

## Cooperative Fish and Wildlife Research Units Program—

# 2017

## Year in Review

**Circular 1438**

Version 2.0, February 2018

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







A large alligator is the central focus of the image, lying on a bed of dry, brown leaves and twigs. The alligator's head is in the lower right, with its mouth slightly open, revealing small teeth. Its body extends towards the upper left, with its long, scaly tail visible. The background is a dense, swampy area with green grass and some dark, vertical logs or tree trunks. The lighting is natural, suggesting daylight. The overall tone is earthy and naturalistic.

# **Cooperative Fish and Wildlife Research Units Program—2017 Year in Review**

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

**Circular 1438**

**Version 2.0, February 2018**

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



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

RYAN K. ZINKE, Secretary

**U.S. Geological Survey**

William H. Werkheiser, Deputy Director  
exercising the authority of the Director

U.S. Geological Survey, Reston, Virginia

First release: 2018

Revised: February 15, 2018 (ver. 2.0)

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment—visit <https://www.usgs.gov> or call 1–888–ASK–USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit <https://store.usgs.gov>.

Any use of trade, firm, or product names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this information product, for the most part, is in the public domain, it also may contain copyrighted materials as noted in the text. Permission to reproduce copyrighted items must be secured from the copyright owner.

Suggested citation:

Organ, J.F., Thompson, J.D., Dennerline, D.E., and Childs, D.E., 2018, Cooperative Fish and Wildlife Research Units Program—2017 year in review (ver 2.0, February 15, 2018): U.S. Geological Survey Circular 1438, 68 p., <https://doi.org/10.3133/cir1438>.

ISSN 1067-084X (print)

ISSN 2330-5703 (online)

ISBN 978-1-4113-4198-2



## Contents

Chief's Message.....	1
Background.....	2
Coop Unit Mission and Facts .....	4
Training the Conservation Workforce—Education and Youth .....	5
Leveraging Resources .....	6
Outreach and Training.....	7
Technical Assistance .....	8
Current (2017) Vacancies.....	10
Budget and Staffing.....	10
Science Themes.....	11
Where Are They Now?.....	60
Accolades .....	61
Professional Services .....	62
2017 North American Wildlife and Natural Resources Conference .....	62
National Cooperators' Coalition Update .....	62
List of Cooperators.....	63
List of Species .....	65
Photograph Credits.....	67









## Chief's Message

The Cooperative Fish and Wildlife Research Units Program was involved in a number of notable events during 2017, many concerning our personnel. Dr. Barry Grand left his position as Leader of the Alabama Cooperative Fish and Wildlife Research Unit to become the Cooperative Units Program Supervisor for the South, replacing Dr. Kevin Whalen who took over as Supervisor for the West. We welcomed Dr. Sarah Converse who left the Patuxent Wildlife Research Center to become Leader of the Washington Cooperative Fish and Wildlife Research Unit. Dr. Amanda Rosenberger joined the Tennessee Cooperative Fishery Research Unit as Assistant Leader, transferring from the Missouri Cooperative Unit. Dr. Scott Carleton left his position as Assistant Unit Leader in New Mexico to become Chief of the Region 2 Migratory Bird Program of the U.S. Fish and Wildlife Service.

We said farewell to many colleagues who retired. Their departure is bittersweet as we wish them health, happiness, and wellness in retirement. We will miss their companionship and the extraordinary contributions they have made to the Cooperative Fish and Wildlife Research Units Program and conservation. Our retirees are:

Phil Bettoli, Tennessee  
David Kremetz, Arkansas  
Chip Leslie, Oklahoma  
Christine Moffitt, Idaho  
Mike Samuel, Wisconsin

Hal Schramm, Mississippi  
Carl Schreck, Oregon  
Glenn Van Blaricom,  
Washington  
Peggy Wilzbach, California

The Cooperative Fish and Wildlife Research Units Program has a record high number of vacant scientist positions due to a combination of retirements and base funding shortfalls. These issues are affecting our ability to meet cooperator needs. Yet, we remain highly productive. For example, this year we released a report (<https://doi.org/10.3133/cir1427>) containing abstracts of nearly 600 of our research projects, covering thematic areas ranging from advanced technologies to wildlife diseases. We provided highly competent, trained scientists and natural resource managers for our cooperators' workforce. We delivered technical training and guidance to professional practitioners. We provided critical information to cooperators for decisions on species status assessments and management of species of greatest conservation need.

This year we had an active presence at major national meetings, including the North American Wildlife and Natural Resources Conference where we co-sponsored a workshop on continuing education as a means to bridge the gap between science and management. During the coming year, with support from the U.S. Geological Survey and our cooperators, we intend to reduce the number of vacancies in the program. It will take time and active support of our cooperators to get back to full strength, but I am committed to this goal and encouraged by the resolve of our partners. We look forward to an even more productive year in 2018!

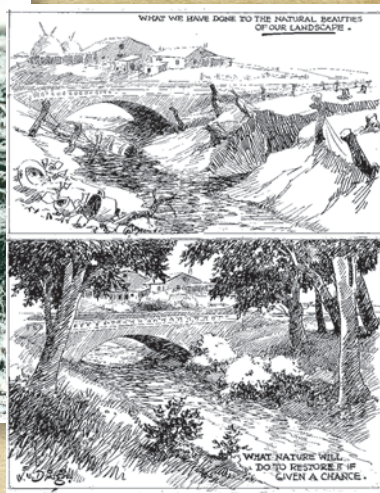
John Organ





## Background

The shortage of wildlife biologists and the lack of information about wildlife management in the early 1930s motivated Ding Darling to use personal funds to establish the first Cooperative Wildlife Research Unit in Iowa. The first Cooperative Fish and Wildlife Research Units Program (Coop Unit) was a partnership between the State land-grant college and the State fish and wildlife agency to conduct research and provide wildlife education at Iowa State College in Ames. Darling subsequently expanded the partnership to include the Department of the Interior and the Wildlife Management Institute. From its inception in Iowa, the Coop Unit Program has grown to 40 Coop Units in 38 States and is now considered to be a national conservation institution.



Left: Ding Darling, and right, cartoon by Ding Darling.



1935 Duck stamp.



Kansas Unit ribbon cutting.



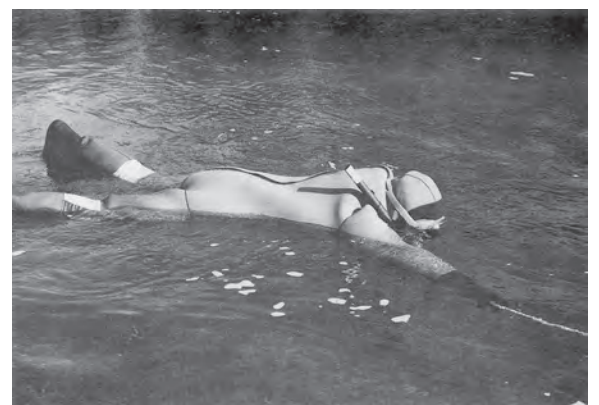
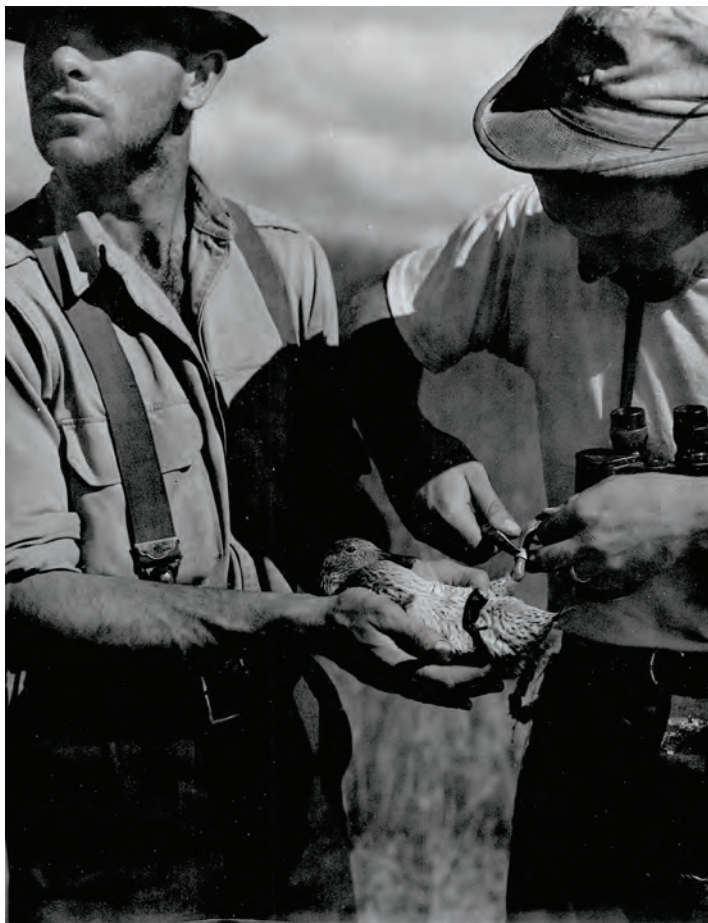
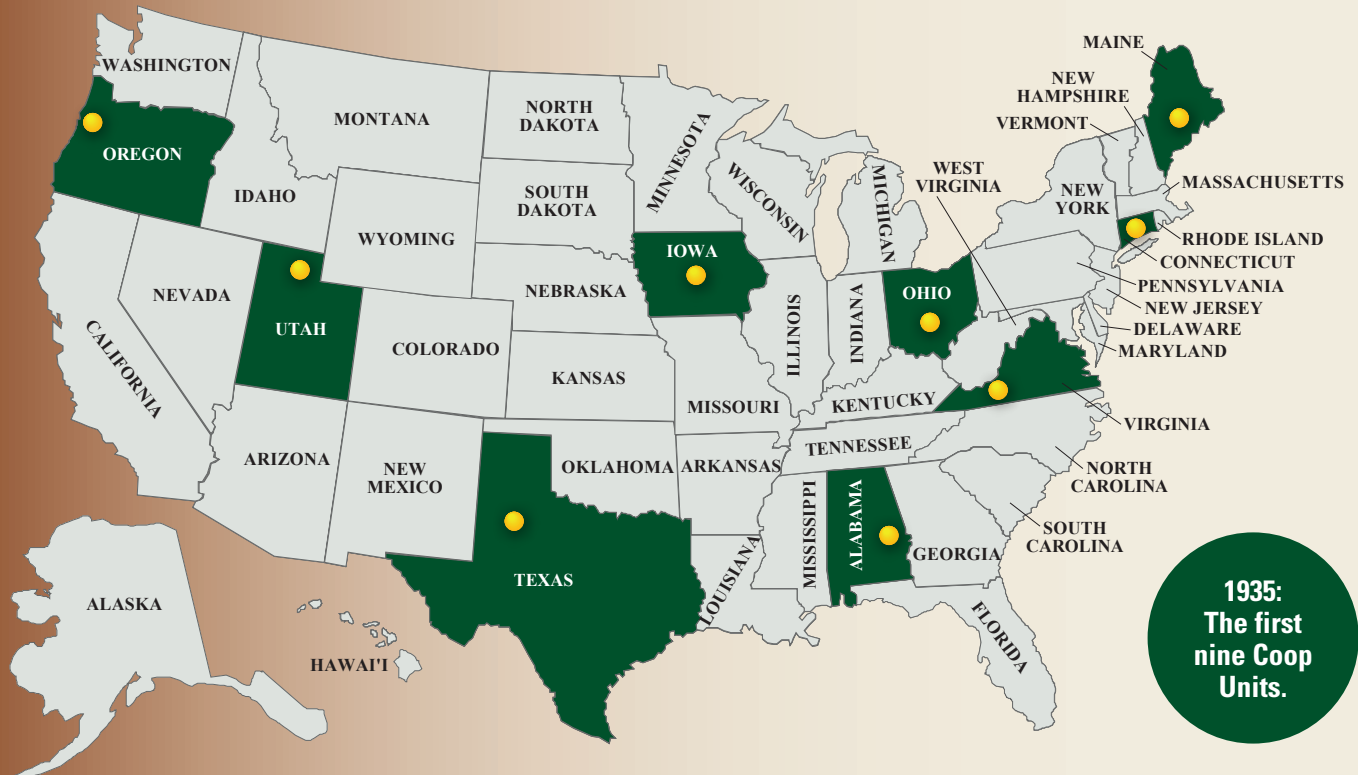
Montana Wildlife Unit, John Craighead was Unit Leader from 1950 to 1977.



North Carolina Unit Leader Mel Huish and students sample fish with an early model backpack electrofisher.

North Carolina Unit Leader Mel Huish and students.







## Coop Unit Mission and Facts

### Mission

- Develop the workforce of the future through applied graduate education
- Deliver actionable science to cooperating agencies and organizations
- Support the training and technical assistance needs of cooperators concerning the application and integration of new science

### Outdoor Recreation Economy Statistics:

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)

Funds generated by sportsmen and women in support of the American system of conservation funding:

**\$823 million** from hunting and recreational shooting-related excise taxes authorized by the Pittman-Robertson Wildlife Restoration Act

**\$686 million** from fishing licenses

**\$624 million** from fishing and boating-related excise taxes authorized by the Dingell-Johnson Sport Fish Restoration Act

**\$821 million** from hunting licenses

More than **\$56.9 billion** or 80 percent of the funding for State fish and wildlife agencies since 1939

(Source: Congressional Sportsmen's Foundation)

### Cooperators:



State Fish and Wildlife Agencies



Universities



Wildlife Management Institute



U.S. Fish and Wildlife Service



U.S. Geological Survey

### Partnerships:

**40 Coop Units in 38 States**



Units receive support from and work closely with their respective State fish and wildlife agency

### Coop Unit Facts:

- Each Coop Unit is staffed by Federal scientists employed by the U.S. Geological Survey (USGS)
- 2–5 Federal research scientists
- More than 1,100 students and university staff
- Coop Unit scientists
  - receive graduate faculty appointments,
  - are assigned office and laboratory space, and
  - receive administrative support from the universities



## Training the Conservation Workforce—Education and Youth

Each year, nearly 550 graduate students participate in natural resources education and training through the Coop Unit Program. Research directed by Coop Unit scientists assists the next generation of professionals to emerge from our programs uniquely prepared to be effective members of the natural resource workforce. The cooperative and applied nature of the program provides this new workforce the opportunity to become oriented and accustomed to the needs and policies of State and Federal natural resource agencies. The success of this approach is evident in that Coop Unit students have gone on to hold important leadership positions in nearly every State and Federal conservation agency.



**525**

Graduate students in the Coop Unit Program



**25**

Ph.D. degrees awarded

**71**

M.S. degrees awarded



Doris Duke conservation scholars

### Coop Unit graduate students





## Leveraging Resources

The unique model of the Coop Unit Program allows each cooperator to receive more from their individual contribution than could be achieved alone. Program wide, the **2–5** Federal research scientists stationed at host universities collectively garner **\$25 million to \$40 million** in State, Federal, and private research funding each year. Non-Federal cooperative faculty annually bring in an additional **\$6 million** in Federal funds through Coop Unit Research Work Orders. Combined research funds support an average of about 1,100 students and university staff annually. Being located at some of the finest land grant colleges and universities provides Coop Unit scientists access to world class research and library facilities. Coop Unit scientists and affiliated university faculty link the research mission of all cooperators with student

# \$29.4M

in State and Federal  
research funding in 2017

# 2–5

Federal research  
scientists per Coop Unit

training, thereby providing students with the opportunity to address the information needed by State and Federal decision makers and managers.

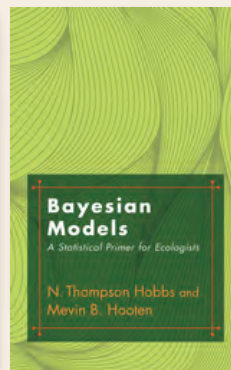
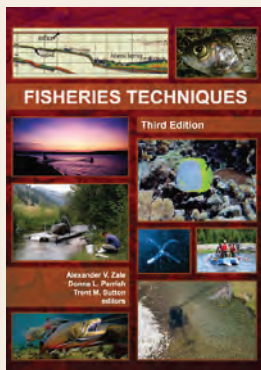
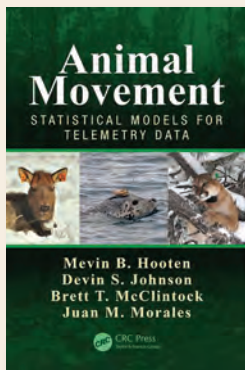
Base funding from the State agencies is leveraged by funding and support from the other cooperators to ensure State agencies have “local” access to state-of-the-art research capabilities and facilities to help meet their contemporary research needs and have a continuous output of highly qualified graduate students for subsequent employment.



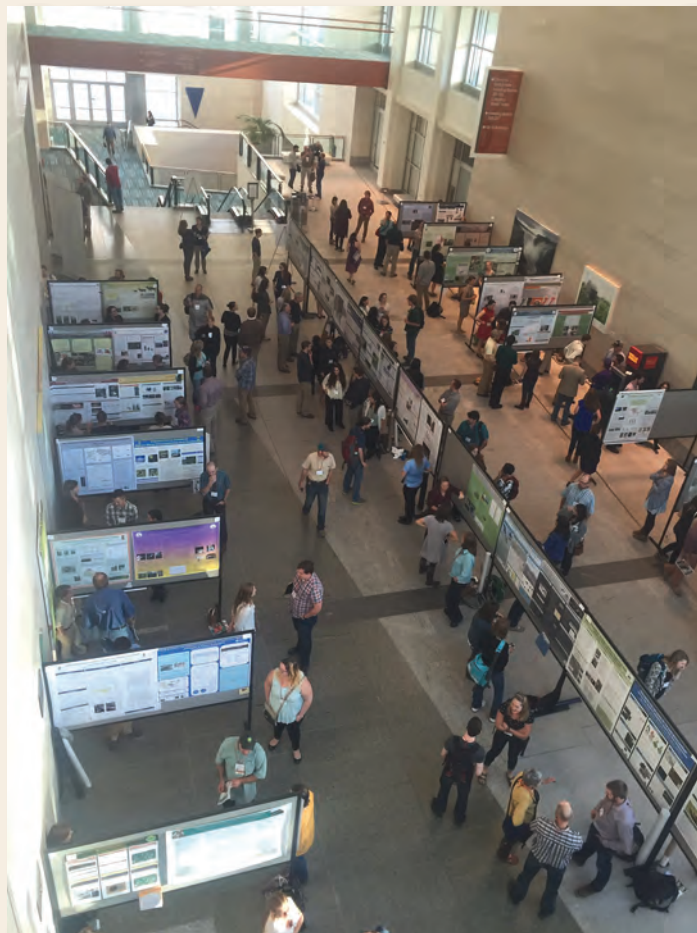


## Outreach and Training

Coop Unit scientists routinely develop programs and applications that can be used by State and Federal natural resource managers to conduct data analyses to inform decision making. The Alabama Unit is providing professional assistance to the U.S. Fish and Wildlife Service Species Status Assessment Framework Implementation Team. The Arizona Unit is providing input to Devils Hole pupfish recovery to conserve this species and providing data to educators to support increased teaching of the concept of “carrying capacity” in core curriculum. The Iowa Unit is offering a 2-day continuing education course for the Iowa Chapter of the American Fisheries Society, “Database Concepts, Design and Application in Fisheries Management.” The Vermont Unit is developing an interactive web tool, BeeMapper, which displays land cover and predicted wild bee abundance across Maine. The Washington Unit is conducting research with the U.S. Fish and Wildlife Service to support its species status assessment for lesser prairie-chicken.



- The Arkansas Unit is providing technical assistance to the Arkansas Game and Fish Commission on the imperiled coldwater crayfish, a species of greatest conservation need.
- The Massachusetts Unit is assessing the effects of outreach efforts on local water conservation programs and policies.
- The New Mexico Unit is providing an effective outreach database that was used to inform interested publics on New Mexico's wildlife conservation issues.
- The South Carolina Unit supports @Biotweeps, an ecology-focused Twitter account for science communication.



# 365

Scientific publications



# 56

Courses taught



# 981

Presentations



# 50

Invited seminars



# 23

Workshops



## Technical Assistance

Coop Unit scientists remain actively engaged in our mission to provide technical assistance to our cooperators by conducting workshops and training for our State and Federal partners through designated, instructor-led courses and special symposia at the National Conservation Training Center in Shepherdstown, West Virginia. Courses covered a variety of subjects, but recurrent topics included structured decision making, R programming and graphics, and Bayesian modeling approaches.

- **Quantitative ecology courses**—Tom Edwards at the Utah Unit teaches graduate level classes in The Design and Analysis of Ecological Research, and Topics in Spatial Ecology. He also teaches two National Conservation Training Center courses, Species Distribution Models Using R, and Ensemble Modelling Approaches: Extending Species Distribution Models to Forecast Environments.

- **American paddlefish sustainability in Tennessee**—In the 1990s, Tennessee exported paddlefish caviar internationally due to the collapse of the sturgeon caviar industry. Overfishing, illegal activity, and more demand caused the paddlefish population to drop dramatically. The Tennessee Fishery Unit outlined the problems and produced management actions that were adopted and helped ensure continued sustainable harvests of paddlefish.

- **Bee abundance and the production of blueberries**—Maine is the world's largest producer of blueberries. The Maine Unit assessed the effectiveness that wild native bees have on blueberry pollination against the managed honey bees. The Unit developed a web-available spatial crop pollination model (InVEST; The Natural Capital Project) that predicts bee abundance across the landscape.

- **Maine fish populations**—The construction of dams on major New England rivers in the 1800s and 1900s halted the migration of fish. This caused human, animal, and plant communities to disappear or decline because of the species dependence on the fish for food. The Maine Unit is working with Penobscot Nation, Federal, State, private, and industry partners to help fish populations recover from hundreds of years of discontinuity.

- **Oyster reef restoration in Louisiana**—The eastern oyster is an economically and ecologically important species, with more than 60 percent of its harvest coming from waters along the northern Gulf of Mexico. Global trends in shellfish resources indicate substantial declines, including a decline in the functional role of these reef-building organisms (eastern oyster). To support the restoration efforts, the Louisiana Unit has been studying the population dynamics of eastern oysters in coastal Louisiana to help refine restoration of the species and inform water management to benefit oyster production. This work has been incorporated





into sustainable oyster production harvest models being developed by the Louisiana Department of Wildlife and Fisheries. The Coop Unit is also working on characterizing the ecosystem services provided by oyster reefs.

- **Unmanned aerial systems in Florida**—The University of Florida Unmanned Aerial Systems Research Group, based at the Florida Unit, has one of the longest-running programs focused on the utility of unmanned aerial vehicles (UAVs) for wildlife research and conservation. Current aerial platforms include fixed wing, rotorcraft, and manned vehicle options for UAV no-fly zones. The Florida Unit is committed to evaluating the benefits of using UAVs to

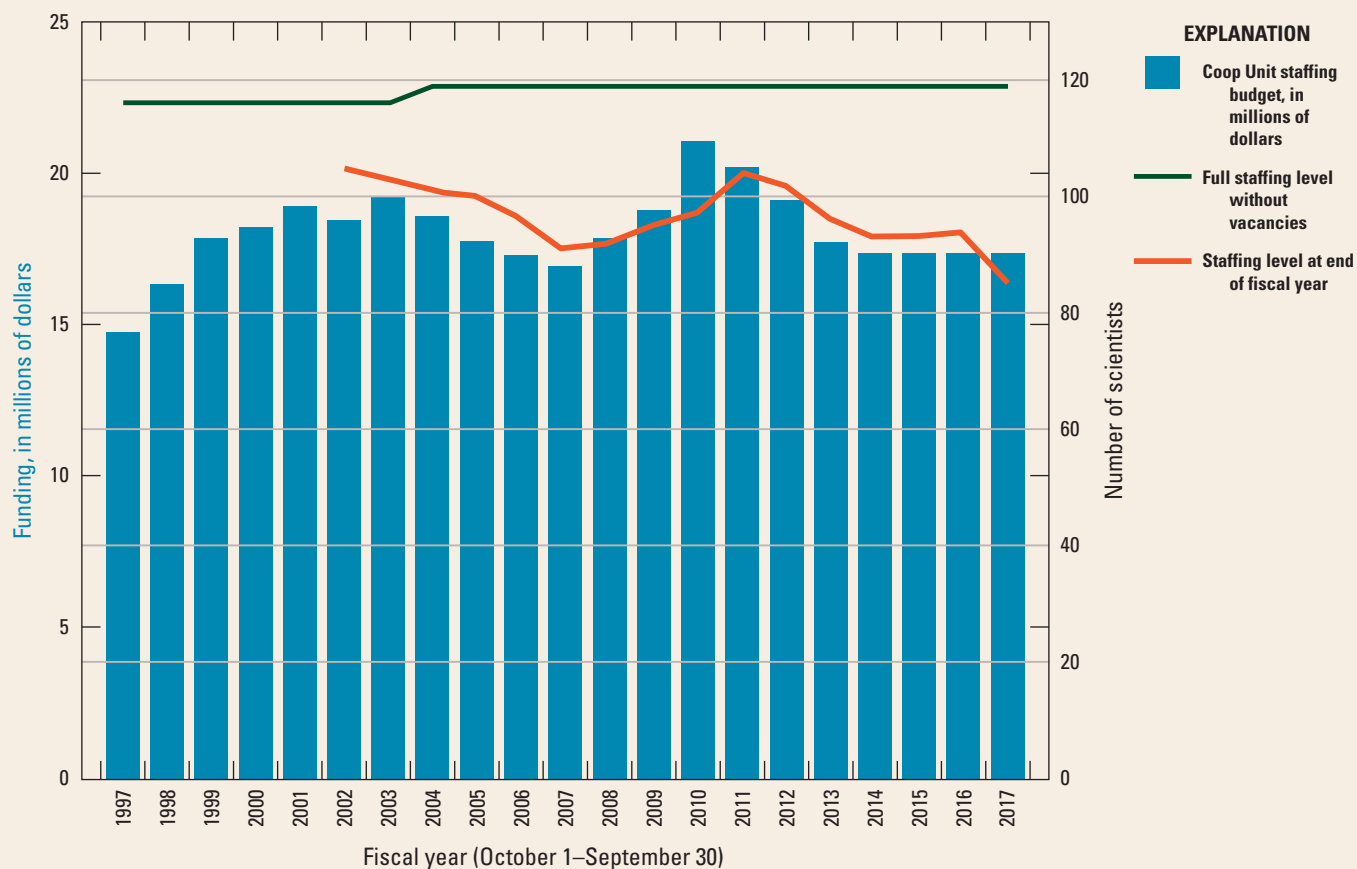
advance natural resource research and management while decreasing the risks to practitioners in the field and educating the public on the important and beneficial applications of this technology.

- **Species of greatest conservation need in New York**—A model developed by the New York Unit was used to analyze assessment data on Species of Greatest Conservation Need (SGCN) and categorize SGCN on the basis of available data concerning their status. SGCN are species that have experienced or are likely to experience population decline in the next 10 years and require conservation actions to stabilize their populations in New York. High Priority SGCN are species that are experiencing population declines or have specific threats that may put them in jeopardy and, thus, are in need of timely management intervention before their populations reach critical levels in New York.
- **Oxbow lakes in Mississippi**—In cooperation with the U.S. Army Corps of Engineers, the Mississippi Unit has been surveying the physical, chemical, and biological characteristics of oxbow lakes, focusing on fish communities. Information obtained by the Unit is shared with conservation organizations and groups with agricultural interests to develop regional plans for restoration and conservation of a resource considered by many to be a national treasure.





## Budget and Staffing



## Current (2017) Vacancies





## Science Themes

We lead research that can provide science solutions for the management needs of cooperators and inform decision making. Featured in this section are examples of the diversity of management-oriented research conducted with State and Federal cooperators. Many more examples are available from individual Coop Units. Featured here are examples of what this cooperative effort can yield.



Species Population, Habitat, and Harvest Management

Species of Greatest Conservation Need

Energy and Wildlife

Decision Science

Endangered Species

Invasive Species

Ecosystem Services

Ecological Flows

Wildlife Health and Disease

Landscape Ecology

Human Dimensions of Fish and Wildlife Conservation

Climate Science

Advanced Technologies



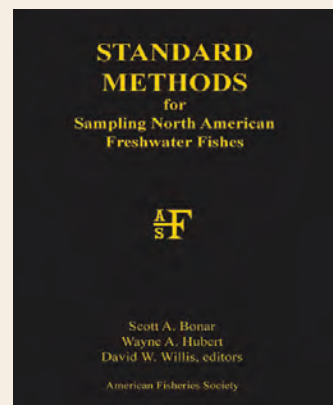
## Species Population, Habitat, and Harvest Management

The management of fish and wildlife populations for the benefit of current and future generations of all Americans is the foundation of this Nation's conservation heritage. Coop Unit scientists assist our cooperators in their mission through a variety of actions, 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 to sustainably manage harvests of game and furbearer species.

The Montana Wildlife Unit is:

- Studying southern temperate songbirds to assess whether their long lives can be explained by reduced energy expenditure of parents compared with northern temperate species.
- Determining the distribution of elk during hunting seasons.
- Developing a framework for the dynamic, adaptive harvest management of wolves and designing a targeted monitoring program for wolves.

The Arizona Unit works with partners on refining standard fisheries sampling techniques in North America.

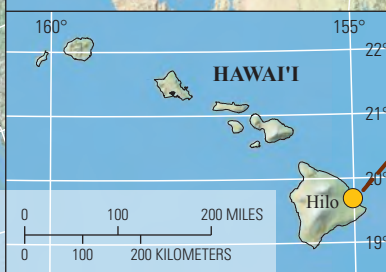


The Alaska Unit is:

- Examining population dynamics of and visitor effects on nesting oystercatchers.
- Assessing the availability and use of seasonal habitats by rainbow trout and linking the habitat characteristics (physical habitat, water temperature, and flow) to fish location and movement.



The Hawai'i Fishery Unit evaluates the relative effects of consumptive and non-consumptive uses on coral reef health and reef fish populations.





### The Iowa Unit is:

- Assessing the utility of wetlands to provide habitat and landscape connectivity to amphibians in the Des Moines Lobe by examining water quality, discerning the presence of amphibian disease, and estimating survival, reproduction, and stress levels in native frogs.
- Developing a model that uses National Wetlands Inventory data to predict Canada goose breeding densities.
- Using population models to determine age structure and population trends for river otters and bobcats.



### The Massachusetts Unit is:

- Using a Global Positioning System (GPS) to track and monitor bears in densely populated suburban, urban, and rural areas in central Massachusetts to inform population management.
- Investigating the effects of dam removal on stream ecosystems.

The Virginia Unit is developing practical and efficient assessments that connect deer population goals to ecosystem effects.

The Kansas Unit is leading research on how movements of a top fish predator affect ecosystem structure and function.

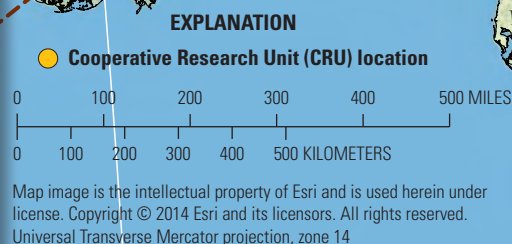
The Oklahoma Unit is establishing a stream-sampling protocol that includes the collection of monitoring data to support environmental flow standards.

The Alabama Unit estimates white-tailed deer demographic rates by using time-lapse photography.

### The Maine Unit is:

- Testing various sampling designs and methodologies to determine the best unbiased predictor of population size and trends over time.
- Conducting surveys of amphibians on coastal islands along the entire coast of Maine to enhance the limited amount of information about amphibian distributions on coastal islands.
- Characterizing the effects of dam removal over time.

The Georgia Unit evaluates the abundance, age, size, and mortality rates for populations of spotted and largemouth bass in three Georgia reservoirs: Lake Lanier, Lake Chatuge, and Lake Nottely.





## Species Population, Habitat, and Harvest Management—Continued

The Washington Unit is:

- Collaborating with the University of Washington and the U.S. Army Corps of Engineers on a project to assess and evaluate the success of restoration sites in western Washington.
- Analyzing high-resolution satellite photographs for the beginning and end of the nesting season periods of snow geese on Wrangel Island.

The South Dakota Unit is identifying potential causes of observed high natural mortality in yellow perch.

The Nebraska Unit is:

- Examining migratory shorebird habitat and how habitat characteristics might influence the condition and potential fitness of shorebirds during spring migration.
- Using radio telemetry to assess hen pheasant reproduction and habitat use.

The New Mexico Unit is:

- Developing a model based on the demography and population ecology of Cooper's hawk, which can provide useful inferences to other raptor populations, including golden eagles.
- Assessing mule deer survival rates, pregnancy rates, and nutrition, and determining how habitat selection by mule deer is influenced by habitat conditions and predation risk from mountain lions.
- Monitoring black bears during wildfire season in the Santa Fe National Forest and on the Valles Caldera National Preserve.
- Comparing predictions from a habitat model with data from a remote-sensing camera to estimate mountain lion abundance and density.



The Missouri Unit is:

- Offering biologists the tools and knowledge necessary to measure and adjust electrofishing output in the field and afford them the opportunity to sample these species in a standardized, efficient, and safe manner.
- Evaluating the effectiveness of various sampling methods to determine the detection probability for amphibians and fish.
- Developing reference stream reaches on the basis of physical habitat in Missouri. Results from this study can inform decisions on aquatic resources and help managers prioritize conservation efforts.





The Minnesota Unit is building upon existing eastern elk restoration research to address two research goals: (1) defining public support for a restored elk population by surveying citizens in and around prospective restoration sites and (2) determining where suitable habitats exist and how many elk could be sustained.



The Wisconsin Fishery Unit is:

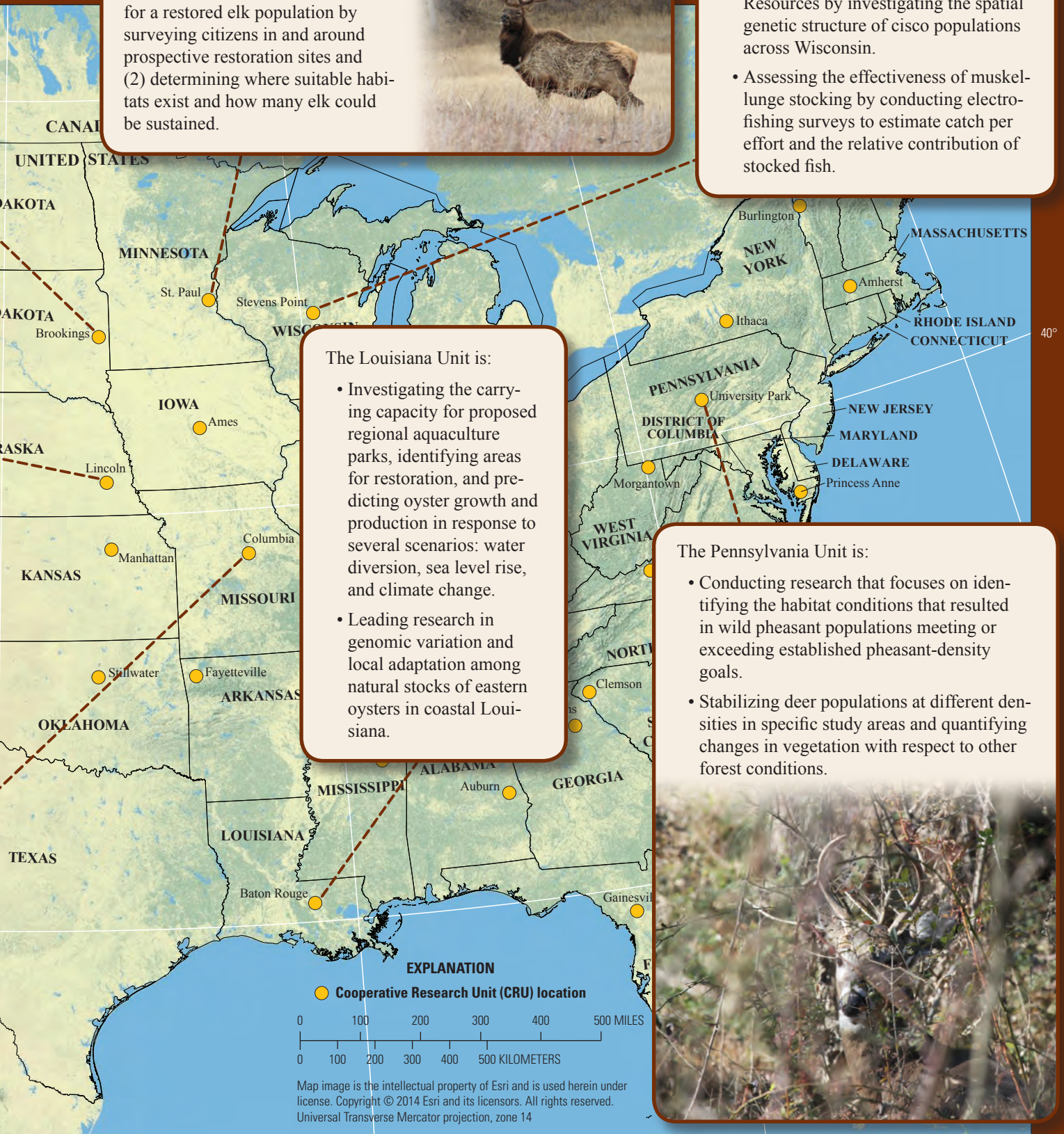
- Extending the survey work of the Wisconsin Department of Natural Resources by investigating the spatial genetic structure of cisco populations across Wisconsin.
- Assessing the effectiveness of muskellunge stocking by conducting electrofishing surveys to estimate catch per effort and the relative contribution of stocked fish.

The Louisiana Unit is:

- Investigating the carrying capacity for proposed regional aquaculture parks, identifying areas for restoration, and predicting oyster growth and production in response to several scenarios: water diversion, sea level rise, and climate change.
- Leading research in genomic variation and local adaptation among natural stocks of eastern oysters in coastal Louisiana.

The Pennsylvania Unit is:

- Conducting research that focuses on identifying the habitat conditions that resulted in wild pheasant populations meeting or exceeding established pheasant-density goals.
- Stabilizing deer populations at different densities in specific study areas and quantifying changes in vegetation with respect to other forest conditions.





## Species Population, Habitat, and Harvest Management—Continued

The Oregon Unit is:

- Leading research on the survival rates and causes of mortality for mule deer and black-tailed deer.
- Studying the effects of recolonizing gray wolf populations on cougars in northeast Oregon.



The Idaho Unit assesses the importance of wetlands on Department of Defense installations for the persistence of wetland-dependent birds.



The Utah Unit is:

- Estimating the abundance and vital rates of a large population of Bonneville cutthroat trout from the Logan River in northern Utah.
- Leading research in how arctic lake fish populations and communities are structured and function with special consideration of the potential effects of climate change.
- Evaluating habitat-based niche requirements for the bluehead sucker.

The Wyoming Unit is:

- Studying the factors regulating the growth of struggling mule deer populations and identifying what, if any, effect elk have on mule deer.
- Evaluating how hunters and elk change their use of the forest as trees die, as dead trees begin to fall, and as beetle-kill management is implemented.
- Using two sources of sheep-harvest data to document long-term trends in horn size and the ages of bighorn sheep, Dall's sheep, and Stone's sheep at a regional level.
- Conducting a statewide moose habitat evaluation with the Wyoming Game and Fish Department to serve as a benchmark for defining the relation between moose habitat and population performance.

The Texas Unit is estimating age/sex-specific survival and connectivity of midcontinental snowy plovers via consistent, long-term banding efforts at interior snowy plover nesting locations in Texas, New Mexico, Oklahoma, and Kansas.





The New York Unit is:

- Developing a conceptual framework for managing black bears.
- Developing models to evaluate the population status of selected species by using spatial capture-recapture methods and noninvasive genetic sampling.
- Using landscape-scale camera trapping for species of conservation or management interest (fisher, bobcat, marten, and black bear).



The West Virginia Unit is examining various methods for creating young forest habitat for early successional-dependent species.



The North Carolina Unit is:

- Sampling American eels in the Roanoke River in North Carolina to assess their age and growth.
- Documenting stocked trout migration and mortality and the persistence of stocked trout in designated streams.

The Tennessee Fishery Unit is developing population management and harvesting management protocols for catfish species in Tennessee reservoirs.

The South Carolina Unit is enhancing the understanding of the relations between migratory shorebirds, particularly red knots, and spawning horseshoe crabs at key locations in South Carolina.





## 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 Grants program. SWAPs contain a list of Species of Greatest Conservation Need (SGCN) and identify information needs, threats, and conservation actions. Coop Unit scientists work with State cooperators to develop the science needed to inform conservation actions.

The Idaho Unit is analyzing seabird population dynamics and environmental drivers at a regional scale.

The Iowa Unit is reviewing habitat restoration efforts and the response of stream fishes of greatest conservation need, specifically Topeka shiners and plains topminnows. An extensive geographic information system (GIS) analysis using a new, state-of-the-art framework could help guide restoration efforts.

The Nebraska Unit is conducting population and genetic studies to improve understanding of swift fox distribution, abundance, and conditions in Nebraska in order to develop best-management practices for this species.

The Wyoming Unit is:

- Comparing small mammal abundance in areas of native mixed-grass prairie to those with exotic grass (cheatgrass) encroachment to inform grassland management in eastern Wyoming.
- Evaluating habitat suitability at potential introduction sites of the hornyhead chub and exploring the effects of predation by nonnative salmonids.



The Colorado Unit is investigating the effects of a dynamic environment on harbor seal movement and resource selection in the coastal waters of southern Alaska.



0 500 1,000 MILES  
0 500 1,000 KILOMETERS

0 100 200 MILES  
0 100 200 KILOMETERS



The Wisconsin Fishery Unit is using acoustic telemetry to describe the movement of lake sturgeon in the Menominee River.



The Pennsylvania Unit is characterizing snowshoe hare habitats in northern hardwood forests in northwestern Pennsylvania and in the scrub oak barrens in the Poconos region.



The Vermont Unit is:

- Assessing stonecat populations in both the Missisquoi and LaPlatte Rivers.
- Documenting adult and juvenile movements, identifying suitable spawning and nursery habitat, investigating age structure, and developing a method for estimating the population size of lake sturgeon in Lake Champlain.



The South Carolina Unit is:

- Estimating current population structure, abundance, and habitat requirements for American alligators in South Carolina.
- Addressing information gaps relative to brown pelicans in the South Atlantic Bight and providing baseline ecological information for the species in the region.



The Florida Unit is providing data on annual productivity of oystercatchers nesting on spoil islands at the Cross Florida Greenway State Recreation and Conservation Area.



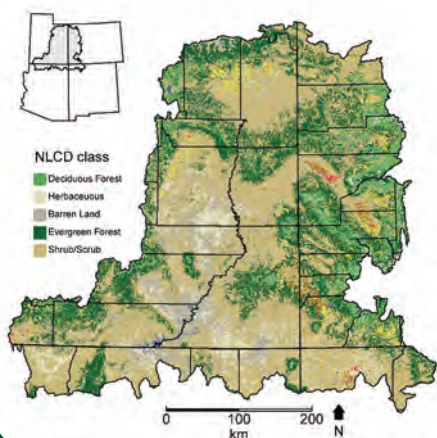


## Species of Greatest Conservation Need—Continued

The Montana Wildlife Unit is analyzing data collected from a multi-State wolverine monitoring program.



The Utah Unit is developing models to investigate rare and sensitive plant distributions and energy development in the Colorado Plateau region.

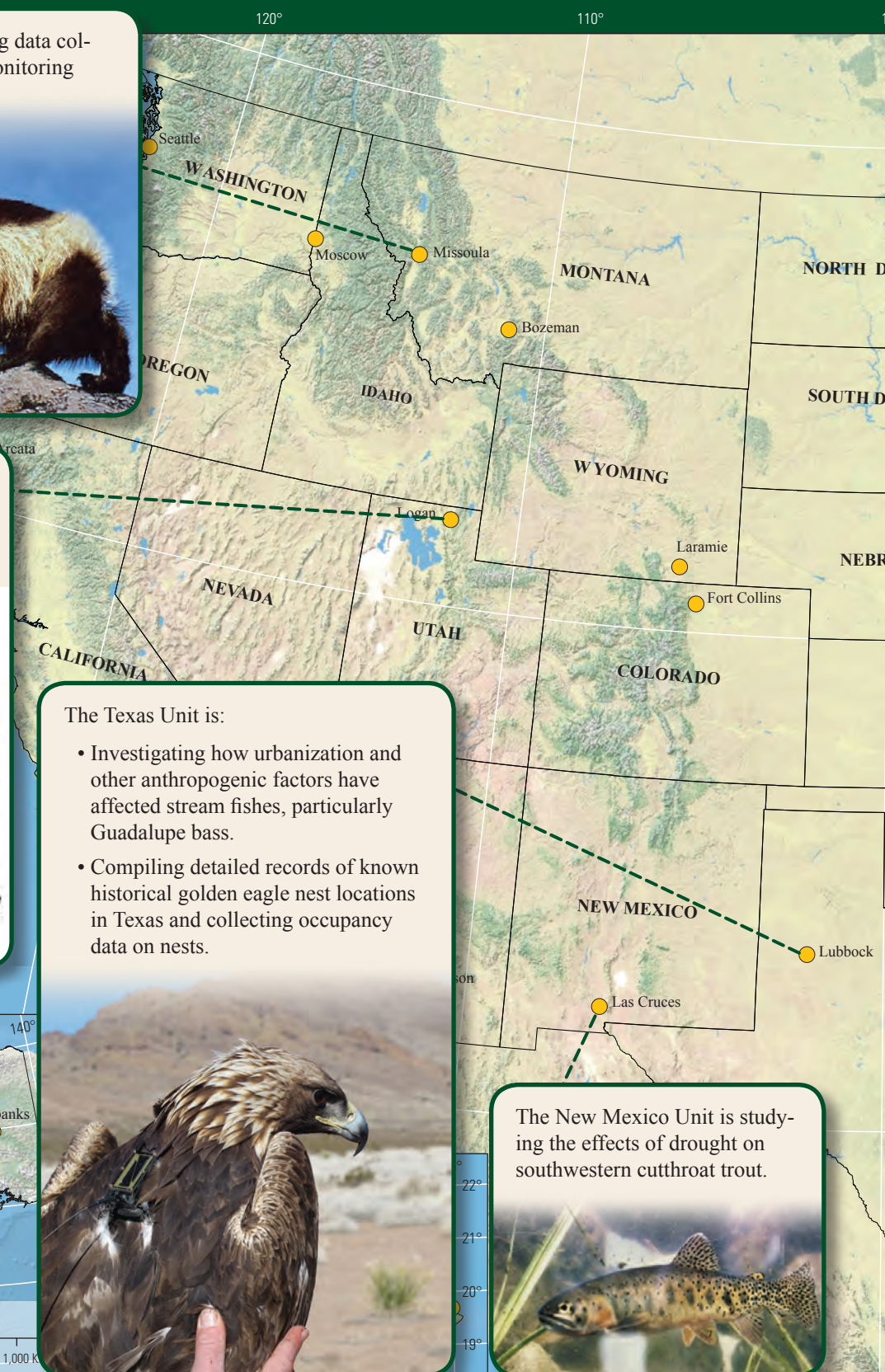


The Texas Unit is:

- Investigating how urbanization and other anthropogenic factors have affected stream fishes, particularly Guadalupe bass.
- Compiling detailed records of known historical golden eagle nest locations in Texas and collecting occupancy data on nests.



The New Mexico Unit is studying the effects of drought on southwestern cutthroat trout.





The North Carolina Unit is:

- Researching how water quality and contaminants affect the robust redhorse in the Pee Dee River of North Carolina and South Carolina.
- Assessing the effects of the National Park Service predator management and vehicle management practices on nesting shorebirds at Cape Hatteras National Seashore.

The Massachusetts Unit is investigating habitat loss, fragmentation, and other anthropogenic sources of mortality that contribute to population decline of the wood turtle.



The Alabama Unit is leading research on nongame fish SGCM in order to identify patterns that can be used to increase the effectiveness of water-quality regulations and conditions below impoundments.

The Tennessee Fishery Unit is assessing sites that historically harbored at-risk mussel species to determine their current distribution. These data can inform management of fisheries conservation efforts throughout the State.

The Georgia Unit is investigating at-risk species in the longleaf pine ecological system.





## Energy and Wildlife

Biologists and land managers use information on the effects of energy development on fish and wildlife species as well as risk analyses related to different options for energy infrastructure siting. Coop Unit scientists work with cooperators to provide a science foundation for biologists and land managers to make decisions.



The Wyoming Unit is leading research in the nutrition and fitness of mule deer exposed to human disturbance across three winter ranges in western Wyoming.

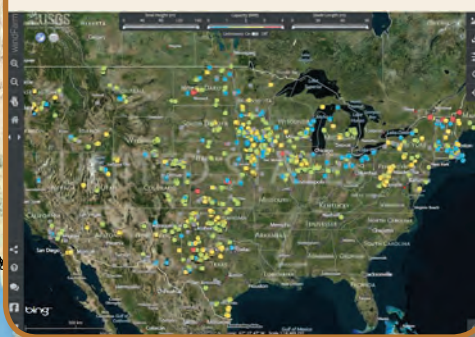


The Kansas Unit is investigating the effects of energy production, habitat selection, and population size on resource selection, survival, and recruitment of lesser prairie-chickens.

The Alaska Unit is assessing post-breeding shore-bird use of the lagoons and estuaries along the coast of northwestern Alaska given the potential vulnerability of Cape Krusenstern National Monument to the effects of offshore energy development.



The Colorado Unit is developing a model to estimate the number of bird fatalities at wind turbine projects by integrating the mortality, scavenging, and detection processes into the model.



The New Mexico Unit is improving the understanding of the movement ecology and landscape genetic structure of golden eagles in the Western United States.

The Texas Unit is assessing survey protocols for eagles and other raptor species.





The West Virginia Unit is:

- Quantifying how the size, shape, age, and placement of gas well pads and pipelines affect the abundance and diversity of forest songbirds across the Marcellus shale region.
- Leading an extensive fishery resource research project on Cheat Lake.



The Massachusetts Unit is conducting rigorous ecological assessments to evaluate the effects of offshore wind power on birds, bats, and fish and other marine species.



The Virginia Unit is quantifying the potential effects of mining on downstream water quality.



The Georgia Unit is evaluating threats to important grassland bird habitats in oil and gas development areas, changes in landownership patterns, and invasive species of the Gulf Coast Prairie.



The South Carolina Unit is addressing information gaps relative to brown pelicans in the Gulf of Mexico and providing baseline ecological information for the species in the region.





## Decision Science

Decision science is becoming a much needed approach to enable transparent, quantifiable decisions in the face of uncertainty and contention, and to allow managers and scientists to learn through management actions.

The California Unit is collaborating with the U.S. Fish and Wildlife Service and the USGS Columbia River Research Laboratory and Texas State University to develop decision-support systems such as the Stream Salmonid Simulator (S3) model.



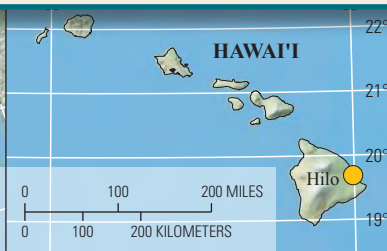
The Minnesota Unit is leading long-term monitoring of trends in waterfowl hunter satisfaction and attitudes toward management.

The Oregon Unit is:

- Employing a structured decision-making process to help managers develop appropriate cruise ship management priorities in Glacier Bay National Park to protect species such as humpback whales and Steller sea lions.
- Working with researchers from the USGS Forest and Rangeland Ecosystem Science Center and State and Federal natural resource managers in the Pacific Northwest to develop a decision-support system for amphibian conservation.

The Nebraska Unit is:

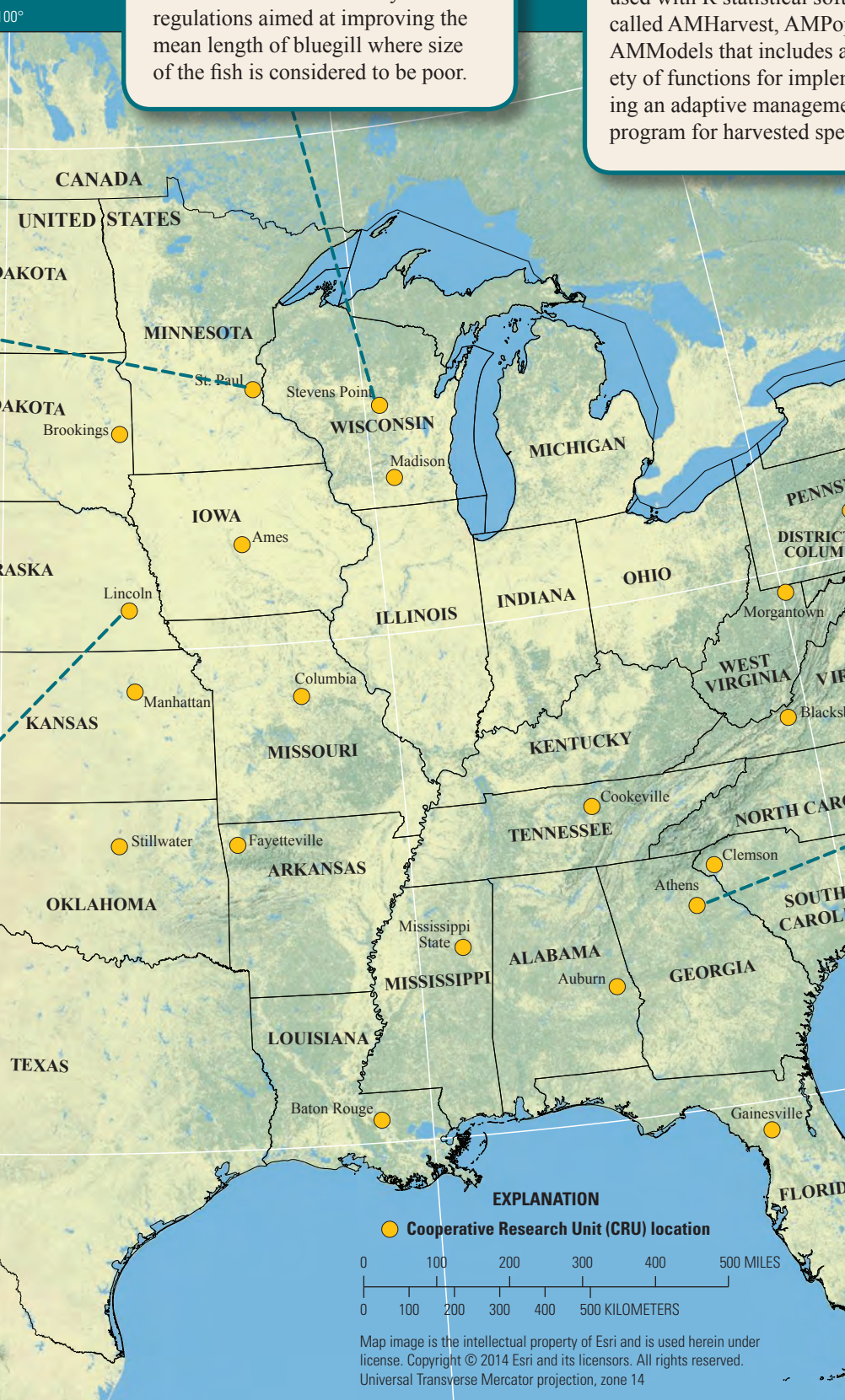
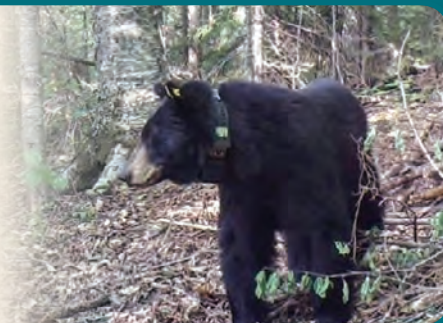
- Exploring how structured decision making can link resilience, adaptive management, and optimization in order to generate a cohesive method of implementing conservation within the emerging social-ecological context.
- Leading research to inform landowners enrolled in the Conservation Reserve Program in Nebraska's Niobrara Valley of how mid-contract management activities affect soil health.





The Wisconsin Fishery Unit is implementing an adaptive management framework to identify effective regulations aimed at improving the mean length of bluegill where size of the fish is considered to be poor.

The Vermont Unit is developing a suite of packages to be used with R statistical software called AMHarvest, AMPop, and AMModels that includes a variety of functions for implementing an adaptive management program for harvested species.



The Georgia Unit is:

- Developing a dynamic adaptive management framework for the public harvest of alligators in Georgia, Florida, and South Carolina.
- Using qualitative information to develop a reliable predictive framework for specific management actions or practices in Georgia forests.
- Engaging in a collaborative assessment to help Georgia Department of Natural Resources update or formulate a trout management strategy that will satisfy most trout anglers and be relatively robust to identified critical uncertainties.
- Providing assistance with structured decision making and population viability analysis related to recovery planning for the Chiricahua leopard frog in southern Arizona.
- Developing a decision-support system that leads to a viable landscape in support of the statewide tortoise population and associated species and communities of interest.
- Using structured decision making and scenario forecasting to evaluate alternative conservation strategies for robust redhorse.





## Decision Science—Continued

The Montana Fishery Unit is developing a decision-support tool to identify and prioritize conservation propagation for threatened, endangered, imperiled, and declining species.



The Montana Wildlife Unit is using integrated population models to help inform management decisions for mule deer and elk.



The Kansas Unit is:

- Developing a spatially explicit, decision-support tool for managing human effects in stream and river networks.
- Developing a model that relates atmospheric, terrestrial, aquatic, and social processes to predict the potential effect of climate variability, climate change, land use, and human activity on water resources.



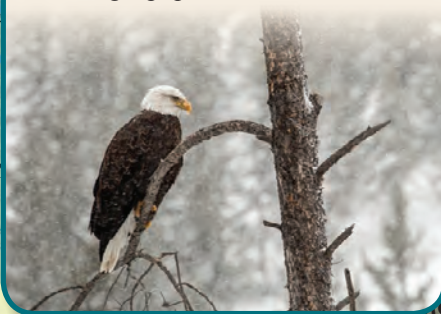
The Missouri Unit is:

- Developing a decision-support monitoring framework designed to maximize the probability of detecting species or assemblage expansions or declines in key areas of Missouri that are the strongholds of mussel diversity.
- Investigating the relation between secretive marsh bird occupancy during the spring migration and wetland habitat characteristics and management practices.





The South Dakota Unit is developing a structured decision-making process that uses surveys to identify core values, sets objectives, identifies reasonable sampling scenarios, and chooses an appropriate sampling regime that optimizes objectives and minimizes cost for bald eagle populations.



The New York Unit is:

- Developing a conceptual framework for joining citizen science efforts with telemetry, spatial capture recapture, and occupancy methods into a single integrated population model for managing black bears.
- Working with local stakeholders and researchers to develop a conservation program that connects existing forest reserves with the newly created ecological corridor for the Andean bear in Ecuador.



The Pennsylvania Unit is working with partners to better understand deer browsing and its relation to deer density, which will help to inform harvest regulations.



The Massachusetts Unit is using structured decision making to address the conservation of headwater stream ecosystems in the face of climate change.



The Alabama Unit is:

- Investigating viable options for the restoration of Dauphin Island as a sustainable barrier island to protect and restore island resources, including habitat and living coastal and marine resources.
- Partnering with the Alabama Department of Conservation and Natural Resources to conduct a long-term study to inform science based adaptive management of eastern wild turkey populations.
- Using decision models developed for grassland bird population management to consider non-avian taxa that rely on the same habitat and that are of high conservation concern.
- Using time lapse photography to estimate demographic rates of white-tailed deer for use in a population model that will inform harvest management decision analysis.

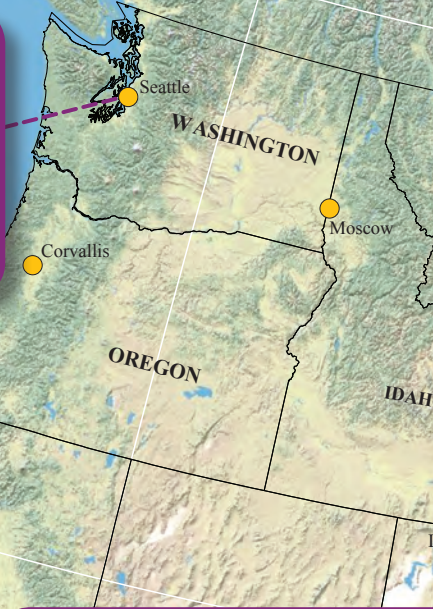




## Endangered Species

Coop Unit scientists work with Federal and State cooperators to answer science questions that inform decision making in implementing the Endangered Species Act.

The Washington Unit, in collaboration with National Oceanic and Atmospheric Administration's National Marine Fisheries Services, is providing new information on critical requirements for successful spawning of wild populations of endangered black abalones.



The New Mexico Unit is conducting research on the Mexican wolf.



The California Unit is leading research on a dual-frequency identification sonar (DIDSON) imaging system to estimate the number of adult steelhead migrating into and out of Redwood Creek.



The Utah Unit is developing methods for collecting accurate data on endangered Colorado River fish populations through detection approaches using passive integrated transponder (PIT) tags.



The Texas Unit is creating an assessment of surveys for golden eagles and other raptor species.

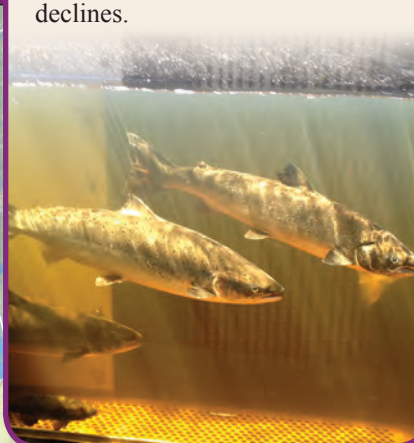




The Wisconsin Fishery Unit is collaborating with the U.S. Fish and Wildlife Service Midwest Region on problem solving and conservation actions related to the purple cat's paw, pearl mussel, and snuffbox.

The Wisconsin Wildlife Unit is identifying where management adjustments may need to occur throughout the geographic distribution of the Kirtland's warbler to identify and implement strategies that mitigate the effects of climate change.

The Maine Unit is evaluating the effect of acid and aluminum exposure to determine the role of acid rain in Atlantic salmon declines.



The Louisiana Unit is determining habitat use, survival, and behavior of released whooping cranes, refining release methods to enhance project success, and assisting land managers in the reintroduction program.



The West Virginia Unit is developing a new sampling approach to examine the diamond darter and its microhabitat.



The Alabama Unit is:

- Developing a framework for assessing species status to inform or support endangered species conservation, including the Sonoran Desert tortoise and the headwater or roundtail chub.
- Contributing research toward the recovery of spectacled and Alaska-breeding Steller's eiders.

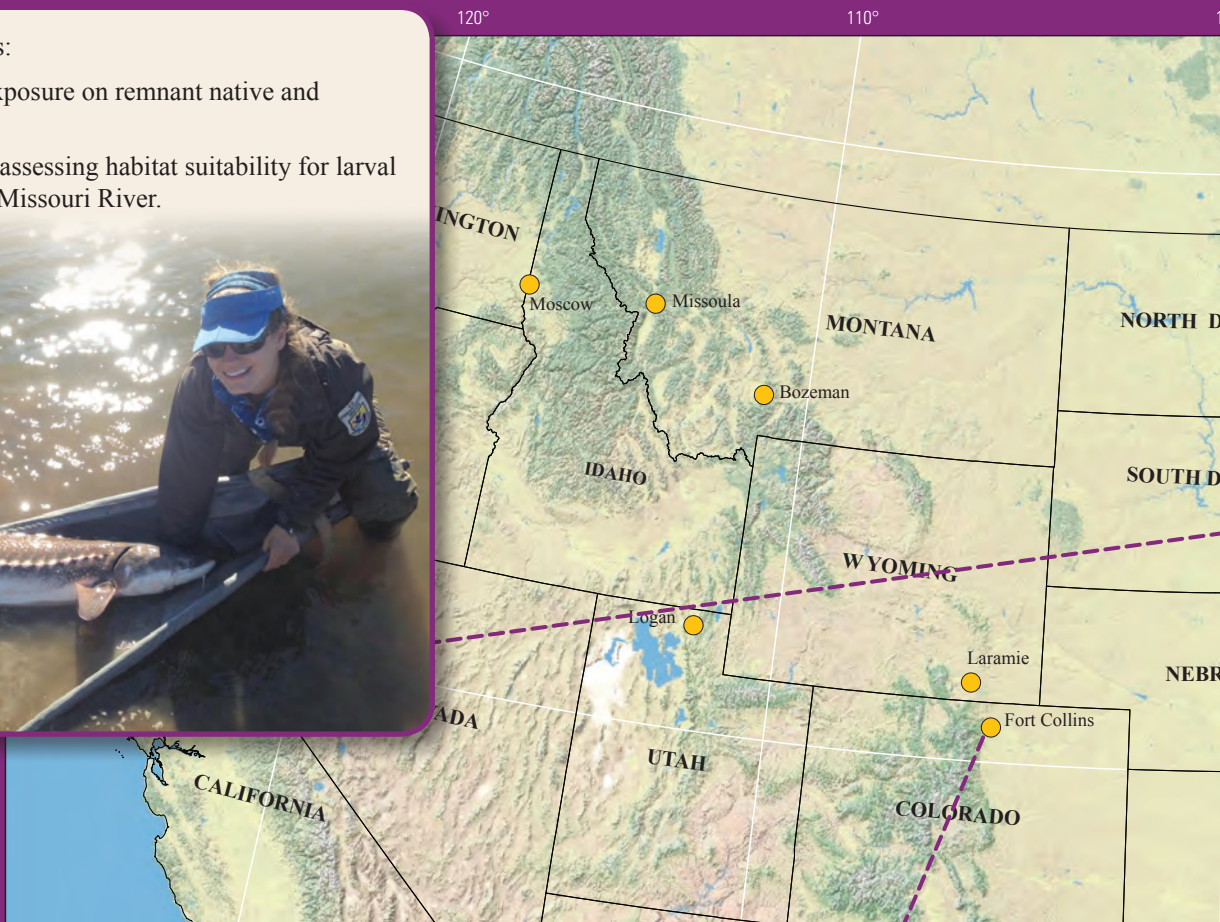




## Endangered Species—Continued

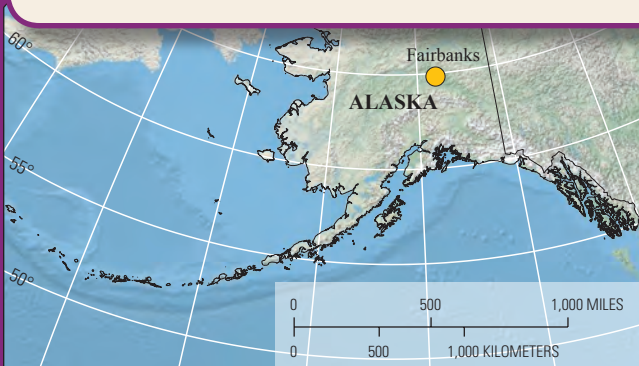
The South Dakota Unit is:

- Assessing pesticide exposure on remnant native and restored grasslands.
- Developing a tool for assessing habitat suitability for larval pallid sturgeon in the Missouri River.



The Colorado Unit is:

- Investigating vital rates of black-footed and Laysan albatross.
- Developing a methodology that uses the existing sources of telemetry and spatially explicit habitat data to better understand resource selection by Steller sea lions in the western and central Aleutian Islands.
- Conducting a field evaluation of a predator-resistant nest box for Micronesian starlings with application to endangered Guam Micronesian kingfishers.





### The Mississippi Unit is:

- Conducting island-wide surveys, identifying mortality threats, determining spatial distribution, and developing habitat suitability models to prevent the extinction of both the broad-winged hawk and sharp-shinned hawk in Puerto Rico.
- Leading research in conserving, managing, and restoring habitats necessary to restore the endangered pallid sturgeon and conserve the threatened shovelnose sturgeon in the lower Mississippi River.



### The Virginia Unit is:

- Studying the spruce-fir moss spider that inhabits high-elevation, spruce-fir forests in the southern Appalachians, considered one of the most endangered ecosystem types in the United States.
- Incorporating Wallops Island bat species presence/absence data into a larger multi-partner, mid-Atlantic landscape and smaller forest stand-level predictive modeling effort.



The Kansas Unit is assessing aspects of livestock grazing and prescribed fire as management tools by quantifying vegetation structure, vegetation composition, and lesser prairie-chicken population response to grazing management and use of fire in Kansas.

### Ecology and Conservation of Lesser Prairie-Chickens



EDITED BY  
David A. Haukos • Clint W. Boal

The North Carolina Unit is using photography, videography, and capture-recapture methods to evaluate the validity of occupancy estimates based on marsh rabbit pellet counts, estimate population size and movement of feral cats, assess the use of artificial structures by woodrats, and estimate the population size and movement of feral cats in woodrat habitats.

The Florida Unit is assisting in the creation of a baseline for rainfall effects on nesting and relocation management techniques on the population of nesting loggerhead sea turtles in Georgia.





## Invasive Species

Invasive species of plants, animals, and microorganisms pose substantial risks to native species, ecosystems, and the health of humans, fish, and wildlife. The economic, environmental, and health-related costs of invasive species exceed those of all other natural disasters combined. Biological invasions may affect the resilience of complex systems and can cause sudden and effectively irreversible changes.

The Idaho Unit is:

- Completing a draft decision control manual that summarizes the invasive New Zealand mud snail.
- Providing guidance documents for risk assessment and control measures for invasive mollusks in fish hatchery operations in Lake Pend Oreille.



The Montana Fishery Unit is:

- Conducting controlled experiments to evaluate the effects of chemical and mechanical methods on the mortality of lake trout embryos.
- Monitoring the movements of lake trout in Yellowstone Lake.

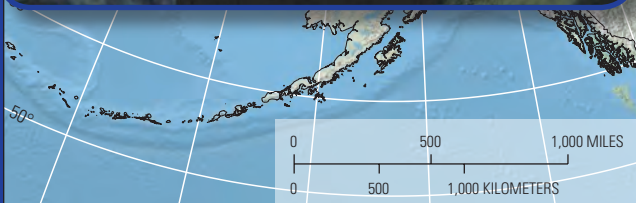
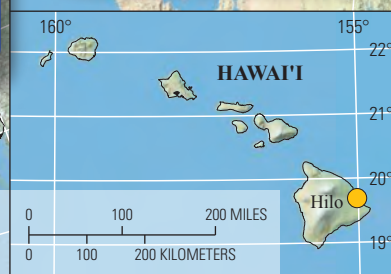


The Iowa Unit is investigating the population ecology of Asian carp in the upper Missouri River Basin.



The New Mexico Unit is estimating the size of the burro population, examining patterns of space use, and employing methods to reduce recruitment.

The Oklahoma Unit is assessing the extent and reproduction potential of the Asian swamp eel population.





The Minnesota Unit is evaluating the response of bird communities to the control of invasive vegetation by developing protocols to assess the effects of several treatments to remove invasive vegetation.

The Pennsylvania Unit is developing models based on population vital rates and habitat use of the invasive flathead catfish to estimate the relative abundance and age and growth characteristics of the species.

The Tennessee Fishery Unit is:

- Evaluating diet niche overlap between native mussels and silver carp in the Duck River over three seasons.
- Evaluating population characteristics of Asian carp, studying recruitment mechanisms, and investigating how larvae relate to environmental factors such as river flows and water temperature.

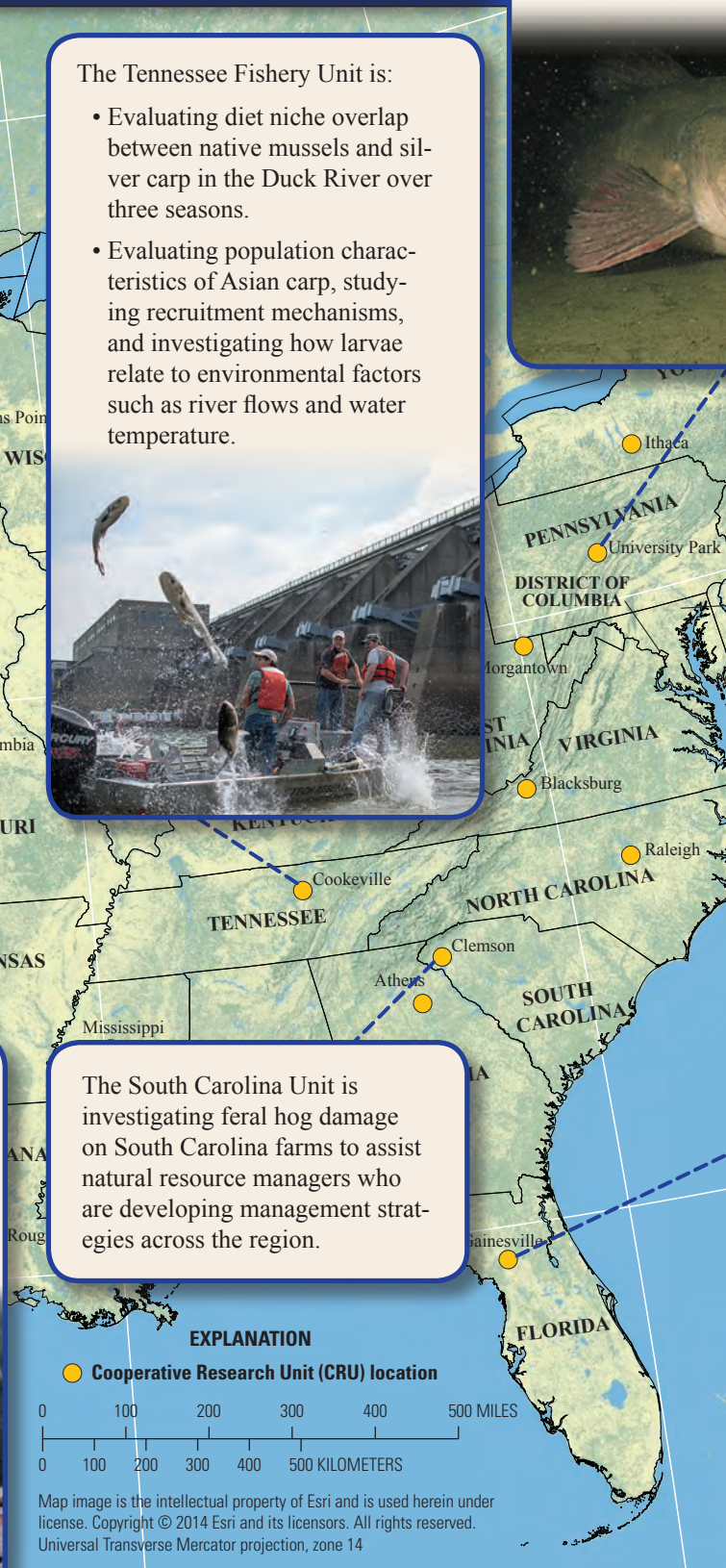


The Florida Unit is:

- Evaluating the effectiveness of using an integrated outreach and trapping program to remove invasive wildlife in south Florida.
- Leading research in the movement, habitat use, and control tools of Burmese pythons in the Greater Everglades.

The Missouri Unit is investigating the thermal preference and tolerance of coldwater crayfish to enhance the understanding of invasive species dynamics.

The South Carolina Unit is investigating feral hog damage on South Carolina farms to assist natural resource managers who are developing management strategies across the region.





## Ecosystem Services

Ecosystem services are attributes and outputs of ecosystems that create value for human users. Public and private support for natural resource conservation can be fostered through increased awareness and understanding of the many benefits healthy ecosystems provide to society. Ecosystem services can be documented through nonmonetary or cultural values. Cultural ecosystem services are more difficult to quantify, but are extremely important in understanding natural resource values to society.

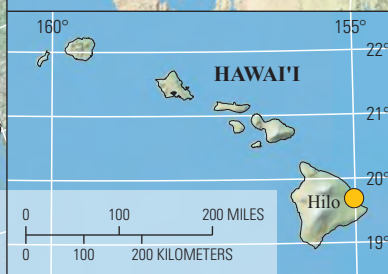
The Washington Unit is assessing the ecological effects of physical disturbances associated with cultured intertidal tracts of Pacific geoduck clams in habitats of southern Puget Sound, Washington.

The Alaska Unit is:

- Building upon an existing modeling framework to represent the key processes that can improve our understanding of the effects of thermokarst disturbance on ecosystem structure and function at the regional scale.
- Studying how climate variability and change are affecting the social-ecological dynamics of rural Alaskan villages by understanding how changes in ecosystem services are affecting community resilience and helping to identify opportunities for adaptation and (or) transformation of community practices.



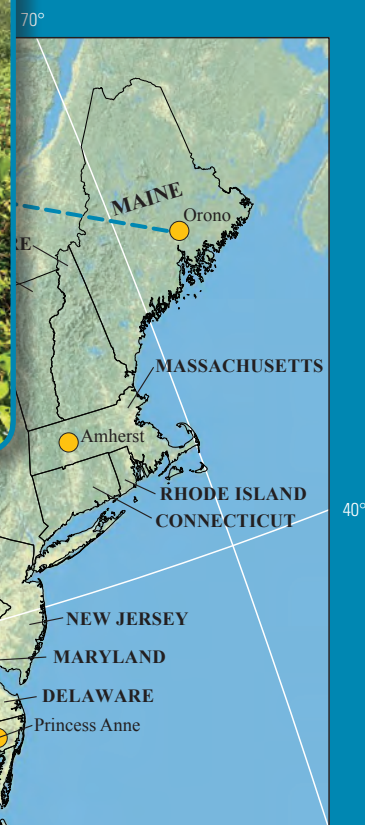
The New Mexico Unit is using USGS National Gap Analysis Program (GAP) data, including land cover, land stewardship, and habitat models for terrestrial species, to map metrics reflecting ecosystem services or biodiversity aspects valued by humans over large areas.





The Maine Unit is:

- Examining factors that may affect native bee pollinators of blueberries with a focus on understanding the relations between native pollinators of wild blueberries and the landscape composition and arrangement around wild blueberry fields.
- Working with a team of ecologists and economists to explore the biophysical and socioeconomic components of conserving vernal pools and other small natural features of great importance.
- Collecting data needed to inform immediate management needs and increase our understanding of the Gulf of Maine coastal marine ecosystem.



The Virginia Unit is developing a spatially explicit framework for mapping the capacity of ecosystems to provide freshwater recreational fishing.



The Georgia Unit is:

- Leading research on Jekyll Island, a Georgia barrier island that supports developed tourism amenities, a residential community, and a State park that is committed to conserving and managing most of the island's area as natural habitat.
- Collaborating with the Working Lands for Wildlife program of the Natural Resources Conservation Service to provide incentives for private landowners to manage their lands in ways that enhance habitat suitability for wildlife species of conservation concern, including the gopher tortoise.





## Ecosystem Services—Continued

The Arizona Unit is:

- Developing habitat suitability criteria for Apache trout that will give managers the information to make informed decisions about recovery stream selection and barrier placement.
- Studying virile crayfish and Apache trout populations.
- Researching whether ecosystem services programs can encourage ranchers to conserve threatened and endangered species on private land.

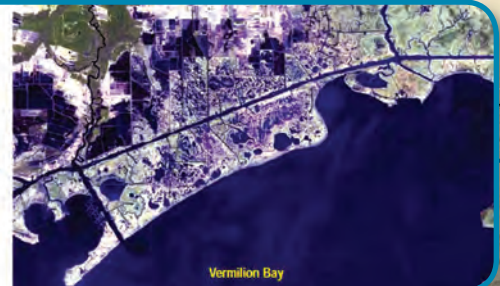


The Nebraska Unit is:

- Researching critical ecosystem services that bats provide in the form of insect consumption, pollination, and seed dispersal.
- Developing a management approach to recreational fisheries that applies resilience science to maintain the integrity of both social and ecological system components.



The Louisiana Unit is leading ecosystem services research on oyster reefs in Vermilion Bay, Louisiana, and is investigating the effects of oyster harvest on Louisiana reef habitat and resident aquatic communities.



0 500 1,000 MILES  
0 500 1,000 KILOMETERS

0 100 200 MILES  
0 100 200 KILOMETERS



Hilo

Vermilion Bay



The South Dakota Unit is evaluating flora and fauna of South Dakota and the potential benefits of the James River Conservation Reserve Enhancement Program.



The Vermont Unit is leading research on the effects of forest biomass energy production on Northern Forest wildlife and forest sustainability.



The Arkansas Unit is:

- Supporting the Federal Pollinator Health Task Force initiatives of monitoring and documenting pollinator diversity and abundance at local and regional scales.
- Surveying pollinator communities to document species richness and diversity in native and managed emergent wetlands in eastern Arkansas and to assess whether those pollinators travel to adjacent croplands to pollinate.



The Oklahoma Unit is:

- Characterizing hydrology and fish-production relations for different ecological groups of fishes living in river and reservoir habitats.
- Demonstrating the relation between water temperature and fish fitness through interactions of surface water and groundwater.



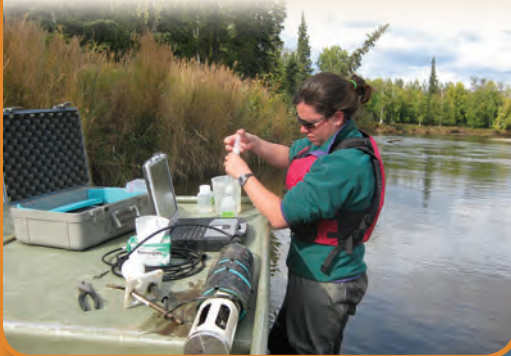


## Ecological Flows

The assessment and prescription of ecological flows require water resource managers and researchers to access and analyze different types of data and select appropriate tools and approaches from a wide variety of established methodologies.

The Alaska Unit is:

- Developing metrics that describe historic, current, and future flow and temperature regimes within the Chena River Basin with regard to chinook salmon.
- Leading research on freshwater ecosystems of Bristol Bay in western Alaska.
- Developing the Integrated Ecosystem Model (IEM) that coordinates the driving components for, and the interactions among, disturbance regimes, permafrost dynamics, hydrology, and vegetation in Alaska and Northwest Canada.
- Collaborating with partners to link information on landscape change with changes in river flow and fish habitat on the Kenai River.



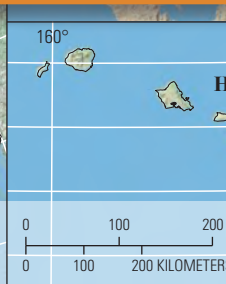
The Wyoming Unit is examining the relation between seasonal out-migration patterns of burbot and the associated flow and temperature regimes.

The Utah Unit is:

- Leading research on flow regimes and ecosystem function of the Rio Grande, a river characterized as having a substantially altered flow regime since the late 1800s.
- Providing a roadmap for making scientific recommendations in future efforts to recover dynamic processes in imperiled riverine ecosystems.



The Texas Unit is evaluating the influence of flow regime on the growth and recruitment of Guadalupe bass across its entire range and monitoring the effect of changing flow regime on the growth and mortality of young-of-year through their first summer.





The Minnesota Unit is leading research on improving the survival of juvenile winged mapleleaf mussels through identification of host fish overwintering areas.

The Wisconsin Fishery Unit is conducting a genetic assessment of seven fish species above and below the Wisconsin River dam at Prairie du Sac.

The Tennessee Fishery Unit is gathering data that resource agencies can use to predict possible effects of any proposed flow reduction and prescribe water allocations for endangered mussels.

The Missouri Unit is:

- Leading research on water supply and energy development projects across the State.
- Addressing ecological flow issues that continue to arise due to climate change, increasing human population, and the associated increased demand for water that makes streamflow management a complex and long-term issue.
- Linking Missouri Department of Conservation fish collections with temperature and dissolved oxygen data to determine the tolerances of fishes to these variables.
- Using radio telemetry to track the daily movement and habitat selection of spotted bass and shorthead redhorse during variable streamflows to provide a better understanding of how streamflow alteration affects these fish.





## Ecological Flows—Continued



The Arizona Unit is:

- Exploring native fish species across multiple rivers to better understand how various habitat suitability criteria relate to distribution.
- Leading research on flow, temperature, and other habitat requirements that are critically important for protecting desert fish communities.



The Oklahoma Unit is:

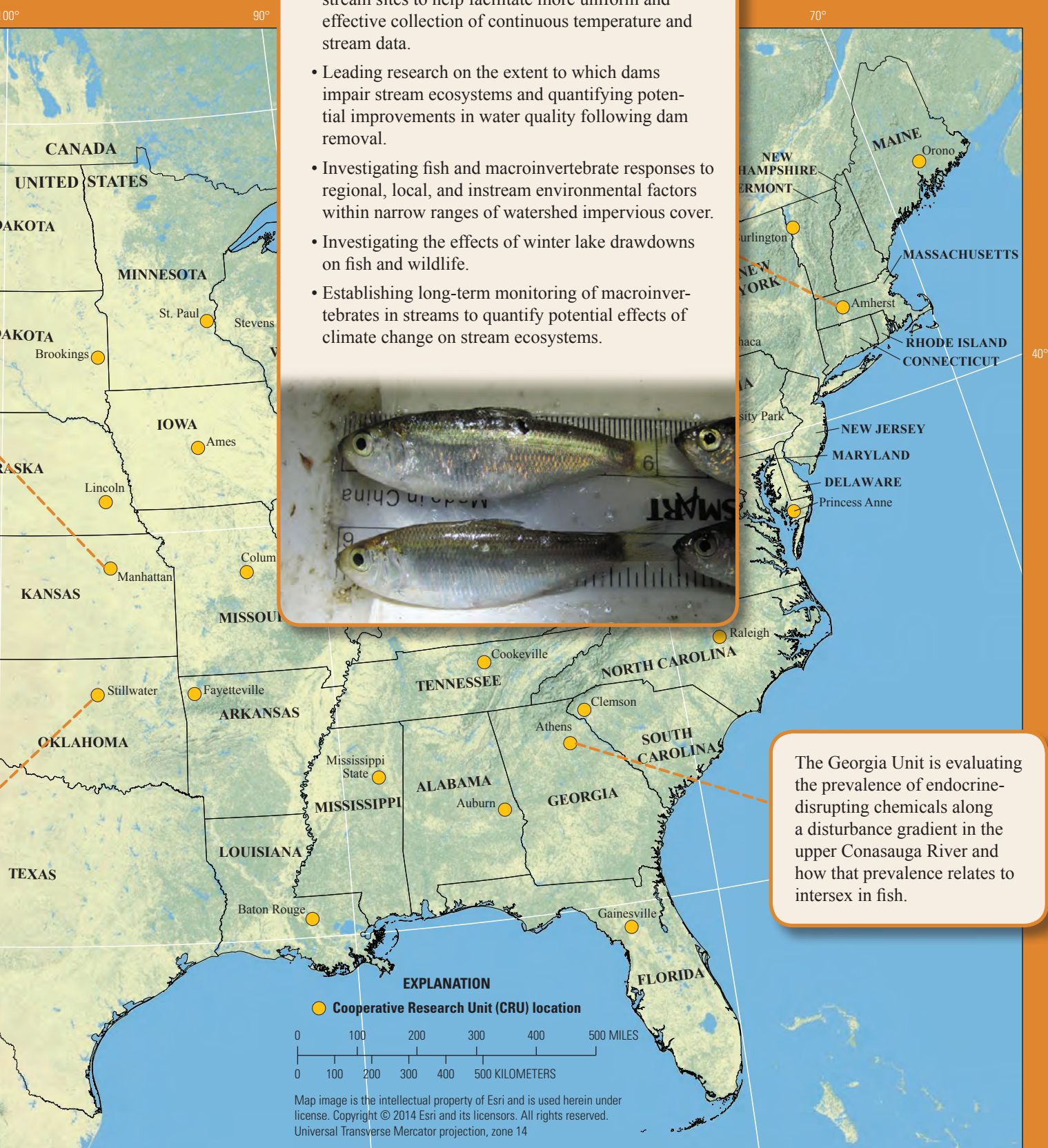
- Developing flow-ecology hypotheses that include alterations to the fitness of stream fish populations.
- Using conceptual advancements to promote trait-based research in stream ecology.





The Massachusetts Unit is:

- Developing a guidance document for sampling stream sites to help facilitate more uniform and effective collection of continuous temperature and stream data.
- Leading research on the extent to which dams impair stream ecosystems and quantifying potential improvements in water quality following dam removal.
- Investigating fish and macroinvertebrate responses to regional, local, and instream environmental factors within narrow ranges of watershed impervious cover.
- Investigating the effects of winter lake drawdowns on fish and wildlife.
- Establishing long-term monitoring of macroinvertebrates in streams to quantify potential effects of climate change on stream ecosystems.





## Wildlife Health and Disease

Wildlife diseases pose potential threats to the viability of wildlife populations and have potential implications to human health and our economy. Coop Unit scientists 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.

The Washington Unit is focusing on recent emergence and displacement events observed with the infectious hematopoietic necrosis virus in salmonid fish in the Pacific Northwest.



The South Dakota Unit is investigating the role of super-shedders in respiratory disease persistence and transmission in bighorn sheep.

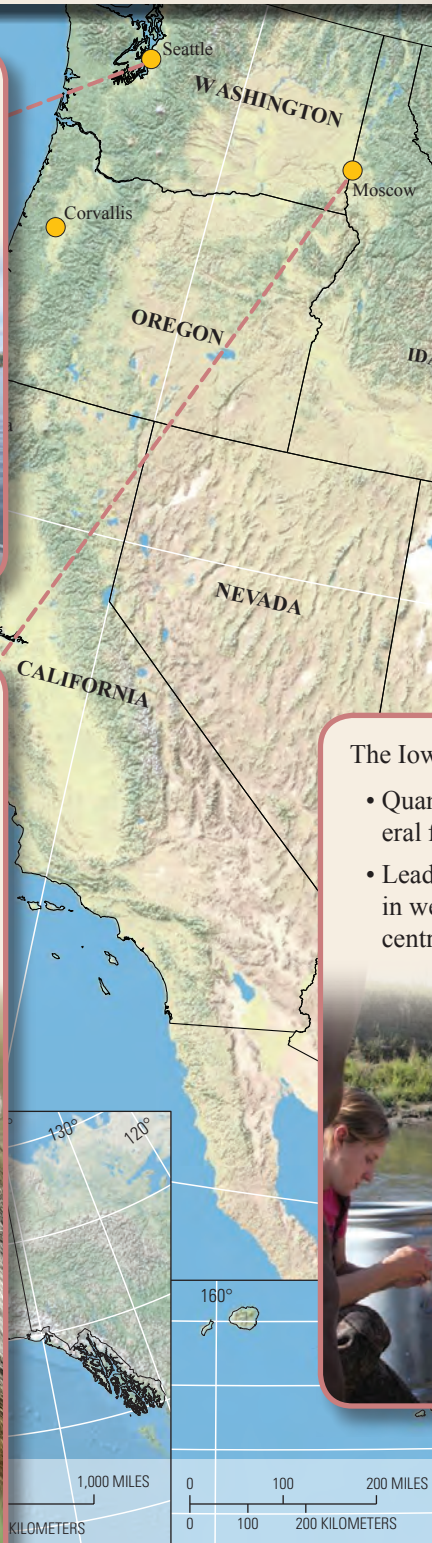


The Idaho Unit is evaluating the effectiveness of habitat-restoration treatments in an attempt to increase populations of the northern Idaho ground squirrel.



The Iowa Unit is:

- Quantifying mercury concentrations in several fish species.
- Leading research in amphibian populations in wetlands of the Des Moines Lobe in central Iowa.





The Wisconsin Fishery Unit is leading research in investigating the possible relation between variations in major histocompatibility complex (MHC) and the prevalence of gill lice in brook trout.



The Massachusetts Unit is using data obtained from a regional snake species assessment to construct an adaptive management framework for developing long-term conservation strategies for as many as 40 of the snake species potentially affected by disease.



The Virginia Unit is revisiting sites that were intensively monitored acoustically for bat activity before the onset of white-nose syndrome across a wide geographic area in the Eastern United States.



The North Carolina Unit is documenting the presence of anthropogenic chemicals, endocrine-disrupting chemicals, and intersex at selected sites and determining whether southern flounder in two brackish water nursery areas have skewed sex ratios based on temperature.

The Georgia Unit is evaluating the prevalence of endocrine-disrupting chemicals in the upper Conasauga River.



## Wildlife Health and Disease—Continued

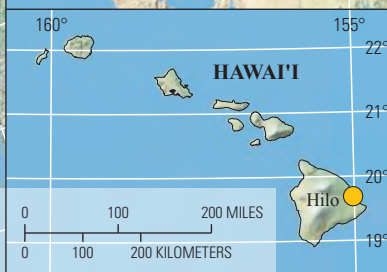
The Montana Wildlife Unit is using radio telemetry to estimate the survival of amphibians.



The Minnesota Unit is:

- Assessing the environmentally relevant exposure risk of grassland wildlife to common soybean aphid insecticides in the farmland region.
- Assessing relations between lead concentrations in eagles and their reproduction throughout National Park Service holdings in the western Great Lakes region.

The Missouri Unit is assessing the biological effects of endocrine-disrupting chemicals on populations of fish and wildlife.

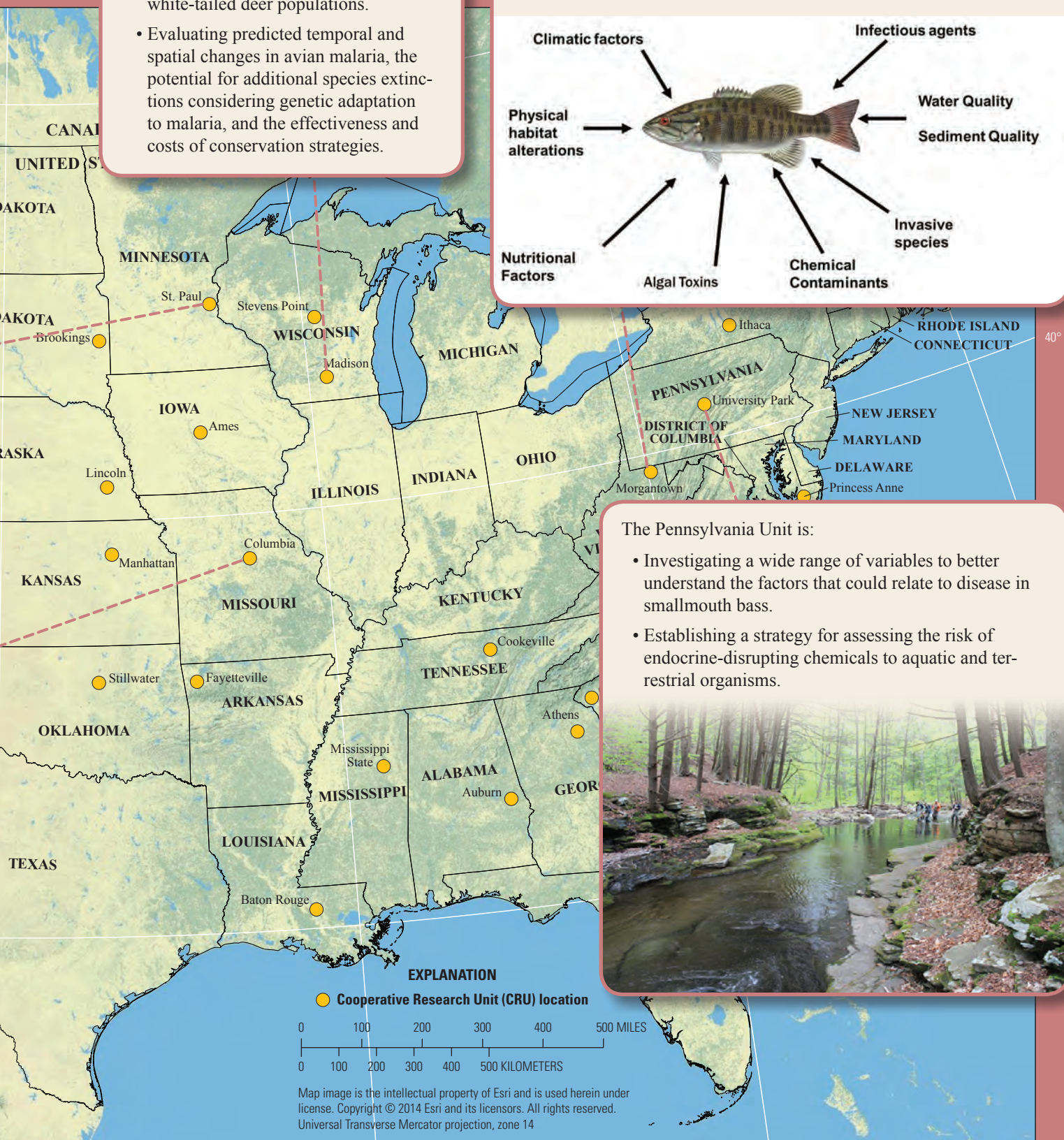
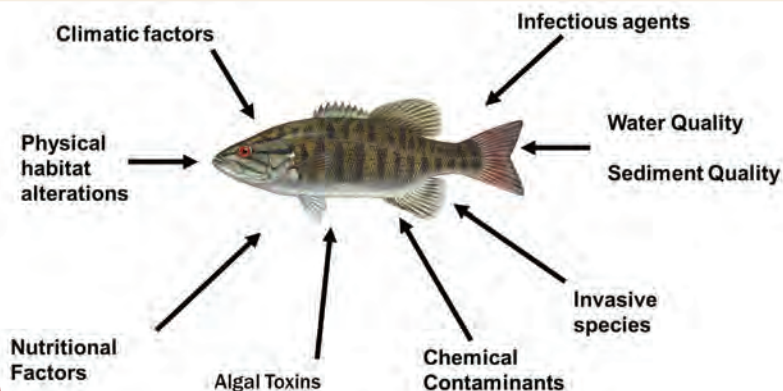




The Wisconsin Wildlife Unit is:

- Investigating the demographic parameters of chronic wasting disease in white-tailed deer populations.
- Evaluating predicted temporal and spatial changes in avian malaria, the potential for additional species extinctions considering genetic adaptation to malaria, and the effectiveness and costs of conservation strategies.

The West Virginia Unit, in collaboration with the USGS Leetown Science Center, is identifying gene sequences and developing techniques to better understand the underlying mechanisms and (or) pathogens associated with certain identified fish-health issues.



The Pennsylvania Unit is:

- Investigating a wide range of variables to better understand the factors that could relate to disease in smallmouth bass.
- Establishing a strategy for assessing the risk of endocrine-disrupting chemicals to aquatic and terrestrial organisms.





## Landscape Ecology

Landscape ecology is 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.

The Montana Fishery Unit is evaluating sediment and nutrient contributions from unpaved forest roads to headwater streams.



The Colorado Unit is constructing fish population models for the Little Colorado River from integrated data sources.

The Alaska Unit is:

- Evaluating the effect of fire history, plant community composition, and landscape characteristics on moose overwinter forage resources and use.
- Examining the genetic and environmental landscape among introduced populations of northern pike in south-central Alaska.



The New Mexico Unit is monitoring the responses of mule deer, elk, black bear, and mountain lion to forest restoration treatments associated with the U.S. Forest Service Southwest Jemez Mountains Collaborative Forest Landscape Restoration Project.

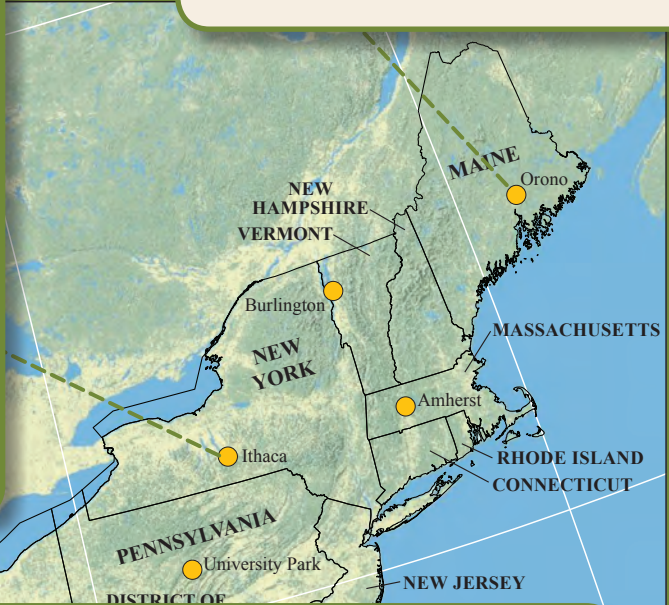




The New York Unit, in partnership with the Saint Regis Mohawk Tribe, is integrating a land stewardship strategy for existing and newly settled Native American lands in the Northern Forest. This research combines Native American ecological knowledge and scientific understanding to achieve sustainable forest management.

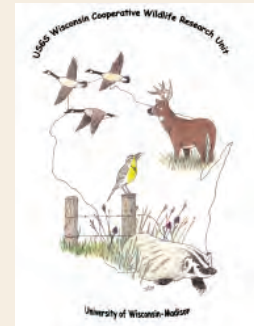


The Maine Unit is leading research on bees found in powerline rights-of-way and examining the use of powerline easements for nesting and foraging by native bees.

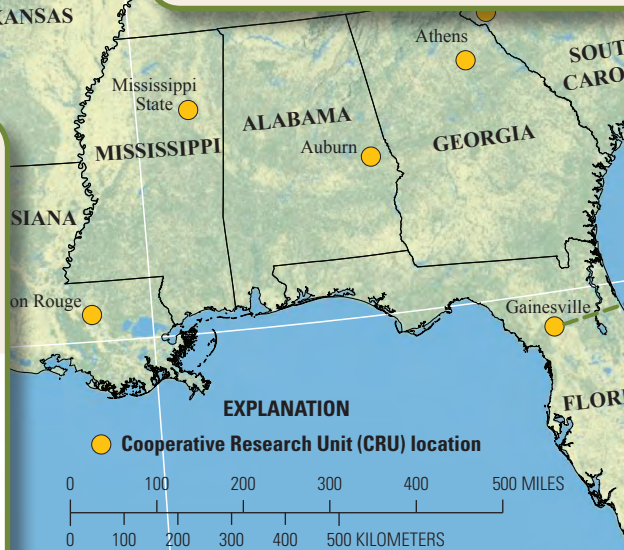


The Wisconsin Wildlife Unit is:

- Designing and implementing an evaluation program for the Wisconsin Bird Conservation Initiative (WBCI) strategic grasslands-implementation plan.
- Working with the U.S. Forest Service Northern Research Station to evaluate two projects: amphibian use of ephemeral ponds and wetlands within forested systems and beaver colony activity along trout streams.



The Arkansas Unit is examining flow alteration in seven natural flow regimes of the U.S. Interior Highlands.



Map image is the intellectual property of Esri and is used herein under license. Copyright © 2014 Esri and its licensors. All rights reserved. Universal Transverse Mercator projection, zone 14

The Florida Unit is investigating changes in mammal communities across the Greater Everglades ecosystem.





## Landscape Ecology—Continued

130°

120°

110°

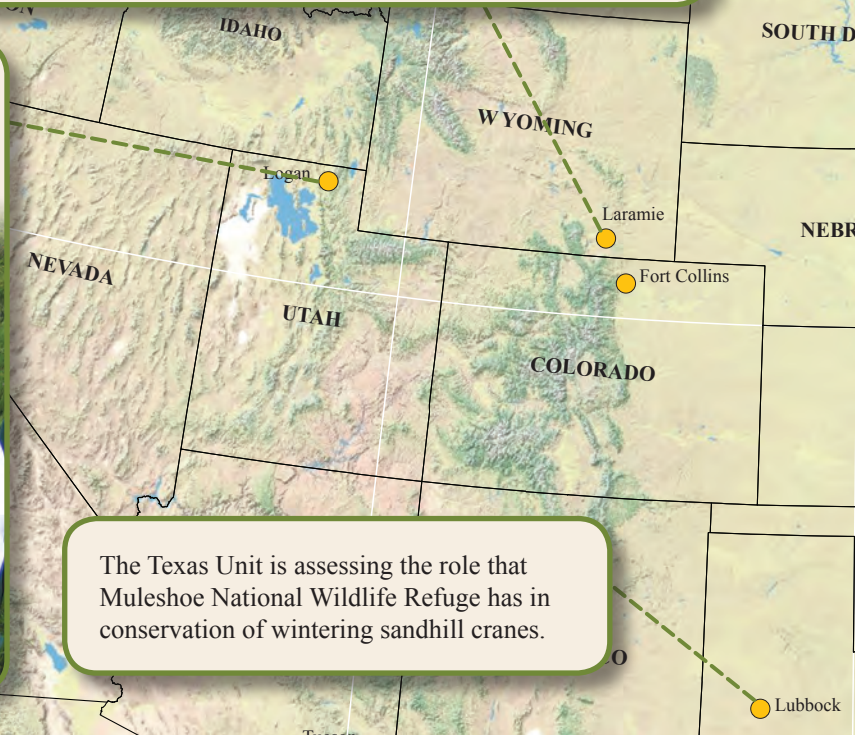


The Wyoming Unit is:

- Using models to describe species distributions to identify conservation priority areas for fresh-water fish, amphibians, mussels, and aquatic reptiles in the Great Plains, Wyoming.
- Developing a method to determine the migratory movement paths and seasonal range use of Wyoming ungulates by using the strontium isotope values recorded in the teeth of these animals.



The Utah Unit is combining hydrological and geomorphological analyses of channel change with data on current fish distributions and habitat needs to help guide restoration efforts on the lower San Rafael River.



The Texas Unit is assessing the role that Muleshoe National Wildlife Refuge has in conservation of wintering sandhill cranes.



The Louisiana Unit is quantifying changes in selected bottomland hardwood forests and determining the effects of hydrologic processes on seed germination and seedling establishment of selected tree species.





The Pennsylvania Unit is exploring nutrient patterns in all continental U.S. lakes to inform estimates of lake contributions to continental and global cycles of nitrogen, phosphorus, and carbon.



The Massachusetts Unit is:

- Investigating fish and macroinvertebrate responses to regional, local, and instream environmental factors.
- Exploring how land-use patterns have influenced population status and habitat use of Andean bears. In addition, researchers are investigating land-use change to provide input into the National Forest and Wildlife Service Andean Bear Conservation Plan in Peru.



The Mississippi Unit is:

- Evaluating water quality and fish assemblages in the Lower Mississippi Alluvial Valley to support restoration efforts.
- Seeding selected plant species that have demonstrated synergistic effects on plant survival and growth or that provide benefits to fish.

The West Virginia Unit is studying the environmental effects of road construction on streams within eastern West Virginia, with a focus on stream health and stream sedimentation.



The Georgia Unit is integrating metapopulation ecology and landscape ecology for improved population viability analysis and conservation decision making.





## Human Dimensions of Fish and Wildlife Conservation

Human dimensions of fish and wildlife conservation is the application of social science to management issues. The integration of human dimensions and ecological science allows for greater insights into management solutions and ultimately more durable decisions.

The Arizona Unit is assessing incentives and how they can be used to help overcome landowner concerns about the critical habitat of endangered species.



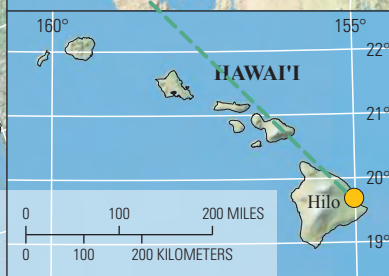
The South Dakota Unit is:

- Leading research on the social and economic effects of fishing in small lakes and impoundments in South Dakota.
- Measuring attitudes and behaviors of landowners toward participating in various conservation programs to help understand land-use decisions by private landowners.



The Hawai'i Fishery Unit is:

- Assisting with the assessment of fishery resources that are economically and culturally important to the people of Hawai'i.
- Strengthening natural resource management partnerships between Federal agencies and community groups.



The Nebraska Unit is:

- Evaluating angler behavior in response to management actions on Nebraska reservoirs.
- Determining what differentiates participating outdoor enthusiasts by compiling available fishing and hunting license datasets and merging them with larger socio-demographic data.





The Minnesota Unit is:

- Assessing the preferences of stakeholders and waterfowl management professionals for waterfowl population management alternatives.
- Using mixed mode survey methods to enhance the understanding of deer hunter attitudes and perceptions of deer populations, hunter motivations and satisfaction, agency trust, and governance statewide.
- Determining the attitudes of landowners and their preferences for future elk management.
- Conducting a visitor use survey of wildlife management areas (WMAs) to determine how the WMAs are used, which species are hunted, the distribution of uses, and economic considerations.
- Evaluating the spring turkey hunting season in Minnesota and examining alternatives that might provide opportunities for improving hunter satisfaction while sustaining the turkey population.



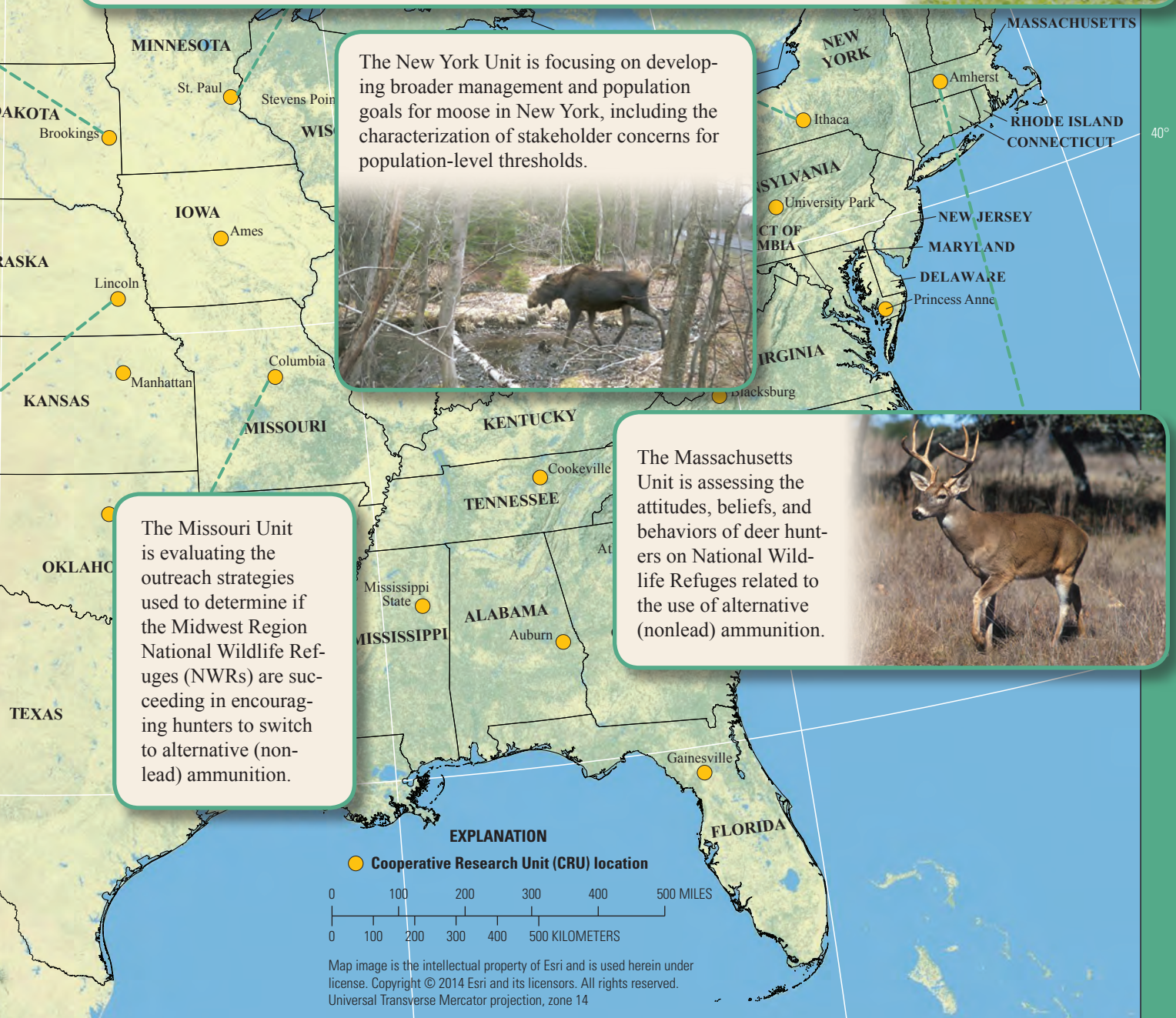
The New York Unit is focusing on developing broader management and population goals for moose in New York, including the characterization of stakeholder concerns for population-level thresholds.



The Massachusetts Unit is assessing the attitudes, beliefs, and behaviors of deer hunters on National Wildlife Refuges related to the use of alternative (nonlead) ammunition.



The Missouri Unit is evaluating the outreach strategies used to determine if the Midwest Region National Wildlife Refuges (NWRs) are succeeding in encouraging hunters to switch to alternative (non-lead) ammunition.





## Climate Science

Uncertainty about the effects of projected climate trends on fish and wildlife populations and habitats is a major concern of natural resource managers. Coop Unit scientists work with cooperators to better understand potential implications and reduce uncertainty so that managers can better evaluate future scenarios and management options.

The Oregon Unit is conducting an investigation into the population dynamics of the Adélie penguin on Ross Island, Antarctica.



The Alaska Unit is evaluating the effects of climate-mediated forest change on the habitats of ungulates important to subsistence and sport hunting.



The Wyoming Unit is exploring how climate change affects behavior, distribution, and abundance of ungulates and their migration patterns.



The New Mexico Unit is looking at whether changes in temperature and precipitation are linked to population declines of American pronghorn in the Southwest.



40°

110°

NORTH D

SOUTH D

WYOMING

NEBR

COLORADO

NEW MEXICO

Lubbock

Tucson

Las Cruces

ALASKA

Fairbanks

0 500 1,000 MILES  
0 500 1,000 KILOMETERS0 100 200  
0 100 200

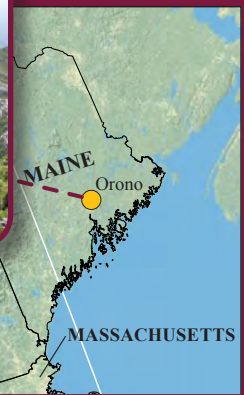
100°



The Wisconsin Fishery Unit is identifying mechanisms behind recruitment failures to help inform the rehabilitation of walleye populations.



The Maine Unit is leading research on amphibian and reptile habitat loss throughout North America.

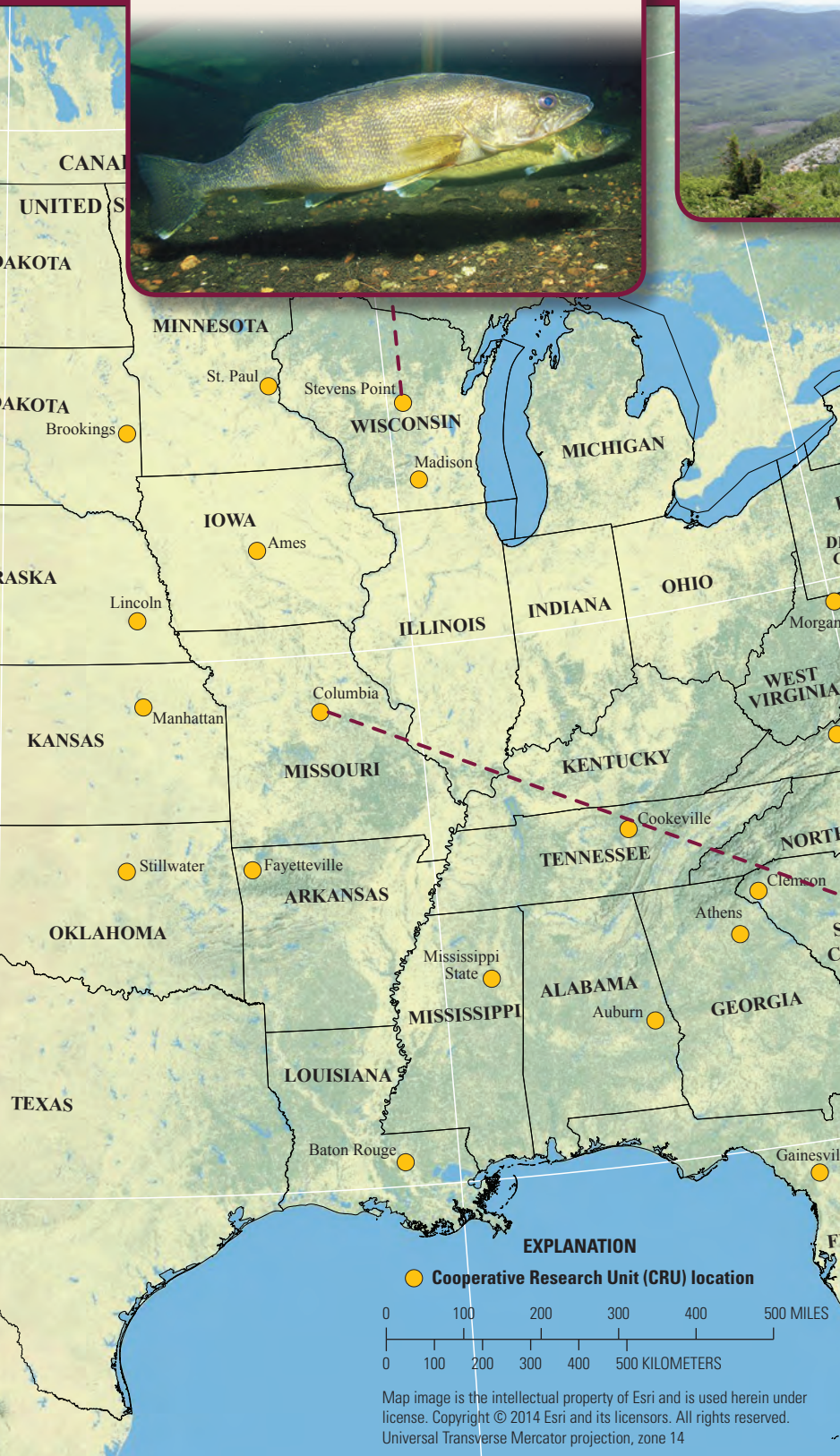
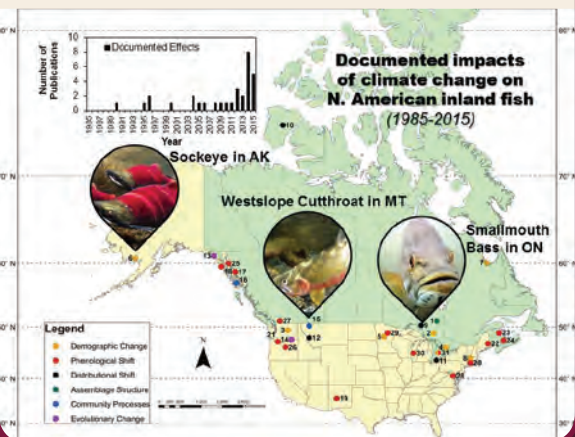


The Pennsylvania Unit is focusing on an economically and socially important species—brook trout—to determine how the interactive effects of genetics and behavior influence differential survival of fish populations under a changing climate.



The Missouri Unit is:

- Investigating the life history and thermal ecology of freshwater crayfish to inform future climate models.
- Researching how climate change might affect inland fish globally.





## Climate Science—Continued

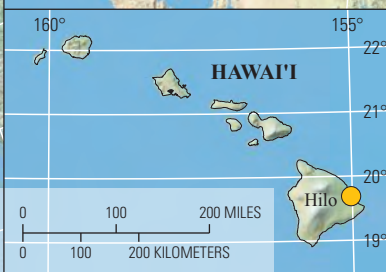
The California Unit is investigating the semipalmated sandpiper to predict how future climate changes may affect their habitats and population.



The Idaho Unit is using National Gap Analysis Program (GAP) data to explain elevational patterns in bird species richness in the United States.



The Montana Fishery Unit is analyzing georeferenced data to assess how changes in climate and other factors have influenced the distributions of native and nonnative fishes through time.



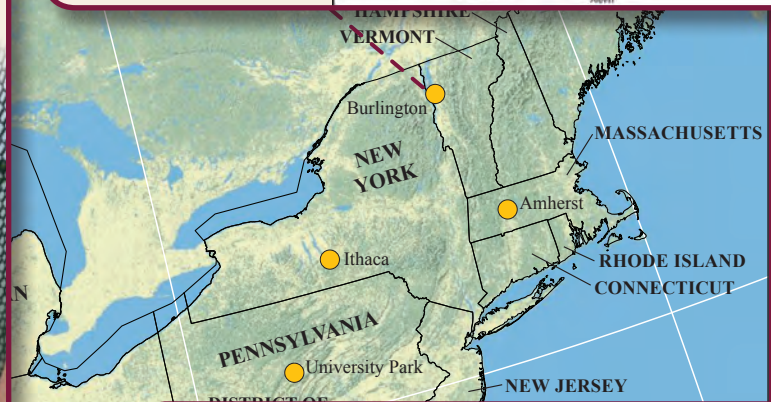
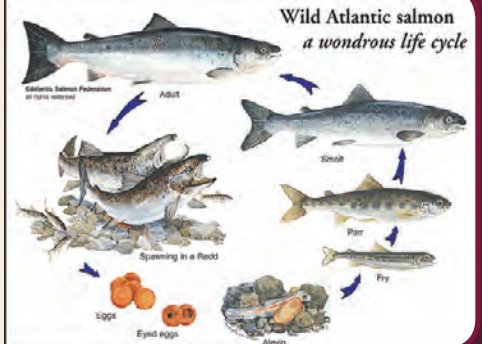


The Kansas Unit is:

- Developing a human-landscape model that incorporates atmospheric, terrestrial, aquatic, and social processes to predict the potential effect of climate variability, climate change, land use, and human activity on water resources.
- Studying the sand shinnery oak and mixed-grass prairie regions of the Great Plains to inform management efforts for lesser prairie-chicken.

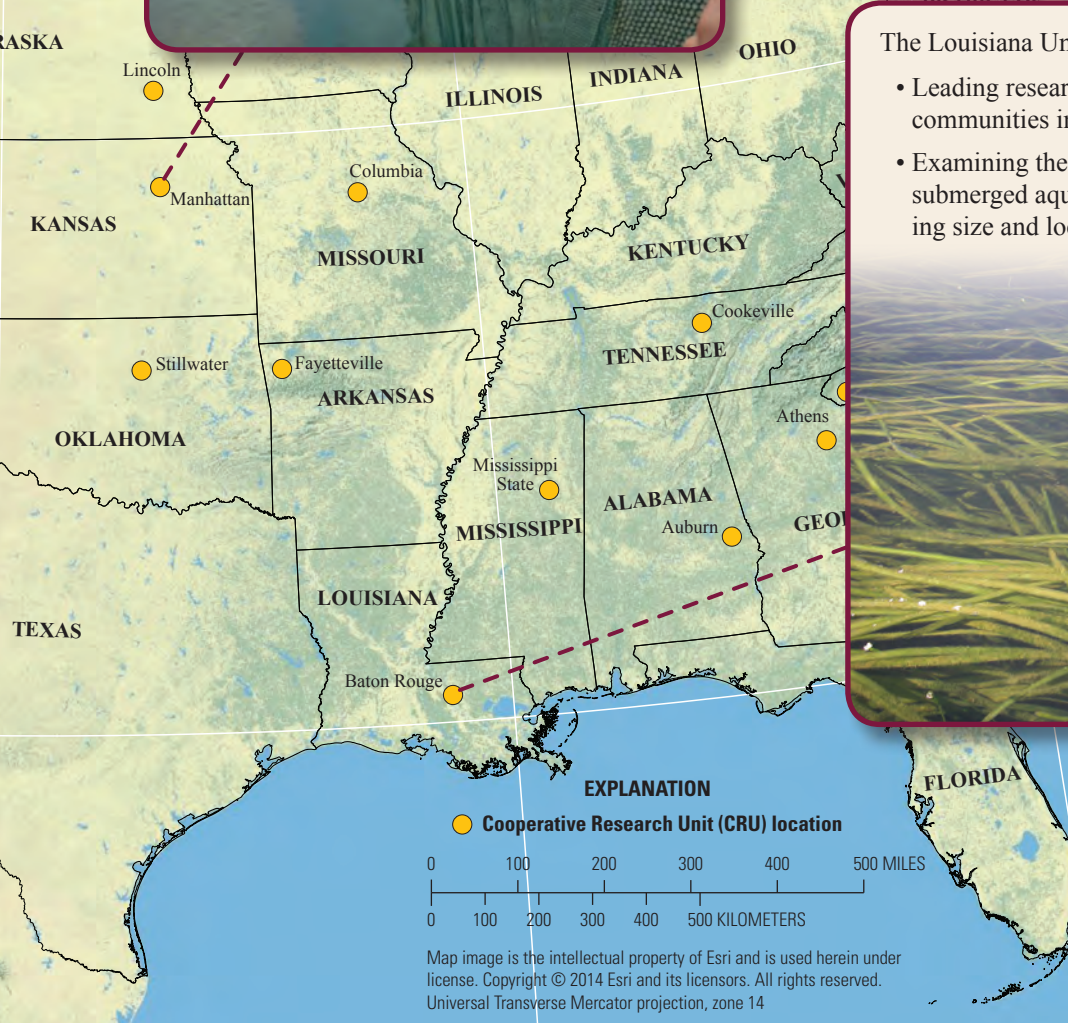


The Vermont Unit is investigating how dams relate to the survival of Atlantic salmon smolts.



The Louisiana Unit is:

- Leading research on submerged aquatic vegetation communities in the northern Gulf of Mexico.
- Examining the fishery community use and value of submerged aquatic vegetation (SAV) habitats of varying size and location across the landscape.





## Advanced Technologies

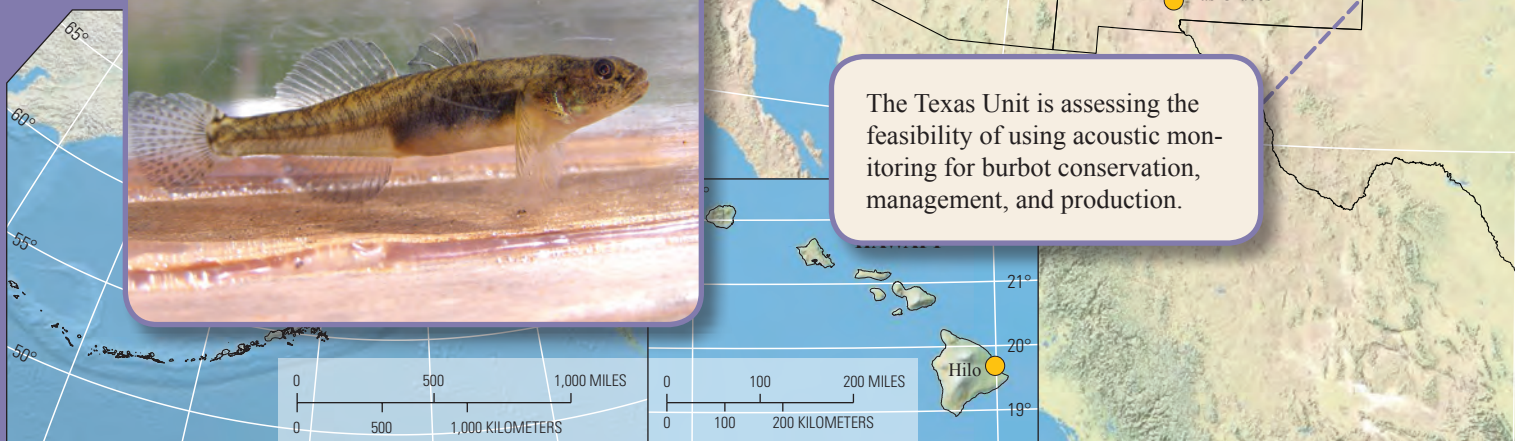
Advanced technologies include the development and adaptation of new technologies and tools that increase the effectiveness, efficiency, safety, accuracy, geographic extent, or timeliness of gathering, disseminating, analyzing, and interpreting natural resource information. It also includes development of new tools that can assist natural resource managers.

The Oregon Unit is using state-of-the-art aerial photography and visual count methods to monitor Leach's storm-petrel, a burrow nesting seabird.

The Montana Wildlife Unit is testing cutting edge camera-based methods to gather data on abundance and occupancy of ungulates.

The California Unit is using environmental DNA (eDNA) in water samples to monitor the endangered tidewater goby. eDNA is a cost effective technique that has been successfully used to monitor a broad range of taxonomic groups, including fishes.

The Texas Unit is assessing the feasibility of using acoustic monitoring for burbot conservation, management, and production.





The New York Unit is:

- Developing case studies using bird monitoring data provided by the National Park Service, after which the team plans to release new tools for the R package for statistical modeling and analysis.
- Creating the iSeeMammals app, which allows users to collect and submit information about bear sightings in New York.



The Oklahoma Unit is using eDNA to verify the presence of cavefish and crayfish populations in caves of the Ozark Highlands.



The South Carolina Unit is evaluating a new tool to monitor the effectiveness of Farm Bill incentive programs related to avian species of conservation concern.





## Advanced Technologies—Continued

The Washington Unit is leading work on the Elwha River dam removal project, including comparing the results generated from visual biodiversity surveys of the seafloor with those generated from eDNA extracted from water samples.



The Wyoming Unit is evaluating the use of remote cameras to monitor population dynamics and migration patterns of elk in northwest Wyoming.



The Alaska Unit is developing an Integrated Ecosystem Modeling (IEM) project designed to meet the needs of land managers in understanding the nature and rate of landscape change, which can provide a framework for specific scenarios of changes in landscape structure and function.



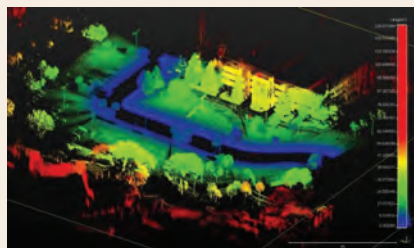


The Wisconsin Fishery Unit is using a portable ultrasound to determine the sex and maturation status of lake sturgeon by combining passive integrated transponder (PIT) technology data with the ultrasound data in the Menominee River.



The Florida Unit is:

- Providing the South Florida Water Management District (SFWMD) with high-resolution vegetation imagery and metadata collection capabilities by building and delivering a pair of external sensor pods (ESPs) for use in aerial surveys.
- Tasked with integrating a light detection and ranging (lidar) sensor to a rotary-wing small unmanned aircraft system (sUAS). Using lidar technology, the generation of high-accuracy terrain mapping and other valuable three-dimensional (3D) products are possible. The systematic integration of lidar into the available sensor options for sUAS is a landmark step in the utility of sUAS as a tool for scientific data collection.



The Pennsylvania Unit is developing statistical support for the USGS Amphibian Research and Monitoring Initiative.



#### EXPLANATION

● Cooperative Research Unit (CRU) location



Map image is the intellectual property of Esri and is used herein under license. Copyright © 2014 Esri and its licensors. All rights reserved. Universal Transverse Mercator projection, zone 14



## Where Are They Now?

One of the greatest legacies of the Coop Unit program is the placement of our students in natural resource agencies and organizations. Key to the concept of an organizational brand is the notion that a hiring official will recognize added value in an applicant who received their graduate education at a Coop Unit. The sheer volume of Coop Unit graduates that are hired

at natural resource agencies and the proportion of those graduates who fill leadership positions is a tribute to the value of a Coop Unit education.

A pillar of the Coop Unit mission is to develop the workforce of the future through graduate education. This table shows where some of our recent graduates have settled into professional positions with State, Federal, university, and nongovernmental positions.



Unit	University	Nongovernmental/ private/other	State government	Federal Government
Alabama	4	2	4	0
Alaska	1	3	2	6
Arkansas	9	6	8	8
Arizona	6	5	2	7
California	3	8	3	0
Colorado	7	6	2	4
Florida	1	4	4	1
Georgia	1	0	0	0
Idaho	6	0	12	5
Iowa	4	5	4	1
Kansas	10	7	5	6
Louisiana	4	6	3	0
Maine	7	4	5	2
Massachusetts	4	9	10	3
Minnesota	5	5	2	3
Mississippi	3	5	14	3
Missouri	3	3	8	1
Montana Fishery Unit	2	2	4	3
Montana Wildlife Unit	3	4	5	0
Nebraska	7	16	10	0
New Mexico	2	1	7	3
New York	4	0	2	0
North Carolina	8	4	5	6
Oklahoma	4	2	6	6
Oregon	2	1	2	2
Pennsylvania	4	6	5	1
South Carolina	2	3	2	3
South Dakota	3	4	3	3
Tennessee Fishery Unit	3	1	8	2
Texas	3	13	3	2
Utah	2	4	5	3
Vermont	2	3	1	1
Virginia	5	3	1	0
Washington	2	2	3	2
West Virginia	4	1	1	8
Wisconsin Fishery Unit	0	0	4	6
Wisconsin Wildlife Unit	5	3	2	3
Wyoming	8	1	6	4
<b>Total*</b>	<b>153</b>	<b>155</b>	<b>173</b>	<b>108</b>

\*Not all Units are listed.



## Accolades

Coop Unit scientists and their students received approximately 80 awards in 2017 from universities, agencies, and societies with recognition at the local, national, and international levels. Highlights include the following:



- Best Paper of the Wildlife Technical Session, Southeastern Association of Fish and Wildlife Agencies (David Kremetz, Arkansas)
- Career Contribution Award, Georgia Chapter of the American Fisheries Society (Cecil Jennings, Georgia)
- Conservation Award, Minnesota Chapter of the Wildlife Society (Minnesota Cooperative Fish and Wildlife Research Unit)
- Athena Woman of the Year—Faculty (Christine Moffitt, Idaho)
- The Wildlife Society Fellows Award, The Wildlife Society (David Andersen, Minnesota)
- Outstanding Faculty Award, Fish and Wildlife Graduate Student Organization, School of Natural Resources, University of Missouri (Amanda Rosenberger, Tennessee)
- Recovery Champion, U.S. Fish and Wildlife Service (James “Barry” Grand, Unit Supervisor, South)
- Promotion to Full Professor, University of Idaho (Courtney Conway, Idaho)
- Harry R. Painton Award for Best Publication in The Condor (Katie Dugger, Oregon)
- Rising Star Honoree by Equal Opportunity Section and Student Subunit, American Fisheries Society (Shannon K. Brewer, Oklahoma)
- College of Agricultural Sciences and Natural Resources Outstanding Researcher Award, Texas Tech University (Reynaldo Patiño, Texas)
- Faculty Research Award, College of Agriculture Sciences and Natural Resources, Texas Tech University (Clint Boal, Texas)
- Honoree for “Ladies Night,” Equal Opportunity Section and the Student Subsection of the American Fisheries Society, American Fisheries Society (Phaedra Budy, Utah)
- The Wildlife Society Fellow (Angela Fuller, New York)
- Leadership Institute Class of 2017, The Wildlife Society (Beth Ross, South Carolina)
- Ralph W. Schreiber Conservation Award (Daniel Roby, Oregon)
- Unit award for excellence of service, Department of the Interior (Dave McGuire, Alaska)



Elisa Baebler, Missouri Cooperative Research Unit, wins the Fenske Award as outstanding fisheries student at a 13-State Midwest fish conference.



Dr. Mevin Hooten, Assistant Unit Leader, Colorado Cooperative Fish and Wildlife Research Unit, named fellow of the American Statistical Association.



## Professional Services

Coop Unit scientists held approximately 177 professional service positions (scientific society officers, technical committees, working groups, panels, and so forth) and served in 73 editorial positions in 2017.



## 2017 North American Wildlife and Natural Resources Conference

### Bridging Science and Management Workshop

The Coop Unit Program co-sponsored a workshop at the 2017 North American Wildlife and Natural Resources Conference with the Association of Fish and Wildlife Agencies, the American Fisheries Society, The Wildlife Society, and the Wildlife Management Institute titled “Bridging Science and Management: Maintaining Relevancy Through Organization Transformation and Professional Development.” The workshop built upon the 2016 workshop, “Barriers and Bridges in Reconnecting Natural Resources Science and Management.”

The 2017 workshop focused on the demands for expertise in team building, communication, organizational leadership, conflict resolution, scientific management approaches, and other issues. The focused “action learning” approach stressed the importance of relationship building, peer-to-peer experiences, and expanded networks. The participants identified key challenges in sustaining conservation relevance along with approaches to meet these challenges through professional development and training.



## Conservation in the Face of a Changing Energy Development Landscape Special Session

Dr. Tom Edwards of the Utah Cooperative Fish and Wildlife Research Unit presented a paper at this special session titled “Using Models to Inform Decision Making Processes Associated with Energy Development and Rare Plants Conservation in the Colorado Plateau of Western North America.” The special session was organized and chaired by Dr. Mona Khalil, [mkhalil@usgs.gov](mailto:mkhalil@usgs.gov), Energy and Wildlife Specialist with the U.S. Geological Survey Ecosystem Mission Area. Dr. Edwards’ presentation detailed how he modeled the distributions of 21 plant species currently listed under the Endangered Species Act, or under consideration as sensitive species by management agencies, with an objective of minimizing the spatial conflict between energy extraction and plant-specific distributions.



## National Cooperators' Coalition Update

The National Cooperators’ Coalition (NCC) comprises the non-Federal cooperators in the Cooperative Fish and Wildlife Research Unit program. The NCC is chaired by John Kennedy, Deputy Director of the Wyoming Game and Fish Department, and is led by a Steering Committee that includes Ken Williams (The Wildlife Society), Jonathan Mawdsley (Association of Fish and Wildlife Agencies [AFWA]), Chad Bishop (University of Montana and National Association of University Fish and Wildlife Programs [NAUFWP]), and Steve Williams (Wildlife Management Institute).

The NCC, under the leadership of Chairman Kennedy, focused its efforts in 2017 on gaining congressional support for full funding of the Coop Units. Chairman Kennedy engaged with key Congressional leaders during a spring visit to the Nation’s capital to raise awareness and build support for the Coop Units. University leaders, through communications from NAUFWP, have been encouraged to raise awareness among their State leaders of the need to fill vacant Coop Unit positions in their States. The Boone and Crockett Club, through efforts of Lowell Baier, James Cummins, and David Anderson, has been instrumental in building support for the Coop Units. The AFWA has worked diligently in encouraging the support of all State fish and wildlife agency directors to urge Congress to fully fund the Coop Units. This coordinated effort by NCC is essential in addressing the record number of vacant scientist positions that currently exists in the program.



# The Cooperative Fish and Wildlife Research Units Program Is Proud To Serve Its Cooperators

## 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 Department

## 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

## HAWAII FISHERY UNIT

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 UNIT

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

## MONTANA WILDLIFE UNIT

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  
Department

## TENNESSEE FISHERY UNIT

Tennessee Technological 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

University of Washington  
Washington State University  
Washington State 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 UNIT

University of Wisconsin Stevens Point  
Wisconsin Department of Natural Resources

## WISCONSIN WILDLIFE UNIT

University of Wisconsin Madison  
Wisconsin Department of Natural Resources

## WYOMING

University of Wyoming  
Wyoming Game and Fish Department





# List of Species

Common name	Scientific name	Common name	Scientific name
Adélie penguin	<i>Pygoscelis adeliae</i>	honey bee	<i>Apis mellifera</i>
American alligator	<i>Alligator mississippiensis</i>	hornyhead chub	<i>Nocomis biguttatus</i>
American eel	<i>Anguilla rostrata</i>	horseshoe crab	<i>Limulus polyphemus</i>
American paddlefish	<i>Polyodon spathula</i>	humpback whale	<i>Megaptera novaeangliae</i>
American pronghorn	<i>Antilocapra americana</i>	Kirtland's warbler	<i>Setophaga kirtlandii</i>
Andean bear	<i>Tremarctos ornatus</i>	lake sturgeon	<i>Acipenser fulvescens</i>
Apache trout	<i>Oncorhynchus apache</i>	lake trout	<i>Salvelinus namaycush</i>
Asian carp	<i>Hypophthalmichthys</i> spp.	largemouth bass	<i>Micropterus salmoides</i>
Asian swamp eel	<i>Monopterus albus</i>	Laysan albatross	<i>Phoebastria immutabilis</i>
Atlantic salmon	<i>Salmo salar</i>	Leach's storm-petrel	<i>Oceanodroma leucorhoa</i>
bald eagle	<i>Haliaeetus leucocephalus</i>	lesser prairie-chicken	<i>Tympanuchus pallidicinctus</i>
bighorn sheep	<i>Ovis canadensis</i>	loggerhead sea turtle	<i>Caretta caretta</i>
black abalone	<i>Haliotis cracherodii</i>	longleaf pine	<i>Pinus palustris</i>
black bear	<i>Ursus americanus</i>	marten	<i>Martes americana</i>
black-footed albatross	<i>Phoebastria nigripes</i>	Micronesian kingfisher	<i>Todiramphus cinnamominus</i>
black-tailed deer	<i>Odocoileus hemionus columbianus</i>	Micronesian starling	<i>Aplonis opaca</i>
bluegill	<i>Lepomis macrochirus</i>	moose	<i>Alces alces</i>
bluehead sucker	<i>Catostomus discobolus</i>	mountain lion	<i>Puma concolor</i>
bobcat	<i>Lynx rufus</i>	mule deer	<i>Odocoileus hemionus</i>
Bonneville cutthroat trout	<i>Oncorhynchus clarkii utah</i>	muskellunge	<i>Esox masquinongy</i>
broad-winged hawk	<i>Buteo platypterus brunescens</i>	New Zealand mud snail	<i>Potamopyrgus antipodarum</i>
brook trout	<i>Salvelinus fontinalis</i>	northern Idaho ground squirrel	<i>Urocitellus brunneus</i>
brown pelican	<i>Pelecanus occidentalis</i>	northern pike	<i>Esox lucius</i>
burbot	<i>Lota lota</i>	Pacific geoduck	<i>Panopea generosa</i>
Chinook salmon	<i>Oncorhynchus tshawytscha</i>	pallid sturgeon	<i>Scaphirhynchus albus</i>
Chiricahua leopard frog	<i>Lithobates chiricahuensis</i>	plains topminnow	<i>Fundulus sciadicus</i>
cisco	<i>Coregonus artedii</i>	purple cat's paw pearly mussel	<i>Epioblasma obliquata obliquata</i>
coldwater crayfish	<i>Orconectes eupunctus</i>	rainbow trout	<i>Oncorhynchus mykiss</i>
Cooper's hawk	<i>Accipiter cooperii</i>	red knot	<i>Calidris canutus</i>
cougar	<i>Puma concolor</i>	river otter	<i>Lontra canadensis</i>
cutthroat trout	<i>Oncorhynchus clarkii</i>	robust redhorse	<i>Moxostoma robustum</i>
Dall's sheep	<i>Ovis dalli</i>	roundtail chub	<i>Gila robusta</i>
diamond darter	<i>Crystallaria cincotta</i>	sandhill crane	<i>Grus canadensis</i>
eastern oyster	<i>Crassostrea virginica</i>	sharp-shinned hawk	<i>Accipiter striatus venator</i>
eastern wild turkey	<i>Meleagris gallopavo silvestris</i>	shovelnose sturgeon	<i>Scaphirhynchus platyrhynchus</i>
elk	<i>Cervus canadensis</i>	silver carp	<i>Hypophthalmichthys molitrix</i>
fisher	<i>Martes pennanti</i>	smallmouth bass	<i>Micropterus dolomieu</i>
flathead catfish	<i>Pylodictis olivaris</i>	snowshoe hare	<i>Lepus americanus</i>
golden eagle	<i>Aquila chrysaetos</i>	snowy plover	<i>Charadrius nivosus</i>
grizzly bear	<i>Ursus arctos</i>	snuffbox	<i>Epioblasma triquetra</i>
Guadalupe bass	<i>Micropterus treculii</i>	Sonoran desert tortoise	<i>Gopherus morafkai</i>
harbor seal	<i>Phoca vitulina</i>	southern flounder	<i>Paralichthys lethostigma</i>
headwater chub	<i>Gila nigra</i>	spectacled eider	<i>Somateria fischeri</i>
		spotted bass	<i>Micropterus punctulatus</i>



## List of Species—Continued

Common name	Scientific name
spruce-fir moss spider	<i>Microhexura montivaga</i>
steelhead	<i>Oncorhynchus mykiss</i>
Steller sea lion	<i>Eumetopias jubatus</i>
Steller's eider	<i>Polysticta stelleri</i>
Stone's sheep	<i>Ovis dalli stonei</i>
swift fox	<i>Vulpes velox</i>
tidewater goby	<i>Eucyclogobius newberryi</i>
Topeka shiner	<i>Notropis topeka</i>
walleye	<i>Sander vitreus</i>
white-tailed deer	<i>Odocoileus virginianus</i>
whooping crane	<i>Grus americana</i>
winged mapleleaf mussel	<i>Quadrula fragosa</i>
wolf	<i>Canis lupus</i>
wolverine	<i>Gulo gulo</i>
wood turtle	<i>Glyptemys insculpta</i>
yellow perch	<i>Perca flavescens</i>

### For more information, contact:

#### Cooperative Fish and Wildlife Research Units Program

U.S. Geological Survey  
12201 Sunrise Valley Drive  
Reston, VA 20192  
Phone 703-648-4260

<http://www.coopunits.org/>



Anne Kinsinger, Associate Director, Ecosystems

John Organ, Chief

John Thompson, Deputy Chief

Mike Tome, Unit Supervisor, North

Kevin Whalen, Unit Supervisor, West

Barry Grand, Unit Supervisor, South

Shana Coulby, Administrative Officer

Don Dennerline, Biologist

Dawn Childs, Information Specialist





## Photograph Credits

All photographs featured in this publication were taken by USGS/Coop Unit scientists and students with the following exceptions:

Pages 5 and 7: Infographic icons from Flaticon, [www.flaticon.com](http://www.flaticon.com). Licensed under Creative Commons 3.0.

Page 6: Mule deer by U.S. Fish and Wildlife Service.

Page 12: Rainbow trout by U.S. Fish and Wildlife Service.

Page 14: Hen pheasant by U.S. Fish and Wildlife Service.

Page 16: Northern harrier by U.S. Fish and Wildlife Service.

Page 18: Harbor seal by National Park Service.

Page 19: Snowshoe hare by U.S. Fish and Wildlife Service.

Page 20: Wolverine by U.S. Fish and Wildlife Service.

Page 20: Rio Grande cutthroat trout by U.S. Fish and Wildlife Service.

Page 21: Wood turtle by U.S. Fish and Wildlife Service.

Page 22: Lesser prairie-chicken by Mark Watson, used with permission.

Page 23: Wind energy by U.S. Fish and Wildlife Service.

Page 26: Mule deer. Original art by Ryan Van Vierssen, USGS student intern at South Lakes High School Secondary Transitions to Employment Program (STEP), used with permission.

Page 28: DIDSON imaging system by California Department of Fish and Wildlife.

Page 28: Mexican wolf by U.S. Fish and Wildlife Service.

Page 29: Diamond darter by S. Welsh, used with permission.

Page 31: Shovelnose sturgeon by U.S. Fish and Wildlife Service.

Page 31: Spruce-fir moss spider by U.S. Fish and Wildlife Service.

Page 33: Flathead catfish by Garold Sneegas, used with permission.

Page 33: Asian carp by Tennessee Tech University, used with permission.

Page 44: Great Plains toad by National Park Service.

Page 46: Moose with calves by U.S. Fish and Wildlife Service.

Page 48: Mississippi alluvial valley map by U.S. Fish and Wildlife Service.

Page 51: Wild turkey by U.S. Fish and Wildlife Service.

Page 51: White-tailed deer by Scott Bower, U.S. Department of Agriculture.

Page 51: Moose by New York Department of Environmental Conservation, used with permission.

Page 52: Alaska mountain range by National Park Service.

Page 53: Walleye by U.S. Fish and Wildlife Service.

Page 54: Semipalmated sandpiper by U.S. Fish and Wildlife Service.

Page 55: Salmon life cycle by U.S. Fish and Wildlife Service.

Page 57: Cave crayfish by Oklahoma Department of Wildlife Conservation.

Page 64: Wood thrush. Original art by Ryan Van Vierssen, USGS student intern at South Lakes High School Secondary Transitions to Employment Program (STEP), used with permission.















ISBN 978-1-4113-4198-2



ISSN 1067-084X (print)  
 ISSN 2330-5703 (online)  
<https://doi.org/10.3133/cir1438>