Wildlife Services

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FY 2010

Leader in Nonlethal Solutions to Wildlife Damage

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USDA Scientists Apply Expertise to Wildlife Conflicts

The National Wildlife Research Center (NWRC) is a world leader in providing science-based solutions to complex issues of wildlife damage management. As the research arm of the Wildlife Services (WS) program, NWRC works with WS operations staff to provide Federal leadership and expertise to resolve human-wildlife conflicts related to agriculture, human health and safety (including wildlife diseases and aviation), invasive species, and threatened and endangered species. In 2010, the majority of NWRC's research funding was devoted to the development or improvement of nonlethal wildlife damage management tools and methods. Many of the nonlethal methods used today by Federal, State, and private sector wildlife professionals stem from research conducted at or through the Center.

Protecting Agricultural Crops, Aquaculture, and Natural Resources

NWRC is committed to finding nonlethal solutions to reduce wildlife damage to agricultural crops, aquaculture, and natural resources. NWRC scientists have shown that "decoy" plantings of sunflower can significantly reduce bird damage to nearby commercial sunflower fields. In recent studies, scientists observed higher blackbird damage in decoy fields than nearby commercial sunflower fields with blackbirds removing an average of 388 pounds/acre and 44 pounds/acre of sunflower seed, respectively. In addition to reducing bird damage to the commercial fields, decoy fields also are benefiting many other bird and wildlife species. In a collaborative study with North Dakota State University, NWRC scientists examined migratory bird use of croplands in North Dakota and found species diversity and densities to be highest in decoy sunflower fields compared to commercial sunflower or other non-sunflower row-crops such as corn, soybeans and wheat. In fact, scientists determined that decoy fields with tall (≥ 4.3 ft/1.3 m), densely planted rows (≥ 1.5 crop plants/linear foot) with some non-crop plants—such as forbs from flowering mustard, cabbage and goosefoot families—resulted in the highest bird densities. Results showed greater bird densities in sunflower and especially in decoy fields than previously reported during fall in fallow, sunflower and wheat fields; in cornfields during the breeding season; in Great Plains forest fragments in spring; and in Conservation Reserve Program grassland and row-crop fields in winter. The cost-benefits associated with decoy fields are still being evaluated. Scientists are hopeful that the proper placement and management of these fields will provide sunflower producers with an economically viable nonlethal blackbird damage management option that also improves wildlife habitat for other migratory birds.

NWRC scientists continue to develop the use of 9,10-anthraquinone (AQ) for repelling birds from newly planted seeds and ripening crops. In laboratory studies, AQ effectively prevented Canada geese, red-winged blackbirds, and ring-necked pheasants from eating treated seed by as much as 80 percent. Information from this and other studies will be used in the registration of AQ-based repellents with the U.S. Environmental Protection Agency.

Birds can also cause a great deal of damage at fish farms and other aquaculture facilities. Currently, NWRC is studying the migratory movements and feeding behavior of double-crested cormorants and other fish-eating birds. NWRC scientists and collaborators have identified a biomarker in the bird's skin that is a predictor of age in double-crested cormorants. This information may lead to a rapid and cost effective technique for identifying age of cormorants and many other species of birds. This technique will help provide a better understanding of the population characteristics of cormorants that are impacting commercial and natural resources in the United States. Bird age estimates are useful for predicting population growth rates and responses to various management activities.

Foraging wildlife can damage forest resources in many ways, such as reducing productivity or disrupting re-vegetation efforts. NWRC researchers discovered that certain food-grade materials, such as milk casein and gelatin, have great potential as repellants to reduce rodent and rabbit consumption of seedlings, ornamental plants and food crops. NWRC researchers also are working to determine how certain wildlife species respond to chemical components in the plants they eat. Ongoing collaborative efforts are determining which traits can be selected to produce less palatable trees. For instance, studies suggest that, when given a choice, deer prefer to eat conifer seedlings with low terpene levels. Tree breeding programs can be used to produce seedlings with elevated terpenes. Understanding these and other mechanisms that control dietary behaviors aid in the development of management strategies for decreasing damage and help create models for predicting where damage is most likely to occur.

Protecting Human Health, Safety and Property

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

The ways in which birds respond to approaching objects is critical when it comes to their ability to detect predators, forage, flock, and avoid collisions with static or moving objects. Understanding variations in animal visual capabilities and other sensory systems may shed light on how animals detect and avoid threats from approaching aircraft, other vehicles, wind turbines and communication towers. NWRC scientists, along with university and private partners, are working to enhance animal detection and avoidance behaviors related to vehicle approach using vehicle-based lighting treatments. Studies show that vehicle lighting varied by pulse frequency can be used to enhance birds' abilities to detect and avoid approaching ground-based vehicles and aircrafts. Researchers also found that the response of a species to an approaching vehicle depends not only on its visual capacity but also on its innate response to predators. For example, brown-headed cowbirds—with a reduced ability to visually track an object—were especially alert to an approaching vehicle under specific vehicle-lighting treatments, which, according to researchers, might also cause them to flush earlier to reduce the risk of predation. In contrast, mourning doves—with wider fields of vision and an ability to detect more-distant objects—maintained position, possibly relying on cover for safety. This new information presents an opportunity for WS and its partners to work with industry to design aircraft lighting systems that detect ambient light conditions, then tailor the lighting output to one more readily discerned by birds under those conditions. More research is forthcoming, but scientists have presented their most recent findings before representatives of a major aircraft manufacturer and already seen their initial findings employed by a commercial airline in a field trial.

Similar studies with vehicle-mounted lighting systems for warning deer found that a combination of standard tungsten-halogen (TH) lamps and constant illumination of a high-intensity discharge (HID) lamp increased the distance in which white-tailed deer reacted to an approaching vehicle, by, on average, as much as 20 meters. These findings could potentially aid in the development of new vehicle lighting systems that enhance deer detection of approaching vehicles and, thus, lower the number of deer-vehicle collisions (DVCs) occurring in the United States and abroad. Each year, DVCs are responsible for more than $1.1 billion in damages, injuries and loss of animals in the United States. Many factors contribute to the number of DVCs in an area, including deer population, demographics, traffic volume and speed, activity patterns, seasonality, and habitat features. Although the majority of these factors are unchangeable, the ability to develop vehicle lighting systems that enhance deer avoidance may be one factor that could be improved.

As goose and pigeon populations in urban areas expand, these birds are often considered a nuisance and potential health problem (fouling land and water, colliding with and damaging aircraft, etc.). NWRC scientists partnered with Innolytics, LLC, a California-based company, to develop an oral contraceptive bait called OvoControl for geese and pigeons. Final regulatory approval and registration of the bait was granted in 2005 for Canada geese (registration # 80224-5) and 2007 for pigeons (registration # 80224-1) by the U.S. Environmental Protection Agency. NWRC was awarded the 2009 Governor's Research Impact Awards in Colorado for their part in the development of OvoControl. Current research is evaluating other potential contraceptives including the chemical 20,25-diazacholesterol dihydrochloride (diazacon) to reduce reproductive output in birds through reduction of blood cholesterol and cholesterol-dependent reproductive hormones. NWRC and researchers at the United Kingdom's Food and Environment Research Agency tested diazacon on captive invasive rose-ringed parakeets and observed a 54 percent reduction in egg fertility rates for the first clutch and 66 percent for the second clutch, compared to control birds. Based on these results, researchers conclude that diazacon has potential for fertility control in rose-ringed parakeets if a suitable formulation and delivery system is developed for free-living populations.

Current NWRC research also protects human health by developing methods to reduce or eliminate disease transmission among wildlife, domestic animals, and humans. In 2009, NWRC researchers successfully registered with the U.S. Environmental Protection Agency the first single-shot, multi-year immunocontraceptive vaccine for use in female white-tailed deer. Called GonaCon™ Immunocontraceptive Vaccine (GonaCon), this new tool may not only be useful

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as part of urban white-tailed deer management plans where traditional options are limited, but it also shows promise in other areas, such as contraception in companion animals and disease prevention. For instance, NWRC and its collaborators are investigating the development of a combined GonaCon-rabies vaccine for use in feral dogs and raccoons. The vaccine is being used for research purposes in the United States, Mexico, Europe, New Zealand and Australia. Future NWRC research with GonaCon will likely involve studies to support expanded registration to other species, develop oral delivery systems, and prevent transmission of wildlife diseases. NWRC received the 2010 Colorado Governor's Award for High-Impact Research for its development of GonaCon.

NWRC has been active in the development and testing of wildlife rabies vaccines. Though rabies is well controlled in domestic animals, its spread among wildlife populations is still cause for concern. Since 1995, WS has been involved in a national rabies prevention and oral rabies vaccination effort. Raboral V-RG®, the oral rabies vaccine used in the United States to immunize free-ranging wildlife requires low temperatures for stability. The longer the vaccine remains viable, the better the odds are for a target animal to encounter the vaccine and become immunized. NWRC scientists have been working on a method called vitrification that may help increase rabies vaccination rates for wild, free-ranging wildlife. Vitrification is the process of preparing materials in a matrix of compounds, usually sugars or polymers, in a manner that, upon drying, results in the formation of a glass rather than a crystallized product. Vitrification of Raboral V-RG® provides protection from a loss of viability at elevated temperatures. This protection extends through temperatures likely to be encountered in outdoor and non-refrigerated storage conditions. NWRC scientists observed that substantial amounts of viable vaccine virus remained in the samples even with 24 hour exposure to temperatures of 50° C or higher. For the three weeks studied at 37° C, the vaccine virus was protected and, essentially, no loss was observed. This is in stark contrast to the standard liquid suspension presently being used where viability decreased measurably over time and no detectable viable vaccine virus remained prior to the three-week time point. These results suggest that the vaccine virus would remain stable for even longer periods of time in a vitrified format.

Protecting Threatened and Endangered Wildlife

NWRC conducts research to help managers protect threatened and endangered wildlife species. These activities focus on protecting listed species from predation and competition with other wildlife, enhancing recovery programs, and increasing the public's ability to live with introduced and expanding populations of listed species. Predators can have a severe impact on rare and endangered species through predation and competition. NWRC and the Florida Department of Environmental Protection examined the biological and bioeconomic results of predator management relative to sea turtles and shorebirds on two adjacent barrier islands (Cayo Costa and North Captiva) along Florida's west coast. Both islands suffered severe nesting losses due to predation and disturbance by raccoons, while Cayo Costa also was impacted by a large population of feral swine. Prior to predator management by WS operations, no least tern production occurred on either island, and sea turtle nest predation was as high as 74 percent. Following predator management on the islands, Cayo Costa and North Captiva produced 20 and 55 least terns and had 16- and 0-percent sea turtle nest predation, respectively. The entire cost for predator management by experts over the course of the study was $39,636, and the returns in additional production of least tern young and hatchling sea turtles were valued at over $1.1 million.

The puaiohi or small Kauai thrush is an endangered bird endemic to the island of Kauai, Hawaii. The sole population of about 500 birds is currently restricted to remote, high elevation areas of the Alakai Plateau. Puaiohi nest primarily on steep stream-side cliffs, and their distribution and abundance are limited partly by the availability of suitable nest sites. Invasive black rats often eat nesting adults, nestlings, and eggs, and ground-based rodent control has not been effective at reducing nest predation. Researchers at the NWRC Hilo, Hawaii field station investigated whether artificial nest structures might be a viable alternative to rodent control by testing and redesigning nest boxes to find one that was resistant to rats. Field tests of a new rat-resistant nest box are currently underway to determine whether the boxes will be successfully used by wild birds.

Mountain beaver (*Aplodontia rufa rufa)* are endemic to the Pacific Coast of North America and can be found in California, Nevada, Oregon, Washington, and British Columbia, Canada. There are seven subspecies of mountain beaver. The U.S. Fish and Wildlife Service classified one of these subspecies, *A. r. nigra*, as endangered and several other mountain beaver subspecies as populations of concern under the Endangered Species Act. However, in some portions of its range, mountain beaver cause significant damage to forestry interests and are managed as a pest species. NWRC scientists are studying the genetics of mountain beaver to determine whether populations in certain areas are "closed" systems or if individuals move across landscapes to new areas to breed. Understanding the genetic continuity and relatedness of a species across habitats can help determine whether a local population is rare, and should be protected, or whether it is part of a larger genetically similar group. In the later case, more management actions may be available. Such studies are critical for understanding the status of mountain beaver populations and informing wildlife damage management practices.

Protecting Against Invasive Species

NWRC develops innovative strategies to minimize the impacts and spread of invasive wildlife species in the continental United States, its territories and nearby countries or islands. For example, the monk parakeet, an invasive species from South America, has become established in Florida and several other states. Monk parakeets often build their large, bulky nests of twigs and other materials on electric utility structures, frequently resulting in power failures as nest materials and birds come into contact with conductors. NWRC investigated the potential use of diazacon, an oral contraceptive, as a nonlethal method for reducing monk parakeet populations. Results from field studies involving wild monk parakeets showed a 68 percent reduction in the number of young produced by birds feeding on diazacon-treated seeds.

NWRC researchers are also testing fencing designs to limit access of feral swine to agricultural crops. There are more than 4 million feral swine in the United States. Their estimated damage, which totals $800 million annually, does not include costs associated with the spread of disease or the loss of native habitats and species. NWRC researchers have evaluated several fence designs to help prevent feral swine access to domestic swine and agricultural crops. In field trials, NWRC scientists observed a 64 percent decrease in crop damage by feral swine and other wildlife in areas protected by electric fences. In addition to fencing, NWRC researchers are also evaluating feral swine-specific feeders for delivering vaccines or toxicants.

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Protecting Livestock

Protecting livestock from predators and disease is an important part of WS' mission. For example, recent restrictions on the use of traps have led NWRC to test a wider array of nonlethal tools and methods that minimize predation on livestock. NWRC scientists and partners continually work to develop new aversive conditioning devices to keep predators away from livestock. Currently, one study is examining the use of electrified fladry that combines an animal's fear of a novel stimulus with conditioning from an unpleasant electric shock. Fladry is simply a line of flags hung along the perimeter of a pasture. It has a long history of use in Europe to deter wolves. Because wolves are often wary of new or novel items in their environment, they are cautious of crossing the fladry. Studies have shown fladry and electrified fladry effectively exclude wolves from a food resource for short periods of time (1 to 14 days), which may be useful during calving seasons.

Bovine tuberculosis (bTB) is a contagious bacterial disease primarily affecting the respiratory tract of both animals and humans. In the U.S. today, the threat of humans contracting bTB from animals is extremely remote. At risk, however, are deer, other wildlife species and livestock.

Recently, an extensive surveillance program conducted by the Michigan Department of Natural Resources identified raccoons as a host for *Mycobacterium bovis*, the causative agent of bTB. NWRC scientists examined the potential for disease transmission between raccoons and livestock and discovered raccoons used anthropogenic features, such as loafing sheds, barns, and feed storage facilities when they are adjacent to forested habitat. Additionally, while simultaneous use of resources by raccoons and cattle was documented, it was determined that pathogen transmission was most likely to occur through indirect means, such as consumption of infected feed or water. Based on these findings, scientists recommend reducing the likelihood of disease transmission between cattle and raccoons by placing feeding and watering facilities away from forested patches.

Chronic wasting disease (CWD) is a fatal neurological disease that infects elk, white-tailed deer, mule deer, and moose. Realized and perceived CWD threats have significant implications for Federal and State wildlife management agencies, domestic cervid farmers, hunters, and businesses and economies reliant on deer and elk. Prions, the infectious agent of chronic wasting disease, bind to a wide range of soils and minerals, potentially forming environmental reservoirs for infection. NWRC scientists assisted colleagues from the University of Nebraska-Lincoln and Creighton University to test the ability of the commercially available enzyme, Prionzyme™, to degrade CWD prions in soil. Investigators concluded the enzyme, produced by soil bacterium, successfully degraded CWD prions bound to contaminated soil. Although it may be impossible to totally eliminate prions in the environment, a topical enzyme treatment could help limit indirect disease transmission to cervids in some areas, such as captive cervid farms.

NWRC scientists are dedicated to resolving conflicts that occur between people and wildlife. Through their efforts, NWRC scientists provide WS field biologists and those who struggle with wildlife damage an array of tools and methods that they can adapt and employ to resolve wildlife conflicts. NWRC scientists protect the welfare of all animals and look for solutions that are biologically sound, environmentally safe, and socially acceptable. This critical research ensures that the broadest array of wildlife damage management tools will continue to be available for use by WS biologists as well as State wildlife agency professionals, landowners, and others.

Selected Publications

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

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

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

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

PILON, J. L., P. B. NASH, T. ARVER, D. HOGLUND, AND K. C. VERCAUTEREN. 2009. Feasibility of infectious prion digestion using mild conditions and commercial subtilisin. Journal of Virological Methods 161:168-172.

REIDY, M. M., T. A. CAMPBELL, AND D. G. HEWITT. 2008. Evaluation of electric fencing to inhibit feral pig movements. Journal of Wildlife Management 72:1012-1018.

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

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Notable Examples of Significant Research

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WS is a science-based program that relies on research and other independent reviews to assess the need for wildlife damage management, the potential impacts of field work, and the costs and benefits associated with program work. Below are several notable studies compiled by WS and partners that highlight the importance and need for WS' assistance in resolving wildlife conflicts.

Potential economic costs to Hawaii of invasive brown tree snakes.

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

The brown tree snake *(Boiga irregularis)* has caused ecological and economic damage in Guam, and the snake has the potential to colonize other islands in the Pacific Ocean. This study quantifies the potential economic damage if the snake were translocated, established in the state of Hawaii, and causing damage at levels similar to those on Guam. Damages modeled included costs of medical treatments due to snakebites, snake-caused power outages, and decreased tourism resulting from effects of the snake. Damage caused by presence of the brown tree snake on Guam was used as a guide to estimate potential economic damage to Hawaii from both medical- and power outage–related damage. To predict tourism impact, a survey was administered to Hawaiian tourists that identified tourist responses to potential effects of the brown tree snake. These results were then used in an input-output model to predict damage to the state economy. Summing these damages resulted in an estimated total potential annual damage to Hawaii of between $593 million and $2.14 billion. This economic analysis provides a range of potential damages that policy makers can use in evaluation of future prevention and control programs.

Detecting chronic wasting disease.

NICHOLS, T. A., B. PULFORD, A. C. WYCKOFF, C. MEYERETT, B. MICHEL, K. GERTIG, E. A. HOOVER, J. E. JEWELL, G. C. TELLING, AND M. D. ZABEL. 2009. Detection of protease-resistant cervid prion protein in water from a CWD-endemic area. Prion 3:1-13.

Chronic wasting disease (CWD) is the only known transmissible spongiform encephalopathy affecting free-ranging wildlife. Although the exact mode of natural transmission remains unknown, soil and surface water contaminated with urine, feces, saliva, blood and decomposing carcasses from prion infected animals have been implicated as possible transmission vehicles for CWD prions. A prion is an infectious protein particle considered to be the agent responsible for CWD. Detecting vanishingly small traces of prions in environmental samples has not been possible with traditional prion detection techniques. Serial protein misfolding cyclic amplification (sPMCA) holds promise as a new technique for ultrasensitive prion detection. Here NWRC researchers and colleagues show for the first time that sPMCA can detect minute concentrations of protease resistant cervid prion protein (PrPCWD) in experimental samples and in environmental water samples. These results demonstrate the detection of very low levels of PrPCWD in the environment is possible and suggest persistence and accumulation of prions in the environment that may promote CWD transmission.

Repellants for birds.

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

Wildlife repellents provide an additional approach for managing bird depredation to agricultural crops. For the purpose of developing an effective avian repellent, NWRC researchers established repellency thresholds of an anthraquinone-based repellent for Canada geese *(Branta canadensis),* red-winged blackbirds *(Agelaius phoeniceus),* and ring-necked pheasants *(Phasianus colchicus)* in captivity. Anthraquinone, which occurs naturally in some plants, produces a laxative effect when eaten. Results showed 80 percent repellency was produced with threshold concentrations of 1450 ppm anthraquinone for geese, 1475 ppm anthraquinone for blackbirds, and 10,450 ppm anthraquinone for pheasants. These data provide a reliable basis for planning future field applications of anthraquinone-based bird repellents for protection of agricultural crops, property, and related natural resources. Supplemental field efficacy studies are necessary for registration of anthraquinone-based repellents for managing agricultural depredation caused by wild birds.

Immunocontraceptive vaccine for white-tailed deer.

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

The development and use of safe, effective and practical wildlife contraceptive agents could reduce reproduction in locally overabundant deer populations. GonaCon Immunocontraceptive Vaccine (the commercial name for a particular gonadotrophin-releasing hormone [GnRH]-based emulsion) was tested in adult female white-tailed deer in a fenced herd near Silver Spring, Maryland. After receiving one injection of GonaCon, 88 percent of treated deer did not become pregnant during the first year and 47 percent did not become pregnant during the second year after vaccination. NWRC researchers are continuing to investigate ways to reduce localized injection site reactions in vaccinated deer. Treatment with GonaCon can be a safe and effective means of inducing temporary infertility in wild white-tailed deer. Ultimately, the management value of GonaCon will be determined by natural-resource professionals who use it to manage deer reproduction.

Understanding raccoon genetics to prevent the spread of rabies.

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

In the United States, raccoons (*Procyon lotor*) are reservoirs for the raccoon rabies virus variant, which can infect humans and other wildlife species. To combat this threat, Wildlife Services conducts a cooperative oral rabies vaccination (ORV) program in many eastern States. In this study, NWRC, WS' Pennsylvania State office , and the Centers for Disease Control and Prevention determined the genetic structure of raccoons in Pennsylvania and the geographic features (e.g., ridges and valleys), if any, that may hinder or enhance raccoon gene flow (i.e., movement) and the movement of rabies virus by this mammal. Results indicated that there was little genetic differences among the raccoon populations sampled. However, geographic distance was found to impact some of the genetic differences, which suggests that adequate widths of ORV zones are critical for success. The researchers concluded that geographic features within this landscape influence gene flow in raccoons only to a limited extent, and geographic features such as ridges are not substantial long-term barriers to the spread of rabies virus. These results may be of value to inform future ORV efforts in Pennsylvania and other eastern States with similar landscapes.

Avian influenza in mammals.

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

Avian influenza (AI) viruses primarily circulate in wild waterfowl populations and are occasionally transmitted to domestic poultry flocks. However, the possible roles of wild mammals in AI virus ecology have not been adequately addressed. Wild mammals on farms have been identified as a risk factor for AI outbreaks in North America. Currently, serological tests are used to assess domestic poultry, domestic swine and human exposure to influenza A viruses, but these tests have not been validated for use in wild mammals. In this paper, NWRC researchers review existing serological techniques and evaluate their potential usefulness in AI surveillance of wild mammals.

Impacts of invasive frogs to Hawaii.

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

Beard et al. provide an overview of the biology and impacts of the invasive coqui frog *(Eleutherodactylus coqui)* to Hawaii. This nocturnal, terrestrial frog is endemic to Puerto Rico and was accidentally introduced to Hawaii via nursery plants in the late 1980s. Over the past two decades, the coqui frog has spread to the four main Hawaiian Islands, and a major campaign was launched to eliminate and control it. One of the primary reasons this frog has received attention is its loud mating call (85–90 decibels at 0.5 m). Many homeowners do not want the frogs on their property, and their presence has influenced housing prices. In addition, the coqui frog has indirectly impacted the floriculture industry because customers are wary of purchasing products potentially infested with frogs. The frog attains extremely high densities in Hawaii, up to 91,000 frogs per hectare, and can reproduce year-round. Although the coqui has been hypothesized to potentially compete with native insectivores, the most obvious potential ecological impact of the invasion is predation on invertebrate populations and disruption of associated ecosystem processes. Multiple forms of control have been attempted in Hawaii with varying success. The most successful control available at this time is citric acid. Currently, the frog is established throughout the island of Hawai'i but may soon be eliminated on the other Hawaiian Islands via control efforts. Eradication is deemed no longer possible on the island of Hawaii.

Determining allowable take of migratory birds.

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

Legal removal of migratory birds from the wild occurs for several reasons, including subsistence, sport harvest, damage management, and the pet trade. A more reliable method is needed to determine how many birds can be removed from a

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wild population without endangering the future sustainability of the population. In this study, researchers from the NWRC, U.S. Geological Survey and U.S. Fish and Wildlife Service advance a simplified version of the standard harvest theory as a useful method for assessing take, and demonstrate this approach with a case study involving the control of black vultures *(Coragyps atratus)* in Virginia. The formula includes an estimate of the minimum size of the animal population, its maximum growth rate, and a variable by wildlife managers, based on how much they need to reduce population size. Precisely estimating local vulture populations is difficult, due to uncertainties about their lifespan and breeding habits. The researchers relied on annual bird-count data from the Breeding Bird Survey and studies of radio-tagged vultures. This method can be adapted for use with other species and situations, such as the incidental take of depleted species, sport harvest, or nuisance control, and can provide a framework for improving communication and coordination among regulatory agencies and their constituencies.

Evaluating cormorant management.

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

The interior population of double-crested cormorants *(Phalacrocorax auritus)* has shown a substantial resurgence over the past 35 years, from approximately 32,000 breeding pairs in the mid-1970s to more than 226,000 breeding pairs (including the Great Lakes States and Canadian provinces) by the mid-1990s. Diverse management techniques are used to mitigate conflicts between humans and cormorants, including harassment (e.g., pyrotechnics) supplemented by lethal removal. In this study, NWRC scientists evaluated impacts of cormorant harassment programs on the walleye *(Sander vitreus)* fishery in Brevoort Lake, MI, and the yellow perch *(Perca flavescens)* and walleye fisheries at Drummond Island, MI. Cormorant foraging declined significantly at both locations after managers and scientists initiated harassment programs in the spring. Overall, harassment deterred 90 percent of cormorant foraging attempts, with less than six percent of the cormorants taken lethally on average at each site. Yellow perch were a predominant prey item in number and biomass at both locations. Walleye made up a small proportion of the diet at both locations. However, estimated cormorant consumption of walleye at Brevoort Lake accounted for a large percentage of the age-one walleye (between one and two years old). Both walleye and yellow perch abundance increased significantly at Drummond Island following cormorant harassment. Walleye abundance increased to record levels in 2008, following three years of cormorant management at Brevoort Lake. These results support the hypothesis that cormorant predation on spawning aggregations of sportfish was a significant mortality factor, and that cormorant management could reduce sportfish mortality and increase abundance at both locations. Continuation of cormorant harassment programs and fishery assessments will determine whether improvement of targeted sport fisheries is sustainable.

Reducing deer-vehicle collisions.

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

Each year, 1.5 million deer-vehicle collisions (DVCs) occur in the United States resulting in more than $1.1 billion in damages and injuries, as well as loss of human and animal life. In this study, NWRC researchers investigated different vehicle-mounted lighting systems for warning deer of approaching vehicles. Most cars are equipped with TH lamps, which might not provide the best compliment to deer visual capabilities at night. NWRC scientists measured flight-initiation distance of white-tailed deer to an approaching vehicle relative to lighting scenarios involving standard TH lamps alone and in combination with a HID lamp set to constant illumination or pulsed. Results showed that a combination of standard tungsten-halogen (TH) lamps and constant illumination of a high-intensity discharge (HID) lamp increased the distance in which white-tailed deer reacted to an approaching vehicle, on average by as much as 20 meters. Though the experiment resulted in a more rapid response by deer to approaching vehicles, further studies are needed to account for variations in deer behavior and habitat types. Many factors contribute to the number of DVCs in an area, including deer population, demographics, traffic volume and speed, activity patterns, seasonality, and habitat features. Although the majority of these factors are unchangeable, the ability to develop vehicle lighting systems that enhance deer avoidance may be one factor that could be improved.

Using thermography to detect disease.

DUNBAR, M. R., S. R. JOHNSON, J. C. RHYAN, AND M. MCCOLLUM. 2009. Use of infrared thermography to detect thermographic changes in mule deer (*Odocoileus hemionus*) experimentally infected with foot-and-mouth disease. Journal of Zoo and Wildlife Medicine 40:296-301.

Infrared thermography (IRT) measures the heat emitted from a surface, displays that information as a pictorial representation called a thermogram, and is capable of being a remote, noninvasive technology that provides information on the health of an animal. Foot-and-mouth disease (FMD) is a severe, highly communicable viral disease of cloven-hoofed animals, including cattle, pigs, sheep, goats and deer. Early detection of the disease may reduce economic loss and loss of susceptible wildlife. The objective of this study was to evaluate the use of IRT to detect possible heat changes associated with sites of FMD infection in experimentally infected mule deer (Odocoileus hemionus). Results indicated infected mule deer had a significant foot-temperature rise over the course of the infection. The increase in foot temperatures of these animals is probably associated with inflammation related to the development and occurrence of lesions. Also, the animals' body temperatures elevated significantly from the pre-infection temperature starting the day before any lesions were observed. These observed changes indicate that IRT may be a rapid, remote, and noninvasive method to screen for suspect animals during an FMD outbreak.

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