to a major irruption. Rodent-proofing may not be a viable option because 90 percent of the buildings are aged Quonset hut-type structures and other unenclosed hanger-type warehouses. Snap trapping, glue boards, and various commercial baits can be used. NWRC will assist WS staff with the monitoring, data collection, and implementation of control measures.

NWRC Advises on Methods for a National Assessment of Nonnative Species—An NWRC scientist was one of six individuals invited to work with the H. John Heinz III Center in Washington, DC, to develop core national indicators on the status of nonnative species throughout the United States. The Heinz Center is known for its report "The State of the Nation's Ecosystems," a comprehensive scientific description on the condition of the lands, waters, and living resources of the United States. General quantitative descriptors of the nonnative species situation in the United States are an important thrust for the Heinz Center in preparation for the development of the next installment of its "State of the Nation's Ecosystems" report.

The outcome from the Washington meeting was to identify two potential indicators of the nonnative species situation that could be obtained from available data, would be descriptive of the state of affairs, and would be readily understandable by politicians and the public at large. For a given geographic unit, the proportion of all species that are nonnative was identified as a useful descriptor of the current situation, and the number of new species discovered within a specified time period would provide an indicator of rate of change in the nonnative species situation.

NWRC Personnel Assist in Plague Outbreak Response—During September 6 through 13, 2005, NWRC personnel from the Gainesville, FL, and Sandusky, OH, field stations assisted in the response to a bubonic plague outbreak in South Dakota. This outbreak threatened the primary reintroduction site of the black-footed ferret and also endangered public health on the Pine Ridge Reservation. To kill fleas that transmit the disease, thereby breaking the disease-transmission cycle, a pesticide was applied to prairie-dog burrows on 810 ha (6,000 acres) in the core black-footed ferret reintroduction area. In addition, NWRC biologists assisted FWS personnel in collecting data on the number of active prairie-dog burrows on the site. Collaborators included the NPS and WS personnel from Arizona, Colorado, North Dakota, and Oklahoma.

Rodent Populations and Baiting Strategy Survey on Cocos Island, Guam—On September 12 through 22, 2005, a researcher from NWRC's Hawaii field station assisted WS biologists in conducting a rodent population and baiting survey on Cocos Island, Guam. The 100-acre atoll, off the southern tip of Guam, is used primarily as a day resort for tourists. Because the island, unlike Guam, remains free of invasive BT infestations, it has been identified as a potential reintroduction site for native species whose populations have been decimated elsewhere. Additionally, various rare gecko species and the endangered Micronesian starling have flourished on Cocos Island in the absence of snakes. Unfortunately, rodent populations are high across the atoll due to poor waste management from the resort and ineffective rodent control.

Rodent eradication is necessary before Guam's rare, native avian and amphibian species can be reintroduced. To prepare for rodent control, rodent censuses and nontoxic bait acceptance plots were setup in six vegetation habitats throughout the island. Polynesian rats were the only species of rodents captured, but mice activity was also noted. Visual and video camera footage showed extensive removal and consumption of the placebo bait pellets by both of the island's land crab species. Bait delivery systems, thus, will have to be developed to exclude bait-take by crabs before operational rodenticide applications can be used.

International Cooperation

Japanese Researchers Visit Hawaii Field Station— The NWRC Hawaii field station hosted a contingent of Japanese researchers interested in research from Amani Island on control of the lesser Indian mongoose. The six-person delegation included representatives from the National Institute of Environmental Studies' Invasive Alien Species Research Team, Japan Wildlife Research Center, Amani Wildlife Conservation Center, National Institute of Forest Science's Forestry and Forest Products Research Institutes, and the University of Tokyo's Departments of Ecosystem Studies and Laboratory and Biodiversity Science. Scientists also hosted Dr. Go Ogura, a Japanese researcher from the Department of Environmental Science and Technology at the University of the Ryukyus, Okinawa. The purpose of these visits was to build partnerships on the control of mongooses and other invasive species.

Successful Monitoring Method for the Ethiopian Wolf—The Ethiopian wolf is the rarest canid in the world. Monitoring its populations is essential to recovery efforts. NWRC has collaborated for the last 2 years with a CSU scientist to develop and test passive tracking index (PTI) methodology for indexing Ethiopian wolf populations. The PTI has successfully monitored pest species, and such canids (members of the dog family) as coyotes and foxes in the United States and dingoes in Australia. The PTI is most efficiently applied if the travel routes of the target animals can be predicted.

In 2003, tracking plots for Ethiopian wolves were set out on roads and trails because this had proven to be the optimal method for monitoring coyotes and dingoes. Unfortunately, the Ethiopian wolf habitat in the Bale Mountains is such that roads and trails did not provide a lesser path of resistance to travel for the wolves than the surrounding landscape.

Last year, further tests were conducted whereby tracking plots were placed on molerat mounds because Ethiopian wolves were observed to move from molerat mound to molerat mound (their primary food source in the area). This plot placement strategy proved to be efficient and effective for collecting Ethiopian wolf spoor from which population index values could be calculated.

The PTI provides useful population information but is easy to apply and requires only minimal resources. Tools such as this are valuable for Ethiopian wolf researchers and managers because they typically have only limited resources at their disposal.

Targeted and Passive Capture of Highly Venomous Australian Snakes With BT Traps—Australia is home to the most venomous snakes in the world. Dangerous snakes are often found in close proximity to human residences and activities, and an effective snake trap could offer a safe means to remove dangerously venomous snakes from the vicinity of humans. NWRC collaborated with Deakin University in Victoria, Australia, to test the WS-developed BTS trap for capture of Australian snakes in residential settings.

Two approaches to trapping were tested in suburban Melbourne. The first approach was a passive application, with trapping conducted on the ground along an exterior wall such that the entrances potentially could intercept snakes that might be traveling along the wall. The other approach involved targeting specific snakes observed entering refugia around residences by placing the trap over the entrances to the refugia.

Two highly venomous species were captured: the eastern brownsnake and eastern tiger snake. The applications of the BT trap in both an active and a passive fashion demonstrated potential for this or a similar trap design to safely capture and remove dangerous snakes in areas where they might endanger human health and safety.

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 Receives Notable Technology Development Award—On September 15, 2005, NWRC received the Notable Technology Development Award from the Federal Laboratory Consortium (FLC), Mid-Continent Region, for its development of a new oral contraceptive bait for Canada geese. The contraceptive bait, called OvoControl–G, was developed in cooperation with Innolytics, LLC, a California-based company and manufacturer of nicarbazin. Nicarbazin, given to broiler chickens to prevent the disease coccidiosis, also decreases egg production and hatching rates. When fed to Canada geese during their breeding season, OvoControl–G effectively reduces the hatching success of eggs. When it is withdrawn from the diet, egg production and hatchability return to normal. OvoControl–G provides wildlife managers with a new tool for managing Canada goose flocks. Kathleen Fagerstone and Kim Bynum accepted this award for NWRC.

Dr. Clay Mitchell Honored—A golden raintree was planted next to the front entrance of the Animal Research Building on the NWRC campus in memory of the late Dr. Clay Mitchell. Mitchell worked for the Denver Wildlife Research Center (now NWRC) between 1969 and 1997. He was known for his research on methods to control paralytic rabies spread by vampire bats to cattle and for successfully training veterinarians in 13 Latin American countries to use these methods. The control methods developed by Dr. Mitchell and the Center have helped thousands of Latin American ranchers protect their cattle, resulting in millions of dollars saved each year. He also worked on methods to control bird and rodent damage to agricultural crops in Africa and Haiti.

In 1988, Mitchell became the Quality Assurance Officer for NWRC. At the time, the Center was the only Government office conducting research for the registration of vertebrate pesticides. He helped establish the Good Laboratory Practices Program to ensure the generation of high-quality and reliable research data. The program is still in use today. In addition to his achievements in research and quality assurance, Clay Mitchell was also known for his humor, friendliness, and generosity.

APHIS Administrator's Civil Rights Employee Award—Charlotte Miller received the APHIS Administrator's Civil Rights Employee Award for 2005. Charlotte serves as NWRC's Information Technology Project Leader and Training Coordinator. In addition to providing education and career opportunities to employees of all backgrounds, she is instrumental in providing Equal Employment Opportunity (EEO) information and understanding to NWRC management and employees. Charlotte also serves as the Diversity Coordinator of the Larimer County Federal Executives Association, was the principal organizer for the Federal Heritage Festival in 2005, and coordinates a local science education program for young minority students in Fort Collins. Award recipients were honored by APHIS Administrator Ron DeHaven at a ceremony on September 15 in Riverdale, MD.

Dr. Will Pitt Receives the Equal Employment Opportunity–Civil Rights (EEO–CR) Award—Will Pitt, NWRC Hawaii field station leader, received the FY 2004 EEO–CR award in recognition of his outstanding efforts in promoting and enhancing WS' policies and practices to ensure a work atmosphere that recognizes employees as a valuable resource;

in actively contributing to employee development and growth; in vigorously seeking to hire and successfully hiring qualified employees from underrepresented groups; and, overall, in creating a diverse, competitive workforce aligned with WS' mission priorities.

WS Publication Awards—NWRC employees Paige Groninger and Tom Seamans were recognized by the WS Publication Awards Committee for their coauthorship on two WS publications for the period of 2002 through 2004:

Hall, T. C.; Groninger, Paige. 2002. The effectiveness of a long-term Canada goose relocation program in Nevada. In: Timm, R. M.; Schmidt, R. H., eds. Proceedings of the 20th vertebrate pest conference; 4–7 March 2002; Reno, NV. Davis, CA: University of California, Davis: 180–186.

Chipman, R. B.; Dolbeer, R. A.; Preusser, K. J.; Sullivan, D. P.; Losito, E. D.; Gosser, A. L.; Seamans, T. W. 2004. Emergency wildlife management response to protect evidence associated with the terrorist attack on the World Trade Center, New York City. In: Timm, R. M.; Gorenzel, W. P., eds. Proceedings of the 21st vertebrate pest conference; 1–4 March 2004; Visalia, CA. Davis, CA: University of California, Davis: 281–286.

Safety Special Achievement Award—The NWRC Hawaii field station received a Safety Special Achievement Award for FY 2004 from APHIS for having no vehicular accidents in last 15 years and over 200,000 miles driven.

2004 Publication Awards

NWRC Director Rick Bruggers congratulates NWRC authors Bradley F. Blackwell, Glen E. Bernhardt, and Larry Clark on their contributions to these two articles that have been recognized with the 2005 Publications Award:

Kirifides, M. L.; Kurnellas, M. P.; Clark, L.; Bryant, B. P. 2004. Calcium responses of chicken trigeminal ganglion neurons to methyl anthranilate and capsaicin. Journal of Experimental Biology (207): 715–722.

Blackwell, B. F.; Bernhardt, G. E. 2004. Efficacy of aircraft landing lights in stimulating avoidance behavior in birds. Journal of Wildlife Management 68(3): 725–732.

Bruggers said of the Kirifides et al. article that it "represents an excellent example of addressing 'how' and 'why' questions to methodology that has been in practice for many years." Of the Blackwell and Bernhardt piece, he said that it "illustrates how applied research leads to important management applications."

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.

Information Services

Black Bear Media Event—On August 26, 2005, scientists from NWRC, the Colorado Division of Wildlife (CDOW), and CSU hosted a half-day media event and informational meeting highlighting a new collaborative study on black bears in Colorado. The meeting was attended by several local reporters and was held at the CDOW Area 8 office in Glenwood Springs, CO. The main objective of the study is to determine how the movement, behavior, and ecology of black bears in urban areas relate to the management of human–bear conflicts. During the meeting, reporters met and interviewed lead scientists and photographed trapping efforts in the Glenwood Springs area.

Special Issue of "Wildlife Research" on Indexing Wildlife Populations—A special issue of the journal Wildlife Research has been published that is a peer-reviewed collection of papers from the symposium "Use of Indices To Monitor Wildlife Populations" at the 3d International Wildlife Management Congress held in December 2003 in Christchurch, New Zealand. The symposium was organized by an NWRC scientist and contains papers contributed by scientists from around the world on a spectrum of topics ranging from the theory and development of indices to specific applications and considerations. This special issue of Wildlife Research should provide a useful reference for researchers and managers on population indexing applications.

Information Outreach—The NWRC Web site has added a new search engine that should provide enhanced searching. A video clip describing Center work has been added to the home page. Reproductive control information has been updated, and new documentation for all projects begun or renewed in 2005 is being added. Florida field station pages were updated, and extensive coverage of wildlife damage to forest resources has been added to the Olympia field station section. New material on analytical chemistry services at NWRC has been produced, including summaries of formulation chemistry, radioisotope laboratory capabilities, and wildlife genetics studies. Pages describing the GIS function at NWRC have been completed. Extensive research on site accessibility is underway, and staff will be working to implement new methods to improve access to Web materials for users with disabilities.

The NWRC 2004 Annual Publication List is complete and links to the full text of all 2004 publications. History pages on "Wildlife Services in World War II" and "Albert Kenrick Fisher" have been added.

Wildlife damage-management Web sites, including university extension, State natural resource agency, and dedicated sites, were evaluated for content and usability, and a summary research report was completed. Information gathered will be used in redesigning the NWRC Web site when USDA design guidelines are finalized. The NWRC webmaster has been consulted by other organizations in the restructuring of their Web sites, including APHIS–Wildlife Services and Veterinary Services' Centers for Epidemiology and Animal Health, and the University of Nebraska's Internet Center for Wildlife Damage Management.

The Information Services Unit has begun collecting realia in the form of taxidermic representations of wildlife species of interest to NWRC and the WS Program. Stuffed specimens of a mountain beaver, cormorant, vulture, coyote, and other animals are now on display for visitors.

Library—Library online catalog holdings increased by 344 items, including NWRC reprints, unpublished reports, and new books. Staff has entered names of all borrowers into the new automated circulation system, and each user has been assigned a unique number. Currently, records of items on loan are being converted from paper to online files. This process is more than halfway completed. A digital scanner has been installed to streamline the checkout process. The library has migrated to a new system (FirstSearch™) for borrowing materials from other institutions. FirstSearch replaces multiple systems previously available. Increasing numbers of NWRC author reprints are now arriving at the library in the portable document format (.pdf), providing higher quality materials for distribution.

New library information brochures are now available. The WebZap™ automated interlibrary loan system is explained in one handout. Another provides step-by-step instructions on using IngentaConnect™ for setting up electronic tables-of-contents and automatic searches. Online access to the "Birds of North America" was secured and is available through the Cornell University Web site. Additionally, online access to the National Geographic Atlas of the World is now available. The library has converted most of its public-access databases from ProCite™ to Reference Manager,™ a personal bibliographic software package.

Information Services Unit staff borrowed or photocopied more than 1,700 items from other libraries in response to information requests from the WS program and lent 170 items in return. Additionally, staff photocopied nearly 1,000 inhouse journal articles, reports, and NWRC-authored reprints for distribution to researchers and WS Operations staff. More than 7,000 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 and 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 annual Archives Week, from October 25 to 29, 2004, was a time to publicize NWRC archival records. An open house on October 27 featured exhibits that detailed a sampling of the extensive fieldwork NWRC has done in the past. The purpose of the open house was to show staff the "cool old stuff" found in archival records and how to use and access this material. In addition to the open house, on October 28, three NWRC retirees participated in a panel discussion entitled "From Fun to Fear: Entertaining Anecdotes by Three NWRC Retirees." The stories told by the former employees highlighted their work over the years and, at times, described the humorous side of fieldwork.

A hallway exhibit case provides NWRC the opportunity to show visitors and staff current and past research. In early 2005, an exhibit on NWRC's invasive species research was installed. This exhibit focused on past and present work involving such species as Caribbean frogs in Hawaii, starlings, and rats. The subject matter of the most recent exhibit is NWRC's research on coyotes, or the "Clever Coyote" as the animal is appropriately named. An exhibit highlight is a computer simulation detailing GPS tracking in Idaho to learn more about coyote movements and interactions with sheep.

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 2005, NWRC hosted 20 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 bird damage, wildlife genetics, forest pests, wildlife rabies, epidemiology, and archiving of data.

James E. Luey	Superfund Technical Assistance Unit, EPA, Region VIII	Overview of the Superfund Technical Assistance Unit
Gail Keirn	APHIS, LPA	NWRC's Strategic Communications Plan
John Cummings	NWRC, Fort Collins	Blackbirds and the Southern Rice Crop
Nancy Freeman	NWRC, Fort Collins	Make Sure Your Data Don't Byte You
Alice Brawley–Chesworth	Tres Rios Project Manager, City of Phoenix	Dry Rivers, New Water, and Beavers
Teresa Howes	APHIS, LPA	Soldier's Life in Kuwait
Ray Sterner	NWRC, Fort Collins	ORV for Raccoon and Skunk Rabies—Some Economics?
John Shivik	NWRC, Logan, UT	Changes, Capabilities, Accomplishments, and Vision for the Logan Field Station
Christen Williams	NWRC, Fort Collins	Management Units, Moms, and Meals: Wildlife Genetics at NWRC
Wendy Arjo	NWRC, Olympia, WA	Rain, Slugs, and Thorns: How To Deal With Forest Pests in the Pacific Northwest
Mike Avery	NWRC, Gainesville, FL	Florida Field Station—Capabilities and Research
Chad Olms	NWRC, Fort Collins	New Security Procedures at NWRC

Zhibin Zhang	Institute of Zoology, Academy of Sciences, Beijing, China	Introduction to the Institute of Zoology and Impact of Rodents on Forest Regeneration
Gordon Gathright	NWRC, Fort Collins	Basics of Biocontainment
Richard Minnis	Mississippi State University	Development of a Surveillance and Monitoring System in Africa: Lessons for the United States
Lori Sheeler	Tennessee Department of Health, Nashville, TN	Bats, Bugs, and Brains: Ecological and Epidemiological Studies
Matthew Farnsworth	CSU, Fort Collins	Of Prions and Virions: Statistical and Mechanistic Models for Understanding Wildlife Epidemiology
Robert McLean	NWRC, Fort Collins	NWRC's Wildlife Disease Research Program and Expansion to BSL–3 Research
Antionette Paggio	University of Colorado, Boulder	Wildlife Management: What's Genetics Got To Do With It?
Julie Blanchong	University of Wisconsin, Madison	Applying Genetic Methods to Wildlife Management: Examples With Wildlife Diseases
Kim Burnett	University of Hawaii Honolulu, HI	Integration, Prevention, and Control of Invasive Species: The Case of the Brown Treesnake
Mike Dunbar	NWRC, Fort Collins	Use of Infrared Thermography To Detect Disease in Wild and Domestic Animals

Meetings, Workshops, and Conference Presentations

Lure Workshop for M–44 Use Held at NWRC— Only a small fraction of M–44s in the hands of specialists conducting predator control are deployed and activated by predators. Discussions with users have identified a lack of reproducible attractants and a need for easy-to-prepare delivery devices as two of the reasons why M–44s are not used more frequently. NWRC has developed two promising attractants and a novel delivery system (lure). However, users of M–44s have not been sufficiently engaged in the development of these devices.

To facilitate increased cooperation between research and operations, a workshop was held at NWRC on September 14, 2004. Eleven specialists from WS operational programs in the States of Wyoming, Nebraska, New Mexico, and Texas attended the workshop. In addition to learning about the latest research in coyote attractants, the attendees were given supplies and hands-on training in the formulation of gelatin-based M-44 lures. Each specialist made 20–24 lures with attractants of their own choosing, and each was provided with 48 more that were prepared with the latest synthetic attractants. The efforts of this workshop have a dual role: educate users in the preparation of novel lure devices for M–44s and foster greater collaboration between scientists and users in the testing of products for vertebrate pest management.

2d National Invasive Rodent Summit a Success at NWRC—On October 19 through 21, 2004, NWRC hosted the 2d National Invasive Rodent Summit in Fort Collins. The conference was jointly sponsored by NWRC, the FWS, and The Wildlife Society's Wildlife Damage Management Working Group. The conference was a followup to the "Rat Summit" held in San Francisco, CA, in 2001.

Like the first "Rat Summit," this conference emphasized the management of rodents to conserve plants, other wildlife, and habitats. The 105 attendees came from 10 countries and territories and 23 States. The scope of the problem, concerns, species involved, and lands affected were all considered. There was an overview of the National Invasive Species Management Plan. Examples of island eradication efforts were presented along with remaining challenges. Registrations, tools, and toxicants were important considerations. Mainland rodent-control efforts were presented and noted to be quite different from island eradications, differing in size of area, duration of effort, land ownership, hazards and nontarget issues, and residue accumulation. A session addressed rodents and disease because many human and livestock diseases are hosted by rodents and their ectoparasites. Nutria, an invasive aquatic rodent, is presenting problems of ecosystem degradation in Maryland and Louisiana; control efforts and research needs were considered.

While many of the basic methods of rodent control were developed for commensal rodent control in and around buildings and for agricultural situations, new approaches are being investigated and implemented. These include integrated pest management efforts at the community level, trap-barrier systems, and fertility control. Issues of development and registration costs and various constraints remain.

There is considerable effort underway to assess the risks of rodenticide use, including primary and secondary hazards to nontarget species and residue accumulations. Modeling efforts and worst-case scenario investigation have contributed to understanding and reducing hazards and have aided in toxicant selection.

While many challenges remain, much progress has been made in the control and eradication of introduced, invasive rodents.

Southeastern University Students Learn About Wildlife Damage Management—On March 4, 2005, NWRC biologists at the Florida field station and the WS Operations office in Gainesville hosted 40 wildlife students and faculty advisors for a 3-hour orientation on general wildlife damage management activities and the WS program in particular. At the station, students learned about dispersal methods and marking techniques for vultures, anatomy and physiology of the invasive monk parakeet, trapping and capture methods for problem wildlife species, and application of reproductive inhibition in nuisance bird populations.

The program at the field station was part of the 3-day 2005 Southeastern Wildlife Conclave hosted by the University of Florida student chapter of The Wildlife Society. The conclave attracted more than 300 students representing 20 universities.

The Wildlife Society Florida Chapter Annual Meeting Presentations—During March 16 through 18, 2005, three biologists from the NWRC Florida field station participated in the spring conference of the Florida Chapter of The Wildlife Society in Tarpon Springs, FL. The conference was a joint meeting of the Coastal Plain Chapter of The Society for Ecological Restoration and the Florida chapter and was held at the Brooker Creek Preserve, a 3,440-ha (8,500-acre) wilderness area in Pinellas County, FL.

One NWRC biologist presented a paper entitled "The use of geographic information systems in wildlife damage control," which was well-received by the more than 70 attendees. Additionally, an NWRC biologist was appointed to the executive board of the Florida Chapter of The Wildlife Society for a 2-year term, and another was appointed to the planning committee for the 2008 international conference of The Wildlife Society, which will be hosted by its Florida chapter.

Presentation to CSU Agriculture Class—An NWRC scientist gave an overview of WS operations and research activities to a CSU agriculture class on April 13, 2005. The 21 graduate students in the audience are part of an M.S. degree program that prepares them for careers in farm management. Students in this program are educated in farm practices, finance and policy, as well as wildlife, range,

and water resources management. The students were shown the research facilities at NWRC and several expressed interest in doing internships with the Center.

Biologist Conducts Wildlife Awareness Class— On May 23, 2005, an NWRC biologist at the Florida field station made a presentation to a group of 25 preschoolers about wildlife biology and wildlife damage problems. The children ranged in age from 2 to 4 and were treated to up-close exhibits that included a black vulture, an American crow, two red-winged blackbirds, and a red rat snake. The class helped to band and release the blackbirds.

The opportunity for these children to see and touch live animals, as well as to examine a variety of prepared skulls and pelts, furthers their appreciation for wildlife, especially in the urban environment. Also discussed were issues dealing with feeding wild animals, snake awareness and safety, and how wild animals can get into trouble when they interact with people and agriculture.

Training Course Instituted for Safe Use of Rocket or Cannon Nets—On June 8 and 9, 2005, the Mississippi field station partnered with the WS Explosives Committee to develop and host a nationwide training course for WS employees in the safe use of rocket and cannon nets for capturing birds. Propellants in the devices can pose safety hazards if not used properly. Because of the events of September 11, 2001, regulations governing the use, transport, and storage of explosives have become more specific and restrictive. Thus, a pilot workshop, with associated standard operating procedures, was developed to ensure that WS employees are trained in the safe use of this tool and are in compliance with relevant regulations. About 30 biologists from 18 states participated in the workshop, and applicants for the course far exceeded the number of seats available. Due to the strong interest in this training, plans for a regular offering of the course are underway.

23^{d} National Sunflower Association Seminar— On June 21, 2005, an NWRC scientist attended the National Sunflower Association meeting in Spearfish, SD. The scientist was invited to give a presentation entitled, "Update on blackbird lure plots (Wildlife Conservation Sunflower Plots)."

NWRC Hosts National WS Advisory Committee Meeting—On June 21 through 23, 2005, NWRC hosted the annual meeting of the National WS Advisory Committee. The Committee provides recommendations to the Secretary of Agriculture on policies, program issues, and research needs associated with the WS program. It also serves as a public forum enabling those interested in WS' activities to have a voice in the program's policies.

During the 3-day meeting at NWRC headquarters in Fort Collins, the Committee received an overview of the Center's research and outreach efforts, and discussed and provided recommendations regarding WS' aerial operations strategic plan, wildlife disease surveillance program, policies associated with several Federal laws, and other wildlife damage management issues.

Recommendations from this meeting were compiled and sent to the Secretary of Agriculture and the WS Management Team. The Committee's 20 members represent a broad spectrum of agricultural, environmental, conservation, academic, animal-welfare, and related interests, and include representatives from the American Sheep Industry, the Idaho Department of Fish and Game, the Native American Fish and Wildlife Society, The Humane Society of the United States, and the Catfish Farmers of America. This is the third time the Committee asked to hold its meeting at NWRC headquarters. Previous meetings were in 1996 and 2000.

Web Evaluation Results Presented—On July 7, 2005, an NWRC information specialist presented research results on the "Heuristic Evaluation of Web Presentation of Wildlife Damage Management Information" to the Web design and development group at APHIS' Centers for Epidemiology and Animal Health in Fort Collins.

Northern Great Plains Workshop—Biologists from the NWRC North Dakota field station and North Dakota and South Dakota WS program attended the Northern Great Plains Workshop August 17–19, 2005, in Brookings, SD. One NWRC scientist presented a paper titled "Aerial mass color-marking of blackbird roosts" as part of the Capturing, Marking, and/or Removal of Birds and Mammals session. NWRC scientists developed this marking technique in the early 1980s and are considered international authorities for the aerial marking of birds. The paper was published in the Proceedings of the Great Plains Workshop.

Scientists Chair Symposium at The Wildlife Society Meeting— Scientists from the NWRC Sandusky, OH, field station and North Carolina WS chaired a symposium entitled "Managing Aviation–Wildlife Conflicts: Challenges for the Wildlife Profession" during the 12th annual conference of The Wildlife Society in Madison, WI, September 25–29, 2005. The symposium was a general introduction to the growing field of airport wildlife management.

Other than wildlife professionals directly working in the field, in general, knowledge of the subject throughout the wildlife profession is limited to basic awareness. National and international wildlife professionals in the field, including several from WS, spoke at the symposium. Topics discussed included the history of aviation–wildlife conflicts, U.S. FAA and U.S. Department of Defense programs to reduce wildlife hazards, interagency cooperation, low- and high-tech solutions for reducing bird strikes, the role of research in aviation–wildlife conflicts, and challenges and opportunities for the wildlife profession. As an organization, WS is recognized as one of the leaders in wildlife hazard research and management at airports.

Scientists Attend the American Chemical Association (ACS) National Meeting—On August 28 through September 1, 2005, six NWRC scientists from Fort Collins participated in the ASC Meeting held in Washington, DC. The scientists made both oral and poster presentations covering a range of research topics, including 3–chloro–p–toluidine metabolism in birds, high-performance liquid chromatography methods for detection of chlorpyriphos and nicarbazin, tetracycline–brodifacoum synergism

in rats, repellants for deer browsing vegetation, and risk assessments of invasive species. Interaction with representatives from academia and industry proved fruitful, and many useful suggestions were made that will benefit the research being conducted at NWRC.

NWRC Registration Manager attends IR–4 Food Use Workshop—During the week of September 12, 2005, the NWRC Registration Manager attended the IR–4 Food Use Workshop in San Diego. The purpose of the workshop was to prioritize IR–4's research schedule for 2006. The NWRC scientist was successful in placing one study for an avian repellant on the IR–4 work schedule. The study will evaluate chemical residues on harvested corn after anthraquinone is applied as a seed treatment or overspray on newly germinated corn seedlings. This product would be used to prevent sandhill crane damage. The study and subsequent tolerance petition should be submitted to the EPA in 2009. If successful, this will be the first use of anthraquinone on a food crop.

Scientist Presents Predator Research—On September 30 and October 1, 2005, a scientist from the NWRC Utah field station gave two presentations. The first (for the general public) was given in Durango, CO, at the invitation of the La Plata County Animal Damage Advisory Committee. The talk, entitled "Methods and Concepts for Minimizing Conflicts Between Humans and Predators," discussed recent developments in methods for managing predation. The second presentation, "Research and Development in Livestock Protection," which discussed predation management methods, coyote behavior, and capture device development, was delivered to producers attending the Four Corners Small Farm and Ranch Conference. About 20 people attended the 2 presentations.

Publications

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

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