



Cooperative Fish and Wildlife Research  
Units Program— **2019** Year in Review

Circular 1463

U.S. Department of the Interior  
U.S. Geological Survey



**Front cover.** A female Florida panther photographed in the wild at the National Audubon Society's Corkscrew Swamp Sanctuary, Florida. Photograph by Carlton Ward, Jr.; used with permission.

**Inside front cover.** American paddlefish and pallid sturgeon. Photograph by Doug Canfield, U.S. Fish and Wildlife Service.

**Back cover.** A male Florida panther photographed on Babcock Ranch, Florida, by using a custom-made camera trap. Photograph by Carlton Ward, Jr.; used with permission.

An underwater photograph of a sea turtle swimming in clear blue water. The turtle is the central focus, with its head and front flippers visible. The water is a deep, clear blue, and the lighting is bright, creating a serene atmosphere. The turtle's shell shows distinct scutes, and its head has a patterned appearance. The overall scene is peaceful and captures the natural habitat of the turtle.

# **Cooperative Fish and Wildlife Research Units Program—2019 Year in Review**

By John D. Thompson, Donald E. Dennerline, and Dawn E. Childs

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**U.S. Department of the Interior  
U.S. Geological Survey**

**U.S. Department of the Interior**  
DAVID BERNHARDT, Secretary

**U.S. Geological Survey**  
James F. Reilly II, Director

U.S. Geological Survey, Reston, Virginia: 2020

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## Abbreviations

app	application
BCWD	bacterial coldwater disease
BKD	bacterial kidney disease
CRU	Cooperative Research Unit
CWD	chronic wasting disease
DoD	U.S. Department of Defense
ESA	Endangered Species Act
M.S.	master of science degree
NGOs	nongovernmental organizations
Ph.D.	doctor of philosophy degree
SDM	structured decision making
SGCN	species of greatest conservation need
SSA	species status assessment
SWAP	State Wildlife Action Plan
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey

## Acting Chief's Message

Dear Cooperators:

Members of the Cooperative Research Units are pleased to provide you with the “2019 Year in Review” report for the Cooperative Fish and Wildlife Research Units (CRUs). You will first note that this report looks a little different than those published in the past few years, as we opted for a shorter, more concise format this year. Inside you will find brief descriptions of just a few highlighted activities of unit scientists, students, and cooperators in support of our joint mission. Because of the shorter format, we are not able to include activities from every unit or State, but rest assured that we continue to value the great work that all of you do across the country and around the world.

In fiscal year 2019, the CRU program was very productive despite challenging conditions, including budget uncertainty, a month-long furlough, and hiring delays. John Organ, Chief of the CRU program, retired in January 2019. The process to replace John was delayed several times, but as I write this, the position has been announced on the Federal Government recruitment site. I am hopeful that by the time you read this, we will have a new permanent chief. Congress provided an increase of \$1 million in our allocation for the express purpose of filling some of the vacancies in our scientific workforce. Since receiving that increase, the management team has been working to fill vacancies.

The program is fortunate to have excellent research scientists, dedicated leadership, and an outstanding administrative staff. However, our accomplishments depend on the tremendous support from all of you. We look forward to a productive 2020.

John D. Thompson





# Cooperative Fish and Wildlife Research Units Program—2019 Year in Review

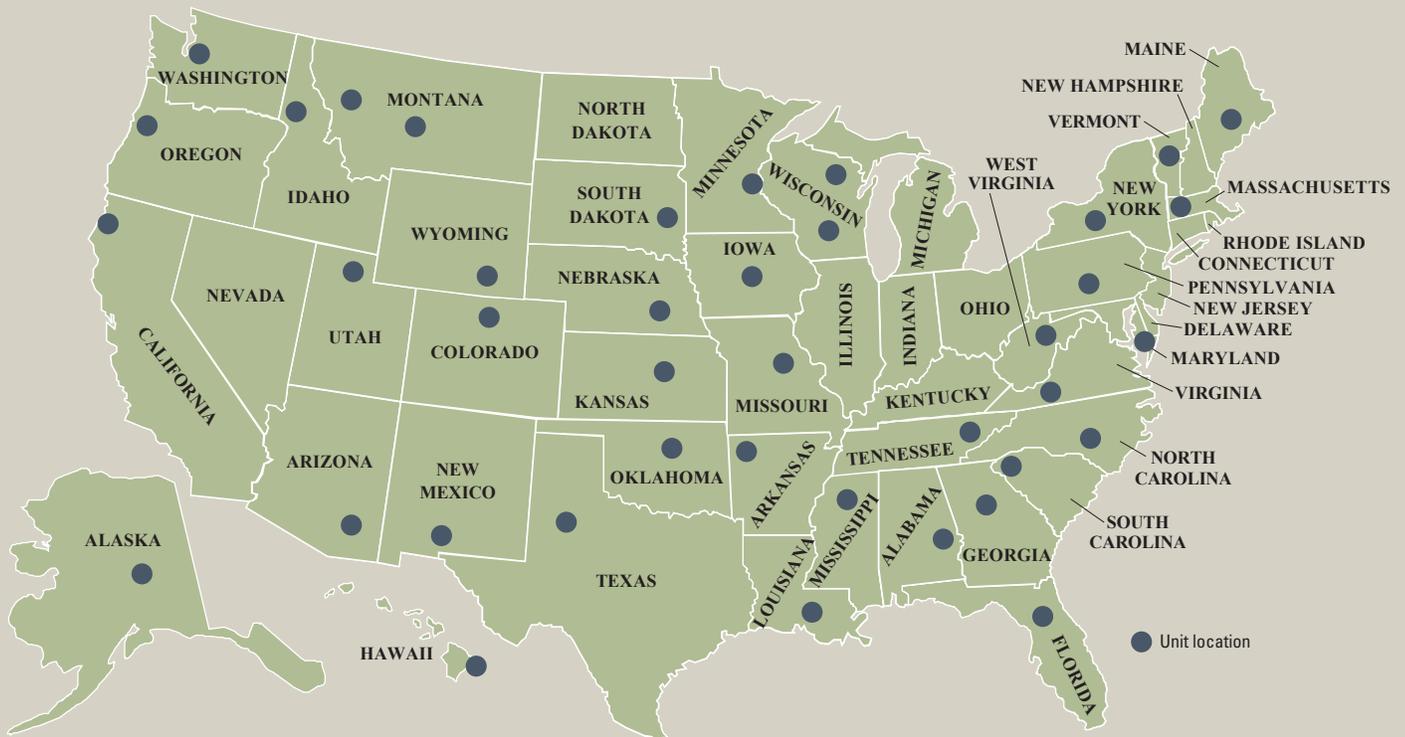
By John D. Thompson, Donald E. Dennerline, and Dawn E. Childs

## About the Cooperative Research Units Program

Established in 1935, the Cooperative Research Units program is a unique cooperative partnership among the U.S. Geological Survey (USGS), the U.S. Fish and Wildlife Service (USFWS), universities, State fish and wildlife agencies, and the Wildlife Management Institute. Designed to meet the scientific needs of natural resource management agencies and the need for trained professionals in the growing field of wildlife management, the program has grown from the original 9 wildlife-only units and today includes 40 Cooperative Fish and Wildlife Research Units located on university campuses in 38 States. Signatory cooperators forming the individual units include 41 universities and 44 State fish and wildlife agencies. The partnerships that form each unit are some of the USGS's strongest links to Federal and State land and natural resource agencies as mandated by the Cooperative Research and Training Units Act of 1960 (P.L. 86-686).

Details about the program follow:

- The research agenda for each unit is approved by the Coordinating Committee, which includes the U.S. Department of the Interior, the State fish and wildlife agency, the university, and the Wildlife Management Institute
- Each unit is staffed by two to five Federal research scientists employed by the USGS
- If fully staffed, units would be served by 119 Federal employees. Unit scientists hold faculty rank at their host university, teach graduate-level courses, and conduct research on a wide variety of fish and wildlife issues
- Research projects typically support graduate students or postdoctoral researchers
- USGS employees in the units work with State fish and wildlife agencies and Federal natural resource agencies, providing them with the science used in management decisions to support sustainable fish and wildlife populations for wildlife watching, fishing, and hunting



Locations of 40 Cooperative Fish and Wildlife Research Units in fiscal year 2019.

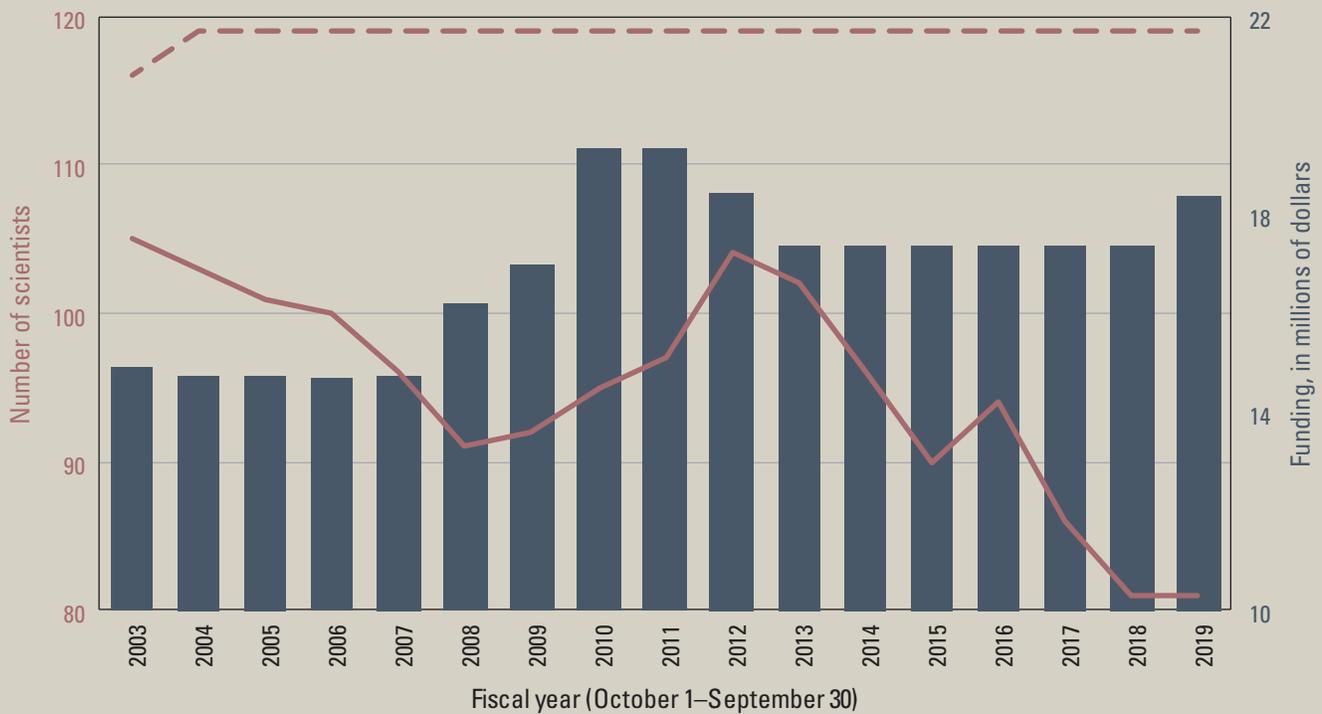
## Performance of the Cooperative Research Units Program

### Budget and Staffing

Congress provided an increase of \$1 million for the Cooperative Research Units program in the 2019 allocation for the express purpose of filling vacancies. While we have been working to fill positions, delays in the allocation and hiring process coupled with retirements and resignations resulted in no net increase in scientific staff by the end of the fiscal year. We hope the staffing situation will improve in 2020.

Cooperators include the following:

-  State fish and wildlife agencies
-  Universities
-  Wildlife Management Institute
-  U.S. Geological Survey
-  U.S. Fish and Wildlife Service



**EXPLANATION**

-  CRU budget, in millions of dollars
-  Full staffing level without vacancies
-  Actual staffing, in number of scientists at end of fiscal year

Graph showing budget and staffing data for the Cooperative Fish and Wildlife Research Units program during fiscal years 2003–2019. The full staffing level would mean that 119 U.S. Geological Survey research scientists would be employed at the 40 units. In fiscal year 2019, there were 38 vacancies nationwide.

## Productivity and Leveraging Resources

The unique model of the Cooperative Fish and Wildlife Research Units program allows all cooperators to benefit from each other's strengths. Host universities receive two to five Ph.D. Federal scientists who teach classes, advise students, provide technical expertise, and bring in Federal and State research funding. Every Federally allocated dollar is matched on about a 1:3 basis by State and host university contributions and grant funds. State agency cooperators benefit from our scientists' expertise and the direct support of graduate student research projects that target their current concerns. The USGS directly benefits from unique funding opportunities provided by State and Federal cooperators. Also, cooperators gain access to the expertise and research infrastructure of our host universities that is invaluable for supporting research and training future State and Federal managers and scientists. Overall, the program links the research and training mission of all cooperators, thereby providing enhanced scientific expertise while training students to enter the conservation workforce.

Unit scientists garner

**\$25 million to \$40 million**

in State and Federal research funding each year

---

Federal investment supports about

**1,100 students and university staff members**

annually

---

Universities provide more than

**\$20 million**

through in-kind support, tuition, and reduced overhead

**277**  
Publications

**41**  
Courses taught

**630**  
Presentations

**29**  
Seminars

**10**  
Workshops and short courses



## Mission of the Cooperative Research Units Program

The mission of the Cooperative Research Units program has three parts: (1) develop the workforce of the future through applied graduate education, (2) deliver actionable science to cooperating agencies and organizations, and (3) fulfill the training and technical assistance needs of the cooperators. Accomplishments during fiscal year 2019 for each of these parts of the mission are described in the following sections.

### Graduate Education To Develop the Conservation Workforce

The Cooperative Research Units program educates more than 500 graduate students annually in natural resource management and conservation. Students are advised by unit scientists and conduct applied research projects that directly address current natural resource concerns of our State and Federal cooperators. Students receive cutting-edge academic

training from our university cooperators and develop expertise on the issues and policies of State and Federal natural resource management and protection agencies. Students who graduate from the program experience are uniquely prepared to be effective members of the natural resource workforce, and the alumni hold important leadership positions in nearly every State and Federal conservation agency.

Unit scientists teach a variety of graduate-level courses including Wildlife Management, Ecology of Running Waters, Bayesian Modeling for Conservation Science, Fisheries Techniques and Management, Data Management and R Software for Fisheries and Wildlife Applications, Wildlife Conservation, Ornithology, Marine Mammalogy, and Communication Skills in Conservation.

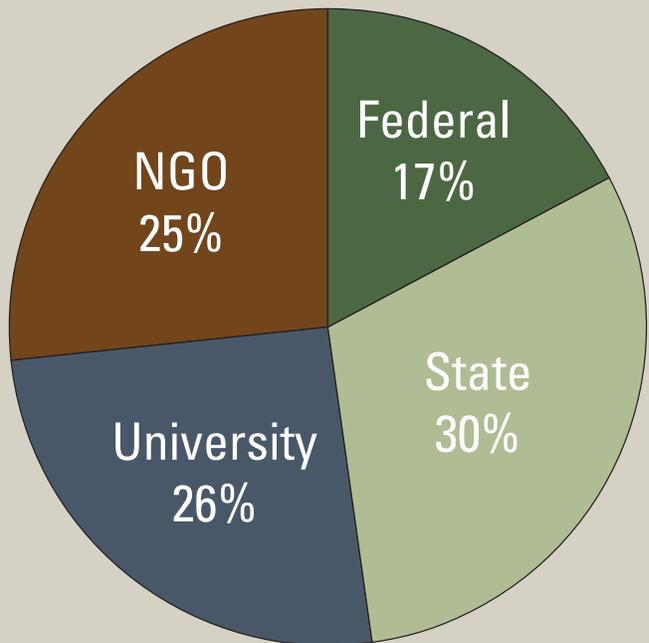
One of the greatest legacies of the program is the placement of our students in natural resource agencies and organizations. A pillar of the program’s mission is to develop the workforce of the future through graduate education.

  
**408**  
 Active graduate students  
 (254 M.S. and  
 154 Ph.D. students)

  
**56**  
 Postdoctoral  
 researchers

  
**74**  
 Graduate degrees  
 awarded (51 M.S. and  
 23 Ph.D. degrees)

  
**40**  
 Undergraduate  
 students



Pie chart showing the types of professional positions obtained by recent graduates who participated in the Cooperative Fish and Wildlife Research Units program. Data are averaged for fiscal years 2012–2019. NGO, nongovernmental organization.

## Applied Research To Meet Cooperators' Science Needs

We lead research that can provide objective science for the management needs of cooperators and inform decision making. Research conducted by unit scientists addresses the broad themes that are important to both our State and Federal cooperators. In this report, we have chosen to highlight just a few of these themes with selected examples of the many management-oriented research projects conducted with our State and Federal cooperators. Many more examples are available online. Each of these examples demonstrates the importance of this cooperative effort and what it can yield.

A photograph of a large brown bear and a smaller cub standing in a grassy field with patches of snow. The bear is looking towards the camera, while the cub is looking to the left. The background is a mix of green grass and white snow.

“Many biologists working for the Alaska Department of Fish and Game, Division of Sport Fish pursued their graduate student education through the Alaska Unit. The knowledge and skills they gained through the Unit program have proved and are invaluable in planning and conducting research projects to improve science-based management decisions made by the department. Many of them have become leaders who mentor others to maintain and improve the fisheries professional credibility of the division to achieve the department’s State constitutional mandate to manage fish resources in the best interest of the economy and well-being of the people of the state, consistent with the sustained yield principle.”

**James Hasbrouck**  
Chief Fisheries Scientist  
Alaska Department of Fish and Game

## Threatened and Endangered Species

Scientists in the Cooperative Research Units program work with Federal and State cooperators to answer science questions about endangered species and those species petitioned for listing as threatened or endangered under the Endangered Species Act (ESA). Research results inform listing decisions under the ESA and also are used for prelisting conservation. Three studies are summarized below.

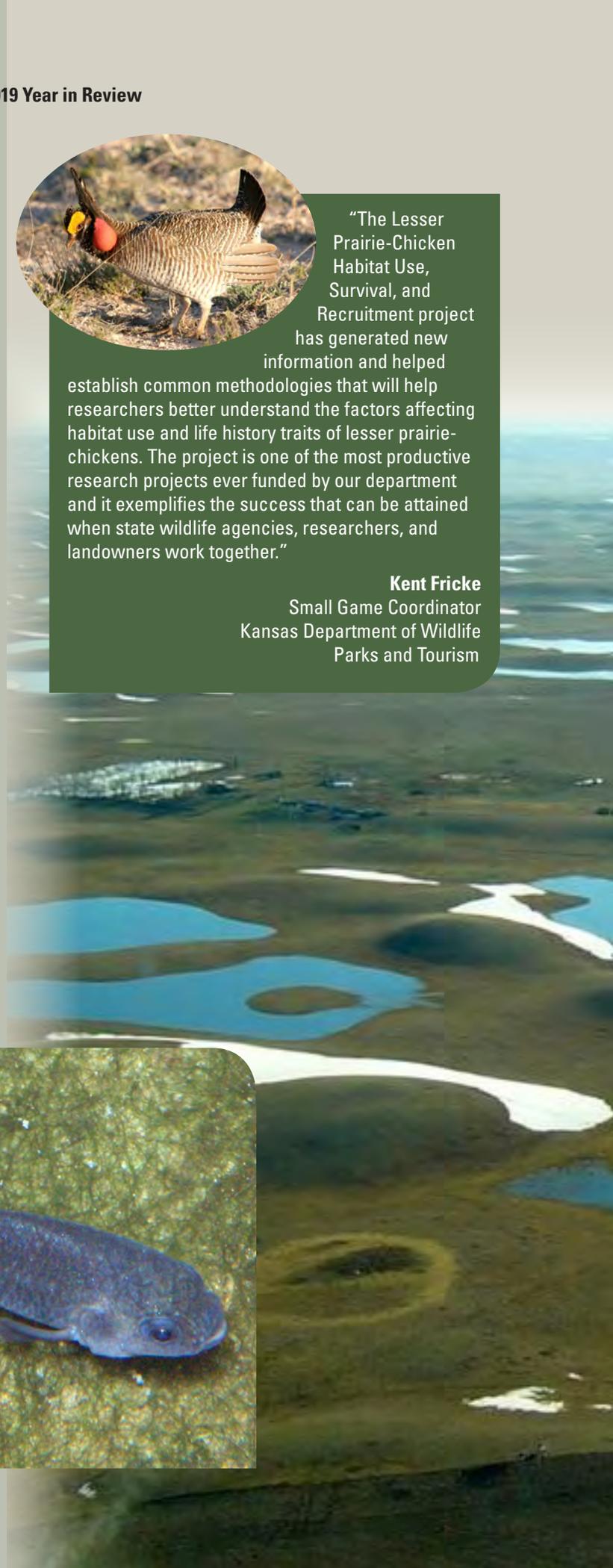
**Using remote videography to investigate behavior in Devils Hole pupfish in Devils Hole, Death Valley National Park, Nevada:** The monitoring of threatened and endangered fishes in remote environments continues to challenge fisheries biologists. The endangered Devils Hole pupfish, which is confined to a single warm spring in the Nevada part of Death Valley National Park, has recently experienced record declines, spurring renewed conservation and recovery efforts. The Arizona Unit investigated the timing and frequency of spawning in the species' native habitat by using three survey methods: underwater videography, above-water videography, and in-person surveys. Videography methods incorporated fixed-position, solar-powered cameras to record continuous footage of a shallow rock shelf that Devils Hole pupfish use for spawning. In-person surveys were conducted from a platform placed above the water's surface. Although the overall number of spawning events per sample did not differ significantly between underwater videography and in-person surveys, underwater videography provided a larger dataset with much less variability than data from in-person surveys. Fixed videography was more cost efficient than in-person surveys, and underwater videography provided more usable data than above-water videography. Furthermore, video data collection was possible even under adverse conditions, such as the extreme temperatures of the region, and could be maintained successfully with few study site visits. The results suggest that self-contained underwater cameras can be efficient tools for monitoring remote and sensitive aquatic ecosystems.

**Development of a species status assessment process for decisions under the Endangered Species Act:** Species management decisions under the ESA require scientific input on the risk that the species will become extinct in the near term and the foreseeable future. A series of critiques on the role of science in ESA decisions has called for improved consistency and transparency in species risk



"The Lesser Prairie-Chicken Habitat Use, Survival, and Recruitment project has generated new information and helped establish common methodologies that will help researchers better understand the factors affecting habitat use and life history traits of lesser prairie-chickens. The project is one of the most productive research projects ever funded by our department and it exemplifies the success that can be attained when state wildlife agencies, researchers, and landowners work together."

**Kent Fricke**  
 Small Game Coordinator  
 Kansas Department of Wildlife  
 Parks and Tourism



“The staff of the Oregon Unit have a long and rich history of collaboration with the Oregon Department of Fish and Wildlife on the key fish and wildlife management issues of the day. Whether it was pioneering work on Spotted Owls and old growth forest relationships, developing the science around the effects of avian predation on juvenile salmon and steelhead, resolving critical uncertainties around what constrains the recovery of Sage Grouse, or ground-breaking research on lesser known species such as Pacific Lamprey, the Coop Unit’s work informs science decision-making for ODFW that is essential to addressing critical economic, human, and ecological issues in Oregon and the Pacific Northwest.”



**Bruce McIntosh**  
Deputy Administrator  
Oregon Department of Fish and Wildlife  
Fish Division

assessments and clear distinctions between science input and policy application. To address the critiques and document the emerging practices of the USFWS, members of the Alabama Unit and the USGS Leetown Science Center in West Virginia devised an assessment process based on principles of risk and decision analyses. The assessment is designed to lead to a scientific report on species status called the species status assessment (SSA). The process has three successive stages: (1) describe the life history and ecological needs of the species to provide the foundation for the assessment; (2) describe and hypothesize causes for the current condition of the species; and (3) incorporate modeling and scenario planning for prediction of extinction risk and apply the conservation biology principles of representation, resiliency, and redundancy to evaluate the current and future conditions. The future condition refers to the ability of a species and its populations to survive in the wild under plausible future scenarios and the potential for conservation methods to be used to improve its status. The SSA results in a scientific report separate from the policy decisions, which contributes to streamlined, transparent, and consistent decision making and allows for greater participation by experts from various agencies and academia.

**Assessment of neonicotinoid exposure on U.S. Fish and Wildlife Service high-diversity grasslands in the Prairie Pothole Region:**

Obligate grassland species of butterflies are rapidly decreasing in the United States because of habitat fragmentation, destruction, and degradation. The Dakota skipper and Poweshiek skipperling—butterflies recently listed as threatened and endangered, respectively, under the ESA—inhabit high-quality grasslands. Additionally, because of significant population declines, the USFWS has initiated a status review of the monarch butterfly under the ESA. The South Dakota Unit is assessing neonicotinoid pesticide exposure on native and restored grasslands and is determining the rate of accumulation of neonicotinoids in native flowering plants through greenhouse trials. Study results should be important

to managers working to restore populations of these three species.



## Fish and Wildlife Health and Disease

Fish and wildlife diseases pose potential threats to the viability of fish and wildlife populations and have potential implications for human health and our economy. Scientists in the Cooperative Research Units program work with cooperators to better understand the causes of these diseases, the effects on wildlife and people, and the means to control, contain, and eradicate them. Three studies are summarized below.

**Hatchery-reared rainbow trout stocked into an Ozark stream:** Pathogens remain one of the most problematic aspects of raising fish in a hatchery, and finding solutions to controlling or eliminating pathogens is a high priority worldwide. The Colorado Unit is pursuing research to develop management options to control two important bacterial pathogens of salmon and trout: *Renibacterium salmoninarum*, which causes bacterial kidney disease (BKD), and *Flavobacterium psychrophilum*, which causes bacterial coldwater disease (BCWD). Outbreaks of these diseases can be catastrophic for hatchery production. The research focuses on the ecology of both pathogens, the resistance of host species, and efficient detection of each pathogen. The research on BCWD focuses on using BCWD-resistant rainbow trout as a means of reducing the effects of the pathogen in the hatchery and avoiding the use of antibiotics. Although antibiotics are currently effective, the development of antibiotic-resistant bacteria is a concern. The researchers are also assessing crossing BCWD-resistant rainbow trout with those that are resistant to whirling disease to allow stocking and reestablishment of rainbow trout in the wild. Assessing this hybrid rainbow trout is a priority for Colorado Parks and Wildlife, the Utah Division of Wildlife Resources, and the U.S. Department of Agriculture. The research on BKD has two goals: (1) assessing nonlethal sampling techniques to reduce the need to sacrifice valuable hatchery stock and (2) examining how the pathogen is transmitted. Transmission can occur from fish to fish or from parent to offspring; the type and rate of transmission will inform best management practices to reduce transmission of the disease. The BKD research is a high priority for Colorado Parks and Wildlife as well as the U.S. Fish and Wildlife Service.



“The South Carolina Unit is an integral partner with the South Carolina Department of Natural Resources (SCDNR) in the development and delivery of science-based technical assistance and resource management information. Scientists within the Unit are responsive to requests from agency staff and provide invaluable information on management and research techniques, species’ status, resource threats, and avenues for future research. Through collaborative efforts between the Unit and SCDNR, new research and survey techniques have been developed and tested, species’ status determined or verified, and ecological relationships validated. Collectively, these efforts have resulted in more efficient survey techniques, improved resource management effectiveness and improved information delivery used in adaptive management frameworks to the benefit of the citizens and natural resources of South Carolina.”

**Billy Dukes**  
Chief of Wildlife  
South Carolina Department of Natural Resources



“The Wisconsin Wildlife Unit is an essential partner in linking research with real-world wildlife management. Whether maintaining habitat for songbirds or the vexing problem of chronic wasting disease, the Unit leverages expertise from across campus to bring the best science to bear. The emphasis on graduate training ensures that future scientists and leaders understand the connection between science and management.”

**Mark Rickebach**  
Chair

Department of Forest and Wildlife Ecology  
University of Wisconsin-Madison

**Endangered Indiana bats on National Wildlife Refuges:** Populations of Indiana bats have fallen more than 20 percent across their range in the last decade, largely because of a serious disease called white-nose syndrome. Protecting critical roosting habitat may help slow the spread of the disease and the population decline. The Missouri Unit has partnered with the USFWS to examine maternity habitat selection by Indiana bats on National Wildlife Refuges in northern Missouri. Results from this study may provide public land managers with valuable insight into habitat selection and assist disease reduction and recovery efforts for this endangered species. Gaining a better understanding of the drivers of habitat selection may allow managers to anticipate future obstacles, prioritize specific habitats, assist efforts to promote new habitat, and guide future land acquisitions.

**Landscape genetics of white-tailed deer to assess population structure for surveillance of chronic wasting disease:** Research on surveillance strategies that consider demographic and environmental factors is lacking in most States where chronic wasting disease (CWD) has not been found. Developing surveillance strategies to maximize the efficiency of sampling white-tailed deer was suggested but requires knowledge of deer behavior and movements and the spatial connectivity of populations. The Pennsylvania Unit is evaluating the effectiveness of targeted removal of white-tailed deer groups on CWD occurrence and distribution. Scientists are also implementing genetic research to understand patterns of disease susceptibility and population connectivity across Maryland, Pennsylvania, and Virginia for targeted CWD mitigation strategies.



## Invasive Species

Invasive species cost the United States more than \$120 billion in damages every year, as quoted in a 2012 fact sheet by the U.S. Fish and Wildlife Service (<https://www.fws.gov/home/feature/2012/pdfs/CostofInvasivesFactSheet.pdf>). The economic, environmental, and health-related costs of invasive species exceed those of all other natural disasters combined. Invasive species of plants, animals, and microorganisms pose substantial risks to native species, ecosystems, and the health of humans, fish, and wildlife.

**Asian carp movement through locks and dams in the Tennessee River:** Invasive Asian carp are a threat to native fish and aquatic communities, sport fisheries, recreational uses, and tourism. All four species of invasive Asian carp (silver carp, bighead carp, black carp, and grass carp) have been captured in the Tennessee River and Cumberland River, which are tributaries to the Ohio River. The Tennessee River and Cumberland River flow through four States, and increasing Asian carp populations have created concerns about ecosystem health and value across the Southeast. The Tennessee River also has connectivity to the Tennessee-Tombigee Waterway that connects to the Mobile River Basin. The Tennessee Unit and the Mississippi Unit are working with multiple State agencies and universities to understand the movement of Asian carp by using acoustic telemetry. Acoustic telemetry provides movement data from fish that are surgically tagged and can inform how control and prevention strategies could be used to stop further invasion. In these systems, there is significant potential for limiting further invasion of Asian carp at navigation locks and dams. The Units and their partners are working with the USFWS and USGS Science Centers (Columbia Environmental Research Center and Upper Midwest Environmental Sciences Center) to propose and plan for barriers that could be deterrents to further invasion. This effort supports national and regional goals for the control of expansion of Asian carp in the United States.

“The Arkansas Unit is an integral partner in the Department of Biological Sciences at the University of Arkansas. The COOP faculty recruit and train outstanding graduate students, and they generously contribute to the teaching mission of our department through course offerings in applied ecology, fish and wildlife management techniques and biometry. Moreover, the COOP faculty provide valuable expertise in statistical data analyses for members of the Department of Biological Sciences.”

**Dr. David McNabb**

Departmental Chair, Biological Sciences  
University of Arkansas



“We are proud of the partnership we have with the U.S. Geological Survey and the Oklahoma Department of Wildlife Conservation (ODWC) that supports the Oklahoma Unit at Oklahoma State University (OSU). Our Unit faculty collaborate closely with ODWC managers and other OSU faculty in seeking research-based approaches to management decisions. Most importantly, the Unit helps us to produce advanced graduates who are ready to serve the fisheries and wildlife management professions.”

**Thomas G. Coon**  
Vice President of Agriculture Programs  
Oklahoma State University

**Do exotic conifer plantations contribute to avian biodiversity?** Exotic Norway spruce plantations remain widespread across the northeastern United States. The effects of these plantations on native wildlife are not fully understood, and best practices for managing them to promote biodiversity are often unclear. In Massachusetts, the decline of eastern hemlock due to the invasive hemlock woolly adelgid lends urgency to the need to preserve conifer-dominant habitat. Understanding how Norway spruce supports wildlife species relative to native forest stands is key to determining how these exotic plantations should be managed. In a study conducted by the Massachusetts Unit in partnership with the Massachusetts Department of Conservation and Recreation, Massachusetts Division of Fisheries and Wildlife, University of Massachusetts-Amherst, and U.S. Department of Agriculture Forest Service, scientists compared biodiversity among Norway spruce plantations and various native forest stand types using birds as indicators. The comparison between spruce and hemlock was of particular interest due to the structural similarities between the two and the potential for spruce to support species commonly associated with declining hemlock habitat. According to the research, Norway spruce plantations in Massachusetts supported bird species and communities like those in surrounding native stands. Species richness within spruce plantations was not significantly lower when compared to richness in native forests, including hemlock stands. This graduate research study was designed to provide science-based information to State wildlife and land management agencies, who were then able to apply our findings to on-the-ground forest management.

**Lake trout suppression in Yellowstone Lake:** Yellowstone cutthroat trout are an important species for the Yellowstone ecosystem because they are a food resource for many terrestrial species (such as grizzly bears, otters, and osprey). Unfortunately, the Yellowstone cutthroat trout population collapsed after invasive lake trout were first discovered in Yellowstone Lake in 1994. Original suppression efforts focused on younger smaller lake trout; however, in recent years, the effort to remove larger mature fish has intensified. Targeting known spawning grounds has proven to be a successful strategy for removing large quantities of mature fish. The Montana Fishery Unit is identifying spawning sites in Yellowstone Lake, and this information could be used to increase the efficacy of the suppression program and aid the recovery of Yellowstone cutthroat trout in this important ecosystem.



## Species of Greatest Conservation Need

Every State has a State Wildlife Action Plan (SWAP) mandated by Congress as a requirement for obtaining funding under the State Wildlife Grant program. Each SWAP contains a list of “species of greatest conservation need” (SGCN) and identifies information needs, threats, and conservation actions. Species on an SGCN list have experienced a population decline or are likely to experience a population decline in the next 10 years and require conservation actions to stabilize their populations. Unit scientists work with State cooperators to develop the science needed to inform conservation actions for species on SGCN lists.

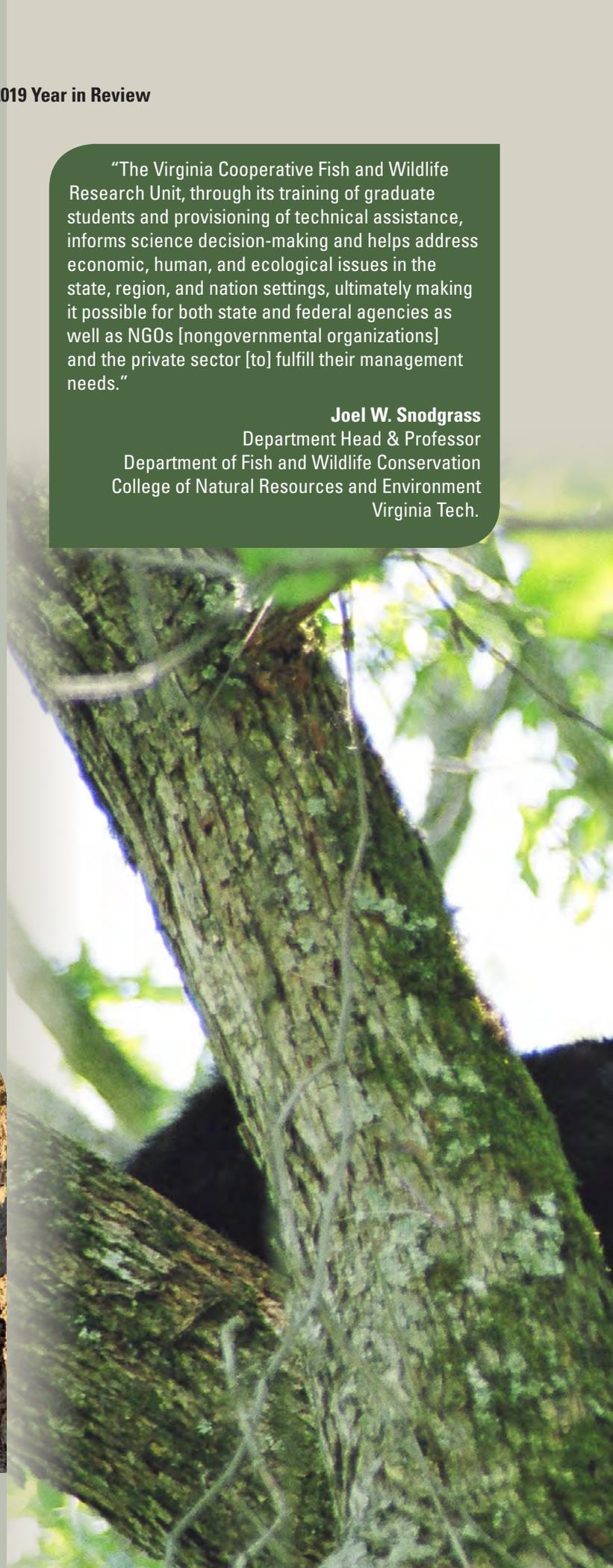
**Burrowing owl research on U.S. Department of Defense lands:** The U.S. Department of Defense (DoD) is responsible for managing species found on DoD lands. The burrowing owl, a declining species, is found on numerous DoD installations throughout the western United States, but scientific information on burrowing owls is needed to successfully manage owl populations. Researchers at the Idaho Unit have attached geolocators to 200 burrowing owls to identify their migratory routes and wintering grounds. The project represents a large collaborative partnership among 17 organizations and 3 countries. This project integrates the goals of DoD’s Integrated Natural Resources Management Plans and SWAPs for improving management of at-risk species and helping to identify priority management needs.



“The Virginia Cooperative Fish and Wildlife Research Unit, through its training of graduate students and provisioning of technical assistance, informs science decision-making and helps address economic, human, and ecological issues in the state, region, and nation settings, ultimately making it possible for both state and federal agencies as well as NGOs [nongovernmental organizations] and the private sector [to] fulfill their management needs.”

**Joel W. Snodgrass**

Department Head & Professor  
Department of Fish and Wildlife Conservation  
College of Natural Resources and Environment  
Virginia Tech.



“The Hawaii Cooperative Fishery Research Unit has been primarily responsible for the most recent discussions and planning initiatives for Fisheries Research priorities among agency and institutional scientists and managers in Hawaii. This has been an important management need within Hawaii as fisheries issues have increased (recreation and aquarium trade harvest) and habitat degradation concerns (coral bleaching/disease, nutrient enrichment) are recognized. The HCFRU has provided valuable research and analytical reports on fisheries data needed for scientifically sound management decisions.”

**Jim Beets**  
Research Ecologist  
University of Hawaii at Hilo

**Commercial harvest of turtles in the Mississippi Delta ecoregion:** Commercial harvest of aquatic turtles in Arkansas has historically been unregulated; from 2004 to 2017, approximately 1.3 million wild aquatic turtles were commercially harvested, of which 95 percent were taken in the Mississippi Delta ecoregion. Turtles are sold to meet global demands for use as food, pets, and curatives in folk medicine. At present, 10 species of aquatic turtles can be legally harvested with no daily or annual bag limits, no size class restrictions, and no specified harvest season(s). The Arkansas Unit is leading research on the effects of commercial harvest on turtle populations across the Mississippi Delta ecoregion. Using a combination of population modeling and field research, researchers plan to quantify the impact of harvest, assess the current population levels of turtles in the delta, and explore potential management options to ensure the long-term sustainability of freshwater turtles in Arkansas.

**Effects of forest management practices on bird communities in the northern deciduous and coniferous forest of Maine:** The Maine and West Virginia Units are evaluating the effects of Maine’s forest harvest practices in the northern deciduous and coniferous forest on forest bird diversity and abundance. The plan is to document birds (such as bay-breasted warbler, Blackburnian warbler, and Cape May warbler) in manipulated stands compared to birds in reference stands and within the larger landscape context. The goal is to inform our understanding of avian responses to stand age and structure as relates to habitat quality and in the context of changing land use practices in the northern forest landscape. The results may help guide future management actions for bird populations.



## Technical Assistance to Cooperators

Technical assistance to our cooperators is an integral part of the mission of the Cooperative Research Units program, and both State and Federal cooperators rely on the scientific and technical expertise of Unit personnel. Unit scientists are frequently asked to provide scientific and technical assistance, including data analysis and interpretation; to give workshops about advanced analytical tools for management; and to consult on a wide variety of natural resource issues. When appropriate, students are encouraged to engage in technical assistance activities as part of their graduate education to further prepare them for entering the State and Federal workforce. Below are just a few examples of this important part of our mission.

**Species distribution modeling training:** Tom Edwards from the Utah Unit developed training platforms for the creation and assessment of decision-quality plant and animal species distribution and habitat models for use in management. Three 40-hour (5-day) and two 24-hour (3-day) training and education courses were developed and taught in fiscal year 2019; they had 72 and 95 participants, respectively.

**Fish identification application (app):** Researchers Chris Guy, Alexander Zale, and Thomas McMahon at the Montana Fishery Unit have developed a fish identification application in collaboration with Montana Fish, Wildlife and Parks. The “Fishes of Montana” app is a 21st century update to the 1971 book “Fishes of Montana” by C.J.D. Brown. The app includes information on 90 native and invasive species and is available for Android and iOS devices.



**Ring-necked pheasant app:** A new web-based application from the Nebraska Unit allows the State’s wildlife managers to examine virtually how manipulating land cover in a region could affect populations of ring-necked pheasants and to estimate how much the changes might cost. The Pheasant Habitat Simulator was created to help the Nebraska Game and Parks Commission manage the species. Lyndsie Wszola (research associate at the Nebraska Unit) and her colleagues built it as an open-source app.



**Monarch butterflies app:** By using a mobile app, the “Monarch Model Validator,” anyone can become a volunteer scientist by visiting potential monarch butterfly roosting sites from Maine to Georgia and answering questions based on their observations. The Maine Unit developed a model that predicts areas that have a high suitability as stopover sites for monarch butterflies during their fall migration south along the U.S. East Coast.



**Texas Parks and Wildlife Commission's Wildlife Diversity Advisory Committee:** Clint Boal from the Texas Unit is an invited member of the Wildlife Diversity Advisory Committee for the Texas Parks and Wildlife Commission. Members of the committee provide professional opinions and advice to the commission relating to wildlife conservation issues in the State of Texas.



**Structured decision making to set waterfowl seasons:** Angela Fuller from the New York Unit guides the New York State Department of Environmental Conservation in a structured decision making (SDM) framework regarding waterfowl season setting.

**Coffee agroecosystems on mountainous landscapes in Puerto Rico:** The Caribbean area of the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS-Caribbean Area) and the Southeast Region of the USFWS sought the expertise of the North Carolina Cooperative Fish and Wildlife Research Unit to develop a habitat conservation strategy that ensures the long-term persistence of resident terrestrial fauna in Puerto Rico. The strategy emphasizes nonprotected, human-modified habitats. The North Carolina Unit summarized relevant information on stakeholders (coffee growers) and enumerated key economic factors to finalize an integrated (ecological and economic) model to inform decision makers.

**Interactive planning tool for inland fisheries management:** The Mississippi Unit is constructing an interactive planning tool for inland fisheries management. The system steers managers through a series of options determined by management goals to generate a plan that outlines problems, objectives, management actions, implementation, and follow-up monitoring and evaluation. Branching logic and decision analysis guide users through alternative data-entry and option-selection screens. Similar software systems are in use in the medical field to arrive at patient diagnosis and health management plans, but the system would be the first of its kind in fish and wildlife management.

**Green turtle habitats:** The Florida Unit is working with the Sea Turtle Conservancy to delineate green turtle abundance hotspots and establish multiple long-term capture sites in a relatively undisturbed part of Florida that contains the second largest seagrass ecosystem in the eastern Gulf of Mexico. The National Marine Fisheries Service and the Florida Fish and Wildlife Conservation Commission need this information so they can assess the population structure, abundance, movements, health, and genetic diversity of green turtles. Additionally, researchers are studying green turtle habitats in hotspots and using multivariate models to examine the factors that drive abundance. The goal of this effort is to help describe critical habitat for the recovery of the species.



"The South Carolina Unit is an integral partner with the South Carolina Department of Natural Resources (SCDNR) in the development and delivery of science-based technical assistance and resource management information. Scientists within the Unit are responsive to requests from agency staff and provide invaluable information on management and research techniques, species' status, resource threats, and avenues for future research. Through collaborative efforts between the Unit and SCDNR, new research and survey techniques have been developed and tested, species' status determined or verified, and ecological relationships validated. Collectively, these efforts have resulted in more efficient survey techniques, improved resource management effectiveness and improved information delivery used in adaptive management frameworks to the benefit of the citizens and natural resources of South Carolina."

**Billy Dukes**  
Chief of Wildlife  
South Carolina Department of Natural Resources

## Cooperator Success Stories

### Louisiana Unit: Growth and Mortality of Eastern Oysters

“Eastern oysters have been an important species, culturally and economically, in Louisiana for over a century, and local information on their growth and mortality in relationship to regarding temperature and salinity is needed to make long-term, sustainable management decisions. Through the Louisiana Unit, a combination of applied research looking at long-term data and graduate research was able to describe growth and mortality as a function of oyster size and local environmental temperature and salinity between two adjacent estuaries (Breton Sound-BR, Barataria Bay-BA) in Louisiana. The study indicated that growth and mortality differed at small spatial scales (immediately east and west of the Mississippi River) despite similar environmental conditions, although the

proximal cause of the difference is unknown. The parameters studied were also able to refine and improve the Sustainable Oyster Shellstock (SOS) budget model. This model and oyster stock data collected annually by the Louisiana Department of Wildlife and Fisheries are used to have a sustainable harvest at no-net-shell-loss reference levels on Louisiana public oyster grounds. These data and models can be used to estimate the effects of coastal restoration projects, disasters, and harvest regimes to help insure successful management of this cultural and commercial species into the future. The Louisiana Cooperative Research Unit has been instrumental in helping to develop these models, and train graduate students to assist the state.”

**Carolina Bourque**  
Oyster Program Manager  
Louisiana Department of Wildlife and Fisheries



## Montana Wildlife Unit: Wolf Harvest Management and Monitoring

“One of the best collaborative efforts that we’ve had with the Montana Wildlife Unit is in relation to wolf harvest management and monitoring program development. The Montana Wildlife Unit has been intimately involved with this effort since the initial planning stages for the first ever regulated hunting season for wolves in the contiguous United States, beginning in 2007. This was hugely controversial because it was implemented immediately on the heels of wolf delisting under the Endangered Species Act, and the public across the country closely scrutinized what transpired as wolves were delisted in 2009, relisted, then delisted again in 2011. Over the first few years of the program, the public interest within Montana was such that Commission meetings to set wolf seasons were moved to the Montana Supreme Court Chambers to accommodate the large public in attendance.

Mike Mitchell and his student at the time (now a scientist at the Idaho Unit) helped develop the first simulation model used to predict the effects of various hunting season quota levels on wolf population sizes. Mike then worked closely with Montana Fish, Wildlife and Parks (FWP) staff to facilitate a structured decision making process that has framed wolf season setting in Montana for every subsequent season. Mike has continued to work closely with FWP staff on population modeling and evaluating the effects of public harvest, including several back-and-forth exchanges in scientific journals with program critics. He helped to develop statistical methods

to estimate wolf population parameters (breeding pairs) that FWP was required to monitor by State and Federal law, saving FWP tens of thousands of dollars annually over the intensive, field-based monitoring otherwise required. Mike then supervised a master’s student and a post-doctoral scientist through development of novel wolf monitoring methods based on occupancy modeling of wolf sightings by hunters to replace the expensive, field-intensive method of collaring and following individual wolf packs to obtain minimum population counts, saving FWP hundreds of thousands of dollars annually. The new monitoring method has officially replaced the field-intensive minimum count method with the 2018 Montana wolf program report, which was just released with population estimates generated by the method Mike helped to develop and without minimum count statistics. Finally, Mike currently has 2 PhD students that are working on evaluating the effects of public wolf harvest on key assumptions that underpin the accuracy of the occupancy-monitoring approach, further developing models to predict the effects of harvest, and packaging the monitoring and modeling methods together with the decision frame he previously helped to create in an Adaptive Management framework. The key to all of this success is that Mike, his staff, and his students at the CRU have worked directly with FWP wildlife managers and researchers in a truly collaborative way, fostering trust and ownership by everyone involved.”

**Justin Gude**

Chief of Research and Technical Services  
Montana Fish, Wildlife, and Parks



## Idaho Unit: Effects of Catch-and-Release Fishing on Survival of Native Trout and Steelhead

“Over the last several years, fish and wildlife agencies have been hearing increasing concern by angling and conservation groups over potential mortality associated with anglers removing fish from water prior to releasing them. In cooperation with the Idaho Department of Fish and Game (IDFG) the Idaho Unit recently completed a series of research projects to better understand the effects of catch-and-release angling on survival and reproductive success of native trout and steelhead. The cornerstone of this work was completed by Michael Quist and graduate student Curtis Roth at the University of Idaho Unit. They evaluated the relative survival of pre-spawn wild Yellowstone Cutthroat Trout caught and exposed to air for various durations. Additionally, genetic parentage assignment was used to compare progeny production from air-exposed and control fish. Finally, covert observation of anglers was used to assess actual duration of air exposure in a catch-and-release wild trout fishery. Results indicated that air exposure of up to

one minute had no effect on adult trout survival or reproductive success. Furthermore, angler observation studies demonstrated that wild trout anglers rarely hold fish out of the water for a duration that would affect survival. The IDFG conducted similar studies of angler-caught hatchery steelhead, measuring air exposure duration and the effects on eye-up rates in their eggs. Again, there was no measurable effect from air exposure durations that typically occur in catch-and-release steelhead fisheries. Results of these projects and other similar work in Idaho have been shared widely in news articles, peer-reviewed literature, interagency and professional meetings, as well as with angling and conservation groups across the state. Collectively, these outreach efforts by the Idaho Unit and IDFG were recently recognized by the Association of Fish and Wildlife Agencies with the Ernest Thompson Seton Award for promoting public awareness and support for the science and practice of fish/wildlife management.”

**Jeff Dillon**

Fishery Research Manager  
Idaho Department of Fish and Game



## Pennsylvania Unit: Identifying Optimal Harvest Regulations for Fall Wild Turkey Hunting Seasons

“Wild turkey populations are a valuable natural resource and the second most popular game species in Pennsylvania. The Pennsylvania Game Commission’s (PGC) main tool for managing wild turkey population levels is through fall hunting season regulations, specifically through the regulated harvest of hen turkeys, as shown through previous applied research with USGS. PGC’s current framework for fall season regulations lacks a standardized decision matrix to predict the effect of different season lengths on future turkey populations. The current research project utilizes results from 3 previous studies with USGS to develop a new wild turkey population dynamics model that predicts the response of turkey populations to changes in fall turkey harvest regulations. Through this cooperative project, also with North Carolina State University, we are integrating the model into a decision-making framework that will allow PGC to identify fall harvest regulations that optimize hunting opportunity and wild turkey populations. Model development has been challenging. USGS has identified several modifications to data variable collection

methodology and analyses to improve the model for more accurately predicting population response to seasons. This research will be incorporated directly into the PGC’s wild turkey management program and may serve as a template for other state wildlife agencies.

The Pennsylvania Unit has been integral to wild turkey research and management in Pennsylvania for over two decades. The Unit brings expertise in designing research projects that we integrate directly into our management program. The Unit developed a new method for estimating survival and harvest rates that resulted in significant cost savings for studies of both hen and gobbler survival and harvest rates. Dr. Diefenbach also assisted with the design of a research project that quantified the effect of fall hunting seasons on turkey harvests. The research projects are now being integrated into a decision model that will help the agency set fall hunting season regulations with the best objective data available. The Pennsylvania Unit has helped greatly in the effort to develop a decision model by bringing in collaborators from the Alabama Unit and NC State University.”

**Bryan Burhans**  
Executive Director  
Pennsylvania Game Commission



## Awards and Accolades

Unit scientists and their students received approximately 60 awards in fiscal year 2019 from universities, agencies, and societies with recognition at the local, national, and international levels. The valuable work done by members of the Cooperative Fish and Wildlife Research Units (CRUs) program is appreciated by many organizations. Some recent awards are summarized below.



### **Wildlife Restoration Award**

The Wildlife Society

**David Haukos, Kansas CRU**

### **Harry R. Painton Award**

American Ornithological Society

**Anna Chalfoun, Wyoming CRU**

### **Distinguished Service Award**

U.S. Department of the Interior

**Sarah Converse, Washington CRU**

### **Fellow**

American Fisheries Society

**Cecil Jennings, Georgia CRU**

### **Award of Excellence**

Nebraska Chapter of the American Fisheries Society

**Kevin Pope, Nebraska CRU**

### **Distinguished Alumni Award**

University of Maine, Department of Wildlife, Fisheries, and Conservation Biology

**Duane Diefenbach, Pennsylvania CRU**

### **Fellow**

The Wildlife Society

**Courtney Conway, Idaho CRU**

### **Professional Award of Merit**

North Central Section of The Wildlife Society

**David Andersen, Minnesota CRU**

### **Ulster University International Collaboration Excellence**

Ulster University

**Suresh Sethi, New York CRU**

### **Promotion to professor**

Oklahoma State University

**Shannon Brewer, Oklahoma CRU**

## Professional Services

CRU scientists give back to their profession in a variety of ways including serving professional societies, technical committees, working groups, and others.

**239**  
Professional service  
positions

**61**  
Editorial positions



## Cooperators of the Cooperative Fish and Wildlife Research Units Program

### Alabama

Auburn University  
Alabama Department of Conservation and Natural Resources

### Alaska

University of Alaska Fairbanks  
Alaska Department of Fish and Game

### Arizona

University of Arizona  
Arizona Game and Fish Commission

### Arkansas

University of Arkansas  
Arkansas Game and Fish Commission

### California

Humboldt State University  
California Department of Fish and Game Wildlife

### Colorado

Colorado State University  
Colorado Division of Wildlife

### Florida

University of Florida  
Florida Game and Fish Commission

### Georgia

University of Georgia  
Georgia Department of Natural Resources

### Hawaii—Fishery

University of Hawaii  
Hawaii Department of Land and Natural Resources

### Idaho

University of Idaho  
Idaho Department of Fish and Game

### Iowa

Iowa State University  
Iowa Department of Natural Resources

### Kansas

Kansas State University  
Kansas Department of Wildlife and Parks

### Louisiana

Louisiana State University  
Louisiana Department of Wildlife and Fisheries

### Maine

University of Maine  
Maine Department of Inland Fisheries and Wildlife

### Maryland

University of Maryland, Eastern Shore  
Maryland Department of Natural Resources

### Massachusetts

University of Massachusetts  
Massachusetts Division of Fisheries and Wildlife  
Massachusetts Division of Marine Fisheries

### Minnesota

University of Minnesota  
Minnesota Department of Natural Resources

### Mississippi

Mississippi State University  
Mississippi Department of Wildlife, Fisheries, and Parks

### Missouri

University of Missouri Columbia  
Missouri Department of Conservation

### Montana—Fishery

Montana State University  
Montana Department of Fish, Wildlife, and Parks

### Montana—Wildlife

University of Montana  
Montana Department of Fish, Wildlife, and Parks

### Nebraska

University of Nebraska Lincoln  
Nebraska Game and Parks Commission

### New Mexico

New Mexico State University  
New Mexico Department of Game and Fish

### New York

Cornell University  
New York Department of Environmental Conservation

### North Carolina

North Carolina State University  
North Carolina Wildlife Resources Commission

### Oklahoma

Oklahoma State University  
Oklahoma Department of Wildlife Conservation

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### Oregon

Oregon State University  
Oregon Department of Fish and Wildlife

### Pennsylvania

Pennsylvania State University  
Pennsylvania Fish and Boat Commission  
Pennsylvania Game Commission

### South Carolina

Clemson University  
South Carolina Department of Natural Resources

### South Dakota

South Dakota State University  
South Dakota Department of Game, Fish, and Parks

### Tennessee—Fishery

Tennessee Tech University  
Tennessee Wildlife Resources Agency

### Texas

Texas Tech University  
Texas Parks and Wildlife Department

### Utah

Utah State University  
Utah Division of Wildlife Resources

### Vermont

University of Vermont  
Vermont Fish and Wildlife Department

### Virginia

Virginia Polytechnic Institute and State University  
Virginia Department of Game and Inland Fisheries

### Washington

Washington State University  
University of Washington  
Washington Department of Ecology  
Washington Department of Fish and Wildlife  
Washington Department of Natural Resources

### West Virginia

West Virginia University  
West Virginia Division of Natural Resources

### Wisconsin—Fishery

University of Wisconsin Stevens Point  
Wisconsin Department of Natural Resources

### Wisconsin—Wildlife

University of Wisconsin Madison  
Wisconsin Department of Natural Resources

### Wyoming

University of Wyoming  
Wyoming Game and Fish Commission



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- p. iii, White-tailed prairie dog. Photograph by John J. Mosesso, USGS.
- p. v, Pelicans and great blue heron (background) at Summer Lake Wildlife Area, Oregon. Photograph by Laura J. Hartley, USGS.
- p. vi, White tern. Photograph by C. Cornett, U.S. Fish and Wildlife Service (USFWS).
- p. 3, Burrowing owl. Photograph by Douglas Barnum, USGS.
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- p. 6–7, Prairie Pothole Region. Photograph from Ducks Unlimited, Inc.
- p. 7, Monarch butterfly specimens. Photograph by Elizabeth A. Sellers.
- p. 7, Northern spotted owl. Photograph from USGS.
- p. 8, Rainbow trout. Photograph by Christopher Mebane, USGS.
- p. 8–9, Indiana bats drinking from a seep along a wall in Wyandotte Cave, Indiana. Photograph by R. Andrew King, USFWS.
- p. 9, Deer with chronic wasting disease. Photograph by Terry Kreeger, Wyoming Game and Fish.
- p. 10, Three species of Asian carp (from top: bighead carp, silver carp, and grass carp) captured on the Missouri River floodplain. Photograph by Colby Wrasse, USFWS.
- p. 10–11, Norway spruce plantation. Photograph by Calvin Ritter, Massachusetts Cooperative Fish and Wildlife Research Unit.
- p. 11, Juvenile lake trout. Photograph by Brett Billings, USFWS.
- p. 12, Burrowing owl nesting pair. Photograph by Douglas Barnum, USGS.
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