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FY 2012

Leader in Nonlethal Solutions to Wildlife Damage

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USDA Scientists Apply Expertise to Wildlife Conflicts

The National Wildlife Research Center (NWRC, Center) is a world leader in providing science-based solutions to complex issues of wildlife damage management. As the Wildlife Services (WS) research arm, 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 2012, the majority of NWRC's research funding was devoted to the development or improvement of nonlethal wildlife damage management tools and methods. Many nonlethal methods used today by Federal, State, and private sector wildlife professionals stem from research conducted at or through the Center. Below are a few NWRC studies related to the development of nonlethal tools and methods.

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. Its scientists evaluate and develop methods for managing blackbird damage to sunflower, rice, and corn in the Great Plains; bird damage to fruit crops; Canada goose damage to sprouting crops; European starling damage and diseases in urban areas, feedlots and dairies; and woodpecker damage to utility structures and buildings. Recently, NWRC scientists investigated whether an ultraviolet (UV) cue and a postingestive repellent can be used to condition food avoidance in red-winged blackbirds. Birds use UV wavelengths for plumage signaling and sexual selection. UV cues may also be used for the process of avian food selection. In studies with captive birds, scientists found that birds conditioned with the UV-absorbent, postingestive repellent subsequently avoided UV-reflective food. These findings support the hypothesized function of UV vision for avian food selection, the implications of which remain to be explored for protecting crops from bird damage.

NWRC scientists continue to develop the use of 9,10-anthraquinone (AQ) for repelling birds from newly planted seeds and ripening crops. Anthraquinone, which occurs naturally in some plants, produces a laxative effect when eaten. In addition, anthraquinone absorbs near-UV light that is visible to most birds. As mentioned above, this color cue may facilitate the repellency effect in birds. 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. In related studies, scientists explored whether anthraquinone could help to alleviate non-target hazards associated with rodenticides. Rodenticides, such as zinc phosphide, are often used to control rodent populations that cause damage in croplands and rangelands. Zinc phosphide breaks down rapidly after ingestion and poses little risk to predators and scavengers that might consume poisoned rodents; however, birds that directly consume the rodenticide bait may be at risk. In an effort to reduce nontarget hazards to birds during rodent control efforts, researchers evaluated whether the addition of anthraquinone to rodenticide baits would prevent consumption of the baits by certain birds. In studies involving captive birds, researchers treated 2-percent zinc phosphide baits typically used in rodenticide applications with 2 to 2.5 percent anthraquinone. No mortality or signs of zinc phosphide toxicosis were observed among the 20 Canada geese, 24 horned larks, and 47 ring-necked pheasants that were offered the repellent-treated zinc phosphide baits. Although some geese and pheasants initially sampled treated baits, all birds survived and subsequently avoided treated baits throughout the remainder of the study. Supplemental performance testing and field efficacy studies are necessary for further development of a combined bird-repellent rodenticide bait.

In addition to damaging agricultural crops, birds can cause a great deal of damage to sport fisheries, as well as fish farms and other aquaculture facilities. Aquaculture industry costs associated with bird damage and damage prevention are estimated to exceed $25 million

annually. Currently, NWRC scientists are studying the migratory movements, feeding behavior, and disease ecology of double-crested cormorants, pelicans, and other fish-eating birds. In Michigan, scientists evaluated the utility of cormorant harassment programs for reducing predation on vulnerable spawning stocks of walleye and yellow perch. Overall harassment deterred 90 percent of cormorant foraging attempts, with an average of less than 6 percent of the cormorants taken lethally at each site. Both walleye and yellow perch abundance increased significantly at each location. These results support the hypotheses that cormorant predation on spawning aggregations of sportfish is a significant mortality factor, and that cormorant management can reduce sportfish mortality and increase fish abundance. Continuation of cormorant harassment programs and fishery assessments will determine whether improvement of targeted sport fisheries is sustained.

Foraging wildlife can damage forest resources by reducing productivity or disrupting re-vegetation efforts. NWRC researchers are working to determine how certain wildlife species respond to chemical components in the plants they eat and 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. In other studies, scientists evaluated the effects of the commercial repellent Seadust Wildlife Controllant™ to reduce browse damage by deer. When used during the spring to protect young Douglas fir seedlings during leader growth, seedlings treated with Seadust Wildlife Controllant™ experienced less browse damage than untreated seedlings. Future evaluations will determine if protection lasts through critical wintering periods without reapplication.

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. The NWRC is dedicated to providing a scientific foundation for WS and Federal Aviation Administration (FAA) programs that reduce wildlife collisions with aircraft. Habitat management is fundamental to reducing wildlife use of airfields. NWRC scientists have studied vegetation types and vegetation-management practices to identify strategies for making areas on and near airports less attractive to wildlife. For example, previous NWRC research has shown that grazing Canada geese do not consume endophyte-infected tall fescue. Grasses containing endophytic fungi have several benefits, such as resistance to both grazing and insect herbivory, heat and drought stress tolerance, and increased vigor. More than 200 varieties of turf-type tall fescue are currently available from the turfgrass industry for use in airfield re-vegetation projects. Scientists identified several commercially available tall fescue cultivars, including Titan LTD, 2nd Millennium, and Crossfire II, which grow successfully in airport environments while providing a feeding deterrent to Canada geese. NWRC scientists also are evaluating wildlife use of various agricultural crops to determine whether some may be safe for planting on and near airports. 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. Earlier research by NWRC scientists and aviation industry collaborators set the stage for developing new aircraft lighting systems intended to enhance bird detection of approaching aircraft and, subsequently, escape behaviors. More recently, NWRC scientists and their collaborators at Purdue University and Indiana State University have confirmed that specific light wavelengths and pulse frequencies can alert and evoke earlier escape responses in birds.

To gain a better understanding of avian visual physiology, NWRC scientists and their colleagues studied the distribution of ganglion cells and photoreceptors in the retinas of captive Canada geese, as well as their eye movements and scanning behavior. Overall, researchers found that the Canada goose's visual system is designed to detect objects such as predators and other geese in open terrain. Furthermore, their ganglion cells are arranged in an oblique formation across the retina, which allows the birds to scan the ground and the sky simultaneously when their heads are up and approximately parallel to the ground. The researchers hypothesize that this cell distribution, along with the birds' large eye size, may reduce the need for the birds to move their heads extensively while scanning their surroundings in open environments, whether in flight or on the ground. Thus, Canada geese might have a higher probability than other birds of detecting a light stimulus from an aircraft, particularly from a light that is designed relative to the species' visual capabilities. Future research efforts will examine physiological response by birds to the combination of light wavelength and pulse frequencies (which aid in movement detection) to narrow specifications for candidate lighting systems. Subsequently, the candidate lighting systems will be tested in field experiments involving birds and approaching aircraft exhibiting the specific lighting treatments.

Current NWRC research also protects human health by developing methods to reduce or eliminate disease transmission among wildlife, domestic animals, and humans. In 2009, 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 as part of urban white-tailed deer management plans where traditional options are limited, but it also shows promise in other areas, such disease prevention. For instance, NWRC and its collaborators are investigating the use of a vaccination program for feral dogs and raccoons that includes a combination of GonaCon and rabies vaccines. As these species are often captured, vaccinated for rabies, and released, experts believe additional benefits could be obtained by also contracepting the animals to reduce population densities in certain areas. Studies are also underway to evaluate whether GonaCon prevents the spread of brucellosis in bison. Brucellosis is a zoonotic bacterial disease that causes infertility, abortions, and lowered milk production in cattle, bison, and elk. The disease is transmitted through contact with bodily fluids, such as milk and after-birth tissues, of infected animals. GonaCon could potentially break the cycle of this disease and reduce transmission by preventing reproduction in infected animals.

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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. NWRC researchers are exploring a new oral rabies vaccine (ORV) called ONRAB for use on raccoons and skunks in the United States. In an initial field trial in West Virginia, ONRAB resulted in the highest seroconversion rate in raccoons ever observed for an ORV bait used in the United States, with 49.4 percent of raccoons showing seroconversion post-ORV versus 9.6 percent pre-ORV. In addition to field trials with target species, researchers also investigated the effects of the vaccine on nontarget species including wood rats, eastern cottontail rabbits, opossums, eastern wild turkey, and fox squirrels, all species whose habitats overlap with ORV target species. Study results demonstrated that ONRAB has very minimal and temporary impacts on these nontarget species.

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 researchers investigated whether landscape features could be used to predict predation risk from coyotes and great horned owls on endangered black-footed ferrets. Exposure to areas near likely owl perches reduced ferret survival, but landscape features potentially associated with coyote movements had no appreciable effect on survival. These results suggest that future decisions concerning the location of reintroduction sites should consider the location and distribution of landscape features potentially used by great horned owls.

The American bullfrog is native to wetland habitats in the central and eastern United States. However, during the 1900s, bullfrogs were intentionally released in many western states as a human food source. With their highly competitive nature and large size, these voracious predators eat almost anything from insects and fish to hatchling turtles, snakes, mammals, and other frogs, like the endangered Chiricahua leopard frog. Center researchers modified and tested the effectiveness of a nonlethal, multiple-capture trap for use on bullfrogs. The floating trap was successful, capturing up to seven bullfrogs at one time. The nonlethal floating trap allows for the removal of non-target species and can be used in habitats where bullfrogs and endangered or threatened amphibians co-exist.

Increased snowmobile use and subsequent snow compaction in Canada lynx recovery areas are a concern for recovery efforts. Researchers observed that coyotes used compacted snow trails as transit routes for approximately 35 percent of their travel distance and traveled closer to snow-compacted trails than expected. By facilitating coyote access to winter lynx habitats, snowmobile use may inadvertently allow for increased competition between the two species. These results support the need for wildlife management agencies to consider winter recreational use patterns that may influence the distribution of coyotes in lynx reintroduction areas.

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 rose-ringed parakeet, an invasive species from Central Africa and Asia, has become established in parts of Europe, Japan and the United States. NWRC researchers investigated the potential use of diazacon (an oral contraceptive) as a nonlethal method for reducing rose-ringed parakeet populations. Results from studies involving captive parakeets showed a 54 percent reduction in the number of young produced by birds orally dosed with a solution of diazacon. Based on 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.

Center researchers also investigated methods for flushing invasive brown treesnakes from within cargo shipping containers on Guam. Vapors of three essential oils (cinnamon, eucalyptus, and wintergreen) and two chemicals (chloroform and tetrachloroethylene) were tested to see whether snakes would travel and exit the length of a darkened tube. Vapors of all agents were repellent to snakes, but only chloroform reliably caused snakes to completely exit the tube. These potential new fumigants could improve efforts to prevent the accidental movement of invasive brown treesnakes from the island of Guam.

More than 5 million feral swine in the United States cause more than $1.5 billion in damages and control costs annually. Feral swine researchers are investigating new fencing, traps, toxicants, attractants, bait delivery systems, and vaccines as well as basic questions related to disease transmission, reproductive biology, ecology, population demographics, and economic impacts. A major concern with feral swine is their potential to maintain and transmit diseases to domestic swine. Although dominated by operations that maintain some level of biosecurity, a portion of the domestic swine industry is considered "backyard," or transitional, production. These smaller operations provide opportunities for disease transmission between feral and domestic swine through fence lines and contaminated surfaces. To help aid in disease management, NWRC researchers collected data on feral swine movements, habitat preference, and the influence of boundaries and corridors near 28 small-scale domestic swine facilities in Texas. Data from collared feral swine showed they preferred habitat characteristics commonly found surrounding domestic swine facilities. Feral swine also demonstrated a disproportionate use of specific vegetation types as compared to their availability during both wet and dry periods. Additionally, the presence of paved, two-lane roads influenced movements of feral swine. This information aids in the development of targeted management and eradication strategies near domestic swine facilities, particularly in emergency situations such as disease outbreaks.

Protecting Livestock

Protecting livestock from predators and disease is an important part of WS' mission. For example, restrictions on the use of traps have led NWRC to test a wider array of nonlethal tools and methods that minimize predation on livestock and aid in monitoring predator populations. Recently, scientists and partners evaluated the use of lures and rubbing posts for monitoring coyote and wolf populations. The rub stations successfully gathered enough hair samples to extract DNA. Researchers note that rub stations can be strategically placed in the environment in accordance with specific sampling designs and provide an inexpensive way to monitor populations, estimate abundance and explore genetic diversity. Researchers also are investigating whether select breeds of livestock protection dogs, such as the larger breeds still used in Europe, are effective at reducing livestock losses to larger carnivores, such as wolves

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and grizzly bear. Field work began in January 2013 and will continue for several years. The goal of the study is to identify the best breed(s) of livestock protection dogs to guard herds from grizzly bears and wolves and maintain this non-lethal tool for producers.

To investigate factors influencing calf mortality and producer detection rates, researchers monitored 930 radio-tagged domestic calves at two sites in New Mexico and Arizona. Study areas differed in grazing practices, density of predators (mountain lions, black bears, coyotes, and Mexican wolves), and the amount of effort spent monitoring cattle. Calves selected by predators were, on average, 25 days younger than surviving calves. The results indicate year-round calving, especially in areas with high predator densities, is subject to higher losses primarily because calves are exposed to mortality agents for longer periods rather than having higher natural rates of mortality. Researchers also found a significant difference in producer detection rates likely due to differences in the intensity of monitoring cattle. These findings support changing husbandry practices to limit calving to a seasonal endeavor. Additional studies may also help determine whether paying producers to maintain sustainable predator populations may be a better compensation strategy than paying producers based on verified losses.

Bovine tuberculosis (bTB) is a contagious, bacterial disease primarily affecting the respiratory tract of both animals and humans. In the United States, the threat of humans contracting bTB from animals is extremely remote, but livestock, deer and other wildlife species are at risk. Recently, NWRC scientists and colleagues from APHIS-Veterinary Services, the Tel-Aviv University and Technion-Israel Institute of Technology developed a method for collecting and analyzing volatile organic compounds (VOCs) from cattle. VOCs are organic compounds that often emit unique odors and emission patterns. Because of these unique characteristics, VOCs have been identified as potential tools in disease surveillance. Gas-chromatography and mass-spectrometry analysis revealed the presence of two VOCs associated with a bTB infection in the exhaled breath of infected cattle. Based on these results, a nanotechnology-based array of sensors was then tailored for detection of bTB-infected cattle via breath. The system successfully identified all bTB-infected animals, while only 21 percent of the non-infected animals were classified as bTB-infected (e.g., were false positives). This technique could form the basis for a real-time cattle monitoring system that allows efficient and non-invasive screening for new bTB infections on dairy farms.

Chronic wasting disease (CWD) is a fatal neurological disease infecting 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 CWD, bind to a wide range of soils and minerals potentially forming environmental reservoirs for infection. If the CWD prion is located in the dirt and dust surrounding the farm, inhaling these particles may cause disease. NWRC researchers intranasally inoculated white-tailed deer with a mixture of either CWD-positive or CWD-negative brain homogenate and a montmorillonite clay dust carrier. The deer were euthanized and samples were collected at necropsy for immunohistochemistry analysis. Results show that montmorillonite clay dust is an efficient carrier of CWD. Positive tissues were observed in deer as early as 98 days after the last inoculation. This verifies that the intranasal route is a viable route of infection and that dust, a natural route of exposure, is capable of delivering the infected material intranasally.

NWRC scientists are dedicated to resolving conflicts that occur between people and wildlife. Through their efforts, Center scientists provide WS field biologists, and those who struggle with wildlife damage, an array of tools and methods to employ and adapt to resolve wildlife conflicts. New information and technologies are shared through publications, reports, workshops, and collaborative studies. NWRC scientists protect the welfare of all animals, and they 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, State wildlife agency professionals, landowners, and others.

Selected Publications

AUSBAND, D. E., J. K. YOUNG, B. FANNIN, M. S. MITCHELL, J. L. STENGLEIN, L. P. WAITS, and J. A. SHIVIK. 2011. Hair of the dog: Obtaining samples from coyotes and wolves noninvasively. Wildlife Society Bulletin 35:105–111.

BLACKWELL, B. F., T. L. DEVAULT, T. W. SEAMANS, S. L. LIMA, P. BAUMHARDT, and E. FERNÁNDEZ-JURICIC. 2012. Exploiting avian vision with aircraft lighting to reduce bird strikes. Journal of Applied Ecology 49:758-766.

BRECK, S. W., B. M. KLUEVER, M. PANASCI, J. OAKLEAF, D. L. BERGMAN, W. BALLARD and L. HOWERY. 2011. Factors affecting predation on calves and producer detection rates in the Mexican wolf recovery area. Biological Conservation 144:930-936.

DORR, B. S., S. L. HANISCH, P. H. BUTCHKO, and D. G. FIELDER. 2012. Management of Double-crested Cormorants to improve sport fisheries in Michigan: 3 case studies. Human-Wildlife Interactions 6:140-153.

FERNÁNDEZ-JURICIC, E., B. MOORE, M. DOPPLER, J. FREEMAN, B. F. BLACKWELL, S. L. LIMA, and T. L., DEVAULT. 2011. Testing the terrain hypothesis: Canada geese see their world laterally and obliquely. Brain, Behavior & Evolution 77:147–158.

KIMBALL, B. A., F. PFUND, M. GOURLEY, D. L. GRIFFIN, and J. H. RUSSELL. 2011. Silvicultural Attempts to induce browse resistance in conifer seedlings. International Journal of Forestry Research Article ID 108529.

PELED, N., R. IONESCU, P. NOL, O. BARASH, M. MCCOLLUM, K. VERCAUTEREN, M. KOSLOW, R. STAHL, J. RHYAN, and H. HAICK. 2012. Detection of volatile organic compounds in cattle naturally infected with mycobacterium bovis. Sensors and Actuators B: Chemical 171-172:588-594.

POESSEL, S. A., S. W. BRECK, D. E. BIGGINS, T. M. LIVIERI, K. R. CROOKS and L. ANGELONI. 2011. Landscape features influence postrelease predation on endangered black-footed ferrets. Journal of Mammalogy 92:732-741.

SLATE, D., R. CHIPMAN, K. NELSON, C. CROSON, S. MILLS, C. RUPPRECHT, and K. VERCAUTEREN. Safety and immunogenicity of ONRAB in raccoons and skunks in West Virginia: 2011 field trial report. USDA/APHIS/WS/National Rabies Management Program. Report to USDA/VS/Center for Veterinary Biologics.

SNOW, N., and G. WITMER. 2011. A field evaluation of a trap for invasive American Bullfrogs. Pacific Conservation Biology 17:285-291.

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WASHBURN, B. E., and T. W. SEAMANS. 2012. Foraging preferences of Canada geese among turfgrasses: implications for reducing human-goose conflicts. Journal of Wildlife Management 76:600-607.

WERNER, S. J., S. K. TUPPER, J. C. CARLSON, S. E. PETTIT, J. W. ELLIS, and G. M. LINZ. 2012. The role of a generalized ultraviolet cue for blackbird food selection. Physiology & Animal Behavior 106:597–601.

WERNER, S., S. K. TUPPER, S. E. PETTIT, J. C. CARLSON, and G. M. LINZ. 2011. Anthraquinone repellent to reduce non-target take of non-target birds from zinc phosphide rodenticide applications. Applied Animal Behavior Science 135:146–153.

WYCKOFF, A. C., S. E. HENKE, T. A. CAMPBELL, D. G. HEWITT, and K. C. VERCAUTEREN. 2012. Movement and habitat use of feral swine near domestic swine facilities. Wildlife Society Bulletin 36:130–138.

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Protecting through Scientific Research

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Notable Examples of Significant Research

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Wildlife Services (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 a several notable studies compiled by WS and partners that highlight the importance and need for WS' assistance in resolving wildlife conflicts.

Domestic Calf Mortality and Producer Detection Rates.
BRECK, S. W., B. M. KLUEVER, J. O. PANASCI, T. JOHNSON, W. BALLARD, L. HOWERY, and D. L. BERGMAN. 2010. Domestic calf mortality and producer detection rates in the Mexican wolf recovery area: implications for livestock management and carnivore compensation schemes. Biological Conservation 14(2): 930–936.

In this study, Breck and collaborators addressed factors underlying conflict between carnivore conservation and livestock depredation and posed evidence-based management solutions to reduce this conflict. Specifically, the authors radio-tagged calves on two sites within a Mexican wolf recovery area to investigate factors that influence calf mortality and producer depredation detection rates. Results from nearly 1,000 tagged calves during the 3.5-year effort indicate that year-round calving was associated with higher depredation rates, likely due to longer exposures to predation risk. Consequently, the authors recommended that ranchers use seasonal calving to reduce depredation. The authors also found that production detection rates can be so highly variable that producer reporting may be unreliable and verification compensation programs may be unfair if producer monitoring efforts are not considered. The authors recommended a performance-payment scheme for operator compensation based on conservation outcomes and expected carnivore damage.

Role of Invasive European Starlings in the Spread of Salmonella.
CARLSON, J. C., A. B. FRANKLIN, D. R. HYATT, S. E. PETTIT, and G. M. LINZ. 2011. The role of starlings in the spread of Salmonella within concentrated animal feeding operations. Journal of Applied Ecology 48: 479–486.

More than 200 million invasive European starlings live in the United States. In addition to crop damage and livestock feed consumption, starlings are known carriers of many human and cattle pathogens. In this study, Carlson, Franklin, Linz, and Petit characterized and provided management recommendations for mitigating the disease risks associated with starling use of concentrated animal feeding operations (CAFOs). The authors combined both field evaluations and sampling with laboratory analysis to evaluate the prevalence of Salmonella enterica in European starlings using CAFOs and the relationship between starling numbers, *S. enterica* contamination in cattle feed and water, and cattle infections. The authors found that the numbers of starlings better explained *S. enterica* contamination of cattle feed and water than other variables, including cattle stocking, facility management, and environmental variables. Accordingly, they concluded that starlings were a source *S. enterica* contamination in CAFOs. Their findings provide important support for starling management tools to reduce the amplification and spread of disease within livestock production systems.

Renewable Energy at Airports.
DEVAULT, T. L., J. L. BELANT, B. F. BLACKWELL, J. A. MARTIN, J. A. SCHMIDT, L. WES BURGER, JR., and J. W. PATTERSON, JR. 2012. Airports offer unrealized potential for alternative energy production. Environmental Management 49(3), 517-522.

Currently, productive land use near airports is limited and keeping the land fallow is usually the norm. In this article, DeVault and colleagues estimated that airport properties in the contiguous United States contain approximately 1,276 square miles of idle grasslands—an area larger than the state of Rhode Island. The authors discussed how much of this land could potentially be converted to biofuel, solar or wind production. Since 2009, NWRC researchers have partnered with Mississippi State University researchers to explore alternative uses for lands on and near airports with the goal of reducing wildlife hazards, while also providing a source of revenue for airports. Current research efforts are investigating wildlife use of solar arrays and biofuel crops, such as switchgrass and mixed warm-season grasses. The goal is to identify biofuel crops or other renewable energy sources that are undesirable habitats for wildlife hazardous to aviation. Finding such land uses will not only help reduce wildlife collisions at airports but also promote renewable energy production in areas inappropriate for wildlife conservation.

Improving Rabies Vaccines for Wildlife.
FRY, T., K. VAN DALEN, J. HURLEY, and P. NASH. 2012. Mucosal adjuvants to improve wildlife rabies vaccination. Journal of Wildlife Diseases 48:1042-6.

RABORAL V-RG® is a recombinant vaccine used in oral rabies vaccination (ORV) programs for wildlife in the United States. The vaccine is delivered as a liquid contained within a plastic sachet coated with fish meal or a sachet surrounded within a fish-meal polymer. Under optimal conditions, when the sachet is pierced by an animal, the vaccine is released into the mouth, coating the mucosae. Currently, vaccination rates for raccoons are substantially lower than vaccination rates for gray foxes and coyotes. It is unknown why vaccination rates in raccoons are lower. One reason could be that the vaccine is not as immunogenic in raccoons, suggesting the need for an adjuvant (a substance that enhances the body's immune response). Another reason could be vaccine spillage, suggesting the need for a more viscous vaccine mixture. In this publication, Fry et al. evaluated the possibility of using two benign compounds, chitosan and N,N,N-trimethylated chitosan (TMC), to increase the viscosity of the vaccine and potentially act as adjuvants to improve the immune response in raccoons. Results from studies using captive raccoons suggest that the addition of a TMC adjuvant could increase the vaccine's efficiency and improve overall ORV program effectiveness.

Foraging Preferences of Canada Geese Among Turfgrasses.
WASHBURN B. E. and T. W. SEAMANS. 2012. Foraging preferences of Canada geese among turfgrasses: Implications for reducing human-goose conflicts. Journal of Wildlife Management 76:600-607.

Because of their large size and flocking behavior, Canada geese pose a serious threat to aviation safety. Previous NWRC research has shown that grazing Canada geese do not consume endophyte-infected tall fescue. Grasses containing endophytic fungi have several benefits, such as resistance to both grazing and insect herbivory, heat and drought stress tolerance, and increased vigor. More than 200 varieties of turf-type tall fescue are currently available from the turfgrass industry for use in airfield revegetation projects. In "Foraging preferences of Canada geese among turfgrasses: Implications for reducing human-goose conflicts," Washburn and Seamans identified several commercially available tall fescue cultivars, including Titan LTD, 2nd Millennium, and Crossfire II, which will grow successfully given the environmental conditions found on airfields while providing a feeding deterrent to Canada geese. This information will aid land managers and landscapers in the selection of turfgrasses when aiming to reduce goose foraging in certain areas.

National Detection System for Avian Influenza in Wild Birds.
DELIBERTO, T. J., S. SWAFFORD, and K. R. VAN WHY. 2011. Development of a national early detection system for highly pathogenic avian influenza in wild birds in the United States of America. Pages 156-175 in S. K. Majumdar, F. J. Brenner, J. E. Huffman, R. G. McLean, A. I. Panah, P. J. Pietrobon, S. P. Keeler,and S. Shive, editors. Pandemic influenza viruses: science, surveillance and public health. The Pennsylvania Academy of Science. Easton, Pennsylvania.

It is generally recognized that countries conducting comprehensive disease surveillance in wildlife populations are more likely to understand the epidemiology of specific infectious diseases and zoonotic outbreaks. These countries are better equipped and prepared to develop solutions that will protect humans, agriculture and wildlife. In this book chapter, Deliberto, Swafford and Van Why describe the development and implementation of a nationally coordinated risked based monitoring and surveillance system for detecting highly pathogenic avian influenza virus (HPAIV) into the United States through wild birds. From April 2006 to March 2009, Federal, State, and tribal wildlife and disease experts collected 367,834 wild bird and wild bird fecal samples for testing as part of the Wild Bird HPAIV National Early Detection System. No HPAIV was detected in any wild bird sample. The nationally coordinated system was a targeted, risk based monitoring and surveillance system that systematically collected ecological and avian influenza virus data on wild birds. It capitalized on existing infrastructure and expertise at state and federal agencies. Continued implementation of systems such as the Wild Bird HPAIV National Early Detection System provides the United States with confidence that if an HPAIV introduction were to occur, predefined management activities would be employed to limit viral spread to poultry and humans.

Bird and Rodent Damage Estimates to California Crops.
GEBHARDT, K., A. M. ANDERSON, K. N. KIRKPATRICK, and S. A. SHWIFF. 2011. A review and synthesis of bird and rodent damage estimates to select California crops. Crop Protection 30:1109-1116.

Wildlife damage takes a large toll on U.S. agriculture. In this study, WS economists conducted a comprehensive literature review identifying the magnitude of bird and rodent damage to 19 economically important crops in California. Interviews with agriculture experts provided additional information about damages. Monte Carlo simulations were used to derive summary estimates of damages to each crop. A meta-analysis indicated that summary damage estimates from expert interviews were higher than estimates from field studies and surveys. It was also found that there has been a downward trend over time in damages to almonds and grapes. The results of the study indicate that damages from bird and rodents remain high for many crops and are likely to be economically significant within the State of California.

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Aerial Broadcast Baiting to Reduce Invasive Brown Treesnakes.
CLARK, L. and P. J. SAVARIE. 2012. Efficacy of aerial broadcast baiting in reducing brown treesnake numbers. Human–Wildlife Interactions 6(2):212–221.

The brown treesnake is an invasive predator that was introduced on Guam as a stowaway in cargo after World War II. Since then, the population has exploded, attaining 50 to 100 snakes per hectare in some areas. The snake has caused the extirpation of ten of the 12 native forest bird species on Guam. WS experts work to deter the spread of snakes from Guam to other islands by employing a variety of control methods including hand capture from fences, trapping, toxic bait stations, and canine inspection of outbound cargo. Clark and Savarie investigated aerial delivery of toxic baits as a potential method for a broader landscape control of brown treesnakes. Study results indicated snake activity in the study area was reduced by 80 to 85 percent following the third aerial application of a toxicant bait. Nontarget bait-take was limited. Aerial delivery of toxic baits holds promise as an economical, targeted method to control invasive brown treesnakes over large areas of land.

Bait Delivery to Feral Swine.
CAMPBELL, T. L., D. B. LONG, and G. MASSEI. 2011. Efficacy of the boar-operated-system to deliver baits to feral swine. Preventive Veterinary Medicine 98:243-249.

Feral swine pose a significant disease threat to livestock and humans. Emerging technologies to reduce feral swine disease transmission risks include vaccination and toxicants. However, for these technologies to be appropriate for field application, a feral swine-specific oral delivery system is needed. In this article, Campbell, Long and Massei evaluated the Boar-Operated-System™ (BOS), an oral delivery system designed to provide bait access only to feral swine. Researchers monitored wildlife visitation, bait removal and ingestion at BOS units using motion sensing digital photography and baits containing the bait marker tetracycline hydrochloride (TH). Results showed the BOS largely prevented bait removal by nontarget animals. Of the 81 feral swine and 23 raccoons sampled in the study area, 90 percent and 13 percent, respectively, had TH-marked teeth, indicating that they had eaten bait from a BOS unit. Raccoons likely feed upon bait spilled from the BOS where swine had feed, as none of the surveillance photos showed raccoons gaining direct access to bait in the feeder. With minor modifications, the authors believe the BOS would be a valuable tool for managing feral swine in certain areas.

Aircraft Lighting to Reduce Bird Strikes.
BLACKWELL, B. F., T. L. DEVAULT, T. W. SEAMANS, S. L. LIMA, P. BAUMHARDT, and E. FERNANDEZ-JURICIC. 2012. Exploiting avian vision with aircraft lighting to reduce bird strikes. Journal of Applied Ecology 49:758-766.

Using lights to make aircraft more visible to birds could help reduce the risk of bird strikes. In this study, Blackwell et al. examined how Canada geese responded to the approach of radio-controlled model aircraft: one that resembled a standard civil aircraft (approximately 9 feet in wingspan) with lights on, the same aircraft with lights off, and another radio-controlled aircraft that resembled a raptor in form and paint scheme. Each of the experiment's aircraft—whether lights on, lights off, or the predator-styled aircraft—elicited similar anti-predator responses from the geese, suggesting that the birds treated the aircraft as predators and sought to avoid a collision. However, one of the key findings from the experiment was that the birds responded sooner to the aircraft with lights on. By combining research findings on the visual capabilities of Canada geese with research about responses to approaching aircraft, the scientists hope to lay the groundwork for collaborations with industry to develop new aircraft designs. These new designs could prompt birds to respond sooner, providing more time to avoid midair collisions.

Deer Response to Chemical Content in Plants.
KIMBALL, B. A., J. H. RUSSELL, and P. K. OTT. Phytochemical variation within a single plant species influences foraging behavior of deer. 2012. Oikos 121 (5): 743-751.

NWRC researchers respond to emerging pests and diseases by developing novel methods to reduce damage caused by herbivory. In this study, Kimball, Russell and Ott investigated how black-tailed deer respond to the flavor, color, texture, and smell of plants while browsing. Researchers offered captive and free-ranging deer rooted cuttings and seedlings of western redcedar with varying monoterpene content. Monoterpenes are chemicals found in conifer plants that have a repellent effect on foraging mammals. Experiments demonstrated that browse preference for individual western redcedar plants was a function of the amount of monoterpene in the leaves of the plants. Researchers note that sense of smell may play a significant role in both fine- and coarse-scale browse behaviors of deer as they employ a risk-averse foraging strategy. This information may prove useful for developing "browse-resistant" seedlings for reforestation efforts.

Optimizing Double-Crested Cormorant Management.
GUILLAUMET, A., B. DORR, and G. WANG. 2012. Towards optimized population control efficiency in space and time: A modeling framework adapted to a colonial waterbird. Ecological Modelling 235: 95-101.

The double-crested cormorant is a native North American waterbird that recently expanded its population dramatically. Population control efforts in the United States and Canada attempt to mitigate cormorant damage to natural resources and aquaculture. However, there is currently no coordination among the various stakeholders involved in management activities as well as no attempt to optimize population control efficiency. For the first time ever, NWRC scientists modeled how individual management strategies combined with demographic and ecological factors might affect cormorant populations at various spatial scales and over time. The majority of current management operations are undertaken when colonies are near or at carrying capacity. In contrast, NWRC's models predict that management is most efficient when it is applied to colonies earlier (below carrying capacity) and to more central colonies. Management appears less efficient when colonies are closer to or at carrying capacity. These NWRC-developed simulation tools provide insights into the efficiency gain that can be expected from the coordinated planning of management activities.

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