



Cooperative Fish and Wildlife Research Units Program—

2016 Year in Review



Circular 1424

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

Cooperative Fish and Wildlife Research Units Program—2016 Year in Review

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



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

U.S. Department of the Interior
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U.S. Geological Survey, Reston, Virginia: 2017

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Chief's Message

The Cooperative Fish and Wildlife Research Units (CRU) Program had a productive year in 2016. Despite vacancies in our scientist ranks exceeding 20 percent, our research, training, and teaching portfolio was full and we graduated 93 students and published 398 manuscripts primarily focused on addressing the real conservation challenges of our cooperators. As I've stated before, our mission is our legacy: meeting the actionable science needs of our cooperators, providing them technical guidance and assistance in interpreting and applying new advances in science, and developing the future workforce through graduate education and mentoring. Our scientists and the manner in which they approach our mission continue to inspire me. The most rewarding part of my job is meeting and engaging with the students they recruit—the conservation professionals of the future. I cannot help but feel uplifted after discussions with and presentations by these young men and women. Personally, I owe my place in the profession today to the mentoring I received as a CRU student, and today's CRU scientists have raised the bar. It gives me hope for the future of conservation, and added motivation to see our vacancies filled so that we can expand our portfolio.

The National Cooperators' Coalition has been active and is strategically working to build support on our behalf. Sincere thanks to the American Fisheries Society, the Association of Fish and Wildlife Agencies, the Boone and Crockett Club, the National Association of University Fish and Wildlife Programs, the Wildlife Management Institute, and The Wildlife Society for their efforts and those of their affiliated members.

We co-sponsored a workshop at the 2016 North American Wildlife and Natural Resources Conference along with the American Fisheries Society, the Association of Fish and Wildlife Agencies, the Wildlife Management Institute, and The Wildlife Society, titled "Barriers and Bridges in Reconnecting Natural Resources Science and Management." The workshop was well received and we have been asked to continue the dialogue with a second workshop in 2017. It was evident during the workshop that the CRU is viewed by our cooperators as an important and essential linkage between academia and practitioners. This is testament to the legacy of the CRU Program and the foundation it is built upon. In this Year in Review report, you will find details on staffing, vacancies, research funding, and other pertinent information. You will also see snapshots of CRU projects with information on how results have been or are being applied by cooperators. That is the essence of what we do: science that matters.



Background

From its inception in Iowa by Ding Darling and the original 9 CRUs, the CRU Program has grown to 40 Units in 38 States with a global presence assigned a mission to (1) deliver actionable science to cooperating agencies and organizations, (2) develop the workforce of the future through applied graduate education, and (3) fulfill the training and technical assistance needs of cooperators.

Images clockwise from upper right: Ding Darling, cartoons by Ding Darling, and 1935 Duck Stamp.



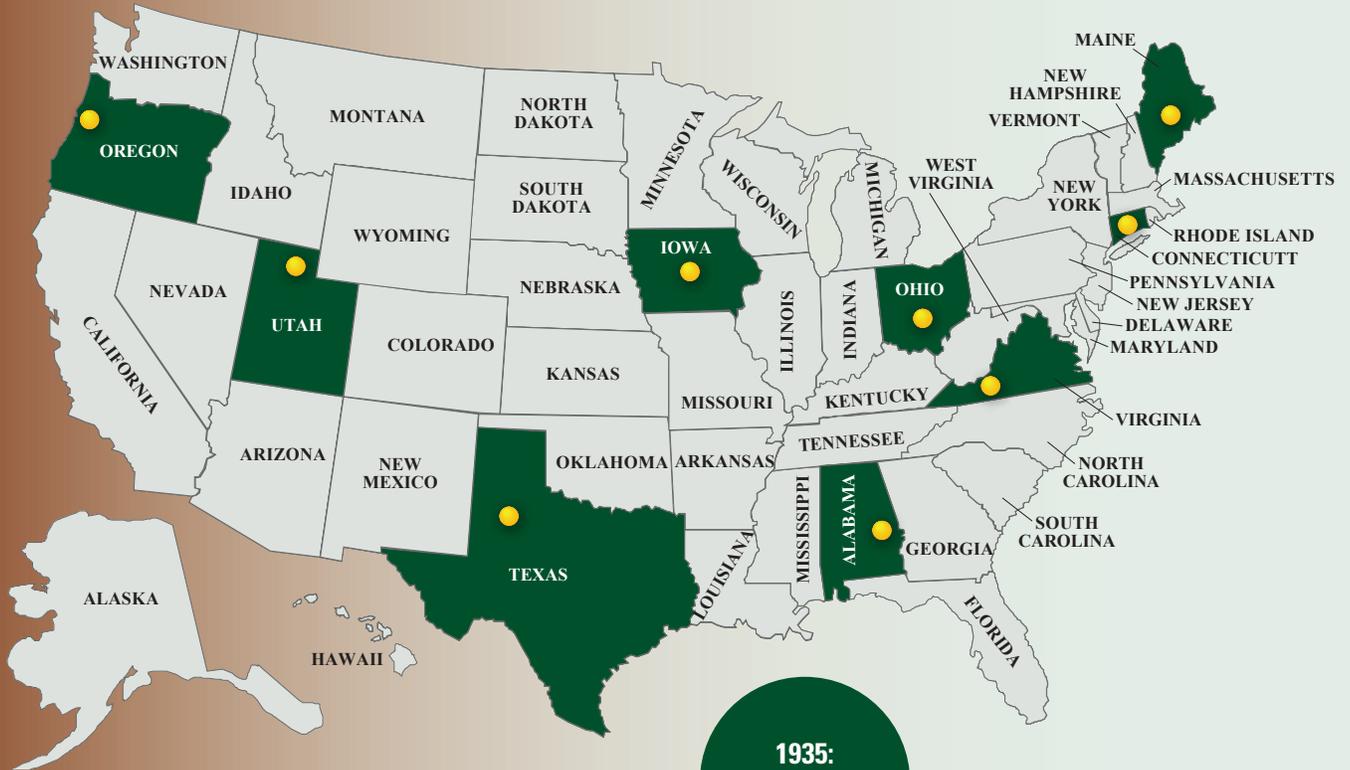
CRU all-hands meeting, Leetown, West Virginia, 1983-84.



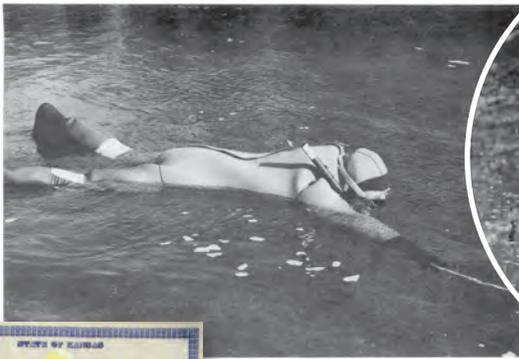
CRU all-hands meeting, Raleigh, North Carolina, 1990.



CRU all-hands meeting, 1993-94.



1935:
the First 9 Units.



behavior of young salmonids in the Chena River.



CRU Mission and Facts

Mission

- Graduate education to develop the workforce
- Actionable research to meet cooperator science needs
- Technical assistance to cooperators on application and integration of new science

CRU scientists:

- are embedded in the graduate faculty of universities
- receive graduate faculty appointments
- are assigned office and lab space, and
- receive administrative support from the universities

Partnerships

40 units in 38 States

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

CRU Facts

Each CRU is staffed by Federal scientists employed by USGS

2-5 Federal research scientists

The CRU program had its 80th anniversary in 2015

Over 1,000 students and university staff

Research Agenda

Approved by the CRU Coordinating Committee including the Department of the Interior, the State fish and wildlife agency, the university, and the Wildlife Management Institute



Partners

- USGS U.S. Geological Survey
- Universities
- State Fish and Wildlife Agencies
- Wildlife Management Institute
- U.S. Fish and Wildlife Service

Training the Conservation Workforce

Each year, nearly 600 graduate students participate in natural resources education and training through the CRU Program. Research directed by CRU 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 nature of the CRU Program provides this new workforce with a familiarity with the needs and policies of State and Federal science and management agencies. The success of this approach is evident in that CRU students have gone on to hold important leadership positions in nearly every State and Federal conservation agency.

The CRU Program continued its participation in minority education through two programs that focus on groups underrepresented in the conservation workforce. In collaboration with the National Wildlife Refuge System of the U.S. Fish and Wildlife Service, a pilot program is being initiated where graduate and undergraduate students will be conducting research on topics of importance to the Refuge System as a means to develop and recruit Federal scientists and natural resource managers. Five units (Arizona, Florida, Idaho, New York, and North Carolina) partner with the Doris Duke Foundation’s Conservation Scholars Program. Through this program, undergraduate students attend leadership training programs, work with scientists and graduate students on selected research projects, and are mentored by CRU-supported graduate students and research scientists. These “Duke Scholars” also complete paid internships with local, State, Federal, and Tribal agencies or nongovernmental organizations.



19

PhD degrees awarded

74

MS degrees awarded



545

Graduate students in the CRU program



Doris Duke conservation scholars

CRU graduate students



Leveraging Resources

The unique cooperative model of the CRU Program allows each cooperator to receive much more from their individual contribution than could be achieved alone. Program wide, the 2–5 Federal research scientists stationed at host universities collectively garner **\$30 million to \$40 million** in State and Federal research funding each year. Non-Federal cooperative faculty annually bring in an additional **\$6 million** in Federal funds through CRU Research Work Orders. Combined research funds at the CRUs support an average of about 1,100 students and university staff annually. Coupled with this, being located on some of the finest land grant colleges and universities provides CRU researchers access to world class research and library facilities. Unit scientists and affiliated university faculty link the research mission of all cooperators with student 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 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.

\$40.2M

in State and Federal
research funding in 2016

2–5

Federal research
scientists per CRU



LUFKIN

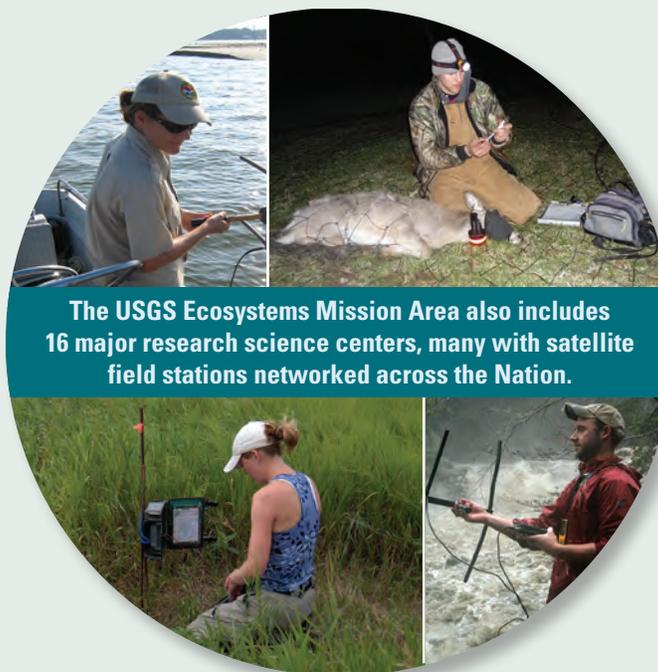
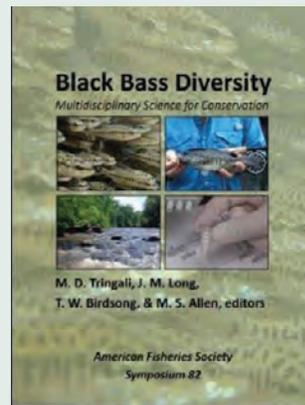
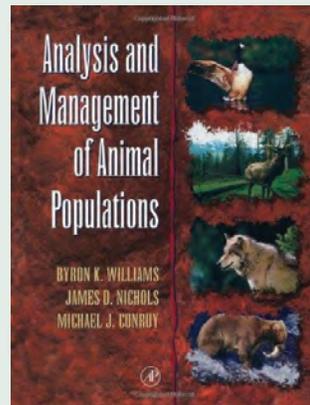
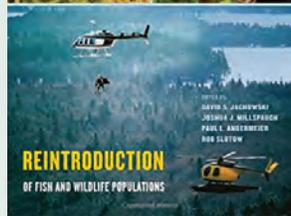
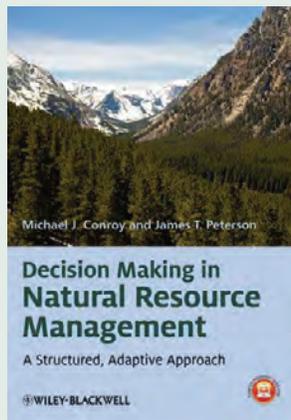
Emergency Phone Number: 307-386-2274
Authorized Personnel Only
Unit Starts Automatically
No Smoking, Open Flames or Lights
Safety Glasses, Steel Toed Boots and
Hard Hats Required on This Location

Outreach and Training

Unit scientists remained actively engaged in our technical assistance mission by delivering 19 workshops and short courses to 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. Scientists recognized for their expertise in specific areas also presented 19 invited seminars in fiscal year (FY) 2016.

Unit scientists routinely develop programs and applications to be used by State and Federal natural resource managers to conduct data analyses to inform decision making. The Colorado Unit co-authored the textbook “Bayesian Models: A Statistical Primer for Ecologists.”

The Arizona Unit developed a simple, web-based tool to compare freshwater fish data collected using American Fisheries Society standard methods. With widespread use, the tool could become an important resource for fisheries biologists. The Virginia Unit co-edited a textbook on reintroducing fish and wildlife populations.



398

Scientific publications



70

Courses taught



909

Presentations



42

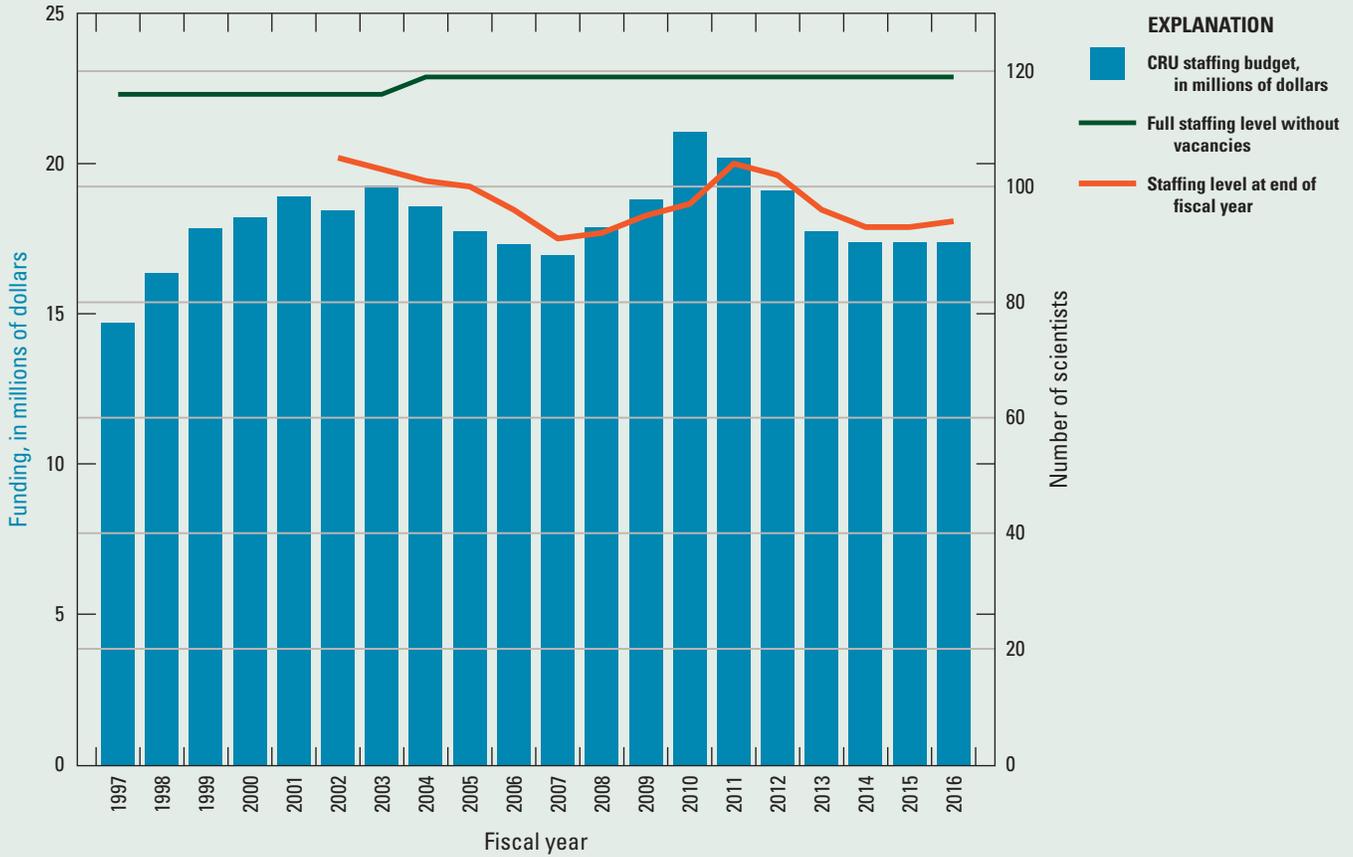
Invited seminars



19

Workshops

Budget and Staffing



Current (2017) Vacancies



Science Themes

One of the three pillars of the CRU mission is to lead research providing science solutions for the management needs of cooperators; research that informs decision making. Featured in this section are examples that display the diversity of management-oriented research conducted for State and Federal cooperators, aligned within science and policy themes. We have many more examples from every Unit, and we will be featuring these in a variety of outlets. This is just a taste of what this cooperative effort yields.



Species of Greatest Conservation Need

Energy and Wildlife

Decision Science

Endangered Species

Harvest and Population Management

Invasive Species

Ecosystem Services

Wildlife Disease

Landscape Ecology

Human Dimensions of Fish and Wildlife Conservation

Climate Science

Advanced Technologies



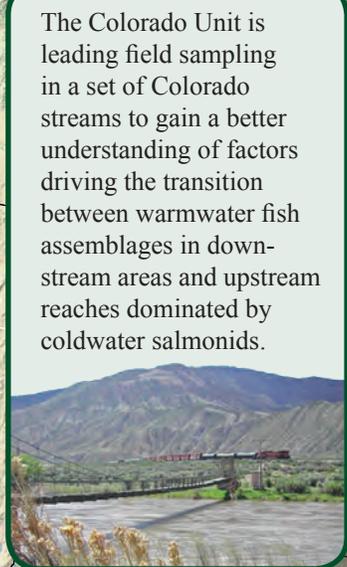
Species of Greatest Conservation Need

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 the information needs, threats, and conservation actions pertinent to them. CRU scientists work with State cooperators to develop the science needed to inform conservation actions.

The Washington Unit is leading research on the Endangered Species Act-listed Puget Sound chinook salmon by investigating size-selective mortality and critical growth periods during early marine life stages. The Unit also leads research on the ESA-listed bull trout in the Yakima River Basin reservoirs, along with herring, surf smelt, and Puget Sound steelhead for the Salish Sea Marine Survival Project.



The Idaho Unit is developing a monitoring protocol for detecting and monitoring the status and trends of greater sage-grouse in the City of Rocks National Reserve and Craters of the Moon National Monument and Preserve.

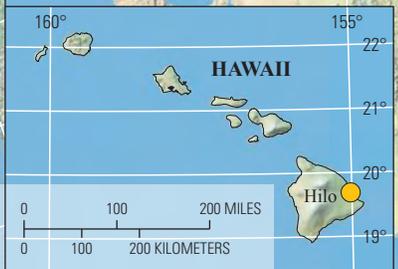


The Colorado Unit is leading field sampling in a set of Colorado streams to gain a better understanding of factors driving the transition between warmwater fish assemblages in downstream areas and upstream reaches dominated by coldwater salmonids.

The Alaska Unit is examining black oystercatcher nests, diet, and chick provisioning to ensure robust interpretation of trends observed in long-term monitoring data collected for this species.



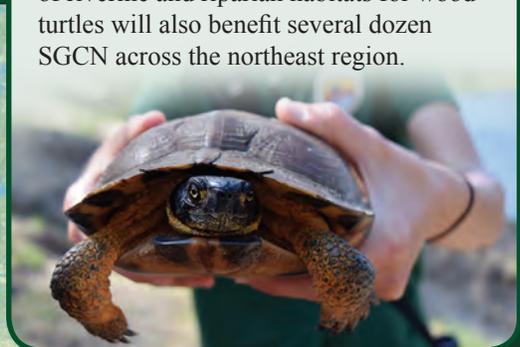
The Arizona Unit is leading research on fish and wildlife species of greatest conservation need. The fisheries team is investigating the growth and survival of apache trout and humpback chub. The wildlife scientists are researching factors influencing conservation of Sonoran desert tortoise, Chiricahua leopard frog, Western yellow-billed cuckoo, and desert bighorn sheep.



Researchers at the New York Unit are using structured decision analysis that can be used to guide habitat management or population restoration actions.



The Massachusetts Unit is leading research on methods to conserve wood turtles and associated riparian species. Successful conservation and management of riverine and riparian habitats for wood turtles will also benefit several dozen SGCN across the northeast region.



The Nebraska Unit is leading research on population and genetic studies of swift fox.



Research at the Louisiana Unit is evaluating habitat use, survival, and behavior of released whooping cranes. Additionally, the team will determine other potential areas for whooping crane release and (or) refine the methods of release to enhance project success.



The Virginia Unit is conducting a survey targeting streams that seem most likely to support logperch across the upper Piedmont portion of the Dan River basin in Virginia. A key need in recovering the endangered Roanoke logperch is to find undiscovered populations.



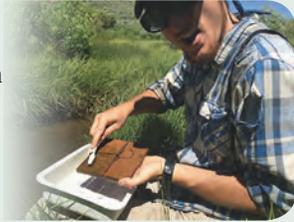
Researchers at the Florida Unit are researching the winter diets of immature green sea turtles on a northern feeding ground by conducting stable isotope analyses.



Energy and Wildlife

Biologists and land managers need information on impacts of energy development on fish and wildlife species, and risk analyses related to different options for energy infrastructure siting. CRU scientists work with cooperators to provide a science foundation for their decisions.

The goal of the Wyoming Unit sagebrush bird project is to generate management and mitigation recommendations for limiting reproductive impacts to already declining sagebrush songbird populations.

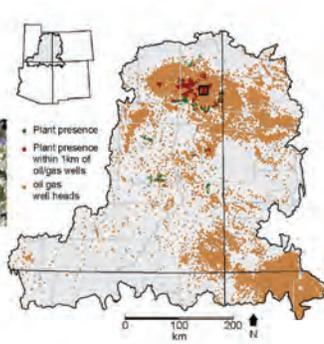


The Wyoming Unit is researching the effects of energy development for native fish communities.



The Utah Unit is

- Working with partners to develop and implement a process for modelling distributions of plant species in areas with current or proposed energy development.
- Leading a 4-year effort organizing existing data on 21 federally listed, rare and sensitive plant species in the Colorado Plateau vulnerable to energy development.



The Pennsylvania Unit is using North American Breeding Bird Survey Data to evaluate potential consequences of energy development and other land-use changes on bird populations in the northeast Appalachian region.

BAND PREFIX	COLOR MARKER CODE	ALPHA CODE	SPECIES #	STATUS	AGE-SEX	REGION	LAT-LONG	LOC	DATE MO.-DAY-YR
1517									
940	KA 944	LAL	062.1	301	ANY-U	096	221-1592	B	01-14-06
	KA 945							C	01-17-06
	KA 946							D	
	KA 947							E	
	KA 948							F	
	KA 949							G	
	KA 001							H	01-18-06
	KA 002							I	
	KA 003				ANY-U			J	
	KA 004				ANY-U			K	01-19-06
	KA 005							L	
	KA 006							M	01-21-06
	KA 007							N	01-22-06
	KA 008	Advised band # 1517-3449			ANY-U			O	
	KA 009	LAL	062.1		ANY-U			P	01-23-06
	KA 010							Q	
	KA 011							R	
	KA 012							S	01-25-06
	KA 013							T	01-26-06
	KA 014							U	
	KA 015							V	
	KA 016							W	
	KA 017							X	01-27-06



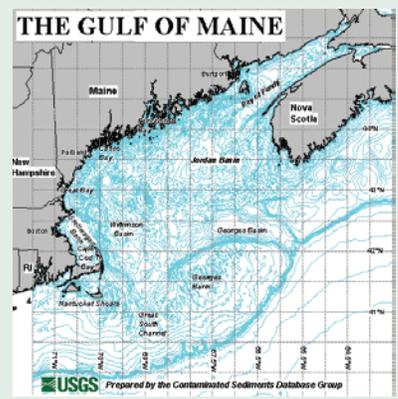
The New Mexico Unit is researching distribution and habitat selection of migratory and resident golden eagles in areas with high potential for wind energy development in New Mexico.



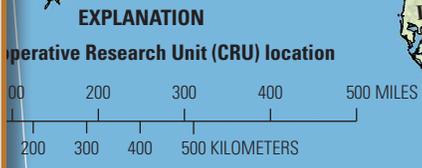
New Mexico Unit researchers are investigating the impacts of energy development on lesser prairie-chicken.



The Maine Unit is surveying biological hotspots in the Gulf of Maine to provide guidance in energy development siting.



The South Carolina Unit is leading research on spatial and reproductive ecology of brown pelicans in the Gulf of Mexico to enable decisions in energy development siting.



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Energy and Wildlife—Continued



The Nebraska Unit is

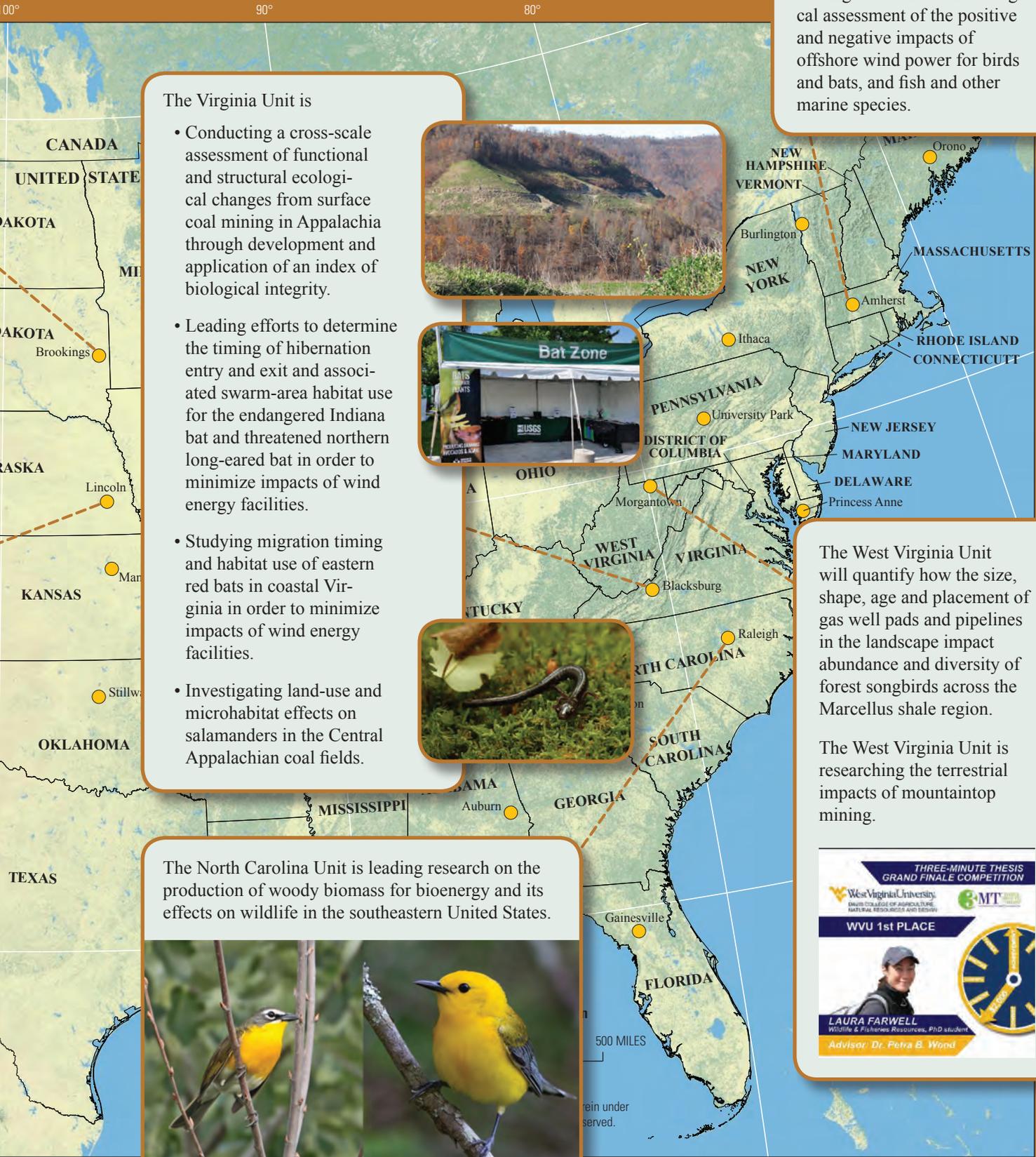
- Identifying important habitats and migratory routes for bats. These data help to determine when to curtail and where to place wind turbines to minimize bat mortalities.
- Leading research to better understand the habitats and conditions that affect bat presence, activity, movement, and migration in Nebraska.
- Investigating potential impacts of switch-grass production on grassland birds.



The Texas Unit is

- Studying wintering distribution of golden eagles in the Southern Great Plains to inform guidance on wind energy development.
- Reviewing the utility of the recommended golden eagle survey methodology given in the 2013 USFWS Eagle Conservation Plan guidance designed to minimize impacts of energy development.
- Conducting research on the potential interactions of migrating raptors and wind energy sites at the international scale.





The Virginia Unit is

- Conducting a cross-scale assessment of functional and structural ecological changes from surface coal mining in Appalachia through development and application of an index of biological integrity.
- Leading efforts to determine the timing of hibernation entry and exit and associated swarm-area habitat use for the endangered Indiana bat and threatened northern long-eared bat in order to minimize impacts of wind energy facilities.
- Studying migration timing and habitat use of eastern red bats in coastal Virginia in order to minimize impacts of wind energy facilities.
- Investigating land-use and microhabitat effects on salamanders in the Central Appalachian coal fields.



The Massachusetts Unit is leading research on an ecological assessment of the positive and negative impacts of offshore wind power for birds and bats, and fish and other marine species.

The West Virginia Unit will quantify how the size, shape, age and placement of gas well pads and pipelines in the landscape impact abundance and diversity of forest songbirds across the Marcellus shale region.

The West Virginia Unit is researching the terrestrial impacts of mountaintop mining.

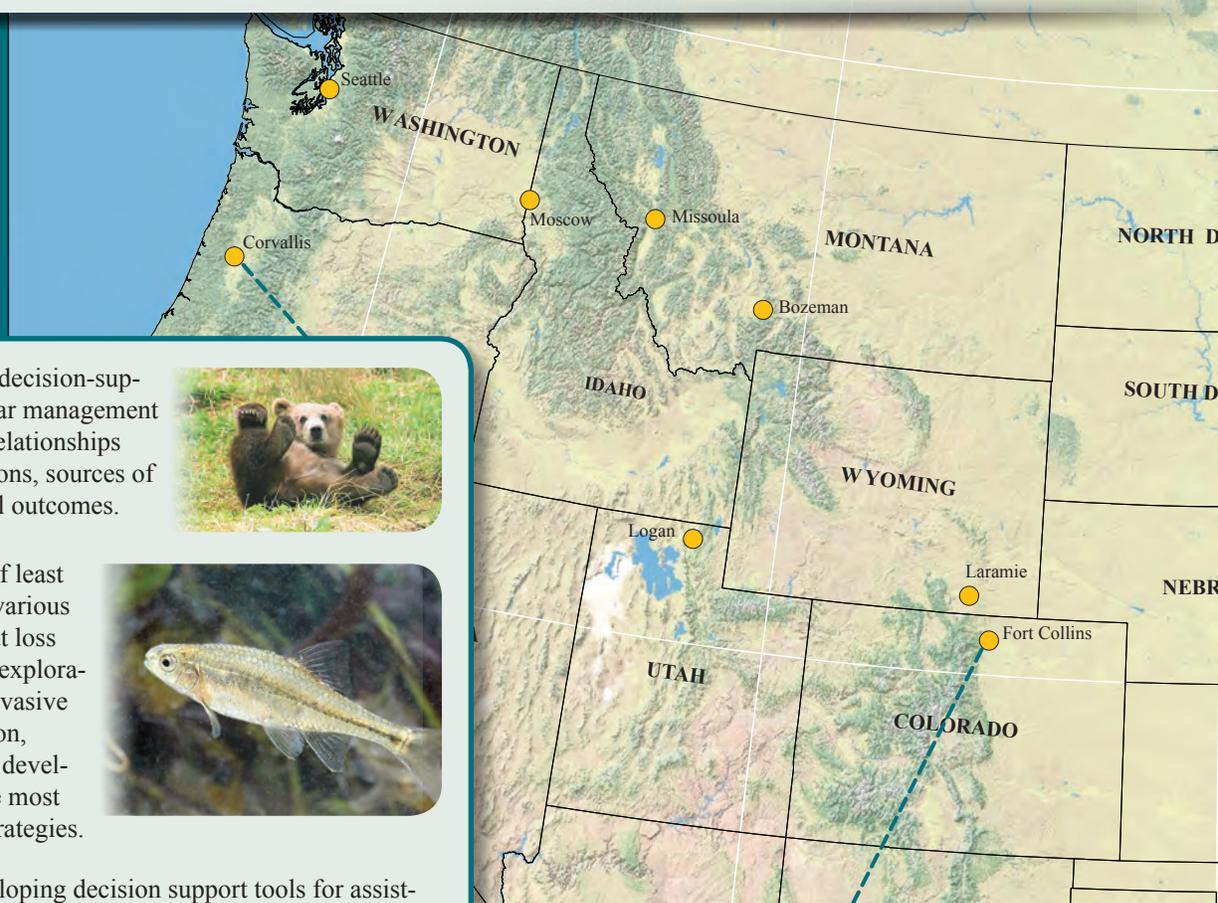
The North Carolina Unit is leading research on the production of woody biomass for bioenergy and its effects on wildlife in the southeastern United States.



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.

110°



The Oregon Unit built a decision-support model for brown bear management in Alaska consisting of relationships among management actions, sources of uncertainty, and potential outcomes.



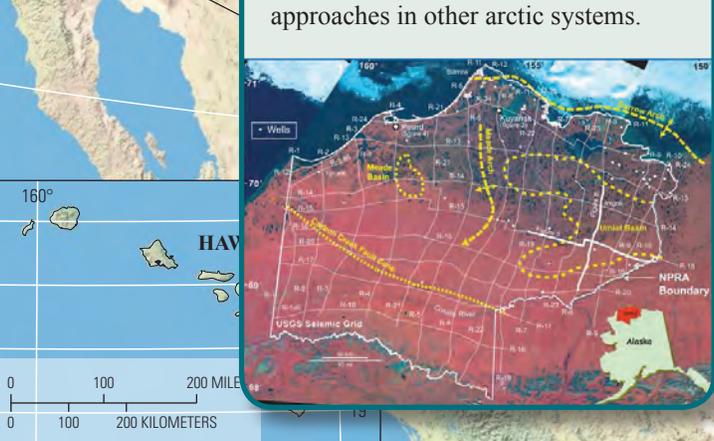
To reverse the declines of least chub that are caused by various reasons, including habitat loss and degradation, energy exploration and development, invasive species, and fragmentation, Oregon Unit researchers developed tools to identify the most effective conservation strategies.



The Oregon Unit is developing decision support tools for assisting biologists to manage at-risk mussels in the lower Flint River Basin. These data will assist the U.S. Fish and Wildlife Service and partners to better protect and recover the listed mussels and other rare species.

The Colorado Unit developed an adaptive management framework for conservation of wildlife populations on the National Petroleum Reserve in Alaska. This effort provides a template for considering adaptive management approaches in other arctic systems.

● Lubbock



120°

110°

100°

The New York Unit developed 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.

The New York Unit is using a structured decision-making approach to consider white-tailed deer buck harvest management options in New York State.



The Georgia Unit is using population models to characterize the viability of the lesser prairie-chicken under various future conservation scenarios. This modeling effort will predict future conditions for the species to support future decisions under the Endangered Species Act in accordance with the U.S. Fish and Wildlife Service's Species Status Assessment framework.



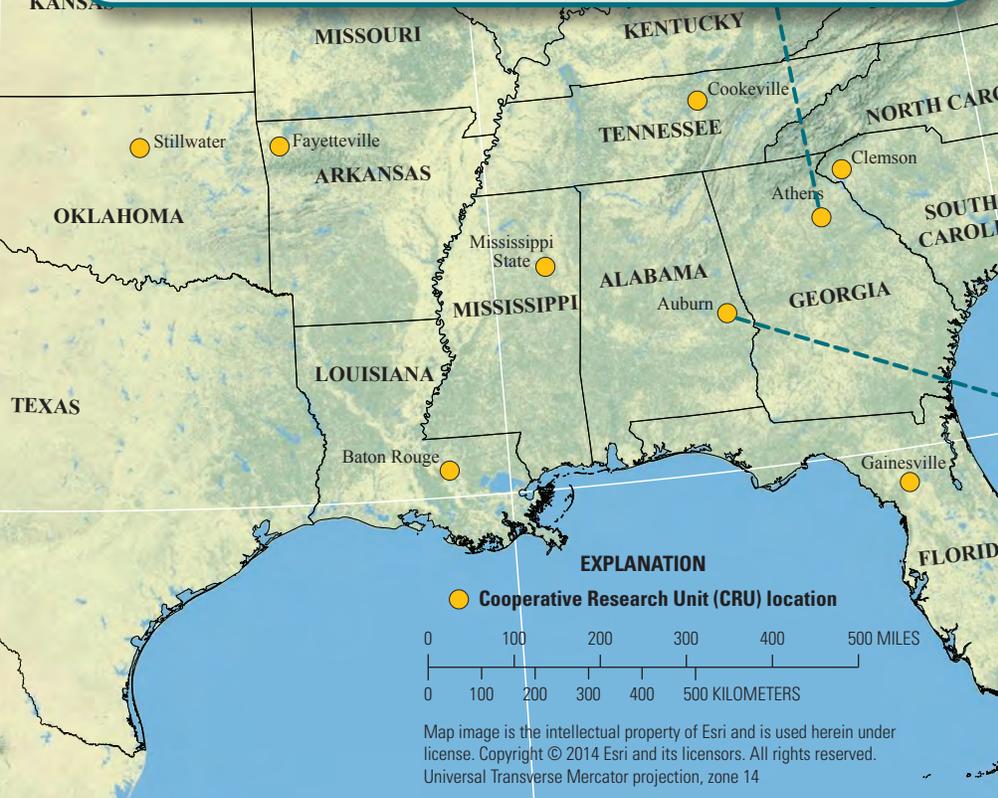
Georgia Unit researchers developed a decision support system for the selection of conservation actions that leads to a viable landscape supporting the statewide gopher tortoise population and associated species and communities of interest.



The Georgia Unit used a structured decision-making approach to consider public alligator harvesting. The approach takes advantage of regional commonalities in population biology, habitat relationships, and sampling characteristics in the development of a set of decision models.



The Alabama Unit, with expertise in shorebird ecology and structured decision making, has been supporting State and Federal efforts to manage horseshoe crab harvest. An adaptive management plan provides managers with the set of management actions that will most likely achieve all the objectives, and enable them to determine the most effective ones.



Endangered Species

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

110°

The Montana Wildlife Unit is collaborating with State research biologists to analyze grizzly bear demographics and habitat use in the Northern Continental Divide ecosystem.

The Montana Fishery Unit is researching the density of pallid sturgeon and food web dynamics in the Missouri River.

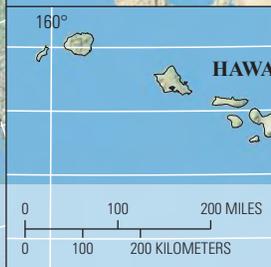


The Utah Unit is studying movement and habitat use of endangered fish in the Colorado River Basin.

The Kansas, Texas, and New Mexico Units are collaborating on a lesser prairie-chicken project involving retrospective analyses of data from two previous 10-year projects.



The Texas Unit is using an adaptive management conservation approach to Guadalupe bass “pre-listing” to prevent further declines that could warrant special status.



120°

110°

100

The Nebraska Unit is researching northern long-eared bat movements across transforming landscapes.



The Massachusetts Unit is sequencing the genome of Canada lynx in the north-eastern United States to apply landscape genetics and metapopulation dynamics to conservation strategies.



The Missouri Unit is researching whether non-native fish can coexist without substantial detriment to native fish, including the humpback chub in Bright Angel Creek and other tributaries.

The Louisiana Unit is investigating the reintroduction of whooping cranes to Louisiana.



The Virginia Unit is conducting an investigation of the foraging and roosting ecology and distribution of bats in the mid-Atlantic and Northeast following white-nose syndrome with emphasis on the threatened northern long-eared bat and the endangered Indiana bat.



The sicklefin redhorse is a candidate for protection under the Endangered Species Act. The North Carolina Unit is examining the early life history and ecology of the sicklefin redhorse, especially as related to habitat suitability, dams, and invasive species.

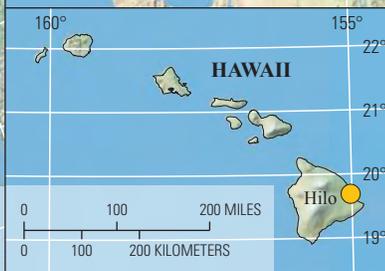


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Harvest and Population Management

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. We 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 Wyoming Unit has discovered and documented heretofore unknown major migration pathways for mule deer, pronghorn, and elk.



The Vermont Unit has developed a user-friendly statistical program called AMHarvest that allows wildlife managers to integrate the data they collect into powerful models that enable them to make better harvest management decisions.



The New York and Pennsylvania Units have developed a decision framework for State fish and wildlife agencies to use in developing hunter harvest strategies that integrate ecological and social objectives.



The Alabama Unit is helping the Alabama Department of Conservation and Natural Resources investigate options to bolster hunter participation and evaluate the potential to sustain or increase hunter populations.

Scientists at the Pennsylvania Unit are investigating the risk of chronic wasting disease transmission to wild white-tailed deer from captive deer facilities that could harbor the disease. The Pennsylvania Unit is also collaborating with the State Bureau of Forestry and the Game Commission to identify goals and objectives for managing deer on the 2.2 million acres of State forest lands.



Invasive Species

Invasive species of plants, animals, and microorganisms pose significant risks to native species, ecosystems, and the health of humans, fisheries, and wildlife. More than 6,500 nonindigenous species are now established in the United States, posing risks to native species, valued ecosystems, and human and wildlife health.

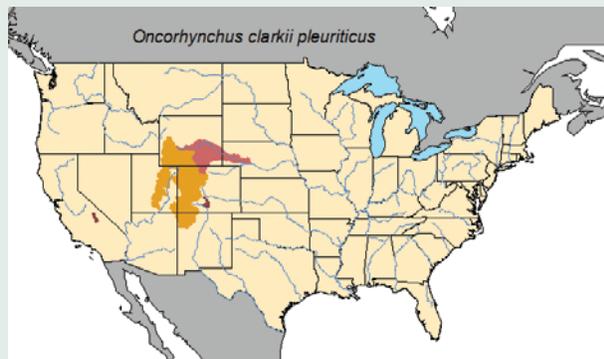
The Oregon Unit led research on the effects of habitat, climate, and invasive barred owls on long-term demography of the native northern spotted owl in Oregon, Washington, and California.



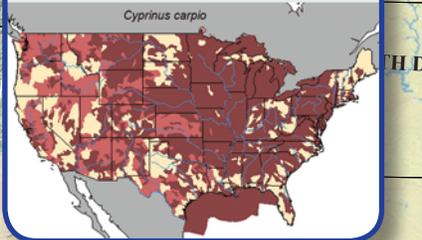
The Idaho Unit is providing a synthesis document to improve operations at fish hatcheries and field sites to reduce the impact or prevent establishment of New Zealand mudsnails and other invasive mollusks.



The Montana Fishery Unit is leading research on Yellowstone cutthroat trout in Spread Creek, Wyoming, with specific linkages to regional climate change and invasive species.



The Iowa Unit is investigating the effects of non-native common carp and zebra mussels on water quality and the native biological community of Clear Lake, Iowa.



The Colorado Unit is studying brown trout removal effects on short-term survival and movement of rainbow trout resistant to salmonid whirling disease in the Cache la Poudre River.





The Minnesota Unit is

- Researching marsh bird response to invasive cattail control using grazing, mowing, and herbicide application in the Prairie Pothole Region of Minnesota.
- Conducting a controlled experiment to test what species of native fish consume common carp eggs and which species are most effective egg predators in Malheur National Wildlife Refuge.
- Evaluating the response of bird communities to control invasive vegetation.



The Arkansas Unit is

- Leading research on trophic dynamics of a stream food web where invasive crayfish appear to be displacing native crayfish in the Spring River drainage of the Ozark Highlands in Arkansas and Missouri.
- Studying the impacts of drought and crayfish invasion on stream ecosystem structure and function.



The Georgia Unit is

- Developing an adaptive management framework to reduce the impact of invasive phragmites in the Great Lakes Basin.

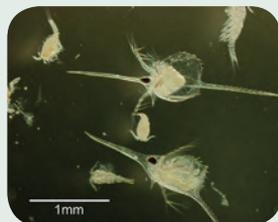


- Evaluating threats to important grassland bird habitats of the Gulf Coast Prairie resulting from oil and gas development, changes in land ownership patterns, and invasive species.



The Oklahoma Unit is

- Researching the invasive Asian swamp eel that occurs adjacent to and within management boundaries of Chatahoochee River National Recreation Area.
- Investigating how reservoir productivity and zooplankton composition, especially the invasive water flea species *Daphnia lumholzi*, affect age, growth, and relative abundance of paddlefish.



- The Florida Unit is evaluating the use of high-resolution aircraft photography acquired by unmanned aerial systems for use in mapping everglades wetland plant communities.



location

400 500 MILES

METERS

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Invasive Species—Continued

The Utah Unit is researching integrating non-native species in niche models to prioritize native fish restoration activity locations along a desert river corridor.



The Missouri Unit is leading research on the negative effects of invasive species in the Upper Colorado River Basin, a location with one of the most threatened fish faunas in the United States. The Missouri Unit is investigating the invasive ringed crayfish and the native coldwater crayfish to enhance the understanding of invasive species dynamics.



The Nebraska Unit is partnering with the Nebraska Invasive Species Project to investigate and prevent the spread of invasive species in the State.



The Nebraska Unit is researching the introduction of invasive species in areas affected by the exploration for oil, gas, and wind energy. The Nebraska Unit, in collaboration with a task force, is participating in the National Wetland Condition Assessment and will add approximately 110 additional sample locations in support of the U.S. Environmental Protection Agency's National Wetland Condition Assessment.



The Kansas Unit is researching wildlife response to the restoration of tallgrass prairie infested with an invasive legume plant, *Lespedeza cuneata*, using fire and grazing.



The New Mexico Unit is leading research on the control of invasive feral burro populations on Fort Irwin, California.



The Texas Unit is researching the spread of invasive golden algae.



The Wisconsin Wildlife Unit is researching one of the most problematic aquatic invasive species in North America—Eurasian watermilfoil.



The Maine Unit is characterizing habitat use and growth of lake whitefish in Maine in the context of invasive species management and climate change.



The Tennessee Unit is assessing the population characteristics (such as age structure, size structure, and growth rates) of Asian carp.



Researchers at the Tennessee Unit are using eDNA to develop occupancy models for several invasive species and imperiled species of concern.

The Massachusetts Unit is leading research on aquatic invasive species across the State.



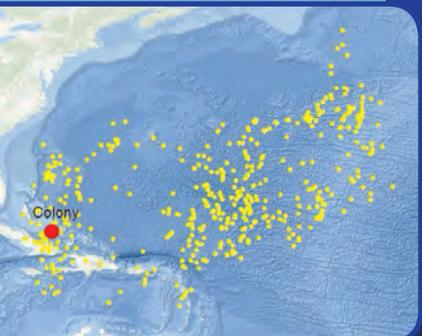
The West Virginia Unit is researching upstream dispersal of an invasive crayfish aided by a fish passage facility.



Louisiana Unit research will develop a better understanding of the mechanisms facilitating water elm expansion and help to develop more effective control practices.

The South Carolina Unit is researching invasive species in coastal wetlands and islands of the Caribbean and the Gulf of Mexico.

In response to growing concerns about the economic and ecological impact of feral hog populations among Federal, State, and local leadership within the State of South Carolina, the South Carolina Unit is developing novel management approaches to reduce invasive feral hog damage.



Ecosystem Services

An ecosystem service is any positive benefit provided to society by fish, wildlife, or components of ecosystems through their functions. 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 (CES) are more difficult to quantify, but extremely important in understanding natural resource values to society.

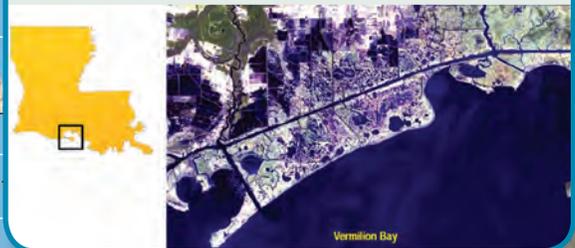
The Alaska Unit is studying how climate change is affecting social-ecological dynamics of rural Alaskan villages by exploring how changes in ecosystem services are affecting community resilience. The team is also helping to identify opportunities for adaptation and (or) transformation of community practices.



The Nebraska Unit is studying fishing for resilience. The project focuses on aquatic-system properties that have the ability to maintain provisioning of important goods and services, including recreational opportunities.



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.



The New York Unit is leading research on landscape conservation in the Choco-Andean biological corridor. An optimal corridor design will ensure landscape connectivity for endangered species, while maintaining critical ecosystem services in South America's rainforests.



The Virginia Unit is investigating regulating ecosystem services as measures of ecological resilience on Department of Defense lands. This project will demonstrate the utility of using information on aquatic ecosystem services (AES) in land-use planning on two military bases (Fort Pickett, Va., and Cherry Point, N.C.).

The Virginia Unit is researching spatial analysis of relations among conservation practices, aquatic biodiversity, ecosystem services, and human well-being.



The Maine Unit is leading research on fish response to dam removal. The Mill Dam removal restored important, but often overlooked, ecological services. The removal of the Mill Dam barrier allowed sea lampreys to spawn in newly accessible reaches and thereby provided an additional prey source for resident drift-feeding fish.



Wildlife Disease

Wildlife diseases pose potential threats to the viability of wildlife populations, and have potential implications to human health and our economy. CRU scientists work with cooperators to better understand the causes of these diseases, the impacts on wildlife and people, and means to control, contain, and eradicate them.

The Oregon Unit is researching the response of desert bighorn sheep in the Mojave National Preserve to respiratory disease.

The California Unit is tracking the effects of withering disease on black abalone in California.

Idaho Unit researchers are conducting experimental field studies to document whether sylvatic plague is reducing survival of the federally threatened northern Idaho ground squirrel.

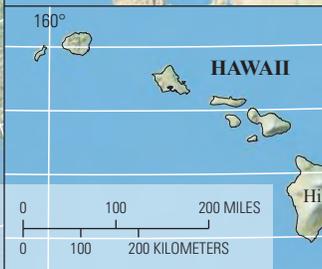


The Montana Wildlife Unit is developing a risk model and decision tool for managing disease outbreaks in bighorn sheep and developing capacity within the tool for evaluating potential reintroduction sites for bighorn sheep.



The Wyoming Unit is investigating the disease status of the Columbia spotted frog, one of the species identified on Wyoming's State Wildlife Action Plan, to determine if disease risks exist.

The Wyoming Unit initiated a large-scale analysis to evaluate the factors potentially responsible for observed declines in Shiras moose.



The Pennsylvania Unit is exploring the relationship between habitat and the distribution of chronic wasting disease in white-tailed deer in the northeastern United States by conducting surveillance and monitoring of the deer. It is also evaluating a strategy to deliver a vaccine to white-tailed deer at a landscape level in the event treatments are developed for chronic wasting disease.



The Massachusetts Unit is researching snake species listed as Species of Greatest Conservation Need because of concerns that an emerging fungal disease may impact their populations.

The Wisconsin Wildlife Unit is studying the dynamics of avian influenza in western Arctic snow geese.



The Wisconsin Wildlife Unit is researching avian malaria in Hawaiian forest birds. The focus is on infection and population impacts across species and elevations.

Wisconsin Wildlife Unit scientists are modeling future conservation of Hawaiian honeycreepers by exploring mosquito management and translocation of disease-tolerant Amakihi.

Researchers at the Wisconsin Wildlife Unit focus on the transmission of chronic wasting disease in Wisconsin white-tailed deer and the implications for disease spread and management.

Researchers at the Virginia Unit are surveying widely for the northern long-eared bat's presence, and have discovered populations along the Mid-Atlantic coast and in the Mid-South that do not hibernate in caves and are never exposed to white-nose syndrome. While disease specialists are working to find a cure, the discovery of unaffected areas means that this species, at least in part of its range, is secure from the prospect of extinction.



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.

A cooperative effort among Montana Fish, Wildlife and Parks; Northwestern Energy; and the Montana Fishery Unit has resulted in a better understanding of how bull trout migrate through the Thompson Falls River drainage.



The Colorado Unit is leading research on landscape genetics by developing spatially explicit models of genetic variation across space. The team is hoping to illustrate how this approach can be used to optimize spatial prediction and sampling design for landscape-genetic data.



The Alaska Unit is synthesizing data on changes in river flow and fish habitat on the Kenai River.



The Alaska Unit is providing data for the Alaska Integrated Ecosystem Modeling (AIEM) Project, designed to meet Alaska land managers' needs to understand the nature and rate of landscape change.



The New Mexico Unit is leading an effort to understand the movement ecology and landscape genetic structure of golden eagles in the Western United States.





The Wisconsin Wildlife Unit is leading research on monitoring wildlife population change and data management for the Chequamegon-Nicolet National Forest.

The Wisconsin Wildlife Unit is leading research on Grassland Bird Conservation Areas, as part of the Wisconsin Bird Conservation Initiative.

The Maine Unit is leading research on the factors potentially affecting the persistence of amphibian species in western and northern Maine.



The Vermont Unit is leading research on healthy landscapes to understand terrestrial resource location and abundance, condition, and trend, and to provide a basis for effective adaptive management.

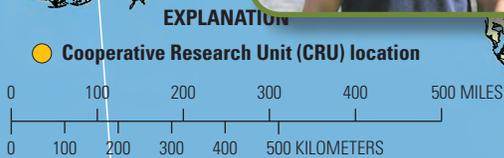


Researchers at the Pennsylvania Unit are working with partners to harness “big data”—large datasets—to develop comprehensive, holistic understanding of lakes and nutrient cycles.



The Massachusetts Unit is developing landscape conservation strategies for Andean bears in Peru.

The North Carolina Unit is involved in the National Gap Analysis project. The purpose is to monitor landscape changes by using decision analysis tools.



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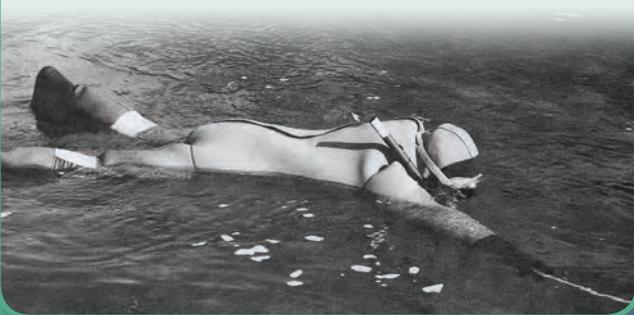
Human Dimensions of Fish and Wildlife Conservation

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

The Idaho Unit is researching means to increase inclusion and diversity in the natural resources workforce.

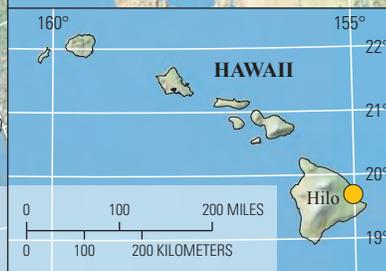


The Alaska Unit is researching landscape changes associated with social-ecological systems, centered around salmon on the Kenai Peninsula.



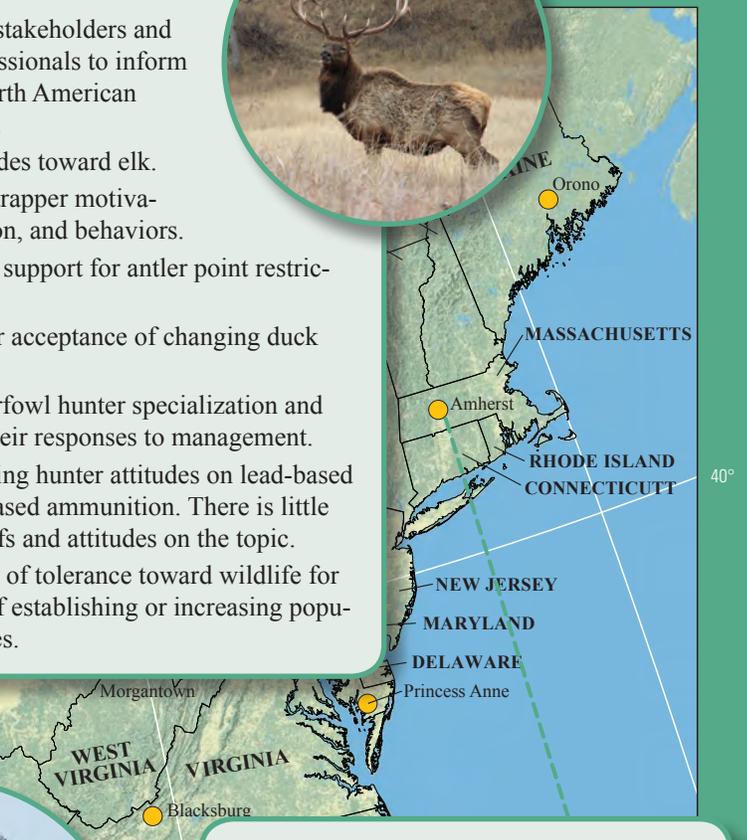
The South Dakota Unit is

- Measuring crowding among deer hunters, a factor that may influence satisfaction in outdoor recreation.
- Documenting the motivation of female deer hunters in the Black Hills.
- Evaluating the value of the Internet for the collection of scientific data (use, harvest, and attitudes) from anglers.
- Documenting the attitudes and behaviors by private landowners in the Prairie pothole region to help understand land use decisions.



The Minnesota Unit is

- Developing experience-based management information for fisheries and wildlife management.
- Assessing the preferences of stakeholders and waterfowl management professionals to inform the implementation of the North American Waterfowl Management Plan.
- Researching landowner attitudes toward elk.
- Documenting changes in fur trapper motivations, involvement, satisfaction, and behaviors.
- Exploring factors that predict support for antler point restrictions.
- Researching waterfowl hunter acceptance of changing duck bag limits.
- Conducting research on waterfowl hunter specialization and identity to gain insight into their responses to management.
- Exploring the beliefs underlying hunter attitudes on lead-based versus alternative non-lead-based ammunition. There is little understanding of hunter beliefs and attitudes on the topic.
- Developing a behavior model of tolerance toward wildlife for use in assessing probability of establishing or increasing populations of controversial species.



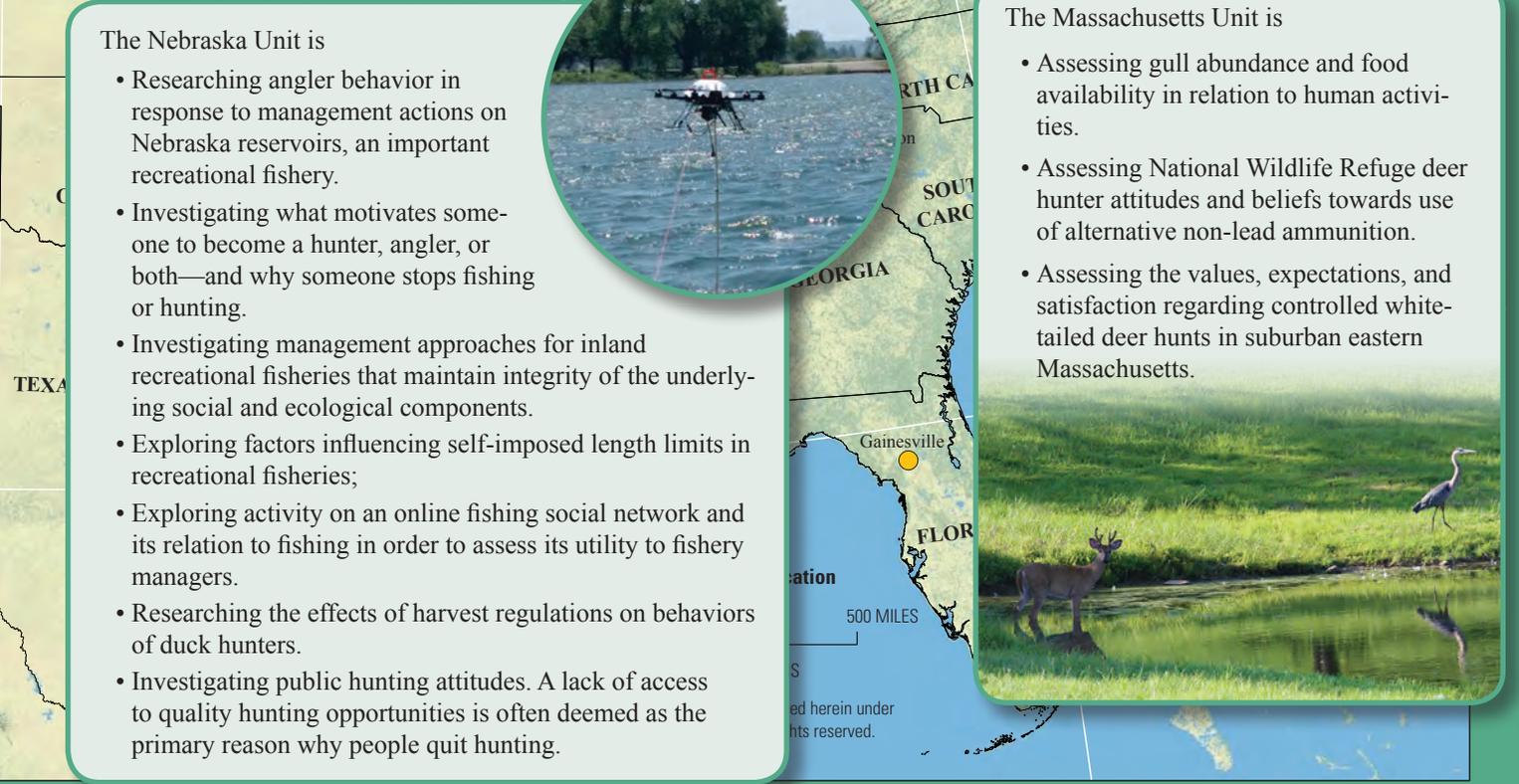
The Nebraska Unit is

- Researching angler behavior in response to management actions on Nebraska reservoirs, an important recreational fishery.
- Investigating what motivates someone to become a hunter, angler, or both—and why someone stops fishing or hunting.
- Investigating management approaches for inland recreational fisheries that maintain integrity of the underlying social and ecological components.
- Exploring factors influencing self-imposed length limits in recreational fisheries;
- Exploring activity on an online fishing social network and its relation to fishing in order to assess its utility to fishery managers.
- Researching the effects of harvest regulations on behaviors of duck hunters.
- Investigating public hunting attitudes. A lack of access to quality hunting opportunities is often deemed as the primary reason why people quit hunting.



The Massachusetts Unit is

- Assessing gull abundance and food availability in relation to human activities.
- Assessing National Wildlife Refuge deer hunter attitudes and beliefs towards use of alternative non-lead ammunition.
- Assessing the values, expectations, and satisfaction regarding controlled white-tailed deer hunts in suburban eastern Massachusetts.



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. CRU scientists work with cooperators to better understand potential implications and reduce uncertainty so that managers can better evaluate future scenarios and management options.

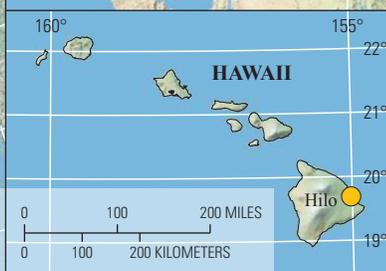
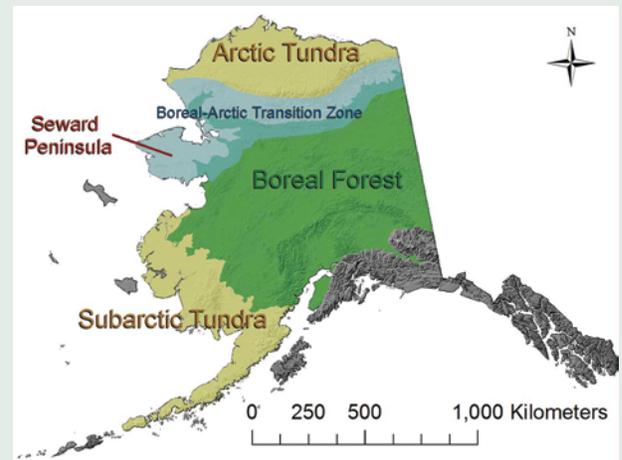
Oregon Unit researchers seek to address the significance and priority goals established in “Rising to the Urgent Challenge” developed by the U.S. Fish and Wildlife Service to establish their strategic climate change plan aimed to assist managers with the development of adaptation and planning strategies.



Scientists at the Alaska Unit are measuring the effects of climate-induced changes on caribou in northern Alaska.



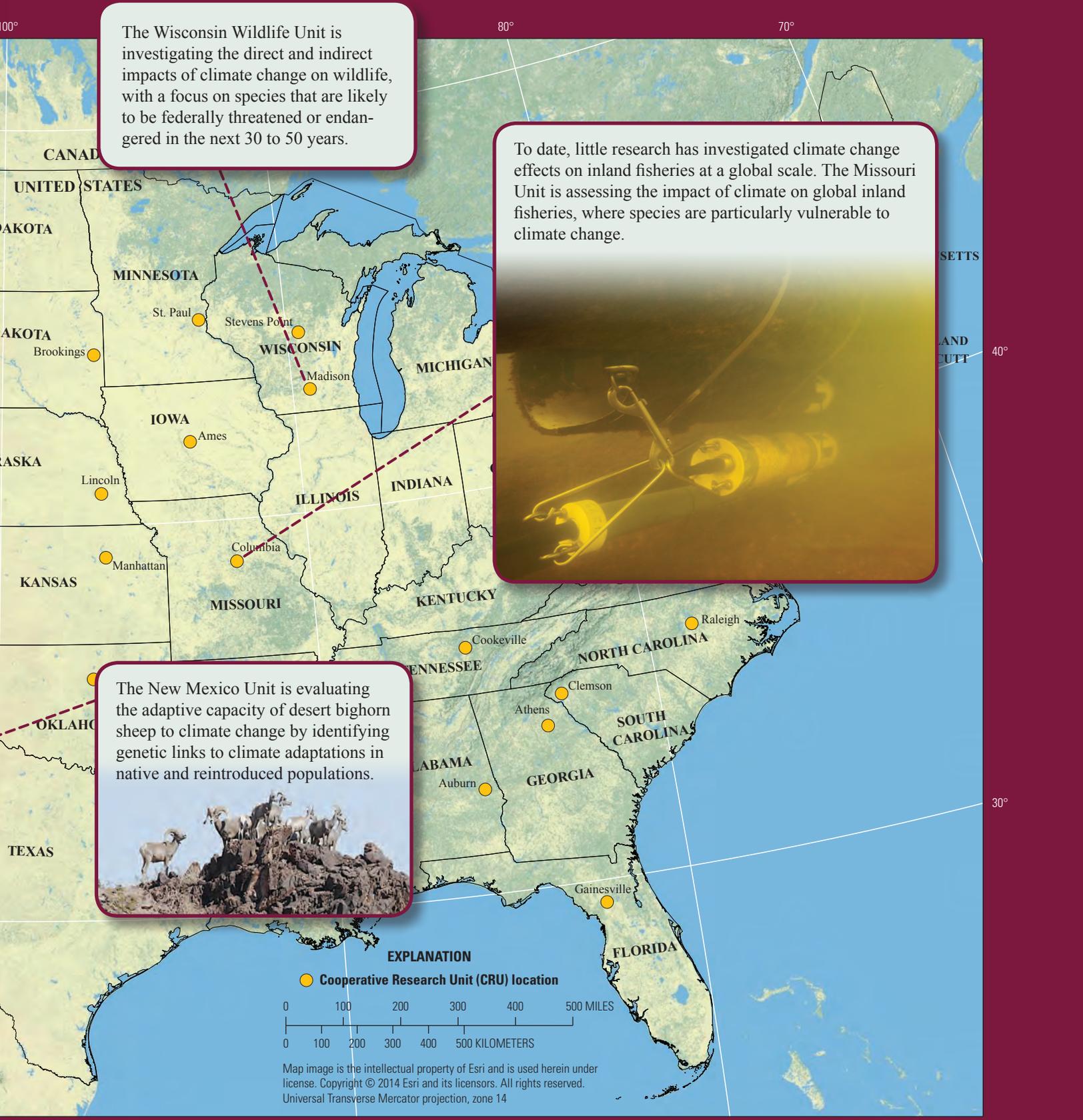
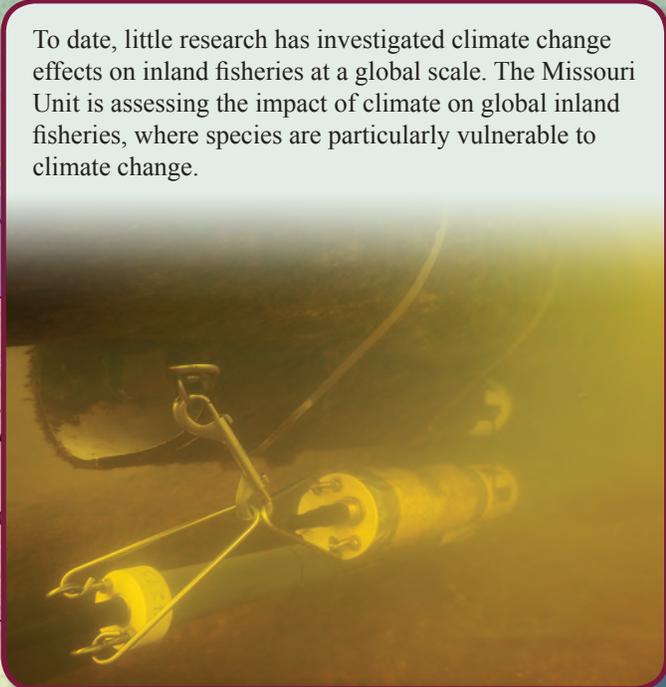
Research at the Alaska Unit focuses on regional consequences of climate change to Alaska’s boreal forest.



The Wisconsin Wildlife Unit is investigating the direct and indirect impacts of climate change on wildlife, with a focus on species that are likely to be federally threatened or endangered in the next 30 to 50 years.

To date, little research has investigated climate change effects on inland fisheries at a global scale. The Missouri Unit is assessing the impact of climate on global inland fisheries, where species are particularly vulnerable to climate change.

The New Mexico Unit is evaluating the adaptive capacity of desert bighorn sheep to climate change by identifying genetic links to climate adaptations in native and reintroduced populations.



Advanced Technologies

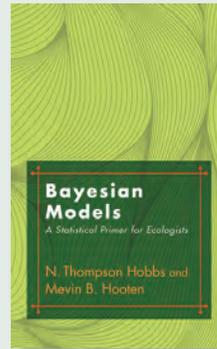
Advanced technologies include development and adaptation of new technologies and tools that increase effectiveness, efficiency, safety, accuracy, geographic extent, or timeliness of gathering data, dissemination, analysis, and interpretation of natural resource phenomena. It also includes development of new tools that assist natural resource managers in decision making and adaptive management.

The Oregon Unit developed experimental methods to assess the effects of contaminated sediment on the growth and behavior of ammocoetes reared in a lab.

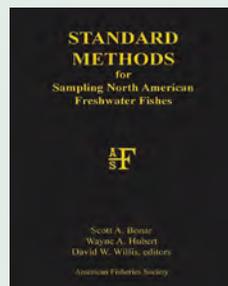
The Colorado Unit is

- Evaluating the efficiency of hoop-netting used for current monitoring of humpback chub compared to that of the new remote passive integrated transponder (PIT) tag antenna array, that does not require repeated handling of fishes in the Little Colorado River.
- Leading research on the construction, use, and performance of two portable floating radio frequency identification antenna systems designed to detect fish that were unavailable for recapture using stationary antennas or electrofishing.

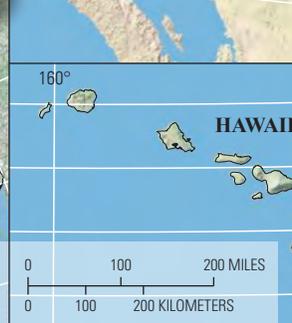
The Colorado Unit co-authored the textbook “Bayesian Models: A Statistical Primer for Ecologists.”



The Arizona Unit developed a simple, web-based tool to compare freshwater fish data collected using American Fisheries Society standard methods. With widespread use, the tool could become an important resource for fisheries biologists.



The New Mexico Unit is leading research to characterize big game animal populations using bio-markers to describe migratory and nonmigratory behavior.



The Maine Unit is developing a new tool for reconstructing habitat use of shortnose sturgeon.



The Pennsylvania Unit released the “Manual of Applied Spatial Ecology” to assist researchers on methods for data management and analysis using R.

The Nebraska Unit, in partnership with the Nebraska Intelligent MoBILE Unmanned Systems Lab (NIMBUS) and the Applied Complex Adaptive Systems Lab, has designed a drone prototype that drops balls filled with combustible material that ignites fire as part of pre-scribed fire management.



The Vermont Unit developed tools for automated acoustic monitoring with the R package (AMHarvest) that includes functions for implementing an adaptive management program for harvested species.

The Florida Unit is evaluating the use of high-resolution aerial photography acquired by unmanned aerial systems for use in mapping everglades wetland plant communities.



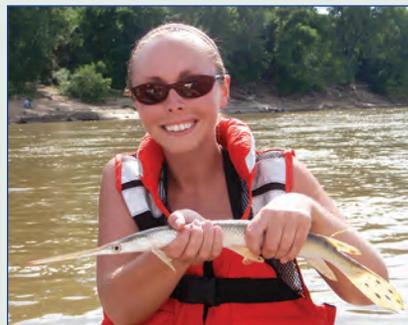
Where Are They Now?

One of the greatest legacies of the CRU program is the placement of our students in natural resource agencies and organizations. Key to the concept of a Unit Brand is the notion that a hiring official will recognize added value in an applicant who received their graduate education in a CRU. The sheer volume of Unit graduates that staff agencies and the proportion of those who are leaders is a tribute to the value of a CRU education.

A pillar of the CRU mission is to develop the workforce of the future through graduate education. This graphic shows where some of our recent graduates have settled into professional positions with Federal and State governments, universities, and nongovernmental organizations.

Unit	University	Nongovernmental/ private/other	State government	Federal Government	Total student headcount
Alaska	0	1	3	4	8
Arkansas	9	6	8	8	31
Kansas	6	5	4	1	16
Massachusetts	3	4	8	10	25
Mississippi	4	2	12	0	18
Montana Wildlife Unit	0	1	3	0	4
New Mexico	0	1	7	1	9
New York	2	1	1	3	7
North Carolina	9	2	5	4	20
Oklahoma	4	1	5	3	13
Oregon	2	4	9	9	24
Pennsylvania	0	0	3	0	3
South Carolina	2	2	5	2	11
Texas	2	1	3	1	7
Utah	1	0	5	2	8
Virginia	5	0	0	1	6
Washington	6	8	7	9	30
West Virginia	3	1	7	6	17
Wisconsin Fishery	0	0	3	6	9
Wyoming	3	2	7	5	17
Total*	61	42	105	75	283

*Not all Units are listed.



Accolades

Unit scientists and their students received approximately 65 awards in 2016 from universities, agencies, and societies with recognition at the local, national, and international levels. Highlights include the following:



- Conservationist of the Year, Cherry Creek Legal and Scientific Team, Arizona/New Mexico American Fisheries Society (Scott Bonar)
- Outstanding Publication of the Year Award, Colorado State University, Warner College of Natural Resources (Mevin Hooten)
- Outstanding Faculty Outreach and Continuing Education, University of Idaho College of Natural Resources (Christine Moffitt)
- Wildlife Publications Award for Outstanding Article 2015, The Wildlife Society (Dave Haukos)
- Sam D. Hamilton Award for Transformational Conservation Science, U.S. Fish and Wildlife Service (Megan LaPeyre)
- Lifetime Achievement Award, Mississippi Chapter American Fisheries Society (Hal Schramm)
- Most Active Large Chapter Award, North Central Division of the American Fisheries Society (Amanda Rosenberger)
- Cooperative Fish and Wildlife Research Units Outstanding Science Award, Cooperative Research Units (James Cain, Colleen Caldwell, Scott Carleton)
- U.S. Fish and Wildlife Service Regional Director Award for Scientific Excellence, U.S. Fish and Wildlife Service Alaska (Suresh Sethi)
- Regional Director's Honor Award, U.S. Fish and Wildlife Service, Region 4 (Jaime Collazo)
- National Fish Habitat Award for Excellence in Scientific Achievement, The National Fish Habitat Partnership (Tyler Wagner)
- Outstanding Fisheries Worker Award for Research, Texas Chapter of the American Fisheries Society (Tim Grabowski)
- Outstanding Achievement Award, Southern Division of the American Fisheries Society (Pat Mazik)



Professional Services

Unit scientists held approximately 331 professional service positions (scientific society officers, technical committees, working groups, panels, and so forth) and served in 72 editorial positions in FY 2016.



Joe Margraf Retirement

Dr. Joe Margraf, Western Units Supervisor, retired on August 31, 2016, after 36 years of service in the Cooperative Fish and Wildlife Research Units. During his illustrious career, Joe served as Assistant Leader and then Acting Leader of the Ohio Fisheries CRU from 1980 to 1987, as Leader of the West Virginia CRU from 1987 to 1996, as Leader of the Maryland CRU from 1996 to 1999, as Leader of the Alaska CRU from 1999 to 2009, and as Western Supervisor from 2009 to 2016. Joe leaves a truly remarkable legacy. Numerous leaders in fisheries conservation today were trained by Joe. Joe was inducted as president of the American Fisheries Society just prior to retirement, so his contributions to conservation will continue well into his retirement.



Dr. Joe Margraf (left) with American Fisheries Society (AFS) immediate past President Ron Essig (right) after his induction as AFS President.



North American Conference Science and Management Workshop

The CRU co-sponsored a workshop at the 2016 North American Wildlife and Natural Resources Conference along with the Association of Fish and Wildlife Agencies, the American Fisheries Society, The Wildlife Society, and the Wildlife Management Institute titled “Barriers and Bridges in Reconnecting Natural Resources Science and Management.”

The workshop was organized around presentations, panel discussions, and audience participation, focused on exploring how management agencies and academic institutions can better integrate, so that the science-management continuum can operate more effectively with meaningful feedback and resource management outcomes. Dr. David Haukos, Leader of the Kansas CRU, presented a case study of the lesser prairie-chicken initiative, and CRU chief Dr. John Organ gave the introductory remarks. A summary of the session will be published by the Wildlife Management Institute in the Conference transactions.



National Cooperators' Coalition (NCC)

The National Cooperators' Coalition met at the North American Wildlife and Natural Resources Conference in Pittsburgh in March 2016 and at the Association of Fish and Wildlife Agencies Annual Meeting in Philadelphia in September 2016. During the March meeting, a memorandum of understanding (MOU) between The Wildlife Society (TWS), American Fisheries Society (AFS), U.S. Geological Survey Cooperative Research Units (CRU), and the U.S. Fish and Wildlife Service (FWS) was signed. The MOU is designed to bolster collaboration among the parties to (1) develop and exchange biological information for natural resource managers; (2) encourage, promote, and increase scientific professionalism and excellence among the TWS, AFS, CRU, and FWS; (3) encourage, promote, and increase learning and professional development of staff within the organizations; and (4) to work



The Wildlife Society Executive Director Ken Williams, U.S. Fish and Wildlife Service Assistant Director Paul Souza, American Fisheries Society Executive Director Doug Austen, and U.S. Geological Survey Cooperative Research Units Chief John Organ at March National Cooperators' Coalition meeting after signing the memorandum of understanding.

collaboratively to plan appropriate symposia, sessions, workshops, and other relevant events leading up to the 2019 joint meeting of The Wildlife Society and the American Fisheries Society.

The NCC has developed a strategy to gain political support for filling the existing vacancies in CRU, and potentially add new CRUs to the system. Major effort is scheduled for 2017.

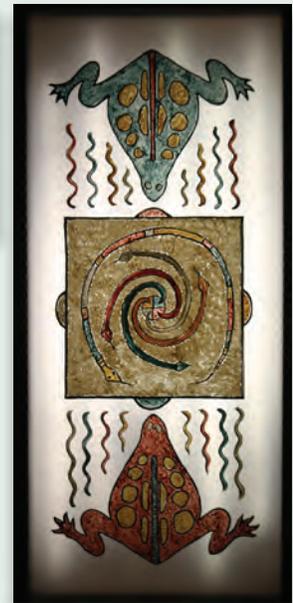
2016 CRU All-Hands Meeting in Santa Fe, New Mexico

The most recent CRU National All-Hands Meeting was held March 7–11, 2016, at the La Fonda on the Plaza in Santa Fe, New Mexico. The meetings are convened every 5 years and are an important opportunity for CRU staff to communicate about program strategic priorities, address pressing concerns, and connect as professionals. The meeting also provides our key cooperators an opportunity to engage CRU staff to discuss prescient concerns, challenges, and opportunities.

We structured the meeting around our roles in research, education, and State partnerships. The programs focused on (1) research—an increasing role for landscape perspectives in the management and conservation of national and international resources, (2) education—training the biologists and scientists of the future, and (3) State cooperators—envisioning a future of science-based management with our partners.

Invited guest speakers added to the meeting by providing critical insights into important issues for the CRUs and challenged our thinking on those issues. We built into the program ample opportunity to connect and network with CRU scientists and administrators, which all agree was a priority goal of the meeting.

Our scientists very much appreciated the perspectives of our cooperators on the role of the CRUs and their recommendations for the future. The meeting was designed to improve our networking and teamwork, and having input from partners helped to inform us about how to do those things more effectively. Our scientists benefitted by hearing from our collaborators and partners about how we can work together more effectively to face the big science and conservation challenges before us.



2016 CRU All-Hands Meeting in Santa Fe, New Mexico.

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 Commission

ARKANSAS

University of Arkansas
Arkansas Game and Fish Commission

CALIFORNIA

Humboldt State University
California Department of Fish and Game

COLORADO

Colorado State University
Colorado Division of Wildlife

FLORIDA

University of Florida
Florida Game and Fish Commission

GEORGIA

University of Georgia
Georgia Department of Natural Resources

HAWAII-FISHERY

University of Hawaii
Hawaii Department of Land and Natural Resources

IDAHO

University of Idaho
Idaho Department of Fish and Game

IOWA

Iowa State University
Iowa Department of Natural Resources

KANSAS

Kansas State University
Kansas Department of Wildlife and Parks

LOUISIANA

Louisiana State University
Louisiana Department of Wildlife and Fisheries

MAINE

University of Maine
Maine Department of Inland Fisheries and Wildlife

MARYLAND

University of Maryland, Eastern Shore
Maryland Department of Natural Resources

MASSACHUSETTS

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

MINNESOTA

University of Minnesota
Minnesota Department of Natural Resources

MISSISSIPPI

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

MISSOURI

University of Missouri Columbia
Missouri Department of Conservation

MONTANA-FISHERY

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

MONTANA-WILDLIFE

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

NEBRASKA

University of Nebraska Lincoln
Nebraska Game and Parks Commission

NEW MEXICO

New Mexico State University
New Mexico Department of Game and Fish

NEW YORK

Cornell University
New York Department of Environmental Conservation

NORTH CAROLINA

North Carolina State University
North Carolina Wildlife Resources Commission

OKLAHOMA

Oklahoma State University
Oklahoma Department of Wildlife Conservation

OREGON

Oregon State University
Oregon Department of Fish and Wildlife

PENNSYLVANIA

Pennsylvania State University
Pennsylvania Fish and Boat Commission
Pennsylvania Game Commission

SOUTH CAROLINA

Clemson University
South Carolina Department of Natural Resources

SOUTH DAKOTA

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

TENNESSEE-FISHERY

Tennessee Tech University
Tennessee Wildlife Resources Agency

TEXAS

Texas Tech University
Texas Parks and Wildlife Department

UTAH

Utah State University
Utah Division of Wildlife Resources

VERMONT

University of Vermont
Vermont Department of Fish and Wildlife

VIRGINIA

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

WASHINGTON

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

WEST VIRGINIA

West Virginia University
West Virginia Division of Natural Resources

WISCONSIN-FISHERY

University of Wisconsin Stevens Point
Wisconsin Department of Natural Resources

WISCONSIN-WILDLIFE

University of Wisconsin Madison
Wisconsin Department of Natural Resources

WYOMING

University of Wyoming
Wyoming Game and Fish Commission

For more information, contact:

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Dawn Childs, Information Specialist

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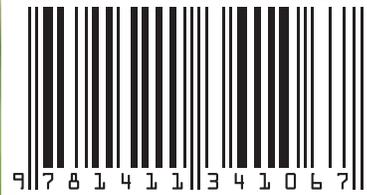
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