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Cooperative Fish and Wildlife Research Units Program—2020 Year in Review

Circular 1478

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

Front cover. A female Kodiak brown bear at the Kodiak National Wildlife Refuge in Alaska. Photograph by Joshua Blouin, used with permission.
Inside front cover. Northern Pintail Drake at Colusa National Wildlife Refuge in north-central California. Photograph by Andrea Mott, U.S. Geological Survey.
Back cover. Sibling Kodiak brown bear cubs at the Kodiak National Wildlife Refuge in Alaska. Photograph by Joshua Blouin, used with permission.

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By John D. Thompson, Donald E. Dennerline, Dawn E. Childs, and Patrick G.R. Jodice

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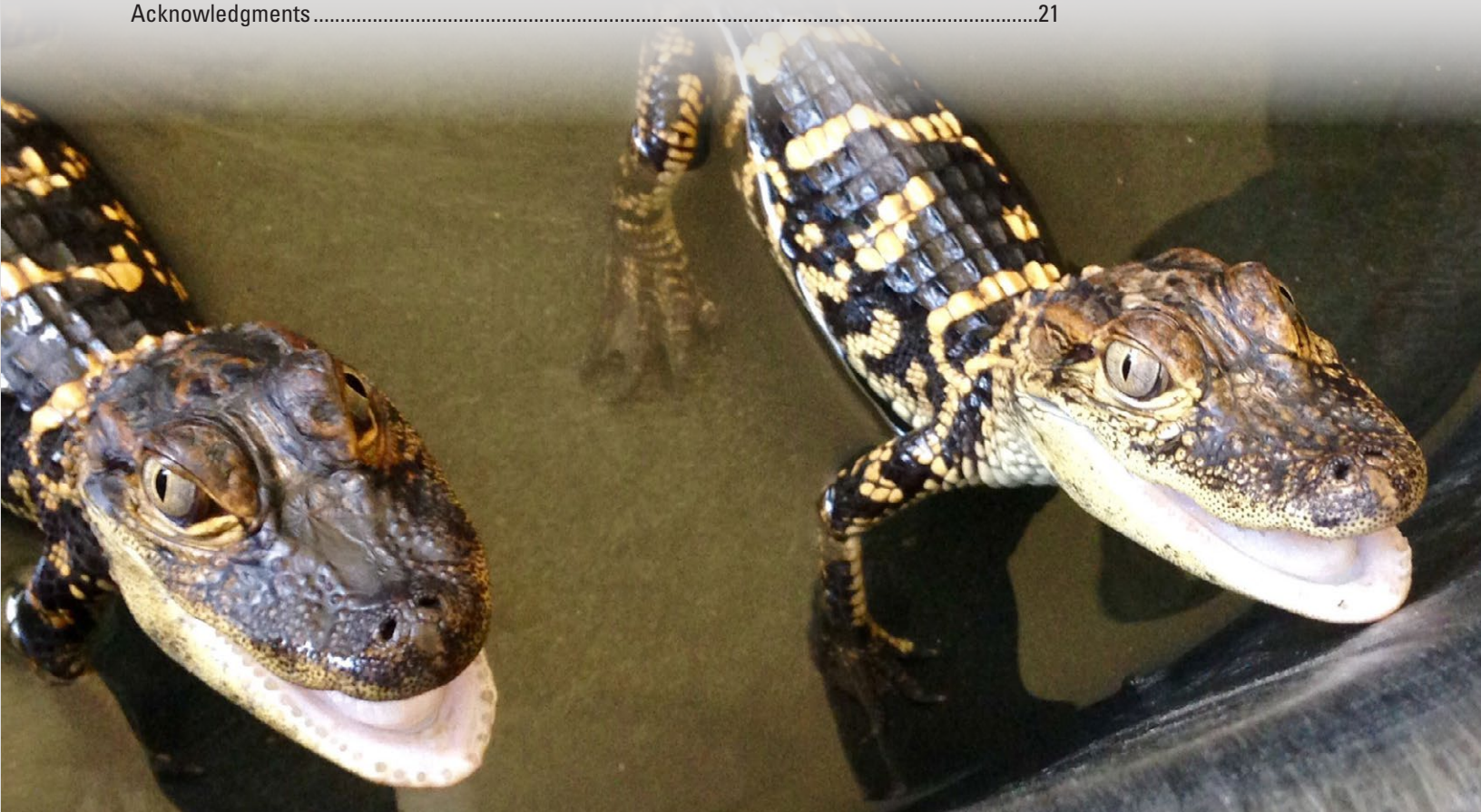


Abbreviations

CRU program	Cooperative Fish and Wildlife Research Units program
CWD	chronic wasting disease
DDCSP	Doris Duke Conservation Scholars Program
DEI	diversity, equity, and inclusion
GDP	gross domestic product
M.S.	master of science degree
NASPS	North American Sturgeon and Paddlefish Society
Ph.D.	doctor of philosophy degree
P.L.	Public Law
SMART	Special Monitoring of Applied Response Technologies
SSA	species status assessment
USGS	U.S. Geological Survey

Chief's and Deputy Chief's Message

Dear Cooperators:

The Cooperative Fish and Wildlife Research Units program (CRU program) is pleased to provide you with the "2020 Year in Review" report. Inside you will find brief descriptions of just a few highlighted activities of unit scientists, students, and cooperators in support of our joint mission. Although space precludes us from highlighting every single activity from every unit and State, that in no way diminishes our appreciation of the excellent work that is conducted by each of our collaborators and partners and the value that this program places on each and every cooperative.

Fiscal year 2020 was an interesting and challenging year owing to the global pandemic that forced many of our host universities and State agencies to change the way they operate, and it also required all CRU program personnel to work from their homes for a significant portion of the year. Nevertheless, the program remained very productive and maintains a very bright future. One of the things contributing to that bright future is a $5.6 million increase in our most recent Congressional appropriations. This amount will help us meet longstanding programmatic needs, such as filling the vacancies in our scientific workforce and providing much-needed upgrades to our research equipment. Our Headquarters staff has been working diligently with collaborators to fill vacancies as quickly as possible. Jonathan Mawdsley, who many of you may already know through his work at the Association of Fish and Wildlife Agencies and The Heinz Center, has been selected as the new permanent Chief of the CRU program, coming on board right at the end of the fiscal year. We look forward to working with you all to continue the great work of this program. The CRU program staff is composed of excellent scientists, dedicated leadership, and an outstanding administrative staff that all work together to meet the program's mission. None of this work could be accomplished without the tremendous support from each cooperator. Thank you.

Jonathan R. Mawdsley, Chief

John D. Thompson, Deputy Chief

Cooperative Fish and Wildlife Research Units Program—2020 Year in Review

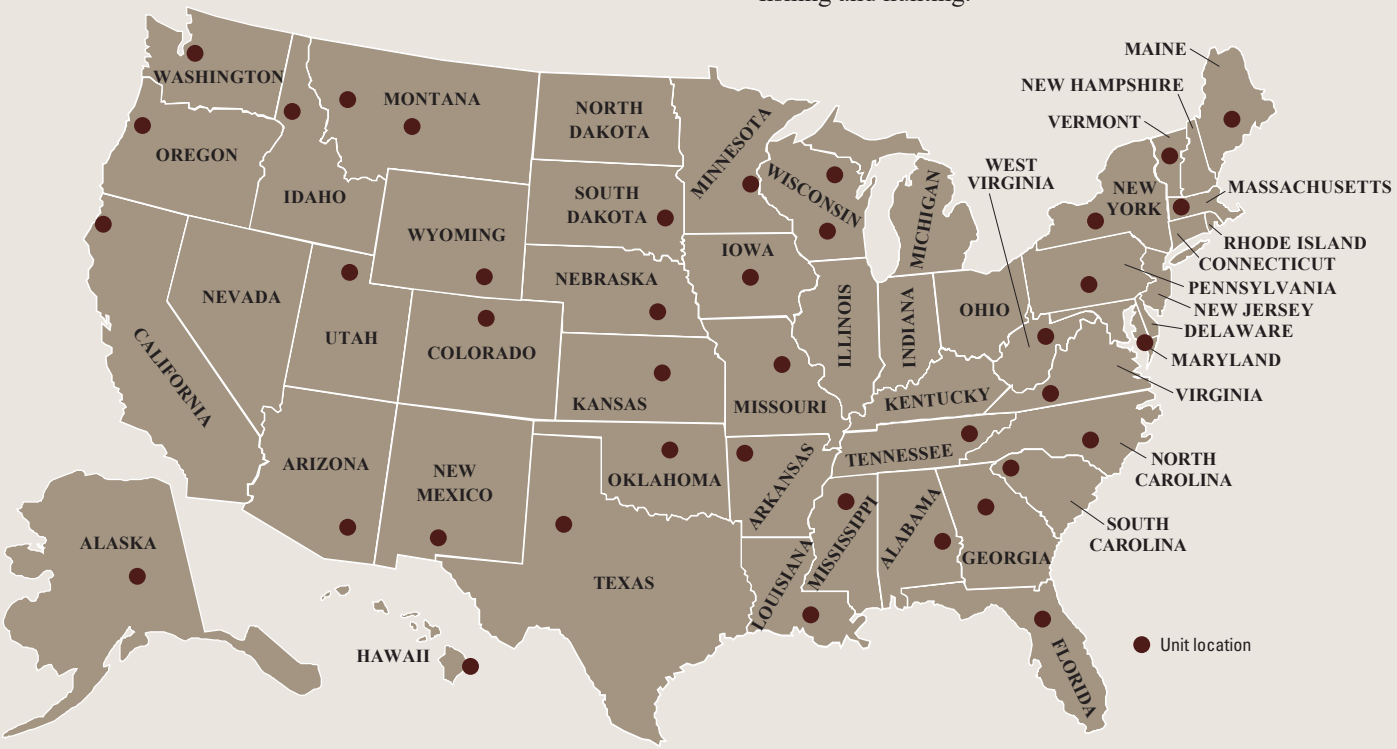
By John D. Thompson, Donald E. Dennerline, Dawn E. Childs, and Patrick G.R. Jodice

About the Cooperative Fish and Wildlife Research Units Program

Established in 1935, the Cooperative Fish and Wildlife Research Units program (CRU program) is a unique cooperative partnership among State fish and wildlife agencies, universities, the Wildlife Management Institute, the U.S. Geological Survey (USGS), and the U.S. Fish and Wildlife Service. Designed to meet the scientific needs of natural resource management agencies and the necessity for trained professionals in the growing field of wildlife management, the program has grown from the original 9 wildlife-only units to a program that today includes 40 Cooperative Fish and Wildlife Research Units located on university campuses in 38 States. 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:

- Each unit is staffed by two to five Federal research scientists employed by the USGS.
- If fully staffed, the units would together 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 and 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, thus helping to maintain biodiversity, encourage healthy ecosystems, and enhance wildlife watching and fishing and hunting.



Locations of the 40 Cooperative Fish and Wildlife Research Units in fiscal year 2020.

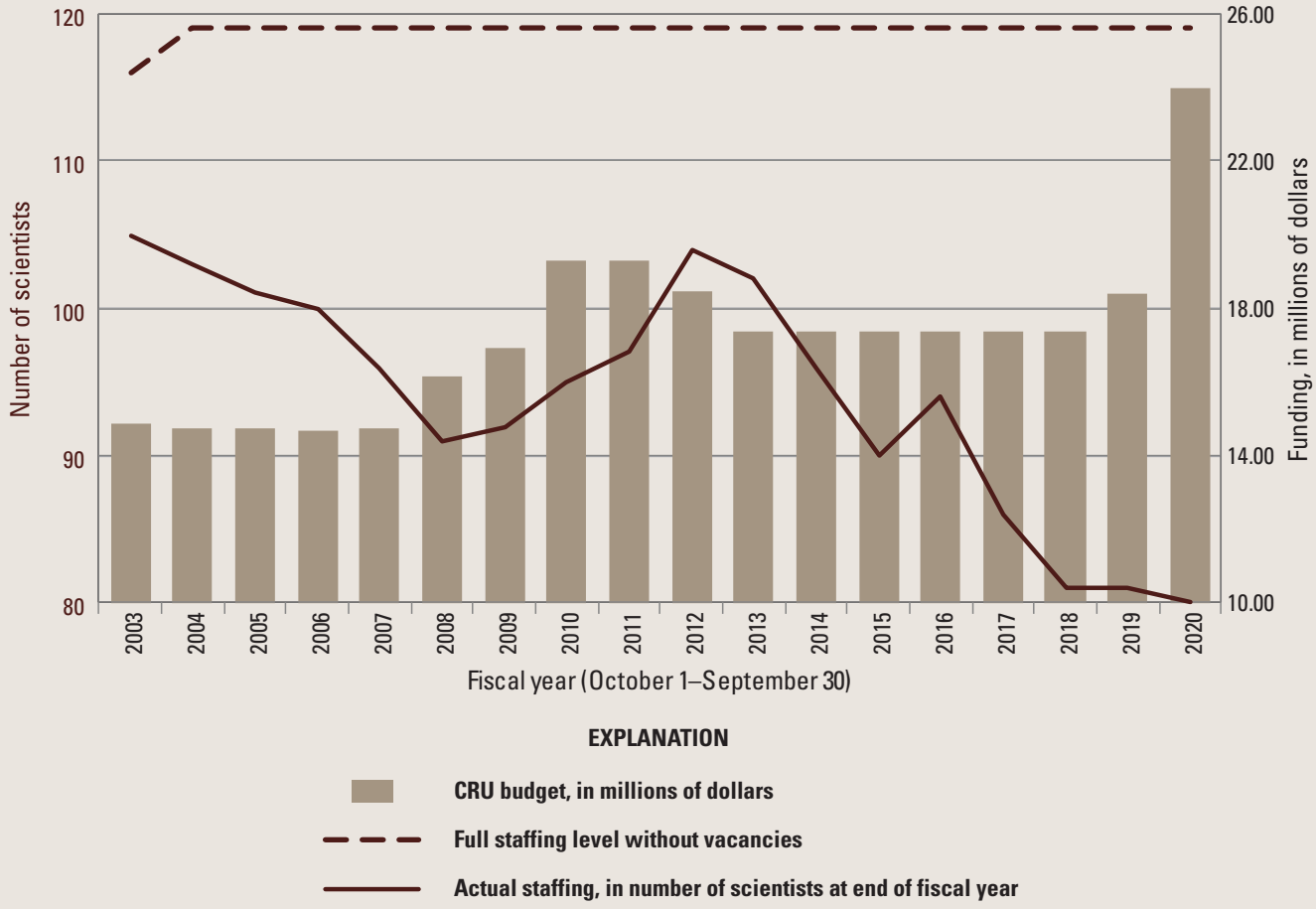
Performance of the Cooperative Fish and Wildlife Research Units Program

Budget and Staffing

Data about the budget and staffing of the CRU program are shown in the graph below. Congressional appropriations for fiscal year 2020 included a significant increase in funding, which will enable the CRU program to approach full staffing in fiscal year 2021.

Cooperators include the following:

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



Graph showing budget and staffing data for the Cooperative Fish and Wildlife Research Units program (CRU program) during fiscal years 2003–2020. The significant increase in congressional appropriations (tan bars) will allow the CRU program to increase the number of scientists currently on staff (solid brown line). Owing to a delay in appropriations and the length of time it takes to hire employees and bring them onboard, however, the number of scientists in the CRU program did not increase in fiscal year 2020. The CRU program is likely to approach full staffing (dotted brown line) in fiscal year 2021.

Productivity and Leveraging of Resources

The unique model of the CRU program enhances productivity by allowing all cooperators to benefit from each other's strengths. By linking the research and training missions of all cooperators, the program provides each with enhanced scientific expertise while training students to enter the conservation workforce. Through these synergies, 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. State agency cooperators benefit from the Federal scientists' expertise as well as the support the program provides for graduate student research projects. The USGS directly benefits from unique funding opportunities provided by State and Federal cooperators. Finally, Federal and State cooperators gain access to the expertise and research infrastructure of the host universities, which are invaluable for supporting research and the training of future State and Federal managers and scientists.

In addition, the model enables the program to leverage available resources for the benefit of all cooperators. Every Federally allocated dollar is matched on about a 1:3 basis by State and host university contributions and grant funds.

Unit scientists garner

$25 million to $40 million

in State and Federal research funding each year

Federal investment supports about

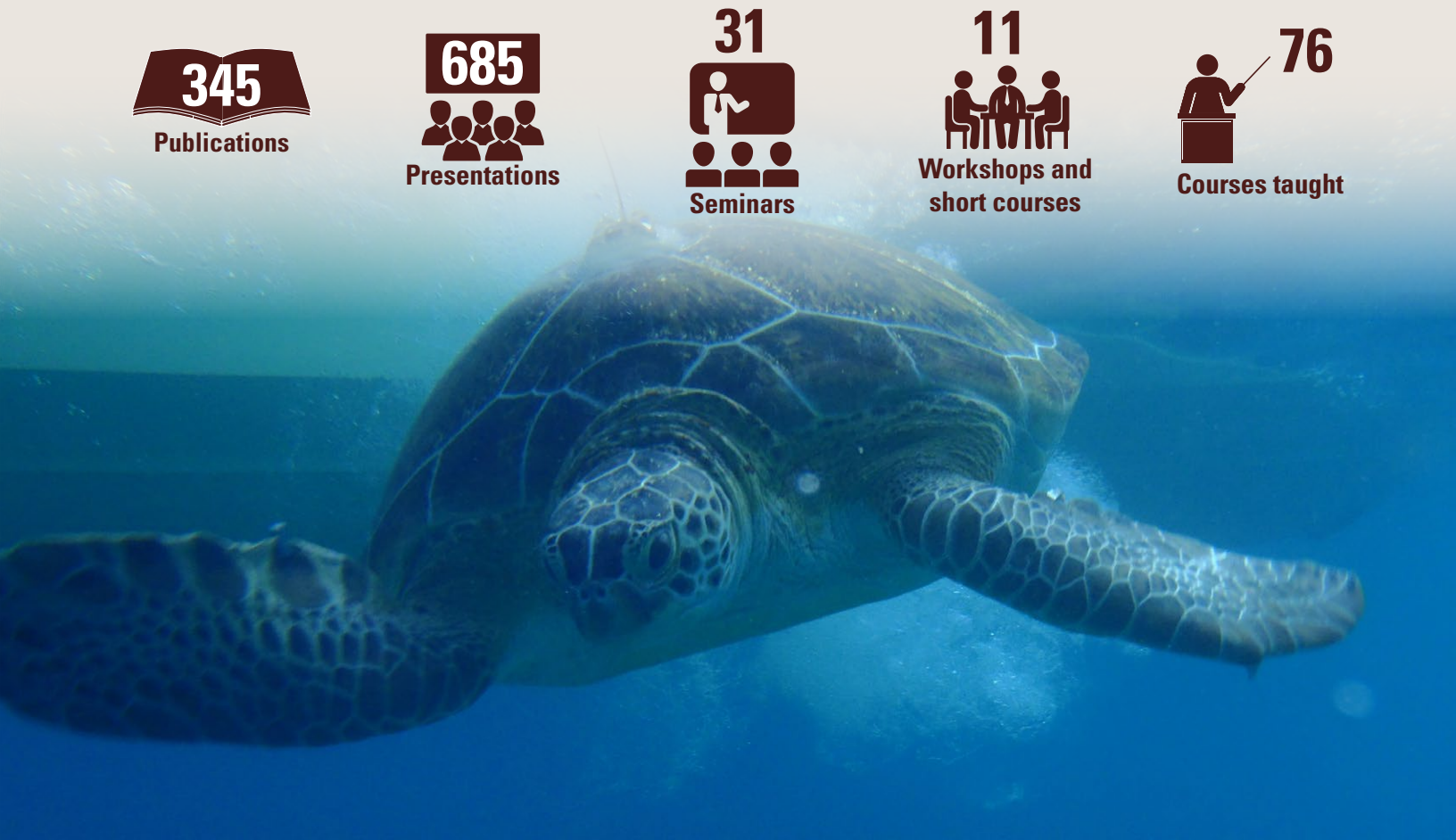
1,100 students and university staff members

annually

Universities provide more than

$20 million

through in-kind support, tuition, and reduced overhead



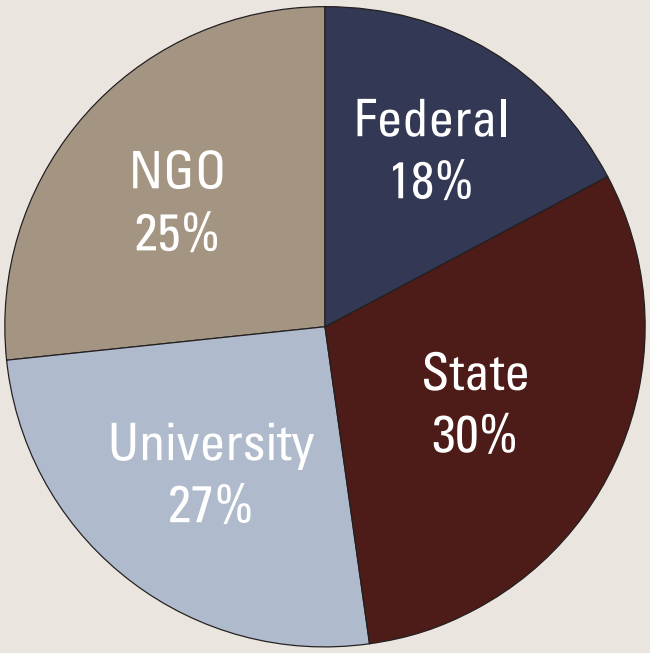
Mission of the Cooperative Fish and Wildlife Research Units Program

The mission of the CRU program has three parts: (1) develop the conservation workforce of the future through applied graduate education, (2) fulfill the training and technical assistance needs of the cooperators, and (3) deliver actionable science to cooperating agencies and organizations. Accomplishments during fiscal year 2020 for each of these parts of the mission are described in the following sections.

Graduate Education To Develop the Conservation Workforce

Part of the CRU program's mission is to develop the workforce of the future through graduate education, and the program educates more than 470 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 the State and Federal cooperators. Students receive cutting-edge academic training from university cooperators and develop expertise on the issues of State and Federal natural resource management and protection agencies.

Students graduate from the experience uniquely prepared to be effective members of the natural resource workforce; in fact, one of the greatest legacies of the program is the placement of students in natural resource agencies and organizations. Alumni hold important leadership positions in nearly every State and Federal fish and wildlife management agency.



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 2012–2020. NGO, nongovernmental organization.

471
Active graduate students (299 M.S. and 172 Ph.D. students)

68
Postdoctoral researchers

66
Graduate degrees awarded (16 M.S. and 50 Ph.D. degrees)

61
Undergraduate students

Graduate Student Spotlights

Ryan Gary

Master of Science Program

Oklahoma Cooperative Fish and Wildlife Research Unit

Born and raised near the Chesapeake Bay in Maryland, Ryan received his bachelor of science degree from Louisiana State University in Natural Resources Ecology and Management with a concentration in Fisheries Science. Ryan's thesis research focuses on the importance of appropriate spawning substrate as a key driver of paddlefish restoration success in reservoirs of Oklahoma. Paddlefish, an important sportfish, have been stocked in reservoirs throughout the State, but these stocking efforts have had variable success. Using side-scan sonar, Ryan is mapping reservoir tributaries and quantifying the amount of suitable spawning substrates to help predict the potential success and efficacy of stocking efforts for establishing self-sustaining populations of paddlefish. Ryan was proud to obtain the In-Memorium Research Award from the North American Sturgeon and Paddlefish Society (NASPS). This award is given to a student who conducts sturgeon and paddlefish research, who demonstrates academic achievement and leadership ability, and whose professional goals support the mission of the NASPS. This award will help fund a paddlefish project to describe the spawning use of the two reservoir tributaries of Keystone Lake, which have differing hydrology and morphology. The Keystone system is notable because it has produced record-size fish, including four State record and two world record paddlefish.

Amelia DuVall

Doctor of Philosophy Program

Washington Cooperative Fish and Wildlife Research Unit

Amelia DuVall is a seabird ecologist and a member of the Quantitative Conversation Lab at the Washington Cooperative Fish and Wildlife Research Unit. Working closely with the National Park Service, Amelia's doctoral research project will include seabird population modeling and an assessment of anthropogenic threats at Channel Islands National Park. Specific threats include invasive rodents, which eat seabird eggs, and changing ocean conditions that affect the availability and distribution of prey. The research will provide park managers with a tool to help make informed management and conservation decisions, as well as refine monitoring methods to improve the accuracy and precision of seabird population trends in a cost-effective manner. Amelia achieved two noteworthy accomplishments to facilitate her research: receiving funding from the USGS-National Park Service Natural Resources Preservation Program and receiving her USGS Bird Banding Laboratory master banding permit. Amelia's fondest memory as a seabird ecologist is of seeing a Scripps' murrelet chick up close—a rare opportunity, because the chicks head out to sea within 24 to 48 hours of hatching.

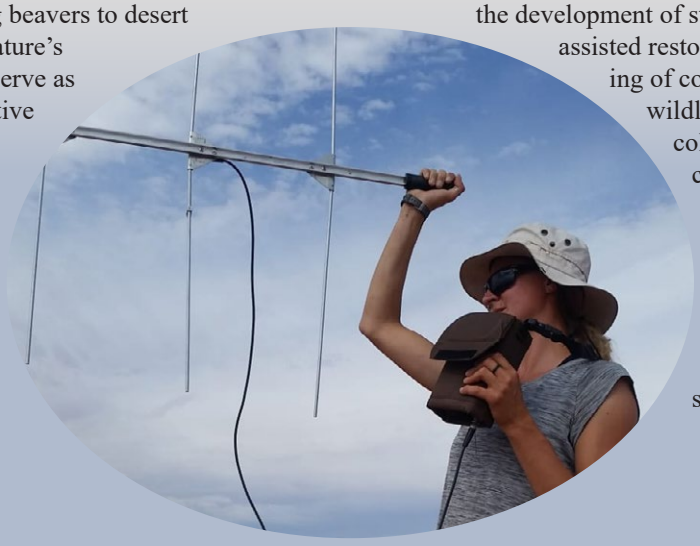
Graduate Student Spotlights

Emma Doden

Master of Science Program

Utah Cooperative Fish and Wildlife Research Unit

Emma Doden is a second-year graduate student evaluating the efficacy of translocating beavers to desert restoration sites. Beavers are nature's ecosystem engineers and may serve as a cost-effective, natural alternative to manmade water restoration projects, especially in arid Western ecosystems. Emma is translocating beavers, which are removed from human conflict situations, to the Price and San Rafael Rivers in eastern Utah to assist with restoration efforts in these degraded desert waterways. The research will facilitate the development of strategies that include beaver-assisted restoration and improve understanding of complex issues associated with wildlife translocation. Emma has collaborated with multiple agencies and stakeholders to capture and translocate 30 beavers that would otherwise have been euthanized. Emma is pleased that she, along with the beavers, is assisting in conservation and restoration efforts in a sensitive arid system.

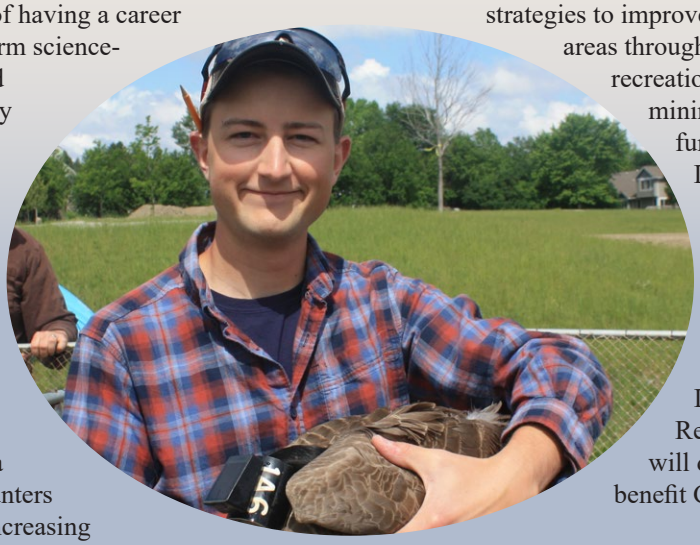


Ben Luukkonen

Master of Science Program

Iowa Cooperative Fish and Wildlife Research Unit

Ben Luukkonen grew up hunting, fishing, and spending time outdoors and dreams of having a career where he can promote and inform science-based wildlife management and conservation. Ben is particularly interested in waterfowl ecology and management, and his research focuses on movement and survival of Canada geese in urban and rural areas of Iowa. In cooperation with the Iowa Department of Natural Resources, Ben is marking geese with global positioning system transmitters and analyzing banding data to learn what role waterfowl hunters can play in helping to reduce increasing human-goose conflicts. The research will help to develop strategies to improve goose management in urban areas through a balance between maximizing recreational hunting opportunities and minimizing conflicts. Ben received funding awards through the Department of Natural Resource Ecology and Management at Iowa State University and the Washington Brant Foundation for his work. Ben is thankful for the partnership and commitment he had from the Iowa Department of Natural Resources, as their joint efforts will directly inform management to benefit Canada geese and humans alike.



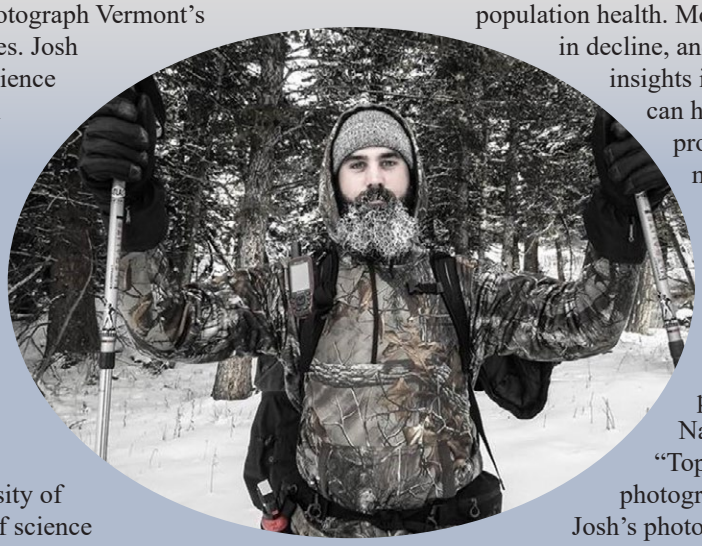
Graduate Student Spotlights

Josh Blouin

Master of Science Program

Vermont Cooperative Fish and Wildlife Research Unit

Josh Blouin is an avid wildlife photographer who loves to travel around the State to photograph Vermont's wildlife and beautiful landscapes. Josh graduated with a bachelor of science degree in wildlife biology from the University of Vermont in 2015. Since then, Josh has worked on various wildlife research projects, including studies of Kodiak brown bears in Alaska, wolves in Yellowstone National Park, wolverines and Canada lynx in northwestern Montana, bats in Yosemite National Park, and black bears in Minnesota. Josh recently returned to the University of Vermont to pursue his master of science degree and is assessing moose habitat suitability in Vermont and how seasonal habitat selection relates to population health. Moose populations in Vermont are in decline, and Josh's research will provide insights into how habitat management can help reverse the decline and promote the wellbeing of Vermont's landscape and wildlife. Josh's passion for wildlife and photography have blended well, as his photographs have been published in various outlets and displayed at several galleries. Notably, one of his photographs was selected by a National Geographic editor as a "Top Photo" during the 2017 nature photographer of the year competition. Josh's photography is on the front and back cover of this circular.



Lucas Schilder

Master of Science Program

Texas Cooperative Fish and Wildlife Research Unit

Lucas Schilder is originally from Sacramento, California, but received his bachelor of science degree in Natural Resources Management with a concentration in Wildlife Biology from Texas Tech University. As an undergraduate, Lucas worked on a project quantifying landscape connectivity for lesser prairie-chickens on the Southern High Plains of Texas and New Mexico. Although still involved with that work, Lucas's master's degree project is focused on quantifying changes in avian and plant community composition and structure following prescribed thinning of pinyon-juniper woodlands. Climate and land use practices have significantly altered pinyon-juniper woodlands throughout the western United States. To mitigate the changes that have taken place, Federal and State agencies have embraced tree removal and thinning, with the goals of reducing fuel loads and restoring historic stand structure. However, the high proportion of avian pinyon-juniper specialists included on national and State lists of concern has created a need to balance thinning targets with conservation objectives of these woodland-obligate bird species. Lucas's research will document avian and vegetation community response to thinning and inform conservation strategies designed to benefit multiple species. The project team is also banding juniper titmice to supplement the community analysis by examining the effects of thinning on the survival, site fidelity, and territoriality for this focal species of high conservation concern.

Technical Assistance to Cooperators

Technical assistance to cooperators is an integral part of the mission of the CRU program, and both State and Federal cooperators rely on the scientific and technical expertise of unit personnel. CRU program scientists and graduate students use their expertise in natural resource management, experimental design, data analysis, and leadership to provide assistance to partners and cooperators on a variety of issues and projects. Below are just a few examples of this important part of the CRU program's mission.

- The Arizona Cooperative Fish and Wildlife Research Unit has been invited to participate in the National Academy of Sciences review of taxonomy for the red wolf.

- The Colorado Cooperative Fish and Wildlife Research Unit consulted with the Colorado Department of Public Health and Environment on ongoing management and implementation of temperature standards in Colorado streams and rivers.
- The Louisiana Cooperative Fish and Wildlife Research Unit represented the Department of the Interior on the Louisiana Trustee Implementation Group's development of Special Monitoring of Applied Response Technologies (SMART) objectives for the use of Natural Resource Damage Assessment restoration funding for submerged aquatic vegetation and oyster resources.

- The Nebraska Cooperative Fish and Wildlife Research Unit codeveloped and coinstructed an 8-hour workshop entitled "Creel Surveys: Designing Complex Solutions to Simple Questions" that was sponsored by Catfish 2020.
- The South Dakota Cooperative Fish and Wildlife Research Unit helped South Dakota Game, Fish and Parks conduct a workshop for college students interested in learning about hunting.
- The Washington Cooperative Fish and Wildlife Research Unit cofacilitated the Cook Inlet Beluga Whale Population Analysis and Monitoring information session at the Alaska Marine Science Symposium.

- The Wisconsin Cooperative Fishery Research Unit provided training to Michigan Department of Natural Resources personnel on how to implant acoustic transmitters into lake sturgeon.
- The Wisconsin Cooperative Wildlife Research Unit is developing a robust modeling framework to understand spatiotemporal patterns in chronic wasting disease (CWD) prevalence and deer demographic rates to provide technical information to State natural resource managers regarding deer population dynamics in the CWD-endemic region of southwestern Wisconsin.

Applied Research To Meet Cooperators' Science Needs

The CRU program is in the forefront of fish and wildlife 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 State and Federal cooperators. In this report, just a few of these themes have been highlighted and are accompanied by a few selected examples of the many management-oriented research projects conducted with 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.

Advanced Technologies

The advanced technologies theme encompasses the development and adaptation of new technologies and tools that increase the effectiveness, efficiency, safety, accuracy, geographic extent, and (or) timeliness of data gathering, dissemination, and analysis, and the interpretation of natural resource phenomena. It also includes development of new tools that assist natural resource managers in decision making and adaptive management of fish and wildlife populations and their habitats.

Snapshot USA

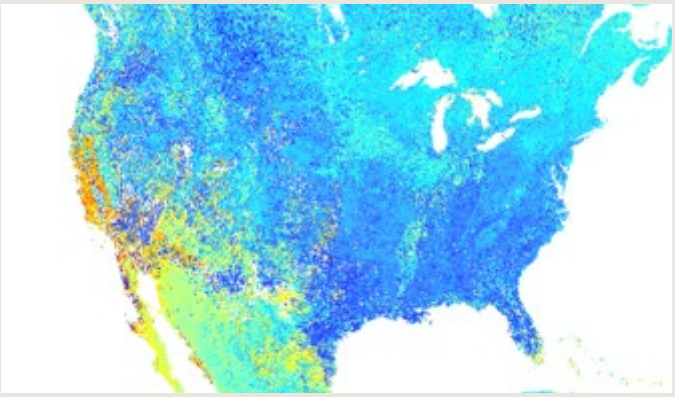
Arkansas Cooperative Fish and Wildlife Research Unit

As natural areas continue to be developed and fragmented, the need for baseline data regarding the abundance and distribution of wildlife populations continues to grow. Snapshot USA is a project that will facilitate the collaboration of cooperators to contribute to a national database of public wildlife data. These data will be used to examine nationwide trends in mammal community assembly rules associated with natural environmental and anthropogenic filters. Collaborators from all 50 States will contribute camera trap data from a standardized camera trap array, and the Smithsonian Institution will compile and lead efforts to analyze data. The results will provide information regarding the occupancy of predators, the activity patterns of animals nationwide, and the relative density of several common species of mammals. This database will be one of the largest repositories for images from camera traps and will provide the raw material for numerous large-scale ecological examinations of mammal populations. Full project details can be found on the Snapshot USA website at https://emammal.si.edu/snapshot-usa.

Capture-Recapture Meets Big Data—Integrating Statistical Classification with Ecological Models of Species Abundance and Occurrence

New York Cooperative Fish and Wildlife Research Unit and USGS Patuxent Wildlife Research Center

Advances in new technologies, such as remote cameras, noninvasive genetics, and bioacoustics, provide massive quantities of electronic data. This research is developing the concept of coupled classification in which statistical classification models are linked to ecological models of species abundance or occurrence. In this new framework, classification (for example, species identification) takes into account the local structure of populations, communities, and landscapes and, unlike current classification methods, does not assume that where a sample is collected is independent of the class structure of the population. The work has widespread application because it provides the possibility of fully automated data collection and processing systems, and a mechanism for directly integrating remotely sensed "big data" with ecological models while accounting for misclassification.



Modeling Species at Risk To Support Species Status Assessments in the Southeast

Mississippi Cooperative Fish and Wildlife Research Unit

Effective conservation planning requires reliable information on the geographic distribution of organisms. Unfortunately, this information is often incomplete for many species, especially for rare ones, because of limited observational data. Species distribution models can be highly valuable for identifying remaining and potential habitats of at-risk species for conservation planning. An important framework that would benefit from species distribution models is the Species Status Assessment (SSA) framework developed by the U.S. Fish and Wildlife Service. The SSA considers multiple elements associated with species condition, including distributions, but there are no standard requirements to estimate species distributions. This research will find an optimal species distribution model approach for at-risk species that can be considered for SSA and similar species monitoring efforts. Results of this work will be extended in the Southeast to address other at-risk species and will incorporate models of future urbanization and climate change to predict future changes to distributions.

Human Dimensions

The human dimensions theme encompasses the application of social sciences (for example, economics and sociology) to fish and wildlife conservation management issues. Integration of human dimensions and ecological science allows for greater insights into management solutions and, ultimately, more durable decisions.

Massachusetts Residents' Attitudes Toward Black Bears and Black Bear Management

Massachusetts Cooperative Fish and Wildlife Research Unit

The black bear population in Massachusetts is growing and expanding in range, and bears are becoming increasingly more common in suburban areas of the State. A recent statewide human dimensions study of Massachusetts residents' attitudes toward black bears and black bear management is helping the Massachusetts Division of Fisheries and Wildlife (MassWildlife) better understand the current challenges facing black bear management in the third most densely populated State in the country. Results of this study have provided a more detailed understanding of Massachusetts residents' opinions about the bear population, experience with bears, and opinions on black bear management options. As a result, variations in public opinion based on geography, human demographic characteristics, and bear population dynamics along the urban-rural gradient in Massachusetts are being used by MassWildlife to tailor the agency's management by region and make informed management decisions about black bears. This research was conducted in collaboration with MassWildlife, and results continue to be implemented and translated into management actions by the State agency.

Minnesota Residents' Attitudes Toward Wolves and Wolf Management

Minnesota Cooperative Fish and Wildlife Research Unit

Long-term survival of wolves in Minnesota has been guided by the Minnesota Wolf Management Plan published in February 2001. Recognizing the potential near-term removal of gray wolves from the Federal listing of endangered species, the Minnesota Division of Fish and Wildlife initiated a public process to update this Minnesota Wolf Management Plan. Public input and engagement were placed at the forefront of these efforts. Understanding the values, beliefs, attitudes, and behaviors of stakeholders can enhance the efficacy of agency decisions with respect to wolf management while helping to minimize conflict. Through a partnership with the Minnesota Department of Natural Resources, researchers assessed stakeholder attitudes toward wolves in Minnesota in general, their preferences for potential management priorities, their values toward wildlife, preferred options for funding wolf management, and tolerance of wolves on the landscape. This information is important for ensuring that the Minnesota Wolf Management Plan is effective and responsive to public interests.

Angler Behavior in Response to Management Actions on Nebraska Reservoirs

Nebraska Cooperative Fish and Wildlife Research Unit

Recreational fishing is a factor in structuring inland fish populations, so biologists typically develop lake-specific management plans based on lake-specific attributes of the fishery, including anglers. This study will evaluate the participation patterns of anglers at multiple spatial and temporal scales and determine how these patterns influence fish populations and associated communities and, in turn, influence angler groups. Study findings will be used to develop appropriate management strategies at both local and regional scales. This project is a collaboration of researchers across multiple agencies and includes the University of Nebraska—Lincoln and the Nebraska Game and Parks Commission.

Landscape Ecology

The landscape ecology theme encompasses the study of the origin, structure, and dynamics of ecosystem components across broad geographic or watershed scales. It includes analysis of spatial and temporal information, effects of stressors, and how the information can be scaled to address specific management needs and support decision making.

Bat Occupancy Patterns as a Function of Wildlife and Forest Restoration Activities

Missouri Cooperative Fish and Wildlife Research Unit

Wildfires are increasing in frequency and severity across the western United States, leading to changes in forest structure and wildlife habitats. Knowledge of how species, especially bats, respond to fire-driven habitat changes in these landscapes is limited and generally disconnected from our understanding of adaptations that underpin responses to fire. This research identified relationships between fire regime, physiographic and forest structure variables, and occupancy and functional traits of a diverse bat community to inform forest management in a fire-prone landscape. Bats with traits adapting them to foraging in open habitats, including emitting longer duration and more narrow bandwidth calls, were more likely to use areas that had burned with higher severity and more frequent fires, whereas bats with traits consistent with clutter tolerance were less likely to use those areas. Predicted increases in fire frequency and severity in the western United States are likely to shift dominance in the bat community to species adapted to open and edge environments and to those bats capable of exploiting post-fire resource pulses (brief but intense episodes of increased resource availability) in insect prey, such as aquatic insects and beetles. Identifying trait-fire regime relationships will help forest managers develop appropriate management interventions and focus limited resources to provide benefits for a broad range of species.

Greater Sage-Grouse Response to Habitat Restoration Efforts in the Devils Garden Plateau of Northern California and Southern Oregon

Oregon Cooperative Fish and Wildlife Research Unit

Range-wide declines in greater sage-grouse populations have been attributed to habitat alteration and fragmentation. Landscape-scale modeling has shown that pinyon-juniper encroachment negatively affects sage-grouse, and recent research has positively linked sage-grouse demographics to pinyon-juniper removal activities. In 2005, the Klamath Basin National Wildlife Refuge Complex, in collaboration with ranchers, the California Department of Fish and Wildlife, the Oregon Department of Fish and Wildlife, the Bureau of Land Management, the Natural Resources Conservation Service, and the U.S. Forest Service, initiated a sagebrush restoration effort and a sage-grouse translocation program to augment sage-grouse numbers and prevent extirpation of the Devils Garden population on the Clear Lake National Wildlife Refuge. Anecdotal accounts suggest that greater sage-grouse are seasonally moving throughout restored areas; however, these earlier monitoring efforts were conducted opportunistically and without targeted objectives, resulting in limited quantitative data. This project will fill knowledge gaps regarding predator community composition, dispersal ecology, seasonal movement patterns, and demographics of sage-grouse relative to the landscape distribution of seasonal habitat and the habitat condition (structure and hydrology) in this area. Results will be used to develop a strategic and successful habitat restoration plan in Devils Garden that meets the seasonal habitat requirements of greater sage-grouse while promoting landscape connectivity and broader ecosystem benefits, including hydrologic efficiencies and habitat resiliency.

A Macrosystems Ecology Framework for Continental-Scale Prediction and Understanding of Lakes

Pennsylvania Cooperative Fish and Wildlife Research Unit

Inland waters are significant hotspots for the storage and transformation of nitrogen, phosphorus, and carbon and influence regional, continental, and global biogeochemical cycles. Most attempts to quantify continental or global fluxes or pools come with caveats regarding the often high—and often unknown—uncertainty associated with these estimates, however. To better understand the role of inland waters in nutrient cycling, new approaches are needed to reduce uncertainty in extrapolating site-level estimates to larger geographical scales. The overarching goal of this research is to understand and predict nutrient patterns for all continental United States lakes to inform estimates of lake contributions to continental and global cycles of nitrogen, phosphorus, and carbon, while also providing locally valuable management information about conditions in unsampled lakes. This work will improve understanding of the role of inland waters in macroscale nutrient cycling. The project is a collaboration of researchers across multiple agencies and includes the USGS, Michigan State University, The Pennsylvania State University, the University of Wisconsin, and the University of Missouri.

"For decades the Tennessee Cooperative Fishery Research Unit has served an integral role in the management of aquatic resources in Tennessee. The Tennessee Wildlife Resources Agency relies on the CRU program to quickly respond to our most challenging resource questions with science-based answers using the latest techniques. This partnership has allowed Tennessee Wildlife Resources Agency to improve its management techniques and conserve aquatic resources." **—Bobby Wilson, Executive Director, Tennessee Wildlife Resources Agency**

Species and Habitat Management

The management of fish and wildlife populations for the benefit of current and future generations is the foundation of the United States' conservation heritage. Through its focus on the theme of species and habitat management, the CRU program assists cooperators in achieving their fisheries and wildlife conservation missions through a variety of actions, ranging from the development and implementation of basic monitoring protocols to complex population modeling. These efforts serve to facilitate the conservation and restoration of rare and declining species and provide scientific information needed to manage harvests of game and furbearer species sustainably.

Spawning Site Contribution and Movements of Lake Whitefish in Northwestern Lake Michigan

Wisconsin Cooperative Fishery Research Unit

The lake whitefish fishery in northwestern Lake Michigan is composed of multiple fish stocks, and the movements of fish within those stocks is not well understood. Previous studies suggested that lake whitefish show relatively high spawning site fidelity, but determining whether stocks are functionally discrete remains an important question for fishery managers. Additionally, lake whitefish from multiple stocks now spawn in tributaries to Green Bay (primarily the Fox River and Menominee River) where spawning had not been observed for nearly a century; the movements of these fish are largely unknown. This project is using acoustic telemetry coupled with genomics to test current understanding of lake whitefish stock structure and describe stock-specific movements and spatial distribution relative to fishing efforts. Use of telemetry will also allow scientists to estimate mortality rates for these stocks, which are needed for determining safe harvest levels. This project is a collaboration between multiple agencies, including the USGS, the University of Wisconsin–Stevens Point, the Wisconsin Department of Natural Resources, the Michigan Department of Natural Resources, and Michigan State University.

"We consider the West Virginia Cooperative Fish and Wildlife Research Unit to be an invaluable conservation partner here in West Virginia and throughout the Nation. They consistently deliver sound scientific research, produce high quality graduate students, provide outstanding technical expertise, and effectively collaborate with us on a wide variety of fish and wildlife management projects. This strong partnership between our agency and the West Virginia Cooperative Fish and Wildlife Research Unit has afforded us the opportunity to move the conservation needle in a very positive direction." —**Paul R. Johansen, Chief, Wildlife Resources Section, West Virginia Division of Natural Resources**

Integrating Satellite and Field Measures for Improved Grazing Land Management at Ranch Scales

Idaho Cooperative Fish and Wildlife Research Unit

Monitoring of forage availability, use, and residual biomass is the primary basis for making livestock management decisions in grazing land systems. New technologies can improve field measures and provide new perspectives on the effects of grazing at the landscape-size scale. This research is assessing the effects of grazing at the ranch-size scale and integrating plot-based field use measurements with livestock global positioning system collar data and remotely sensed measures of grazing intensity. The resulting estimates of grazing intensity across pastures will improve our understanding of livestock effects on greater sage-grouse populations and will be integrated into the RangeSAT online tool to analyze and visualize forage availability and grazing intensity. The project is a collaborative effort of ranchers, the USGS, the University of Idaho, the National Resources Conservation Service, and The Nature Conservancy.

Changing Fish Communities in the Penobscot River After Dam Removal

Maine Cooperative Fish and Wildlife Research Unit

Dam removals reestablish natural flow regimes and increase connectivity, affecting fish assemblages throughout the watershed. In Maine, the Penobscot River Restoration Project removed the two lowermost dams on the river and improved fish passage at other dams to help recover declining sea-run fishes and increase resilience of entire ecosystems. To quantify spatial and temporal changes associated with these river rehabilitation efforts, fish assemblages are being assessed using boat electrofishing surveys (3 years each, in spring and autumn) prior to dam removal, shortly after removal, and 6 years post removal (currently in process). Together with the National Oceanic and Atmospheric Administration and The Nature Conservancy, researchers have described distinct fish assemblages present prior to dam removal and followed how these communities have changed to a more riverine assemblage. These changes and their timelines are important for understanding the management outcomes of dam removal.

Diversity, Equity, and Inclusion Committee

In response to requests in 2019 from women in the CRU program, the CRU program's leadership team created an ad hoc committee for diversity, equity, and inclusion (DEI). The DEI committee was charged with making recommendations to the leadership team to promote diversity in hiring and workplace inclusivity. The DEI committee is composed of unit scientists and one member of the leadership team. Committee members serve from 1 to 3 years. In the future, the DEI committee plans to make recommendations for developing a mentorship program for early career scientists and one for developing hiring and retention strategies to promote a diverse, equitable, and inclusive workforce.

Doris Duke Conservation Scholars Program

The CRU program continued its participation in minority education through two programs that focus on groups underrepresented in the conservation workforce. The first program, which is being conducted in collaboration with the National Wildlife Refuge System of the U.S. Fish and Wildlife Service, is a program to develop and recruit Federal scientists and natural resource managers. Graduate and undergraduate students conduct research on topics of importance to the Refuge System. The first student participating in this program recently graduated with her master of science degree. In the second program, four units (Arizona, Florida, Idaho, Massachusetts) are partnering with the Doris Duke Foundation's Conservation Scholars Program. Through this program, undergraduate students attend leadership training programs, work with scientists and graduate students on selected research projects, and are mentored by unit-supported graduate students and research scientists. These "Duke Scholars" also complete paid internships with local, State, Federal, and tribal agencies or nongovernmental organizations.

"Each year, CRU program graduate students mentor undergraduates from the Doris Duke Conservation Scholars Program (DDCSP) who have a passion for fish and wildlife conservation and for increasing diversity in the conservation field. CRU program faculty, graduate students and agency partners provide unique opportunities for these young motivated scholars to gain valuable field experience by contributing to conservation projects, conducting independent research, and presenting scientific data to varied audiences. This two-year experiential training program empowers future conservation leaders, fosters professional development, and promotes diversity, equity and inclusion in the fish and wildlife sciences. The CRU program is proud to be a part of the DDCSP in mentoring this next generation of diverse conservation professionals." **—Anne Yen, graduate student, Idaho Cooperative Fish and Wildlife Research Unit**

Doris Duke Conservation Scholars Spotlights

Keara Clancy

Florida Cooperative Fish and Wildlife Research Unit

Keara Clancy is an alumna of the Doris Duke Conservation Scholars Program. She graduated cum laude from the University of Florida's Wildlife Ecology and Conservation program in May 2020 and, in August, she began pursuing a master of science degree, also through the University of Florida. While a Duke scholar, Keara worked in four laboratories, assisted with three research projects, coauthored a paper looking at gender demographics in myrmecology, and carried out her own research project involving occupancy modeling across three species of woodpeckers. Keara's master's degree is focusing on invasion ecology. Keara is proud that through the Duke program she gained the experience necessary to design her own research—an independent project using occupancy modeling to determine how land management practices affect woodpecker species. She also was awarded a grant from the University of Florida's University Scholars Program to research the historical presence of chytridiomycosis, an infectious disease of amphibians, within the State of Florida. Keara hopes to continue her work in ecology and that her research will better inform management practices and species survival plans in the future. Keara has been heavily involved with work in the areas of justice, equity, diversity, and inclusion, including as an officer for the Natural Resources Diversity Initiative, Youth Conservation Director for the Florida Wildlife Federation, and board member of the University of Florida Wildlife Ecology and Conservation Department's Inclusion, Diversity, Equity and Access Committee.

Kassandra Townsend

Idaho Cooperative Fish and Wildlife Research Unit

Kassandra Townsend, a member of the Acoma Pueblo tribe, is an Ecology and Conservation Biology major at the University of Idaho College of Natural Resources. Through the Doris Duke Conservation Scholars Program, Kassandra gained real-world employment experience in natural resources while balancing rigorous coursework at school and making contributions to her community. She works with the University of Idaho Experimental Forest as an administrative assistant and wildlife program lead. This summer, Kassandra was a crew member assisting Idaho Cooperative Fish and Wildlife Research Unit graduate student Matt Nelson in conducting black bear research in northern Idaho. This work involved trapping and collaring black bears, using trail cameras, and collecting genetic samples. During an internship with the U.S. Fish and Wildlife Service at Keālia Pond National Wildlife Refuge in Maui, Hawai‘i, Kassandra reestablished a refuge nest monitoring program for endangered Hawaiian coots and Hawaiian stilts to determine occupancy and nest success and to conduct predator removal. Her presentation on this research earned her the Best Student Presentation award at The Wildlife Society—Idaho Chapter's annual conference. Kassandra is proud to be an All Nations Louis Stokes Alliance for Minority Participation Program Scholar and a Doris Duke Conservation Scholars Program alumna. Kassandra was awarded a 2019 American Indian Services Scholarship and a 2019 Udall Foundation Scholarship Honorable Mention. Currently, Kassandra is in the process of applying for the "Bridge to Doctorate" graduate program and fellowship at the University of Idaho to continue her exciting journey as a wildlife professional and conservation leader.

Christopher Jenney

Arizona Cooperative Fish and Wildlife Research Unit

Christopher Jenney is a master of science degree student at the Arizona Cooperative Fish and Wildlife Research Unit at the University of Arizona and a graduate mentor for the Doris Duke Conservation Scholars Program. Prior to his time at the University of Arizona, he worked with the Oregon Department of Fish and Wildlife and completed his undergraduate degree at Oregon State University. Christopher's research is focused on assessing native and nonnative fish habitat use on two "wild and scenic" rivers of central Arizona.

Christopher's proudest achievement has been presenting his research to a broader scientific audience. He has presented his research at both regional and national conferences of the American Fisheries Society, and the feedback he received has been overwhelmingly positive. Additionally, one of the Doris Duke Conservation Scholars that he mentored was awarded the Best Student Poster at the Arizona-New Mexico Joint Annual Meeting of The Wildlife Society and the American Fisheries Society. That student's research focused on fish abundance in relation to travertine deposition in Fossil Creek. Christopher feels that being a part of that project and watching his mentee's hard work and dedication pay off was truly a special experience.

The cooperator success stories that follow were supplied by members of State fish and wildlife agencies or universities.

Amphibian Disease Ecology

Wyoming Cooperative Fish and Wildlife Research Unit at the University of Wyoming

Infectious diseases pose a serious threat to the health of people, domestic animals, and wildlife alike. A deeper understanding of how organisms respond to disease better equips us to improve human and animal health in the face of infectious onslaughts. Since 2015, the Wyoming Cooperative Fish and Wildlife Research Unit, in collaboration with the Wyoming Game and Fish Department and the U.S. Forest Service, has investigated amphibian responses to a pathogenic fungus. The chytrid fungus, which causes a skin disease in amphibians, is responsible for declines in hundreds of amphibian populations globally. Boreal toads, once common in high-elevation habitats across the Rocky Mountain West, have suffered severe declines as a result of chytrid fungus in recent decades. By evaluating the movement and infection status of boreal toads through time, Gabriel Barrile (Ph.D. candidate) and faculty advisors Anna Chalfoun and Annika Walters (assistant unit leaders) revealed a defensive strategy whereby individuals used moist, sheltered habitats when disease-free but moved to warmer, more open habitats when infected. Switching habitats in response to infection appeared to be advantageous, as increased warmth in open habitats was associated with the clearing of infection. These findings suggest that small-scale microhabitat manipulation to create warm patches may be an effective mitigation action against the chytrid fungus and possibly other amphibian diseases. The Wyoming Unit is also conducting an extensive mark-recapture project to examine how the chytrid fungus influences population dynamics of boreal toads, such as annual survival and recruitment rates. Results of these studies will be used by the Wyoming Game and Fish Department and other management agencies working to protect boreal toad populations. Further, by investigating the behavioral and demographic responses of wild animals to disease, this research advances our understanding of host-pathogen relationships and informs conservation efforts geared toward precluding further declines of populations challenged with infectious disease.

Wendy Estes-Zumpf
Herpetological Coordinator
Wyoming Game and Fish Department

State-Threatened, Riparian-Obligate Raptors in the Trans-Pecos Region

Texas Cooperative Fish and Wildlife Research Unit at Texas Tech University

Desert riparian systems are distinct narrow drainages that provide environmental conditions for vegetation dependent on permanent or ephemeral surface and subsurface water. Desert riparian zones associated with these systems provide important nesting and foraging habitat in an otherwise highly arid landscape. These riparian systems have been identified as a priority for conservation throughout the southwestern United States. Within these riparian zones in the Chihuahua Desert Ecoregion of Texas are three State-threatened birds of prey—the common black hawk, the gray hawk, and the zone-tailed hawk. Only the most basic observed presence information has been available for these species in the region; thus, species assessments and management has been hampered by a lack of quantitative data. The Texas Cooperative Fish and Wildlife Research Unit has partnered with the Texas Parks and Wildlife Department, Big Bend Ranch State and National Parks, and private conservation entities to assess the abundance, habitat characteristics, productivity, and community structure of these species in riparian zones of the Trans-Pecos region of Texas. Researchers anticipate that the results will provide the Texas Parks and Wildlife Department with data to make informed decisions for status assessment updates and identification of priority areas for conservation and restoration of these State-threatened species.

Russell Martin
Wildlife Diversity Biologist
Texas Parks and Wildlife Department

Tracking Seabirds

South Carolina Cooperative Fish and Wildlife Research Unit at Clemson University

Conservation efforts are challenging for species of wildlife that are highly transboundary in their movements. Seabirds epitomize this transboundary challenge, regularly occupying terrestrial and marine ecosystems and often traversing State, regional, and international boundaries on a regular basis while foraging. During the past 10+ years, the South Carolina Cooperative Fish and Wildlife Research Unit has been collaborating with the U.S. Fish and Wildlife Service, as well as with other State, Federal, and international agencies, to enhance understanding of the daily and annual movement patterns of seabirds. The South Carolina Unit has undertaken two extensive projects focused on the spatial ecology of brown pelicans. In the Gulf of Mexico, Juliet Lamb (a former Ph.D. student; now a Marie Curie Fellow) used satellite tags to assess risk exposure of brown pelicans throughout their annual cycle, identifying temporal and spatial "hot-times and hot-spots." In the South Atlantic Bight region, Ph.D. candidate Brad Wilkinson is using satellite tags to explore brown pelican daily movement patterns and to model how their migration patterns may be affected by climate change. The South Carolina Unit has also undertaken several efforts to track seabirds that breed in the Caribbean and southern Gulf of Mexico, but perhaps none is more important than their work on the endangered Black-capped Petrel. This research continues to substantially increase knowledge of this endemic and enigmatic seabird, thereby identifying threats that the species faces in United States waters as well as in international waters. Information learned from these studies is being used by the U.S. Fish and Wildlife Service and other resource management decision makers to inform actions, such as management of marine and terrestrial systems, to provide key science information in species status assessments and to underpin science critical to oil spill planning and response.

William B. Uihlein, III
Assistant Regional Director,
Science Applications and Migratory Birds,
South Atlantic-Gulf and Mississippi Basin
U.S. Fish and Wildlife Service

Awards and Accolades

Unit scientists and their students received approximately 58 awards in 2020 from universities, agencies, and societies, with recognition at the local, national, and international levels. The valuable work done by members of the CRU program is appreciated by many organizations. Some of the recent awards are summarized below.

Unit Scientists

2020 Outstanding Achievement Award for "Wild Migrations: Atlas of Wyoming's Ungulates"
Renewable Natural Resources Foundation

Matt Kauffman, Wyoming Unit

2020 Ralph W. Schreiber Conservation Award
American Ornithological Society

Jaime Collazo, North Carolina Unit

Recognition for Excellence in Research, Scholarship, or Creative Activity
Texas Tech University

Dave Haukos, Kansas Unit

W.L. McAtee and G.V. Burger Award for Outstanding Service as an Associate Editor 2020 for the two journals of The Wildlife Society: Journal of Wildlife Management and Wildlife Society Bulletin
The Wildlife Society

Clint Boal, Texas Unit

Gordon Kirkland Lifetime Achievement Award
Pennsylvania chapter of The Wildlife Society

Duane Diefenbach, Pennsylvania Unit

Director's Award for Faculty Service
School of Environmental and Forest Sciences, University of Washington

Sarah Converse, Washington Unit

Graduate Students

Best Student Presentation
Arkansas chapter of The Wildlife Society

Lassiter Ellery, Arkansas Unit

Outstanding Graduate Service to Wildlife Ecology and Conservation Award
Department of Wildlife Ecology and Conservation, University of Florida

Alexis Cardas, Florida Unit

Best Graduate Student Presentation
Minnesota chapter of The Wildlife Society

Katelin Goebel, Minnesota Unit

Noreen Clough Memorial Scholarship
Bass Anglers Sportsman's Society

Hadley Boehm, Missouri Unit

Outstanding Graduate Student in Fisheries
Department of Natural Resource Ecology and Management, Oklahoma State University

Thomas Hafen, Oklahoma Unit

Robin's Awards: Graduate Student Teacher of the Year
Utah State University

Jack McLaren, Utah Unit

2020 Outstanding Dissertation Award
Office of Graduate Education, University of Wyoming

Ellen Aikens, Wyoming Unit

Professional Services, Leadership, and Editorial Positions

Members of the CRU program serve widely on technical committees, working groups, and panels; hold leadership positions as officers, committee chairs, and appointed liaisons; and serve as editors for numerous publications.

167 professional service positions
69 society leadership positions
71 editorial positions

Outdoor Recreation Economy Statistics

Research conducted by the CRU program helps to support the management of harvestable fish and wildlife populations by State and Federal agencies. In 2016—

- Consumer spending by hunters, anglers, and target shooters supported more than **1.6 million jobs** in total.
- 13.3 million hunters and 32 million target shooters added **$55.4 billion** to the gross domestic product (GDP), providing for **854,000 jobs**.
- 45.8 million angers contributed **$63.5 billion** to the Nation's GDP, supporting **802,000 jobs**.
- **$93.7 billion** was spent on gear, motorboat fuel, licenses, travel, clothing, and more.

Source: The Impact of Fishing, Hunting, and Target Shooting in America—Driving the U.S. Economy (Congressional Sportsmen's Foundation fact sheet, available at http://congressionalsportsmen.org/reports/2018-sportsmens-economic-impact)

The Outdoor Recreation Economy Generates:

$887 BILLION
in consumer spending annually

$7.6 MILLION
American jobs

$65.3 BILLION
in Federal tax revenue

$59.2 BILLION
in State and local tax revenue

Source: Outdoor Industry Association

Acknowledgments

The CRU program is a unique cooperative partnership among State fish and wildlife agencies, universities, the Wildlife Management Institute, the USGS, and the U.S. Fish and Wildlife Service. The cooperating universities and State fish and wildlife agencies for each of the 40 units are listed below.

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 Wildlife

Colorado
Colorado State University
Colorado Parks and Wildlife

Florida
University of Florida
Florida Fish and Wildlife Conservation Commission

Georgia
University of Georgia
Georgia Department of Natural Resources

Hawai‘i—Fishery
University of Hawai‘i
Hawai‘i 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, Parks and Tourism

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

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 State 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

"The Georgia Cooperative Fish and Wildlife Research Unit is an integral part of our well-regarded fisheries and wildlife programs in the Warnell School of Forestry and Natural Resources at the University of Georgia. Their timely and impactful research that finds management solutions to real-world problems involves our graduate students with learning opportunities that are invaluable. The CRU program model is an outstanding example of how to leverage resources through collaboration of Federal research agencies with strong university research programs." **—W. Dale Greene, Dean, Warnell School of Forestry and Natural Resources, University of Georgia**

Photograph credits

p. i, Yellow-legged frog. Photograph by Devin Edmonds, U.S. Geological Survey (USGS).

p. iii, American alligator hatchlings. Photograph by Abigail Lawson, USGS.

p. v, Shovelnose sturgeon. Photograph by Zach Klein, USGS.

p. vi, Golden eagle with GPS backpack. Photograph from USGS.

p. 3, Green sea turtle. Photograph by Andrew Crowder, USGS.

p. 4, Canada geese. Photograph from USGS.

p. 5, Ryan Gary with paddlefish. Photograph by Phil Bettoli, USGS.

p. 5, Amelia Duvall. Photograph by Jim Howard.

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p. 8, Maryland oysters. Photograph by Will Parson, courtesy of the Chesapeake Bay Program.

p. 8, Beluga whale with calf. Photograph from NOAA Fisheries.

p. 8, White-tailed deer. Photograph by Scott Bauer, U.S. Department of Agriculture.

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p. 11, Louisiana black bear and cubs. Photograph by Clint Turnage, U.S. Department of Agriculture.

p. 11, Wolf eyes close up. Photograph by Paul Cross, USGS.

p. 13, Lake whitefish in Maine. Photograph from USGS.

p. 14, Amelia DuVall. Photograph by Andrew Yamagiwa.

p. 15, Keara Clancy. Photograph from USGS.

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p. 17, Boreal toad on a burned log. Photograph by Blake Hossack, USGS.

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p. 20, Panfish tournament. Photograph by Timothy Bishop, Baker County Tourism.

p. 22, American white pelicans. Photograph by Pat Jodice, USGS.

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