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Innovative Solutions to Human-Wildlife Conflicts

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The mission of the National Wildlife Research Center (NWRC) is to apply scientific expertise to resolve human-wildlife conflicts while maintaining the quality of the environment shared with wildlife. NWRC develops methods and information to address human-wildlife conflicts related to the following:

- agriculture (crops, livestock, aquaculture, and timber)
- human health and safety (wildlife disease, aviation)
- property damage
- invasive species
- threatened and endangered species

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Cover: The National Wildlife Research Center works with a variety of partners to help resolve human-wildlife conflicts. Many of its research studies are done in collaboration with Wildlife Services' operational employees.

Photos by (top to bottom) USDA, James Mason; USDA, Daniel Quinones; and USDA, Samantha Whitworth. Main photo by USDA, Shane Siers.

Message From the Director

Conflicts between people and wildlife are inherently difficult to resolve. They require a strong understanding of animal behavior and ecology, creativity to adapt and explore new tools and techniques, and a sensitivity to social values and concerns. To successfully address these complex problems, institutions need to establish collaborative partnerships involving experts from a wide range of scientific disciplines, management organizations, and interested stakeholder groups.

As an organization, the National Wildlife Research Center (NWRC) exemplifies this core collaborative strategy. Last year, 86 percent of all NWRC studies included at least one outside partner. In all, we worked with more than 370 State and Federal government agencies, nongovernmental organizations, universities, foreign institutions, and private sector companies or other groups. Each collaboration leveraged assets, which together helped to improve the success of our research and development efforts.

A critically important collaborative relationship is with our own Wildlife Services operational program. Each year, over 25 percent of NWRC's studies are conducted in cooperation with Wildlife Services' State and national programs. These collaborations are valuable for a number of reasons. First, they draw on the diverse and practical experience of Wildlife Services' knowledgeable field biologists and specialists. Second, Wildlife Services is well connected to its regional stakeholders, and as a result, offers important recommendations about field study locations and local contacts to enhance the success of our research efforts. Third, these collaborations allow researchers to test their ideas under practical wildlife management scenarios, thus tying the research and development process into its ultimate goal—to produce practical, economical, feasible, and effective information, methods, and tools for use in wildlife damage management.

Larry Clark, NWRC Director *Photo by USDA, Gail Keirn*

As the business leader, author, and lecturer Joel Barker once said, "Vision without action is merely a dream. Action without vision just passes the time. Vision with action can change the world." It is this combination of vision and action that underlies the collaborative nature of Wildlife Services' research and operational units and leads me to proudly introduce this year's NWRC Accomplishments Report.

Larry Clark, Director
National Wildlife Research Center
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Research Spotlights

The National Wildlife Research Center (NWRC) is the research arm of Wildlife Services, a program within the U.S. Department of Agriculture's (USDA) Animal and Plant Health Inspection Service (APHIS). NWRC's researchers are dedicated to finding biologically sound, practical, and effective solutions for resolving wildlife damage management issues. The following spotlights highlight the breadth and depth of NWRC's research and support services expertise and its holistic approach to addressing today's wildlife-related challenges.

Spotlight: Feral Swine Research Supports Management Efforts

Free-ranging populations of feral swine (also called feral hogs and wild pigs) in the United States are located in more than 35 States. Some experts estimate their numbers at over 6 million, with the largest populations located in California, Florida, Oklahoma, and Texas. This invasive species causes extensive damage and disease threats to crops, public property, native ecosystems, livestock health, and human health.

In 2014, Congress appropriated $20 million to USDA-APHIS to create a collaborative, national feral swine damage management program. The overarching goal of the APHIS National Feral Swine Damage Management Program (NFSDMP) is to protect agricultural and natural resources, property, animal health, and human health and safety by managing damage caused by feral swine in the United States and its Territories. To accomplish this goal, APHIS is working in cooperation with States, tribes, other Federal agencies, universities, organizations, the public, and other stakeholders. APHIS also collaborates with Canada and Mexico to support border activities and exchange information on feral swine disease monitoring and control.

The NFSDMP is led by APHIS' Wildlife Services (WS) program. The NFSDMP uses an integrated approach to feral swine damage management issues, incorporating the latest scientific research, improvements in field tactics, and communication and outreach tools to accomplish its goal.

As the research arm for WS, the NWRC plays a pivotal role in investigating and developing feral swine management tools, damage and disease assessments, and population modeling. Below are highlights of some of the NWRC's recent feral swine research.

Toxicant Bait Formulation

Trapping and aerial gunning are two of the most common methods for controlling feral swine. Toxicants offer promise as another cost-effective management tool because female feral swine and their offspring frequently feed in groups and can be attracted to artificial bait sites.

Since 2013, NWRC researchers have been evaluating sodium nitrite for use as a feral swine toxicant. Sodium nitrite, a meat preservative found in sausage, is proving effective and may someday be used to quickly and humanely remove feral swine.

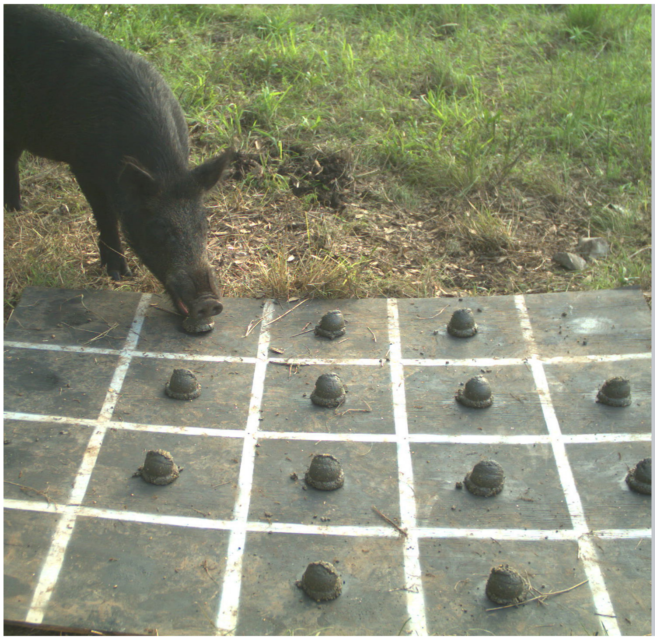
Manage the damage—NWRC research finds new ways to track and prevent feral swine damage.

“Sodium nitrite may be the Achilles heel of feral swine because of their sensitivity to this substance relative to many other mammals,” notes Kurt VerCauteren, a supervisory research wildlife biologist with NWRC. “Since we currently do not have any toxicants registered for use with feral swine in the United States, we’re very interested in evaluating its effectiveness against feral swine and ensuring that it is used in such a way that it isn’t hazardous to nontarget animals.”

Researchers have tested about 20 different sodium nitrite bait formulations to determine the safest and most effective one. A final formulation has been identified and tested—showing 95-percent mortality rates in tests with captive feral swine. APHIS submitted a data registration package and request for an Experimental Use Permit to the U.S. Environmental Protection Agency (EPA) in August 2016. EPA has approximately 18 months to review and approve or request further information on the product. If granted the permit, NWRC and WS Operations will begin field testing the bait on free-ranging feral swine populations in several areas across the country.

As NWRC researchers and chemists continue efforts to register a sodium nitrite toxicant for feral swine, other NWRC experts are evaluating different oil-based bait. The goal is to find a mixture that not only masks the salty taste of the sodium nitrite bait so feral swine eat it, but also minimizes the bait’s appeal to nontarget species.

“We field-tested three different placebo bait mixtures on free-ranging feral swine in south-central Texas,”



NWRC researchers evaluated different oil-based placebo bait mixtures for use with free-roaming feral swine. The goal is to find a mixture that masks the salty taste of a sodium nitrite-based toxicant so feral swine eat it, while also minimizing the bait’s appeal to nontarget species. *Photo by USDA*

says Nathan Snow, a research biologist at the NWRC. The placebo bait mixtures included the following:

- Peanut paste
- Black-colored peanut paste (to make it less attractive to other wildlife)
- Peanut-based slurry with whole-kernel corn

Researchers compared the uptake of the bait by feral swine and other wildlife to a reference food (whole-kernel corn) that feral swine readily eat.

NWRC partnered with the National Agricultural Statistics Service to survey more than 9,500 producers in 11 States about feral swine damage to crops. Feral swine cause more than $190 million in damages each year to corn, soybeans, wheat, rice, peanuts, and sorghum (*pictured*). *Photo by USDA*

The amount of bait eaten was also estimated using remote trail cameras and grid boards. Initially, feral swine did not visit the uncolored peanut paste and peanut slurry mixtures as often as the other bait. This difference eventually subsided, suggesting that feral swine needed time to accept these bait types. Feral swine visited the black-colored peanut paste as often as the whole-kernel corn control bait. They also ate enough of the black-colored peanut paste to have ingested lethal doses of micro-encapsulated sodium nitrite if it had been included in the mixture.

All of the bait mixtures were visited and eaten equally by nontarget species, with the most common species being white-tailed deer and raccoons. As such, researchers are evaluating swine-specific delivery systems designed to keep other wildlife species from accessing the bait.

Economic Damage Assessment

While some estimates exist for localized feral swine damage, there is a need to understand crop damage by feral swine on a national level—how it affects a broad range of crops and regions. To address this need, the USDA National Agricultural Statistics Service administered a survey designed by NWRC researchers to more than 9,500 producers in 11 States: Alabama, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, and Texas. About 4,300 producers of corn, soybeans, wheat, rice, peanuts, and sorghum responded to the survey.

"Our results showed that peanut and corn farmers in the Southeast and Texas experienced the highest yield loss from feral swine," says NWRC economist Aaron Anderson. "However, the economic burden from feral swine was not limited to just crop damage. Producers also spent a great deal on damage management and control costs."

Many growers reported using a suite of control methods, including shooting and trapping. The costs of control measures, as well as losses in yield, were substantial for crop producers, many of whom typically operate on very small profit margins.

Survey results indicate that feral swine damage to crops exceeds $190 million in the United States annually. Though large, this number likely represents only a small fraction of the total damage by feral swine because it includes damage to only six crops.

In a similar study, NWRC economists partnered with Tuskegee University to survey limited-resource farmers* associated with extension services at 1890 land-grant universities across the United States. The survey aimed to understand the extent and types of feral swine damage, as well as the respondents'

* *A person with direct or indirect gross farm sales not more than $176,800 in each of the previous 2 years, and a person with a total household income at or below the national poverty level for a family of four or less than 50 percent of county median household income in each of the previous 2 years.*

preferences toward hunting, potential control methods, and environmental resources in general.

Of the 543 producers surveyed, 35 percent reported feral swine present on their farm in the last 3 years. Thirty-one percent of crops were reported by producers to have experienced feral swine damage during that same time. The estimated crop yield (agricultural output) lost to feral swine damage varied, but was approximately 3 percent across all crops and producers. Twenty-nine percent of respondents also experienced property damage from feral swine. Thirty-three percent of respondents have taken action to control feral swine; the most common actions were shooting, trapping, and hunting with and without dogs. Shooting on sight and hunting with dogs were considered the most effective. The majority of respondents (55 percent) indicated they did not have feral swine and did not want them. Respondents were willing to pay an average of $30 per acre to guarantee that feral swine never spread to their land.

Findings from these surveys will help guide feral swine control efforts and research and serve as a benchmark for evaluating the effectiveness of future control efforts.

Disease Monitoring

NWRC's National Wildlife Disease Program (NWDP) coordinates wildlife disease monitoring and surveillance throughout the United States on a variety of species, including feral swine. Feral swine are known to carry over 30 diseases and 37 parasites that can be transmitted to livestock, people, pets, and wildlife.

To better understand the prevalence of some of these pathogens in feral swine, WS biologists collected serum samples from 3,213 feral swine in 32 States in fiscal year (FY) 2016. The table below shows results of surveillance for six diseases in FY 2016. Classical swine fever only infects swine. Pseudorabies virus can infect swine and a few other species of animals. Swine brucellosis, influenza A virus, toxoplasma, and leptospira are zoonotic diseases, meaning they can infect people as well as animals. These results are all from antibody testing of serum or organ tissues and indicate previous exposure. The tests do not detect current infections.

Researchers conclude that feral swine are a potential reservoir for several endemic diseases found in domestic pigs and several zoonotic agents that can impact people.

Pathogen	Percent Positive FY 2016	Average Percent Positive FY 2008–2015 (Range)	Disease or Illness Caused
classical swine fever virus	0	0	classical swine fever
pseudorabies virus	19.2	12–20	pseudorabies (a type of herpesvirus)
swine brucella	5.3	4–10	brucellosis
influenza A virus	4.8	4–9	influenza
Toxoplasma gondii*	22.9	6–28	toxoplasmosis
Leptospira**	53.1	23–54	leptospirosis

* *Toxoplasmosis testing is done in collaboration with USDA's Agricultural Research Service on samples from selected areas only.*

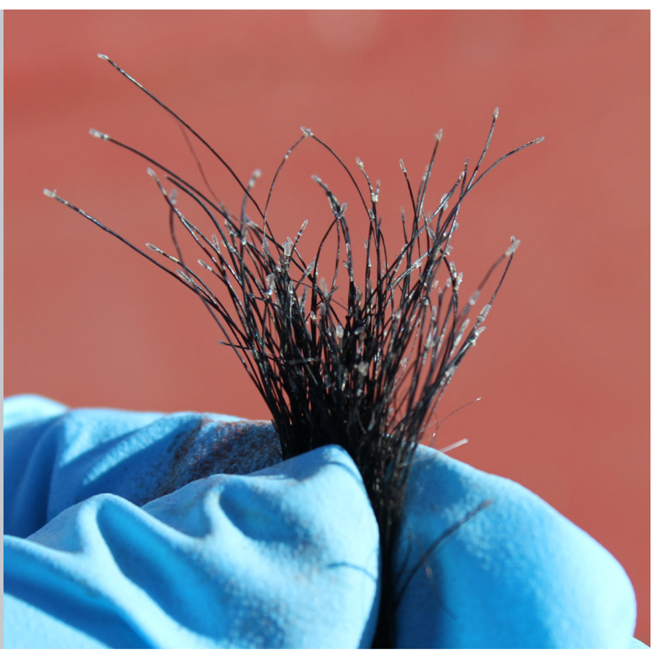
** *Leptospira testing is done with samples from selected areas only.*

Plucking Hairs: New Feral Swine Genetic Archive

NWRC is leading a national effort to create a feral swine genetic archive. WS field specialists in 39 States and Guam are collecting hair samples from feral swine. The samples provide NWRC geneticists with enough DNA to genotype or "genetically fingerprint" individual feral swine. The hairs will help scientists identify and distinguish among current feral swine populations as well as determine their origins.

To date, more than 5,400 samples have been collected by WS biologists and field specialists, with 75 percent of those added to the archive within the last few years. Samples from Canada and Mexico were added to the archive in late 2016.

Analysis so far has revealed nine genetically distinct feral swine populations in the United States associated with: (1) southeastern States; (2) south-central States; (3) Great Smoky Mountains National Park; (4) North Carolina and Virginia; (5) south-central Indiana; (6) west-central Illinois; (7) Oahu, HI; (8) Kauai, HI; and (9) northwest Arizona. Geneticists are also beginning to compare the genetics of emerging feral swine populations with potential source populations (including domestic breeds and wild boar) to help identify the origins of new populations.



Feral swine hair samples are collected opportunistically as part of WS' operational efforts to control feral swine damage. Hair is plucked from the back of the animal and used in genetic studies to help determine the origins of specific feral swine populations.
Photo by USDA, Brandon Schmit

"The genetic insights we're gathering from these feral swine samples will help us determine the effectiveness of current management efforts, as well as how feral swine may be spreading across the country," says NWRC geneticist Toni Piaggio. "For instance, did an emerging feral swine population in Minnesota originate from Texas or Canada? Was this population the result of a failed eradication attempt or the illegal movement of feral swine by people? The answers may help guide future management actions, policies, or regulations."

As the genetic archive continues to grow, NWRC experts will soon have the sample sizes needed to address questions about local or regional processes that influence feral swine expansion and their impacts on native ecosystems.

Monitoring Feral Swine Populations

Knowing how many and where feral swine are in the United States is critical to the success of the National Feral Swine Damage Management Program. Such information not only guides operational and disease mitigation efforts, but also helps evaluate the program's effectiveness.

NWRC modelers developed a method for estimating feral swine abundance before and after management actions based on the number of animals removed and the amount of effort expended to find feral swine ("search effort"). In addition to inferring the proportion of feral swine removed in an area, the population estimation tool allows managers to assess how effective their management actions are by estimating capture rates.

NWRC researchers are investigating compounds that cause permanent sterility in mammals, such as free-roaming dogs and feral swine. *Photo by USDA, Gail Keirn*

Other studies have evaluated the cost-effectiveness of three different techniques for estimating feral swine density. Information on the use of different density estimators has led to the development of an application with a simple graphical user interface. The interface uses a slide bar that can be adjusted to quickly show how changes in the number of samples taken (for example, the number of cameras or traps used) or the length of time spent sampling affects the cost and quality of the estimation tool's answer.

Fertility Control

APHIS views fertility control as a complementary, not an alternative, tool to current invasive species management methods. Although fertility control does not address immediate feral swine damage and disease concerns, it may be useful in certain situations when lethal methods are impractical or infeasible or when the goal is to maintain animal numbers at specific levels. As such, NWRC researchers are investigating potential methods to cause permanent sterility in feral swine.

Successful reproduction in feral swine and other mammals depends on an adequate number of healthy oocytes (eggs) being maintained within the ovaries over the lifetime of the animal. There is only a finite number of oocytes in the ovaries of mammals, which if destroyed would leave the animal permanently sterile.

NWRC and university researchers are investigating whether oocytes utilize clathrin-mediated endocytosis (CME), a process by which cells actively internalize hormones, proteins, and other compounds. Researchers used fluorescent immunohistochemistry to show that clathrin and dynamin II (two key components of CME) are present in oocytes at all stages of maturation. This suggests CME may occur in feral swine oocytes. Further research is underway to characterize the internalization process and identify compounds that trigger CME. Researchers hope they can use this process to deliver chemosterilants specifically to the oocytes and cause permanent sterility.

Next Steps—NWRC is exploring the use of unmanned aerial vehicles (UAVs) to locate feral swine and assess their damage to crops and natural resources. Experts are looking into whether UAVs can cover more area, more cost effectively than ground-based assessments. NWRC experts also are using models to estimate feral swine abundance and distribution across the United States and are evaluating different data collection techniques and strategies for feral swine disease surveillance.

Spotlight: Managing Predator Damage With Nonlethal Methods

Predators, such as coyotes, wolves, mountain lions, bears, and feral dogs, are responsible for millions of dollars in livestock losses each year. Such losses can be devastating to livestock producers, causing some individuals to lose their livelihoods.

Conflicts among people and predators, such as black bears and coyotes, in urban areas are also a cause for concern. These urban encounters are increasing and can result in damaged property, harm to or loss of pets, and injuries to people.

NWRC researchers work with WS field staff to develop, test, and evaluate new and existing predator damage management tools and techniques for reducing impacts not only to livestock, property, and human safety, but also natural resources such as endangered species and game animals.

Nonlethal tools for protecting livestock include fencing; predator sterilization; livestock protection dogs or other guard animals (llamas, donkeys); shepherding; night penning; lambing pens; and other good husbandry practices. To prevent urban wildlife conflicts, methods include public outreach, keeping pets indoors overnight, removing trash and other attractants, hazing to keep wildlife away, and not feeding wildlife.

Researchers at NWRC's Utah field station are leaders in designing and carrying out studies to evaluate predation and predator damage management methods. The summaries below highlight recent research and outreach efforts related to nonlethal methods for managing predator damage in rural and urban areas.

Livestock Protection Dogs

Ranchers and herders around the world have used guarding dogs for centuries to protect livestock, and "man's best friend" remains one of the most often used nonlethal methods to manage predation damage today. Without guarding dogs, thousands more sheep, lambs, and calves would be killed or injured each year.

Over the last 30 years, U.S. sheep operators have stepped up use of nonlethal methods to protect their flocks, especially livestock protection dogs. In 1994, 28 percent of sheep operations used dogs for protecting sheep, with that number growing to 40 percent in 2014.

Since the successful reintroduction and spread of wolves throughout the Rocky Mountain region, livestock protection dogs are now being challenged with larger, more formidable foes. When coyotes were the primary predator, U.S. ranchers relied on readily available Old World dog breeds such as the Great Pyrenees (France), Anatolian shepherd (Turkey), and Akbash (Turkey). These breeds offered good protection against coyotes and other predators of this size, and they are still in service in certain regions.

Yet today, larger predators such as wolves and grizzly bears are challenging, outnumbering, and ultimately killing these dogs. The NWRC has taken the lead to evaluate other larger and more robust Old World dog breeds that may be more capable and better suited to withstand conflicts with larger predators.

Researchers at NWRC's Utah field station are leaders in designing and carrying out controlled studies to evaluate predation and predator damage management methods.

"Unfortunately, many of the dog breeds most commonly used are struggling in areas with larger predators, such as wolves and grizzly bears, which are becoming more prevalent," notes NWRC supervisory research wildlife biologist and Utah field station leader Julie Young. "Finding suitable dog breeds for use as livestock protection dogs against wolves and bears not only helps us safeguard livestock and the livelihoods of ranchers, but also enhances and encourages coexistence between people and large predators."

Ideally, these new dog breeds would be bold toward predators, tolerant of people, and athletic enough to thrive in the rugged and remote settings where livestock and large carnivores co-occur.

Three breeds—Karakachans (Bulgaria), Kangals (Turkey), and Cão de Gado Transmontanos (Portugal)—are part of a study in the northwestern States of Montana, Wyoming, Idaho, Washington, and Oregon. Data collection, including global positioning system (GPS) collars on the dogs, sheep, wolves, and grizzly bears, is focused on determining which, if any, of these breeds are better suited to reduce large predator conflicts with livestock. If the research finds these breeds are more effective in preventing predator attacks and protecting livestock, WS will identify and develop the most effective training and management practices to help producers use the dogs on their own farms.

Preliminary results from the research look promising. All of the imported dog breeds show high fidelity to their sheep, meaning they stay close to their herds. The dogs distinguish between experimental wolf and deer decoys and respond appropriately toward the wolf decoys (for example, they bark, move toward the decoy, and group sheep). Trail cameras and space-use data also confirm that the dogs, sheep, wolves, and grizzly bears share the same habitat during the grazing season, but more analysis is underway to see how often overlap and interactions

A Karakachen livestock protection dog stands guard over his flock of sheep. This dog breed from Bulgaria is one of several European breeds being evaluated by NWRC and Utah State University researchers to help protect livestock from wolves and grizzly bears.
Photo by Patrick Schirf

occur. Fieldwork was completed in October 2016, and ongoing data analysis will help determine whether certain dog breeds are better at deterring grizzlies versus wolves or whether some are more effective in different environments such as forested, open, or fenced landscapes.

While WS has taken the lead to identify more effective breeds to circumvent wolf and grizzly bear confrontations with livestock, it has also worked to reduce potentially threatening confrontations between livestock protection dogs and humans. More people are using public lands for recreation, often in areas that are also used for livestock grazing.

Unfortunately, conflicts with people and livestock protection dogs have occurred. Mountain bikers have triggered protective behaviors by some dogs, resulting, in at least one instance, in injury to people. Additionally, increasing urbanization has led to conflicts between livestock protection dogs and residents in historically rural areas. As a result, land managers are considering the need to keep sheep farther from recreational trails, and some ranchers are proactively exposing dogs in training to bicyclists.

In collaboration with the USDA Forest Service, the Bureau of Land Management, and the American Sheep Industry Association, WS created informative signs and brochures about livestock protection dogs and is distributing the materials in areas where the dogs and public may intersect. Trailheads, visitor centers, and highway fences are just a few of the places where people may encounter these informational signs, which offer suggestions for appropriate behaviors around the dogs and the flocks they protect and also explain the purpose and need for livestock protection dogs.

Fladry

Fladry is a tool used to protect livestock from predators, such as wolves, in smaller areas like calving and lambing grounds. It is not effective on large, open rangeland where livestock are dispersed across broad ranges. Fladry is made of a line with brightly colored flags hung at regular intervals. For extra protection, the line carrying the flags can be electrified; this is called “turbofladry.”

Because wolves are neophobic (afraid of new things, such as fluttering flags), they are cautious about crossing the fladry barrier—at least for a few weeks. But that added time of protection may be enough to protect calves and lambs during critical periods.

The NWRC played a large role in developing and testing both fladry and turbofladry. NWRC continues this research by addressing technical problems with its use. Perhaps one of the more important problems is that the flags hanging off the line can coil up around the line when it is too windy or in dense vegetation. This creates gaps through which predators can pass, and once a fladry line is crossed, the fear associated with its novelty ends.

“We tested seven fladry designs made from rip-stop nylon and marine vinyl. Our goal was to identify one or two designs that not only resist coiling, but are also economically feasible alternatives to traditional fladry,” says NWRC supervisory research wildlife biologist Julie Young.

Eighty-four strands of fladry were developed and installed in fields at the NWRC Utah field station. The strands were checked, and the percentages of coiled and frayed flags were recorded each day for 47 days. Wind speeds recorded from a nearby weather station confirmed that the fladry experienced wind conditions known to cause coiling.

Flags made from marine vinyl held up better and coiled less often than rip-stop nylon. Although marine vinyl outperformed rip-stop nylon, it also cost and weighed more. Its cost is likely offset by its ability to last longer, but its added weight may cause

Fladry is a nonlethal predation damage management tool that consists of a line of brightly colored flags hung around pastures. Because of its novelty in the environment, predators such as coyotes and wolves are cautious of crossing the fladry barrier. NWRC researchers evaluated the effectiveness of several different fladry designs.
Photos by USDA

a problem for producers carrying it to remote areas using pack animals or backpacks.

The shower-curtain design (see “d” in image above, where the flags are attached via circular links) and the top knot (see “g” above, where a knot is tied in the flag below its point of attachment) experienced the least amount of coiling. Researchers noted the top knot flags did not move as much as the other flag designs and cautioned that decreases in flag movement may impact the fladry’s effectiveness. Researchers completed tests of both designs with captive coyotes, and preliminary results showed no difference in efficacy. Further tests in areas with wolves and coyotes are still needed to determine which may be most effective at reducing damage.

As producers learn more about fladry, NWRC experts hope the tool will become more common in areas where wolves (or coyotes) and sheep coexist.

Interactions between large carnivores and people are on the rise. NWRC researchers and partners are studying how coyotes and black bears have adapted to urban living and ways that people can help prevent conflict and minimize use of lethal management techniques.
Photo by USDA, Sharon Poessel

Urban Bears and Coyotes

Interactions between large carnivores and people are on the rise across the country. The cause of the increase is attributed to many things, including the loss of natural habitat, more people living and recreating in wild areas, and animals' abilities to adapt to and exploit human environments.

NWRC is collaborating with State, Federal, and university researchers to study how two large carnivore species—coyotes and black bears—have adapted to urban living and ways that people can help prevent conflict and minimize the use of lethal management.

Since 2005, NWRC research wildlife biologist Stewart Breck and researchers from Colorado Parks and Wildlife have studied black bear movements, ecology, and behavior in mountain cities in Colorado. "One of the more long-term and sustainable strategies for reducing human-bear conflicts in urban and suburban areas is the elimination of human-related food sources, such as trash, bird feeders, and pet food," says Breck. "This multi-year study has shown how bears have altered their ecology to take advantage of human food sources and how managers can most effectively invest their time and resources to reduce problems."

Results from radio-collared black bears show that bear locations and activity patterns were dependent on the availability of natural foods: bears became more nocturnal and used urban areas in poor food years, but switched back to natural areas in subsequent good food years. Researchers also noticed that garbage was the main food source for bears foraging in urban areas. Selection of foraging sites was influenced not only by the presence of garbage, but also by proximity to riparian habitat and the presence of ripe cultivated fruit trees. While 76 percent of the garbage containers at random locations were bear-resistant, 57 percent of these bear-resistant containers were not properly secured. Researchers recommend that wildlife managers focus on making urban environments less attractive to bears by reducing available garbage and fruit trees, especially near riparian areas. Also, public outreach and proactively enforcing bear-resistant container laws can help ensure garbage is properly secured and ultimately reduce human-bear conflict.

In a similar study exploring the behaviors of urban coyotes in the Denver Metro Area, researchers analyzed data from 24 radio-collared coyotes to learn more about coyote movements and behavior, home range sizes, diet, disease status, and the effectiveness of hazing for reducing negative interactions with coyotes. A concurrent citizen science program also recorded coyote behavior and interactions with people and domestic pets.

Results demonstrate how coyotes have adapted to urban living by staying relatively inactive during the day and venturing throughout urban/suburban neighborhoods at night. Not surprisingly, the diet of urban coyotes varies greatly, including rodents and rabbits, many different fruits from native and introduced plants, and occasionally a cat or dog. The research team also found that urban coyotes adapted to show bolder behavior, especially toward people. These results led to a study of how hazing performed by citizens in Denver helped reduce conflict. The researchers found that hazing can be an effective short-term solution for reducing dangerous interactions with coyotes but that sometimes individual coyotes become severe problems that do not respond to hazing. In these cases, Breck and his team recommend humane removal as the best management decision.

Predation Damage Management Workshops

WS partners with State agencies, universities, and producer associations to host training courses and workshops that showcase new and existing tools and techniques to help prevent livestock predation. Over the last few years, nonlethal predation damage management workshops have been held in California, Colorado, Idaho, Minnesota, Montana, Nevada, North Dakota, South Dakota, Oklahoma, Oregon, Texas, Utah, and Wisconsin.

As the research arm for WS, NWRC supports these workshops by providing experts and information on the latest predation damage management research.

"I and others at NWRC have taken an active role in attending and presenting information at WS' predation damage management workshops. It gives us an opportunity to share and discuss our research results directly with producers and conservationists," says NWRC supervisory research wildlife biologist Julie Young. "We can hear their concerns and challenges, which helps us to design more practical and feasible damage management tools."

Workshop attendees represented a broad range of interests and expertise, including livestock production, animal welfare and conservation, and State and Federal wildlife management. About 2,000 participants have attended the workshops to date, with the majority being livestock producers. Responses to the workshops have been positive, including support from animal conservation and welfare groups, livestock producers, and resource managers alike.

Next Steps—Future research on predation damage management issues will include expanding the urban coyote study to investigate the role of genetics and learning in coyote behavior, evaluating the impact of different surgical sterilization techniques on coyote pair bonding, and assessing the role of husbandry and range riders in reducing grizzly bear predation on cattle.

About 2,000 participants have attended Wildlife Services-sponsored predation damage management workshops since 2014. The workshops give ranchers, conservationists, and natural resource managers information on the latest tools and techniques to help prevent livestock predation. *Photo by USDA, John Steuber*

Spotlight: Wildlife Rabies

Rabies is an acute, fatal viral disease—most often transmitted through the bite of a rabid mammal—that can infect people, domestic pets, livestock, and wildlife. The majority of rabies cases in the United States occur in wildlife, including raccoons, skunks, foxes, and bats. Impacts to society from this and other wildlife diseases can be great. For instance, the cost of rabies detection, prevention, and control work in the United States exceeds $300 million annually.

Since 1995, WS' National Rabies Management Program (NRMP) has been working cooperatively with local, State, and Federal governments, universities, and other partners to address this public health problem. They distribute oral rabies vaccine (ORV) baits in targeted areas to halt the spread of and eventually eliminate rabies in land-dwelling (terrestrial) wildlife in the United States. This cooperative program targets species such as raccoons, skunks, coyotes, and gray foxes. NWRC researchers support these efforts by researching the behavior, ecology, movement, and population structure of raccoons and other wildlife hosts. NWRC also evaluates methods and techniques to vaccinate wildlife against rabies; the goal is to decrease the number of animals carrying and potentially spreading the disease in the wild. Below are a few case studies highlighting these efforts.

The WS National Rabies Management Program uses a variety of oral rabies vaccine baits to target wildlife species. In 2006, NWRC researchers conducted field trials in several States with the ONRAB bait *(far right)*. The new bait is currently registered in Canada for use with raccoons and skunks. *Photo by USDA*

Testing New Rabies Vaccine Baits

NWRC researchers are exploring a new ORV product called ONRAB for use with raccoons and skunks in the United States. Field trials have been completed in four targeted regions, and three additional studies are ongoing to evaluate its safety and immune effects.

"The National Rabies Management Program hopes to improve the effectiveness of its vaccination programs for raccoons and skunks. The current registered ORV product, RABORAL V-RG, has been successful at halting the westward spread of raccoon rabies, but the vaccination rate with this product may not be sufficient for the purpose of eliminating raccoon rabies," says NWRC research biologist Amy Gilbert. "The new ONRAB bait product is showing promise at improving vaccination rates."

The multiyear field trial in New Hampshire, New York, and Vermont resulted in the highest vaccination rates observed in raccoons after ORV treatments. On average, raccoons showed a vaccination rate greater than 70 percent—a level high enough to eliminate raccoon rabies across broad landscapes.

In 2016, NWRC presented the field trial results to an interdisciplinary panel of rabies and wildlife experts, who used the data in formal recommendations to the NRMP on a comprehensive 30-year strategy to eliminate raccoon rabies in the United States. NWRC also reported the ONRAB field trial results to the USDA Center for Veterinary Biologics; the

Rabies is one of the oldest known viral diseases, yet today it remains a significant wildlife-management and public-health challenge.

information helped support a formal product review and potential product registration by industry. If registered, this new vaccine will offer an added tool in NRMP's efforts to eliminate the raccoon strain of rabies in the United States.

Estimating Mongoose Densities for Rabies Management

The small Indian mongoose *(Herpestes auropunctatus)* is an invasive species that is a reservoir for rabies in Puerto Rico. Mongooses were introduced to the island during the 19th century to control rats on sugar cane plantations.

"Mongooses account for more than 70 percent of the reported rabies cases in Puerto Rico," says NWRC wildlife biologist Are Berentsen, who has been studying the species on Puerto Rico and other islands. "An average of 280 Puerto Ricans are bitten each year by mongooses. Currently, no rabies vaccination program for mongooses exists on the island, and the vaccination of pets and domestic animals is limited."

In the continental United States, the NRMP coordinates efforts to keep terrestrial rabies from spreading in raccoons, coyotes, and gray foxes. These efforts mainly involve enhanced rabies surveillance and an ORV program. The ORV program distributes bait by aircraft or hand. The number of baits distributed depends on the population size and density of the target species.

Body measurements and blood samples are taken from a captured invasive Indian mongoose in Puerto Rico. The animal is also fitted with a radio collar as part of a study to determine their movements and population density. The information will help with rabies prevention and control. *Photo by USDA*

To see the potential for an ORV program on Puerto Rico for mongooses, NWRC researchers collected data on mongoose population dynamics, distribution, and density within two different ecosystems on the island—Cabo Rojo (Cabo Rojo) National Wildlife Refuge, made up of forest-scrub and grasslands; and El Yunque (El Yunque) National Forest, a subtropical rainforest.

“We trapped mongooses in both areas and then estimated their density using four different methods,” says NWRC biologist Shylo Johnson.

The density estimation methods included: (1) a mongoose density index (MDI) adapted from the NRMP raccoon density index, (2) capture-mark-recapture, (3) spatially explicit capture-recapture, and (4) examining spatial distribution of mongooses within the study plots.

“The MDI method gave us the lowest density estimates. It also showed a seasonal difference with greater densities of mongoose during the wet season (55 mongooses per kilometers^2 [km^2]) than the dry season (34 mongooses per km^2) at Cabo Rojo. At El Yunque, MDI detected 33 and 49 mongooses per km^2 in the dry and wet seasons, respectively,” continues Johnson.

Researchers concluded the MDI estimation model can be used to inform bait distribution strategies and maximize ORV bait uptake by mongooses.

Future NWRC studies likely will focus on bait consumption by nontarget species and habitat features influencing where mongooses live and move in the different regions of Puerto Rico.

Heating Up: Rabies and Vampire Bats

Although NWRC rabies research focuses mainly on terrestrial mammals, NWRC geneticists recently studied the potential for vampire bat populations to expand into the southern United States.

The common vampire bat feeds on the blood of livestock and other wildlife in Latin America. These bats also sometimes bite and feed on human blood and are currently the most important reservoir and vector of rabies to cattle and people in Latin America.

Recently, vampire bats have been documented within 35 miles of the Texas border. This has caused concern and speculation about their potential movement to areas within the United States due to rising global temperatures. To better understand the likelihood of such movement, NWRC geneticist Toni Piaggio partnered with U.S. Geological Survey scientist Mark Hayes to analyze and map the possible distribution of vampire bats under various climate scenarios.

“Because there are relatively high numbers of cattle and other livestock in northeastern Mexico and southern Texas, wildlife managers and ranchers are concerned that vampire bats could survive in these areas and spread disease,” says Piaggio. “This could have serious economic impacts to livestock producers since vampire bat bites are known to weaken cattle, reduce milk production, and cause secondary infections and sometimes death, especially if cattle contract rabies.”

Piaggio and Hayes used more than 7,000 reports of vampire bats in northern Mexico and 5 modeling approaches to map the species’ potential distribution along the U.S.-Mexico border through the year 2070. They then used the models’ results to reflect future climate scenarios.

“Our analysis suggests it is possible that vampire bats could expand their range into the United States—most likely into the southern tip of Texas and Florida. However, their range may be limited by winter temperatures. We suggest continued monitoring for vampire bats along the Gulf coastal plains and southern Texas plains in the coming decades,” says Piaggio.

Learning more about the potential northward spread of vampire bats gives disease specialists, health officials, wildlife managers, and livestock producers valuable information in the fight against rabies. In 2016, the NRMP worked with WS programs in Arizona, Florida, and Texas to develop and carry out a vampire bat rabies monitoring pilot program along the U.S.-Mexico border and in southern Florida. WS and cooperators also distributed over 800 copies of an educational DVD titled "Vampire Bats and Cattle" (which WS created in 2015) to livestock owners and government officials in the United States and Mexico.

Improving Vaccine Technology

In December 2015, the U.S. Patent and Trademark Office issued a joint patent ("Adjuvanted Rabies Vaccine with Improved Viscosity Profile" [US 9,216,213]) to NWRC researchers and their Merial Ltd. cooperators for a new technology to intensify immune responses in raccoons to rabies vaccines. This technology uses two benign compounds, chitosan and N,N,N trimethylated chitosan (TMC), to enhance the body's immune response to the RABORAL V-RG oral rabies vaccine. The compounds thicken the vaccine. This helps increase the amount of oral contact the raccoons have with the vaccine.

"The RABORAL V-RG vaccine is delivered as a liquid in a plastic sachet. Under optimal conditions, when an animal's teeth pierce the sachet, the vaccine is released into its mouth and absorbed," explains NWRC research biologist Amy Gilbert. "While foxes and coyotes tend to pick up the entire bait with their mouths, releasing a full dose of vaccine as they chew, raccoons and skunks sometimes hold the vaccine sachet on the ground and bite only small portions at a time, allowing the open sachet to leak."

Chitosan is deacetylated chitin, a compound found naturally in crustaceans, insects, and mushrooms. When chitin is converted to chitosan and added to a vaccine, it improves the transport and absorption of the vaccine. In NWRC studies, adding TMC to existing RABORAL V-RG bait allowed raccoons to consume baits more easily and without leakage, and it did not interfere with the vaccine-induced immunity. NWRC is now seeking licensing partners for this new technology.

Recent analysis by NWRC and U.S. Geological Survey scientists suggests it is possible that vampire bats could expand their range into the United States. Wildlife managers and ranchers are concerned the bats could spread rabies to livestock, wildlife, and people.
Photo by USDA, Luis Lecuona

Next Steps—Future NWRC rabies research will focus on the ecology and densities of targeted (raccoon) and nontargeted (opossum) wildlife species in the southeastern United States and their impacts on vaccine bait consumption. Researchers will also continue studies on the effectiveness of various vaccine bait shapes, sizes, and attractants to improve bait consumption by skunks. Work in Puerto Rico with mongooses will focus on conducting and evaluating the first placebo vaccine bait drop to optimize baiting strategies and densities on the island.

2016 Accomplishments in Brief

NWRC employs about 150 scientists, technicians, and support staff who are devoted to 17 research projects (see Appendix 1). Below are brief summaries of select findings and accomplishments from 2016 not already mentioned in this year's report.

Devices

- **Automated Aerial Bait Delivery System for Brown Treesnakes.** Since 1994, WS has systematically developed and evaluated tools to control invasive brown treesnakes on Guam. These tools include snake traps, baiting stations, snake-sniffing detector dogs at ports and airports, chemical repellents, and fumigants. A crucial next step in controlling brown treesnakes over large areas—including remote and inaccessible parts of Guam—is to create an effective way of delivering toxicant baits aerially.

  NWRC worked with Applied Design Corporation, a private engineering firm, to design such a system. The result was a machine-made bait cartridge and a global positioning system (GPS)-enabled, automated delivery system that can rapidly and accurately deliver baits from an aircraft over large forested areas. The technology uses acetaminophen-treated dead mouse baits attached to biodegradable streamer-like cartridges. Acetaminophen is registered with the U.S. Environmental Protection Agency (EPA) as a brown treesnake toxicant. Launched from a helicopter or airplane, the baits are designed to snag in trees where the snakes feed. The system delivers baits at a rate of up to four per second, ensuring proper bait coverage in Guam's dense forest canopies.

  In 2016, NWRC and its partners at the U.S. Department of the Interior (DOI) and U.S. Department of Defense (DoD) tested this new system, deploying baits from a helicopter on a 270-acre site within Andersen Air Force Base. Researchers will monitor snake activity at the site through 2017 to determine impacts of the baiting and guide future control efforts. Initial results from the bait drops show a reduction in snake activity. If successful on Guam, the device could be adapted for other invasive species management efforts. *Contact: Shane Siers*

- **Promising New Bait for Brown Treesnakes.** For many years, dead neonatal mice have been the "gold standard" lure for baiting invasive brown treesnakes on Guam. Yet, finding, keeping, and using mice can be costly and messy—not to mention that a dead mouse bait in the tropics can decompose quickly, making it unacceptable to snakes. Recently, NWRC tested a new brown treesnake bait made of processed meat and an artificial mouse fat mixture. Results showed the new bait was eaten by snakes at rates similar to the current dead mouse bait. It also remained viable and lasted longer under field conditions. Researchers are continuing to streamline the manufacturing process for the new bait. Estimates indicate that each new bait could be about $0.50 less than the current mouse bait, which would lower the costs of brown treesnake control efforts. *Contact: Bruce Kimball*

Pesticides

- **Reducing Active Ingredients in Rodenticides.** Historically, vole damage to artichokes has been managed using first-generation anticoagulant rodenticides. These rodenticides were effective for many years until voles began to develop a resistance to them. In efforts to find new tools, NWRC researchers and colleagues at the University of California tested the effectiveness of rodenticides using cholecalciferol (vitamin D3) and diphacinone (a first-generation anticoagulant). By combining these compounds, researchers hope to develop a safer and more effective management tool. Under normal conditions, vitamin D helps the body maintain appropriate levels of calcium. However, toxic doses of cholecalciferol cause high levels of calcium in the blood, which affects organ functions. NWRC researchers found that adding a small dose of cholecalciferol to diphacinone bait is effective against voles resistant to anticoagulants. The combination also reduces risks to other wildlife; it uses lower concentrations of both compounds and shortens the vole's time to death.
  Contact: Gary Witmer

- **Secondary Hazards of Prairie Dog Rodenticide Bait.** Animals and carcasses that contain residues from anticoagulant rodenticides can poison wildlife, hampering conservation efforts and contaminating the environment. Consequently, secondary hazards to mammals and birds that eat treated animals are a concern among land managers. NWRC researchers studied one commonly used pesticide, Rozol Prairie Dog Bait (chlorophacinone 0.005 percent), to better define its impacts on wildlife. Rozol Prairie Dog Bait is registered to control black-tailed prairie dogs in 10 States throughout the mid-western and western United States. The researchers fed Rozol Prairie Dog Bait to captive black-tailed prairie dogs for 2 days and analyzed their livers and whole bodies (without livers) for chlorophacinone residues.

  Results showed the greatest levels of residues in livers and whole bodies after 3 days. Residues in both tissues declined rapidly over time, with estimated half-lives of about 6 days post-exposure. However, a risk assessment of secondary toxicity

NWRC worked with a private engineering firm to design a machine-made, biodegradable bait cartridge (*photo*) and a GPS-enabled automated delivery system that can rapidly and accurately deliver acetaminophen-treated dead mouse baits from an aircraft to control invasive brown treesnakes. The bait is designed to snag in trees where the snakes feed.
Photo by USDA

NWRC researchers studied potential secondary risks to predatory and scavenging mammals and birds associated with rodenticide residues in black-tailed prairie dog tissues. Results confirm that certain Rozol Prairie Dog Bait should not be used in areas where endangered black-rooted ferrets or other sensitive species occur.
Photo by USDA, Gail Keirn

to nontarget mammals indicated high risks for mammal species up to 27 days post-exposure. There were negligible risks for birds. The results suggest that the greatest risk of secondary toxicity occurs 14 days or less after applying Rozol Prairie Dog Bait. This corresponds to the time when chlorophacinone residues are high and prairie dogs show signs of intoxication—likely making them more susceptible to predation and scavenging. These results confirm that Rozol Prairie Dog Bait should not be used in areas with endangered black-footed ferrets or other sensitive species.
Contact: Gary Witmer

Repellents

- **Use of Anthraquinone for Pest Management and Crop Protection.** Anthraquinone (AQ) has been used in pest management and agricultural crop protection since the early 1940s. It is commonly found in dyes, pigments, and many plants and organisms, and it is now used as a chemical repellent, perch deterrent, insecticide, and feeding deterrent for wild birds, mammals, insects, and fish. NWRC researchers reviewed more than 100 publications on AQ applications for international pest management and crop protection and summarized its use for protecting newly planted and maturing crops from pest birds.

  Conventional applications of AQ-based repellents include pre-plant seed treatments for corn, rice, sunflower, wheat, millet, sorghum, pelletized feed, and forest tree species, as well as foliar applications for rice, sunflower, lettuce, turf, sugar beets, soybean, sweet corn, and nursery, fruit, and nut crops. AQ has also been used to treat toxicants for protecting nontarget birds. Few studies have shown AQ repellency in mammals, such as wild boar, thirteen-lined ground squirrels, black-tailed prairie dogs, common voles, and house mice. Natural sources of AQ and its derivatives have also been identified as insecticides and insect repellents. As a natural or synthetic biopesticide, AQ is a promising candidate for many contexts of nonlethal and insecticidal pest management.
  Contact: Scott Werner

Other Chemical and Biological Methods

- **Simplifying Sample Collection for Environmental DNA.** Environmental DNA (eDNA) refers to DNA that is shed by an organism into the environment (for example, water, soil, or air). The genetic material could come from shed skin, hair or scales, mucous, urine, or feces. Wildlife managers have used eDNA samples from water to detect the presence of invasive species, such as Burmese python and feral swine. Capturing eDNA from water begins by filtering water samples at the collection site or by taking the water samples to a laboratory and concentrating and extracting the eDNA there. To preserve DNA in water, samples require cold storage or an added preservative for transporting filters from the field to the lab. Having field personnel filter samples or manage a continuous cold chain can be expensive, challenging, and time-consuming. Further, freezing and thawing samples before analyzing them reduces DNA viability and thus detection.

To simplify this process, NWRC researchers tested the effectiveness of adding Longmire's lysis buffer (a solution of 100 millimolar (mM) Trizma base, 100 mM ethylenedinitrilo tetraacetic acid, 10 mM sodium chloride, 0.5-percent sodium dodecyl sulfate, and 0.2-percent sodium azide) to freshwater samples for preserving eDNA. Water samples from a 25-gallon tub served as the water source for a single feral swine sow in captivity. Sixty 15-milliliter (mL) samples were randomly assigned to one of five treatment groups. Samples were stored for 56 days at either (1) -80° C; (2) a high concentration (1:3) of Longmire's solution to sample water; (3) a medium concentration (1:6) of Longmire's solution to sample water; (4) a low concentration (1:15) of Longmire's solution to sample water; and (5) a no-treatment control of 15 mL sample water without lysis buffer or cold storage. The no-treatment and Longmire's solution groups were stored outside in a covered, but not enclosed, area. One half of each treatment group was extracted after 28 days, and the second half was extracted after 56 days, during which times eDNA degradation was allowed to occur.

Results showed that eDNA was effectively preserved in 15 mL water samples treated with Longmire's solution. eDNA detection in samples treated at the highest concentrations of Longmire's solution was similar to samples stored at -80° C at both 28- and 56-days extraction. Medium and low concentrations of Longmire's solution preserved eDNA out to 56 days, but not as well as freezing or the highest concentration of Longmire's solution. NWRC researchers conclude that Longmire's lysis buffer used at the high concentration treatment level (1:3) is a viable alternative to cold chain storage and can simplify eDNA collection in water by eliminating the need for filtering. This allows more time for sample collection, which could translate to an increase in the chances of detecting a rare or elusive species.
Contact: Toni Piaggio

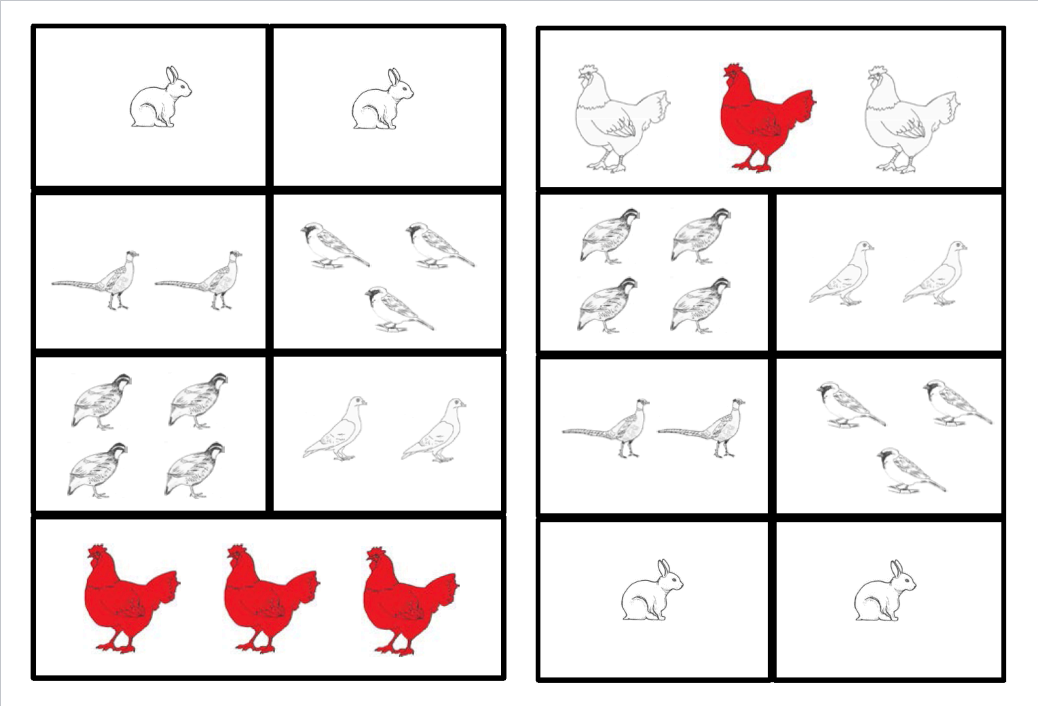
- **DNA Barcoding To Verify Invasive Species Detection.** Detecting invasive animals early is critical to manage them successfully and keep them from spreading. At the beginning stages of a detection, invasive species are easier to control as the population is likely made up of only a few individuals. Finding these first few individuals can be challenging, and managers often rely on the general public to report sightings of invasive animals or signs of their presence. DNA barcoding can help verify public reports when identifying the species by its outward appearance or anatomy is not possible or uncertain (such as with a degraded or partial specimen). This method relies on obtaining a DNA sequence from a relatively small fragment of mitochondrial DNA and comparing it to a database of sequences with a variety of expertly identified species.

  NWRC geneticists used barcoding to identify a degraded specimen of a non-native, potentially invasive Nile monitor lizard, after a citizen in Jackson County, MS, discovered and reported it. Researchers note it is unknown whether the specimen represents an emerging population or the chance observation of a single escaped or released individual. Yet, results show how helpful DNA barcoding can be in identifying invasive species and how important citizens are in early detection efforts.
  Contact: Toni Piaggio

- **Improving Storage of Blood Samples Collected on Filter Paper.** Collecting blood samples from wildlife is often time- and labor-intensive. It can also be logistically difficult to maintain sample viability when transporting samples from remote field locations where centrifuging, refrigeration, or freezing are not feasible. Methods that simplify the field

To test whether domestic chickens can spread influenza A virus to co-housed chickens or other animals in an experimental live animal market, NWRC and Colorado State University researchers infected four chickens (*noted as red in graphic*) and housed them in cages on top, below, or adjacent to cages with other species. One of the infected chickens successfully transmitted the virus to quail located directly below it.

Graphic by USDA



collection and storage of blood samples not only increase the chance of viable sample collection, but also overall sampling numbers.

NWRC researchers used blood samples collected on filter paper from coyotes experimentally infected with plague *(Yersinia pestis)* to determine optimal storage conditions over time. Blood samples collected on filter paper were stored for 454 days or more in four groups: (1) at ambient temperature and relative humidity, (2) at ambient temperature with desiccant (a drying agent), (3) at 4° C with desiccant, and (4) at -20° C with desiccant. Results showed that samples stored at 4° C or -20° C with desiccant had detectable antibodies for a longer period of time than the samples stored at room temperature. Using this blood sample collection and storage technique in combination with validated diagnostics is a simple and cost-effective method. *Contact: Sarah Bevins*

Disease Diagnostics, Surveillance, Risk Assessment, and Management

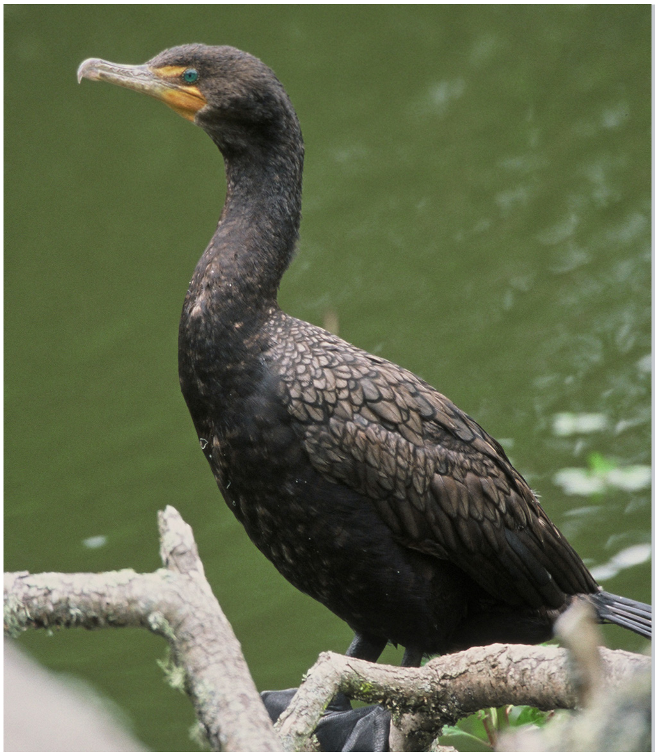
- **Spread of Avian Influenza in Experimental Live Animal Market.** Live animal markets have a long history of association with influenza viruses. The prevalence of influenza A virus (IAV) in live animal markets can be high: rates greater than 25 percent for some IAVs have been reported for both chickens and ducks in China. To test whether domestic chickens can spread emergent H7N9 IAV to co-housed chickens and other animal species in live animal markets, NWRC and Colorado State University researchers infected four chickens with H7N9 and housed them in cages on top, below, or adjacent to cages housing ring-necked pheasants, quail, other chickens, rock pigeons, house sparrows, and cottontail rabbits. Results indicated that an infected chicken failed to initiate viral shedding of H7N9 to naïve co-housed chickens, but did successfully transmit the virus to quail located directly below it. Oral shedding by indirectly infected quail

was, on average, more than ten-fold that of directly inoculated chickens. No other naïve animals or species were infected. Researchers recommend that best management practices in live animal market systems consider the position of quail in stacked-cage settings.
Contact: Jeff Root

- **Reassortment of Avian Influenza Viruses in North America.** Avian influenza is a virus that infects wild birds and domestic poultry. The viruses are classified by a combination of two groups of proteins: the hemagglutinin or H proteins, of which there are 16 (H1–H16), and neuraminidase or N proteins, of which there are 9 (N1–N9). Strains also are divided into two groups based upon the ability of the virus to produce disease in poultry: low pathogenic avian influenza (LPAI) and highly pathogenic avian influenza (HPAI). The spread of HPAI viruses in commercial poultry and backyard flocks in the spring of 2015 affected nearly 50 million domestic birds, cost over $800 million, and required the expertise of more than 600 APHIS employees and 2,700 contractors and Federal partners. The cause of these outbreaks has been traced back to the spread of Asian HPAI H5N8 viruses into North America during the 2014 autumn bird migration.

  Scientists with APHIS, USDA's Agricultural Research Service, the U.S. Geological Survey, and the University of Texas completed genome sequencing and phylogenetic analysis of 32 H5 viruses collected from wild birds and domestic poultry in 2014 and 2015. The results identified three novel viruses of mixed origin: H5N1, H5N2, and H5N8. These viruses emerged in late 2014 through the reassortment (mixing) of the Asian HPAI H5N8 virus with North American LPAI viruses. With several different viruses circulating in wild birds, it is not unexpected that the birds harbored a new, mixed-origin virus. Viruses continually mutate and form new combinations with genetic material from similar viruses. The continued circulation of HPAI viruses in wild and domestic birds contributes to the persistence and diversity of circulating avian influenza viruses. Enhanced disease surveillance offers an opportunity to monitor the spread and reassortment of viruses and strengthen the biosecurity of farms in affected regions.
  Contact: Thomas DeLiberto

- **Prevalence of Newcastle Disease Virus in Wild Birds.** Avian paramyxovirus serotype 1 (APMV-1), also referred to as Newcastle disease virus (NDV), infects and causes disease in both wild and domestic birds. Because NDV is a reportable foreign animal disease, sampling for the virus is conducted by State and Federal agencies when death or disease occurs in cormorants, pigeons, doves, or pelicans. To calculate the prevalence of the virus in apparently healthy wild birds, NWRC researchers and USDA colleagues collected



NWRC researchers analyzed samples from 3,500 wild birds representing a variety of taxonomic orders for the presence of antibodies for Newcastle disease virus. Antibody prevalence in double-crested cormorants was 45 percent, the highest of all orders tested.
Photo by U.S. Fish and Wildlife Service, Lee Karney

swab and serum samples from more than 3,500 wild birds representing 8 orders (Suliformes, Pelecaniformes, Anseriformes, Columbiformes, Accipitriformes, Charadriiformes, Gruiformes, and Passeriformes). Antibody prevalence was highest in double-crested cormorants (Suliformes, 45 percent) followed by pelicans (Pelecaniformes, 24 percent), waterfowl (Anseriformes, 23 percent), and pigeons/doves (Columbiformes, 12 percent). Results suggest that wild birds are commonly exposed to NDV, but active viral shedding in apparently healthy birds is relatively uncommon. Consequently, the risk to poultry appears low.
Contact: Thomas DeLiberto

- **Pigeons and Avian Influenza.** Pigeons (also known as rock doves) often live and roost near domestic poultry facilities, are commonly found in cities and live animal markets, and are one of several poultry species sold as food in Asia. As a result, pigeons are likely exposed to avian influenza A viruses; some studies have also shown they are susceptible to these viruses. Because of this and the fact that pigeons often gather in large groups, there is concern among animal health experts that pigeons could shed the viruses in areas that may impact domestic poultry. Even a small proportion of higher-than-average shedders could spread viruses within and between poultry operations. Outbreaks of LPAI can cause production losses for poultry operations, and outbreaks of LPAI H5 or H7 subtypes are internationally reportable diseases that often have severe economic consequences and require domestic flocks to be depopulated.

  Because pigeons use farms for forage sites and usually move between farms, NWRC researchers inoculated 53 wild-caught pigeons with LPAI to determine if genetic differences in individuals affected viral shedding rates. Inoculated pigeons showed low avian influenza susceptibility and limited amounts of viral ribonucleic acid (RNA) in their feces, but at least one individual had RNA amounts indicative of the potential for viral transmission to other birds. NWRC researchers concluded that pigeons generally play a negligible role in avian influenza dynamics.
  Contact: Susan Shriner

- **Optimizing Tests for Detecting Avian Influenza Antibodies in Mallards.** Although many validated commercial tests are available to detect pathogens in livestock, few are optimized for use with wildlife. To evaluate the effectiveness of the commercial assay IDEXX AI MultiS-Screen Ab with wildlife, NWRC researchers tested more than 800 serum samples from uninfected and experimentally infected mallards for antibodies to influenza A viruses using the test. This product is commercially available for use with domestic poultry and has been shown as a valid test for screening avian influenza samples from wild birds.

  Applying the test per the manufacturer's recommendations resulted in good performance, with 84-percent sensitivity and 100-percent specificity. Performance further improved to 98-percent sensitivity and 98-percent specificity by increasing the recommended cut-off threshold. The manufacturer-suggested threshold for a positive sample is a sample-to-negative (S/N) ratio of less than 0.5. However, researchers recommend the threshold for detecting influenza antibodies in mallards be increased to less than 0.7. Using this alternative threshold for identifying positive and negative samples would greatly improve sample classification, especially for field samples collected months after infection when antibody titers have waned from the initial primary immune response. Furthermore, a threshold that balances sensitivity and specificity reduces estimation bias in samples.
  Contact: Susan Shriner

- **Impacts of Landscape Patterns on the Spread of Disease in Wild and Domestic Cats.** In North America, mountain lions, bobcats, and domestic cats occupy a wide range of natural and modified

To learn more about how bobcats, mountain lions, and domestic cats may be exposed to similar pathogens, particularly in urban areas, NWRC and partners sampled the species in habitats along a wildland-urban gradient for feline immunodeficiency virus, *Toxoplasma gondii*, and other pathogens. *Photo by U.S. Fish and Wildlife Service, Gary Kramer*

habitats. Mountain lions and bobcats live mainly in wildlands, while domestic cats live in more human-dominated landscapes, with overlap among these three species often occurring at the boundary between these two habitats. All three species can be infected by similar pathogens, though exposure risk varies widely. If pathogen transmission is more likely to occur at the wildland-urban interface, then the proximity of mountain lions and bobcats to urban areas and the proximity of domestic cats to natural habitats might influence their exposure to disease.

To better understand how natural and urban landscapes, along with host and pathogen traits, impact pathogen exposure, an NWRC researcher and multiple State, Federal, and university partners sampled more than 1,000 mountain lions, bobcats, and domestic cats along wildland-urban gradients in California, Colorado, and Florida. Samples were analyzed for exposure to six pathogens: *Bartonella* sp., *Toxoplasma gondii,* feline immunodeficiency virus (FIV), feline herpesvirus (FHV-1), feline panleukopenia virus, and feline calicivirus. Pathogen prevalence differed among the species, with mountain lion and domestic cats having the highest and lowest prevalence, respectively. Pathogens, such as *Toxoplasma gondii,* that are spread indirectly through soil, air, and water or prey consumption had a higher prevalence in all species. For mountain lions, the use of suburban landscapes increased their exposure to *Bartonella* sp. in southern California and FHV-1 exposure in Florida. This suggests disease spread from domestic cats via fleas (California) and direct contact (Florida) around cities. Bobcats captured near cities had increased exposure to *Toxoplasma gondii* in Florida.

Researchers note that the species' use and proximity to the wildland-urban interface generally did not increase the likelihood of disease exposure. Although rare, interactions among these species may still result in disease exposure. Wildlife managers may want to prevent the likelihood of such contact or vaccinate one of these groups around the wildland-urban interface.
Contact: Sarah Bevins

- **Reducing Wildlife-Related Risks of Foodborne Pathogens.** Wildlife is an increasing potential threat to food safety because of its ability to spread pathogens to agricultural crops and livestock, mainly through contaminated feces. To help farmers and ranchers reduce wildlife contamination, NWRC researchers developed a framework for creating strategic programs to lower and manage these risks at agricultural operations. This adaptive approach was originally developed for use in natural resource management. The multi-step framework helps producers identify the potential risks, the species involved, and the extent and nature of their impact; take effective action to address the problems; and then continually review and adapt their methods. NWRC researchers also recommend that producers form local coalitions to share resources; partner with universities, State, and Federal agencies to develop strategies; and consider an integrated damage management approach to reduce wildlife intrusion in agriculture fields and facilities. *Contact: Alan Franklin*

- **Impacts of Dietary Minerals on Chronic Wasting Disease Progression.** Chronic wasting disease (CWD) is a neurodegenerative disease in deer, elk, and moose caused by mis-shaped proteins called prions. The disease is an ongoing and expanding problem in both wild and captive North American cervid populations and is difficult to control, in part due to the ability of CWD prions to persist in the environment for many years. To better understand the role of environmental and dietary minerals, such as copper (Cu) and magnesium (Mg), on the progression of CWD in elk and deer, NWRC, Colorado State University, Case Western Reserve University, and Canadian Food Inspection Agency researchers collected and analyzed soil and water samples from CWD-negative and -positive captive cervid facilities and natural areas.

  Results showed that CWD-negative sites had higher concentrations of magnesium and a higher Mg/Cu ratio in the water than CWD-positive sites. Researchers also fed mice that were genetically modified with elk genes a diet lacking magnesium and copper and then supplemented drinking water with varied Mg/Cu ratios. They observed that mice fed water with higher Mg/Cu ratios had longer survival times after being inoculated with CWD. These mice also expressed fewer neuroinflammatory gene expression changes and had less neuroinflammation present in the brain 60 days after inoculation. Copper appeared to be the most significant factor in survival time. This work demonstrates that external factors can alter CWD disease progression. *Contact: Tracy Nichols*

- **Modeling Disease Emergence in Feral Swine.** How quickly a disease spreads through an animal population depends on several factors, including movement behavior, social structure, the number of susceptible individuals in the population, and the life history of the pathogen. To better understand the influence of social structure, NWRC researchers modeled how differences in contact structure and rates between individuals in a population affect the likelihood of a disease outbreak, its size, and its progression. Hypothetical populations of feral swine were exposed to either foot-and-mouth disease virus (FMDV) or classical swine fever virus (CSFV). Results from previous analysis of field data on within-herd and between-herd contact rates gave realistic contact rates and structure among individuals.

  Findings showed the persistence probability of FMDV under a wide range of feral swine population scenarios was near zero, while it was more probable that CFSV could persist. Even when feral swine population growth rates were up to 300 percent annually, FMDV persisted in less than 25 percent of the simulations, regardless of contact rates and probabilities. As a result, an FMDV detection in feral swine likely would not warrant very early response and management. However, simulations showed that responding to a CSFV detection was generally effective at limiting the outbreak’s size and scope. Also, when pre-emergence culling of feral swine caused population declines, it was effective at decreasing the size of outbreaks for both diseases by more than 80 percent. *Contact: Kim Pepin*

- **Benefits and Costs of Disease Management.** Disease transmission at the wildlife-livestock interface can significantly impact human health, threaten global trade and tourism, cause significant economic loss, and provide a potential mechanism for bioterrorism. Yet, given budget limitations, resource managers often must seek to maximize the benefits and minimize the costs of disease mitigation efforts. To address this issue, NWRC, APHIS Veterinary Services, and Texas A&M University researchers and economists developed a benefit-cost analysis decision framework. It helps managers make informed choices about whether and how to target disease management efforts in wildlife and livestock populations.

Specifically, the framework offers a way to identify, assemble, and measure the components that are most vital to animal disease mitigation efforts. Benefits or damages avoided cover such areas as consumption demand, human health, livestock production, and wildlife losses. Costs include not only the operational costs of disease mitigation, but also the impacts of disease spillover, such as reduced agricultural production or lost recreational opportunities. The framework can also be applied to commercially raised and free-ranging species at various levels of management—from detailed intervention strategies to broad programmatic actions. The ability of the framework to illustrate the benefits of disease management projects per dollar spent helps managers evaluate their options. This

Issue	Surveillance Efforts
Avian Influenza	In 2016, NWDP sampled more than 21,800 wild birds for HPAI. NWDP also developed and carried out the Interagency Wild Bird HPAI Surveillance Plan, Wild Bird HPAI Implementation Plan, and HPAI Procedures Manual in support of collecting 32,000 wild bird samples from May 1, 2016, through March 31, 2017.
Avian Health	NWDP collected serum samples from over 1,000 wild birds in 2016 to assess exposure to Newcastle disease virus and several arboviruses. About 600 samples were tested for antibodies to West Nile virus, eastern equine encephalitis, Turlock virus, and St. Louis encephalitis virus. Over 800 tissue samples from birds associated with livestock feedlots were tested for *Salmonella*. NWDP is in the process of testing all wild bird serum samples for exposure to Newcastle disease virus.
Feral Swine Diseases	NWDP sampled more than 3,200 feral swine in 31 States and Guam for classical swine fever, pseudorabies, swine brucellosis, leptospirosis, toxoplasmosis, and influenza A virus.
Plague and Tularemia	NWDP routinely tests wildlife for exposure to plague *(Yersinia pestis)* and tularemia *(Francisella tularensis)* in conjunction with other surveillance activities. In fiscal year (FY) 2016, NWDP biologists and their cooperators collected blood samples from 1,956 animals across the United States. This sample set was spread over 47 different species, although the vast majority of samples came from coyotes.
Cervid Health	NWDP sampled more than 500 deer in 13 States and the U.S. Virgin Islands for West Nile virus, Powassan virus, St. Louis encephalitis virus, Maguari virus, La Crosse virus, epizootic hemorrhagic disease, and bluetongue virus.
Leptospirosis	NWDP tested more than 350 raccoons, 40 red foxes, 275 coyotes, 20 gray foxes, 45 arctic foxes, and 2 mongooses for exposure to leptospirosis.

In 2016, NWRC's National Wildlife Disease Program sampled more than 21,800 wild birds for highly pathogenic avian influenza (HPAI). *Photo by USDA, Sara Harmon*

framework is useful to natural resource managers who wish to maximize financial and other returns invested in wildlife and livestock disease management programs.
Contact: Stephanie Shwiff

- **NWDP Surveillance Accomplishments.** Each year, NWDP conducts and coordinates wildlife disease monitoring and surveillance throughout the United States. See previous page for summary of its 2016 efforts.

Wildlife Damage Assessments

- **DNA-Based Approach for Identifying Sage-Grouse Predators.** The predation of ground-nesting birds and their eggs is a concern for conservationists and wildlife managers. Accurately identifying species responsible for nest and bird predation is key to effective management. The greater sage-grouse is a ground-nesting bird at risk of extinction in multiple U.S. States and Canada. Predation events on sage-grouse nests are rarely seen, and it is difficult to visually identify the responsible predator species from nest remains alone. To help identify common mammalian predators, NWRC geneticists analyzed predator saliva DNA from depredated sage-grouse eggshells and bird carcasses in Wyoming. Researchers monitored sage-grouse nests using radio telemetry of hens and infrared trail cameras. They collected egg remains and/or hen carcasses when a nest failed or a hen was eaten.

  In 79 percent of the nest and 47 percent of the carcass samples, researchers identified the mammalian predator species involved using a multilocus approach. This approach involved sequencing DNA fragments of two mitochondrial genes and obtaining microsatellite genotypes with canid-specific primers. Eighty-six percent of the detected mammal predators were canids, including coyotes and dogs. Other taxa included rodents, striped skunk, and cattle. NWRC researchers acknowledge that identifying nest and adult predators is challenging given the lack of species-specific signs at nests and the difficulty in differentiating predators from scavengers using DNA evidence. The results of this study suggest that the best approach is to use multiple techniques, including field surveys, camera monitoring of depredation events, and DNA forensics-based methods.
  Contact: Toni Piaggio

- **Feral Swine Impacts to Rangelands.** Grazing lands in central Florida are a mosaic of sown pastures, native grasslands, wetlands, and woodlands that offer a variety of important ecosystem services. Feral swine damage to these areas negatively impacts economic productivity and biodiversity. In a recent study, NWRC and University of Florida researchers looked at the specific impacts of feral swine damage in pastures and grasslands. They found that feral swine rooting in native grassland

NWRC and international partners in Romania combined photos with overlaid geographic information system data to calculate wild boar damage to alpine grazing pastures. *Photo by USDA, Richard Engeman and Justin Fischer*

pastures reduced the number of plant species, while rooting in sown pastures increased the number of plant species. In both sown pastures and native grasslands, swine rooting altered plant communities and reduced agricultural productivity. Forage grasses were mainly associated with unrooted areas, whereas low-quality forage or nuisance species dominated rooted areas.

The researchers estimated that more than 300,000 hectares (about 741,000 acres) of pasture and forage are lost to feral swine rooting in central Florida each year, amounting to a $2 million loss in cattle production. More stringent programs to manage feral swine populations could minimize the negative impact of their rooting on valuable grazing lands. *Contact: Michael Avery*

- **Photographic Estimation of Wild Boar Damage to Pastures.** A variety of methods are available to measure and estimate wild pig (wild boar, feral swine) damage to natural habitats. For example, remote photographic methods using aircraft, satellites, and unmanned aerial vehicles offer several options for measuring damage. In mountainous areas, high-resolution cameras can also gather images from a nearby vantage point, such as a neighboring hillside. NWRC and Ruprecht-Karls-University Heidelberg researchers developed a combined photographic and geographic information system (GIS) method for calculating wild boar damage to alpine grazing pastures in Romania's Carpathian Mountains. They collected data via photographs of the slopes from vantage points. Researchers then mapped the rooted areas and used GIS software to estimate the relative proportions of the total area versus damaged grazing areas. Results showed that wild boar damaged 11 and 14 percent of two study pastures, respectively, which decreased the economic benefit of the rented pastures to livestock owners. This new method offers a quick and efficient way to estimate damage in alpine grazing pastures and may be

Although the number of damaging wildlife strikes at airports has declined since 2000, the number of damaging strikes occurring beyond airport boundaries has gradually increased during that time. NWRC research identified Canada geese, turkey vultures, American robins, and mallards as the species most often struck by aircraft beyond airport boundaries.
Photo by USDA, R. Anson Eaglin

useful in other mountainous areas where wild boar damage occurs as well.
Contact: Richard Engeman

- **Gulls and Water Quality.** Ring-billed gulls are long-lived birds, with an average lifespan of 10–15 years. Urban areas often provide safe nesting areas for gull colonies, and gulls return year after year to the same region. These factors have contributed to high numbers of ring-billed gulls on and around Chicago-area beaches. Unfortunately, gull fecal material has been linked to *E. coli* contamination in the water at various beaches. The Chicago Ring-Billed Gull Damage Management Project includes experts from the Chicago Park District, WS Operations, and NWRC. Since 2007, the project has focused on reducing gull populations by oiling eggs in more than 103,800 gull nests. Coating eggs with 100-percent food-grade corn oil is a proven method for reducing their hatchability. By using this method to limit hatching success, along with other management efforts, experts hope to improve water quality by reducing the amount of bird droppings on the beach and in the water.

  By 2015, gull use of beaches declined by 86 percent. Gull reductions also led to improved water quality at 18 Chicago-area beaches. Researchers note that continued management of gull colonies in the Chicago area will further help to reduce local water quality issues. They recommend egg oiling combined with other damage management methods at the beaches themselves to further deter gulls. These methods include reducing litter and feeding of gulls, using canine patrols or other hazing techniques, and locating and limiting gull reproduction at other nearby nesting colonies.
  Contact: Richard Engeman

- **Bird-Aircraft Collisions Beyond Airport Boundaries.** Wildlife collisions with aircraft (“wildlife strikes”) continue to pose human safety concerns and cause extensive economic losses to the civil aviation industry. A recent summary of U.S. data indicated there were 11,315 wildlife strikes reported to the Federal Aviation Administration (FAA) National Wildlife Strike Database in 2013 under a voluntary reporting system, costing the civil aviation industry up to $937 million in direct and indirect losses. Although these economic losses and safety concerns remain serious, the overall number of wildlife strikes on airport properties has declined from a peak of 764 in 2000 to 601 in 2013. Unfortunately, the number of damaging strikes occurring beyond airports has gradually increased during that time.

NWRC and Mississippi State University scientists used FAA National Wildlife Strike Database records from 1990 to 2014 to identify bird species most often involved in collisions with aircraft beyond airport boundaries and investigate whether body mass, group size (single or multiple birds), region (flyway), and season influenced the likelihood of aircraft damage. In the United States, turkey vultures, Canada geese, American robins, and mallard ducks were struck most often by aircraft beyond airport boundaries. Waterbirds (such as cormorants, ducks, geese, and to a lesser extent, gulls) and raptors (including vultures) were most likely to damage aircraft when strikes occurred. Body mass was an important predictor of hazard level; group size, region, and season had lesser effects on hazard level. Management strategies to reduce bird strikes with aircraft beyond airport properties should prioritize waterbirds and raptors and be active throughout the year.
Contact: Travis DeVault

- **Economic Impacts of Birds to Sweet Cherry Production.** The United States is the world's second-largest cherry producer, accounting for 15 percent of the world's total cherry production. Bird damage is a common and costly problem for cherry and other fruit producers. In 2012, NWRC economists used survey data from producers in five U.S. States to estimate bird damage to sweet cherry *(Prunus avium)* crops with and without the use of bird management. Respondents reported American robins and European starlings as the most damaging bird species. Growers also reported using bird management methods such as repellents, shooting, trapping, exclusion netting, and scare devices; they identified shooting and exclusion netting as the most effective methods. By producers' estimates, average yield loss due to bird damage was 13 percent. Using bird management methods reduced losses by about 21 percent. For those who did not manage bird damage, yield losses increased by a predicted 26 percent.

  To put this in larger context, the economists applied a model to the survey data to estimate changes in cherry production costs when bird management is absent. Results showed that a lack of bird damage management increases the cost of cherries to society by as much as $238 million in the short-term and, as producers and consumers adjust to the new market over time, reach $29 million in the long-term, annually.
  Contact: Julie Elser

- **Isotopes Used To Track Cormorant Diets.** Hidden in the feathers of birds are clues to their diet and migratory behavior. That's because, over time, atoms that make up the food animals eat remain in their feathers and other tissues. To learn more about double-crested cormorant diet and behavior, NWRC and Cornell University researchers looked for differences in the ratios of carbon, nitrogen, and sulfur atoms in cormorant feathers from Eastern North America. Researchers discovered that the feathers from birds feeding on Mississippi farm-raised catfish showed a unique isotope signature, compared to the feathers of birds feeding on natural or marine resources. Birds that ate farm-raised catfish showed relatively low levels of sulfur and nitrogen in their feathers. They also showed carbon-13 values that were in between those found for birds feeding in natural marine and freshwater habitats.

  This isotope approach confirmed what researchers suspected about cormorant migratory patterns and winter habitat use. All sampled cormorant colonies use aquaculture habitats during the winter. However, more male than female cormorants feed at aquaculture habitats. Researchers note that targeting birds at wintering grounds may be more effective to reduce damage. Similar isotope studies with European starlings at feedlots are ongoing.
  Contact: Tommy King

NWRC researchers studied the impact of American white pelicans on stocked rainbow trout in Idaho. Estimated pelican and angler take of trout averaged 18 and 21 percent, respectively. Mean angler catch was nearly 4 times higher when pelican predation was low. Findings suggest that pelican predation on stocked trout often exceeds the total catch of those fish by anglers.

Photo by Missouri Department of Conservation

- **Environmental Impacts of Cormorants on Forested Islands.** Within the last 10–15 years, double-crested cormorants have begun nesting on islands in Gunterville Lake, AL, causing concern among managers and recreationalists about impacts on area fisheries, vegetation, soil, and water quality. To better assess these impacts, NWRC and Mississippi State University researchers compared water quality, soil chemistry, and tree health of six forested islands with and without nesting cormorants at Gunterville Lake. Results showed that water quality and chemistry did not differ between islands with and without cormorant colonies. However, soil from islands with nesting cormorants was more acidic and had greater concentrations of phosphorous than soils from islands without nesting cormorants. Researchers also found evidence that cormorants are negatively affecting tree health and vigor. Although nesting cormorants are impacting forested islands, researchers note this is a natural process. Managers working to reduce cormorant damage may want to consider allowing some habitats to experience these natural ecological processes.
  Contact: Brian Dorr

- **Competition Between Pelicans and Anglers.** Since the 1960s, American white pelican populations in North America have been recovering from long-term declines likely caused by extensive pesticide use and lack of protections. Their increased populations, however, bring concerns about pelican predation and potential competition with anglers for recently released hatchery trout. The Idaho Department of Fish and Game (IDFG) annually stocks about 1.8 million trout statewide at a cost of about $2.5 million. To estimate pelican predation and angler catch at 12 areas in Idaho, NWRC and IDFG researchers tagged rainbow trout internally (with passive integrated transponders, or “PIT” tags) and externally (with anchors). Some PIT-tagged trout were fed to juvenile birds at pelican nesting colonies to estimate tag deposition rates by pelicans. After juvenile birds fledged and left the nesting grounds, researchers recovered the PIT tags from both stocked and hand-fed fish that were deposited by the birds while on the nesting grounds.

Deposition rates for pelican-consumed tags averaged 21 percent. Pelican predation on hatchery trout averaged 18 percent and ranged from 0 to 48 percent. Angler catch was estimated by the number of anchor-tagged fish captured and reported by anglers. Angler catch averaged 21 percent and ranged from 0 to 82 percent. Results also showed that the mean angler catch was nearly 4 times higher when pelican predation was less than 25 percent. Findings suggest that, in this scenario, predation by American white pelicans on stocked trout often exceeds the total catch of those fish by anglers.
Contact: Tommy King

- **Evaluation of Invasive Reptile Management and Research.** Invasive (or non-native) reptiles and amphibians have been in Florida for over 135 years, and their populations have increased quickly in the last half century. Exotic snakes, lizards, frogs, turtles, and crocodilians are all breeding in Florida. NWRC researchers led a team of scientists and managers to identify the invasive reptile species with the greatest ecological threats to Florida and find out the most useful ways to reduce their damage. They evaluated 37 invasive reptile species and scored them based on their impacts to endangered or threatened species, eradication potential, stage of invasion (localized versus widespread), and adaptability. Results showed seven species with the highest potential for negative impact: Argentine giant tegu lizard, Burmese python, Nile monitor lizard, North African python, spectacled caiman, black spiny-tailed iguana, and yellow anaconda. Next, the team looked at vulnerabilities in each species that might be exploited for control purposes and the overall potential for successful management. They recommended the Nile monitor, black spiny-tailed iguana, and Argentine giant tegu for further research on management methods. Developing new tools for these species, along with practical management programs, have the highest probability of success in some areas.
Contact: Richard Engeman

Wildlife Management Methods and Evaluations

- **Evaluation of Avian Radar To Prevent Bird Strikes.** The Federal Aviation Administration and WS' Airport Wildlife Hazards Program continue to look for better tools and methods for preventing bird collisions with aircraft. One tool receiving considerable attention is avian radar. These systems have the potential to track bird activities on and near airports during the day and night—giving real-time estimates of bird locations, altitude, and speed, which

Results from recent NWRC studies of commercial avian radar systems suggest that avian radar can be a useful tool for monitoring bird flock activity at airports, but less so for monitoring single, large birds, such as raptors.
Photo by USDA

could warn pilots and ground personnel of possible wildlife hazards. To evaluate the ability of such systems to detect and track free-flying raptors and waterbirds, NWRC and Indiana State University researchers compared data gathered from a Merlin Aircraft Birdstrike Avoidance Radar (DeTect, Inc.) and field observers at the Terre Haute International Airport in Indiana.

Researchers focused initial studies on large species, such as turkey vultures, red-tailed hawks, Canada geese, and sandhill cranes. A field observer would notify a radar operator when a bird entered the study area and provide updates on the bird's location every few seconds. The operator would confirm whether or not the bird was being tracked by the radar. Such an approach helped identify instances when known birds were not tracked by the radar system. Most of the large, single birds seen by field observers within 2 nautical miles of the radar were tracked by the radar about 30 percent of the time. Flocks of large birds, even those that were located several nautical miles away, were tracked by the radar about 40 to 80 percent of the time. The results suggest that avian radar can be a useful tool for monitoring bird flock activity at airports, but less so for monitoring single, large birds such as raptors.
Contact: Travis DeVault

- **Supplemental Feeding for Endangered Vultures.** Supplemental feeding stations (SFS) have been used to increase populations of threatened vultures and other avian scavengers for over half a century. Unfortunately, SFS also change the natural distribution of food resources for scavengers, often resulting in large gatherings of birds. When in large numbers, these birds may impact surrounding vegetation, smaller prey species, soil nutrients, and water. In an evaluation of SFS, an NWRC scientist and several national and international partners concluded that SFS may be useful for reaching specific conservation goals as part of an adaptive management strategy and with strict monitoring. However, the long-term conservation of vultures and other avian scavengers depends on not only recovering wild ungulates (hoofed mammals) in rural areas and maintaining healthy agro-grazing practices, but also having effective laws for sanitary practices, lead ammunition use, and proper disposal of medicated livestock carcasses.
Contact: Travis DeVault

Wildlife Population Monitoring Methods and Evaluations

- **Monitoring Endangered Mexican Wolves Using Genetics.** The Mexican gray wolf *(Canis lupus baileyi)* is the smallest, most genetically distinct, and most endangered subspecies of gray wolf in North America. Monitoring the population status of Mexican gray wolves in the wild is a critical component of recovery efforts for this species. Molecular approaches today make it possible for biologists to identify individuals via DNA from noninvasively collected samples such as feces, hair, or saliva. With the U.S. Fish and Wildlife Service and several universities, NWRC researchers and geneticists applied 10 canid microsatellite loci (rapidly evolving, repetitive DNA sequences used as genetic markers) to 235 Mexican gray wolf samples, 48 coyote *(C. latrans)* samples, and 14 domestic dog *(C. lupus familiaris)* samples to identify genes that distinguish the species. Experts then evaluated an approach for using fecal DNA genotypes from Mexican gray wolves combined with mark-recapture methods to estimate wolf populations.

  This method proved effective for distinguishing Mexican gray wolf scat (feces) from dogs and coyotes. Researchers were also able to identify 5 of 14 individual wolves known to be members of 3 different packs and 3 previously undetected wolves occurring in the study area. Although the

NWRC geneticists are helping the U.S. Fish and Wildlife Service monitor endangered Mexican gray wolf populations in the wild by using genetic techniques to identify individuals from feces, hair, and saliva. *Photo by Wikimedia Commons*

low numbers of wolves detected and recaptured resulted in wide confidence intervals, the DNA-based estimates of abundance corresponded with the known number of wolves in the study area. Researchers recommend this approach as an alternative tool to monitor recovering Mexican gray wolf populations over the long term. *Contact: Toni Piaggio*

- **Double-Crested Cormorant Reproduction.** Double-crested cormorants are fish-eating birds whose populations are often managed to reduce damage to aquaculture and natural resources. Management includes egg oiling, nest and egg destruction, and lethal take of adult birds by Federal, State and tribal entities on their breeding and wintering grounds. To prevent damage from cormorants while also sustaining healthy populations of them over the long term, wildlife managers must understand the birds' reproductive biology and the impacts of various methods. NWRC researchers examined the reproductive organs of more than 1,700 cormorants as part of management programs in seven States to see the timing of the organs' development and the proportion of breeding and non-breeding individuals in local populations.

  The average proportion of non-breeding female cormorants was 14.9 percent for those culled from breeding colonies and 22.1 percent for those from foraging flocks on the breeding grounds. Overall, 20 percent of the females collected were non-breeding. Mean and maximum reproductive potential was 5 and 13 ovum (egg cells), respectively. For male cormorants, gonad (sex organ) development peaked in late March to early April, which corresponds with males arriving earlier on the breeding grounds than females. Female gonadal development peaked in late April to early May, suggesting that peak breeding and egg-laying for cormorants over much of their breeding range in eastern North America occurs during that time. Researchers recommend this demographic information be considered when evaluating and

NWRC was part of a multi-agency team that used more than 20 years of demographic data for endangered northern spotted owls to estimate owl survival and population changes, as well as the potential impacts of barred owl competition and climate change.
Photo by U.S. Fish and Wildlife Service

modeling effects of cormorant management in North America.
Contact: Katie Hanson-Dorr

- **Effects of Habitat, Climate, and Barred Owls on Northern Spotted Owls.** The northern spotted owl has been listed as a threatened subspecies under the U.S. Endangered Species Act since 1990. The Northwest Forest Plan, adopted in 1994, protects habitat for all native species in the region, including the northern spotted owl. To understand whether this plan was benefiting the northern spotted owl, several Federal agencies together developed an Effectiveness Monitoring Program to estimate range-wide trends for the owl's populations on Federal lands. They also collected more than 20 years of demographic data for northern spotted owls as part of the effort. An NWRC researcher helped with meta-analysis of the data to estimate rates of adult and juvenile survival, reproduction, population change, and local extinction and colonization. The analysis also looked at the potential impacts of barred owls, habitat availability, and climate patterns on northern spotted owls in Washington, Oregon, and northern California.

  Results showed that competition with barred owls may be the main cause of current northern spotted owl population declines. Habitat loss and climate patterns also affected northern spotted owl survival, occupancy of a given habitat, recruitment, and, to a lesser extent, reproduction rates. The findings are consistent with other studies that have found links between habitat and population characteristics of northern spotted owls and support past recommendations to preserve as much high-quality habitat in old growth forests as possible. Yet, researchers note that barred owl densities may now be high enough across the range of the northern spotted owl that, despite continued efforts to conserve owl habitat on Federal lands, the long-term prospects for their survival may be in question without further intervention.
  Contact: Alan Franklin

- **Indexing Abundance of Voles in Artichoke Fields.** Nearly 100 percent of U.S. artichoke production comes from California's Monterey County. Unfortunately, California meadow voles threaten the profitability of growing artichokes in this region. A practical method for monitoring vole populations would help guide and evaluate damage management efforts. Toward this end, NWRC researchers compared two types of materials—nontoxic, grain-based wax bait blocks and artichoke bracts (modified fleshy leaves)—to see their effectiveness as chewing mediums to record vole presence and index their populations. Researchers also compared presence-absence observations of chewing on bait blocks to the total percent chewed, as well as three sizes of observation grids (4x4, 5x5, or 6x6 meters), to see which recording methods best tracked population abundance. After intense trapping, they determined the actual number of voles in the area to better assess the different methods.

Results showed that bait blocks were better than artichoke bracts and continuous measuring was better than presence-absence observations for accurately determining vole abundance. All three grid sizes worked well to track the number of known voles; however, researchers caution that the largest grid size may be best if vole abundance is unknown or low.
Contact: Richard Engeman

- **Monitoring Cryptic Amphibians and Reptiles**. Many amphibians and reptiles are cryptic—they have camouflaged coloring or other ways of concealing themselves—and are thus difficult to observe. Yet, monitoring their population trends can be vital for wildlife management and research, especially with invasive and endangered species. To help address this issue, NWRC worked with research partners in Pennsylvania and Florida. The group evaluated artificial coverboards as a tool for detecting, observing, and collecting cryptic amphibians and reptiles in a south Florida park. Coverboards are sections of cover material, most often wood or metal, that can be placed on the ground in various habitats without disturbing the environment. They act like natural-cover objects, trapping moisture and attracting a variety of species.

  Using this tool in areas preferred by the target species, researchers recorded the daily number of each species observed under each coverboard. They used this data to calculate a coverboard abundance index. Seventeen species were seen at least once, and the coverboard index values helped monitor abundance and seasonal patterns for six species from spring to summer, including an invasive species (greenhouse frog) and a threatened species (Florida scrub lizard). Researchers identified winter as the optimal time in the area to monitor populations. This combined observation and indexing approach gives wildlife managers an economical way to track population trends for multiple cryptic species.
  Contact: Richard Engeman

- **Effects of Nutrition on Coyote Reproduction.** Existing information on coyote reproduction has shown that

NWRC and Utah State University researchers investigated the effects of a reduced calorie diet during the 7 months before estrus on the reproductive rates of captive female coyotes and their subsequent pups. Findings suggest that well-fed females tend to have more male pups and that the amount and quality of food may affect future breeding cycles. *Photo by USDA, Chris Schell* litter size changes in response to the availability of prey. However, little is known about how the amount and nutritional value of food available before mating may influence the number and gender of pups in coyote litters. NWRC and Utah State University researchers studied the effects of a reduced-calorie diet on the reproductive rates of 11 captive female coyotes and their subsequent pups. Female coyotes were fed a reduced diet for 7 months prior to becoming sexually receptive (went into estrus, or heat). The 2-year study allowed researchers to monitor each female coyote's reproductive performance over two seasons (once on a high- and once on a low calorie diet). They assessed the number of implantation scars, number of pups born, sex ratios of pups, average pup weight at birth and 2- and 6-weeks of age, and the survival rates between implantation and 2 weeks of age for two diet treatments.

Findings showed that food intake before conception influenced the mean number of implantation sites and pups whelped during a reproductive cycle. Also, some evidence suggested that the effects of nutritional stress may persist for added breeding cycles and that well-fed females tended to have more male pups. The information will be used by State management agencies and researchers to improve coyote population models.
Contact: Eric Gese

- **Birth Rates in Female Yearling Coyotes.** NWRC and West Virginia University researchers, with help from the West Virginia Division of Natural Resources, completed a study to learn more about the reproductive rate of young female coyotes in that State. The team examined uterine tracts of 66 female coyotes collected from February to May 2010. Nine (14 percent) of the female coyotes were pregnant with visible fetuses. Seven of the nine examined were also considered yearling females between 1.5 and 2.5 years old. The average litter size was 5.4 pups. Estimated conception and delivery dates were within the reported range for coyotes, though one female successfully bred in early January, which is earlier than reported in current scientific literature. The relatively high proportion (30 percent) of yearling females breeding in West Virginia may reflect abundant food resources, a low density of coyotes, increasing human-caused mortality, or a combination of these factors. Researchers note this information is helpful in monitoring coyote population trends and assessing management strategies.
Contact: Julie Young

- **Effects of Water Availability on Coyote Populations.** The availability of water in arid environments can greatly influence the movement and behavior of wildlife species in certain areas. Understanding the relationship between water sites and coyotes in the Great Basin Desert of Utah may influence kit fox conservation strategies and coyote management programs. Kit fox are a species of concern in Utah, and their density has been negatively impacted by coyote abundance. Wildlife biologists and land managers speculate that an increase in permanent water sites in the Great Basin Desert in the last several decades may have indirectly decreased available kit fox habitat by way of increased competition and predation from coyotes.

To determine the impacts of available water on coyotes in the Great Basin Desert, NWRC and Utah State University researchers radio-collared 41 coyotes and followed their movements and visits to known water sites for 4 years. Results showed that visits to water sites averaged 13 visits per season. Water sites with riparian vegetation had higher visitation than "guzzlers" (sites with no riparian vegetation). Researchers found no evidence that the removal of water influenced the size or shifted the location of coyote home ranges. They conclude that water sites, especially guzzlers, in the area are

NWRC researchers studied the movement behavior and contact ecology of feral swine. Using GPS data from radio-collared feral swine in more than 10 areas across the country, researchers discovered that most direct contact between family groups (sounders) occurred when their home ranges were within 2 kilometers of each other. *Photo by USDA*

not a crucial resource for coyotes and likely have little impact on the coyote population.
Contact: Eric Gese

- **Using Harvest Indices To Monitor Cougar Survival and Abundance.** Given their large home ranges, low population densities, and overall elusiveness, estimating the abundance and other demographics of cougar populations is challenging. Because of this, State wildlife agencies must often make cougar management decisions based on information gathered from harvested animals. As part of a 17-year study involving 235 radio-collared cougars, NWRC and Utah State University researchers looked at whether cougar harvest statistics correlated with changes in cougar survival rates and abundance. Results showed that using previous years' harvest statistics to determine harvest quotas for cougars was justified. Specifically, the total number of females harvested and the fraction of females in the harvest were negatively correlated with annual survival—as harvest rates for female cougars increased, survival rates decreased. In a management area where cougar mortality from hunting was high, the percentage of permits filled was also a good proxy to changes in overall annual survival, as well as annual female and male survival. The highest correlation was between the number of cougars treed per day and the annual abundance of cougars. This suggests that pursuit indices may be useful for determining cougar population trends in intensely harvested areas.
Contact: Eric Gese

- **Feral Swine Movement and Contact.** Tools for managing any wildlife population should be based on the ecology of the target species—and feral swine are no exception. NWRC researchers studied the movements and interactions among feral swine using GPS data from radio-collared feral swine in

more than 10 areas across the country. They found that feral swine are more mobile in the western part of the United States than the east. Feral swine movement rates were highest when temperatures and atmospheric pressures were at intermediate levels and when the center of their home range was further from water sources. In a separate analysis, the same data showed that most direct contact between feral swine family groups (sounders) occurred when the centers of home ranges were within 2 kilometers of each other. This data and other contact-related information on feral swine is crucial for assessing disease risk and response strategies.
Contact: Kim Pepin

- **Correcting for Scat Removal in Carnivore Scat Surveys.** Scat (fecal) surveys are often used to monitor wildlife populations and estimate animal abundance. For carnivores, these surveys typically happen along roads and trails. But survey results may not be accurate if variation exists in scat detection, decay and deterioration, or scat removal. NWRC and University of Idaho researchers, along with U.S. Army cooperators, examined the factors influencing scat removal on roads under varying traffic and environmental conditions at the U.S. Army Dugway Proving Ground and neighboring lands in western Utah. They placed previously collected and frozen scat from captive coyotes and kit foxes systematically across study plots along gravel and dirt roads during the summer and winter. The location of the placed scat was recorded and photographed in case native coyotes or kit foxes defecated on the plot. This is the first study to quantify the effects of anthropogenic (human-caused) disturbance on scat surveys.

  Results showed that scat removal varied by species (kit fox scat was removed more rapidly) and spatially. Survey conditions (such as road type and traffic speed and frequency) also influenced time until removal. The impact of environmental conditions on disappearance rates was low compared to removal rates in the presence of traffic. Researchers note that a failure to account for variation in scat removal may bias results of monitoring programs, leading to flawed conclusions and ineffective management decisions. They recommend that surveyors: (1) conduct pilot studies to reveal patterns and rates of scat deposition and removal, (2) minimize variation in removal among surveys during the design phase of studies, and (3) avoid surveys along roads and trails with extremely high levels of disturbance and removal.
  Contact: Eric Gese

- **Optimizing Scat Detection Methods for Feral Swine.** Much research has been done to optimize scat (fecal) sampling methods for carnivores *(see previous summary)*, but further studies would help improve methods for social ungulates (hoofed mammals), such as feral swine. Toward this end, researchers with NWRC, University of Georgia, Savannah River Ecology Laboratory, and Warnell School of Forestry and Natural Resources evaluated the effects of sampling protocol, scat characteristics (such as fecal pellet size and number), and environmental factors (such as percentage of vegetative ground cover and occurrence of rain immediately before sampling) on scat detection rates for feral swine. They found that sampling protocols with a 15- or 20-meter search radius located more scats than the previously used "adaptive cluster" sampling approach (which searched across habitat types). Also, fecal pellet size, number of fecal pellets, percentage of vegetative ground cover, and recent rain events were significant predictors of scat detection.

  These results suggest that the use of a fixed-width radial search protocol may increase the number of scats detected for feral swine or other social ungulates. This would allow for more robust population estimates using noninvasive genetic sampling

methods. Further, as fecal pellet size affected scat detection, juvenile or smaller-sized animals may be harder to detect than adult or large animals, which could introduce bias into abundance estimates. Knowing the relationships between environmental variables and scat detection may allow researchers to optimize sampling protocols and maximize the usefulness of non-invasive sampling for feral swine and other social ungulates.
Contact: Fred Cunningham

- **Validating Abundance Indices Based on Count Data.** Practical field methods for assessing the relative abundance of wildlife species allow managers and researchers to infer and compare population differences, trends, and changes over time or between geographical areas. Indices are observational methods combined with analytical procedures that produce a statistic of relative abundance. Because they are easy to use, indices are a common method for monitoring wildlife populations.

  A general indexing paradigm developed by NWRC is applicable to many wildlife observation methods. However, statistical inference about index values has been based on traditional normal (Gaussian) distributions and confidence intervals. Count observations form the most common examples of indexing data and include examples such as the number of intrusions (number of sets of tracks) by a species into a tracking plot, the number of individuals (or intrusions) of a species photographed at a camera station, and the number of each species seen at an observation station in a fixed amount of time. For many of these count observation methods, data also involve low numbers and zeros. Thus, raw count observations typically are not normally distributed.

  To fill the inferential gap about whether indices based on count observations actually are suitable for normal distribution-based statistical inference, NWRC and University of Colorado researchers ran a computer simulation study. Results showed that statistical inference for normal distributions performed well when applied to indices based on count data. Abundance estimations improved by increasing the number of observation days, and confidence interval coverage rates performed very well when day-to-day variability was small. These results give a strong basis for applying the general indexing paradigm to count data, as well as valuable information for improving the design of studies using count observations.
  Contact: Richard Engeman

Registration Updates

- **EPA Registration Review of DRC-1339 Products.** An Environmental Protection Agency (EPA) Registration Review of DRC-1339 was initiated in 2011. DRC-1339 is a toxicant used to control several bird species that damage crops and property and prey on livestock and nesting birds. The NWRC Registration Unit is overseeing five studies to address EPA requirements and supply data needed to assess the potential environmental impacts of DRC-1339 use. One study was completed with funding from the WS NWRC Technology Transfer Program. Two more studies are under contract. These data are required to maintain the EPA registration of APHIS' DRC-1339 products.
  Contact: Jeanette O'Hare

- **EPA Registration Review of Gas Cartridge.** The start of a Registration Review for APHIS' gas cartridge products marked a new approach to pesticide regulation by EPA to meet its obligations under the Endangered Species Act (ESA). Because APHIS also has obligations under the ESA, we need a mechanism that allows both Federal agencies to comply with the ESA and perform our programmatic missions. As a result, we have submitted new

"APHIS-only" gas cartridge labels to the EPA; the new labels will allow APHIS to consult with the U.S. Fish and Wildlife Service on the use of our agency's gas cartridge products. This new pesticide label approach will serve as a regulatory template for other APHIS pesticide products.
Contact: Jeanette O'Hare

- **Feral Swine Control—Regulatory Path Forward for a Sodium Nitrite Product.** In June 2016, the NWRC Registration Unit submitted a data package to EPA in support of an Experimental Use Permit (EUP). The EUP will allow NWRC and its partners to conduct a field study of HOGGONE, a sodium nitrite-based pesticide product for controlling feral swine. The EUP application package addresses 51 EPA data requirements on the performance, product chemistry, toxicology, ecological effects, and environmental effects of HOGGONE and its active ingredient, sodium nitrite. The submission of the data package marks a significant regulatory step toward development of a new product for feral swine control.
Contact: Jeanette O'Hare

Technology Transfer

- **Patents, Licenses, and New Inventions.** 2016 was a banner year for the NWRC in terms of new technologies and products. The U.S. Patent and Trademark Office (PTO) awarded us two patents during the past year. The first was for the ultraviolet characteristics of materials for developing chemical tools to repel birds from crops and other areas (Patent #US 9,131,678 B1). Soon after publication, this patent was licensed to Arkion Life Sciences. NWRC worked with Arkion Life Sciences after that to further develop this revolutionary technology. We then submitted three other related patent applications to PTO. A second patent was awarded to NWRC scientists for advancements in the field of vaccine technology. Working in collaboration with Merial, Inc., three NWRC scientists were awarded a patent on a new technology for thickening vaccine formulations (Patent #US 9,216,213 B1). This technology offers significant advantages for the oral delivery of vaccines to animals over more liquid vaccine formulations. The NWRC is now seeking a licensing partner for this new vaccine technology.

In addition to the abovementioned patents, NWRC presented three new inventions to USDA's Agricultural Research Service this year for consideration to patent. One of the three inventions was selected for patent preparation. This invention advances the idea of using cellular fragments of bacteria to enhance the overall effectiveness of the vaccine. The two inventions declined by ARS were for developing bird-resistant feeds to alleviate bird problems in dairies. Despite not being advanced for patent, there is strong interest in this idea from the dairy industry and academic institutions. We are partnering with them to continue developing prototype feeds and subsequent laboratory and field tests.

In 2016, SpayFIRST! licensed the rights to Patent #US 7,731,939 "Vaccine Composition and Adjuvant." This license is for developing a product line around the Immunocontraceptive "GonaCon" for managing wild and feral horses and burros. SpayFIRST! is now applying for its first product registration through the EPA. Finally, Tomahawk Live Trap licensed the rights to Patent #US 8,407,031 "Trapping Methods and Apparatus." This license allows Tomahawk to produce and market a novel live trap for capturing large snakes. The product is now available on the company's Web site. Revenue generated so far from the licensing and royalty fees totaled $17,500. These revenues are directly available to the NWRC.
Contact: John Eisemann

Awards

- **2016 NWRC Publication Award.** Each year, the NWRC Publication Awards Committee, composed of NWRC scientists, reviews over 100 publications generated by their NWRC colleagues. The resulting peer-recognized awards honor outstanding contributions to science and wildlife damage management. In 2016, three publications received the award for outstanding NWRC research publication for their contributions to basic and applied science. The winners include the following:

  - **Stewart Breck** and his research partners for the article "Shifting perceptions of risk and reward: dynamic selection for human development by black bears in the western United States" (*Biological Conservation* 187:164–172)

  - **Jeff Root, Susan Shriner, Jeremy Ellis, Kaci VanDalen, Heather Sullivan, and Alan Franklin** for the article "When fur and feather occur together: interclass transmission of avian influenza A virus from mammals to birds through common resources" (*Scientific Reports* 5)

  - **Travis DeVault, Brad Blackwell, Tom Seamans,** and their research partners for the article "Speed kills: ineffective avian escape responses to oncoming vehicles" (*Proc. R. Soc. B,* 282: 20142188)

- **NWRC Employee of the Year Awards.** The winners of this award are nominated by their peers as employees who have clearly exceeded expectations in their contributions toward the NWRC mission. The winners this year are:

  - **Antoinette Piaggio**
    Research Grade Scientist; Genetic Methods To Manage Livestock-Wildlife Interactions Project; Fort Collins, CO

  - **Katie Hanson-Dorr**
    Support Scientist; Defining Economic Impacts and Developing Strategies for Reducing Avian Predation in Aquaculture Systems Project; Starkville, MS

  - **Joseph Halseth**
    Technician; Management of Ungulate Disease and Damage Project; Fort Collins, CO

  - **Michael Davis**
    Administrative Support Unit; Millville, UT

2016 Publications

The transfer of scientific information is an important part of the research process. NWRC scientists publish in a variety of peer-reviewed journals that cover a wide range of disciplines, including wildlife management, genetics, analytical chemistry, ornithology, and ecology. (Note: 2015 publications that were not included in the 2015 NWRC accomplishments report are listed here.)

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Appendixes

Appendix 1

More information about these projects is available on the NWRC Web page at: **www.aphis.usda.gov/wildlifedamage/nwrc**

List of 2016 NWRC Research Projects

Methods Development and Population Management of Vultures and Invasive Wildlife
Project Leader: Michael Avery

Defining Economic Impacts and Developing Strategies for Reducing Avian Predation in Aquaculture Systems
Project Leader: Fred Cunningham

Improving Management Strategies To Reduce Damage by Forest and Aquatic Mammals
Project Leader: Jimmy Taylor

Developing Control Methods, Evaluating Impacts, and Applying Ecology, Behavior, Genetics, and Demographics To Manage Predators
Project Leader: Julie Young

Development of Injectable and Mucosal Reproductive Technologies and Their Assessment for Wildlife Population and Disease Management
Project Leader: Douglas Eckery

Understanding, Preventing, and Mitigating the Negative Effects of Wildlife Collisions With Aircraft, Other Vehicles, and Structures
Project Leader: Travis DeVault

Improving Rodenticides and Investigating Alternative Rodent Damage Control Methods
Project Leader: Gary Witmer

Developing Methods To Evaluate and Mitigate Impacts of Wildlife-Associated Pathogens Affecting Agricultural Health, Food Security, and Food Safety
Project Leader: Alan Franklin

Economic Research of Human-Wildlife Conflicts: Methods and Assessments
Project Leader: Stephanie Shwiff

Defining Economic Impacts and Developing Control Strategies for Reducing Feral Swine Damage
Project Leader: Kurt VerCauteren

Methods and Strategies for Controlling Rabies
Project Leader: Amy Gilbert

Management of Ungulate Disease and Damage
Project Leader: Kurt VerCauteren

Methods and Strategies to Manage Invasive Species Impacts to Agriculture, Natural Resources, and Human Health and Safety
Project Leader: Shane Siers

Methods Development and Population Biology of Blackbirds and Starlings in Conflict With Agriculture, Concentrated Animal Feeding Operations, and Urban Environments
Project Leader: Page Klug

Chemosensory Tools for Wildlife Damage Management
Project Leader: Bruce Kimball

Genetic Methods To Manage Livestock-Wildlife Interactions
Project Leader: Antoinette Piaggio

Development of Repellent Applications for the Protection of Plant and Animal Agriculture
Project Leader: Scott Werner

Appendix 2

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Baroch, John	(970) 266-6308 john.a.baroch@aphis.usda.gov	NWDP: wildlife disease
Berentsen, Are	(970) 266-6221 are.r.berentsen@aphis.usda.gov	Rabies
Bevins, Sarah	(970) 266-6211 sarah.n.bevins@aphis.usda.gov	NWDP: wildlife disease
Blackwell, Bradley	(419) 625-0242 ext. 15 bradley.f.blackwell@aphis.usda.gov	Aviation hazards, lighting systems
Breck, Stewart	(970) 266-6092 stewart.w.breck@aphis.usda.gov	Carnivores
Carlson, James	(970) 266-6127 jim.c.carlson@aphis.usda.gov	Chemistry
Chandler, Jeff	(970) 266-6090 jeffrey.c.chandler@aphis.usda.gov	Wildlife disease, microbiology
Cunningham, Fred	(662) 325-8215 fred.l.cunningham@aphis.usda.gov	Project Leader: aquaculture, cormorants
Davis, Amy	(970) 266-6313 amy.j.davis@aphis.usda.gov	Feral swine
DeVault, Travis	(419) 625-0242 ext. 11 travis.l.devault@aphis.usda.gov	Project Leader: aviation hazards
Dorr, Brian	(662) 325-8216 brian.s.dorr@aphis.usda.gov	Aquaculture, cormorants

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Franklin, Alan	(970) 266-6137 alan.b.franklin@aphis.usda.gov	Project Leader: emerging infectious diseases
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Gidlewski, Tom	(970) 266-6350 thomas.gidlewski@aphis.usda.gov	Program Manager: attending veterinarian, zoonoses surveillance
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Goldade, David	(970) 266-6080 david.a.goldade@aphis.usda.gov	Chemistry
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Horak, Katherine	(970) 266-6168 katherine.e.horak@aphis.usda.gov	Physiological modeling, pesticides
Humphrey, John	(352) 448-2131 john.s.humphrey@aphis.usda.gov	Invasive species, vultures

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Appendix 3

Acronyms and Abbreviations

APHIS	Animal and Plant Health Inspection Service
APMV-1	avian paramyxovirus serotype 1
AQ	anthraquinone
CME	clathrin-mediated endocytosis
CSFV	classical swine fever virus
Cu	copper
CWD	chronic wasting disease
DNA	deoxyribonucleic acid
eDNA	environmental DNA
DoD	U.S. Department of Defense
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
ESA	Endangered Species Act
EUP	experimental use permit
FAA	Federal Aviation Administration
FHV-1	feline herpesvirus
FIV	feline immunodeficiency
FMDV	foot-and-mouth disease virus
FY	fiscal year
GIS	geographic information system
GPS	global positioning system
H	hemagglutinin
HPAI	highly pathogenic avian influenza
IAV	influenza A virus
IDGF	Idaho Department of Game and Fish
km	kilometer
LPAI	low pathogenic avian influenza
MDI	mongoose density index
Mg	magnesium
mL	milliliter
mM	millimolar
N	neuraminidase
NDV	Newcastle disease virus
NFSDMP	National Feral Swine Damage Management Program
NRMP	National Rabies Management Program
NWDP	National Wildlife Disease Program
NWRC	National Wildlife Research Center
ORV	oral rabies vaccine
PIT	passive integrated transponder
PTO	U.S. Patent and Trademark Office
RNA	ribonucleic acid
SFS	supplemental feeding station
S/N	sample-to-negative
TMC	trimethylated chitosan
UAV	unmanned aerial vehicle
USDA	U.S. Department of Agriculture
WS	Wildlife Services

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