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Cooperative Fish and Wildlife Research Units Program—2020 Research Abstracts

Circular 1477

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

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Yellow-billed loon. Photograph by Ryan Askren, U.S. Geological Survey.

U.S. Geological Survey, Reston, Virginia: 2021

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Contents

Cosumnes River Preserve. Photograph by Bob Wick, Bureau of Land Management.

Abbreviations

>	greater than
AM	adaptive management
BCWD	bacterial coldwater disease
BLM	Bureau of Land Management
BMP	best-management practice
BOEM	Bureau of Ocean Energy Management
CWD	chronic wasting disease
DEER	deer-elk ecology
DNA	deoxyribonucleic acid
DNR	Department of Natural Resources
DoD	U.S. Department of Defense
EDC	endocrine disrupting compound
eDNA	environmental DNA
ESA	Endangered Species Act
ETS	electron transport system assay
GDE	groundwater-dependent ecosystem
GLRI	Great Lakes Restoration Initiative
GPS	global positioning system
I–80	Wyoming Interstate 80
MDC	Missouri Department of Conservation
MYY	Trojan male brook trout
NABat	North American Bat Monitoring Program
NASA	National Aeronautics and Space Administration
NCC	nutritional carrying capacity
NDVI	normalized difference vegetation index
NGO	nongovernmental organization
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NSF	National Science Foundation
PIT	passive integrated transponder
Reclamation	Bureau of Reclamation
ROW	right-of-way
S3 model	Salmonid Simulator Model
SAV	submerged aquatic vegetation
SDM	species distribution models
SGCN	species of greatest conservation need
SWAP	State Wildlife Action Plan
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTC	urban tree canopy
VCNP	Valles Caldera National Preserve
WLCI	Wyoming Landscape Conservation Initiative
WNS	white-nose syndrome
WRP	Wetland Reserve Program

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Introduction

The U.S. Geological Survey (USGS) serves as the research arm of the U.S. Department of the Interior and has established a series of strategic goals that focus its efforts on serving the American people. Within the USGS, the Ecosystems Mission Area is responsible for conducting and sponsoring research that addresses the following thematic objectives under the overarching strategic goal of "Science that Supports Our Resources in Wild and Urban Spaces, and the Landscapes In-Between":

- Science supporting a legacy of sustainable fish and wildlife,
- Social science and human components in land, water, and wildlife conservation,
- Trusted science supporting hard decisions on at-risk species,
- Science to battle costly biological threats,
- Providing science for managing risks and responding to extreme events,
- Science for preservation and restoration of iconic landscapes, and
- Science to support adaptation and address impacts of climate and land change.

This report provides abstracts of most of the ongoing and recently completed research investigations of the USGS Cooperative Fish and Wildlife Research Units program (CRU program). The report is organized by the following major science themes that contribute to the objectives of the USGS:

- Advanced Technologies
- Climate Science
- Decision Science
- Ecological Flows
- Ecosystem Services
- Energy
- Fish and Wildlife Health and Disease
- Human Dimensions
- Invasive Species
- Landscape Ecology
- Species and Habitat Management
- Species of Greatest Conservation Need
- Threatened and Endangered Species

About the Cooperative Fish and Wildlife Research Units Program

The CRU program meets the science and technical assistance needs of Federal, State, and local natural resource managers. Each of the 40 Cooperative Fish and Wildlife Research Units (CRUs), located in 38 States, is a partnership of the USGS, a State fish and wildlife agency, a host university, the Wildlife Management Institute, and the U.S. Fish and Wildlife Service (USFWS). Since 1935, this cooperative relationship has provided a strong connection between the USGS, Federal and State management agencies, and the national university community. Surveys of cooperators indicate a greater than 95 percent satisfaction rate with program execution. The CRU structure leverages cooperator resources to deliver program outcomes that exceed what any cooperator could achieve alone. The majority of CRU appropriated funding is invested in scientist salaries, with funding for research projects supplied by program partners. Collectively, the cooperators provide a three-to-one match for USGS funding. The program positions USGS scientists at universities to help identify and respond to natural resource information needs, coordinate pooling of resources among agencies, train and mentor graduate students, and assist Federal and other natural resource managers' access to university expertise and facilities.

The CRU program has a 3-part mission that has been consistent throughout the history of the program:

- Actionable research to meet cooperator science needs,
- Graduate education to develop the fish and wildlife science and management workforce of the future, and
- Technical assistance to cooperators on application and integration of new science.

Program direction for the CRUs comes at two levels that interact fluidly: (1) USGS Headquarters provides direction based on Department of the Interior, USGS, and USGS Ecosystems Mission Area priorities and national cooperators' needs; and (2) each Unit has a coordinating committee composed of USGS, other Department of the Interior partners, State, and university cooperators that formulate the ongoing research, education, and technical assistance duties of the individual Units. This combination of a centralized and grassroots direction yields a diverse portfolio without duplication where the total effect is greater than the sum of the parts.

Project Abstracts

Project abstracts are organized alphabetically by Cooperative Fish and Wildlife Research Unit within each of the thematic areas. Research conducted as part of the CRU program is determined, approved, and supported by each unit's coordinating committee composed of representatives from the USGS, one or more of the respective State fish and wildlife agencies, the host university, the Wildlife Management Institute, and the USFWS. The stakeholder-driven nature of the program's research portfolio is designed to ensure that the science aligns with the USGS's strategic goals and serves the needs of the U.S. Department of the Interior and the States, as well as the needs of their strategic conservation partners.

Scientific names for species referred to by their common names in the abstracts are listed in a table at the back of this book.

List of Projects

Kodiak brown bear. Photograph by Josh Blouin; used with permission.

Kodiak brown bear. Photograph by Josh Blouin; used with permission.

Advanced Technologies

American Fisheries Society Standard Fish Sampling Techniques and Environmental DNA for Characterizing Fish Relative Abundance, Biomass, and Species Composition in a Large Reservoir

Arizona Cooperative Fish and Wildlife Research Unit

Examining environmental deoxyribonucleic acid (eDNA) in water samples has demonstrated promise for identifying fish species present in water bodies. However, whether or not this same approach can be used to assess relative abundance, biomass, and species composition in large (greater than [>] 200-hectare) waterbodies is unclear. This research compared largemouth bass and gizzard shad catch at electrofishing and gill netting sites with their eDNA in water samples collected at those same sites. Results suggest that eDNA data can be used to characterize relative abundance and biomass across a large lake system, but its use may not be effective at smaller scales. Partners include the USGS and the Arizona Game and Fish Department.

Researchers collecting water samples. Photograph by the U.S. Geological Survey.

An Integrated Approach to Using YY Technology and Mechanical Control Methods for Invasive Fish Control

Arizona Cooperative Fish and Wildlife Research Unit

Nonnative fishes substantially affect native fishes through competition and predation. Targeted removal of the most harmful nuisance species has always been elusive. This research is examining the feasibility of producing supermales (males with an extra Y-chromosome) of short- and long-lived common, nonnative species of the southwestern United States that are invasive. The goal of this research is to demonstrate the feasibility of integrated control of nonnative species by first using mechanical removal to reduce the population and then stocking supermales to the population at different rates. This approach allows for the manipulation of the sex of fishes that will spawn with existing nuisance fishes to produce all-male progeny which, over time, could reduce and even eliminate nuisance populations. Partners include the USGS and the Bureau of Reclamation (Reclamation).

Assessing Modified Pre-Positioned Areal Electrofishing Devices for Surveying Fish Habitat Use in Desert Streams

Arizona Cooperative Fish and Wildlife Research Unit

Precise methods are commonly needed to characterize habitat use by fishes, especially for litigation and detailed habitat modeling. Pre-positioned areal electrofishing devices (PAEDs) that have been developed to survey stream fishes and create habitat suitability criteria are less intrusive than other electrofishing methods, and result in little to no flight response in fishes from the electrical stimuli. Various forms of pre-positioned areal electrofishing devices are being compared to establish a technique for effective fish sampling at remote sites that considers fright bias, fish mortality, and the size of the electrical field. Data can be used to design effective methods to sample stream fishes in remote areas with pre-positioned areal electrofishing devices when collecting microhabitat parameters. Partners include the USFWS and the U.S. Forest Service (USFS).

Black-Tailed Prairie Dog Taxonomy and Population Connectivity

Arizona Cooperative Fish and Wildlife Research Unit

The black-tailed prairie dog has declined throughout its range over the past century and was extirpated from Arizona in the 1960s. In 2008, black-tailed prairie dogs from New Mexico and Sonora, Mexico, were reintroduced in southern Arizona. Despite ongoing management efforts, little is known regarding the historical level of connectivity, taxonomic relatedness, and subspecies designation between populations native to Arizona and other populations in the southwestern United States and Mexico. This research uses modern and

museum samples, along with a whole genome approach, to examine taxonomic relatedness and the level of connectivity of the ancestral populations of black-tailed prairie dogs in Arizona compared to the rest of its range. Results can be used to aid reintroduction efforts by providing information on which extant black-tailed prairie dog species are most closely related to those formerly found in Arizona and to the reintroduced population. Partners include the Arizona Game and Fish Department.

Black-tailed prairie dog. Photograph by Dean Biggins, U.S. Geological Survey.

Comparing the Spherical Densiometer and Inexpensive Hemispherical Photography to Assess Streamside Canopy

Arizona Cooperative Fish and Wildlife Research Unit

Assessing coverage of riparian vegetation over streams is a common focus of fish habitat studies, stream surveys, and sampling protocols. The spherical densiometer and hemispherical photography have been used to collect such data, although the densiometer cannot document an ever-changing canopy, and hemispherical photography is typically expensive, time consuming, and highly susceptible to damage when used in aquatic environments. This study developed an inexpensive, fast, and rugged hemispherical photography system that can be used in aquatic ecosystems without damaging equipment. A comparison of data between densiometer readings and hemispherical photographs using action cameras demonstrated the reliability of the new technology. Hemispherical photography, with further development, can be a useful addition or alternative to measuring stream canopy with densiometers. Partners include the USGS, the USFWS, and the USFS.

Determine Relatedness of Certain Mexican Species of Bobwhite

Arizona Cooperative Fish and Wildlife Research Unit

The genetic relationships among Mexican subspecies of bobwhite are unclear but required for conservation planning. This study used contemporary and museum samples and a high-throughput targeted capture approach to examine taxonomic differences among relevant subspecies of Mexican bobwhite. Deoxyribonucleic acid (DNA) was extracted from 85 contemporary feather and tissue samples and from museum specimens in a dedicated ancient DNA laboratory. The study examined genetic relationships among bobwhite subspecies in the southwestern United States and Mexico. The newly gained taxonomic information was used to aid recovery efforts for the endangered masked bobwhite, particularly with respect to potential translocations into masked bobwhite areas from Mexico. Partners included the Arizona Game and Fish Department.

Developing Low-Cost, High-Definition Videography Methods for Documenting Underwater Flora and Fauna and Creating Education Presentations

Arizona Cooperative Fish and Wildlife Research Unit

Freshwater biotic communities are complex ecosystems that are typically unseen by the public. Education and outreach efforts about these ecosystems often required that fish and other organisms be brought to the surface or that expensive underwater video and camera techniques be used. However, biologists and educators can now inform the public with high-quality video due to greater accessibility of low-cost, ultrahigh-definition underwater cameras and enhanced processing power of personal computers. This project tested and developed inexpensive methods to film underwater aquatic ecosystems of southern Nevada and California. Results can provide biologists and educators with tools to effectively produce presentations of underwater viewscapes of freshwater ecosystems. Partners included the USFWS and the Nevada Department of Wildlife.

Publication

Ulrich, T.L., and Bonar, S.A., 2020, Inexpensive, underwater filming of rare fishes in high definition: Fisheries, v. 45, no. 3, p. 121–130, https://doi.org/10.1002/fsh.10391.

Genetic Diversity of Caracara in Florida

Arizona Cooperative Fish and Wildlife Research Unit

The caracara is an endangered raptor in Florida and occurs only in small populations in Texas and Arizona. Little is known about genetic diversity and genetic relatedness among populations within its range. This project developed microsatellite markers using whole genome sequencing, assessed genetic diversity of samples from Florida, and compared those samples with samples from Texas and Arizona. Genotypes from this study can be used to estimate population-level genetic characteristics, which can then estimate inbreeding, determine potential bottlenecks, and inform managers of the genetic health of this endangered population. This project is a collaborative effort between the USGS and Trinity College in Hartford, Connecticut.

Phylogeography of the Masked Bobwhite

Arizona Cooperative Fish and Wildlife Research Unit

The masked bobwhite, a subspecies of bobwhite, occurs in grassland habitats in the Sonoran Desert of Arizona and Mexico. The species is endangered primarily because of overgrazing, which has reduced the quality of grassland habitats in this ecosystem. This study seeks to better define the genetic relationship among nine subspecies of bobwhite by using genomic methods of data collection from samples of contemporary and ancient museum specimens. This study can support the captive breeding program for the subspecies by assessing changes to the genome of the subspecies since being brought into captivity, informing potential selection for captivity, and supporting management decisions for this subspecies related to genetic characteristics and traits. Cooperators include the USGS and the USFWS.

Restriction Site-Associated DNA Sequencing to Assess Behavior Ecology Genomics for Pumas on the Uncompahgre Plateau of Colorado

Arizona Cooperative Fish and Wildlife Research Unit

Hunting can exert selective pressure on the behavioral or biological traits of a wildlife population, but such effects can be difficult to measure on wildlife populations that are regularly harvested. This study focused on a population of puma in Colorado's Uncompahgre Plateau where hunting was eliminated for 5 years and then reinstated for 5 years, providing an opportunity to assess behavioral and biological traits with and without hunting. Results from this study can be used by wildlife managers to assist with making more-informed harvest regulations and limits for pumas. This project is in collaboration with the USGS, the Colorado Park and Wildlife Department, and the Summerlee Foundation.

Use of Citizen Scientists to Monitor Cameras for Jaguar and Ocelot Detection

Arizona Cooperative Fish and Wildlife Research Unit

Jaguars and ocelots are rare and secretive species across southern Arizona and southwestern New Mexico and are therefore difficult to find and monitor. A large-scale monitoring effort for these species uses remote cameras to detect individuals, but extensive investments of time are needed to retrieve data from the 200 cameras across the landscape. This study trained citizen scientists to collect these data and then compared them to similar information collected by scientists. This approach is being used to monitor eight mountain ranges in southern Arizona for jaguars and ocelots. Partners include the USGS, the USFWS, and the University of Arizona.

Using High-Definition Video Technology to Acquaint the Public with Cryptic Desert Fishes of the Southern Nevada-Death Valley Region

Arizona Cooperative Fish and Wildlife Research Unit

Desert fishes are cryptic and challenging to detect and monitor, which has led to a lack of awareness on the part of the public toward these unique fishes and their ecosystems. To address this knowledge gap and obstacle to conservation, low-cost videography presentations featuring the unique and often rare desert fishes of Nevada and Death Valley are being created to acquaint and educate the public with these species. By combining low-cost underwater and aerial imagery with widely recognized social psychology principles, the effectiveness of these presentations can be maximized. Partners include the USGS, the USFWS, and the Nevada Department of Wildlife.

Publication

Ulrich, T.L., and Bonar, S.A., 2020, Inexpensive, underwater filming of rare fishes in high definition: Fisheries, v. 45, no. 3, p. 121–130, https://doi.org/10.1002/fsh.10391.

Using a Mechanistic Model to Develop Management Strategies to Cool Apache Trout Streams Threatened by Climate Change

Arizona Cooperative Fish and Wildlife Research Unit

This project used the field-tested Stream Segment Temperature model to simulate how altering discharge, groundwater input, channel wetted width, and shade prevents the temperatures of White Mountain, Arizona, stream reaches from exceeding the thermal tolerance of Apache trout under existing conditions and under a climate-change scenario. Simulations suggested increasing shade, either through streamside planting of specific numbers and species of plants or by other means, would be most effective and feasible for cooling the stream reaches studied. Existing models provide suggestions to cool stream reaches. Further development of accessible software packages that incorporate evaporation, fragmentation, and other projected climate-change effects into their routines can provide additional tools to help manage climate-change effects. Partners include the Arizona Game and Fish Department.

Publication

Baker, J.P., and Bonar, S.A., 2019, Using a mechanistic model to develop management strategies to cool Apache trout streams under the threat of climate change: North American Journal of Fisheries Management, v. 39, no. 5, p. 849–867, https://doi.org/10.1002/nafm.10337.

Integrating Spatial Data for Predicting the Effect of Altered Hydrologic and Thermal Conditions on Fish Assemblage Traits and Taxa Across Stream Flow Regimes

Arkansas Cooperative Fish and Wildlife Research Unit

Hydrologic and thermal gradients strongly affect the fitness of individual fish species and the species' success by imposing fundamental constraints on behavior, metabolic rates, reproduction, growth, and ecological interactions. Stream hydrology and water temperature are also among the most-altered components of lotic systems because of human activities and other environmental disturbance. The Interior Highlands (Oklahoma, Arkansas, and Missouri) and Gulf Coastal Plains regions are characterized by high biological diversity and species endemism, in addition to a rapidly growing human population dependent on freshwater resources. The goal of this project is to leverage high-performance computing resources at the University of Arkansas and through the Google Earth engine to quantify the effect of hydrology, temperature, and landscape change on fish and aquatic macroinvertebrate assemblages. Researchers intend to link large species' taxonomic and functional trait databases with information derived from the USGS national streamgaging network and with satellite remote-sensing data; these data include daily precipitation from the National Aeronautics and Space Administration (NASA) Integrated Multi-satellite Retrievals for Global Precipitation Measurements and daily land-surface temperature and emissivity from the NASA Moderate Resolution Imaging Spectroradiometer. Results can indicate substantial hydrologic, temperature, and land-use thresholds for individual fish species and functional traits and can be used to address important natural resource questions at local, regional, and national scales.

Snapshot USA Project

Arkansas Cooperative Fish and Wildlife Research Unit

The need for baseline data regarding the abundance and distribution of wildlife populations continues to grow as natural areas continue to be developed and fragmented. Snapshot USA is a project intended to facilitate data contribution to a national, public wildlife database. These data could be used to examine nationwide trends in mammal community assembly rules associated with natural environmental and anthropogenic filters. Collaborators for all 50 States intend to contribute camera trap data from a standardized camera trap array at the same time from each site, and the Smithsonian Institution plans to compile and lead efforts to analyze data. Results could provide information regarding the occupancy of mesopredators, activity patterns of animals nationwide, and relative density of several common species of mammals. This database could be one of the largest repositories for images from camera traps and could provide the raw material for numerous large-scale ecological examinations of mammal populations.

Using Hydrophones to Survey for Underwater Calling Frogs

Arkansas Cooperative Fish and Wildlife Research Unit

A key step in conserving wildlife is understanding where species occur and how many individuals are present. Audio surveys are commonly used to collect such data for species that vocalize in a way that is readily audible to the human ear or to recording devices (for example, birds and frogs). However, emerging research indicates that some frogs primarily or exclusively call underwater, and these vocalizations rarely break the air-water surface and are unlikely to be detected by surveyors. Therefore, to determine if an efficient and cost-effective method can be established to document the presence, distribution, and abundance of several imperiled frog species that primarily call underwater, a novel method using hydrophone recorders is being tested at sites in Georgia, Arizona, and Arkansas. This tool, if successful, could provide land managers with an innovative and

important new method to survey for, and then conserve, these imperiled species. Partners include the USGS, Cornell University, and the U.S. Army Corps of Engineers (USACE).

Characterizing Marine Faunal Community Composition Across the Gulf of California Using Next-Generation Sequencing of eDNA

California Cooperative Fish and Wildlife Research Unit

Sampling for the presence of organisms in remote marine habitats can be challenging. Water samples can, however, yield signatures of fish, mammals, and birds that have recently contacted the water through eDNA, which is being increasingly used as a noninvasive sampling method for presence and abundance. This project sampled 37 sites throughout the Gulf of California. eDNA samples collected from those sites can be sequenced with high-throughput sequencing and analyzed bioinformatically to determine the amount of DNA signal for each taxonomic group present in the samples. Fish and invertebrates were surveyed simultaneously using conventional approaches, allowing for the calibration of eDNA signal strength in an open ocean environment. Results could determine the spatial limits of eDNA and provide targeted monitoring of stocks of ecologically and commercially significant marine species.

Comparing Standard and eDNA Methods for Estimating Chinook Salmon Smolt Abundance in the Klamath River

California Cooperative Fish and Wildlife Research Unit

Successful management of Chinook salmon requires that smolt abundance during seaward migration be determined. The use of eDNA to determine smolt abundance has distinct advantages compared to standard monitoring. Some of these benefits are that eDNA is cheaper, noninvasive, and less likely to be constrained by high-water flows and debris that may cause flawed sets and (or) dangerous conditions for field surveying. The goal of this study is to provide eDNA-based estimates of weekly smolt abundance of Chinook salmon within the main stem of the Klamath River by comparing standard and eDNA-based estimates of weekly and seasonal totals of Chinook salmon at the Kinsman site, Klamath River. Results can be used to supplement or potentially replace standard sampling methods and can serve as a foundation and justification for applying the eDNA methods to other areas within the Klamath and Trinity River watersheds and the Pacific northwest and to other commercially, recreationally, and tribally important species.

Juvenile Rearing Distribution of Threatened Coho Salmon at Habitat Restoration Sites on the Hoopa Valley Reservation

California Cooperative Fish and Wildlife Research Unit

Coho salmon seem to be at very low abundance in streams on the Hoopa Valley Reservation; therefore, relying only on visual observation and capture of coho salmon is likely to underestimate the extent of their distribution. The goal of this project is to combine standard visual surveys with eDNA sampling to determine the presence of coho salmon. This multimethod approach can also provide insight into the potential for eDNA surveys to evaluate small-scale patterns in coho salmon distribution associated with restoration activities. The Hoopa Valley Tribe recently made substantial investments in habitat restoration and improvement projects to aid in coho salmon recovery in streams on Tribal land. Results of this project can provide information necessary to assess coho salmon use of restored and unrestored sites to guide future restoration efforts. This project is a collaboration among the USGS, the Hoopa Valley Tribe, and Humboldt State University.

Is a Novel Cat Collar Cover More Effective at Stopping Domestic Cats from Killing Birds at Higher Latitudes?

Florida Cooperative Fish and Wildlife Research Unit

This project examines a novel conservation tool, a cat collar cover, that has the potential to be effective at keeping domestic cats from killing songbirds. The goal of this research is to determine if the effectiveness of the collar cover changes depending on the latitude. Because birds at higher latitudes have a shorter breeding season and a concurrent higher spike in testosterone than birds at lower latitudes, it has been posited that the more “distracted” breeding birds in the northern latitudes will show a higher magnitude difference in predation by cats with and without the collar cover. Results can be used to better manage human-wildlife conflict as it pertains to pets and wild birds and can provide excellent outreach opportunities to nongovernmental organizations (NGOs) and the public.

An Interdisciplinary Approach to Building Data Literacy in Wildlife Survey Technologies

Maine Cooperative Fish and Wildlife Research Unit

Many of Maine's nesting seabird species are difficult to survey, which often prohibits accurate population assessments in the coastal habitats that are critical to their persistence. Consequently, this research uses Gulf of Maine colonial nesting birds as the focal species to develop surveys, image collection and processing, and data analysis methods and technologies that are transferable to other taxa and survey goals. The research intends to compare nesting seabird data collected during airplane, unmanned aerial system, and ground-based surveys to examine effects of platforms, sensors (type, spatial, and temporal resolution), timing, and deployment approaches on species' detectability, counts, and behaviors. These surveys traditionally require substantial time for interpretation by observers, so automating the interpretation and counting process is expected to increase the precision, accuracy, and affordability of these surveys. Results of this research could include artificial intelligence and machine learning detection algorithms to process the imagery; toolkits that include instructions for best practices of combining unmanned aerial system surveys, traditional survey methods, and automated analysis for conducting population assessments; and a user interface that can be accessed by professionals and citizen scientists in applications requiring coastal wildlife monitoring. Partners are the USFWS and the Maine Department of Inland Fisheries and Wildlife.

The Maine Geospatial Institute—A Statewide Collaboration for Workforce Development, Education, and Research to Facilitate Economic Growth

Maine Cooperative Fish and Wildlife Research Unit

The Maine Geospatial Institute was developed to support economic growth; workforce development; and education and research in geospatial technologies used in transportation, municipal and county government, environmental services, resource management, and utilities. Maine has a substantial geospatial technology sector, and training students to understand and use these technologies can prepare them for diverse careers. This research is committed to taking this workforce development out of the campus and classroom and into the surrounding communities through K–12 and continuing education opportunities, workshops, and clinics to increase literacy in spatial science. These efforts are concentrated in three areas: education and research; information, technology transfer, and infrastructure; and community outreach. The Maine Geospatial Institute is linking the education and research sector to industry, facilitating technology transfer, project collaboration, and research and development partnerships. The Maine Geospatial Institute is a collaboration of the seven campuses of the University of Maine System and intends to develop partnerships with State and Federal agencies, industries, municipalities, and other universities in Maine.

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

Mississippi Cooperative Fish and Wildlife Research Unit

Effective conservation planning requires reliable information on the geographic distribution of organisms. Unfortunately, this information is commonly incomplete for many species, especially for rare ones, because of scanty observation data. Species distribution models (SDMs) are highly valuable in determining critical remaining and potential habitats of at-risk species for conservation planning. An important framework that could benefit from SDM is the Species Status Assessment developed by the USFWS. The Species Status Assessment considers multiple elements associated with species condition, including distributions, but standard requirements to estimate species distributions do not exist. This research intends to find an optimal SDM approach for at-risk species that can be considered for the Species Status Assessment and similar species monitoring efforts. Results of this work could be extended in the Southeast to address other at-risk species and could incorporate models of future urbanization and climate change to predict future changes to distributions.

Improving Ungulate Sampling Efficiency and Population Estimation in Idaho

Montana Cooperative Wildlife Research Unit

Traditional estimation of mule deer and elk populations rely heavily on aerial surveys and radio telemetry. Safety, efficiency, and cost-effectiveness raise fundamental questions about how best to estimate such populations in the future. The goal of this study is to research the cost-benefit analysis of helicopter use, survival rate, and data weighting. Managers face a fundamental tradeoff when deciding on methods for monitoring animal populations: are the data obtained worth the cost and potential risk to human life? This work quantifies such tradeoffs, allowing managers to make these decisions objectively. This work provides managers with a tool that considers budget constraints, personnel safety, and public expectations to determine the optimal monitoring method. Cooperators include the University of Montana and Idaho Fish and Game.

Novel Ecological Uses for Unmanned Aerial Vehicles

Nebraska Cooperative Fish and Wildlife Research Unit

Wildfire and prescribed fires present dangers to humans but can be critical for maintaining and managing ecosystems. Implementing prescribed fires in remote areas can be problematic and life threatening because of a variety of factors such as rough terrain and uncertain weather conditions (increasing or shifting winds). This project developed a prototype unmanned aerial vehicle to remotely ignite controlled burns to help manage grasslands, including the reduction of woody invasive species such as eastern red cedar. The prototype was used to ignite a large prescribed fire in the Loess Canyons of Nebraska and a public burn at the National Park Service's (NPS's) Homestead National Monument of America. These burns were deemed successful, and funding has been secured to continue developing and enhancing this technology. Partners include the National Science Foundation (NSF) and the Nebraska Game and Parks Commission.

Publication

Beachly, E., Higgins, J., Laney, C., Elbaum, S., Detweiler, C., Allen, C., and Twidwell, D., 2017, A micro-UAS to start prescribed fires in Kulić, D., Nakamura, Y., Khatib, O., and Venture, G., eds., 2016 International Symposium on Experimental Robotics: Cham, Switzerland, Springer International, Springer Proceedings in Advanced Robotics series, p. 12–24, https://doi.org/10.1007/978-3-319-50115-4_2.

Abundance and Habitat-Related Use of White Sands Pupfish

New Mexico Cooperative Fish and Wildlife Research Unit

Fish sampling in desert ciénega systems is logistically challenging. The small size of the White Sands pupfish adds to the monitoring challenge. Although these fish are locally abundant, they are short-lived and can alter their reproductive strategy as environmental conditions change. Use of minnow traps with an index of abundance (in other words, catch-per-unit-effort) for White Sands pupfish can be affected by basic methodological choices such as trap soak time (that is, effort), as well as the timing and trap placement. This project tested sampling techniques to provide alternative methodologies to natural resource managers tasked to monitor the species. Research results provided more defensible alternatives to the use of passive-capture traps in characterizing White Sands pupfish populations throughout a desert ciénega. Collaborators include the Environmental Stewardship Branch of the Department of the Army, White Sands Missile Range, New Mexico.

Male Brook Trout as an Eradication Tool of Wild Brook Trout Populations in New Mexico

New Mexico Cooperative Fish and Wildlife Research Unit

In New Mexico, native Rio Grande cutthroat trout populations are declining because of habitat loss and competition from nonnative brook trout. To date, viable removal options for nonnative brook trout have been limited to chemical piscicide and manual removal. Piscicides are effective but are nontargeted and kill desired species, and manual removal has a low success rate. A novel, genetic-based approach, the development of the Trojan male brook trout (hereafter, referred to as MYY), may offer a species-specific and cost-effective method of eradicating invasive brook trout. MYY produces only male offspring and could theoretically drive the wild brook trout population to 100 percent males and eventual eradication. The goal of this project is to assess the efficacy of MYY to shift sex ratios of selected populations of wild brook trout toward all male fish and eventual eradication. The results have substantial widespread potential if the MYY approach is successful as a targeted and efficient management tool for eliminating undesired species to enhance future conservation efforts of native fishes. Collaborators include the New Mexico Department of Game and Fish and the USFS.

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

New York Cooperative Fish and Wildlife Research Unit

Advances in new technologies such as remote cameras, noninvasive genetics, and bioacoustics provide massive quantities of electronic data. Much work has been done on automated (machine learning) methods of classification that produce sample class designations (for example, identification of species or individuals) that are regarded as observed data in ecological models. However, these data are derived quantities (or synthetic data) and subject to various important sources of bias and error. If the derived quantities are used to make ecological determinations without considering these biases, those inferences that inform monitoring, conservation, and management could be flawed. The goal of this research is to develop the concept of coupled classification in which statistical classification models are linked to ecological models of species abundance or occurrence. In this new framework, classification (for example, species identification) accounts for the local structure of populations, communities, and landscapes and does not assume that the sampling location is independent of the population's class structure, which is common practice. The work is transformative and has widespread application

because it provides a mechanism for directly integrating remotely sensed "big data" with ecological models while accounting for misclassification. It also has the possibility of fully automating data collection and processing systems.

Conservation Finance for Fisheries

New York Cooperative Fish and Wildlife Research Unit

Presently (2020), there is a global conservation gap, whereby the funds necessary to conserve Earth's resources are insufficient. Government and philanthropic funds are insufficient to meet this need. In response to this gap, new efforts to link private capital with investment opportunities that achieve financial return and improve environmental and social sustainability of natural resources—conservation finance—have emerged. This project is synthesizing the state of conservation finance for fisheries. Results from this work intend to raise awareness of this exciting new field with a goal of attracting interest across scientific fields and catalyzing the rate of investments to improve fisheries sustainability. Partners include the Atkinson Center for a Sustainable Future.

Novel Approaches to Big Problems—Integrating Citizen Science to Monitor and Estimate Black Bear Populations in New York

New York Cooperative Fish and Wildlife Research Unit

Black bears are an important game species in New York State. In the past two decades (2000s and 2010s), the bear population in the State has been growing because of conservative bear management and increasing anthropogenic resources. Successful management of the bear population requires estimating population and home range sizes and understanding patterns of resource selection and population density in relation to land cover. To collect spatially representative data for such a large region, approaches to sampling that supplement intensive, traditional capture-recapture and occupancy methods are needed. The goal of this project is to develop a conceptual framework for joining noninvasive citizen science efforts with telemetry, spatial capture-recapture, and occupancy methods into a single integrated population model for managing black bears. This integrated approach can be valuable for identifying patterns of black bear distribution, resource selections, and movement across a range of spatial scales. This framework will provide a more mechanistic understanding of black bear population dynamics and help the development of a comprehensive black bear management plan in New York. Partners include the New York State Department of Environmental Conservation.

Publications

Sun, C.C., Fuller, A.K., Hare, M.P., and Hurst, J.E., 2017, Evaluating population expansion of black bears using spatial capture-recapture: The Journal of Wildlife Management, v. 81, no. 5, p. 814–823, https://doi.org/10.1002/jwmg.21248.

Sun, C.C., Royle, J.A., and Fuller, A.K., 2019, Incorporating citizen science data in spatially explicit integrated population models: Ecology, v. 100, no. 9, article e02777, https://doi.org/10.1002/ecy.2777.

The Next Frontier in Bioacoustics—Modeling Sound Attenuation and Individual Space Usage to Estimate Density of Animal Populations

New York Cooperative Fish and Wildlife Research Unit

Population density is a metric commonly used to assess species status; however, estimating the density of species that are difficult to identify visually is challenging. Passive acoustic monitoring is a new survey method with the potential to provide quick and reliable population density estimates for species that are easy to detect acoustically; however, statistical methods that reliably produce on-site density estimates from acoustic data depend on human interpretation of call rates. This research intends to extend and evaluate statistical models to estimate density by incorporating information about the spatial structure of endangered gibbons using acoustic sampling data from the population in Borneo, Indonesia. Results could demonstrate how bioacoustic detectors can be used to estimate the density of other species that can be detected acoustically, leading to more reliable conservation and land-use decisions worldwide for any vocalizing species. Partners include the Atkinson Center for a Sustainable Future.

Assessing the Value of Prior and Novel Information in Managing a Mixed-Stock Recreational Chinook Salmon Fishery

Oregon Cooperative Fish and Wildlife Research Unit

Mixed-stock fisheries are notoriously difficult to manage. When different stocks have varying levels of abundance, productivity, and vulnerability to fishing pressure, fishery managers commonly are faced with the competing objectives of protecting the more vulnerable stocks while maximizing sustainable harvest on remaining healthy stocks. The efficacy of mixed-stock fishery management is challenged by the degree of uncertainty in preseason run size forecasts, creel surveys, and tagging data to assess in-season exploitation rates for the different management stocks and changes in angling behavior. This project intends to develop an integrated approach to incorporate these sources of information to more effectively manage mixed-stock fisheries. Results can be used to develop needed tools (including novel assessment methods and regulatory options) and systemic understanding necessary to promote effective management of a mixed-stock fishery in the face of existing conservation priorities and changing angler behavior. Partners include the Oregon Department of Fish and Wildlife.

Monitoring Success of Farm Bill Programs in Conserving Avian Wildlife

South Carolina Cooperative Fish and Wildlife Research Unit

The purpose of this study is to evaluate a new tool to monitor the effectiveness of, and inform, Farm Bill incentive programs related to avian species of conservation concern. Researchers intended to demonstrate the utility of new remote acoustical detecting technology to monitor avian community responses on private lands in South Carolina. Findings may provide guidance on improved monitoring effectiveness of incentive programs and provide unique insights into how such technology can be used to identify areas of future focus. The project could also evaluate the transferability of this technology and provide several trainings and a technical manual on how managers, field personnel, and landowners can use acoustic monitoring devices to monitor for avian species. The project is a collaboration with the U.S. Department of Agriculture (USDA) Natural Resource Conservation Service (NRCS) and the South Carolina Department of Natural Resources (DNR).

Publication

Wood, J.M., Tegeler, A.K., and Ross, B.E., 2020, Vegetation management on private forestland can increase avian species richness and abundance: The Condor—Ornithological Applications, v. 122, no. 4, 16 p., https://doi.org/10.1093/condor/duaa048.

Research on Data Integration

South Carolina Cooperative Fish and Wildlife Research Unit

Combining multiple sources of data is a new area of research, and developing new models allows for the integration of data sources from different data streams to better inform management and conservation. This project, in partnership with the South Carolina DNR, Environment and Climate Change Canada, and the NRCS, is investigating several developments related to data integration approaches including combining multiple data sources and power analyses for integrated population models on various projects related to data integration. The research could inform potential conservation efforts related to a wide variety of vertebrate species.

An Investigation of Transmitter Effects on Bird Hunting and Capture Success

Texas Cooperative Fish and Wildlife Research Unit

Radio and global positioning system (GPS) transmitters are common, if not critical, tools in current use for wildlife research. However, transmitters have received little critical evaluation concerning their effect on predatory bird hunting effort and capture success, or their effect in terms of handicapping prey. Transmitters are commonly used for assessments of survival and causes of mortality. Yet, if they are presenting unknown negative effects, current knowledge of survival rates and causes of mortality may be biased and inaccurate. Collaborating with the Rolling Plains Quail Research Ranch, this study is conducting field trials to better understand the effects of transmitters of different weight and attachment method. Data from the study could provide a clearer understanding of the effect of different transmitters size and weights on the flight effort of raptors and if radio-tagging of prey birds influences the extent to which these birds are targeted by raptors.

Developing an Automated System for Screening Wildlife

Texas Cooperative Fish and Wildlife Research Unit

Trail cameras are commonly used to monitor wildlife in a variety of situations. These motion-activated cameras can result in a huge volume of digital images, many of which do not contain animals. The screening process to remove images without an animal is time and labor intensive. The goal of this study is to develop a machine-learning method that will allow an automated process to determine images that do and do not have wildlife present. Those with positive detections can then be sent to a folder for human evaluation. If this process is successful, it could provide substantial cost savings to agencies and other researchers using motion-activated cameras as part of research, monitoring, or both programs.

Satellite Monitoring of Wildlife Habitat in Utah

Utah Cooperative Fish and Wildlife Research Unit

This project, in collaboration with Utah State University, intends to derive daily normalized difference vegetation index (NDVI) data from 2000 to 2014. The NDVI is a satellite-derived metric of the reflectance of photosynthetic biomass. The NDVI is available through terraPulse at daily, 500-meter (m) resolution from atmospherically corrected estimates of red and near-infrared surface reflectance from the MODerate-resolution Imaging Spectroradiometer sensors aboard the NASA Aqua and Terra satellites. Raw measurements are subject to extensive processing, in which data are masked for snow, cloud, and high aerosols and are corrected for distortions produced by variation in solar angles. The second phase of the project in year 1 would entail developing a web-based mapping prototype to help visualize the NDVI data for the area of interest. This prototype hosted at terraPulse could be made available to project collaborators for testing purposes.

Understanding and Quantifying Fish Movement, Habitat Use, and Survival Through Passive Integrated Transponder Tag Technology

Utah Cooperative Fish and Wildlife Research Unit

Beginning in the 1990s, recovery programs throughout the Colorado River Basin have relied on passive integrated transponder (PIT) tagging to individually mark fish, which allows researchers to track fish over time and eventually provide population estimates. These population estimates are critical to determining the effects of management actions and lead to decisions on whether the fish populations can recover and be delisted. The goal of this project is to assist Reclamation in the continued technological development of fish-detection systems, specifically those related to PIT tags. The project also strives to analyze and store the data derived from these systems and to see how they relate to management of Reclamation facilities and waters. This is a collaborative project among the USGS, Utah State University, and Reclamation and has direct benefit to the Upper Colorado and San Juan River Recovery programs.

Publication

Stout, J.B, Conner, M.M., Budy, P., Mackinnon, P.D., and McKinstry, M.C., 2019, We ain't afraid of no ghosts—Tracking habitat interactions and movement dynamics of ghost tags under differing flow conditions in a sand-bed river: North American Journal of Fisheries Management, v. 39, no. 6, p. 1337–1347, https://doi.org/10.1002/nafm.10371.

Developing Distribution Models for Select Wildlife Species in Utah

Utah Cooperative Fish and Wildlife Research Unit

Arguably, the most fundamental need for effective land and wildlife management is for managers to know the location, whether actual or potential, of the things they intend to manage. SDMs exist for most of Utah's wildlife species; however, these models are almost 30 years old, having resulted from the Utah Division of Wildlife Resources being one the first national collaborators to implement the Gap Analysis Program in 1989. The need for credible, usable species distributions is the largest of 12 assessed data gaps in Utah's Wildlife Action Plan, affecting 82 species or well over one-half of all those in the Wildlife Action Plan. This project is a structured approach to updating SDMs for select Utah wildlife species centered on a process that initially relies on extant information to construct distributional map products.

Unifying Mathematical and Statistical Approaches for Modeling Animal Movement and Resource Selection

Utah Cooperative Fish and Wildlife Research Unit

Modeling animal movement through landscapes is a key component to understanding population ecology, how populations can be managed, how human actions affect the population, and how the population could respond to anthropogenic change factors such as climate, urbanization, or both. Dramatic improvements in two critical types of data have recently occurred: remotely sensed environmental data and high-resolution animal location (telemetry) data. These data drive a statistical industry serving Federal and State wildlife management agencies, private companies, and academia. This is a collaborative project with Colorado State University and the South Dakota School of Mines and Technology. They plan to combine statistical approaches and mechanistic dispersal models, as well as develop a method for telemetry data analysis that accounts for migration barriers and

varying habitat. Developed tools could be applied to foraging ungulates in Utah, harbor seals in the Gulf of Alaska, and Canada lynx in Colorado.

Canada lynx. Photograph courtesy of Bill Byrne, MassWildlife; used with permission.

Research, Education, and Training in the Proper Application of Species Distribution and Habitat Models to the Management and Conservation of Plant and Animal Species

Utah Cooperative Fish and Wildlife Research Unit

Virtually all spatially based (landscape-scale) management and conservation rely, to some extent, on models of species distributions and habitats. At the level of the Endangered Species Act of 1973 (ESA, 16 U.S.C. §1531 et seq.), distributions are clearly integral to the vast bulk of ESA-related Federal Register documentation. However, for many species, the distribution map shows >25-year-old gap analysis outputs or locations tagged to land tenure units often the size of U.S. counties (that is, polygon based). None of these provide spatial resolutions needed for species and habitat management today. Training courses have been developed that can educate a wide range of scientists, students, and Federal and State biologists in the proper constriction of defensible Species Distribution and Habitat Models. The process can facilitate meeting user-specific research objectives related to Species Distribution and Habitat Models and their application to management. This project is a collaboration among the USGS, the Association of Fish and Wildlife Agencies, the USFWS Ecological Services Program, the USFWS National Conservation Training Center, and the Utah Division of Wildlife Resources.

Advancing Adaptive Management in the Riverside East Solar Energy Zone

Vermont Cooperative Fish and Wildlife Research Unit

The Riverside East Solar Energy Zone is a vast area in southern California designated for large-scale solar development. The Bureau of Land Management (BLM) is charged with monitoring wildlife in this area to minimize the effects of the solar production on wildlife species. However, consistent monitoring of wildlife across vast spatial landscapes over time has proven to be a daunting challenge. This study investigates if cell phones can be used as a primary monitoring tool for documenting wildlife occurrence through time and space and develops data management practices and software that allow rapid analysis and reporting. The primary product of this effort is the open-source software package AMMonitor. In a world confronting climate change and rapidly shifting land uses, cost- and time-effective methods for monitoring natural resources are critical to support scientifically informed management decisions. By combining remote data-collection methods with a streamlined data management and analysis feature, the AMMonitor software package supports the tracking of species occurrence, colonization, and extinction patterns through time, introducing the potential to place monitoring initiatives within an adaptive management (AM) framework. This project is a collaboration between the USGS and the BLM.

Researcher setting up a wildlife monitoring station; the cell phone is used to collect audio recordings. Photograph by the U.S. Geological Survey.

Publications

Balantic, C., and Donovan, T., 2019, Dynamic wildlife occupancy models using automated acoustic monitoring data: Ecological Applications, v. 29, no. 3, article e01854, 14 p., https://doi.org/10.1002/eap.1854.

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Balantic, C., and Donovan, T.., 2020, AMMonitor—Remote monitoring of biodiversity in an adaptive framework with R: Methods in Ecology and Evolution, v. 11, no. 7, p. 869–877, https://doi.org/10.1111/2041-210X.13397.

Wildlife Monitoring in the U.S. National Parks with Cell Phones

Vermont Cooperative Fish and Wildlife Research Unit

The Indiana Dunes National Park is a model of active restoration of wetlands and savannas. Monitoring in real time can provide feedback on whether management activities have been successful in achieving the Indiana Dunes National Lakeshore's management objectives. The purpose of this pilot research effort is to test a protocol for incorporating wildlife monitoring and analysis into the Indiana Dunes National Lakeshore's Resource Stewardship Strategy. The use of cell phones to collect and transmit wildlife data is novel and has the potential to substantially benefit science, the local community, and recreational and educational opportunities. Cell phones can be used to collect and transmit acoustic data and imagery automatically, focusing primarily on monitoring wildlife species that vocalize, including birds and amphibians. This pilot study intends to place the Indiana Dunes National Lakeshore's Resource Stewardship Strategy into an AM framework, which can facilitate management decisions in the future. The project is a collaboration between the USGS and the NPS.

Development of an eDNA Protocol for Detecting Candy, Variegate, and Kanawha Darters

Virginia Cooperative Fish and Wildlife Research Unit

Three species of saddle darters (candy, variegate, and Kanawha) occur in Virginia. All are rare and difficult to sample because of their preference for fast riffle habitat. Better understanding of the distribution of saddle darter populations could inform management planning and enhance the cost effectiveness of management actions. Future surveying efforts for saddle darters could benefit from tools that help identify streams with high probabilities of occupancy, as well as from sampling methodologies that are rapid, noninvasive, cost effective, and exhibit high detection probability. This project seeks to develop a set of eDNA markers and protocols that selectively amplify the DNA marker of the candy, variegate, and Kanawha darters within ambient water samples, and to use field studies to develop a preliminary estimate of the detectability of their eDNA in streams where the darters occur. Results from the study could allow researchers to make recommendations on the use of eDNA techniques in subsequent studies of saddle darters in Virginia. The project is a collaboration among the USGS, the Virginia Department of Game and Inland Fisheries, and Virginia Polytechnic Institute and State University (Virginia Tech).

Developing a High-Throughput Marker Panel for Lake Sturgeon to Standardize Analyses Across the Great Lakes

Wisconsin Cooperative Fishery Research Unit

Lake sturgeon are a culturally and ecologically valuable fish in the Great Lakes region that have experienced substantial population declines over the past century. This project intends to develop a new genetic tool for lake sturgeon that can facilitate parentage analysis and stock identification. This tool could allow researchers to answer important questions about lake sturgeon distributions and reproductive biology that can help to inform management. This project is a collaboration with multiple geneticists from the Université Laval, Michigan State University, and West Virginia University.

Developing eDNA Metabarcoding Methods to Identify Invasive Species and Examine Community Structure

Wisconsin Cooperative Fishery Research Unit

eDNA surveillance has the potential to make traditional fishery surveys and detection of invasive fishes more efficient and economical, but the development and standardization of this tool has been inefficient because of focusing on individual species. This project intends to use survey data and a comprehensive life-history database for fishes captured in the Upper Midwest to evaluate the utility of different eDNA sampling techniques with present and past catch data and to identify which life-history traits correlate with eDNA detection. The model could be incorporated into an electronic interface that natural resource managers and scientists can use to assist in decision making and to more

efficiently manage invasive fishes at regional and national scales. The project is a collaboration of researchers across multiple agencies and includes the USGS, the University of Wisconsin-Stevens Point, and the University of Wisconsin-Madison Center for Limnology.

Developing eDNA Techniques for Detecting Endangered Purple Cat's Paw Pearly Mussel and Snuffbox

Wisconsin Cooperative Fishery Research Unit

Populations of freshwater mussels have undergone substantial declines, leading to multiple ESA listed and extinct species. It is difficult to detect remnant individuals using traditional survey methods because of low abundance. eDNA shed from mussels can be used to detect them in low abundances and in environments where traditional surveys are not feasible. However, developing eDNA methods for mussels is necessary to use this technique. This project intends to develop eDNA tools that can be used to detect populations of endangered mussels, including the purple cat's paw pearly mussel and snuffbox. This research is a collaboration among the USGS, the USFWS, the University of Wisconsin-Stevens Point, and the Wisconsin DNR.

Evaluating Car Counters and Trail Cameras for Estimating Angler Effort on Wisconsin Lakes

Wisconsin Cooperative Fishery Research Unit

Angler effort can affect the quality and long-term sustainability of fish. Angler effort is typically estimated using creel surveys, although surveys are rarely conducted on most lakes because of costs and logistics. When creel surveys are possible, small sample sizes (few interviews) may lead to large variance and poor confidence intervals associated with estimates of effort. The objective of this study was to determine if low-cost remote vehicle counters can be used to estimate trends in angler effort. Researchers compared vehicle counter results to boat ramp use determined from trail cameras deployed at 14 study lakes. Results suggest vehicle counters can be used to remotely monitor trends in angler effort on some water bodies. Vehicle counters could provide more accurate estimates of temporal trends in angler effort through continuous monitoring at many lakes compared to sporadic counts conducted during traditional creel surveys. This study is a collaboration among the USGS, the University of Wisconsin-Stevens Point, and the Wisconsin DNR.

Using Genomics to Improve Stock Structure Resolution and to Assess Recruitment Dynamics of Lake Whitefish in Lake Michigan

Wisconsin Cooperative Fishery Research Unit

Lake whitefish support economically and culturally important fisheries on Lake Michigan, but evidence suggests that recruitment failure is occurring in some areas, whereas recruitment seems to be increasing in other locations. The lake whitefish population in Lake Michigan consists of multiple stocks, and mixing of these stocks does occur. Recent (2020) trends in lake whitefish abundance suggest previous methods used to assign lake whitefish to specific stocks may no longer be completely valid. Genomics represents a new tool that provides fishery managers with the Wisconsin and Michigan Departments of Natural Resources, the Sault St. Marie Tribe of Chippewa Indians, and the Little Traverse Bay Bands of Odawa Indians with an improved method for spatially allocating harvest to ensure that individual lake whitefish stocks are managed sustainably. Initial results suggest that previous conclusions regarding lake whitefish stock structure are not consistent with current (2020) conditions in some parts of Lake Michigan. Specifically, a new stock was identified in Green Bay, and some stocks that were designated as separate units are not as divergent as previously thought. These results highlight the need for changes in the way lake whitefish are managed.

Monitoring Elk Migrations with Remote Photography

Wyoming Cooperative Fish and Wildlife Research Unit

Most elk population estimates are based on data collected from aerial surveys. Although aerial surveys are an excellent source of data, they are costly and dangerous. Recent wildlife underpass projects and pilot projects to monitor migratory elk populations suggest digital cameras may obtain accurate estimates of annual elk population trends as animals move through migration bottlenecks during their spring and fall migrations. This project intends to evaluate the use of remote cameras to monitor population dynamics and migration patterns of elk in northwest Wyoming.

Climate Science

Quantifying Temperature and Metabolic Patterns for Nongame Riverine Fishes with Potential for Assessing Fish Tolerances Below Dams

Alabama Cooperative Fish and Wildlife Research Unit

Climate uncertainty and increasing water demands for multiple uses present challenges for provision of suitable instream water-quality conditions for natural resources. The diversity of aquatic organisms in the southeastern United States presents a major challenge when trying to set reasonable and effective temperature and dissolved-oxygen requirements. A temperature regime tolerated by one species may be stressful or fall outside the range of tolerance to another. An innovative approach—electron transport system assay (ETS)—has been recently proposed by researchers that could be used as a screening tool to determine and compare optimal and stressful thermal regimes among species. The ETS provides a quantitative measure of the potential oxygen consumption rate of an organism if all enzymes function maximally, and the relation between ETS enzyme activity and temperature may be used as an indicator of thermal tolerance for some species. Therefore, this project is evaluating ETS as a screening tool to distinguish among organisms with varying tolerance levels. Results could be of great value to the Alabama Department of Conservation and Natural Resources, the USFWS, and private dam operators because they can provide quantitative evidence as to whether measured temperature regimes below dams provide nonstressful conditions, especially for species of interest. These data could inform decisions for modification of flow releases to minimize stress to downstream organisms and inform decisions relative to flow regulations associated with dam relicensing.

Application of an Integrated Ecosystem Model—A Multi-Institutional and Multidisciplinary Effort to Understand Potential Landscape, Habitat, and Ecosystem Change in Alaska and Northwest Canada

Alaska Cooperative Fish and Wildlife Research Unit

Natural resource managers and decisionmakers require an improved understanding of the potential response of ecosystems to climate change in Alaska and northwest Canada. The Integrated Ecosystem Model for Alaska and northwest Canada was developed to meet this need. The Integrated Ecosystem Model integrates the driving components for, and the interactions among, disturbance regimes, permafrost dynamics, hydrology, and vegetation succession and provides an improved understanding of the potential response of ecosystems to climate change. The projections produced by the Integrated Ecosystem Model can facilitate integration of how landscapes may respond to climate change into resource-management decisions.

Assessing the Resilience of Southeast Alaskan Salmon to Shifting Temperature and Discharge Regimes Using a Life-Cycle Perspective Coupled with Community-Based Monitoring

Alaska Cooperative Fish and Wildlife Research Unit

Salmon that spawn and rear in forest streams of southeast Alaska are important to the region's economic vitality and cultural identity. Environmental changes, including climate change, that compromise the ability of these streams to support salmon could undermine the capacity of streams in the region to support productive fisheries by altering water temperature and flow regimes and, subsequently, freshwater life stages. This project intends to use climate scenario planning sessions to educate communities about how to prepare for, and adapt to, environmental change. The presenters may showcase user-friendly versions of life-cycle models and explain model results to project partners and residents of southeast Alaska. This project is a collaboration among the University of Alaska Fairbanks, the USFS, and the Southeast Alaska Watershed Coalition.

Climate Change Effects on Kenai River Salmon

Alaska Cooperative Fish and Wildlife Research Unit

How shifts in the water temperature regime may affect juvenile salmon freshwater rearing habitat depends on the local temperature and food conditions, neither of which are well characterized for the Kenai River watershed. Regional stakeholders in the Kenai Peninsula are concerned about the future of salmon populations in the face of climate change. A more detailed understanding of how environmental variables affect juvenile salmon growth rates could help inform how these fish will fare in a changing landscape. This project intends to characterize how juvenile Chinook and coho salmon growth rates respond to projected rising water temperatures across diverse landscape settings and examine the degree to which stream temperature monitoring sites in lower reaches are representative of upstream thermal conditions. Project results could provide support to the growing consensus that diverse habitats within a watershed support diverse early life-history opportunities for juvenile salmon and underscore the regional variability of climate change effects on Pacific salmon life cycles.

Effects of Large-Scale Climate Patterns on Calving Ground Location, Forage Availability, and Calf Survival of the Porcupine Caribou Herd

Alaska Cooperative Fish and Wildlife Research Unit

Inclement weather, remote locations, and difficulty refueling survey aircraft often compromise aerial survey estimates of calving sites, calving dates, and birthing rates of barren-ground caribou. Recently developed methods based on minimum travel rates of GPS-collared caribou have shown promise for remotely monitoring calving, but the method was developed for nonmigratory rather than migratory caribou. The project aims to compare aerial survey data estimating calving location, timing, and birthing rates against the same information estimated from two models based on GPS movement rate methods. Managers may use these results to implement a new tool for remote monitoring of migratory caribou birthing rates, calving locations, and dates.

Habitat Selection in an Arctic Shorebird—Implications for Climate Change

California Cooperative Fish and Wildlife Research Unit

Climate change is projected to have its greatest effect in Arctic regions where temperature increases are forecasted to cause rapid changes to ecosystems and the wildlife dependent on them. These changes range from phenological mismatches to altered habitats where warmer climates favor successional changes in plant communities. The semipalmated sandpiper is an Arctic shorebird likely to be affected by climate change and is undergoing a decline in population size. This research intends to examine habitat selection by semipalmated sandpipers in the Colville River Delta, Alaska, by modeling nest site selection. Results may be used to predict how climate change may affect their habitats and population size.

Semipalmated sandpiper. Photograph by Bill Thompson, U.S. Fish and Wildlife Service.

Managing Coastal Wetlands for Wildlife and Sustainability in the Face of Sea-Level Rise

Louisiana Cooperative Fish and Wildlife Research Unit

Coastal marshes are critical habitat for a wide variety of wildlife and fisheries species. Marsh loss, however, is common along the Gulf coast and may increase with increased rates of sea-level rise. To keep up with sea-level rise, marsh accretion rates must exceed decomposition rates. Common marsh management practices, such as fire, flooding, and drawdowns, affect decomposition and accretion and have led to elevation declines of several feet in many waterfowl management units. The USGS is working with the Texas Parks and Wildlife Department to determine the effects of selected management practices on accretion and decomposition processes in waterfowl management units at the J.D. Murphree Wildlife Management Area near Port Arthur, Texas. This research could be used to develop waterfowl management practices that benefit waterfowl and allow marshes to adjust to increasing sea levels.

Assessing the Effect of Climate Change on Global Inland Fisheries

Missouri Cooperative Fish and Wildlife Research Unit

Freshwater biodiversity is declining at a faster rate than any terrestrial biome, and the threats posed by anthropogenic land use, climate change, flow modification, and invasive species are likely to exacerbate the situation. These changes are commonly driven by changes in temperature and precipitation. Accounting for stream change is essential for managing and conserving fishes and their habitats. Managers can more effectively conserve, protect, and restore stream fish and their habitats if this information is presented in an integrated, spatially continuous, and scalable format. This research generated a synthetic, comprehensive analysis of how climate change affects fish in North America and developed a plan that can be used to assess how climate change may affect fishes at a global scale.

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Factors Affecting Demography of Songbirds in Tropical Rainforests

Montana Cooperative Wildlife Research Unit

Climate can strongly affect energy expenditure and thereby demography of songbirds through the interacting effects of rain and temperature. Research on the ecological consequences of climate change has focused on effects of temperature and ignored the effects of rain. The effects of changing rainfall may differ among species related to their behaviors and nest structures. Unfortunately, measurements of energy expenditure among coexisting species with respect to varying rain and temperature conditions is completely lacking. This project intends to provide data on the differential demographic sensitivities of species in response to climate change. The information could allow prioritization of species for management and also advance the conceptual understanding of why species differ in demographic sensitivity. This project is a collaboration with Sabah Parks in the state of Sabah, Malaysia, on the island of Borneo.

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Strategies for Climate-Ready Fishing Communities—Optimal Fishing Portfolios for Changing Ocean Ecosystems

New York Cooperative Fish and Wildlife Research Unit

Climate change is advancing rapidly, particularly in high-latitude oceans, and is shifting marine species distributions and affecting fish population productivity and variability. As a result of the changes in marine ecosystems, fishing communities risk losing access to fishing—a loss that poses threats to their local economies and cultural heritage. This project seeks to address a key sustainability challenge for fishery-reliant communities: How can communities maintain access to commercial fishing resources in the face of climate-driven ocean changes? This research seeks to quantify climate risk facing fishing communities by using Alaska fisheries as a focal system. Identifying optimal community fishing rights portfolios that include climate-driven fishery changes is also a main focus of the work. This assessment could connect fishing portfolios containing climate change adaption strategies with innovative financing opportunities. Collaborators include Cornell University, The Nature Conservancy, Alaska Pacific University, and fishing stakeholders.

Characterizing Uncertainty in Changing Precipitation Regimes for Ecological and Hydrological Applications in the Southeast and the Caribbean United States

North Carolina Cooperative Fish and Wildlife Research Unit

Changing precipitation, such as changes to rainfall intensity or prolonged drought, threaten the natural and built environment. Changes in local to regional precipitation is a result of complex interactions within the climate system, and better understanding of how these climate system processes change in a warmer climate requires special attention to regionally relevant atmospheric processes. Climate change simulations are typically at spatial scales (>100 kilometers), and it is well known that climate models are unable to resolve important precipitation processes at these coarser resolutions, especially with respect to precipitation extremes. This research uses high-resolution regional climate models at relevant spatial scales to better characterize, quantify, and understand changing precipitation processes as the climate warms. The research uses a co-production framework where stakeholders inform the design of the high-resolution climate model experiments while creating data relevant to the needs of ecological and hydrological applications within the Southeast and Caribbean United States. This project is a joint effort of researchers within the USGS and the U.S. Environmental Protection Agency, the USFWS, the USFS, the Federal Highway Administration, and the North Carolina Department of Transportation.

Developing a Long-Term Acoustic Monitoring Program and Projected Species Distribution Under Future Scenarios in the Caribbean

North Carolina Cooperative Fish and Wildlife Research Unit

Land-use patterns and projected global warming represent two major drivers that induce population declines and range contractions of many resident avian and amphibian species in Puerto Rico. This project intends to create species distribution maps for bird and anuran (frog) species that are critically endangered, vulnerable, or data deficient. Present protected areas will not suffice to safeguard species of great conservation need under climate change; therefore, decision makers might consider establishing larger protected areas, buffer zones, and connectivity between protected areas. This work provides State and Federal conservation agencies with a blueprint to frame habitat conservation strategies. The project is a collaboration with researchers from the University of Puerto Rico

(Rio Piedras), the USGS Southeast Climate Adaptation Science Center, and biologists of the Science Applications and Caribbean Field Office of the USFWS.

Effects of Global Change on Biotic Resistance, Resilience, and Ecosystem Services in Caribbean Fish Assemblages, Fisheries, and Aquatic Ecosystems

North Carolina Cooperative Fish and Wildlife Research Unit

Understanding and planning for the effects of disturbances, such as extreme weather events, on natural resources may help managers respond to the effects of extreme events more effectively. The diversity of freshwater fish species in Puerto Rico may provide natural biotic resistance and resilience to colonization by nonnative species after disturbances; however, this has not yet been studied in Caribbean island freshwater ecosystems. Puerto Rico provides an ideal study location to test this hypothesis in Caribbean fish assemblages, and the results can be applied to other similar closed freshwater inland systems. The objectives of this research are to (1) determine changes in stream and river fish assemblages over time at multiple temporal scales (for example, seasonal, annual, and decadal); (2) examine fish assemblages and fisheries dynamics in relation to biotic resistance from exotic species invasions while relating changes to landscape (for example, dams, and reservoirs) and climate effects; (3) project changes in fish assemblages and their ecosystem services in the future; and (4) determine the effects of changes in fish assemblages on the community and stakeholders. Results can be used by regional stakeholders to help guide strategic planning efforts. This work is a collaboration among the USGS, South Carolina State University, and the Puerto Rico Department of Natural and Environmental Resources.

Adélie Penguin Response to Climate Change

Oregon Cooperative Fish and Wildlife Research Unit

The Adélie penguin is a sea-ice obligate species, so ocean habitats in the Southern Ocean surrounding Antarctica are crucial during all stages of the species' annual cycle. Changes in wind, temperature, and associated sea-ice patterns in some of the more northern regions of the species' range are causing reductions in the size and distribution of Adélie penguin breeding colonies. This NSF-funded study is designed to investigate the effects of environmental variation on vital rates and population size for Adélie penguins at three colonies within a metapopulation in the southern Ross Sea. The southern Ross Sea has a small human footprint compared to other regions on the planet and provides a unique and invaluable opportunity to disentangle climate change effects from anthropogenic effects for a species sensitive to predicted environmental changes. The results of this study could provide estimates of population-level vital rates that produce population change and attempt to understand the ecological factors that affect these vital rates. Collaborators include Point Blue Conservation Science and HT Harvey and Associates.

Adélie penguins. Photograph by Katie Dugger, U.S. Geological Survey.

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Fish Habitat Restoration to Promote Adaptation—Resilience of Sportfish in Lakes of the Upper Midwest

Pennsylvania Cooperative Fish and Wildlife Research Unit

Climate change is affecting fish communities in lakes throughout the Upper Midwest. Popular sport fish such as walleye are declining in many lakes, whereas warmwater species such as largemouth bass are increasing. However, not all lakes or fish species respond in the same way, even to the same conditions. In some cases, local management actions such as restoration or protection of lake habitat can slow down or mitigate the negative effects of climate change on economically and ecologically important fish species. This project aims to understand how multiple fish species (walleye, yellow perch, northern pike, largemouth and smallmouth bass, and cisco) with different temperature preferences respond to climate change and how their responses are affected by lake habitat conditions. Researchers intend to develop models to predict responses to climate change in tens of thousands of lakes in the Upper Midwest. By identifying habitat factors that make certain lakes more or less vulnerable to climate change, this research can enable lake and watershed managers to prioritize management actions aimed at reducing the negative effects of climate change. At the same time, lakes where certain species are unlikely to exist under future conditions could also be identified, which could enable managers and citizens to prepare for shifts in fish community composition. Project results could be communicated to managers and the public using online data visualization and communication tools to demonstrate how lakes in the Midwest are affected

by climate change and to identify lakes where local actions may be effective in preserving cold- and cool-water fish species as the climate warms. The project is a collaboration of researchers across multiple agencies and includes the University of Minnesota, the University of Missouri, the USGS, the Wisconsin DNR, the Minnesota DNR, the Midwest Glacial Lakes Partnership, and the Michigan DNR.

Climate Change in Arctic Landscapes

Utah Cooperative Fish and Wildlife Research Unit

The Arctic is one of the most rapidly warming regions on Earth. Responses to this warming involve acceleration of processes common to other ecosystems around the world (for example, shifts in plant community composition) and changes to processes unique to the Arctic (for example, carbon loss from permafrost thaw). The objectives of the Arctic Long-Term Ecological Research Project for 2017–23 are to use the concepts of biogeochemical and community "openness" and "connectivity" to understand the responses of Arctic terrestrial and freshwater ecosystems to climate change and disturbance. This research intends to compare key ecosystems of the Arctic to determine how their degree of openness governs their responses to climate change and acute disturbance such as fire and surface slumping associated with permafrost thaw. The proposed research could also determine how the responses to climate change and disturbance are mediated by landscape connectivity and the movement of nutrients, organic carbon, and organisms across Arctic landscapes. Partners include the NSF.

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Avian Community Change Across Time, Elevations, and Latitudes

West Virginia Cooperative Fish and Wildlife Research Unit

Changing environmental conditions because of global climate change can have substantial consequences for regional bird populations and communities over time, particularly along elevational and latitudinal gradients. For instance, populations of high-elevation species may decline and low-elevation species may begin to expand into higher elevations in response to increasing temperatures, but the rates of such changes may differ across latitudes. Thus, investigating the effects of climate change on long-term community dynamics while incorporating elevational variability and latitudinal ranges is critical. The goal of this research is to improve understanding of the extent and causes of avian community change over time and across elevational and latitudinal gradients within the Appalachian Mountains. The specific aims of this study are to quantify the relations of climate factors, habitat, elevation, and latitude with changes in avian species abundance and community turnover. The research could advance current scientific understanding of the role that changing climatic conditions have played in long-term avian community and population dynamics with explicit consideration for patterns arising across elevational and latitudinal gradients. The study also lays the foundation for future research focused on climate change effects of birds in high-elevation habitats and mountain ranges, an important focus for emerging investigations of climate refugia. This research is in collaboration with the American Wildlife Conservation Foundation, the NSF, the USFS, and the West Virginia Division of Natural Resources.

Wisconsin's Wildlife and a Changing Climate

Wisconsin Cooperative Wildlife Research Unit

Grassland ecosystems originally dominated central North America. Now (2020), prairies in general, and tall-grass prairies in particular, are one of the most extensively human-altered ecosystems and one of the most vulnerable to changing climate. Grassland bird conservation focuses on habitat restoration, but how effects of changing climate on grassland birds might be mitigated by management actions is not well understood. Understanding if habitat microclimates might help nesting grassland birds avoid some of the effects from events such as drought and heat waves could help inform the development of new habitat management strategies for grassland birds. This project is documenting the importance of habitat microclimates for grassland bird productivity to

inform natural resource managers in Wisconsin. This project is in collaboration with multiple organizations and includes the Wisconsin DNR, the University of Wisconsin-Madison, and the USFWS Region 3.

Publications

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Climatic Variability and the Productivity of Nongame Sagebrush Birds

Wyoming Cooperative Fish and Wildlife Research Unit

Sagebrush habitats have been extensively converted, fragmented, and altered via a wide range of human activities, which has resulted in concomitant declines in associated wildlife species, including sagebrush-obligate songbirds. Simultaneously, climatic regimes can affect wildlife, especially species that inhabit exposed, arid environments such as the sagebrush steppe. Biologists and managers, however, do not yet have the requisite information with which to assess how weather patterns such as high temperatures and moisture deficits will affect sagebrush songbird populations. Results of this study could address information gaps identified by the Sagebrush Conservation Strategy, be used to update the Wyoming Comprehensive Wildlife Conservation Strategy, and contribute to the development of better monitoring and mitigation strategies for ssuagebrush songbirds most at risk from additional habitat change range-wide. The primary project partner is the Wyoming Game and Fish Department.

Phenology Tracking in Migratory Mule Deer

Wyoming Cooperative Fish and Wildlife Research Unit

In terrestrial ecosystems, there is a critical need to understand the effect of climate change on the spatial and temporal heterogeneity in the quantity and quality of forage and the wildlife species that depend on it. Nevertheless, observing and quantifying how climate change affects behavior, distribution, and abundance of wildlife is difficult. In response to seasonal changes in plant growth and phenology, and local climatic conditions, ungulates migrate between high-elevation summer ranges and low-elevation winter ranges. This study seeks to evaluate the green wave hypothesis [see "Surfing the Green Wave" at https://www.usgs.gov/media/videos/surfing-green-wave] as it relates to phenological tracking along migration routes and summer ranges of migratory mule deer in western Wyoming. Various stakeholders, including the public, depend on this critical research.

Migratory mule deer. Photograph by Matt Kauffman, U.S. Geological Survey.

Decision Science

Adaptive Management for Listed Freshwater Mussels and Gulf Sturgeon in the Apalachicola-Chattahoochee-Flint River Basin

Alabama Cooperative Fish and Wildlife Research Unit

Quantitative models that predict the effect of alternate flow management regimes on populations of listed species do not exist within the Apalachicola-Chattahoochee-Flint River Basin. The goal of this project is to develop incidental take and AM monitoring plans for listed species in the Apalachicola River by facilitating a 4.5-day SDM workshop. This SDM workshop could leverage significant existing products, expertise, and interagency partnerships to efficiently integrate stakeholder and scientific expert knowledge to quantify biological objectives and measurable biological endpoints and inform quantitative predictive models. The models could forecast and predict the effect of flow management in the basin to populations of seven listed species. The project has the potential to make substantial progress in achieving informed and prudent multiuse water management goals to conserve and recover aquatic species and habitats in a river basin that has high-profile and challenging conservation issues. The Apalachicola-Chattahoochee-Flint Management Team includes the USGS and the USACE, Mobile District in Alabama.

Adaptive Management for Turkey Harvest in Alabama

Alabama Cooperative Fish and Wildlife Research Unit

This long-term research project, undertaken for the Alabama Department of Conservation and Natural Resources, is working to inform science-based AM of eastern wild turkey populations across the State. Applying AM techniques to eastern wild turkey populations requires a decision tool based on region-specific vital rates. Current, region-specific vital rates and harvest rates are unavailable, except as expert opinion. The AM tool developed from this research could use a population model that predicts the dynamics of eastern wild turkey populations based on vital rates and a management

Eastern wild turkeys. Photograph by the U.S. Fish and Wildlife Service.

model that predicts the effects of harvest regulations on vital rates. This research could estimate the temporal and spatial variation in vital rates, update the recently developed expert-driven model, test methods for monitoring decision criteria, and provide the agency with a method for incorporating the best-available information in decisions regarding eastern wild turkey harvest.

Modeling and Decision Tools to Support Recovery of Listed and At-Risk Species in the Apalachicola-Chattahoochee-Flint River Basin

Alabama Cooperative Fish and Wildlife Research Unit

The goal of this project is to provide expertise to ongoing efforts of the USFWS in the Apalachicola-Chattahoochee-Flint River Basin to recover listed species, conserve at-risk species, and implement an AM process to minimize incidental take of listed species from water-management operations. Existing information can be synthesized to create an updated analysis of threats and to use hydrologic modeling and spatial analyses to quantitatively assess the primary threats to recovery of the six listed freshwater mussels species in the Apalachicola-Chattahoochee-Flint River Basin: endangered purple bankclimber, threatened Chipola slabshell, endangered fat threeridge, endangered oval pigtoe, shinyrayed pocketbook, and endangered Gulf moccasinshell. Hydrologic modeling can be applied to evaluate alternative water-management operations to investigate effects to at-risk species and assist in upcoming reanalysis of the Apalachicola-Chattahoochee-Flint Biological Opinion. This project has multiple high-value, decision-relevant deliverables that can support the ongoing AM process with the USFWS, the USACE, and scientific experts and thus develop decision endpoints.

Purple bankclimber mussel. Photograph by the U.S. Fish and Wildlife Service.

Boreal Aquatic Ecosystem Vulnerability to Fire and Climate Change

Alaska Cooperative Fish and Wildlife Research Unit

Fire frequency, size, and severity are increasing in Alaska because of climate warming. Interactions among fire, climate, permafrost, vegetation, and hydrologic and watershed processes are poorly understood, yet critical for conservation and management of boreal aquatic habitats in a changing environment. This research can combine detailed field experiments and measurements with an integrated suite of spatially and temporally explicit climate, terrestrial, and aquatic habitat models to better understand the effects of fire and climate change on aquatic communities in boreal ecosystems of interior Alaska. Results could support an SDM approach to define management objectives, decision options, and management scenarios, and to conduct cost-benefit analyses. The end goal is to create a web-based decision-support tool developed to inform decision making. Collaborators include the University of Alaska Fairbanks, the USGS, the Alaska Department of Fish and Game, the USFWS, the U.S. Department of Defense (DoD), and the Alaska Fire Science Consortium.

Stream Salmonid Simulator Model for the Klamath Basin

California Cooperative Fish and Wildlife Research Unit

The current Stream Salmonid Simulator Model (S3 model) in development for the Klamath River tracks causes of mortality throughout the subadult life history of Chinook salmon within a 233-mile section of the main-stem Klamath River spanning from Keno Dam in Oregon to its confluence with the Pacific Ocean in California. The S3 model for the Klamath River represents an integrated set of submodels that predict the effects of water-management alternatives on the production of juvenile Chinook salmon. This synchronized series of submodels reflects the array of physical and biological processes that interact to affect the growth, movement, and survival of fish at a given life stage. A benefit to this method of model construction lies in the ability to update submodels as new data, new analyses, or new scientific discoveries arise. The researchers strive to evaluate best practices for assigning flow-to-habitat relations for large river systems, include juvenile coho salmon in the Klamath Basin S3 model, and extend it into the Trinity Basin. An ocean component and International Business Machines-type upstream adult migration submodule will also be added to the model. Partners include the USFWS, the USGS Columbia River Research Laboratory, Watershed Systems Group, Inc., and Texas State University.

Adaptive Monitoring and Modeling of Sea Otters and Other Wildlife

Colorado Cooperative Fish and Wildlife Research Unit

Data associated with reintroduced or invasive wildlife species, or both, are commonly collected but are not typically best for desired inference. Nonetheless, the ability to formally make inferences about, and forecast, spreading wildlife populations is critical for guiding future monitoring efforts and for understanding the mechanisms associated with their dynamics. The researchers intend to develop formal statistical models that account for the various sources of uncertainty in monitoring populations to provide forecasts that can then optimally guide future decisions about monitoring efforts. Partners include the NPS.

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Sensitive Plants and Animals in the Intermountain West

Colorado Cooperative Fish and Wildlife Research Unit

Intermountain West ecosystems involve sensitive plant and animal communities that are adapted to specialized and commonly harsh conditions. Invasive species such as cheatgrass can dramatically affect these natural systems. The goal of this project is to develop a large-scale western regional experiment to learn about the connections among genetics, traits, and population dynamics in cheatgrass under a variety of environmental conditions. This research can help improve understanding of how and why cheatgrass has been such a successful invader. This project involves a variety of institutions and agencies, including Colorado State University, Utah State University, The Pennsylvania State University, the University of Nevada-Reno, and the USDA. This research can provide guidance about how the mechanisms in the biology of this invasive species lead to varying levels of success depending on environmental conditions and other biotic interactions.

Modeling Tree Growth in National Parks of Alaska

Colorado Cooperative Fish and Wildlife Research Unit

Alaskan ecosystems are undergoing rapid environmental change, yet the extent to which this change affects ecological communities is not well understood. For tree species that depend on certain environmental conditions, an improved understanding of how growth and volume may have changed over the past several decades is needed. Substantial progress has been made in developing ecosystem models that simulate vegetation communities and nutrient cycling over decades; however, formal statistical implementations of these models that assimilate field data are still evolving and have not been applied in many systems throughout Alaska. The goal of this project is to develop ways to fit ecosystem models to tree-ring data collected in the Alaska network of national parks to better understand changes in growth and volume of tree species over time. The combination of computational ecosystem models and field data could elucidate management and conservation needs for important protected ecosystems in national parks. This project is a collaboration with the NPS and Colorado State University.

Nearshore Ecosystem Processes of Glacier Bay, Alaska

Colorado Cooperative Fish and Wildlife Research Unit

Glacier Bay National Park contains one of the world's largest protected tidewater glacier ecosystems. A variety of complex and dynamic relationships among species in Glacier Bay exist and are critical to conservation and management. The goal of this project is to combine multiple sources of data that have been collected in Glacier Bay for decades to better understand the ecological processes in nearshore communities of the park. This research could combine existing scientific information about the nearshore food web in Glacier Bay with various disparate data sources to identify knowledge gaps that can help guide future monitoring and protocol in the park. This project involves a collaboration among partners at the NPS, the USGS, and Colorado State University.

Statistical Method to Estimate Population Boundaries

Colorado Cooperative Fish and Wildlife Research Unit

Nonbiological factors are commonly used to delineate management units for wildlife species. In cases where species distribution and movement data are available, functional boundaries may be preferred. The ability to formally delineate population boundaries based on the movement and distribution of actual animals can aid in the effective management of wildlife populations. Formal statistical models that account for the phenology of sea ice in the north Arctic Ocean and Bering Sea on the movement of polar bears can help cluster individuals into subpopulations on the basis of their distribution. These subpopulations and estimated boundaries can help set future management decisions. This project is in collaboration with the USFWS.

Ecology and Wildlife Habitat in Alaskan National Parks

Colorado Cooperative Fish and Wildlife Research Unit

Extensive data have been collected over the past several decades on plant communities throughout Alaskan national parks. The goal of this project is to develop and apply new spatially explicit statistical models to assimilate these data and to improve understanding of the ecology and wildlife habitat in Alaska. This project leverages an extensive field-plot dataset collected over the past decade to learn as much as possible about the status and possible future trends in woody plant communities of northern Alaska that govern the distribution, character, and quality of wildlife habitat across the eight large national park units that compose the Central Alaska and Arctic Networks of parks. The research could provide statistically valid knowledge about the quality and quantity of wildlife habitat over these large, naturally regulated landscapes to improve management and wildlife conservation efforts now and in the future. Partners include the USGS, the NPS, and the National Oceanic and Atmospheric Administration (NOAA).

Accelerating Conservation of At-Risk Species in the Longleaf System

Georgia Cooperative Fish and Wildlife Research Unit

The USFWS Southeast Region is working with State wildlife agencies and other partners to assess the status of >300 species awaiting reviews pending a listing decision and to implement conservation for these species on public and private lands. The longleaf pine ecosystem supports several priority at-risk species; and for many of these species, comprehensive efforts to synthesize information and identify knowledge gaps for their conservation are nonexistent. Efficiencies for planning conservation action can emerge by collectively analyzing species within an ecosystem compared to individually assessing each species. The goals of this project are to synthesize data for five priority species and to develop models that predict population viability as a consequence of predicted exogenous threats and conservation actions. These products can be delivered in a form that facilitates a future, formal decision analysis in which tradeoffs in alternative conservation actions may be explored. This work relies on a collaboration among the USGS, the USFWS, the University of Georgia, and several State, Federal, and NGO partners.

Publications

Crawford, B.A., Maerz, J.C., and Moore, C.T., 2020, Expert-informed habitat suitability analysis for at-risk species assessment and conservation planning: Journal of Fish and Wildlife Management, v. 11, no. 1, p. 130–150, https://doi.org/10.3996/092019-JFWM-075.

Crawford, B.A., Olds, M.J., Maerz, J.C., and Moore, C.T., 2020, Estimating population persistence for at-risk species using citizen science data: Biological Conservation, v. 243, article 108489, 13 p., https://doi.org/10.1016/j.biocon.2020.108489.

Adaptive Management of Federal Investments to Great Lakes Restoration Activities

Georgia Cooperative Fish and Wildlife Research Unit

The Great Lakes Restoration Initiative (GLRI) is a large Federal program aimed at protecting and restoring the largest system of surface freshwater in the world. Among its project portfolios are efforts to prioritize terrestrial conservation projects to increase habitat connectivity for species of conservation importance to GLRI partners. An area of focus of the GLRI is supporting decisions aimed at restoring and conserving areas that link habitats across Federal Government-owned lands in the ecoregion. This program can produce analyses of landscape connectivity under alternative future scenarios and can quantify local-level contributions to regional-scale connectivity. This information could aid decision makers charged with choosing conservation acquisitions and actions aimed at maintaining high levels of connectivity in the face of uncertain future landscapes. The principal partners in this program are the USGS and the University of Georgia, as well as other Federal agencies involved in the GLRI.

National Resource Conservation Service Conservation Practices on Gopher Tortoise Habitat

Georgia Cooperative Fish and Wildlife Research Unit

The NRCS Working Lands for Wildlife program for the gopher tortoise was started in 2013 in Alabama, Florida, and Georgia; however, the program's effectiveness has not been assessed, and challenges in the program's implementation have not been identified. The goals of this research are to assess enhancements to the field survey protocol, to determine if allocating public dollars to incentivize private landowners is working, and to clarify how gopher tortoise populations respond to habitat management actions across its range. The research is also expected to inform the NRCS about the effectiveness of the Working Lands for Wildlife program in meeting habitat objectives and to identify attributes (local to landscape scale) that contribute to or impinge on meeting those objectives. This is a collaboration among the USGS, the NRCS, the University of Georgia, and the Joseph W. Jones Ecological Research Center.

Black Rail Ecology to Inform Effective Survey Design and Support Population Modeling

Georgia Cooperative Fish and Wildlife Research Unit

Black rails have experienced population declines, breeding range retractions, and breeding location reductions within its core range; therefore, the species is currently (2020) under review by the USFWS for protection under the ESA. This project includes multiple research and technical assistance components to address the research priorities identified by conservation partners. The goals of this work are to produce estimates of vital rate parameters usable in predictive population models supporting decision making, to provide modifications of existing marsh bird protocols to better monitor this secretive species, and to directly inform the status assessment for the black rail's candidacy for protection under the ESA. Collaborators include the USGS, the USFWS, and the University of Georgia.

Completing a Double-Loop Learning Cycle in the Native Prairie Adaptive Management Program

Georgia Cooperative Fish and Wildlife Research Unit

Under the USFWS Native Prairie Adaptive Management Program, land managers in the National Wildlife Refuge System receive annual habitat management guidance to restore prairies to desired composition levels of native grasses and forbs. Although this operational AM program has successfully provided guidance through nine decision cycles, longstanding concern about the use of expert-elicited quantities in the predictive models has not abated among the managers and the developers of the program, and the concern has prompted a comprehensive "double-loop" evaluation of the framework elements. This evaluation, completed in 2020, resulted in models for decision guidance that conform more closely with the system responses observed to date, leading to better management performance in the future. The models supporting the decision framework were used for the August 2020 decision cycle, and the resulting management recommendations provided to cooperators reflected the improved decision guidance. This research is in collaboration with the USGS, the USFWS, and the University of Georgia.

Demographic Estimation and Conservation Modeling for the Loggerhead Sea Turtle

Georgia Cooperative Fish and Wildlife Research Unit

Decision making aimed at recovering the loggerhead sea turtle from threatened status depends on models that evaluate population vulnerability based on potential threats and that assess tradeoffs of alternative conservation actions. Crucial uncertainties in population mechanisms exist, and demographic models can be used to identify those uncertainties to which targeted information gathering would yield more effective conservation delivery. The goals of this work are to provide the needed framework to advance conservation for the loggerhead sea turtle and to provide a blueprint for model development and decision analysis for related conservation problems hampered by uncertainty. This work can result in a population model that integrates multiple sources of data including genetic mark-recapture, nest counts, and in-water surveys and can be used as a scenario and decision analysis tool for generating demographic output of use to managers. Collaborators include the USGS, the University of Georgia, and the Georgia DNR.

Develop Adaptive Management Framework for Robust Redhorse

Georgia Cooperative Fish and Wildlife Research Unit

Robust redhorse is an imperiled, native freshwater fish species that inhabits a few river systems on the Atlantic slope of the southeastern United States. The species faces threats such as sedimentation and migration barriers created by hydropower dams. Through a collaboration of the USGS and the robust redhorse conservation committee, this project intends to develop an AM framework to help stakeholders make informed management decisions. The goals of this study are to assess current population status for each robust redhorse

ecologically significant unit and to complete scenario forecasts for each ecologically significant unit to investigate population viability under different conservation strategies. The results from the forecasting models could then help decision makers identify preferable management options.

Development of an Adaptive Management Framework to Reduce the Effect of Invasive Phragmites in the Great Lakes Basin

Georgia Cooperative Fish and Wildlife Research Unit

Wetland invasion of the common reed in the Great Lakes coastal zone is a substantial ecosystem and economic threat. Best approaches for the control of the common reed are uncertain, and current management attempts are disjointed and have not been informative to other efforts. The goal of this project is to provide a framework in which results from management actions across the region can be synthesized and converted into knowledge useful for future decision making. The research has led to models, monitoring methods, and a decision-support infrastructure (the Phragmites Adaptive Management Framework, https://www.greatlakesphragmites.net/pamf/) that has successfully been implemented as an AM system. This work involves a collaboration among the USGS, the University of Georgia, and the Great Lakes Commission.

Incorporating Structured Decision Making and Alternative Sources of Data into Management of White-Tailed Deer in Georgia

Georgia Cooperative Fish and Wildlife Research Unit

In Georgia, the management of white-tailed deer populations is challenging because of regional variation in landscapes, deer population status, property ownerships, and other factors. Sources of harvest data available to the State of Georgia, primarily through self-reporting mechanisms, are potentially usable for providing harvest management decision support, but these data sources have unknown biases. The goal of this project is to investigate the utility of data sources under an SDM framework, which establishes the context for the types of data needed to support harvest decision making and their required degree of quality. The research could recommend one or more candidate harvest decision-support frameworks that address the goals of stakeholders and that identify priorities for data collection most useful for guiding management. This work is a collaboration between the University of Georgia and the Georgia DNR.

Modeling and Optimization to Advance Decision Making for Trust and At-Risk Species

Georgia Cooperative Fish and Wildlife Research Unit

Since 2012, an AM framework has been in place to guide harvesting of horseshoe crabs in the Delaware Bay in a way that maximizes crab harvest while leaving sufficient foraging resources for shorebirds. However, estimates of horseshoe crab abundance that inform the decision model have biases, and the software that generates tables of optimal actions runs only on outdated, unsupported operating systems. Basing harvest management decisions on biased information compromises management performance, and outdated optimization software prevents technical improvements. Addressing both shortcomings of the decision-making framework can increase quality of harvest management decisions. The goals of this research are to refine the model and to create a new optimization platform.

Statistical Support for Long-Term Natural Resource Monitoring

Georgia Cooperative Fish and Wildlife Research Unit

Throughout the world, monitoring surveys provide essential information for understanding, restoring, and managing populations. The NPS Inventory and Monitoring Program aims to understand status and trends in resource conditions and to provide accessible information. This project evaluates sampling designs and pilot data, as well as analytical and reporting approaches for monitoring data, to support development of statistically sound long-term natural resource monitoring. Results can directly assist the NPS by developing interactive data dashboards for reviewing and analyzing long-term monitoring data for a variety of resources including, but not limited to, water, vegetation, cave biota, and amphibians. Collaborators include the NPS and the University of Georgia.

Technical Assistance to the Georgia Department of Natural Resources for Nongame Bird Monitoring and Research

Georgia Cooperative Fish and Wildlife Research Unit

The Wildlife Conservation Section of the Georgia DNR Wildlife Resources Division, which has management authority for a diversity of animal and plant species within Georgia, needs (1) reliable population estimates of nesting Florida

sandhill cranes in Okefenokee National Wildlife Refuge and (2) reliable inferences on demographic parameters of Henslow's sparrow. The goal of this work is to provide survey design enhancements and analytical models to meet these needs. Producing reliable biological information for these two species can help the State of Georgia better target their resources toward actions that conserve these species. This work is a collaboration between the Georgia DNR and the University of Georgia.

Guiding Present and Future Native Fish Restoration Using a Strategic Planning Process, Literature Synthesis, Database Analysis, Landowner Outreach, Field Protocol Development and Testing, and Adaptive Management

Kansas Cooperative Fish and Wildlife Research Unit

Although the conservation profession is making good use of existing tools for management and sustainability, natural and human threats to ecosystems are increasing rapidly. The goal of this project is to deliver a process that guides data collection and that links data to future restoration activities for fish and other freshwater resources. Results can inform State Wildlife Action Plan (SWAP)-guided conservation and restoration activities and provide a foundation for a monitoring, research, and restoration agenda for multiple species, locations, and environmental threats. Cooperators include the USGS and the Kansas Department of Wildlife, Parks, and Tourism Ecological Services Section.

Development of Monitoring and Adaptive Management Plans for Restoring the Gulf Coast

Louisiana Cooperative Fish and Wildlife Research Unit

In 2016, the Natural Resource Damage Assessment Trustees reached a settlement with British Petroleum to resolve British Petroleum's liability for natural resource injuries from the *Deepwater Horizon* oil spill as part of the Natural Resource Damage Assessment process. This assessment helped the trustees select a comprehensive, integrated ecosystem approach to restoration in the Gulf of Mexico. Given the unprecedented temporal, spatial, and funding scales associated with the *Deepwater Horizon* oil spill restoration effort, robust monitoring and AM to support restoration planning and implementation are integrated into planning efforts. This work, in collaboration with all trustees and State and Federal agencies managing coastal resources, aims to develop a framework that can evaluate restoration effectiveness; address uncertainties, as applicable, related to project planning and implementation; and provide feedback to inform future restoration decisions.

Understanding Decision-Making Behavior Regarding Fish Passage and Management in New England

Maine Cooperative Fish and Wildlife Research Unit

More than 52 dams in Maine, New Hampshire, and Rhode Island will require Federal Energy Regulatory Commission relicensing in the next decade. Many of these dams are approaching the end of their design life, and attitudes and preferences for dams and ecosystem services are changing. Despite increased momentum for change to consider a broader range of options including removal, dams remain a symbol of cultural identity, economic prosperity, and technological innovation, and they are a source of clean energy and recreational opportunities. Reconciling these competing demands is difficult, and decisions are often fraught with intense controversy as stakeholders face uncertainties related to different management options. Numerous Federal and State resource and regulatory agencies are charged with the difficult task of balancing ecological, economic, and social tradeoffs related to dam relicensing decisions. Agencies have the unique opportunity to serve as agents of change, and conceptual plans for basin-scale hydropower development have been introduced (for example, NOAA's Basin-Scale Opportunity Assessment Initiative).

Support Tool for Fisheries Management

Mississippi Cooperative Fish and Wildlife Research Unit

Organizing and planning are among the most demanding tasks of fisheries professionals. Commonly, this process is overwhelming because clear linkages among agency-wide goals, management plan objectives and actions, and monitoring metrics are nonexistent. The goal of this research is to develop an online computer application to support structuring and increased rigor of management plans. The application may guide the user through a series of menus to build a management plan that clearly outlines objectives, management actions, monitoring protocols, and outcome evaluations. The ability to link monitoring to agency-specified objectives and actions could help fisheries professionals more efficiently and effectively organize and plan management activities and facilitate optimization of management decisions.

Mussel Conservation in Missouri

Missouri Cooperative Fish and Wildlife Research Unit

In Missouri, resource managers are seeking a strategic framework for the State-level mussel conservation programs. The goal of this research is to document current State-level management actions, strategies, and resources used to manage

freshwater mussels through an online survey of personnel from State natural resource agencies. The information can be synthesized into a comprehensive mussel conservation assessment strategy with a proposed implementation plan for Missouri. Incorporating resource limitations and other challenges identified by agency personnel into the framework can improve the effectiveness of mussel conservation efforts through strategic planning and implementing restoration actions.

Integrated Population Model for Black Bears and Bobcats

Montana Cooperative Wildlife Research Unit

Understanding the dynamics of large carnivore populations is challenging because they are uncommon and elusive. Management decisions such as setting harvest quotas and controlling damage are thus hampered by a lack of understanding of abundance and trends for such animals. Game populations interact with predator populations in complex ways. Agencies commonly have good information on the dynamics of game populations, but the absence of such information on predator populations makes discerning the complex interactions highly difficult. This difficulty impedes effective management decisions for game and predator species. The goal of this project is to develop integrated population models for black bears and bobcats to provide the needed information for agencies to meet their legislated management mandate. Results can be used to help set harvest quotas for game and predator species and to inform management decisions related to damage management, public safety, and wildlife health. Cooperators include the University of Montana; the Montana Department of Fish, Wildlife and Parks; and the Idaho Department of Fish and Game.

Large Mammal Predator-Prey Modeling Dynamics

Montana Cooperative Wildlife Research Unit

Few wildlife management problems in the western United States compare to the challenges of managing multiple predator and prey species in the same ecosystem. This work provides critical context for managers to make the difficult decisions for balancing predator and prey populations to meet public expectations. Results of the study can directly inform the decisions made by wildlife managers responsible for setting harvest quotas to meet population objectives. These decisions are fundamental to the mandates of State agencies, and the data that can improve reliability and transparency of harvest decisions are critical as public scrutiny increases. Cooperators include the University of Montana and Idaho Fish and Game.

Montana Wolf Monitoring Study

Montana Cooperative Wildlife Research Unit

Wolves have recolonized western Montana and have been managed as a game species since they were delisted. Because they are a species of strong interest to a diversity of public stakeholders, documenting wolf abundance and the effects of harvest must be transparent and scientifically rigorous. Addressing these issues requires developing a monitoring system that is cost effective, reliable, and accurate; missing knowledge of the biological mechanisms driving territoriality, pack size, and reproduction, however, can hamper robust estimation of abundance and the effects of harvest. This work can provide managers with the tools needed to produce credible estimates of wolf abundance across Montana and defensible harvest regulations in an AM framework. This project is in collaboration with the Montana Department of Fish, Wildlife and Parks.

Montana Mule Deer Study

Montana Cooperative Wildlife Research Unit

Mule deer populations in western Montana are declining, but little is known about why, or how the trend can be reversed. A suspected contributor is the decline of early successional habitat across the variety of biomes mule deer inhabit in montane areas. Managers need to know how and where methods for creating early successional habitat (prescribed fire, mechanical thinning, and even-aged harvest) can be used to manage winter and summer ranges for mule deer in diverse forest habitats; however, substantial questions about the migratory behavior of mule deer, the effects of disturbance on local flora, and the efficacy of management actions on habitat quality remain to be answered. The goal of this project is to develop a decision tool that can allow the Montana Department of Fish, Wildlife and Parks managers to weigh the costs and benefits of habitat management tools for winter and summer ranges across western Montana. This project is in collaboration with the University of Montana and the Montana Department of Fish, Wildlife and Parks.

Strategic Bat Conservation and Recovery in Nebraska and Wyoming

Nebraska Cooperative Fish and Wildlife Research Unit

North American bats face unprecedented threats from disease, habitat loss, fragmentation, and wind turbines. In anticipation that threats are likely to increase in severity, an opportunity is available to improve the resiliency of summer habitat, to learn how changes affect local bat populations, and to establish regional monitoring that can inform local decisions and national actions. The goal of this project is to provide decision makers with decision-support tools and a conservation plan that can result in more strategic conservation of bats across Wyoming and Nebraska. This project is a collaboration of researchers with the Nebraska Game and Parks Commission and the Wyoming Game and Fish Department, and State and Federal natural resource managers throughout the midwestern United States.

Carnivore Occupancy and Intraguild Interactions Across New York

New York Cooperative Fish and Wildlife Research Unit

The distribution and abundance of carnivore species can have substantial effects on ecological communities through top-down and cascading trophic effects. Several carnivore species are present in New York, and in addition to their ecological importance, they have economic and recreational value to humans as fur-bearing species. Understanding the factors that affect their spatial distribution can help managers maintain sustainable populations. This research estimated the density of the American marten and developed occupancy models for a suite of carnivore species (marten, fisher, bobcat, coyote, and red fox) in New York. Results from the fisher surveys have already resulted in the opening of conservative trapping seasons in new wildlife management units previously closed to trapping. The results demonstrate the efficiency and value of large-scale camera-trapping surveys to develop single-species and multispecies occupancy models and guide decisions on harvest, conservation of habitat, and population management.

Lake Ontario Salmonid Management Risk Assessment—Refinement of Predator-Prey Models

New York Cooperative Fish and Wildlife Research Unit

Lake Ontario supports a thriving Chinook salmon fishery. Sustainable management of this resource requires maintaining a balance between predator numbers and the primary Chinook salmon prey item, the alewife. The goal of this project is to develop stock assessment tools to inform management decisions for Lake Ontario Chinook salmon. By combining stock assessments for predators (Chinook salmon) and prey (alewife), researchers hope to develop a decision-support tool that can lead to robust ecosystem level management decisions for fisheries specifically in Lake Ontario and more broadly in the Great Lakes.

Leveraging Spatial Partial Identity Information to Advance Sampling of Animal Populations and Improve Conservation Decision Making

New York Cooperative Fish and Wildlife Research Unit

A variety of new, noninvasive methods for monitoring wildlife species, such as genetic data from hair or scat samples, remote cameras, and bioacoustic monitoring, have allowed researchers to collect more data than was previously possible. Unfortunately, these noninvasive approaches commonly do not provide an unambiguous determination of individual identity, which is needed for estimating population parameters relevant to conservation decisions, such as population density and growth rates. Because animal populations are spatially structured, the location where a noninvasive sample was collected contains some information about its individual identity. This information, coined "spatial partial identity," may improve the utility of noninvasive methods and development of new, more-efficient study designs. This research can generalize and adapt the spatial partial identity model to accommodate three types of noninvasive sampling methods: genetic material from scat or hair samples, remote camera studies of species with more ambiguous natural marks (for example, pumas), and bioacoustic surveys. The results can have broad application and can extend the utility of noninvasive sampling methods for improving conservation decisions to a wide range of threatened species worldwide.

Living with Leopards—Implications of Human-Leopard Interaction on Food Security and Public Health in the Foothills of the Himalayas

New York Cooperative Fish and Wildlife Research Unit

In Nepal, human-leopard conflict threatens food security of local communities because of livestock loss and causes injuries and death to humans and leopards. Generating well-informed, policy-led interventions for sustainable conservation actions requires understanding key drivers and effects of human-leopard interactions across a rural-urban gradient. The goals of this research are to analyze leopard diet to better understand the extent to which leopards prey on livestock and feral species and to develop a spatial conflict risk model to help manage or mitigate human-leopard interactions. Results can be used to secure national policy commitment by developing a national policy document to enable site-specific, sustainable conflict-management responses and to promote local stewardship for the survival of leopards in shared landscapes without compromising human well-being.

Managing for Long-Term Sustainability of Seafood Production at State, Federal, and Global Scales

New York Cooperative Fish and Wildlife Research Unit

About 20 percent of global seafood is derived from trawl-based commercial fisheries. Although efficient, trawl-based gears can contact and affect benthic ecosystems. This collaborative project is developing seascape-scale habitat effect models to support commercial fisheries' gear management. The models can be used to evaluate potential gear modifications or spatial closures to reduce habitat effects from fishing gear, providing a decision-support tool to accompany fisheries policy at State, Federal, and global scales. Results from this project address a priority information need identified by the U.S. Fishery Management Council, and modeling results are informing fisheries management options to conserve benthic ecosystems globally. As of 2019, the model had been adopted as a decision-support tool by the North Pacific U.S. Federal Fisheries Council, and the model is currently (2020) under development for use by the New England Fishery Management Council.

Invasive Species Management in New York

New York Cooperative Fish and Wildlife Research Unit

Managing invasive species across large areas often requires making decisions with multiple objectives that include numerous species with a wide range of biological characteristics, effects to valued goods and services, and many treatment options. The goal of this project is to develop a novel decision tool for managing invasive species in New York that considers alternatives for prevention, surveillance, control, and education. The results can guide managers in determining which species should be prioritized, where those species should be managed, and the best approach to managing them to ensure management dollars are well spent. The approach and resulting decision tool can have broad applications for managing invasive species across the globe. Collaborators include the New York State Department of Environmental Conservation and leaders from the eight New York Partnerships for Regional Invasive Species Management.

Spatial Risk Mapping—A Tool to Plan and Implement Human-Andean Bear Conflict Mitigation in Ecuador

New York Cooperative Fish and Wildlife Research Unit

The Chocó-Andean region of Ecuador lies at the convergence of two of the world's top 25 biodiversity hotspots and is home to more endemic species than any other hotspot on Earth. Unfortunately, one-half of this region has been deforested; and the expansion of agriculture, development, and mining concessions threatens the remaining forest. The goal of this research is to use a socioecological system approach to generate alternative strategies to guide public policies that can help communities cope with the effects of environmental changes. The results can be used to develop a decision-making tool to preemptively avoid conflict with Andean bears and to identify areas for management interventions (for example, sustainable crop management practices).

Testing the Feasibility of Acoustic Sensors to Estimate Sardine Biomass to Facilitate Science-Based Fishery Management in the Philippines

New York Cooperative Fish and Wildlife Research Unit

In the Philippines, sardine fisheries support millions of livelihoods. Proper management and harvest of these important fisheries depend on accurate estimates of population abundance. This project, an international collaboration, assessed the potential for active and passive acoustic technologies to support small-scale nearshore pelagic fishery assessments. By coupling passive with active technology, results are providing an opportunity to validate whether new passive gears can successfully detect pelagic fish stocks, potentially expanding the set of tools available for fisheries monitoring. Results can assist the Philippines in moving toward science-driven fisheries management for pelagic fish stocks. Collaborators include the USGS, Cornell University, State University of New York at Stony Brook, the Environmental Defense Fund, and the Philippines Bureau of Fisheries and Aquatic Resources.

Applying Downscaled Climate Projections to Inform Decisions

North Carolina Cooperative Fish and Wildlife Research Unit

Many species of frogs in the *Eleutherodactylus* genus are at risk of becoming listed as endangered under the ESA. *Eleutherodactylus* spp. are of conservation interest, and are typified by high endemism, relatively low vagility, and largely stenoclimatic. The goal of this project is to assess physiological thresholds (temperature, humidity) of selected *Eleutherodactylus* spp. (biological models) to forecast species distribution in response to environmental changes and to identify potential environmental refugia. Another goal of this project is to develop and test translocation protocols to enhance populations via reintroductions or translocations to locations characterized by long-term suitability (refugia). Results can include a decision-support tool to assess habitat threats and risks for *Eleutherodactylus* spp. that can help the USFWS formulate conservation measures by identifying suitable areas for long-term conservation.

Natural Resources Conservation Service Habitat Enhancement and Best-Practices Program—Opportunities to Maximize the Presence of Pollinators and the Positive Effect of the Program on Natural Resources and Coffee Growers

North Carolina Cooperative Fish and Wildlife Research Unit

Land-use patterns in Puerto Rico have severely fragmented forests island wide, threatening species persistence through habitat isolation and declining habitat quality. Habitat protection is expensive and may exclude alternatives that yield desirable conservation outcomes. Incorporating nonprotected habitats (for example, restored-shade coffee plantations) into strategy habitat conservation initiatives is a viable strategy to enhance species persistence and best-management practices (for example, pollinators) without affecting the economic bottom line of landowners. This project can inform decision makers of the USDA–NRCS (Caribbean) and the USFWS on where and when to invest shade-restoration efforts in the central mountainous region of the island. Alternatives can be ranked by costs and benefits in terms of landscape habitat connectivity and redundancy and, ultimately, species persistence. The project is in coordination with the USDA–NRCS (Caribbean) and the USFWS Caribbean Field Office.

Adaptively Managing Instream Flows for Ecological Needs

Oregon Cooperative Fish and Wildlife Research Unit

Streamflow regulation is one of the most important issues facing natural resource managers and planners, and aquatic resource managers need tools for assessing the potential effects of river regulation and water development on ecological systems. Several tools have been developed for assessing the effects of streamflow alteration, but none have been integrated with decision making and monitoring to reduce critical uncertainties. Consequently, this project developed an integrated adaptive framework to manage aquatic resources, identify information gaps, and facilitate the development of aquatic resource-management strategies. The integrated adaptive framework, which includes quantitative decision models, can be used to inform decisions on management actions to achieve environmental flows that maximize benefits to threatened salmonids.

Publication

DeWeber, J.T., and Peterson, J.T., 2020, Comparing environmental flow implementation options with structured decision making—Case study from the Willamette River, Oregon: Journal of the American Water Resources Association, v. 56, no. 4, p. 599–614, https://doi.org/10.1111/1752-1688.12845.

Integrating Monitoring, Modeling, and Management for Amphibian Conservation in the Western United States

Oregon Cooperative Fish and Wildlife Research Unit

Amphibians are the most threatened class of vertebrates, and global declines are related to a variety of factors including habitat, climate change, disease, contaminants, and invasive species. As nongame vertebrates, amphibians have received little direct research or management until the past few decades when declines became well documented and recognized. The goal of this project is to develop an integrated, adaptive framework for identifying data gaps and for developing management strategies for amphibians and their habitats in the Pacific Northwest. Outputs can include a decision-making model that can approximate the complex life cycle of amphibians while balancing the complexity with available information. The model can integrate subsequent amphibian monitoring data to reduce uncertainty about the factors affecting amphibians and their habitats and to improve the reliability of the model predictions.

Southern torrent salamander. Photograph by the U.S. Geological Survey.

Publication

Duarte, A., Peterson, J.T., Pearl, C.A., Rowe, J.C., McCreary, B., Galvan, S.K., and Adams, M.J., 2020, Estimation of metademographic rates and landscape connectivity for a conservation-reliant anuran: Landscape Ecology, v. 35, no. 6, p. 1459–1479, https://doi.org/10.1007/s10980-020-01030-8.

The Development and Evaluation of Monitoring Protocols to Inform Water-Resource Decision Making

Oregon Cooperative Fish and Wildlife Research Unit

Effective water-resource management relies on the quality of monitoring and research data. Unfortunately, the adequacy of sampling protocols for meeting monitoring objectives is rarely assessed. The goal of this project is to evaluate the adequacy of long-term monitoring data from the Sacramento-San Joaquin Delta to depict the status of fish populations and develop alternative estimators and sample designs. The resulting sample designs and estimators can be integrated with decision-support models for managing water resources in the Sacramento-San Joaquin Delta. Collaborators include the USFWS, Reclamation, the National Marine Fisheries Service, and California State and Federal managers in the Sacramento-San Joaquin Delta.

Publications

Duarte, A., Adams, M.J., and Peterson, J.T., 2018, Fitting N-mixture models to count data with unexplained heterogeneity—Bias, diagnostics, and alternative approaches: Ecological Modelling, v. 374, p. 51–59, https://doi.org/10.1016/j.ecolmodel.2018.02.007.

Kirsch, J.E., Day, J.L., Peterson, J.T., and Fullerton, D.K., 2018, Fish misidentification and potential implications to monitoring within the San Francisco Estuary, California: Journal of Fish and Wildlife Management, v. 9, no. 2, p. 467–485, https://doi.org/10.3996/032018-JFWM-020.

Peterson, J.T., and Barajas, M.F., 2018, An evaluation of three fish surveys in the San Francisco Estuary, 1995–2015: San Francisco Estuary and Watershed Science, v. 16, no. 4, https://escholarship.org/uc/item/1pv443h2.

The Development of Integrated Adaptive Management for Restoration of Freshwater-Estuarine Ecosystems

Oregon Cooperative Fish and Wildlife Research Unit

California's Central Valley is the largest basin-estuary complex on the Pacific coast, and it supports more than 500 fish, wildlife, and plant species. The valley is also the home of millions of people who depend on the freshwater resources of the area. Water-resource management in the Central Valley necessarily involves evaluating potential tradeoffs between conservation objectives, such as restoring or conserving at-risk species, and other values, such as providing reliable water supply to the public. Competing objectives such as these can result in conflict and make decision making difficult. The goal of this research is to integrate management, science, and monitoring using the SDM process to develop an adaptive framework for restoring aquatic ecosystems. The adaptive framework can help develop and evaluate restoration strategies, identify factors that largely drive restoration decision making, and prioritize research and monitoring to reduce critical uncertainties. This project is a collaboration with researchers and managers in multiple State and Federal agencies including the USFWS, Reclamation, the National Marine Fisheries Service, the California Department of Fish and Wildlife, the California Department of Water Resources, NGOs, and local municipalities operating in the Central Valley.

Chinook salmon smolts. Photograph by Dan Cox, U.S. Fish and Wildlife Service.

Publications

McDonnell, K.N., 2019. The influence of scale in a structured decision making framework for Chinook salmon management: Corvallis, Oreg., Oregon State University, Ph.D. dissertation, 310 p., https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/sj139764z.

Peterson, J.T. and Duarte, A., 2020, Decision analysis for greater insights into the development and evaluation of Chinook salmon restoration strategies in California's Central Valley: Restoration Ecology, v. 28, no. 6, p. 1596–1609, https://doi.org/10.1111/rec.13244.

South Carolina Alligator Adaptive Management Strategies—Population Dynamics, Habitat Use, and Conservation Threats

South Carolina Cooperative Fish and Wildlife Research Unit

The American alligator is an iconic species in South Carolina of ecological and economic importance. This study is investigating alligator population ecology using multiple analytical methods to establish an AM framework for harvest decision making. The South Carolina Unit is collaborating with the SCDNR and the Georgia Unit to provide stakeholders with tools to enhance decision making. Resulting models can serve as the basis to evaluate population-level responses to management or harvest decisions and to determine the intensity of monitoring required to produce reliable population estimates.

Publications

Lawson, A.J., 2019, Reducing uncertainties in conservation decision-making for American alligators: Clemson, S.C., Clemson University, Ph.D. dissertation, 233 p., https://tigerprints.clemson.edu/cgi/viewcontent.cgi?article=3337&context=all_dissertations.

Lawson, A.J., Moore, C.T., Rainwater, T.R., Nilsen, F.M., Wilkinson, P.M., Lowers, R.H., Guillette, L.J., Jr., McFadden, K.W., and Jodice, P.G.R., 2020, Nonlinear patterns in mercury bioaccumulation in American alligators are a function of predicted age: Science of the Total Environment, v. 707, article 135103, 15 p., https://doi.org/10.1016/j.scitotenv.2019.135103.

Advancing Adaptive Management of Harvested Animals with Modeling Platform, R

Vermont Cooperative Fish and Wildlife Research Unit

Agencies are called to implement their harvest programs within an AM framework. The process generally involves identifying the natural resource management problem, setting management objectives, identifying potential alternative management actions, estimating the likely consequences of each alternative, and then weighing each alternative and identifying tradeoffs among alternatives. AM is the application of such approaches when a decision problem is iterative, such that new information can be incorporated into decision making. Although a substantial amount has been written about the process of AM, understanding how to implement an AM program that seamlessly integrates data collection, models, decision making, analysis, and outputs can be difficult. To aid this process, a suite of R packages called AMHarvest, AMPop, and AMModels that includes a variety of functions for implementing an AM program for harvested species is being developed using the open-source modeling platform, R. These tools can help agencies organize their data and metadata and analyze harvest data in an efficient and repeatable manner. The project is a collaboration of the USGS, the Vermont Fish and Wildlife Department, and the Maine Department of Inland Fisheries and Wildlife.

American alligator. Photograph by the U.S. Geological Survey.

Integrated Forest Ecosystem Assessment to Support Sustainable Management Decisions in a Changing Climate

Vermont Cooperative Fish and Wildlife Research Unit

Since the 1970s, temperatures across the northeastern United States have warmed 0.25 degree Celsius per decade, which has been accompanied by a wide range of biological changes. Climate change may continue to restructure forests over the coming century, although the details of expected change remain uncertain. To refine understanding of how climate may affect forested ecosystems, this project examines the role of climate in forest ecosystem health and function through a combination of monitoring, experimental, and modeling activities. The project plans to focus on 10 key species, including high-profile species such as white-tailed deer, American black bear, and moose. Maps of current and projected wildlife distribution patterns can be developed and used to assess various management alternatives in a spatial structured decision framework. Anticipated results can inform real-world decisions about forest management, land-use planning, green and gray infrastructure investment, and conservation priority setting.

Publications

Pearman-Gillman, S.B., 2020, Predicting wildlife distributioususns and resilience under alternative futures: Burlington, Vt., University of Vermont, Ph.D. dissertation., 234 p., https://scholarworks.uvm.edu/graddis/1237.

Pearman-Gillman, S.B., Duveneck, M.J., Murdoch, J.D., and Donovan, T.M., 2020, Drivers and consequences of alternative landscape futures on wildlife distributions in New England, United States: Frontiers in Ecology and Evolution, v. 8, article 164, 19 p., https://doi.org/10.3389/fevo.2020.00164.

Development of a Structured Decision-Making Framework to Guide Translocation of Imperiled Aquatic Species in the Roanoke and Dan River Basins

Virginia Cooperative Fish and Wildlife Research Unit

Translocating wild or propagated animals is a potential tactic for mitigating extinction risks for imperiled species. However, biologists must weigh the risks associated with a suite of linked decisions when considering translocation as a recovery tool. These decisions could be made more quickly, objectively, and transparently if based on criteria that were previously agreed upon by species experts and preapproved by management agencies. Demographic models that forecast conservation outcomes under varying scenarios will be developed by combining stakeholder conservation goals with best-available data. These models can be used to pinpoint the strategies that best meet species-specific conservation objectives for four focal species in the Roanoke and Dan River Basins. Project outcomes can include optimized translocation strategies, as well as an interactive decision-support tool that can be used to weigh risks and predict likely outcomes of selected translocation scenarios for many other aquatic species. The project is a collaboration among the USGS, Georgia Southern University, and Virginia Polytechnic Institute and State University (Virginia Tech).

U.S. Geological Survey streamgage located in Virginia.
Photograph by Alan Cressler, U.S. Geological Survey.

Ecological Flows

Relationship Between Native and Nonnative Fish Presence and Components of the Hydrograph in Streams of the Mogollon Rim Emphasis Area, Arizona

Arizona Cooperative Fish and Wildlife Research Unit

Streams of the southwestern United States support many endemic and endangered species of fish. Conserving these species requires knowledge of what physical and biological conditions enable their populations to be sustained at particular locations. The goal of this project is to identify relations between the presence of select native and nonnative fish species and each of the five components of the hydrograph: water level, flow duration, rate of change, frequency, and timing. Hydrograph components can be expressed as discharge and mean velocity, and the history of these flows and their relation with fish presence also can be examined. This information can improve instream flow management, inform the use of flow management to manage interactions among native and nonnative fishes, and provide additional information for habitat improvement projects.

Effects of Flow Regime and Habitat on Fish Assemblage Structure

Arkansas Cooperative Fish and Wildlife Research Unit

An important question in conservation ecology is how fishes of conservation concern use habitats and persist in their environment. This question was examined in streams with two distinct flow regimes in the Ozark Plateau of Arkansas, Missouri, and Oklahoma. Groundwater flashy and runoff flashy streams were sampled for fish and crayfish to assess the potential of refuge habitats in these streams to help colonization and extinction dynamics during drought, and if those dynamics differed between flow regimes. The use of refuge habitats during drought can be incorporated to assess the potential of refugia to serve as a driver of metapopulation dynamics. This research can be useful for managers to assess which habitats and flow regimes should receive conservation attention. Partners include the USGS and the Arkansas Game and Fish Commission.

Exploring Assumptions of Community Occupancy Models in Stream Systems

Arkansas Cooperative Fish and Wildlife Research Unit

Effectively determining distribution and abundance of organisms is vital to conservation efforts. Occupancy analyses have provided a useful tool to determine the distribution and abundance of species across a landscape, as well as how certain habitat and environmental factors could affect a species. However, occupancy methods have not been widely used at the assemblage level, nor have they been used much in freshwater stream systems. Field surveys and mathematical modeling approaches can explore the effect of a suite of habitat and environmental characteristics on the distribution of stream communities in the Ozarks. Results of this study can be used to inform stream conservation and management in the Ozark-Ouachita Interior Highlands and beyond. Project partners include the USGS and the University of Arkansas.

Flow-Ecology Relations and an Environmental Flow Assessment within the Ozark-Ouachita Interior Highlands and the West Gulf Coastal Plains

Arkansas Cooperative Fish and Wildlife Research Unit

Providing adequate water quantity and quality in streams and rivers is an important global issue. Determining appropriate environmental flows in streams is critical for defining and designing landscapes capable of sustaining natural resources at desired levels. This project develops the second phase in a multiyear study involving a series of steps toward the goal of producing the scientific basis for environmental flow standards within the Ozark-Ouachita Interior Highlands and the West Gulf Coastal Plains. Important products of this work can be regional flow-ecology relations that can form the scientific framework for setting environmental flow standards and for understanding effects of land use and climate change. These flow-ecology relations can help determine environmental flow needs in the Ozark-Ouachita Interior Highlands and the West Gulf Coastal Plains and can provide the basis for conserving numerous aquatic species of greatest conservation need. Partners include the USGS, the Arkansas Game and Fish Commission, and the University of Arkansas.

Publications

Bruckerhoff, L.A., Leasure, D.R., and Magoulick, D.D., 2019, Flow-ecology relationships are spatially structured and differ among flow regimes: Journal of Applied Ecology, v. 56, no. 2, p. 398–412, https://doi.org/10.1111/1365-2664.13297.

Fox, J.T., and Magoulick, D.D., 2019, Predicting hydrologic disturbance of streams using species occurrence data: Science of the Total Environment, v. 686, p. 254–263, https://doi.org/10.1016/j.scitotenv.2019.05.156.

Effect of Flow Regime and Land Use on Food-Web Dynamics in Streams

Arkansas Cooperative Fish and Wildlife Research Unit

Food chain length, or the maximum trophic position within a food web, is an important aspect of food webs and community dynamics. Understanding the effect of disturbance on food webs and community stability is essential as climatic patterns shift and disturbance becomes more intensive. This study examines the effect of land use and flow regime on food chain length in the Ozark-Ouachita Interior Highlands. Knowing how land use affects basal resources and food chain length can inform decisions regarding land and stream management. Project partners include the USGS and the University of Arkansas.

Effect of Land Use and Flow Regime on Habitat and Fish Assemblage Structure at Multiple Spatial Scales

Arkansas Cooperative Fish and Wildlife Research Unit

Flow regime and land use can be overarching factors affecting stream ecosystems. Flow regime can act as the master hydrologic variable in streams, and land use and cover can affect geomorphology and hydrology. Rarely, however, have the effects of these two factors on stream assemblage structure been examined together. This project examined the effect of flow regime and land use and cover on stream fish and crayfish assemblage structure and body condition of select species. Results of this study can be used to improve management of stream ecosystems focused on strategies related to landscape and local-scale habitat management. Partners include the USGS and the University of Arkansas.

Climate, Cultivation, and Culture in the Great Plains—Understanding Water Supply and Water Quality in a Fragile Landscape

Kansas Cooperative Fish and Wildlife Research Unit

Humans adversely affect aquatic resources through land use, water removal, dam building, and altered biodiversity. This project addresses how fish communities are affected by natural and anthropogenic drivers and how these biotic effects interact with social science drivers and policy options. A coupled human-landscape model that incorporated linkages and feedbacks among atmospheric, terrestrial, aquatic, and social processes to predict the potential effect of climate variability, climate change, land use, and human activity on water resources was developed. Results demonstrated that drivers of watershed-scale fish biodiversity vary regionally, that urbanization reduced fish biodiversity in the lower region of the watershed, and that disturbed conditions associated with a reduction in the desired historical condition reduced fish biodiversity in the middle and upper regions of the watershed. Results were linked to policies that protect land and water resources by explicitly linking natural patterns of biodiversity with human behavior. Partners included the NSF and the Ecological Services Division of the Kansas Department of Wildlife, Parks, and Tourism.

Publications

Caldas, M., Mather, M., Bergtold, J., Daniels, M., Granco, G., Aistrup, J.A., Haukos, D., Sheshukov, A.Y., Sanderson, M.R., and Heier Stamm, J.L., 2019, Understanding the Central Great Plains as a coupled climatic-hydrological-human system—Lessons learned in operationalizing interdisciplinary collaboration, *in* Perz, S.G., ed., Collaboration across boundaries for social-ecological systems science: Palgrave-Macmillan, Cham, p. 265–294, https://doi.org/10.1007/978-3-030-13827-1_8.

Granco, G., Heier Stamm, J.L., Bergtold, J.S., Daniels, M.D., Sanderson, M.R., Sheshukov, A.Y., Mather, M.E., Caldas, M.M., Ramsey, S.M., Lehrter, R.J., II, Haukos, D.A., Gao, J., Chatterjee, S., Nifong, J.C., and Aistrup, J.A., 2019, Evaluating environmental change and behavioral decision-making for sustainability policy using an agent-based model—A case study for the Smoky Hill River Watershed, Kansas: Science of the Total Environment, v. 695, article 133769, 15 p., https://doi.org/10.1016/j.scitotenv.2019.133769.

Developing and Testing a Spatially Explicit, Science-Based Decision-Support Tool for Making Riverscape-Scale Management Decisions—How Dams and Culverts Affect a Threatened Native Stream Fish, the Neosho Madtom, and Select Tributary Fish Species

Kansas Cooperative Fish and Wildlife Research Unit

Low-head dams pose a major threat to aquatic biodiversity by altering geomorphology, hydrology, and ecological patterns and processes. However, relatively little research has been done on the >2,000,000 smaller low-head dams that block U.S. streams and rivers. This research quantified habitat, geomorphology, hydrology, and fish communities at six low-head dams and at six undammed sites within the Neosho River, Kansas, by quantifying geomorphic

dam footprints, detecting keystone habitat effects, identifying the importance of habitat mosaics, and determining that alternative approaches to measuring dam effects provided contrasting scientific information. This research affected management decisions on dam removal, renovation, and associated watershed management by providing original Kansas-based data on dams that agency cooperators can use in communicating with private landowners and policymakers. Collaborators included the Ecological Services Division of the Kansas Department of Wildlife, Parks, and Tourism.

Identification, Characterization, and Threat Assessment of Groundwater-Dependent Ecosystems in the Northeastern United States with an Integrated Geographic Information System- and Field Survey-Based Approach

Maine Cooperative Fish and Wildlife Research Unit

Groundwater is an important source of freshwater for human populations worldwide, and management of this resource typically is focused on ensuring quality and quantity for human use. Many aquatic systems also rely on groundwater inputs (for example, springs, seepages, subterranean streams, fens, and vernal pools) for ecological integrity and persistence. Groundwater-management decisions for human use commonly do not consider ecological effects of those actions on groundwater-dependent ecosystems (GDEs) and can result in negative repercussions for GDEs and human populations that rely on them. The goal of this research is to apply spatial analysis tools to identify areas likely to contain GDEs. A further objective is to conduct field-based assessments of the areas predicted to contain high-quality GDES or GDE clusters to discern their landscape context, understand watershed-level threats, characterize hydrologic conditions, and identify the species they support. Products could include an assessment of threats to areas predicted to contain GDEs, a user guide for deploying continuous hydrological monitoring equipment, and resources for evaluating GDE presence in areas predicted to contain these systems. This project is a collaboration with the USFWS, the University of Maine, and Tennessee State University.

Effects of Surface-Water Supply Reservoirs on Streamflow and Biota

Massachusetts Cooperative Fish and Wildlife Research Unit

In 2010, the Massachusetts Sustainable Water Management Initiative was created to develop a water allocation program that satisfies human water needs while protecting aquatic ecosystem health. The current framework includes a safe yield approach to allocation, biological categorization of streams using fish communities as a surrogate for aquatic integrity, and streamflow criteria. The Sustainable Water Management Initiative process is continuing, but researchers have identified uncertainty in flow alteration caused by surface-water withdrawals from reservoirs as a major data gap moving forward. Hence, the goal of this research is to quantify flow alteration caused by surface-water withdrawals from reservoirs and the relation between instream flow and biotic assemblages downstream from water-supply reservoirs. Researchers could also investigate relations between flow and temperature alteration, fish assemblages, and macroinvertebrate assemblages to determine the aspects of the flow and temperature regime that predict biotic assemblages. Hydrologic monitoring in streams can help to understand variability in flow alteration and directly link hydrology to biotic responses, which is critical for making decisions on how to manage water supply while protecting stream ecosystems. This project is a collaboration with the Massachusetts Division of Fisheries and Wildlife.

Potential for Conservation Lands in Middle Mississippi River Flood Plains

Missouri Cooperative Fish and Wildlife Research Unit

Large river flood plains provide a multitude of important ecosystem services that are frequently at odds. Furthermore, tools that address the spatiotemporal patterns of inundation are needed to improve large river flood-plain management. Researchers developed a model of 200 river miles of the Middle Mississippi River flood plains that generates a spatial database that collapses 85 years of daily river hydrodynamics and hydroclimatic variability into seasonality, duration, frequency, and magnitude of flood-plain inundation under existing land-use conditions. These results can be used to predict the effects of removing flood protection levees on flood-plain inundation patterns and can help the USFWS and other partners develop flood-plain management scenarios that provide ecosystems services while balancing other needs such as flood control.

Gila National Forest Stream Temperature and Intermittency Monitoring Network for Species of Special Interest

New Mexico Cooperative Fish and Wildlife Research Unit

Management of imperiled fishes of greatest conservation need in the arid Southwest requires an understanding of their habitat. The importance of stream temperature is well recognized, especially considering a changing climate where a major shift in temperature and precipitation is predicted for the 21st century. Willow Creek, Gila National Forest, New Mexico, is home to a population of Gila trout that were extirpated in the 2012 Whitewater-Baldy Wildfire but were subsequently re-established. This project deployed a stream temperature and intermittency-monitoring network in Willow Creek, Gila National Forest, New Mexico, to assess temperature and flow regimes and the system's (current) ability and (future) vulnerability to support Gila trout. Temperatures throughout Willow Creek during the study

period were suitable and not an immediate threat to Gila trout persistence. Results of this study include implementation of a long-term monitoring network to document temperature and flow data during the summer months across a variety of water years (high flow, low flow, and drought) to assess the sensitivity of the system to support Gila trout in the future.

Effect of Stream Temperature, Intermittency, and Nonnative Fishes on the Current and Future Distribution of Native Fishes in the Gila and Mimbres Drainages

New Mexico Cooperative Fish and Wildlife Research Unit

Stream temperature, flow, and the presence of nonnative fishes can affect the distribution of native cold- and cool-water fishes. This is especially true for native fishes that have already experienced substantial contractions in their historic range. The Gila and Mimbres drainages, in southwestern New Mexico, support a unique cold- and cool-water native fish fauna adapted to the arid stream systems in which they evolved. These fishes, however, are losing ground to nonnative fishes and to loss of habitat caused by intermittency from stream drying. Researchers for this study implemented a temperature monitoring network throughout current and historical fish distributions to assess localized temperature effects on the distribution of the native fishes. Researchers are working with the USFWS, the USFS, the New Mexico Department of Game and Fish, and citizen scientists to provide a comprehensive outlook of the dynamics that air and water temperature have on these arid-land fishes for future water planning needs.

Association of Flow Regime with Fish and Invertebrate Assemblages in Caribbean Streams and Rivers

North Carolina Cooperative Fish and Wildlife Research Unit

The flow regime (in other words, the rate and timing of water flow) is a central physical factor regulating the dynamics of biotic communities in stream and river ecosystems. Determining optimal flow regimes that meet societal demands for water resources while sustaining and enhancing aquatic life is especially applicable to tropical island aquatic ecosystems, and the Caribbean island of Puerto Rico is an ideal landscape upon which to empirically research such dynamics. Recent destructive tropical storms in the Caribbean warrant and facilitate the study of extreme disturbance, such as flooding and drought, and the need to plan adaptation strategies is critical. The goal of this project is to determine how streamflow dynamics affect aquatic communities in Puerto Rico. The results can be used to develop environmental flow prescriptions to sustain and enhance aquatic life in streams and rivers of Puerto Rico.

Flow-Ecology Relations of Red River Stream Fishes

Oklahoma Cooperative Fish and Wildlife Research Unit

Changes in weather patterns and anthropogenic disturbance have severely altered stream ecosystems. Consequently, stream fishes are declining at an alarming rate owing, in part, to changes to flow regimes. Despite improved theoretical perspectives and analytical advancements, stream fish flow-ecology relations remain poorly understood. The goal of this research is to use modeled streamflow data and assemblage-level surveys from 1980 to 2016 to examine flow-ecology relations of Red River stream fishes. In addition to providing important ecological information, the model can be used to predict future Red River stream fish distributions under different climate change and groundwater pumping scenarios. The results could contribute to the development of conservation and management strategies and water-use policies in the south-central United States that balance human water-use needs with the ecological integrity of aquatic ecosystems.

Innovative and Adaptive Desert River Restoration

Utah Cooperative Fish and Wildlife Research Unit

Important tributaries to the Upper Colorado River have been affected by hydrological alterations, habitat fragmentation, and nonnative woody riparian vegetation establishment. In the lower river areas, spring snowmelt floods have declined in magnitude and duration because of water capture in the upper part of the basin. The overall objective and mission of this restoration and monitoring project is to guide conservation and recovery efforts targeted to imperiled and endemic fish species and riparian corridors in desert tributaries of the Upper Colorado River Basin. This project represents ongoing efforts started on the San Rafael River in 2006 and is part of an effective partnership between the BLM, Utah State University, the Utah Division of Wildlife Resources, and Reclamation. This project has direct benefits to natural resource management and invasive species prevention.

Publication

Laub, B.G., Thiede, G.P., Macfarlane, W.W., and Budy, P., 2018, Evaluating the conservation potential of tributaries for native fish in the Upper Colorado River Basin: Fisheries Magazine, v. 43, no. 4, p. 194–206, https://doi.org/10.1002/fsh.10054.

Evaluating the Satisfaction and Distribution of Anglers Within the Logan River Basin

Utah Cooperative Fish and Wildlife Research Unit

Summer base flows for rivers are critical for maintaining water quality, healthy fish populations, and a functional aquatic ecosystem. Low summer base flows can increase water temperatures and reduce dissolved oxygen concentrations. These conditions can stress brown trout energetically and thus result in lower angler catch. The goal of this study is to determine if low river flows and higher water temperatures affect angler catch rates of brown trout on the lower Logan River, Utah. Data suggest that even on a higher-than-average runoff year, angler success is affected by low summer base flows. Maintaining increased river flow during typical summer low-flow periods could increase angler catch rates and, ultimately, even greater satisfaction with this potential Blue Ribbon fishery. This project is a collaboration of the USGS, Utah State University, Trout Unlimited, the Utah Division of Wildlife Resources, and the USFS Rocky Mountain Research Station.

The San Rafael River, an upper tributary of the Colorado River. Photograph by the U.S. Geological Survey.

Assessment of the Dynamics and Biotic Effects of Fine Sediment to Assist Conservation of Stream Fishes in the Dan and Roanoke River Basins

Virginia Cooperative Fish and Wildlife Research Unit

Adverse effects of excess fine sediment on the water quality and ecosystem services provided by streams are pervasive. Managers could prioritize actions that improve recovery of silt-sensitive fishes if they could identify the sources and fates of silt, how silt-loading affects benthic habitat, and how benthic condition alters silt-sensitive fish distribution and abundance. This project integrates spatially explicit analyses of relations among sediment sources and fates across upland, riparian, and instream components of watersheds, benthic habitat condition, and the distribution and abundance of benthic stream fishes. Project results can help managers decide where, how much, and what kinds of riparian and flood-plain management are most likely to protect and enhance recovery of silt-sensitive fishes. The project is a collaboration with Plymouth State University and Virginia Polytechnic Institute and State University (Virginia Tech).

Drought, Water Availability, and the Implications for Fish

Wyoming Cooperative Fish and Wildlife Research Unit

In semi-arid systems, water availability is a critical resource for species to track, but water availability is not well quantified. Climate change and increased water abstraction will increase the frequency and intensity of drought, but the ecological implications are not well understood. To better quantify water availability and evaluate implications for fish populations, this study aims to develop maps of spatial and temporal variation in water availability that can be useful in planning and prioritizing management actions. This project is a collaboration with the Wyoming Landscape Conservation Initiative.

Ecosystem Services

Sustainable Restoration of Dauphin Island, Alabama

Alabama Cooperative Fish and Wildlife Research Unit

Dauphin Island is a strategically important barrier island along the coast of the northern Gulf of Mexico, serving as the only barrier island providing protection to much of the State of Alabama's coastal natural resources. The island has been affected by storms and the 2010 *Deepwater Horizon* oil spill, warranting evaluation of restoration options. This research intends to identify the most beneficial and effective restoration activities for Dauphin Island that, if implemented, would ensure long-term sustainability and resiliency of the island, its habitats, the living coastal and marine resources it supports, as well as estuarine conditions in the adjacent Mississippi Sound and the extensive coastal wetlands to the north. The project integrates multiple models to determine long-term effects of storms and sea-level rise on restoration activities and consequent effects on the conservation value of the island. The Alabama Department of Conservation and Natural Resources engaged multiple scientists from the USGS and the USACE to develop the decision-support system that can inform restoration decisions.

The Invertebrate Community of Humboldt Bay

California Cooperative Fish and Wildlife Research Unit

Numerous studies on the U.S. west coast have documented differences in species diversity and abundance associated with estuarine habitat types with and without oyster culture. However, because of the relatively recent transition to off-bottom culture, few studies have addressed how and whether off-bottom oyster culture affects species use and abundance or whether these differences affect the overall food web ecology of the system. The goal of this project is to examine how off-bottom oyster culture affects the benthic invertebrate community in Humboldt Bay, California's second largest estuary. Results can further the understanding of how benthic invertebrate communities are affected by the presence of oyster aquaculture by examining the environmental effects of shellfish aquaculture.

Assessing Fish Habitat and Population Dynamics of Fisheries Resources at Kaloko Fishpond

Hawai´i Cooperative Fishery Research Unit

Throughout Hawai´i, fishponds are considered important cultural touchstones, a source of local, sustainably produced food, and a significant component to the development of community-based management for nearshore fisheries. Within Kaloko Honokōhau National Historic Park, the restoration of Kaloko Fishpond for traditional aquaculture management is an immediate goal of the NPS and an eager, dedicated community group. This project intends to investigate the ecology of Kaloko Fishpond, particularly as it pertains to the population dynamics of its fish species and fish-habitat quality. Results can be used to adapt traditional pond management practices to restore and manage Kaloko Fishpond.

A heron walks on a beach on Dauphin Island, Alabama. Photograph by Soupy Dalyander, U.S. Geological Survey.

Assessing the Functional Equivalency of Hawaiian Fishponds

Hawai´i Cooperative Fishery Research Unit

Hawaiian fishponds were important cultural and economic resources for native Hawaiians because they were a significant component of a sophisticated, integrated food production system. However, changing demographics and systems of land ownership resulted in a decline in the use and upkeep of Hawaiian fishponds throughout the 19th century. The cultural value of Hawaiian fishponds has not diminished, and there has been a concerted effort from numerous community groups to restore fishponds in Hawai´i since the early 1990s. Hawaiian fishponds potentially may be an important component of the productivity of nearshore fisheries because there is a relatively small amount of estuarine habitat among the islands. The goal of this project is to evaluate the role of fishponds on the productivity of nearshore fisheries in Hawai´i and to determine the interaction among actively managed fishponds; inactive, abandoned, or otherwise unmanaged fishponds; and natural estuaries. Results can be used to inform permitting decisions and best-management practices and hence better manage nearshore fisheries resources.

Effects of Tile Drainage on Restored Oxbows as Habitat for Endangered Topeka Shiners and Other Biota

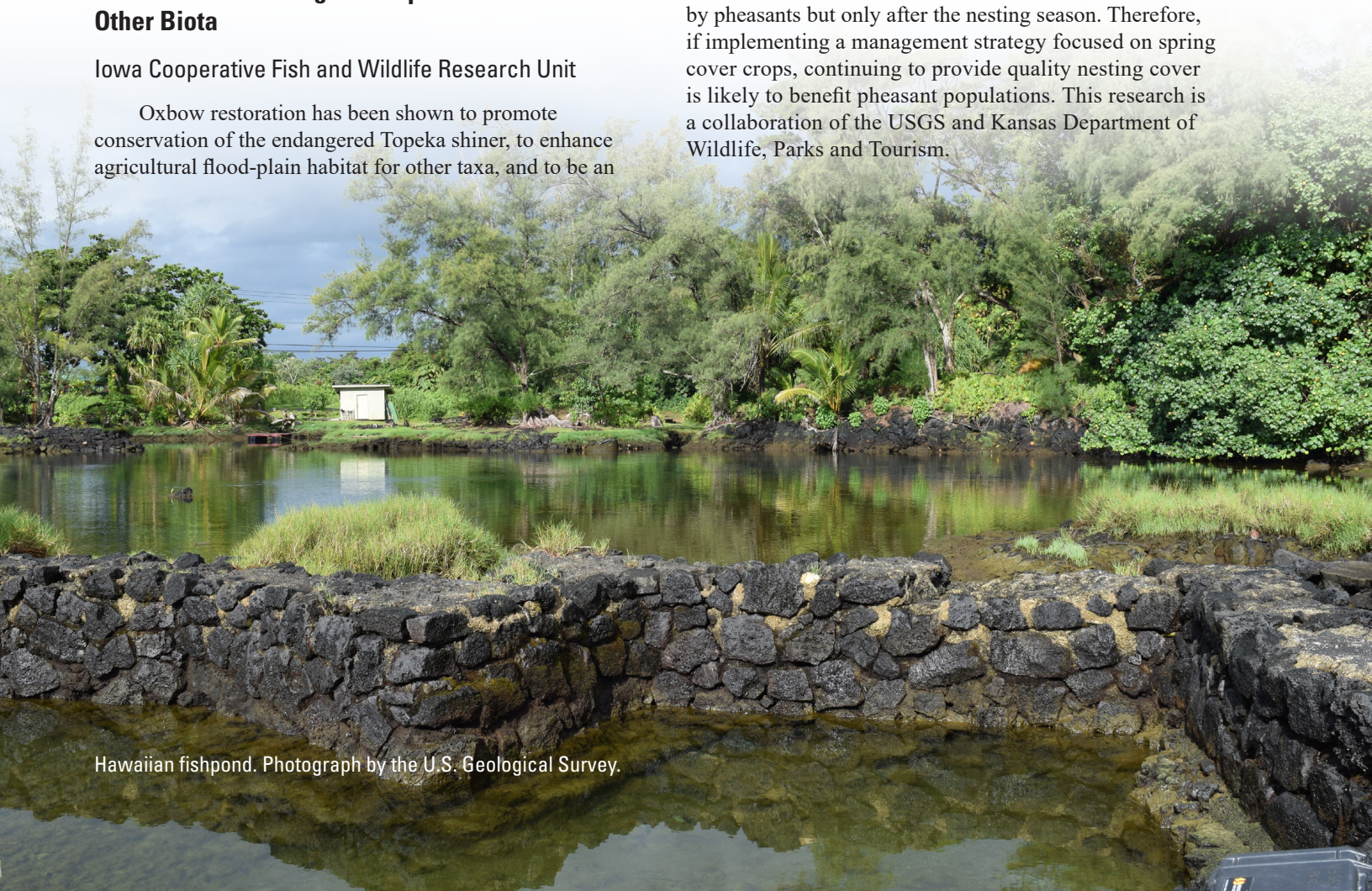
Iowa Cooperative Fish and Wildlife Research Unit

Oxbow restoration has been shown to promote conservation of the endangered Topeka shiner, to enhance agricultural flood-plain habitat for other taxa, and to be an effective strategy for reducing nutrient export from cropland to Iowa's waterways. Because of this potential benefit, oxbow restoration was recently adopted by the Science Advisory Team of the Iowa Nutrient Research Center as an approved conservation practice. An important and yet unanswered question is whether introduction of tile drainage will affect the conservation benefits of restored oxbows. This research will quantify the establishment of biota and habitat conditions in recently restored oxbows, with and without tile drainage, to test the effects of tile drainage on conservation benefits of oxbow restoration. Numerous agencies are partners in this research and may benefit from its results, including the USFWS, The Nature Conservancy, The Iowa Soybean Association, and the Iowa DNR.

Ring-Necked Pheasant Population and Space Use Response to Landscapes Including Spring Cover Crops

Kansas Cooperative Fish and Wildlife Research Unit

Ring-necked pheasant populations are declining across the midwestern United States. Pheasant hunting is a critical contribution to the economy of these areas. Developing alternative management strategies is important for management of pheasants. Use of spring cover crops may benefit pheasants and producers. Spring cover crops are used by pheasants but only after the nesting season. Therefore, if implementing a management strategy focused on spring cover crops, continuing to provide quality nesting cover is likely to benefit pheasant populations. This research is a collaboration of the USGS and Kansas Department of Wildlife, Parks and Tourism.



Hawaiian fishpond. Photograph by the U.S. Geological Survey.

Effects of Drought on Seed Germination and Biomass Allocation in Seedlings of Bottomland Hardwood Trees

Louisiana Cooperative Fish and Wildlife Research Unit

Global changes to flood-plain hydrology for flood control and water-management coupled with increased climatic variability has led to intensified drought conditions in riparian forest communities, including bottomland hardwood forests of the southern United States. Bottomland hardwoods are experiencing range-wide shifts in species composition to less flood tolerant species, but there is a lack of process-level understanding regarding the effects of altered hydrology on bottomland hardwood community structure. The goal of this project is to evaluate the effects of drought, or differing levels of water availability, on seed germination of select bottomland hardwood species. In addition, greenhouse and field experiments can evaluate how different species of bottomland hardwood seedlings allocate carbon among roots, stems, and leaves under varying soil moisture conditions. This research could begin to allow researchers to understand how the mechanisms of bottomland hardwood regeneration are affected by drought and to develop more effective forest management approaches under changing hydrologic and soil moisture conditions.

Exploring Louisiana's Oyster Populations' Tolerances to Salinity

Louisiana Cooperative Fish and Wildlife Research Unit

Ongoing and predicted changes in precipitation and river flow are likely to continue to affect key estuarine species, such as the eastern oyster. Oysters act as estuarine sentinels, serving as indicators of change, and as ecosystem engineers, altering their environment and providing ecosystem services, including critical habitat and supporting a valuable economic product. However, an estimated 50 to 89 percent of native oyster populations have been functionally lost in the northern Gulf of Mexico. This project tests the performance of previously untested populations of oysters from Louisiana waters under different water-quality conditions. The goal is to identify potential stocks for a breeding program and identify oyster populations that can thrive under current and future water-quality conditions. This is a collaboration among the USGS, the Louisiana Department of Wildlife and Fisheries, and Louisiana Sea Grant.

Genomic Variation and Local Adaptation Among Natural Stocks of Eastern Oysters in Coastal Louisiana

Louisiana Cooperative Fish and Wildlife Research Unit

For any fishery, natural genetic variation among and within stocks is of critical importance, affecting aquaculture success, the outcome of restoration, recovery from overharvest, and the capacity to respond to environmental change. Nevertheless, there are no comprehensive data on genetic variation among or within Louisiana oyster stocks, limiting managers' abilities to choose stocks for aquaculture. Data that could predict how environmental change may differentially affect stocks with varying environmental histories also do not exist. This project examines oysters growing under different environmental conditions. Identifying potential markers applying either low or high salinity tolerance on oysters would enable stock selection of oyster populations for aquaculture and restoration.

Managing Louisiana's Coastal Wetlands for Sustainability in the Face of Sea-Level Rise

Louisiana Cooperative Fish and Wildlife Research Unit

Management of coastal marshes for wetland wildlife is a common practice along the Gulf and Atlantic coasts. Marsh management practices, such as drawdowns and fire, can, however, accelerate decomposition rates of organic soils and lead to loss of elevation and marsh conversion to open water. These same practices, however, can also accelerate plant production and potentially lead to elevation gain through increased long-term accretion rates. The goal of this study is to quantify the long-term accretion rate of managed and unmanaged marshes while companion and future studies intend to quantify the specific effects of selected marsh management practices on annual accretion and decomposition rates. Ultimately, this research can identify long-term marsh management approaches that allow for, or accelerate, marsh vertical accretion while also providing desired wildlife benefits.

Occurrence and Variation in Submerged Aquatic Vegetation Along the Northern Coast of the Gulf of Mexico

Louisiana Cooperative Fish and Wildlife Research Unit

Submerged aquatic vegetation (SAV) communities are highly productive ecosystems that provide important ecological benefits within coastal areas, including support for many important species of fish and wildlife. Despite their critical importance, and loss globally, consistent baseline data on SAV resources across the coastal salinity gradient is lacking. The goals of this project are to provide data on the occurrence and abundance of SAV resources within the northern Gulf of Mexico, quantitatively assess environmental factors affecting its spatial and temporal variation, and develop a conceptual model of factors affecting SAV resources. This work can contribute to the refinement of existing models of ecosystem change and directly benefit efforts of the Gulf Coast Joint Venture, the Gulf Coast Prairies Landscape Conservation Cooperative, and the Gulf Coastal Plains and Ozarks Landscape Conservation Cooperative in forecasting the effects of these

changes on distribution, abundance, and diversity of SAV resources and the priority fish and wildlife populations that depend upon them.

Publications

DeMarco, K.E., 2018, Shifting niche space in coastal landscapes—Spatio-temporal patterns driving submerged aquatic vegetation across the northern Gulf of Mexico: Baton Rouge, La., Louisiana State University, Ph.D. dissertation, 113 p., https://digitalcommons.lsu.edu/gradschool_dissertations/4603/.

DeMarco, K.E., Couvillion, B., Brown, S., and La Peyre, M., 2018, Submerged aquatic vegetation mapping in coastal Louisiana through development of a spatial likelihood occurrence (SLOO) model: Aquatic Botany, v. 151, p. 87–97, https://doi.org/10.1016/j.aquabot.2018.08.007.

Hillmann, E.R., 2018, Analysis of submerged aquatic vegetation resources across the northern Gulf of Mexico—Communities and biomass: Baton Rouge, La., Louisiana State University, Ph.D. dissertation, 159 p., https://digitalcommons.lsu.edu/gradschool_dissertations/4564/.

Using the Submerged Aquatic Vegetation Likelihood of Occurrence Model to Inform Restoration

Louisiana Cooperative Fish and Wildlife Research Unit

Greater than 50 acres of SAV within Jean Lafitte National Historical Park and Preserve was affected during the 2010 *Deepwater Horizon* oil spill off coastal Louisiana. To inform and guide decision making, a down-scaled model of a coast-wide likelihood occurrence model is being applied to the national park waters. This model can enable managers to make decisions related to restoration options.

Wetland Management Effects to Pecos Sunflower, Wright's Marsh Thistle, and Leoncita False-Foxglove

Louisiana Cooperative Fish and Wildlife Research Unit

Pecos sunflower, Wright's marsh thistle, and leoncita false-foxglove are rare species that are present on Bitter Lake National Wildlife Refuge in New Mexico. A greater understanding of seed germination and establishment requirements could allow for moist-soil management strategies that could increase the populations of all three species. The goals of this study are to conduct laboratory and field experiments to identify the effects of soil moisture and salinity on germination and establishment of these species, and to evaluate energy availability for waterfowl for moist-soil units managed for these rare plant species. The researchers could identify critical parameters for germination and establishment of these species and develop experimental moist-soil management regimes to enhance rare plant populations. The USFWS and Bitter Lake National Wildlife Refuge are collaborators on this project.

Pecos sunflower. Photograph by Dave Showalter, U.S. Fish and Wildlife Service.

Natural-Ecological and Sociopolitical Factors Affecting Urban Forest Management in Massachusetts

Massachusetts Cooperative Fish and Wildlife Research Unit

With estimated losses of 36 million trees per year, urban tree canopy (UTC) cover continues a downward trend nationwide. UTC cover losses may result from a variety of factors including development, maintenance practices, and pests. Conservative estimates of national UTC cover benefits equate to $100 million per year, compared to carbon sequestration, pollution removal, reduced energy, and reduced power plant emissions. These, and other ecosystem services, are enjoyed by thousands of citizens living and working in urban settings, including an estimated 90 percent of Massachusetts' residents. To gain further understanding into emergent urban forest management issues in Massachusetts, researchers conducted qualitative research interviews with community-based urban forestry decision makers, known as municipal tree wardens. Results, when available, can inform urban forestry integrated research and extension initiatives designed to maintain or enhance the ecological services provided by UTC. This project involves collaboration among the USGS, the USFS, the Massachusetts Department of Conservation and Recreation, the University of Massachusetts Center for Agriculture Food and the Environment, and the University of Massachusetts Department of Environmental Conservation.

Evaluating the Role of Wetland Reserve Program Easements in Providing for Multiple Ecosystem Functions

Missouri Cooperative Fish and Wildlife Research Unit

Bottomland hardwood forests were once the dominant ecosystem in the Mississippi Alluvial Valley; however, conversion to agricultural purposes reduced the area of forest across the Mississippi Alluvial Valley by 75 percent. Because of wetland loss and subsequent effects on biotic communities and water quality, the Wetland Reserve Program (WRP) was started in 1990 to restore marginal agricultural lands to wetlands. This project can evaluate the effectiveness of WRP restoration projects at providing multiple ecosystem services, including nutrient cycling and wildlife habitat in the Mississippi Alluvial Valley. Providing information on the extent to which wetlands provide wildlife habitat and nutrient cycling can help to guide future restoration efforts and ensure that project goals are met.

Playa Wetlands—Ecosystem Function and Potential Risk in a Changing Climate

Missouri Cooperative Fish and Wildlife Research Unit

Playas are shallow, recharge wetlands throughout the Great Plains and provide many essential ecosystem functions, including nutrient filtration, groundwater recharge, and wildlife habitat. However, predicted increases in temperature and alterations to precipitation patterns over the next century may affect these ecosystem services. Researchers conducted controlled experiments to quantify effects of predicted climate change on wetland biogeochemical cycles. These results indicate that playa hydroperiod and soil moisture affect soil carbon and nitrogen biogeochemical cycles to varying extents. These results can be used with future climate scenarios to assess shifts in playa nutrient cycles and the resulting effects to nutrient filtration and habitat functions.

Global Change, Vulnerability, and Resilience—Management Options for an Uncertain Future

Nebraska Cooperative Fish and Wildlife Research Unit

Ecological regime changes can be surprising, can be difficult to manage or respond to, and may threaten achievement of management goals. For example, undesired regime changes can lead to species extinctions or, on DoD properties, can affect military readiness. The goals of this project are to develop models to detect and assess ecological regime shifts in space and time, to identify components of adaptive capacity, and to identify species and techniques that may serve as leading indicators of thresholds of changing ecological regimes. Monitoring and surveying data currently available in North America (for example, breeding bird surveys) can be used with novel statistical tools and theory to assess long-term trends in the resilience of landscapes, changes in ecological regimes in both space and time, and species vulnerable to decline and extinction. The results of this research could help in the development of approaches and techniques to monitor regime changes and provide early warning of impending regime changes. This project is a collaboration with the DoD, including Fort Riley and Eglin Air Force Base.

Implementing the North American Bat Monitoring Program Through Citizen Science in Nebraska

Nebraska Cooperative Fish and Wildlife Research Unit

Bats are important to ecosystems and humans. Their significance is demonstrated through the ecosystem services they provide, which include seed dispersal, pollination, and insect population control. Many bat species are declining, but methods to monitor their populations are poorly developed. Consequently, this project used the North American Bat Monitoring Program (NABat) protocols to study the full range of bats in Nebraska and to determine the habitat characteristics that affect bat presence or absence based on a combination of stationary and mobile ultrasound acoustic detectors. The combined use of stationary points and mobile transects establishes a novel framework for determining the distribution of bat species across the State and can help provide warning of population declines and improve bat-habitat models. Results can be incorporated in a monitoring program and citizen science program to monitor bats across Nebraska.

Changes in Stream Fish Distribution and Occurrence in Seven National Park Service Units of the Eastern Rivers and Mountains Network

Pennsylvania Cooperative Fish and Wildlife Research Unit

The NPS mission to preserve, protect, and maintain the integrity of park ecosystems for the enjoyment of future generations relies upon access to science-based information regarding the status and trends in the condition of the ecosystem. The Eastern Rivers and Mountains Network includes nine parks in four States (New York, New Jersey, Pennsylvania, and West Virginia), ranging in size from about 66 to 30,000 hectares with >690 kilometers of rivers and streams. The Eastern Rivers and Mountains Network documents long-term change in the ecological integrity of one of the most abundant surface-water ecosystem types in the network (high-gradient, wadeable streams) by monitoring stream fish communities. Assessment of changes in fish community composition, occupancy, and abundance is necessary to ensure the NPS mission is achieved. The statistical models developed during this project can inform decision-making processes for the management of park ecosystems. The project is a collaboration of researchers from the USGS, the NPS, and The Pennsylvania State University.

An Exploration of the Direct and Indirect Effects of Climatic Warming on Arctic Lake Ecosystems

Utah Cooperative Fish and Wildlife Research Unit

Arctic lakes support trophic interactions, biological processes, and critical habitat at all trophic levels; however, climatic warming threatens to alter the structure and function of aquatic communities and overall system production. Arctic ecosystems are warming at some of the fastest rates observed on Earth, and Arctic lakes are experiencing more frequent years of warmer surface water and deeper mixing. However, the ability to detect and quantify ecosystem effects and specific biological responses (for example, bacterial diversity, invertebrate production, and fish growth) to these climatic changes has been primarily limited to nonmechanistic modeled scenarios and observational studies in uncontrolled environments. By providing some of the first empirical evidence of how fundamental processes can change in the face of climate change, this research could also improve understanding of ecosystem service sustainability (for example, subsistence fisheries). The project is a collaboration of researchers across multiple entities including the USGS, Oregon State University, and the Marine Biological Laboratory in Woods Hole, Massachusetts.

Publication

Klobucar, S.L., 2018, The abiotic and biotic controls of Arctic lake food webs—A multifaceted approach to quantifying trophic structure and function: Logan, Utah State University, Ph.D. dissertation, 141 p., https://digitalcommons.usu.edu/cgi/viewcontent.cgi?article=8407&context=etd.

Ecosystem Services in the Roanoke River Basin

Virginia Cooperative Fish and Wildlife Research Unit

The Roanoke River Basin provides many ecosystem services. This project explored economic outcomes from potential resource-management actions that can affect the value of key ecosystem services in the region, focusing on recreation, urban and agricultural runoff, coal ash, and uranium mining. Initial ecosystem service assessments provide baseline values of ecosystem services such as air quality, water supply, protection from extreme events, and soil formation based on the land-cover distribution in the region. After performing a baseline ecosystem service assessment, researchers held community workshops to gather input from stakeholders, including watershed organizations, landowners, town planners, and State officials. The key ecosystem services cited most frequently by stakeholders included fishing and other water-based recreational activities, access to high-quality drinking water, habitat for species, aesthetic values, and erosion control. This information is useful to planners and managers as they develop best-management practices to preserve and enhance the ecosystem services provided by the basin.

Lake ecosystem in Alaska. Photograph by the U.S. Geological Survey.

Energy

Assessment of Effects of Flow Management on Macroinvertebrate Assemblages at the R.L. Harris Dam

Alabama Cooperative Fish and Wildlife Research Unit

Hydroelectric dams remain one of the primary sources of renewable energy globally. Hydropeaking regimes used to generate electricity cause disturbances in natural flow and thermal conditions. Pulses of various magnitude create dual waves of sheer and thermal stress, which, in general, cause a decrease in community complexity, richness, and native diversity downstream from hydropeaking dams. As human populations increase and become more reliant on renewable resources, reducing uncertainty regarding how hydropower affects natural ecosystems is important to State and Federal partners as well as other stakeholders interested in multiple uses of river systems. The R.L. Harris Dam is a hydropeaking facility in the upper-central Tallapoosa River Basin that has been subject to an adaptive flow-management project (R.L. Harris Adaptive Management Program) since 2005. Long-term data indicate that, despite the improved flow regime plans implemented under the Adaptive Management Program, communities in the regulated river remain dissimilar from those unaffected by the dam. The Alabama Department of Conservation and Natural Resources can use these data to investigate and predict how future alternate flow regime decisions from the dam may affect their biological objectives for biota. Metrics defining variation in flow, temperature, and local environmental variables can be used to best predict effects to stakeholder values related to future flow regime decisions ultimately set by the Federal Energy Regulatory Commission during dam relicensing.

Determining Species-Specific Dissolved Oxygen and Temperature Requirements for Nongame Riverine Fishes

Alabama Cooperative Fish and Wildlife Research Unit

Large instream hydropower dams are required to maintain a minimal level of dissolved oxygen in discharged water; this minimal level is typically determined based on the temperature and oxygen requirements of largemouth bass or other game fishes. However, data regarding critical physiological limits of most nongame fishes are lacking. This project involves applying respirometry to quantify the dissolved oxygen and temperature requirements of several nongame fishes. Knowing these requisite tolerance ranges may help determine suitable water conditions below impoundments. Species from the southeastern United States will be selected to determine if specific physiology requirements are linked to taxonomy or habitat requirements. These data can have immediate application to the USFWS and other regulatory agencies for determining whether current regulations for dissolved oxygen are appropriate for species of concern. Findings and predictions can assist in decision making for specific projects and could be applicable to delivery of conservation actions relative to impounded river systems and habitats across the region and beyond.

Integrating Sonar and Aerial Photogrammetry To Quantify Habitat Persistence for Shoal Dwelling Fishes and Invertebrates in Relation to Flow Prescriptions

Alabama Cooperative Fish and Wildlife Research Unit

Instream flow incremental methodologies are hydraulic or hydrologic models that are applied at the reach level and are valuable for evaluating the variation in physical and hydraulic habitat units in relation to variation in flow regimes. Instream flow incremental methodologies have been used in several Alabama river systems for decision support to determine flow-habitat relations for at-risk species; however, technology and knowledge of ecohydrology have far surpassed the methods and scientific inference that were applied in the past. The goal of this project is to integrate existing remote-sensing technologies with two- and three-dimensional hydraulic models to deliver a visual tool that can quantify the effects of instream habitat relative to variation in flow regimes. This project is focused on the Tallapoosa River, Alabama, and the ecohydrology decision-support system developed in the project could be valuable for informing the Alabama Department of Conservation and Natural Resources and other stakeholders.

Assessing Shorebird Use of Lagoons in Cape Krusenstern National Monument

Alaska Cooperative Fish and Wildlife Research Unit

Cape Krusenstern National Monument's coastline includes lagoons and estuaries, which are important areas for migratory bird breeding and staging activities. Despite the vulnerability of these areas to effects of offshore energy development, little is known regarding abundance, species composition, distribution, or use of coastal habitats by migrating waterbirds (shorebirds, waterfowl, and seabirds). The goals of this project are to determine when postbreeding shorebirds inhabit the coastline and to document species abundance, diversity, and habitat use. A comparison between these data and historic records will also be developed. Data from this research can be used by Federal and State stakeholders to improve understanding of anthropogenic effects to this unique area and the species that live there. This work is a collaboration among the NPS, the USFWS, and the University of Alaska.

Landscape Genetic Structure of the Western Continental Golden Eagle Population

New Mexico Cooperative Fish and Wildlife Research Unit

Studies of golden eagle mortality linked to wind energy facilities are cause for concern, especially when coupled with the knowledge that golden eagles move great distances between breeding and wintering areas. Thus, mortalities that occur at a particular wind energy facility may not only affect a local breeding population of golden eagles but could also affect breeding populations on a continent-wide scale. Understanding the movement ecology and landscape genetic structure of golden eagles in the western United States would be critically important toward understanding the potential risks wind energy facilities pose to the continental population of golden eagles. The goal of this project is to assess the landscape genetic structure of golden eagles in the United States to understand the distribution of breeding populations of eagles, the level of connectivity that exists among them, and where individuals from these populations migrate to in the winter. This information may allow for more informed management of golden eagles on a continent-wide scale. This project is a collaboration with the USFWS and the Department of Fish, Wildlife and Conservation Ecology at New Mexico State University.

Modeling Bald and Golden Eagle and Other Raptor Populations and Take Rates

New Mexico Cooperative Fish and Wildlife Research Unit

Eagle collisions with turbines at wind energy facilities is a common occurrence in some areas of the United States. If wind turbine collision-related mortality rates are sufficiently high, it could compromise population growth rates and population persistence. The goal of this research is to conduct demographic analyses using the collision risk model and then update estimates with fatality monitoring data. The results can aid in the issuance of incidental take permits to operators of wind energy facilities, be used to improve the models used to predict fatalities, and be used under individual permits to formally update the overall modeling process. Covariates that might affect eagle exposure or collision risk can also be incorporated into the collision risk model to improve the accuracy of, and decrease the uncertainty around, the estimates. This project is a collaboration among the USGS, the USFWS, and the Department of Fish, Wildlife and Conservation Ecology at New Mexico State University.

Golden eagle. Photograph by the U.S. Geological Survey.

Analysis of Bird Population Count Data

South Carolina Cooperative Fish and Wildlife Research Unit

Sea ducks are understudied relative to other species of waterfowl, especially in the southern part of the U.S. Atlantic coast. Climate change and human activity (for example, wind energy development) could affect sea duck wintering sites by causing negative carryover effects through the rest of their life cycle. This study was designed to better describe wintering sites, movement, and habitat use of black scoters along the southern U.S. Atlantic coast using satellite telemetry and aerial survey data. The output from this study could be used to better inform survey methods for black scoters or to decrease conflict with wind energy development in the area. This project is a collaboration among the USGS, the USFWS, and Environment Canada.

Publication

Plumpton, H.M., Gilliland, S.G., and Ross, B.E., 2020, Movement ecology and habitat use differences in black scoters wintering along the Atlantic coast: Avian Conservation and Ecology, v. 15, no. 2, article 6, 12 p., https://doi.org/10.5751/ACE-01654-150206.

Eastern Brown Pelicans—Dispersal, Seasonal Movements, and Monitoring of Polycyclic Aromatic Hydrocarbons and Contaminants in the Northern Gulf of Mexico

South Carolina Cooperative Fish and Wildlife Research Unit

The Gulf of Mexico contains a high density of oil and gas infrastructure and coastal development. The region is also of year-round importance to seabirds, including local breeding populations and breeders from distant locations that occur within the Gulf throughout the year. A species of high conservation concern in the region is the brown pelican. Despite the species' long history as a focus for conservation and restoration efforts, much of the information required to understand pelican population dynamics, habitat requirements, or responses to environmental stress remains unknown or is poorly understood. Results from the research are informing restoration activities in the Gulf and have played a major role in the development of guidelines for long-term monitoring plans for seabirds in the region. Results are also used by agency partners for the development of spill response plans, assessment activities, and marine spatial planning. This project is a collaboration among the Bureau of Ocean Energy Management, the USGS Outer Continental Shelf Program, State agencies (Texas, Louisiana, Alabama, and Florida), and NGOs.

Brown pelican. Photograph by Jackie Orsulak, U.S. Fish and Wildlife Service.

Publications

Lamb, J.S., Fiorello, C.V., Satgé, Y.G., Mills-Parker, K., Ziccardi, M., and Jodice, P.G.R., 2018, Movement patterns of California brown pelicans (*Pelecanus occidentalis californicus*) following oiling and rehabilitation: Marine Pollution Bulletin, v. 131, pt. A, p. 22–31, https://doi.org/10.1016/j.marpolbul.2018.03.043.

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Lamb, J.S., Satgé, Y.G., and Jodice, P.G.R., 2020, Seasonal variation in environmental and behavioural drivers of annual-cycle habitat selection in a nearshore seabird: Diversity and Distributions, v. 26, no. 2, p. 254–266, https://doi.org/10.1111/ddi.13015.

Lamb, J.S., Satgé, Y.G., Streker, R.A., and Jodice, P.G.R., 2019, Ecological drivers of brown pelican movement patterns, health, and reproductive success in the Gulf of Mexico: New Orleans, La., Bureau of Ocean Energy Management, OCS Study BOEM 2020–036, 231 p., https://espis.boem.gov/final%20reports/BOEM_2020-036.pdf.

Ndu, U., Lamb, J.S., Janssen, S., Rossi, R., Satgé, Y.G., and Jodice, P.G.R., 2020, Mercury, cadmium, copper, arsenic, and selenium measurements in the feathers of adult eastern brown pelicans (*Pelecanus occidentalis carolinensis*) and chicks in multiple breeding grounds in the northern Gulf of Mexico: Environmental Monitoring and Assessment, v. 192, article 286, 9 p., https://doi.org/10.1007/s10661-020-8237-y.

Gulf of Mexico Marine Assessment Program for Protected Species

South Carolina Cooperative Fish and Wildlife Research Unit

Seabirds are one of the most threatened groups of birds globally yet understudied in many regions of the United States. Limited information is available regarding the species composition, distribution, and abundance of seabirds using the nearshore and offshore waters of the Gulf of Mexico. This region also supports some of the highest densities of oil and gas development in marine ecosystems in the world. The sparse data available on distribution and abundance of seabirds in the Gulf, combined with the extent of oil and gas activity, hinders resource managers' understanding of seabird ecology and ability to plan for or respond to data needs during oil and gas activities. The researchers intend to combine seabird data with similar data collected on marine mammals and sea turtles and, collectively, these data can permit spatially explicit modeling of abundance and distribution of marine vertebrates

across the Gulf. Models can provide stakeholders with tools to predict occurrence and potential impacts with respect to marine spatial planning and future spills. The goal of this study is to conduct vessel-based surveys for pelagic seabirds in the northern Gulf. Collaborators include the Bureau of Ocean Energy Management, the USFWS, the USGS Eastern Ecological Science Center, the USGS Wetlands and Aquatic Research Center, NOAA, and Michigan State University.

Ecology, Habitat Use, and Effects of Wind Energy on Burrowing Owls

Texas Cooperative Fish and Wildlife Research Unit

Burrowing owls are small owls that are of substantial conservation concern across their breeding distribution in the prairies and steppes of North America, both areas of substantial wind energy development. Wind energy development is increasing at a rapid pace throughout much of the developed world, and wind energy facilities have threatened avian species, including direct mortality of burrowing owls. The goal of this project is to provide comparison data between burrowing owl breeding pairs in context of site occupancy, productivity, and habitat use in areas with and without wind energy development. These data can allow assessments of burrowing owl response to wind energy development and the potential direct and indirect effect of associated structures. In turn, these assessments can provide important data with which to understand and evaluate risks and to determine the need for conservation actions in the context of renewable energy development.

Bird and Bat Communities Near Wind Energy Facilities

Texas Cooperative Fish and Wildlife Research Unit

Wind energy is a clean form of energy, but the negative effects on birds through direct mortality and habitat displacement are not well understood. Research and monitoring of the local avian community near a wind energy facility is necessary to assess immediate and long-term effects of the facility. This research, being conducted in collaboration with Texas Tech University, is aimed at assessing direct mortality of volant species because of wind turbines at a Scaled Wind Farm Technology facility. The study could also evaluate long-term trends in occupancy and, for select species, survival and productivity of resident and migrant grassland species.

Interactions of Juvenile Swainson's Hawks with Wind Energy Facilities During Dispersal and Migration

Texas Cooperative Fish and Wildlife Research Unit

Swainson's hawks breed in the prairies and steppes of North America, both areas of high wind energy development, then migrate to the grasslands of Argentina, an area also experiencing rapid wind energy development. Wind energy facilities have threatened avian species through direct mortality and habitat loss, and raptors may experience proportionally greater population-level effects through direct mortality or habitat loss associated with wind energy development. This study can provide survival estimates, movement data, and habitat use data for juvenile Swainson's hawks throughout their migrations from Texas to Argentina and back. This can provide important data with which to understand and evaluate hemispheric-level risks to the species and other similar long-distance migrant birds.

Coastal Bat Migration

Virginia Cooperative Fish and Wildlife Research Unit

Tree bats such as the eastern red bat, hoary bat, and silver-haired bat exhibit south-to-north spring and north-to-south autumn migrations rather than engage in hibernation during the dormant season. Use of the Appalachian Mountains and Atlantic coast for migration coupled with substantial wind energy generation in these regions have increased wind-energy related mortality for these species. Efforts are underway to examine environmental and climate relations to tree bat presence and movements to better understand migration ecology. Bats have been tagged with small transmitters, called nanotags, in coastal Virginia, Delaware, and New Jersey and tracked using the stationary Motus wildlife tracking system. Red bats have shown surprising cross-water movements in the Delaware and Chesapeake Bays, indicating a higher use of open-water flight than previously thought in the mid-Atlantic. Results from the study can be used to inform development of wind-energy best-management practices.

Hoary bat. Photograph by Frank Bonaccorso, U.S. Geological Survey.

Eastern red bat. Photograph by Gary Peeples, U.S. Fish and Wildlife Service.

Evaluations of Yellow Perch Spawning and Water-Level Fluctuations for Cheat Lake, West Virginia

West Virginia Cooperative Fish and Wildlife Research Unit

Hydropower reservoirs provide many recreational and economic benefits, including for recreational fisheries. These reservoirs often undergo seasonal water-level drawdowns for power production. Drawdowns commonly conflict with fish spawning times, where reduced water levels result in dewatered fish eggs and negative effects to fish populations. This study examined spawning success of a yellow perch population relative to drawdowns of Cheat Lake, a hydropower reservoir in northern West Virginia. Results can inform decisions of the West Virginia Division of Natural Resources for management of the yellow perch fishery and be used for negotiation of the extent of drawdowns during Federal Energy Regulatory Commission relicensing of the hydropower dam. This study was a collaborative effort by the USGS and the West Virginia Division of Natural Resources.

Long-Term Louisiana Waterthrush and Avian Community Response to Shale Gas Development in the Central Appalachian Region

West Virginia Cooperative Fish and Wildlife Research Unit

Shale gas development in the central Appalachian region has increased exponentially in recent years, leading to concerns related to fragmentation of the region's forests and to effects on water resources, particularly forested headwater streams. This 6-year study evaluated multiple measures of avian population response to a changing landscape from shale gas development activities. Measures included avian community changes, Louisiana waterthrush demographic response, and benthic community changes. Results suggest that headwater systems are affected and that effects scale up through the food chain, ultimately affecting Louisiana waterthrush demography. Findings can help to better define ecosystem-level responses across the terrestrial-aquatic interface.

Publications

Farwell, L.S., Wood, P.B., Dettmers, R., and Brittingham, M.C., 2020, Threshold responses of songbirds to forest loss and fragmentation across the Marcellus-Utica shale gas region of central Appalachia, USA: Landscape Ecology, v. 35, p. 1353–1370, https://doi.org/10.1007/s10980-020-01019-3.

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Frantz, M.W., Wood, P.B., Latta, S.C., and Welsh, A.B., 2020, Epigenetic response of Louisiana waterthrush (*Parkesia motacilla*) to shale gas development: Ibis, v. 162, no. 4, p. 1211–1224, https://doi.org/10.1111/ibi.12833.

Frantz, M.W., Wood, P.B., Sheehan, J., and George, G., 2018, Demographic response of Louisiana waterthrush, a stream obligate songbird of conservation concern, to shale gas development: The Condor—Ornithological Applications, v. 120, no. 2, p. 265–282, https://doi.org/10.1650/CONDOR-17-130.1.

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Decadal Abundance Trends of Avian Species of Greatest Conservation Need in Wyoming's Natural Gas Fields

Wyoming Cooperative Fish and Wildlife Research Unit

Sagebrush-obligate songbird species continue to demonstrate considerable range-wide population declines. The year 2018 marked the 10-year anniversary of avian point-count surveys at 160 points spanning a gradient of energy development within the Jonah and Pinedale Anticline natural gas fields in western Wyoming. Particularly within the Jonah field, the 2008 and 2009 surveys revealed decreases in the abundance of two sagebrush-obligates (Brewer's sparrow and sagebrush sparrow) with increasing well densities; whether such trends in abundance remain, or have stabilized or worsened, however, is unknown. This current project is repeating the 2008–9 surveys to address these informational gaps. Results can inform status assessments for sensitive bird species inhabiting the sagebrush steppe in Wyoming and beyond. The primary project partner is the Wyoming Game and Fish Department.

Evaluating the Effect of Wind Energy on the Movement, Distribution, and Habitat Quality of Pronghorn

Wyoming Cooperative Fish and Wildlife Research Unit

Wyoming has about 50 percent of the world's total population of pronghorn, and local herds are strongly challenged by harsh winter weather. Much of the Shirley Basin in southeast Wyoming is designated crucial winter range for the Medicine Bow pronghorn herd. The Shirley Basin winter range contains a substantial footprint of proposed wind energy development and thus presents an opportunity to learn about how pronghorn respond to wind development. Scientists are studying the effects of wind energy development on the movement of pronghorn that winter in the Shirley Basin. The overall goal of the study is to evaluate whether and how wind development affects pronghorn habitat use. The study's results can be compared to previous research that assessed oil and gas development effects on mule deer and elk. This information may be used to help guide pronghorn management amid continued development. The project is a collaboration among the USGS, the Wyoming Game and Fish Department, and The Nature Conservancy, in cooperation with the associated wind power companies.

Southwestern pronghorn. Photograph by the U.S. Geological Survey

Full Life-Cycle Effects of Natural Gas Development on Sagebrush-Obligate Songbirds

Wyoming Cooperative Fish and Wildlife Research Unit

One of the primary challenges for the management of sagebrush habitats and wildlife is the conversion and fragmentation of habitat for energy extraction. All three species of sagebrush-obligate songbirds (Brewer's sparrow, sagebrush sparrow, and sage thrasher) are declining and are species of concern for many State and Federal agencies. Large gaps in understanding remain, moreover, about how development affects key life stages outside of the nesting period, including the postfledging period and annual survival, and the extent to which the fidelity of birds to breeding sites may affect trends in abundance. Additionally, the migratory routes and overwintering locations for sagebrush songbirds remain unknown, which precludes the ability to assess which life stages may be most limiting. The goals of this project are to address vital informational gaps necessary to update species conservation plans and to inform future sighting decisions. Project cooperators include the Wyoming Game and Fish Department and the Wyoming Landscape Conservation Initiative (WLCI).

Brewer's sparrow. Photograph by the U.S. Geological Survey.

Wyoming Range Native Fish and Energy Development

Wyoming Cooperative Fish and Wildlife Research Unit

The rapid expansion of natural gas development has raised concerns about potential effects of energy development for fish and wildlife. An understanding of the effects of oil and natural gas development is required to balance the expansion of development with the protection of natural areas. In collaboration with the WLCI, this project is addressing the effects of oil and natural gas development on native fish communities. This research provides insight into the responses of fish populations and the potential mechanisms underlying the effects. These results can be used to develop monitoring and mitigation strategies for fish most at risk from oil and gas development.

Electroshocking fishes in North Beaver Creek in the Wyoming Range. Photograph by the U.S. Geological Survey.

Fish and Wildlife Health and Disease

Effects of Perfluoroalkyl and Polyfluoroalkyl Substance Contaminants on Oyster Health and Food Safety

Alabama Cooperative Fish and Wildlife Research Unit

Maintaining sustainable oyster fisheries is a primary objective of State management agencies in the Gulf of Mexico region. A primary driver of productive oyster fisheries is provision of water quality that maintains viable populations that are safe for human consumption. This research is investigating the potential effects of perfluoroalkyl and polyfluoroalkyl substances, which are long-lasting toxins, on oyster populations in Mobile Bay, Alabama. This study intends to measure variation in the body burden of perfluoroalkyl and polyfluoroalkyl substances in oysters in relation to environmental conditions throughout Mobile Bay, Alabama. The physiological consequences of these toxins on respiration and growth of oysters also may be measured. Stakeholders include marine resource and public health agencies in the region, the U.S. Environmental Protection Agency, and NGOs that focus on water quality and public safety. Results can be used to help decision makers site locations for oyster restoration, set season and creel limits, and determine food safety standards.

Research and Development of a Predictive Model for *Ceratonova shasta* Waterborne Parasites in Support of Klamath River Water-Management Decisions and the Klamath Basin

California Cooperative Fish and Wildlife Research Unit

Ceratonova shasta is a parasite endemic to the Klamath River Basin that has been linked to population declines in native salmonids. High densities of waterborne spores of the parasite are known to cause increasing infection and mortality risk for juvenile salmonids. A recently constructed population dynamics model for Klamath River salmonids, the S3 model, includes a submodel to simulate *Ceratonova shasta* disease and mortality risk for emigrating juveniles in response to potential management alternatives. This submodel uses inputs of spore density, which has identified associations between peaks in spore density and the prevalence of infection in hatchery-originated juveniles. The updated model should be better able to estimate mortality risk for juvenile salmonids and provide an adaptive management tool for managers to understand how different decisions (for example, flow) might affect the population. The project is a collaboration of researchers at the USGS and the USFWS.

Evaluating the Status and Distributions of Bats in White-Nose Syndrome-Free Areas Using Standardized Acoustic Monitoring Data from the North American Bat Monitoring Program

Colorado Cooperative Fish and Wildlife Research Unit

White-nose syndrome (WNS) has caused substantial declines to populations of hibernating bats across North America. The North American Bat Monitoring Program (NABat) was established to assess the ecological effects of these unprecedented declines, providing standardized monitoring protocols and a continental-scale collaborative framework to evaluate the status and distributions of bat species. After 4 years of conducting the survey, a current assessment of species distribution and changes therein, and dissemination of results to partners, is needed. Maps of distribution and status of bat populations to date can provide a baseline for comparison with further encroachment by WNS and other threats. Evaluating the survey methods and data can inform refinement of the NABat. The project is a collaboration among the USGS, the NPS Upper Columbia Basin Network, and numerous partners throughout the range of the NABat.

Transmission of Bacterial Kidney Disease in Colorado Greenback Cutthroat Trout

Colorado Cooperative Fish and Wildlife Research Unit

Since 2015, several State fish hatcheries in Colorado have had positive detections of *Renibacterium salmoninarum*, the causative agent for bacterial kidney disease in salmonids. The Colorado native greenback cutthroat trout is one species of concern because depopulation caused by disease may endanger populations of critical broodstocks. This project is assessing the bacterial load of greenback cutthroat trout within parents, evaluating the vertical transmission to progeny, and developing nonlethal management strategies. The results can directly inform management decisions at hatchery facilities in Colorado and can be used at a national scale. This research is being done in collaboration with Colorado Parks and Wildlife.

Investigating Bacterial Coldwater Disease in Salmonids

Colorado Cooperative Fish and Wildlife Research Unit

Aquaculture is one of the fastest growing industries worldwide, and bacterial coldwater disease (BCWD), which is caused by *Flavobacterium psychrophilum*, is one of the most detrimental hatchery diseases. Outbreaks of BCWD can result in economic losses to producers of salmon and rainbow trout. Antibiotics are used to treat BCWD, and concerns exist about the development of antibiotic resistance. This project is producing rainbow trout that are genetically resistant to BCWD and whirling disease. Results can provide an alternative disease management option for reestablishing rainbow trout fisheries and positively affect aquaculture by lowering costs, improving survival, and providing alternative markets for rainbow trout. Collaborators include Colorado Parks and Wildlife.

Mitigating Emerging Disease Effects in Fisheries—Adaptive Strategies to Ensure a Safe, Healthy Seafood Supply

Georgia Cooperative Fish and Wildlife Research Unit

As demands for seafood increase, the health and population size of fish stocks are becoming an even more important aspect of food production and security. In Georgia, commercial shrimp harvest is an important industry but is detrimentally affected by an ongoing epidemic of a parasitic ciliate called shrimp black gill. The goals of this project are to develop systematic and comprehensive analyses and new tools to address consequences and to form adaptive strategies for managing disease outbreaks in fisheries. Results can broaden the capacity of stakeholders to anticipate and respond to emerging diseases that threaten provision of safe and sustainable seafood. Collaborators include the USGS and the University of Georgia.

Bighorn Sheep Respiratory Disease Monitoring

Iowa Cooperative Fish and Wildlife Research Unit

Bighorn sheep face the ongoing threat of a polymicrobial infection, bighorn sheep respiratory disease, which can reduce juvenile survival for many years, decimate populations, and lead to local extinctions. Within Glacier National Park, bighorns are thought to be free of the disease, although a corridor of contiguous wilderness connects the park to populations that have tested positive for the most critical pathogen associated with this disease. As such, efficient biosurveillance programs are essential to anticipating and mitigating the effects of bighorn sheep respiratory disease outbreaks in Glacier National Park. The goal of this project is to develop an animal-behavior-based, citizen-driven biosurveillance program for bighorn sheep respiratory disease in Glacier National Park. The USGS is cooperating with Glacier National Park, the USFS, and the Montana Department of Fish, Wildlife and Parks staff on this project to provide the NPS with a tool to detect bighorn sheep respiratory disease and thus determine when mitigation strategies are necessary.

Assessing Attitudes Toward Chronic Wasting Disease

Minnesota Cooperative Fish and Wildlife Research Unit

Chronic wasting disease (CWD) is an infectious disease of animals belonging to the family Cervidae including deer, elk, moose, and caribou. Since 2002, CWD has been found in wild deer populations and captive deer farm facilities throughout the midwestern United States, including Minnesota. The disease is always fatal and represents a significant threat to the long-term health of wild deer populations and the future of deer hunting opportunity where it is found. Identifying effective avenues for disease management is a concern for the Minnesota DNR. Many of the identified solutions for CWD such as containment, risk management, and elimination require the voluntary participation of statewide deer stakeholders including hunters, landowners, and the public (see the Minnesota Chronic Wasting Disease Response Plan at https://www.dnr.state.mn.us/cwd/cwd-response-plan.html). This project can support several studies designed to better understand hunter, landowner, and public beliefs about, attitudes toward, and perceived risks of CWD and their support of management actions and policies to address CWD in Minnesota. This human dimension information can be integrated with ecological information to develop effective strategies to address CWD in Minnesota. The expected outcome of the research is to help minimize CWD effects on deer and deer hunters in Minnesota.

Linking Exposure to Sublethal Stressors to Individual Vital Rates and Population Abundance

Montana Cooperative Wildlife Research Unit

Wildlife management will be more effective and less expensive when managers can quickly identify populations that are most susceptible to decline. This challenge is especially large for species with complex life cycles that depend upon aquatic and terrestrial environments. Stressors such as increased salinity are increasing globally, including on U.S. Department of the Interior lands, such as national wildlife refuges. The goal of this study is to identify tools that may allow researchers to link sublethal exposures to contaminants to individual-level vital rates and to population abundance. The resulting data could represent a novel approach to investigating the potential effects

of contamination on aquatic communities. The project is a collaboration of researchers and managers from the USGS, the University of Montana, and the USFWS.

Establishing a Strategy for Assessing Risk of Endocrine-Disrupting Compounds to Aquatic and Terrestrial Organisms

Pennsylvania Cooperative Fish and Wildlife Research Unit

Endocrine disruption is a national and global concern that affects fish, wildlife, and human populations. Through interactions with neural, endocrine, and immune systems, endocrine disrupting compounds (EDCs) can affect growth, development, reproduction, disease, and mortality, which then causes adverse outcomes for populations, communities, and ecosystems. Within the Chesapeake Bay, understanding the effects of EDCs on fish and wildlife populations has been identified as a priority to help inform natural resource management. This project is developing a risk assessment that can integrate understanding of the population dynamics of the fish or wildlife species of interest, mechanisms through which EDCs interact with individuals, and exposure pathways between sources of EDCs, including hydrological conditions and land-use practices. This assessment could help identify short- and long-term effects of compounds or chemicals of concern, potential environmental conditions and stressors that may mediate the effects of EDCs, and how land-use management practices may reduce exposure to EDCs.

An Assessment of Neonicotinoid Exposure on U.S. Fish and Wildlife Service High-Diversity Grasslands in the Prairie Pothole Region

South Dakota Cooperative Fish and Wildlife Research Unit

Neonicotinoids are a class of neuroactive insecticides developed in the 1990s because of widespread pest resistance and environmental objections to organophosphorus insecticides. Neonicotinoids are now the most widely used class of insecticides worldwide, partially because of their flexibility of use (that is, seed treatment, foliar sprays on horticultural crops, and direct applications to soil and water). However, only a small part of the insecticide actually reaches its intended plant target because most of the application accumulates in soil and water. This accumulation has caused concern because of the acute toxicity of neonicotinoids to nontarget species such as birds, mammals, bees, butterflies, and aquatic invertebrates. Yet, limited data concerning the uptake of neonicotinoids on nontarget plants exist. The goal of this study is to estimate the rate of uptake, accumulation, persistence, and concentration of neonicotiniods in native prairie plants on USFWS remnant native and restored grasslands in the Prairie Pothole Region. These data could provide important information to guide management of native and restored grasslands, especially those intended to promote the health and persistence of pollinating insects.

Effect of Environmental Variables on Growth of Toxigenic Golden Alga (*Prymnesium parvum*)—A Laboratory Test of Field-Generated Hypotheses

Texas Cooperative Fish and Wildlife Research Unit

Golden alga is a harmful algal species that has caused serious ecological damage to inland aquatic habitats worldwide and in the United States, especially the Southwest. Although much field research has been done to characterize environmental factors associated with golden algal blooms, the information generated has been mostly descriptive and insufficient to fully understand what triggers or facilitates these blooms. Based on an experimental approach, this study's purpose is to test the validity of several hypotheses about environmental factors responsible for driving golden alga range expansion or bloom formation. The information obtained could reveal cause-effect associations between specific environmental variables and golden alga growth and inform efforts to predict and control toxic blooms.

Publication

Rashel, R.H., and Patiño, R., 2019, Growth response of the ichthyotoxic haptophyte, *Prymnesium parvum* Carter, to changes in sulfate and fluoride concentrations: PLOS ONE, v. 14, no. 9, article e0223266, 19 p., https://doi.org/10.1371/journal.pone.0223266.

Salinity Adaptation in the Ichthyotoxic Golden Alga

Texas Cooperative Fish and Wildlife Research Unit

Golden alga is a toxin-producing species, with a wide tolerance of salinities, responsible for killing fish worldwide. In Texas, toxic blooms occur in inland brackish waters but, for reasons unknown, not in high-salinity coastal environments. Information on the ability of inland strains of golden alga to adapt to high salinity would enhance understanding of its geographic distribution and may also provide insights as to why it has failed to invade coastal areas and how to keep it that way. The purpose of this study is to characterize the growth potential of golden alga in high-salinity water of different ionic composition over multiple generations. The information obtained may improve an understanding of salinity as a driver of golden alga distribution and inform management efforts to limit its further expansion, especially into coastal waters.

Population Ecology of Moose in Vermont

Vermont Cooperative Fish and Wildlife Research Unit

In the past decade, concern has risen in Vermont and neighboring States regarding high mortality and low recruitment rates of resident moose populations because the declines could result in the local extinction of this iconic species from Vermont. High winter tick infestations are considered to be a major cause of these trends, and information is needed on age-specific survival rates, cause of mortality, and habitat selection in relation to winter tick load. The goals of this research project are to provide estimates of survival and reproductive rates of moose in Vermont and to identify critical habitats and gene flow. More precise estimates of mortality and recruitment rates and the factors that affect these vital rates could provide the Vermont Fish and Wildlife Department information needed to help reverse this downward population trend. This project is a collaboration among the USGS, the University of Vermont, and the Vermont Fish and Wildlife Department.

Chronic Wasting Disease Management in the Midwest

Wisconsin Cooperative Wildlife Research Unit

Wildlife management agencies have historically applied a variety of disease control strategies to slow the spread of CWD, a fatal disease of deer, elk, and moose, but manipulation of harvest regulations has been the primary tool used to reduce density and presumably slow the spread of CWD. Despite the widespread use of harvest as a CWD management tool, it is difficult to measure the effects of harvest approaches within a single jurisdiction. Therefore, rigorous evaluations of how harvest regulations reduce CWD risk have not been conducted. A critical examination of the effect of harvest regulations on hunting and CWD dynamics can be done and used to guide a regional application of adaptive management strategies for wildlife agencies to coordinate disease mitigation efforts. The project is a collaboration among the USGS, the University of Wisconsin-Madison, and the Wisconsin DNR.

Effects of Climate Change on Plague Exposure Pathways and Resulting Disease Dynamics

Wisconsin Cooperative Wildlife Research Unit

Periodic outbreaks of sylvatic plague caused by the bacterium *Yersinia pestis* has had near catastrophic impacts on prairie dogs and the endangered black-footed ferret. Although human plague cases in the United States are relatively infrequent, the disease can be fatal, and its occurrence generates considerable public concern and media attention. Sylvatic plague is relevant to the DoD because prairie dogs, ground squirrels, and other susceptible rodents are present on military installations in several western States, and the occurrence of plague has curtailed military exercises in the past. Furthermore, plague still occurs in many parts of the world where troops might be deployed, and *Y. pestis* has the potential to be developed as a biological weapon. Arthropod-borne diseases, like plague, are thought to be particularly sensitive to local climate conditions and expected changes in temperature and humidity over the next several decades will likely increase the eastern and northern expansion of plague outbreaks in wildlife. Through a combination of field and laboratory work, along with data-driven modeling, researchers may evaluate the potential effects of climate change on plague exposure pathways in prairie dogs and other rodents and provide guidance to DoD partners regarding the potential for future outbreaks. Scientists could also validate the use of an orally delivered sylvatic plague vaccine for use as a management tool to prevent outbreaks.

Effects of Chronic Wasting Disease on White-Tailed Deer Populations in Wisconsin

Wisconsin Cooperative Wildlife Research Unit

CWD was discovered in Wisconsin white-tailed deer harvested in the fall of 2001, and CWD frequency has increased in all sex and age classes and increased in spatial extent ever since. It is uncertain what effect CWD is currently having on deer populations and what effect it may have as prevalence increases. This project is developing a robust modeling framework to understand spatiotemporal patterns in CWD prevalence and deer demographic rates to provide technical information to State natural resource managers regarding deer population dynamics in the CWD-endemic region of southwestern Wisconsin. This project is a collaboration among the USGS, the University of Wisconsin-Madison, and the Wisconsin DNR.

White-tailed deer. Photograph by the U.S. Geological Survey.

Human Dimensions

Videography Presentations to Educate the Public about Arizona Trout

Arizona Cooperative Fish and Wildlife Research Unit

Gila trout and Apache trout are critically threatened species of the Southwest. This project used surface and underwater videography to create an educational video on Gila and Apache trout from Mount Graham streams to be displayed at a Coronado National Forest visitor center and other locations. Analyses of images viewed most commonly by people revealed that macro images, contrasting colors, texture, and movement held audience attention the longest. Results can be used to better design videos to acquaint people with species that are not commonly seen, thus aiding in their conservation. Partners include the USGS, the USFS, and Arizona Game and Fish Department.

Apache trout. Photograph by Scott Bonar, U.S. Geological Survey.

Assessment of Trout Management in Georgia

Georgia Cooperative Fish and Wildlife Research Unit

North Georgia is home to the native brook trout, but brown trout and rainbow trout are now considered to be naturalized in the State. In the early 2000s, the Georgia Trout Management Plan was developed, and now the efficacy of this plan is a question of immediate interest to fishery managers. The goal for this project is to increase the amount and usability of socioecological information available to managers when making fisheries management decisions. A stakeholder survey could be used to increase socioecological information available to managers when making fisheries management decisions, such as choosing among potential future stocking scenarios. This project is a collaboration of the Fisheries Section of the Georgia DNR, the University of Georgia, and the USGS.

Brook trout. Photograph by Craig Snyder, U.S. Geological Survey.

Publication

TenHarmsel, H.J., Boley, B.B., Irwin, B.J., and Jennings, C.A., 2019, An importance-satisfaction analysis of trout license holders in Georgia: North American Journal of Fisheries Management, v. 39, no. 6, p. 1227–1241, https://doi.org/10.1002/nafm.10353.

Assessing Attitudes and Effects to Society Associated with the Use of Nontoxic Ammunition for Hunting on National Wildlife Refuges

Massachusetts Cooperative Fish and Wildlife Research Unit

Since the 1960s, the documented negative effects of lead on humans and wildlife has resulted in regulations to reduce human exposure and the amount of lead introduced into the environment. Federal restrictions on lead-based ammunition for waterfowl hunting were implemented in 1991. However, lead is still a primary component of ammunition used for nonwaterfowl hunting in the United States. The continued use of lead-based ammunition for hunting white-tailed deer, in particular, facilitates completed pathways to lead exposure for hunters, their family members, and for nontarget species that scavenge the nonharvested remains of deer left in the field. Voluntary approaches to reducing lead-based ammunition have seen increased support from hunters and have been recognized

as viable options for mitigating the effects of lead from hunting activities. This research conducted surveys and group interviews with hunters at targeted national wildlife refuges in the northeastern United States to identify practical barriers and other factors associated with a voluntary transition to nonlead alternatives. Identifying the barriers to nonlead use will help the National Wildlife Refuge System direct more targeted outreach and education strategies to better achieve behavioral change in regard to hunter ammunition choice. This project is a collaboration between the USGS, the USFWS, and the University of Massachusetts Amherst.

Assessing Hunter Values, Expectations, and Satisfaction Regarding Controlled White-Tailed Deer Hunts in Suburban Eastern Massachusetts

Massachusetts Cooperative Fish and Wildlife Research Unit

White-tailed deer are abundant throughout Massachusetts, particularly in eastern parts of the State where suburban landscapes provide high-quality habitat. Ecological degradation from overbrowsing and increased human-deer conflicts result in a need to address overabundant deer populations. Regulated hunting is a widely accepted deer management strategy used to effectively reduce and maintain deer densities, although its use in suburban landscapes presents challenges. The long-term participation of devoted hunters in highly controlled hunts is uncertain because controlled hunts may restrict participants in ways that minimize satisfaction. Consequently, a better understanding of suburban hunters' expectations, preferences, and limitations is of great importance if effective deer management programs are to be implemented. Results of this study can assist wildlife managers in better understanding what motivates hunters to participate in controlled deer hunts so that communities may be guided through developing more successful, lasting deer management programs. This research effort is a collaboration between the USGS and the Massachusetts Division of Fisheries and Wildlife.

Massachusetts Residents' Attitudes Toward Black Bears and Black Bear Management

Massachusetts Cooperative Fish and Wildlife Research Unit

The black bear population in Massachusetts is growing in size and expanding in range, and bears are becoming increasingly more common in suburban areas of the State. As the Massachusetts' black bear population increases and expands, it continues to push into areas where the public is largely inexperienced with bears. A statewide human dimensions study of Massachusetts residents' attitudes toward black bear and black bear management could help the Massachusetts Division of Fisheries and Wildlife better understand the current challenges facing black bear management in the third most-densely populated State in the country. Results of this study can provide a more detailed understanding of Massachusetts residents' opinions on the bear population, experience with bears, and opinions on black bear management options. These results could further examine how those opinions change with geography and demographic characteristics and could be used by the Massachusetts Division of Fisheries and Wildlife to make informed management decisions regarding black bears.

Human Dimensions of Wolf Management in Minnesota

Minnesota Cooperative Fish and Wildlife Research Unit

The Minnesota DNR has a high demand for research related to stakeholder and public attitudes and behaviors related to management programs, issues, and policy preferences. Such social science is seen as essential by the Minnesota DNR to assist in making critical planning and management decisions. Two issues of primary concern are CWD management and wolf management planning. This project provides funding for a research associate and operating funds to assist the Minnesota DNR in developing long-term strategies for addressing the threat of CWD to deer populations in Minnesota and to hunter participation. In addition, this project could assist the Minnesota DNR in developing a revised management plan for wolves in Minnesota as management responsibility for the species has devolved to the State. The information obtained through this project will assist the Minnesota DNR in making policy decisions about disease management and population management. The social science information could be integrated with ecological information to ensure competent decisions that are broadly supported by the Minnesota public.

Minnesota Residents' Attitudes Toward Wolves and Wolf Management

Minnesota Cooperative Fish and Wildlife Research Unit

Wolves are no longer listed as a federally threatened species in Minnesota as of 2020, so management responsibility for the wolf will move to the Minnesota DNR. The Division of Fish and Wildlife is engaged in an update to the Minnesota Wolf Management Plan. Public input and engagement are at the forefront of these efforts. Understanding the values, beliefs, attitudes, and behaviors of stakeholders can enhance the legitimacy and efficacy of agency decisions with respect to wolf management, while helping to minimize conflict. Researchers propose to assess stakeholder attitudes toward wolves in Minnesota in general, their preferences for potential management priorities, their values toward wildlife, preferred options for funding wolf management, and tolerance of wolves on the landscape. This information is important for ensuring that the Minnesota Wolf Management Plan is effective and responsive to public interests.

Minnesota Statewide Angler Survey

Minnesota Cooperative Fish and Wildlife Research Unit

Fisheries management inherently involves assessing fish populations and human demand and use of those fish populations. The Minnesota DNR Fisheries is interested in monitoring angler preferences for management strategies and policies at a statewide level every few years. This project collects data from a sample of 2,000 anglers from five geographic regions to help identify trends and determine current angler preferences. Findings from this study can be used to develop acceptable fisheries management policies. In addition, the study could identify key management issues that may lead to stakeholder conflict about Minnesota fisheries management in the future.

Angler Behavior in Response to Management Actions on Nebraska Reservoirs—Part 2

Nebraska Cooperative Fish and Wildlife Research Unit

Recreational fishing is the most influential factor structuring fish populations, especially in inland systems with intensive fishing pressure. Anglers often target apex predators such as largemouth bass and walleye, which can have important consequences for fish communities in lakes and reservoirs via top-down controls. To complicate matters, predator dynamics among fishes vary spatially (for example, within and among reservoirs) and temporally (for example, within and among years), as does angler participation. Inland fishery biologists rarely incorporate spatial and temporal patterns, including angler participation and catch, into management strategies. This research can focus on incorporating spatial and temporal patterns of angler participation into fishery management strategies that can shift the focus from lake-specific management to regional management. Information gained on angler behavior could be important for increased effectiveness of fishery management, as well as increased effectiveness of angler recruitment and retention activities. This project is a collaboration of researchers across multiple agencies and includes the University of Nebraska-Lincoln and the Nebraska Game and Parks Commission.

Angler Behavior in Response to Management Actions on Nebraska Reservoirs—Part 3

Nebraska Cooperative Fish and Wildlife Research Unit

Recreational fishing is a major factor in structuring inland fish populations, so biologists typically develop lake-specific management plans based on lake-specific attributes of the anglers and fishery. However, a broader approach is needed by State agencies if they want to understand and maximize angler satisfaction across larger spatial scales to develop more comprehensive, regional management strategies. This study can evaluate the participation patterns of anglers at multiple spatial and temporal scales and determine how these patterns affect fish populations and associated communities. Study findings could be used to develop appropriate management strategies at local and regional scales. This project is a collaboration of researchers across multiple agencies and includes the University of Nebraska-Lincoln and the Nebraska Game and Parks Commission.

Comprehensive Evaluation of the Nebraska Outdoor Enthusiast

Nebraska Cooperative Fish and Wildlife Research Unit

The decline in hunters and anglers is of increasing concern to natural resource management agencies that depend on these individuals for annual funding. The dependence on hunters and anglers by natural resource management agencies makes the North American Model of Conservation unique but vulnerable to declining participation in outdoor recreation. Comprehensive understanding of the hunting and fishing public is needed to inform and direct wildlife and fisheries management, as well as recruitment and retention efforts by natural resource management agencies. For this project, participation levels can be quantified among groups of hunters and anglers, and models can be developed to describe recruitment and development of these groups of people. Findings could help identify key sociodemographic parameters that predict movement among and retention in each of the user groups (for example, from hunter education program to small-game hunter to angler to big gamehunter). This project is a collaboration of researchers across multiple agencies and includes the University of Nebraska-Lincoln and the Nebraska Game and Parks Commission.

Use and Satisfaction of Public Hunting Opportunities

Nebraska Cooperative Fish and Wildlife Research Unit

The retention and recruitment of hunters is of increasing concern to wildlife management agencies nationwide. A lack of access to quality hunting opportunities is often deemed the primary reason why people stop hunting. In an effort to provide hunting opportunities for their constituency, the Nebraska Game and Parks Commission invests considerable time and resources into the development and management of public wildlife management areas and private lands through the Open Fields and Waters Program. Investment in these programs is assumed to fulfill the needs of the hunting community, but evaluating the use of public or private land

by hunters, and their overall satisfaction with the hunting experience, is challenging. This project can analyze hunter participation data to understand how users of publicly accessible lands distribute on the landscape and to understand the effect of hunting and hunter participation on wildlife populations, hunter recruitment, and retention. Results could provide managers with a better understanding of hunter participation at the scales for which management occurs and identify effective strategies for providing opportunities for outdoor enthusiasts in Nebraska.

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Public Opinions of Native Fishes in the Black Hills

South Dakota Cooperative Fish and Wildlife Research Unit

Maintaining intact native fish communities in the Black Hills of South Dakota is difficult because of game fish stocking throughout the area. Given the importance of fishing in the Black Hills, understanding the public's attitude and values related to native fishes and their management is essential if the objective is to maintain select areas that contain native fish species. The "Fisheries Management Plan for Black Hills Streams—2015–2019" lists options for managing fish populations in the Black Hills; option 5 is native fish. This project was designed to collect information to help fisheries managers better understand public acceptance of this option and as an education strategy to begin talks concerning native fish management in the Black Hills.

Social and Economic Effect of Fishing in Selected Small Lakes and Impoundments in South Dakota

South Dakota Cooperative Fish and Wildlife Research Unit

South Dakota Department of Game, Fish, and Parks needs information on the economic effect of fishing in selected small lakes and impoundments because this information can help inform decisions regarding expensive habitat renovation projects to improve or maintain quality recreational services. This study collected angler use and expenditures to estimate fishing pressure and total expenditures for several lakes and types of fishing (shore, boat, and ice fishing). This information is used to inform cost-benefit decisions regarding restoration activities for various types of small lakes and dams in South Dakota.

Structured Decision Support for Bald Eagle Monitoring in Alaska

South Dakota Cooperative Fish and Wildlife Research Unit

Bald eagles are currently monitored by the Southwest Alaska Inventory and Monitoring Network as part of their Vital Signs Monitoring Plan. Bald eagles were selected to represent terrestrial animals as a signal of biological integrity because of their role as a keystone predator in the system on various avian and fish populations. The parks within the system use different methods to monitor nests, making it more difficult for park managers to use overall bald eagle population trends as indicators of environmental quality. Because of these discrepancies, the monitoring program has been disconnected from management goals. This project was designed to provide the NPS with a standardized set of objectives and protocol for bald eagle monitoring that optimizes information content and minimizes cost. Using a Delphi process to foster consensus, the project solicited expert opinions from NPS biologists and natural resource chiefs regarding core values, objectives, and priorities. Through this process ranked objectives for bald eagle monitoring and several scenarios by which to achieve them were obtained.

Invasive Species

Examining Effects of Invasive Crayfish and Drought on *Faxonius marchandi*, an Ozark-Endemic Petitioned Crayfish

Arkansas Cooperative Fish and Wildlife Research Unit

The Mammoth Spring crayfish is a narrow-ranged endemic species present in the Ozark Highlands of northern Arkansas and southern Missouri and is under consideration by the USFWS for listing under the ESA. Population genetics indicate two main clades, one in the upper and the other in the lower reaches of the Spring River drainage, suggesting these populations be given evolutionarily significant unit status. The threat of an advancing invasive species that displaced two native species, along with potential habitat loss and fragmentation, makes determining potential invasive species effects extremely important. The goals of this research are to examine differences in effects on stream structure and function between native and invasive crayfish. Results can be used to inform the listing decision and conservation actions for the species. Partners include the USGS, the USFWS, and the University of Arkansas.

Linking Predation Mortality to Predator Density and Survival for Out-Migrating Chinook Salmon and Steelhead in the Lower San Joaquin and South Delta

California Cooperative Fish and Wildlife Research Unit

Abundance data for fish predators in the lower San Joaquin River and South Delta region are lacking and have been identified as a primary research need in the region. Native and nonnative species of predator fishes inhabit the South Delta and feed on migrating smolts, and substantial annual and seasonal variation in the presence or absence of individual predators is probable. Predators are likely to exhibit positive selectivity for salmonid species because salmonids are energy dense, naive to invasive predators, and have no physical defense structures. Through a combination of paired electrofishing sampling and results from acoustic surveys conducted using dual-frequency identification sound navigation and ranging, this research can quantify the abundance of potential predatory fish throughout the study region. The research could enhance opportunities to develop quantitative inferences about the scale and effects of fish predation on salmonid populations in this region.

Sampling Designs and Population Dynamics of Burbot in the Green River System—Tools for Management

Idaho Cooperative Fish and Wildlife Research Unit

Although burbot are a species of high conservation concern over much of their distribution, they are an invasive species in the Green River, Wyoming, where they were illegally introduced. The purpose of this research is to provide managers with information on the distribution, habitat associations, and population dynamics of burbot in the Green River. In addition, the project is evaluating several different sampling gears across multiple systems and habitat to determine the best methods for removing burbot from the system. Collaborators include the Wyoming Game and Fish Department.

Evaluating Controls, Effects, and Behaviors of Invasive Carp Throughout the Upper Mississippi River Basin

Iowa Cooperative Fish and Wildlife Research Unit

Invasive carp are invasive species spreading throughout the Upper Mississippi River Basin. Like many invasive species, invasive carp have negative economic and ecological effects. Despite the lack of optimal reproductive habitat for invasive carp within the Upper Mississippi River Basin, tributaries of the basin contain stretches of free-flowing sections where reproduction has been documented in the Des Moines and Skunk Rivers. This project is evaluating stock-recruitment trends present within the Upper Mississippi River where adult stock and recruits have been sampled (Des Moines, Skunk, and Iowa Rivers). The objective is to also assess the accuracy of previously constructed random forest models that identify fish species based on egg morphometrics within the Upper Mississippi River Basin. Results can be used to inform management plans for these invasive species.

Invasive Carp in the Tennessee River System

Mississippi Cooperative Fish and Wildlife Research Unit

Introduced bighead carp pose a threat to many aquatic ecosystems, and they have recently expanded into the lower Tennessee River. Managers are extremely concerned about

bighead carp entering the Tennessee-Tombigbee Waterway, which is connected to the Tennessee River, because they would then have access to various river systems that drain into the Gulf of Mexico. This research can determine if bighead carp have expanded into the Tennessee-Tombigbee Waterway, if seasonal water-level patterns encourage movements, and whether there have been changes in the fish assemblages that could be attributed to the expansion of bighead carp. Results could be used to develop management actions to minimize the expansion of bighead carp through the Tennessee-Tombigbee Waterway. The project collaborators include fisheries management agencies in Kentucky, Tennessee, Alabama, and Mississippi.

Effects of Water Chemistry on Lake Trout Embryos and Fry

Montana Cooperative Fishery Research Unit

Introductions of nonnative lake trout into lakes of the northwestern United States have posed serious threats to native fish assemblages because lake trout are keystone predators that directly or indirectly affect all other sympatric fishes as well as other taxa. Currently, intensive gillnetting is the primary method of lake trout suppression used by fisheries managers, but development of alternative suppression methods to be used in concert with intensive gillnetting is highly desired. The project results could allow managers to incorporate effective embryo suppression in an Integrated Pest Management approach to provide more effective lake trout suppression in the long term.

Identifying the Threats of Smallmouth Bass to Yellowstone Cutthroat Trout in the Yellowstone River

Montana Cooperative Fishery Research Unit

Nonnative smallmouth bass were thought to be limited to the warm, downstream waters of the Yellowstone River, Montana, but adults were recently observed far upstream in coldwater reaches that support a major trout fishery. This research identified the factors associated with current distribution and potential future establishment (that is, successful recruitment) of smallmouth bass in the Upper Yellowstone River. Comparative hatch dates, growth rates, and growth durations were counter to predictions and suggest that age-0 overwinter mortality is not preventing upstream establishment in the Yellowstone River. Collaborators on this project include the USGS Northern Rocky Mountain Science Center and the Montana Department of Fish, Wildlife and Parks.

Lake Trout Population Modeling and Annual Assessment of Suppression Netting

Montana Cooperative Fishery Research Unit

Invasive lake trout within Yellowstone Lake, Yellowstone National Park, Wyoming, have greatly reduced the abundance of native Yellowstone cutthroat trout and disrupted the ecosystem through food-web alteration. The NPS gillnets juvenile and adult lake trout, and part of the lake trout carcasses collected are subsequently placed at lake trout spawning sites to suppress embryo development. Adding carcasses causes hypoxic conditions unsuitable for developing lake trout embryos. The novel concentration of nutrients from lake trout carcasses could further affect the adult stages of lake trout and Yellowstone cutthroat trout by providing concentrated areas of prey not historically available. The goal of this study is to determine if the addition of carcass material is changing the diets of fishes in Yellowstone Lake and the trophic structure of the food web using diet and stable isotope analysis. Results could provide information needed to understand the consequences associated with a novel suppression action in Yellowstone Lake.

Mobile Tracking of Lake Trout on Yellowstone Lake

Montana Cooperative Fishery Research Unit

Invasive lake trout were first discovered in Yellowstone Lake in 1994. The population quickly grew, decimating the native Yellowstone cutthroat trout population. Removal efforts of lake trout began shortly after and have grown into a multimillion-dollar operation. Original efforts focused on removing younger, smaller lake trout, but targeting larger, mature lake trout on known spawning grounds has proven to be a successful strategy for removing large quantities of mature fish. Unfortunately, managers and researchers only know of relatively few confirmed spawning sites in Yellowstone Lake. NPS biologists have stressed the need for a better understanding of lake trout spawning distribution throughout Yellowstone Lake. The goal of this study is to monitor movements of lake trout in Yellowstone Lake with the objective of confirming previously unknown spawning locations. Accurate locations of where lake trout are spawning could be a great asset to suppression crews on the lake.

Invasion, Cost-Share Programs, and Private Landowners—Resolving the Challenges of Scale with Managing Eastern Red Cedar on Nebraska's Rangelands

Nebraska Cooperative Fish and Wildlife Research Unit

Eastern red cedar is an invasive species that degrades grassland habitat and reduces rangeland productivity. Eastern red cedar can be controlled via regular burning, which removes woody brush and revitalizes native grasses; however, public opinion and use of prescribed fire is uncertain. Cost-share programs provide funding to offset costs and provide outreach to landowners on local ecological issues and solutions. Research to determine which incentives are preferred by landowners has been conducted, but those efforts largely focused on landowner preferences rather than ecological science. The goals of this study are to document

the perceptions of Nebraskan landowners with respect to eastern red cedar management and adoption of cost-share programs and to identify where these programs are succeeding at their conservation goals. Results could be used to develop cost-share programs that encourage landowner participation, improve methods to minimize the spread and effects of eastern red cedar, and better restore degraded habitats. This project is a collaboration with agronomists and with the Nebraska Game and Parks Commission.

Monitoring, Mapping, and Assessing Risk and Managing Invasive Species in Nebraska

Nebraska Cooperative Fish and Wildlife Research Unit

Invasive species pose a threat to ecosystems and often have negative effects on endemic species and ecosystem services. The negative effects and their costs are often poorly understood by constituents who are trying to weigh in on management actions and policy decisions. Consequently, the goal of this study is to provide outreach to and facilitate communication among stakeholders regarding biological invasions, coordinate the Nebraska Invasive Species Council, and supply scientific information needed for any additional legislation regarding invasive species. Results could include management tools such as an invasive species AM plan, a risk analysis for high-risk invasive species in Nebraska, a multiagency prevention protocol for preventing the spread of invasive species (terrestrial and aquatic), and identification of invasive species introduction pathways. This project is a collaboration among numerous State and Federal entities that interface with invasive species in Nebraska.

Susceptibility of Rio Grande Cutthroat Trout to Displacement by Nonnative Brown Trout—Implications for Future Management and Persistence of the Most Southern Subspecies of Cutthroat Trout in the Face of a Changing Climate

New Mexico Cooperative Fish and Wildlife Research Unit

Rio Grande cutthroat trout is the New Mexico State fish, but habitat loss and nonnative trout invasions threaten the persistence of Rio Grande cutthroat trout populations throughout its historical range. A better understanding of how temperature and nonnative fishes affect this southernmost subspecies of cutthroat trout, especially its reproductive capacity, is needed. This project used a production framework to evaluate how temperature and competition with nonnative brown trout affected the ecological success of Rio Grande cutthroat trout populations. Specifically, annual changes in production of Rio Grande cutthroat trout populations were related to changes in their diets in the presence and absence of brown trout across a temperature continuum. Results can be used by managers to identify and focus restoration efforts on streams with the greatest potential to support Rio Grande cutthroat trout while maintaining an economical balance with brown trout, a popular sportfish. Collaborators include stakeholders from two State agencies, eight Federal agencies, two Tribal nations, three Pueblos, and three private groups.

Characterizing the Ecological Niche of Round Goby

New York Cooperative Fish and Wildlife Research Unit

Round goby were introduced into the Great Lakes from the Ponto-Caspian region in the mid-1990s and have since spread rapidly throughout all five Great Lakes. Presently, the invasion front is moving inland via connected waterways. In this project, researchers characterized the ecological niche of round goby to inform expectations about the suitability of inland lakes to round goby invasions. Novel statistical techniques and videography provided accurate estimates of round goby biomass at whole-lake scales. Results show that depth may mediate the effect of round goby on inland lakes, where shallow habitats are preferred during summer months. These insights are informing managers about which waters are most at risk of round goby establishing self-sustaining populations. This project also provided an important educational opportunity, serving as the basis for a graduate seminar at Cornell University on fisheries assessment modeling, thus contributing to training the next generation of fisheries ecologists.

What Role Do Invasive Round Goby Have in the Contaminant Cycle?

New York Cooperative Fish and Wildlife Research Unit

Round goby were first introduced into the Great Lakes from the Ponto-Caspian region in the mid-1990s. In the decades that have followed, this invasive species has spread throughout all five Great Lakes and is now moving inland through connected waterways. Round goby prey upon invasive Dreissenidae species of mussels and are prey to most game fish in temperate North America. This research is investigating whether round goby invasions change the mercury fish contaminant cycle. Results from this work could inform fisheries managers about whether fish consumption advisories need to be updated. This project is also providing an important educational opportunity as well, serving as the basis for a graduate seminar at Cornell University on fish bioenergetics monitoring.

Assessing the Invasion of the Asian Swamp Eels in the Chattahoochee River National Recreation Area

Oklahoma Cooperative Fish and Wildlife Research Unit

The Asian swamp eel is an invasive species that was introduced into the Chattahoochee River National Recreation Area, Georgia, and has persisted for more than 20 years. The Chattahoochee River National Recreation Area manages, protects, and interprets the biota and landscape of the Chattahoochee River corridor, and the Asian swamp eel is an invasive species that threatens the resources essential to the purposes of the park. The goal of this project is to assess the extent of the invasion and reproduction-emigration potential of this species at the Chattahoochee River National Recreation Area. These results could enable NPS managers to better understand the scope of the invasion and plan for future control or eradication measures to conserve the natural resources of the area.

Juvenile Asian swamp eel. Photograph by Leo Nico, U.S. Geological Survey.

Comparison of Age and Growth Parameters of Flathead Catfish in Invasive and Native Populations—A Meta-Analysis with Implications for Invasive Species Management in Pennsylvania

Pennsylvania Cooperative Fish and Wildlife Research Unit

Flathead catfish are a long-lived apex predator native to the Mississippi, Mobile, and Rio Grande River drainages and the Laurentian Great Lakes region. These fish have been introduced into most of the east coast and areas of the western United States. Introduced flathead catfish populations often have detrimental effects on native fauna. In the Atlantic slope parts of Pennsylvania, the status of flathead catfish has not been adequately documented. Several large- to medium-sized river systems in Pennsylvania have yet to be surveyed, so the residency status of flathead catfish in those systems remains unknown. The primary objective of the project is to determine flathead catfish distribution and to estimate abundance and population characteristics for native and introduced populations in Pennsylvania. Much of the focus of the research could include age and growth analysis and modeling to put the current

Mississippi River. Photograph by Mark D. Tomer, Agricultural Research Service, U.S. Department of Agriculture.

population status of flathead catfish in the introduced range in a larger regional context. Several other Atlantic slope drainages have had similar invasions in recent decades, so comparing the data for those populations to the data for the Pennsylvania populations could help predict what to expect in the future for the existing populations as well as what might happen for the populations in areas that have not yet been invaded.

Diet Composition of Invasive Flathead Catfish in the Susquehanna River Basin—Quantifying Effects on Native and Migratory Fishes and Recreational Fisheries

Pennsylvania Cooperative Fish and Wildlife Research Unit

Flathead catfish are an indiscriminate predator of other fish and an expanding invader to large river systems outside of its native range, including the Susquehanna River Basin in Pennsylvania. Research efforts are beginning to provide insight on the distribution of this invader in the Susquehanna River Basin; however, the potential ecological effects of flathead catfish are uncertain. In particular, there are concerns about their effects on native and migratory fish species and on economically important recreational fisheries. To begin understanding the ecological effects of flathead catfish invasion, this project is a comprehensive diet study on flathead catfish in the Susquehanna River Basin. The researchers plan to quantify flathead catfish diet composition using morphology and molecular identification of ingested prey items. Study results could help inform future fisheries management in the Susquehanna River Basin by increasing understanding about the predatory effects and potential ecological consequences of invasive flathead catfish. The project is in collaboration with the Pennsylvania Fish and Boat Commission and The Pennsylvania State University.

Early Detection and Rapid Response to the African Walking Catfish in Puerto Rico—Identification and Removal of a Threat to Endemic Species and Minimizing Risk to Continental U.S. Expansion

Tennessee Cooperative Fishery Research Unit

Invasive species negatively impact ecological communities. In Puerto Rico, African walking catfish were recently discovered as a new invasive species. The goal of this project is to use eDNA to sample streams and help inform where physical removal efforts of catfish should be allocated. Investigators are working with the USFWS and the University of Puerto Rico to identify removal and monitoring locations. The outcomes of the project could help inform control strategies for this invasive species.

Movements and Lock and Dam Passage of Invasive Carp in the Tennessee River

Tennessee Cooperative Fishery Research Unit

Invasive invasive carp, including silver carp and bighead carp, are spreading in the Ohio River Basin and many of its tributaries. Increasing occurrences in one of the major tributaries, the Tennessee River, has created concerns for the five States that manage fisheries within the Tennessee River's watershed. Upstream passage by invasive carp occurs through locks at dams, and multiple agencies in several States have begun an effort to understand the movement of these carp in the Tennessee River Basin through the use of acoustic telemetry. Quantifying the lock passage by carp through the collection of telemetry data could inform removal efforts in downstream areas and warn of invasions in the upper parts of the Tennessee River Basin. It could also help inform potential lock management practices and the placement of movement barriers at locks.

Relative Population Densities of Invasive Carp in the Tennessee River and Cumberland River Drainages

Tennessee Cooperative Fishery Research Unit

Invasive carp are increasingly expanding within multiple Tennessee river systems, but knowledge of current distributions and abundance is lacking. Bighead carp have been observed in the Tennessee waters of the Cumberland and Tennessee Rivers for at least 10 years. Silver carp were first observed in Tennessee waters around 2008, but they were not observed in the headwaters of the lowermost reservoirs in each river system until around 2012. Invasive carp invasion presents a threat to native species, fishing, and tourism. The objectives of this project are to assess spatial variation in relative abundance of invasive carp in the main basins of two Tennessee River impoundments (Kentucky and Pickwick Lakes) and two Cumberland River impoundments (Barkley and Cheatham Lakes); develop indices of invasive carp abundance in the headwaters (that is, dam tailwaters) of these four impoundments, which are proximal sources for further upstream invasion; evaluate tailwater sampling efficiency and relate tailwater invasive carp indices to invasive carp catches in the main basins; and test novel gears and models for sampling and control measures in southeast reservoirs. Partners include the States of Kentucky, Tennessee, Mississippi, and Alabama; and the USFWS.

Long-Term Logan River Trout Viability Study and Monitoring

Utah Cooperative Fish and Wildlife Research Unit

Although the importance of reducing the effects of nonnative species is increasingly recognized in conservation, the feasibility of such actions is highly dependent upon several key uncertainties including the stage of invasion, the size of the ecosystem being restored, and the magnitude of the restoration activity. This multiyear study is investigating nonnative brown trout removal and native Bonneville cutthroat trout recovery in a small tributary in the U.S. Intermountain West. Trout populations were monitored for 7 years before the onset of eradication efforts, which included 2 years of mechanical removal followed by 2 years of chemical treatment. Cutthroat trout populations were then seeded with low numbers of eggs and juvenile trout. Population demographics and estimated population growth rates and carrying capacities were monitored for both trout species from long-term depletion estimate data, assuming logistic growth. After brown trout eradication and initial seeding efforts, cutthroat trout populations have demonstrated exponential growth. These results demonstrate native trout species have substantial capacity to rapidly recover after the removal of invasive species in otherwise minimally altered habitats. Although these locations are likely limited in extent individually, collectively they may serve as source populations for larger connected systems. In such cases, these source populations may provide additional conservation potential through biotic resistance. This project is a collaboration of biologists, academics, and anglers and includes the USGS, the Utah Division of Wildlife Resources, the USFS Rocky Mountain Research Station, Trout Unlimited, and Utah State University.

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Early Detection and Rapid Response—Choosing Monitoring Targets to Promote Management Effectiveness

Washington Cooperative Fish and Wildlife Research Unit

Invasive species are a leading driver of biodiversity loss globally. Despite considerable efforts to control nuisance invasive species, such efforts are rarely successful because of financial constraints and uncertainty regarding the implementation of management and monitoring strategies. In decision-making processes, monitoring data can improve decision outcomes through two distinct processes: first, in state-dependent decisions, monitoring data can inform the manager about the state of the system, and second, in adaptive decisions, monitoring data can reduce critical uncertainties. The purpose of this project is to evaluate how different monitoring data streams can improve management outcomes for invasive species control within a state-dependent AM setting. The management of invasive rusty crayfish in the Columbia River Basin can be used as an illustrative case study. Results of this work could inform invasive species managers about improved approaches to monitoring and optimally managing invasive species to reduce economic and ecological damage. This project is a collaboration between the USGS and the University of Washington School of Aquatic and Fishery Sciences.

Rusty crayfish. Photograph by Peter Pearsall, U.S. Fish and Wildlife Service.

Evaluating and Mitigating the Effects of Brown Treesnakes on Guam's Birds

Washington Cooperative Fish and Wildlife Research Unit

The brown treesnake is an invasive species on the island of Guam and is responsible for the extinction of much of Guam's birds. Control of brown treesnakes is critical to the conservation of the remaining native fauna and to the eventual reintroduction of many native species. Refinement of field and statistical methodologies is needed to provide information on brown treesnake populations, and this information needs to be fit within system models to inform control and reintroduction activities. The USGS, in collaboration with the University of Washington, the DoD, and USDA Wildlife Services, is working to develop methods for monitoring brown treesnakes and to fit that information within management models to inform brown treesnake control and reintroduction of native fauna. Results of this work can inform ongoing monitoring and management efforts targeted at restoring Guam's fauna and reducing the economic and ecological damage caused by brown treesnakes.

Brown treesnake eating a white tern in Guam. Photograph by Nathan Sablan, U.S. Geological Survey.

Effects of Imidacloprid Treatment of Hemlocks on Aquatic Ecosystems—Is the Cure Worse Than the Disease?

West Virginia Cooperative Fish and Wildlife Research Unit

The invasive exotic insect, hemlock woolly adelgid, is decimating hemlock ecosystems, and treatment with the neonicitonoid, imidacloprid, is frequently used to control hemlock woolly adelgid. This study examined the risks and nontarget effects of imidacloprid treatments in riparian hemlock forests on water quality, benthic macroinvertebrates, and stream salamanders. The study determined that stream salamanders bioaccumulated imidacloprid. Results could be used to reassess the hemlock woolly adelgid treatment programs in the study areas (national parks and the Monongahela National Forest), as well as other lands that have hemlock woolly adelgid treatment programs.

Ohio River Invasive Carp Program

West Virginia Cooperative Fish and Wildlife Research Unit

Invasive species have become a major concern of natural resource agencies, in part, because of negative effects to native species. Invasive carp, which include several species, are invasive in the Mississippi River drainage basin and are expanding their ranges upstream into the Ohio River drainage basin. Invasive invasive carp have altered ecosystems through trophic cascade effects on food chains. Many native species, often unable to compete with invasive carp, experience reduced population sizes. Monitoring the population expansion of invasive carp in the Ohio River and taking steps to curb growth are important measures to reduce the negative effects of these invasive species. Data on the expansion of invasive carp in the Ohio River can inform management decisions of the West Virginia Division of Natural Resources. This research is a collaborative effort involving the USGS, the USFWS, West Virginia University, the West Virginia Division of Natural Resources, and Missouri State University.

Development of a Genetic Marker Panel for Grass Carp to Better Understand Reproducing Populations in Lake Erie Tributaries

Wisconsin Cooperative Fishery Research Unit

Invasive grass carp have spread to Lake Erie, but knowledge of their spawning biology and the number of individuals that have colonized is lacking. The goal of this project is to develop

genetic tools (a GTseq panel) that can be used to analyze parentage of grass carp. The panel can be used to analyze grass carp eggs to determine parental contributions, which could inform management of grass carp in Lake Erie. The project is a collaboration between the USGS and the University of Wisconsin-Stevens Point.

A Survey of Current Distributions for Wyoming Crayfishes

Wyoming Cooperative Fish and Wildlife Research Unit

Many North American crayfishes are highly imperiled; an estimated 48 percent are at some level of extinction risk. For most Wyoming crayfish species, abundance and population status are unknown. Crayfish can play an important positive role in ecosystems through consuming detritus and serving as forage food for fish, but nonnative species, such as rusty crayfish, can have serious negative effects. An understanding of native crayfish distribution and early detection of nonnative crayfish is critical for management and control. In collaboration with the Wyoming Game and Fish Department, researchers are updating Wyoming crayfish distributions to refine range maps and species of conservation need rank.

Distribution, Habitat Use, and Evaluation of Potential Reintroduction Sites for Finescale Dace in Wyoming

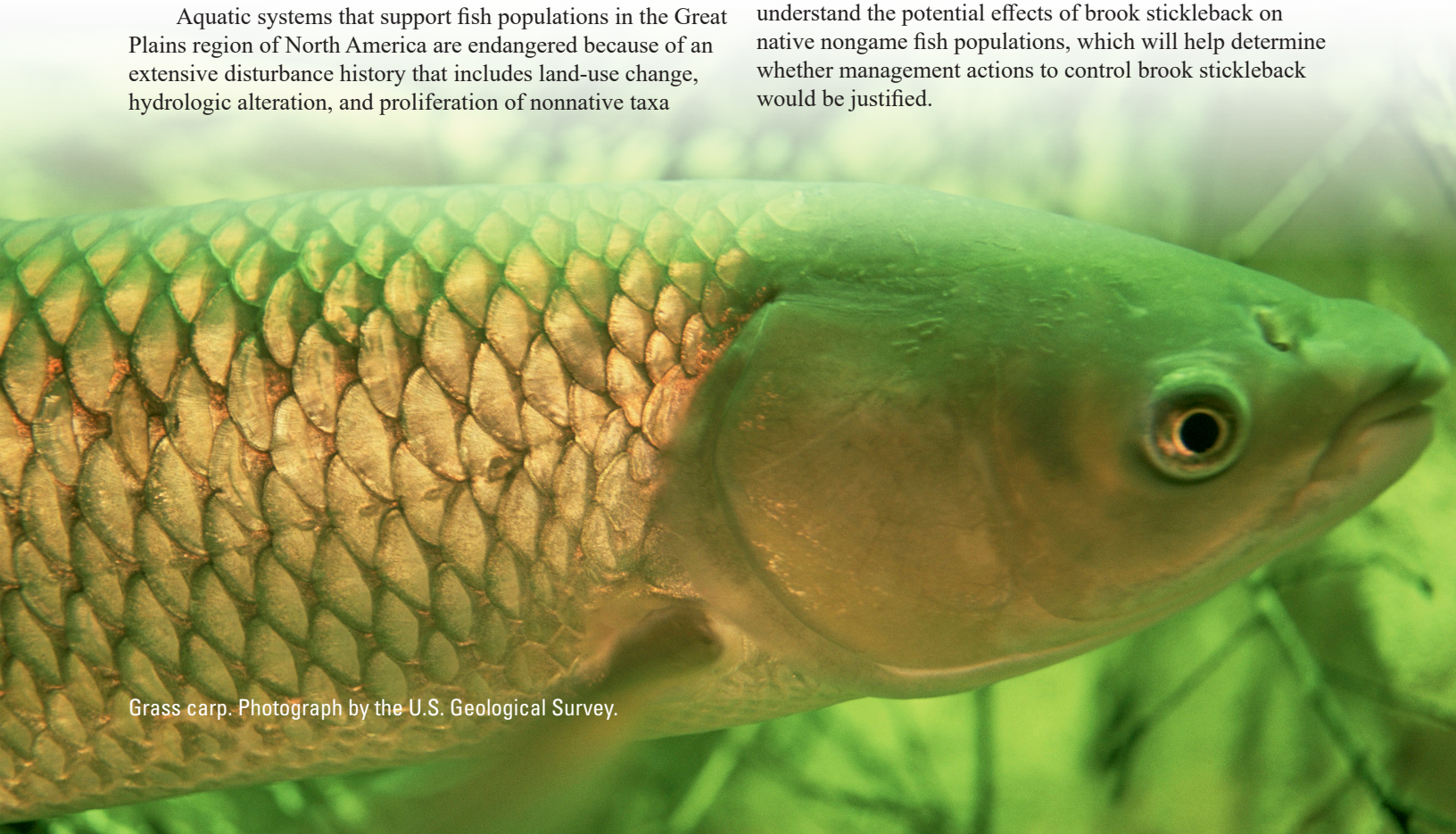
Wyoming Cooperative Fish and Wildlife Research Unit

Aquatic systems that support fish populations in the Great Plains region of North America are endangered because of an extensive disturbance history that includes land-use change, hydrologic alteration, and proliferation of nonnative taxa within watersheds. Finescale dace are a Great Plains fish with a highly limited and fragmented distribution in Wyoming. The recent finding of northern pike in one of their core sites puts this population at increased risk for extirpation. A better understanding of ecologically limiting factors that may affect the persistence of rare or threatened taxa can be used to inform conservation and management strategies aimed at preserving regional biodiversity. In collaboration with the Wyoming Game and Fish Department, this project is evaluating the current status of finescale dace in Wyoming. Given the limited distribution of finescale dace and the threats from northern pike and habitat degradation, additional populations need to be established to ensure their persistence in Wyoming. This research could guide the identification of potential reintroduction sites within their historical range.

Evaluating the Effects of Brook Stickleback on Native Nongame Fishes

Wyoming Cooperative Fish and Wildlife Research Unit

Nonnative species pose a substantial threat to aquatic ecosystems. Brook stickleback is a small, nonnative fish in Wyoming where it co-occurs with native nongame fish including at least six species that are listed as species of greatest conservation need. Despite this extensive overlap, there has been no research on potential interactions between these species, so it is unclear what level of risk brook stickleback establishment and expansion pose to the Wyoming native nongame fish assemblage. This work, in collaboration with the Wyoming Game and Fish Department, seeks to understand the potential effects of brook stickleback on native nongame fish populations, which will help determine whether management actions to control brook stickleback would be justified.



Grass carp. Photograph by the U.S. Geological Survey.

Landscape Ecology

Connectivity for Landscape Conservation Design and Adaptation Planning

Alaska Cooperative Fish and Wildlife Research Unit

Climate change is projected to substantially alter ecosystem composition, structure, and function. Northern regions, including those in Alaska and northwestern Canada, are frequently characterized as having high landscape conservation capacity, given their high percentage of protected areas and highly intact landscapes. However, these regions are susceptible to a growing number of pressures from climatic and anthropogenic change. This project could identify corridors among protected areas in Alaska and northwest Canada that promote long-term connectivity and have the potential to facilitate species movements under projected climate change. Identifying climate connectivity corridors provides a useful framework for prioritizing areas to increase landscape connectivity in the face of climate change. Given anticipated development throughout the study area, protecting connectivity while habitat is still intact can advance planning objectives.

Estimating the Spatial and Temporal Extent of Snowpack Properties in Complex Terrain—Leveraging Novel Data to Adapt Wildlife and Habitat Management Practices to Climate Change

Idaho Cooperative Fish and Wildlife Research Unit

Snow refugia and winter severity can strongly affect species abundance and distribution. Currently, the ability to accurately measure the locations of snow refugia and the relative severity of the winter is limited. Developing cost-effective indices using remote cameras to measure these locations can help decision makers survey for species that rely on snow refugia and predict species responses to severe winter weather (for example, ungulates). Results could provide managers with potential locations of snow refugia important for species of conservation concern and an index of winter severity that can be used to improve population predictions and subsequent management. This project is a collaborative effort among the USGS Northwest Science Climate Adaptation Center, the Idaho Department of Fish and Game, and the University of Idaho.

Greater Prairie-Chicken Response to Natural and Anthropogenic Disturbance on Fort Riley

Kansas Cooperative Fish and Wildlife Research Unit

Greater prairie-chickens are sensitive to disturbances on the landscape. However, effects of military activities on greater prairie-chicken demography and space use are unknown. Determining if military activities and other stochastic disturbances affect greater prairie-chickens is important for developing conservation and mitigation strategies. Given that Fort Riley supports a stable population of greater prairie-chickens, assessing space use and movements of that population may assist in management of other declining populations. Results indicate that greater prairie-chickens seem to adjust their movements and space use in response to military activity. Further, the population supported by Fort Riley is isolated and does not seem to be connected to other populations. This research is a collaborative effort between the USGS and Fort Riley, Kansas DoD.

Landscape Patterns Contributing to Lek Establishment and Morphometrics of Attending Lesser Prairie-Chickens

Kansas Cooperative Fish and Wildlife Research Unit

Lesser prairie-chickens are a species of conservation concern because of declining populations and occupied range. Managers are developing strategies, including translocation, to restore populations. Assessing lek locations, establishment, and persistence is necessary to determine the success of the strategy. Results indicate that translocated birds do join and establish leks; however, leks are associated with quality nesting habitat and relatively high female densities, which are not typically found at the release sites. This research is a collaborative effort among the USGS; the Kansas Department of Wildlife, Parks and Tourism; Colorado Parks and Wildlife; and the USFS.

Lesser Prairie-Chicken and Grassland Response to Intensive Wildfire in the Mixed-Grass Prairie

Kansas Cooperative Fish and Wildlife Research Unit

The occurrence of widespread, intensive wildfires is increasing in the range of the lesser prairie-chicken. These fires may affect population demography of lesser prairie-chickens. Documenting the population response to intensive wildfires is important for developing conservation strategies. After measuring wildfire effects, mitigation strategies can be developed. Results indicate that lesser prairie-chickens avoid areas affected by wildfire for at least 3 years after the fire. However, annual survival and nest success are not affected. This research is a collaborative effort among the USGS; the Kansas Department of Wildlife, Parks and Tourism; and the NRCS Lesser Prairie-Chicken Initiative.

Network Analyses of Inland, Depressional Wetlands of the Great Plains

Kansas Cooperative Fish and Wildlife Research Unit

Isolated, depressional freshwater wetlands are rapidly declining in the Great Plains. Connectivity among wetlands is critical to support biodiversity. Establishing connectivity patterns and predicting the effect of future conditions on wetland connectivity can aid in developing conservation strategies and determining species distributions. Wetlands critical to the connectivity of the wetland system were identified in the playa lake and Rainwater Basin systems. Both systems are nearly at the threshold for system collapse with continued loss of wetlands. This research is a collaborative effort among the USGS, the NSF, the Playa Lakes Joint Venture, and the Rainwater Basin Joint Venture.

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Resource Selection and Activity Patterns of Female Mule Deer and White-Tailed Deer in Western Kansas

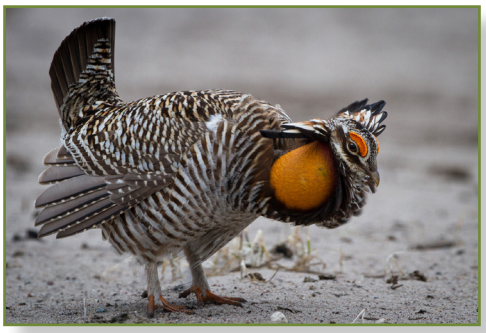
Kansas Cooperative Fish and Wildlife Research Unit

Mule deer have been decreasing in abundance and range in Kansas for the past three decades. Increasing numbers and expanding white-tailed deer may be contributing to trends in mule deer population. Mule deer are highly prized game animals that generate considerable revenue for the Kansas Department of Wildlife, Parks and Tourism and for private landowners. Understanding landscape segregation, space use, and movements by female mule deer and white-tailed deer can inform landscape-scale management strategies and determine the effect of the presence of white-tailed deer on mule deer populations. Female habitat use and vegetation selection could lead to the development of beneficial management strategies for mule deer. This project is a collaboration among the Wildlife Enterprise and Outdoor Management Program at Kansas State University; the Kansas Department of Wildlife, Parks and Tourism; the Kansas Bowhunters Association; and the Mule Deer Foundation.

Spatial Ecology and Resource Selection by Female Lesser Prairie-Chickens Within Their Home Ranges and During Dispersal

Kansas Cooperative Fish and Wildlife Research Unit

Lesser prairie-chickens are sensitive to disturbances on the landscape, especially grazing and fire. Understanding the response of lesser prairie-chickens to a variety of grazing and prescribed fire practices is important for conservation planning. Prescribed fire and grazing management are critical tools for managing lesser prairie-chickens. Landowners might be able to use these tools for management of lesser prairie-chicken populations. Results indicate that lesser prairie-chickens do benefit from heterogeneity of vegetation created by patch-burn grazing and, therefore, that grazing intensity affects habitat selection by lesser prairie-chickens. This research is a collaborative effort among the USGS; the Kansas Department of Wildlife, Parks and Tourism; and the NRCS Lesser Prairie-Chicken Initiative.



Male lesser prairie-chicken. Photograph by Dan Wundrock.

Assessing Priority Amphibian and Reptile Conservation Areas and Vulnerability to Climate Change in the North Atlantic Landscape Conservation Cooperative

Maine Cooperative Fish and Wildlife Research Unit

Amphibians and reptiles are experiencing severe habitat loss throughout North America; however, this threat to biodiversity can be mitigated by identifying and managing areas that serve a disproportionate role in sustaining herpetofauna. Identifying such areas must consider the dynamic nature of habitat suitability. As climate rapidly changes, areas currently deemed suitable may become unsuitable in the future. To address these needs, researchers have generated spatially explicit data to identify the following: Priority Amphibian and Reptile Conservation Areas as discrete areas most vital to maintaining reptile and amphibian diversity; project regions of current and future climatic suitability for a number of priority reptiles and amphibians in the North Atlantic Landscape Conservation Cooperative; and gaps in distributional data for these species that may prevent or inhibit the identification of species-level climatic suitability. In addition to the modeled conservation area boundaries, the climate niche and species distribution models are hosted on the web by the USFWS and being used for herpetofauna conservation planning. The project is a collaboration of the USGS, the USFWS, Tennessee State University, the Maine Department of Inland Fisheries and Wildlife, and Clemson University.

Publication

Sutton, W.B., Barrett, K., Moody, A.T., Loftin, C.S., DeMaynadier, P.G., and Nanjappa, P., 2015, Predicted changes in climatic niche and climate refugia of conservation priority salamander species in the northeastern United States: Forests, v. 6, no. 1, p. 1–26, https://doi.org/10.3390/f6010001.

Literature Review and Meta-Analysis of Rights-Of-Way Management for Native Insect Pollinators with Focus on Application in Maine and the Northeastern United States

Maine Cooperative Fish and Wildlife Research Unit

Roadside and powerline rights-of-way (ROWs) are managed lands that compose a relatively small part of the northeastern landscape overall but can potentially have a disproportionate effect on pollinator communities because they may simultaneously fragment, connect, create, enhance, or compromise pollinator habitat. Whether ROWs serve as pollinator population sources or sinks likely is confounded by landscape context. Although knowledge of the role of roadside and powerline ROWs in pollinator conservation is rapidly growing, most research has been focused on understanding effects of habitat type and less focused on landscape context and pattern effects on pollinator abundance and diversity. The goal of this project is to provide a systematic review, conducted as a meta-analysis, of patterns and variability reported in the published science on pollinators and land management that focuses on roadsides and ROWs. Results could broadly inform pollinator conservation in the northeastern United States and provide a comprehensive baseline for guiding current ROW management recommendations and hypotheses for future research. Project collaborators include the University of Maine, the Maine Department of Inland Fisheries and Wildlife, and the Maine Department of Transportation.

Of Pools and People—Small Natural Features with Large Ecosystem Functions in Urbanizing Landscapes

Maine Cooperative Fish and Wildlife Research Unit

The value of natural landscape features is not necessarily reflected in their size, and some small features play a significant role in maintaining biodiversity or providing ecosystem services. Conserving these features and the functions they provide while developing tools that help reconcile property rights and rules of environmental protection across scales and jurisdictions provides novel opportunities for resource management. Seasonally inundated wetlands (vernal pools) are a model system to study the dynamics of managing small natural features. The goals of a team of ecologists and economists from multiple subdisciplines and institutions are to explore the biophysical and socioeconomic components of one type of small natural feature, vernal pools, as a coupled-systems model for management of these features; improve strategies for conserving vernal pools and other small natural features with large significance; and create novel and cutting-edge research, training, and educational experiences. This project is a collaboration of the USGS, the University of Maine, Clark University, and Bowdoin College.

Publication

Homola, J.J., 2018, Eco-evolutionary implications of environmental change across heterogeneous landscapes: Orono, University of Maine, Ph.D. dissertation, 198 p., https://digitalcommons.library.umaine.edu/etd/2900/.

Pollination Security for Fruit and Vegetable Crops in the Northeast

Maine Cooperative Fish and Wildlife Research Unit

Pollinator-dependent crops require a readily available source of pollinators. Although honey bees provide this service for a variety of crops, a diverse pollinator community is needed to ensure sustainability in this service. Native bee pollinators potentially contribute to this sustainability; however, knowledge about factors that affect their abundance and distributions is lacking. This research is focused on understanding relations between native pollinators of wild blueberries and the landscape composition and arrangement around wild blueberry fields. The goals of this research are to develop web tools for understanding native bee spatial use of the landscape, develop guidance for pollinator conservation for the agricultural community, evaluate the InVEST crop pollination model, and publish several scientific articles. This project is a collaboration of a team of scientists from the USGS, the University of Maine, the University of Massachusetts Amherst, the University of Connecticut, the University of Tennessee, and Cornell University.

Interannual Variation in Juvenile River Herring Productivity and Responses to Dam Removal

Massachusetts Cooperative Fish and Wildlife Research Unit

River herring have been valued by human societies from the precolonization era but are at historical low abundance and at risk of continued declines given anthropogenic stressors, including climate change. River herring densities vary widely across New England watersheds, and the numbers and timing of river herring migrations also vary greatly from year to year. The goals of this research are to document how densities and growth of juvenile river herring vary among years in relation to environmental conditions and to document changes in river herring productivity after dam removal. Knowledge of the link between run counts and juvenile productivity are critical to update population models. Fluctuating yearly growth and density data may explain the uncertainty surrounding population estimates, which can inform river herring management decisions. Data from dam removal sites can provide valuable, new insights about annual changes in river herring densities with novel access and can be used to develop expectations for future aquatic connectivity restoration projects. This research is a collaboration between the USGS, the University of Massachusetts Amherst, the Massachusetts Division of Marine Fisheries, and The Nature Conservancy.

Restoring Aquatic Habitats Through Dam Removal

Massachusetts Cooperative Fish and Wildlife Research Unit

Thousands of small dams in Massachusetts fragment and impair nearly every stream and river throughout the State, altering fish passage, flow, sediment, and nutrient movement and making these ecosystems less resilient to natural and anthropogenic disturbances. To date, nearly 60 dams have been removed in the State, yet only a fraction of these streams have been monitored to assess water quality, habitat, and biotic responses to dam removal. Information on the benefits of dam removal, including the watershed and long-term effects of these changes, is critical for the public to understand expectations after dam removal and to gain support for future dam removals. A better understanding of ecological changes after dam removal is also needed to better answer questions from the local, regional, and national regulatory community that effect the ability to advance projects. The assessment of the responses of water quality, macroinvertebrates, and fishes to dam removal can be used to model the collective ecological benefits of dam removal statewide. This project is a collaboration among the USGS, Massachusetts Division of Ecological Restoration, the USDA, the USFS, Trout Unlimited, and the Massachusetts Division of Fisheries and Wildlife.

Modeling with Long-Term Datasets to Inform Management of National Park Grasslands

Minnesota Cooperative Fish and Wildlife Research Unit

Large ungulates in northern Great Plains national parks are of special management concern. Several parks annually acquire information on ungulate condition and population size, along with environmental data and data on other herbivores. To date (2020), these data had not been integrated into models or other structures that could be used to inform decision making. This project developed novel population models using existing data to better understand species interactions and environmental factors that affect population ecology of ungulates and other grazers in the northern Great Plains. Results of this project could be used to inform management in national parks and other landscapes in the northern Great Plains. Project collaborators include the NPS and the University of Minnesota.

Biological Evaluation of Federally Funded Erosion Control Measures in Mississippi Streams

Mississippi Cooperative Fish and Wildlife Research Unit

Soil erosion is a major contributor to degradation of valuable farmland in the southeastern United States. In addition to the agricultural losses, eroded sediments and the associated agricultural additives are one of the largest sources of nonpoint pollution in southern watersheds. Starting in 1936, Congress authorized various projects to control soil erosion; two of the longest running were conducted in northern Mississippi: the Yazoo Little Tallahatchie Flood Prevention Project 1945–85 and the Delta Headwaters Project, formerly known as the Demonstration of Erosion Control 1984–present (2020). Through the implementation of these two projects, many methods of erosion control were constructed and tested for effectiveness, which led to a substantial reduction in suspended sediments in area streams. The goal of this project is to evaluate various methods of erosion control based on their effects on the biotic community to demonstrate any changes these structures may have provided to the native ecosystem. The effect of the proposed project is considerable because it can test if structures designed for one purpose (that is, controlling erosion and lowering suspended-sediment load) can provide environmental benefits, such as creating stable habitat for the biotic community.

Inventory and Classification of Oxbow Lakes in the Mississippi Alluvial Valley

Mississippi Cooperative Fish and Wildlife Research Unit

The Mississippi Alluvial Valley contains a diverse mosaic of aquatic habitats formed through the meandering of multiple rivers. The valley includes hundreds of perennial lakes formed via channel cutoffs, known as oxbow lakes. Water quality and environmental degradation are primary concerns in most of these lakes, stemming from disturbances associated with agriculture, regulation of discharges from major flood-control reservoirs, and stream channelization. Environmental data are available for some of these lakes but are limited spatially and temporally and scattered throughout multiple databases, which greatly limits broad-scale characterizations of this resource. The goal of this project is to create an inventory of the lakes in the Mississippi Alluvial Valley containing biophysical data (including water quality and fish assemblage composition) relevant to the management of biological resources. The study results could be of value to various State and Federal agencies with jurisdiction over the alluvial valley. This project is a collaboration of the USGS, the USACE, and Mississippi State University.

Migration Ecology of North American Turkey Vultures Wintering in the Neotropics—Spatial and Population Dynamics

Mississippi Cooperative Fish and Wildlife Research Unit

Landscape composition and configuration have affected the migration of raptors. However, the effects that ecological and functional roles of the landscape, at multiple scales, and weather may have on the migration strategies of North American turkey vultures are unknown. Furthermore, information on factors triggering the processes of outbound and return migration of the turkey vulture is limited. The goal of this research is to analyze and synthesize a database of >60 vultures radiomarked with satellite transmitters during the past decade. Results could fill critical knowledge gaps focusing on three North American turkey vulture subpopulations: *Cathartes aura meridionalis*, *C. a. septentrionalis*, and *C. a. aura* across North America. This research could provide much needed information on migration strategies, migratory connectivity, space use, resource selection, and survival of these vulture populations. The study will also shed light on the effect that multiresolution landscape characteristics, anthropogenic disturbance, and weather conditions play in the life cycle of this North American raptor.

A Spatial Assessment of the Status and Risks to Mussel Concentrations in the Meramec River Drainage

Missouri Cooperative Fish and Wildlife Research Unit

A method to identify risks and threats to mussels in Missouri's Meramec River drainage in a spatially explicit manner is needed to help develop a monitoring and conservation program. As a crucial step in a long-term plan for a conservation assessment of Missouri's mussel fauna, this research plans to use geomorphological and landscape models to identify potential core areas of abundance in the Meramec River. Then, validated and standardized sampling is expected to be conducted at the sites identified as suitable for mussel habitation to determine presence or absence. Correlates of occupancy of diverse mussel assemblages in these areas could be used to identify risks and threats on the landscape, including natural (for example, isolation) and anthropogenic (for example, dams) factors that could threaten mussel assemblages. The results could provide a risk-based approach that can classify existing areas as either vacant habitats with high potential for occupancy, occupied habitats at risk, or occupied habitats at low risk. Researchers can subsequently develop monitoring plans and protocols for

each based on their risk status. If successful in the Meramec drainage, this study could serve as a model for a statewide conservation assessment.

Agent-Based Modeling of Movements and Habitat Selection of Mid-Continent Mallards

Missouri Cooperative Fish and Wildlife Research Unit

Landscape management for waterfowl conservation depends on evaluating waterfowl responses to habitat conditions, which may be based on complex and emergent interactions among behavioral, environmental, and anthropogenic factors. Agent-based models offer a spatially and temporally explicit approach to simulate and evaluate the response of waterfowl populations to conservation scenarios. The goal of this research project is to develop a tool that can be used by managers to test the suitability of alternative conservation allotments to sustain and promote mallard populations during the nonbreeding season, consisting of different amounts, configurations, and conditions of management units under a range of management and future environmental conditions.

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

Missouri Cooperative Fish and Wildlife Research Unit

Wildfires are increasing in incidence and severity across the western United States, leading to changes in forest structure and wildlife habitats. Knowledge of how species, especially bats, respond to fire-driven habitat changes in these landscapes is limited and generally disconnected from understanding of adaptations that underpin responses to fire. This research identified relations among fire regime, physiographic and forest structure variables, and occupancy and functional traits of a diverse bat community to inform forest management in a fire-prone landscape. Relations between edge-adapted bat species and fire were driven by prey preference or habitat availability and configuration at a landscape scale. Predicted increases in fire frequency and severity in the western United States are likely to shift dominance in the bat community to species adapted to open environments and those able to exploit postfire resource pulses (aquatic insects, beetles, and snags). Managing for pyrodiversity within the western United States is likely important for maintaining bat community diversity, as well as diversity of other biotic communities. Identifying trait-fire regime relations could help forest managers develop appropriate management interventions and focus limited resources to provide benefits for a broad range of species.

Conservation and Management of Missouri's Midsized Rivers—Developing Sampling Protocols and Applying Them to Priority Watershed Rivers

Missouri Cooperative Fish and Wildlife Research Unit

Substantial monitoring and research are conducted on main-stem big rivers and on smaller, wadeable streams, but little information exists for the midsized rivers in Missouri. However, these rivers can be important for fisheries management and conservation because they may provide refuge and interbasin movement corridors for small-stream fishes during drought, possess unique habitats and resources for large-river fishes moving into these systems during floods, and offer buffer capacity because their flood plains may be less modified than big rivers and thus create substantial productivity and refuge for downstream systems. Knowing how midsized rivers are used by large-river and small-stream fishes, and to what degree these rivers have their own unique fish communities, could help the Missouri Department of Conservation (MDC) identify important rivers to target for conservation and restoration. The methods developed and data collected by this project could provide a tool for developing standardized sampling protocols for fish communities in rivers from MDC priority watersheds and other watersheds and could help the Missouri DNR in the development of fish biocriteria for large rivers.

Publications

Dunn, C.G., Brooke, B.L., Hrabik, R.A., and Paukert, C.P., 2018, Intensive sampling reveals underreported use of great-river tributaries by large-river fishes in Missouri: Southeastern Naturalist, v. 17, no. 3, p. 512–520, https://doi.org/10.1656/058.017.0316.

Dunn, C.G., and Paukert, C.P., 2020, A flexible survey design for monitoring spatiotemporal fish richness in nonwadeable rivers—Optimizing efficiency by integrating gears: Canadian Journal of Fisheries and Aquatic Sciences, v. 77, no. 6, p. 978–990, https://doi.org/10.1139/cjfas-2019-0315.

Coordinating Aquatic Conservation Tools to Connect Priority Geographies and Guide Landscape-Level Conservation

Missouri Cooperative Fish and Wildlife Research Unit

Recent efforts by the MDC have focused on landscape-level conservation planning, but managers are not fully aware of the diversity of conservation planning tools that are currently available, or in development, to assist them with conservation decisions or how to coordinate their use to

maximize effectiveness. The objectives of this project are to identify areas of greatest aquatic conservation value within and outside the existing priority geographies and priority watersheds including priorities for creating or maintaining spatial connectivity of important habitats; work with the priority watershed development team to identify information needed to make landscape-level conservation decisions associated with priority watersheds; and develop a decision tree or similar guide with supporting datasets to help managers coordinate use of existing tools to answer landscape-level questions. This project could enhance knowledge and use of the various tools available by the MDC and its partners to identify important landscapes within and outside of the existing priority geographies and priority watersheds and target areas that would benefit from actions that improve connectivity within and among geographies.

Determining Geomorphological and Landscape Factors Contributing to Diverse Unionoid Mussel Communities in Missouri River Systems with Particular Emphasis on the Meramec River Drainage

Missouri Cooperative Fish and Wildlife Research Unit

The MDC is frequently queried regarding the general status of endangered and threatened mussels in Missouri. Unfortunately, a sufficiently rigorous and comprehensive assessment and monitoring framework to answer that question has not yet been implemented in Missouri because of the diverse nature of the State's mussel fauna and the limited personnel devoted to its conservation and assessment. A conservation assessment of Missouri's fauna can permit for statewide, strategic, and spatially explicit monitoring that maximizes probability of detection of population and (or) distributional changes in mussel species, while minimizing the costs and hours dedicated to monitoring programs. This project developed standardized sampling methods for freshwater mussels and identified factors that affect mussel capture and detection probability or affect measures of assemblage characteristics. In addition, the habitat properties that support diverse mussel assemblages (our biological unit of interest) were identified, with emphasis on geomorphological and landscape factors that best predict core areas of mussel diversity in the State. This research is directly contributing to long-term goals of the agency to develop a decision-support monitoring framework designed to maximize the probability of detecting species or assemblage expansions or declines in areas of the State that are strongholds of mussel diversity and to conduct a comprehensive conservation assessment of mussels in the State.

Determine Concentrations and Persistence of Imidacloprid, Clothianidin, and Thiamethoxam in Terrestrial Agricultural Settings on Missouri Public Areas

Missouri Cooperative Fish and Wildlife Research Unit

Agricultural field margins can serve as important bee foraging habitat, but these areas may also accumulate neonicotinoid insecticides via runoff events and planter dust. Few field studies have evaluated the effects of neonicotinoid insecticides on wild pollinator communities, including solitary, ground-nesting bees (for example, sweat bees and longhorn bees). This research assessed the distribution and effects of neonicotinoid exposure on native bee floral (diet specialization) and nesting guilds (for example, soil and cavity). Neonicotinoid residues were detected in field soils during all sampling periods but were infrequently detected in margin soils with no residues detected in flowers from field-margin or soybean plants. In addition, wild bee abundance was substantially less in fields with greater neonicotinoid concentrations, and soil-nesting bee richness was substantially greater in margins surrounding untreated fields compared to previously treated fields. These results could be used to develop best-management practices to balance tradeoffs and reduce potential deleterious effects of neonicotinoid insecticides on nontarget taxa.

Fish Community Response to Stream Flow Alterations in Wadeable Missouri Streams

Missouri Cooperative Fish and Wildlife Research Unit

Ensuring adequate water quantity and quality in stream, riparian, and wetland systems is a pressing issue worldwide, and the science related to streamflow management is rapidly evolving. The information needed to address the diversity of ecological flow issues that will continue to arise because of climate change, increasing human population, and the associated increased demand for water make streamflow management a complex and long-term issue facing the MDC. This project conducted a literature review to identify fish species' responses linked to streamflow alteration metrics and identified 76 studies that evaluated fish responses to streamflow for hydrologic and biologic metrics. This information was incorporated into a framework that is being used by researchers, managers, and policymakers to inform ecological flow decisions.

Movement and Habitat Selection of Fishes Under Different Flow Regimes

Missouri Cooperative Fish and Wildlife Research Unit

Flow regime plays a fundamental role in the biology of aquatic species whose life events are often triggered by changes in streamflow. This study used radio telemetry to provide a better understanding of how streamflow affects movement and habitat selection of spotted bass and shorthead redhorse in a highly regulated river below a hydroelectric dam with dynamic habitat conditions. Movement rates increased with maximum daily discharge for spotted bass during summer but not during other seasons. In contrast, shorthead redhorse movement rate was not related to maximum daily discharge in any season. The asynchronous responses to flows for two native fish species help to illustrate the complexity in spatial ecology of fishes in dynamic river environments. The results can assist the MDC and managers of hydroelectric dams identify reservoir releases that may help sustain native fish populations.

Publication

Edge, E.N., Paukert, C.P., Lobb, M.D., III, Landwer, B.H.P., and Bonnot, T.W., 2020, Seasonal selection of habitat by spotted bass and shorthead redhorse in a regulated river in the Midwest, USA: River Research and Applications, v. 36, no. 7, p. 1087–1096, https://doi.org/10.1002/rra.3637.

Improving Conservation Status of Arctic Grayling—Assessing and Increasing Landscape Connectivity Benefits of Denil Fishways in the Big Hole River

Montana Cooperative Fishery Research Unit

Hydraulic structures such as irrigation diversions are common to the river systems in arid agricultural regions but can restrict necessary fish movements. Denil fishways have been installed in irrigation diversions, and many more installations are planned, but their effectiveness has not been assessed. The goals of this research are to test the effectiveness of Denil fishways at providing Arctic grayling passage in the Big Hole River watershed and to test their design criteria. Conservation partners need to know the efficiency of fish passage for Arctic grayling and other aquatic species and their economics and water usage. Assessment of Denil fishways could enhance AM strategies and lead to better design features that increase passage success and landscape connectivity while providing more economical use of water when it is scarcest. Partners are the USFWS; the Montana Department of Fish, Wildlife and Parks ; the NRCS; the Montana Department of Natural Resources and Conservation; local ranchers; and NGOs.

Seasonal Movements of Rainbow Trout, Brown Trout, and Mountain Whitefish in the Smith River, Montana

Montana Cooperative Fishery Research Unit

Movements of stream-dwelling fishes can be obstructed or hindered by habitat alterations and instream barriers, and such fragmentation of habitats deleteriously affects many taxa worldwide. Conversely, diverse movement and life-history patterns can optimize resource availability, increase genetic exchange, and promote population resilience to environmental disturbances. This research determined the factors affecting unconstrained fish movements and how those movements and vital rates interrelate in a large, inland watershed. Watershed-scale movements were common, diverse, and overlapped, thereby connecting distant groups of fish. Accounting for the diversity and spatial extent of movement patterns expressed by all species in the fish assemblage can promote species diversity and ensure the persistence of robust fish populations. Managers may best protect life-history diversity of inland fishes by emulating management actions that benefit highly migratory anadromous fishes, which seeks to facilitate unhindered movements.

Rainbow trout. Photograph by the U.S. Fish and Wildlife Service.

Spawning Readiness, Spawning Locations, and Habitat Use of Pallid Sturgeon in the Missouri River Above Fort Peck Reservoir, Montana

Montana Cooperative Fishery Research Unit

Habitat alterations, including the construction of large dams, in the Missouri River have inhibited successful recruitment of pallid sturgeon and resulted in the species being listed as endangered. A conservation propagation program was started, and the hatchery-origin pallid sturgeon are now becoming sexually mature and adding to the number of reproductively active fish in the system. However, fishery managers are uncertain how the

reproductive ecology of hatchery-origin pallid sturgeon relates to the few remaining wild fish. The goals of this project are to estimate spawning readiness of hatchery-reared and wild pallid sturgeon, to identify spawning locations, and to document habitat characteristics at spawning locations. The information is central to the management of pallid sturgeon in the Upper Missouri River given the current understanding of drift distance, anoxic conditions in the transition zone above Fort Peck Reservoir, and the high occurrence of atresia in pallid sturgeon. These results could provide expected, relative reproductive contributions of hatchery and wild sturgeon and water-level management actions to improve recovery efforts for pallid sturgeon.

Effects of Conifer Expansion and Removal on Songbird Abundances and Reproductive Success in High-Elevation Sagebrush of Southwestern Montana

Montana Cooperative Wildlife Research Unit

Conifer removal is a core practice in sagebrush-steppe restoration to benefit elk and greater sage-grouse, as well as other sagebrush species of management concern. However, research of the demographic effects on sagebrush-obligate songbirds, as well as conifer-dependent songbird species, is lacking. The goal of this research is to evaluate the consequences of conifer removal on the abundance and reproductive output of songbirds using both conifer and sagebrush habitats in high elevation Montana. Results could be used to develop best practices for the management removal of conifer trees in stands of mountain big sagebrush habitats and provide specific recommendations on the landscape contexts and distances from woody cover that will collectively benefit songbirds the most. Partners include the USFWS; the BLM; the Montana Department of Fish, Wildlife and Parks; The Nature Conservancy; and private landowners.

Songbird Grazing

Montana Cooperative Wildlife Research Unit

About 75 percent of sagebrush-associated bird species are declining nationally including several songbird species (for example, Brewer's sparrow and sage thrasher). Declines in sagebrush-associated avian species are congruent with substantial losses of sagebrush ecosystems from human-induced changes. Domestic livestock grazing is a newly founded conservation tool used in parts of the western United States to benefit sagebrush-steppe systems. Notably, conservation efforts to protect declining greater sage-grouse populations have implemented various grazing management strategies. The benefits of how these conservation managed-grazing regimes for greater sage-grouse affect another avian species of conservation concern is lacking. Hence, the goal of this project is to determine how multiple migratory songbird species respond to conservation managed-grazing strategies. The songbird species response variables include community-level responses (for example, species richness, species diversity, and community composition) and species-level responses (for example, abundance, density, nest density, nesting success, and fledging success). Results could inform land managers how and when, during the songbird breeding season, conservation-based livestock grazing benefits these wildlife populations. The project is a collaboration of resource managers and biologists across multiple agencies and NGOs and includes the University of Montana; the Montana Department of Fish, Wildlife and Parks; the BLM; the Safari Club International Foundation; and the USFWS.

Sage thrasher. Photograph by the U.S. Fish and Wildlife Service.

Avian Habitat Relationships Across Ecological Scales

Nebraska Cooperative Fish and Wildlife Research Unit

Throughout the Great Plains, changing land-use practices are resulting in large-scale biodiversity loss and an ever-increasing dependence on effective conservation and restoration efforts provided by private, State, and Federal agencies. However, for restoration efforts to be effective, managers need to understand how grassland bird communities select habitat based on local vegetative composition as well as larger landscape attributes. This project analyzed data from avian point count surveys and local vegetation assessments within a larger land-cover layer of Nebraska to create species-specific spatial models for the State, which identified focal areas for management efforts to maximize benefits to grassland bird communities. The findings from this study are now being used by the Nebraska Game and Parks Commission to help direct pheasant management efforts in Nebraska.

Publications

Stuber, E.F., and Fontaine, J.J., 2018, Ecological neighborhoods as a framework for umbrella species selection: Biological Conservation, v. 223, p. 112–119, https://doi.org/10.1016/j.biocon.2018.04.026.

Stuber, E.F., Gruber, L.F., and Fontaine, J.J., 2017, A Bayesian method for assessing multi-scale species-habitat relationships: Landscape Ecology, v. 32, no. 12, p. 2365–2381, https://doi.org/10.1007/s10980-017-0575-y.

Ecology of Swift Fox in Nebraska

Nebraska Cooperative Fish and Wildlife Research Unit

In Nebraska, the loss and degradation of grasslands has substantially affected many grassland species, including the swift fox. Swift fox are a Nebraska Natural Legacy Plan Tier-1, at-risk species that currently occupy only 20 to 25 percent of their historical range. With increasing interest in developing infrastructure in western Nebraska for gas, oil, and wind energy, there is a clear need to document the distribution of swift fox and identify threats to swift fox populations. Coyotes are one such threat because they are dominant to swift fox and often cited as an important source of mortality. Increases in the abundance and distribution of coyote after the development of western Nebraska likely restricted the range of swift fox despite the availability of suitable vegetative conditions. The goals of this project are to document the occurrence of swift fox in western Nebraska and to identify the anthropogenic and ecological factors that limit swift fox distribution. Results can identify where swift fox are located and identify the ecological mechanisms shaping the distribution of canid communities in Nebraska by developing and testing a series of species distribution models based on the habitat requirements and intraguild interactions of Nebraska's canid community. Collaborators include the Nebraska Game and Parks Commission, the Nebraska Department of Roads, the Nebraska Environmental Trust, the USFS Nebraska National Forests and Grasslands, the University of Nebraska-Lincoln, and Chadron State College.

Assessment of Nutrition and Predation as Limiting Factors for Mule Deer in New Mexico

New Mexico Cooperative Fish and Wildlife Research Unit

Mule deer have declined across New Mexico, and studies in other parts of their range indicate that predation and (or) nutritional limitations are contributing to declines. The goal of this research is to evaluate the relative roles of nutrition and predation on a nonmigratory mule deer population to determine factors limiting mule deer in New Mexico.

Swift fox. Photograph by Scott Somershoe, U.S. Fish and Wildlife Service.

Specifically, this research can provide needed estimates of survival rates and cause-specific mortality, pregnancy rates and fawn recruitment, forage biomass and nutritional quality, diet composition, prey composition and kill rates for mountain lions, and how habitat selection by mule deer is affected by habitat conditions and predation risk. Results could improve knowledge of limiting factors driving mule deer population dynamics in semiarid regions, including the independent and interactive effects of climate, forage dynamics, and predation.

Effects of Drought on Southwestern Cutthroat Trout—Effects of Changes in Discharge and Stream Temperature on the Persistence of Rio Grande Cutthroat Trout Populations

New Mexico Cooperative Fish and Wildlife Research Unit

Rio Grande cutthroat trout are the southernmost subspecies of cutthroat trout and currently occupy less than 12 percent of their historical range. Loss of habitat because of competition and hybridization with introduced trout and habitat alteration has restricted the remaining 122 populations to small (5.8-kilometer median length) isolated habitat patches. A stream temperature and discharge monitoring program also identified that most occupied habitat patches, although currently thermally suitable for the subspecies, have very low summer baseflows, which restrict fish movement and increase the risk of population extirpation because of stochastic disturbances (that is, drought). This research is using otoliths and multistate capture-mark-recapture data collected along a temperature and stream drying gradient to assess life-history traits and persistence of Rio Grande cutthroat trout. In addition, the researchers are using secondary production to determine if stream temperature has affected Rio Grande cutthroat trout abundance and growth. Results can be used to develop and implement a comprehensive long-term management strategy for the southernmost subspecies of cutthroat trout in the United States. Collaborators include the USGS, the USFS, and the New Mexico Department of Game and Fish.

Population Trajectories and Extinction Probabilities for Populations of Large Ungulates

New Mexico Cooperative Fish and Wildlife Research Unit

Understanding the importance of life-history parameters is vital to managing wildlife populations and predicting the effects of translocation efforts. Many translocation efforts fail to achieve management objectives, frequently because of a failure to fully consider demographic, management, and climatic contexts in which the translocations are implemented. In collaboration with the USFWS, the researchers are evaluating the minimum population size, optimal demographic characteristics (for example, survival and recruitment), and release strategies (for example, number of animals and translocation schedules) that balance population growth and persistence for target and source populations involved in translocation efforts. Furthermore, through modeling efforts, the researchers are also evaluating the effects of recurring droughts and various predator management strategies on the trajectories of translocated populations. This work could inform wildlife management agencies on translocation strategies that are most likely to lead to population persistence of source and target populations involved in these translocation efforts.

Predation Rates and Use of Habitats and Wildlife Drinkers by Mountain Lions

New Mexico Cooperative Fish and Wildlife Research Unit

Wildlife management agencies maintain manmade water sources for wildlife in arid environments based on long-held assumptions that they benefit wildlife and do not have adverse consequences. However, these water sources may allow predators to occupy areas that would otherwise be inhospitable and use these water sources to ambush prey, thus increasing predation on species that these water developments are intended to benefit. The goal of this project is to determine the effect of manmade water sources on mountain lion habitat and prey selection and whether kill sites of ungulates are disproportionately near manmade water sources (in other words, waters are used as ambush sites). The results of this study could affect wildlife water-development programs across the West. Furthermore, this project could greatly expand knowledge on large carnivore water dependency and the effect of water on predator space use, resource selection, and predator-prey dynamics in arid ecosystems. This project is a collaboration with the USFWS, the New Mexico Department of Game and Fish, and the Arizona Game and Fish Department.

Resilience Landscapes—Effect of Fire and Forest Restoration on Spatial and Temporal Distribution of Fish and Invertebrate Communities

New Mexico Cooperative Fish and Wildlife Research Unit

In 2011, the Las Conchas Fire became the largest wildfire in New Mexico. In less than 1 week, one-third of the Valles Caldera National Preserve (VCNP) was burned. The severity of the fire within the forested watershed of the streams resulted in variable flow and elevated sediment that has continued to affect recovery of fish assemblages and the benthic macroinvertebrate community 8 years after the fire. Recovery of the aquatic community on the VCNP is listed as a priority need by the NPS. Monitoring has revealed continued suppression of the salmonid population 8 years after the fire compared to before the fire with little to no fish recruitment in the burned areas. In addition, the aquatic benthic invertebrate

community continues to experience variable diversity throughout the fire-affected streams of the VCNP, which suggests ecological recovery is ongoing 8 years after the fire. The research results can be used by VCNP biologists to make informed decisions regarding the management and restoration of the forested watershed and riparian areas of the streams.

Responses of Large Mammals to Forest Restoration Treatments in the Southwest Jemez Mountains, New Mexico

New Mexico Cooperative Fish and Wildlife Research Unit

Decades of fire suppression, overgrazing, and logging in the western United States have increased tree densities, altered habitat conditions for many wildlife species, and increased the risk of stand-replacing wildfires. Land managers are currently implementing landscape-scale treatments in efforts to mitigate catastrophic wildfires and to restore historical forest conditions. The goal of this project is to monitor the responses of mule deer, elk, black bears, and mountain lions to forest restoration treatments associated with the Southwest Jemez Mountains Collaborative Forest Landscape Restoration Project. Specific responses could include assessing changes in forage conditions, movements, and resource selection of mule deer, elk, black bears, and mountain lions in relation to prescribed fires, restoration thinning, and previous wildfires. The results of this project could allow for more informed design and implementation of restoration treatments that simultaneously mitigate wildfire risk and enhance habitat conditions for mule deer, elk, black bears, and mountain lions. This research is a collaboration among the New Mexico Cooperative Fish and Wildlife Research Unit, the DNR Management at Texas Tech University, the NPS, the USFS, Jemez Pueblo, and the New Mexico Department of Game and Fish.

Publications

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Roerick, T.M., Cain, J.W., III, and Gedir, J.V., 2019, Forest restoration, wildfire, and habitat selection by female mule deer: Forest Ecology and Management, v. 447, p. 169–179, https://doi.org/10.1016/j.foreco.2019.05.067.

National Biogeographic Analysis and Synthesis

North Carolina Cooperative Fish and Wildlife Research Unit

The threats to ecological systems posed by climate change, urbanization, and invasive species underscore the need for proactive management and planning. However, conservation planning at regional and national extents continues to be limited by the lack of consistent, detailed, and current data on biological resources. The goals of this project are to analyze trends in biodiversity, to investigate drivers of change and potential implications for future changes in diversity, to synthesize data and update species-habitat distribution maps to document the current status of biodiversity in the Nation, and to assist in building a national biogeographic map and a central tool for disseminating the synthesis of information. The results could provide data, synthesis, and analyses to increase understanding of the status of biodiversity and drivers of change with emphasis on factors affecting national trust resources.

Determining Crayfish Invasion Potential Across the Landscape

Oklahoma Cooperative Fish and Wildlife Research Unit

Crayfish is a globally diverse group of invertebrates and one of the most important taxa in North American streams. Many crayfishes are identified as species of concern because of anthropogenic alteration, narrow distributions, and interactions with invasive crayfish. An estimated 48 percent of North American crayfish are at risk of extinction. Because of their important role in stream structure and function, including serving as a primary diet for smallmouth bass, widespread stream changes may result from loss of crayfish species. The goals of this research are to compile existing crayfish data, to determine the hierarchical structure of habitats associated with crayfishes, to ascertain crayfish demographics, and to identify factors related to the spread of nonnative crayfishes

within the Ozark Highlands ecoregion. The results could be used by managers to develop strategies for maintaining native crayfishes including removal of invasive crayfish, monitoring vectors if necessary, and developing important linkages between key prey and sportfish populations.

Evaluating Sustainable Water Availability in Drought-Prone Watersheds of Southeast Oklahoma

Oklahoma Cooperative Fish and Wildlife Research Unit

A better understanding of how drought and fragmentation of watersheds interact to structure aquatic communities, alter the vulnerability of species to local extirpation, and determine the trajectory of recovery from disturbance is needed to inform proactive conservation and management actions. The goal of this project is to examine the effects of previous droughts on fish populations by compiling fisheries datasets that have been temporally replicated within the Red River Basin. Hydrologic regime can be characterized to develop statistical relations among fish traits, species, and indicators of drought. Results could show which traits are most susceptible to drought and which spatial locations have been most problematic for recovery after drought. The resulting model could be useful to developing water-management strategies in the basin that support vulnerable fish populations and human needs. This project is a collaboration of the USGS and the Chickasaw Nation.

Movement and Flow-Recruitment Relationships of Prairie Chubs

Oklahoma Cooperative Fish and Wildlife Research Unit

The prairie chub is classified as a pelagic broadcast-spawning cyprinid based on phylogenetic relations and shared morphological characteristics with other *Macrhybopsis* spp. Great Plains pelagic-spawning cyprinid populations have undergone substantial population and range declines because of their sensitivity to anthropogenic changes to the natural flow regime. Currently, there is a paucity of information regarding prairie chub biology and life history; thus, little is known about specific factors (that is, discharge magnitudes) that promote successful recruitment in the Upper Red River Basin. The purpose of this project is to improve the conservation and management of prairie chub and other pelagic broadcast minnows including members of the *Macrhybopsis* complex. Specifically, this project intends to establish relations among flow regimes, fish movements, and population recruitment across several locations. These results could inform future water-management decisions that may help conserve populations of pelagic broadcast-spawning cyprinids in the Upper Red River Basin.

Barred Owls in the Pacific Northwest—Using an Experimental Removal Project to Understand Predator-Prey Interactions of a Nonnative Raptor

Oregon Cooperative Fish and Wildlife Research Unit

The barred owl is a medium-sized forest owl native to eastern North America. Starting in the late 1800s, the barred owl began expanding its geographic range north and west, and its newly expanded range now completely overlaps that of the federally threatened northern spotted owl. Strong evidence indicates that competition with invading barred owls is causing rapid declines in populations of northern spotted owls and that, in some parts of the Pacific Northwest, barred owls now occur at much greater densities relative to northern spotted owls. However, little research exists on the overall effects of this newly established apex predator on other forest species and general food-web dynamics. This project plans to take advantage of the experimental design associated with an ongoing barred owl removal experiment to evaluate the effect this novel avian predator is having on the food web in the Pacific Northwest. Understanding the effect of barred owls on the food web is critical for understanding population-level responses of spotted owls and other native species, particularly as barred owl densities begin to reach carrying capacity. Collaborators include the USGS and the USFWS.

Barred owl. Photograph by the U.S. Fish and Wildlife Service.

Demographics and Habitat Use of Greater Sage-Grouse in Wildfire-Affected Habitats in Oregon

Oregon Cooperative Fish and Wildlife Research Unit

Southeast Oregon contains part of one of the largest contiguous sagebrush-steppe habitats remaining within the extant range of greater sage-grouse. During the summer of 2012, several large wildfires included more than 1 million acres of Oregon sage-grouse habitat within their perimeters. This project is a long-term study to evaluate acute (short-term) and chronic (long-term) effects of large-scale wildfire on female greater sage-grouse demographics and habitat use and selection. The research findings could inform the prioritization of areas for postfire habitat rehabilitation and restoration and help identify areas requiring further protection and (or) active management to reduce risk of wildfire and ensure sage-grouse population persistence.

Publications

Anthony, C.R., 2020, Thermal ecology and population dynamics of female greater sage-grouse following wildfire in the Trout Creek Mountains of Oregon and Nevada: Corvallis, Oreg., Oregon State University, Ph.D. dissertation, 156 p.

Anthony, C.R., Hagen, C.A., Dugger, K.M., and Elmore, R.D., 2020, The effects of fire on the thermal environment of sagebrush communities: Journal of Thermal Biology, v. 89, article 102488, 9 p., https://doi.org/10.1016/j.jtherbio.2019.102488.

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Fire Refugia in Late-Successional Forests—Predicting Habitat Persistence to Support Land Management in an Era of Rapid Global Change

Oregon Cooperative Fish and Wildlife Research Unit

Recent stand-replacing wildfires in late-successional and old-growth forests and the threat of increasing wildfire extent and severity predicted under climate change for the U.S. Pacific Northwest have increased land manager interest in fire refugia in late-successional and old-growth forests. Forest fire refugia (that is, places that remain unburned or experience minimal tree mortality compared to surrounding areas) are key components of contemporary burn mosaics and can provide vital habitat for threatened and endangered species, including the northern spotted owl, the marbled murrelet, and red tree voles. However, conservation practitioners lack information on which locations are protected from, versus vulnerable to, high-severity, stand-replacing fire. Contemporary refugia have been identified as priority locations for biodiversity conservation and climate change adaptation strategies at regional and national scales. However, little is known about the predictability of late-successional and old-growth forest fire refugia in the Pacific Northwest. The goal of this project is to produce maps of the probability of contemporary fire refugia and stand-replacing fire in late-successional and old-growth forests based on topography, fuels, fire weather, and climate. The maps and associated products could provide timely information about the likely persistence and loss of late-successional and old-growth forests under current and future climate conditions.

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

Oregon Cooperative Fish and Wildlife Research Unit

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

Intraguild Predator Dynamics—The Effects of Recolonizing Gray Wolf Populations on Cougars in Northeast Oregon

Oregon Cooperative Fish and Wildlife Research Unit

Since the reintroduction of wolves in Idaho, Montana, and Wyoming in 1996, recovering wolf populations have expanded their distributions into Oregon, and other western States where they had largely been extirpated (since the 1940s in Oregon). Since the near extirpation of cougars in Oregon in the 1960s, cougar populations have now recovered to stable levels throughout the State, and their ecology and population dynamics before the arrival of wolves is well studied. The recolonization of wolves into Oregon raises important questions regarding their effects on prey populations (deer and elk), livestock depredation, and interspecific competition with cougars. Within this context, this study intends to investigate prey selection of co-occurring wolves and cougars, and the effect of wolves on the demographics, habitat use, and movement patterns of cougars. The results from this study can provide information that could aid in the management of these two large carnivores in Oregon.

Publication

Orning, E.K., 2019, Carnivore competition—Spatial and dietary implications of gray wolf recolonization for cougars in northeast Oregon: Corvallis, Oreg., Oregon State University, Ph.D. dissertation, 213 p., https://ir.library.oregonstate.edu/concern/graduate_thesis_or_dissertations/m900p119m.

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

Pennsylvania Cooperative Fish and Wildlife Research Unit

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

Changes in Avian and Plant Community Composition and Structure After Prescribed Thinning in Pinyon-Juniper Woodlands

Texas Cooperative Fish and Wildlife Research Unit

Pinyon-juniper woodlands are an extensive and biologically important vegetation community across the western United States. A history of overgrazing and fire suppression has resulted in pinyon-juniper woodlands expanding beyond its historical distribution and encroaching into predominantly grassland vegetation communities. This expansion has led to efforts to reduce pinyon-juniper as part of grassland restoration, but it also has been documented that pinyon-juniper thinning and removal reduces avian diversity and abundance. This reduction is of concern because pinyon-juniper woodlands have the highest diversity of birds, the highest density of nesting birds, and the highest number of bird species throughout the year compared to other upland habitats in the West. Of special concern is how thinning practices may affect pinyon-juniper obligate species of concern, especially the juniper titmouse and the pinyon jay. This project is addressing this issue in New Mexico with the BLM and the USFWS. Specifically, researchers are assessing avian community structure in pinyon-juniper areas in thinned and unthinned plots, and before and after thinning occurs, to acquire data that facilitates informed management decision analysis for landscape-level management.

Understanding the Role of Muleshoe National Wildlife Refuge

Texas Cooperative Fish and Wildlife Research Unit

The purpose of this project is to assess the role of Muleshoe National Wildlife Refuge in Texas and the surrounding landscape in the context of overwintering sandhill cranes. Researchers plan to develop a model that incorporates the role of the refuge for species conservation in context of a changing landscape because of climate change and its effects on land use in the High Plains. Information obtained could allow assessment of what constitutes sustainable landscapes for sandhill cranes and the possible management strategies that can be put into place to protect these landscapes. This is especially important for long-term conservation actions because the Southern High Plains is projected to become hotter and drier with decreased, yet more intense precipitation events because of climate change.

Blue Catfish and Flathead Catfish Population Demographics, Habitat Use, and Movement in the Robert C. Byrd Pool of the Ohio and Kanawha Rivers

West Virginia Cooperative Fish and Wildlife Research Unit

Fishes of large river ecosystems provide important recreational fisheries with real economic contributions. Management of these large river fish populations, however, is often limited because of a lack of ecological information. Currently little information is known about the population ecology of blue catfish and flathead catfish in the Ohio and Kanawha Rivers of West Virginia. Data from this study on population demographics, habitat use, and movement of blue catfish and flathead catfish could inform management decisions for these species and provide data to aid the West Virginia Division of Natural Resources toward further development of these large river fisheries. This collaborative study involves researchers from the USGS, West Virginia University, the West Virginia Division of Natural Resources, and Missouri State University.

Blue catfish. Photograph by Brett Billings, U.S. Fish and Wildlife Service.

Safe Operating Space for Walleye—Adapting Inland Recreational Fisheries for Climate Change

Wisconsin Cooperative Fishery Research Unit

Global change, including large-scale changes in climate, land use, hydrology, and biogeochemistry, creates unprecedented pressure on inland recreational fisheries. Local fish managers have little effect on these large-scale changes, but they can manipulate factors such as harvest, food web structure, and some features of habitat. The safe operating space concept establishes a framework for analyzing a fishery in the context of large-scale and local factors. Adaptation is the manipulation of local factors (such as harvest, food web structure, or habitat) to maintain the safe operating space of a fishery as the climate changes. This research can use comparative studies, a whole-lake experiment, models, and synthesis of extant long-term data to quantify the walleye safe operating space over a diverse landscape with thousands of lakes. Researchers could develop tools for classifying lakes with respect to the walleye safe operating space. The project is a collaboration of researchers across multiple agencies and includes the USGS, the University of Wisconsin-Stevens Point, and University of Wisconsin-Madison Center for Limnology.

Landscape-Scale Management of Forest Wildlife Populations in Wisconsin

Wisconsin Cooperative Wildlife Research Unit

Conservation of species has shifted from single-site efforts to landscape-scale approaches because of the scale

Walleye is an important sportfish across much of North America. Photograph by Eric Engbretson, U.S. Fish and Wildlife Service.

at which forest management operates. USFS national forest managers conduct monitoring activities on populations according to the forest plan but lack time and expertise to analyze the data to help inform their management actions. This project will evaluate several long-term wildlife monitoring programs to provide science-based information to support inventory and monitoring efforts that contribute to ecosystem management in the national forests of Wisconsin. The project is a collaboration of researchers and managers across multiple agencies and includes the USGS, the USFS Northern Research Station, and managers from the Chequamegon-Nicolet National Forest.

Effect of Energy Development and Climatic Variability on Sagebrush Songbirds

Wyoming Cooperative Fish and Wildlife Research Unit

Changing temperature and precipitation regimes, especially within arid systems such as the sagebrush steppe, are broad-scale factors that will affect landscapes in addition to other forms of physical habitat loss and fragmentation. The combined, and potentially interactive, effects of climatic conditions and habitat loss and fragmentation on wildlife species of concern, however, are unknown. Simultaneously, all three species of songbirds (Brewer's sparrow, sagebrush sparrow, and sage thrasher) that nest almost exclusively within North American sagebrush habitats have been exhibiting population declines, at least partly because of habitat changes on breeding grounds. This project leverages a large, multiyear nesting dataset of sagebrush songbirds containing >2,000 nests and remotely sensed weather data to investigate the joint effect of climatic conditions and energy development on the reproductive success of sagebrush songbirds within the WLCI area in western Wyoming. Information generated by the research can be used to update the Wyoming Comprehensive Wildlife Conservation Strategy and Wyoming State Wildlife Action Plan, inform Climate Vulnerability Assessments, and address informational needs articulated by the multiagency Sagebrush Conservation Initiative. Project partners include the WLCI, the USFWS Western Association of Fish and Wildlife agencies, Wyoming Wildlife Foundation, and the Wyoming Game and Fish Department.

Stable Isotopes to Delineate Seasonal Range Use for Wyoming Ungulates

Wyoming Cooperative Fish and Wildlife Research Unit

For over a century, wildlife ecologists have sought to describe animal movements and differentiate populations across the vast landscapes they occupy. Understanding the movement biology of terrestrial mammals, especially large ungulates, is important for conserving migratory corridors. The project team plans to develop a method to determine the migratory movement paths and seasonal range use of Wyoming ungulates from the strontium isotope values recorded in their teeth. The analyses have the potential to decrease overall costs, manpower, and time associated with tracking and describing animal movement patterns.

Wyoming Migration Initiative

Wyoming Cooperative Fish and Wildlife Research Unit

Wyoming's ungulate migrations, like the vast landscapes on which they occur, are a vital part of the State's cultural heritage. But migration corridors are facing new and ongoing threats, and their conservation is constrained by a still-incomplete understanding of migration ecology and by misconceptions among public stakeholders. In 2012, the Wyoming Migration Initiative was created with the broad goals of understanding and conserving ungulate migration routes through migration research, developing conservation tools, and doing public outreach and education. Current research is focused on mapping undocumented corridors and studying the benefits and challenges of long-distance migration. The work on conservation tools focuses on creating a powerful archive of corridor data that can guide on-the-ground conservation and policy. Outreach and education programs continue to tell the story of migration to a broad audience, focusing on "live" tracking of migrations, compelling new videos, storytelling, and resources for K–12 instructors. This work is conducted in collaboration with the Wyoming Game and Fish Department in addition to a wide variety of other State and Federal partners and conservation groups.

Elk traveling on winter range. Photograph by Jonny Armstrong, University of Wyoming.

Species and Habitat Management

Broad Whitefish Ecology on the Arctic Coastal Plain

Alaska Cooperative Fish and Wildlife Research Unit

Subsistence fisheries provide an important food resource for communities on Alaska's Arctic Coastal Plain. Despite the importance of the Colville River's summer run of broad whitefish to Native communities and the potential habitat effects associated with climate change and petroleum development, the basic ecology of this migratory species remains poorly understood. The goals of this project are to identify key habitats and seasonal migration patterns, to investigate the prevalence and role of anadromy, and to conceptualize how ongoing climate change will likely affect broad whitefish growth, phenology, and their habitats. Adult migratory fish can be studied in summer riverine habitats and stable isotopes can be analyzed to estimate the contribution of marine food resources and to determine life history type. Seasonal movements among freshwater habitats also could be determined. Findings from this research could provide insight into potential effects from climate and landscape change to better conserve this important subsistence resource on the Arctic Coastal Plain.

Chena River Juvenile Chinook Salmon Outmigration Timing from Significant Rearing Areas

Alaska Cooperative Fish and Wildlife Research Unit

Since 2001, Chinook salmon returning to the Yukon River drainage have been designated as a stock of concern by the Alaska Board of Fisheries, and the Chena River supports one of the largest spawning stocks in the Alaskan part of the Yukon River drainage. The goal of the Chena River juvenile Chinook salmon study is to provide a method to estimate the outmigration timing and magnitude of smolt production from several rearing areas on a highly used stock. These estimates could lead to a mark-recapture study design that generates accurate and precise estimates of smolt abundance and marine survival that can improve the stock assessment models that are used to establish sustainable escapement goals. Models could aid managers when making decisions about the Yukon River's important subsistence, commercial, and sport fisheries. The project could also identify and characterize important fall rearing areas for juvenile Chinook salmon. This study is a collaboration between the University of Alaska Fairbanks and the Alaska Department of Fish and Game.

Migration Trends for King and Common Eiders and Yellow-billed Loons Past Point Barrow in a Rapidly Changing Environment

Alaska Cooperative Fish and Wildlife Research Unit

Most of the king and common eiders and yellow-billed loons nesting in northern Alaska and northwestern Canada migrate twice annually past Point Barrow, Alaska, during their northward spring migration and their southward fall migration. Historical records from spring and fall counts indicate both eider species have experienced population declines, whereas trends for loons have yet to be assessed. The goal of this project is to evaluate long-term and current trends in population estimates of king and common eiders by comparing recently collected data with those from the 1970s, 1990s, and early 2000s. Additionally, the project could evaluate observer error through photographic and radar techniques and obtain estimates of yellow-billed loon populations that can be compared to the previous counts. Such data are essential to assess conservation needs of these species, both now and in the future. This study is a collaboration among the Wildlife Conservation Society, North Slope Borough, and University of Alaska Fairbanks.

Publication

Powell, A., Bentzen, R., and Suydam, R., 2018, Migration trends for king and common eiders and yellow-billed loons past Point Barrow in a rapidly changing environment: Bureau of Ocean Energy Management, OCS Study BOEM 2018–059, 19 p.

King eider. Photograph by the U.S. Geological Survey.

Spawning Potential Ratio Assessment and Sensitivity Analysis Utilizing Estimates of Age at Maturity and Fecundity for Yelloweye Rockfish in Prince William Sound, Alaska

Alaska Cooperative Fish and Wildlife Research Unit

Yelloweye rockfish are a highly valued catch in recreational and commercial fisheries throughout Alaska and make up an important part of the subsistence harvest in communities along the Gulf of Alaska. The recreational harvest of yelloweye rockfish in Prince William Sound has been increasing for over 15 years. However, no management or assessment strategies exist for yelloweye rockfish in Prince William Sound, and to date (2020) no abundance estimates have been made. The goal of this research is to create a framework for harvest that can be applied to the management of yelloweye rockfish in Prince William Sound. Results could be used to inform conservation planning of this species in a unique region where it has economic and cultural importance. This project is a collaboration between the University of Alaska Fairbanks and the Alaska Department of Fish and Game.

Habitat Suitability Criteria for Native Fishes in Intermediate-Sized Arizona Rivers

Arizona Cooperative Fish and Wildlife Research Unit

Many populations of endemic fishes of the arid southwestern United States have declined because of anthropogenic stressors. Identifying the habitat conditions needed by these species is critical for their successful management and doing so across multiple rivers permits better understanding of how different environments are occupied under various circumstances. This research developed stream-specific and generalized criteria for longfin dace, speckled dace, and desert sucker across five streams in central Arizona. Generalized habitat suitability criteria for all three species were significantly transferable except for substrate class. Results on the relations between fish presences and habitat structure could be used to increase the efficiency of monitoring protocols. Partners include the USGS, the USFWS, and the USFS.

Habitat Suitability Criteria for Nonnative Fishes in Intermediate-Sized Arizona Rivers

Arizona Cooperative Fish and Wildlife Research Unit

Nonnative fishes have been stocked into Arizona streams for at least the past century and are currently found in most streams of the State. Commonly, species introduced to Arizona can outcompete or prey on native Arizona stream fishes, and fish communities can become dominated by nonnatives. However, in some areas, nonnatives have not been able to outcompete native fishes, and both occur within the same habitats. This research sampled four streams in Arizona containing a variety of habitats and documented habitat used by nonnative fishes. This information could be used to manage habitat of Arizona's native and nonnative fish communities by predicting where nonnative species might persist and determining how habitat might be managed to reduce their numbers or discourage their establishment. Partners include the USGS, the USFWS, and the USFS.

Habitat Suitability Development for Fishes of the Middle Verde River

Arizona Cooperative Fish and Wildlife Research Unit

Streams of the southwestern United States contain some of the most unique and endangered fish species in the world. Conserving these species requires knowledge of what physical and biological conditions enable them to inhabit particular locations. The goal of this project is to identify specific physical and biological habitat needs of select fish species by examining habitat usage of fishes in the wild and scenic section of the middle Verde River, Arizona. Results could allow for improved habitat management, provide information to aid in protection of instream flows, and contribute to recovery of endangered and sensitive native fish species. Data from this research could be combined with that from a co-occurring project on habitat suitability criteria being conducted across several Arizona rivers and streams in the development of river-specific and generalized habitat suitability criteria. Partners include the USGS and the USFS.

The Role of Riparian Vegetation and Instream Habitat on Fish Communities in Intermediate-Sized Arizona Rivers

Arizona Cooperative Fish and Wildlife Research Unit

Many populations of native fish in the southwest United States are endangered and declining because of multiple anthropogenic stressors. Although habitat has been defined through habitat suitability criteria primarily using stream depth, flow, and substrate, the role of riparian vegetation in habitat suitability remains uncertain and needs to be assessed to implement management practices to conserve fish populations of interest. This research sampled >1,200 sites using pre-positioned electrofishing devices in four streams within central Arizona. The goal was to identify relations among fish presence and riparian and instream habitat variables during the summer low-flow period. Results can be used by agencies to better manage riparian areas in the arid southwest and, subsequently, fish populations that reside within these systems. Partners include the USGS, the USFS, and the USFWS.

Biological Responses of Ozark Stream Communities to Compounded Stressors—The Convergence of Drought, Nutrient Pollution, and Novel Predation

Arkansas Cooperative Fish and Wildlife Research Unit

Drought, nutrient pollution, and apex predation have diverse effects on stream community structure and function. Although research has examined how these stressors shape stream communities individually, little is known about if, and how, these stressors interact to affect stream systems. This project used mesocosm experiments and a mathematical model to explore the compound effects of drought, nutrient pollution, and increased apex predation on a subset of Ozark stream community fauna. Results indicated that each of the individual stressors affected several aspects of stream community structure and functioning and that stressors interacted in additive and antagonistic ways. Results of this study could inform best-management strategies that mitigate effects of multiple stressors on stream communities. Partners include the USGS and the University of Arkansas.

Body Condition Index of Overwintering Instream Mallards in Arkansas

Arkansas Cooperative Fish and Wildlife Research Unit

Many waterfowl species spend the winter in the southern United States before migrating north to breeding grounds in the spring. During the winter, these birds must maintain or gain weight to successfully attain mates, migrate north, and immediately start reproduction. This research combines newly collected data with historical data from the 1970s, 1980s, and 1990s to examine how body mass in mallards varies across time and, subsequently, how environmental variables such as precipitation and temperature affect body mass. The project also could examine how waterfowl management practices are affecting waterfowl body mass and health by assessing the relation between body mass of hunter-collected ducks with management practices on surrounding lands. Data could be used by management agencies to manage food availability for this economically important species. Partners include the USGS and the Arkansas Game and Fish Commission.

Effects of Commercial Harvest on Freshwater Turtle Populations

Arkansas Cooperative Fish and Wildlife Research Unit

Most turtle species are long-lived, mature at advanced ages, and have slow reproduction. These life-history traits make their populations especially vulnerable to even modest levels of adult mortality. Currently, 10 species of aquatic turtles can be legally harvested within Arkansas with no daily or annual bag limits, no size class restrictions, and no specified harvest season. This project is investigating the effects of commercial harvest on turtle populations and demography. A combination of population modeling and field research could be used to quantify the effect of harvest, assess the current population levels of turtles in the Delta, and explore potential management options to ensure the long-term sustainability of freshwater turtles in Arkansas. Partners include the USGS and the Arkansas Fish and Game Commission.

Glade Restoration and Conservation Management of Eastern Collared Lizards in Northern Arkansas

Arkansas Cooperative Fish and Wildlife Research Unit

The eastern collared lizard is a State-protected lizard species that occurs within the Ozark glade ecosystem, a declining habitat type. Eastern collared lizards must maintain high body temperatures to forage and mate. The encroachment of shrubs into glade habitats, however, reduces their suitability by interfering with the thermoregulatory requirements of the lizards. The goal of this study is to assess how lizard populations respond directly to management by using brush removal and prescribed fire to improve glade-habitat quality and connectivity at nine glades within the Ozark Highlands. Objectives include removing cedar from >200 acres of glade habitat and restoring or reintroducing eastern collared lizards to each glade. These actions could directly improve the viability of eastern collared lizard populations in Arkansas. Partners include the USGS, the NPS, the USFS, and the Arkansas Game and Fish Commission.

Eastern collared lizard. Photograph by the U.S. Fish and Wildlife Service.

Nest Ecology of Bluebirds Across Land Cover Types

Arkansas Cooperative Fish and Wildlife Research Unit

The bluebird regularly uses nest boxes across much of the eastern United States. However, it has yet to be explored how this species alters its behavior and ecology depending on the habitat in which it nests. Understanding these patterns of behavior and nest survival can inform management plans for this charismatic songbird and provide valuable information for how a widespread habitat generalist responds to local stressors and pressures. This project examines differences in growth, survival, thermal environment, and nest predators for bluebirds nesting in a variety of landscapes across northwest Arkansas. Results could allow stakeholders to use bluebirds as an indicator of ecosystem health. Partners include the USGS, the University of Arkansas, the Northwest Arkansas Land Trust, and the City of Fayetteville, Arkansas.

Nesting Ecology of Songbirds Along an Urban to Rural Gradient

Arkansas Cooperative Fish and Wildlife Research Unit

Nest predation is the primary cause of nest failure for most bird species and thus plays a crucial role in avian population dynamics. Ornithologists are interested in what choices birds can make when selecting nest sites to reduce predation risk. However, for birds that nest along an urban to rural gradient, the identity of nest predators is likely to change; therefore, birds must alter their nest site selections accordingly. Working with volunteer homeowners, Northwest Arkansas Land Trust, and the City of Fayetteville, Arkansas, this project examines how nest site selection, predator identity, and predation risk varies for six bird species that nest along an urban to rural gradient. Results could inform predator-prey theory and provide practical management applications for managers tasked with recovering birds that nest in human-dominated ecosystems.

Banding Needs Assessment of Banding Data for the Western Gulf Coast Population of Mottled Ducks

Colorado Cooperative Fish and Wildlife Research Unit

The mottled duck is a relatively sedentary hunted waterfowl species dependent on coastal marsh and other habitats along the Gulf coast for its entire life cycle and is therefore subject to development and habitat loss that is occurring there. Various monitoring programs are in place to assess the status of this species and to inform harvest and habitat management decisions. A banding needs assessment is needed to evaluate the experimental banding done since the 1990s; to design an operational banding program that accounts for harvest rates, survival rates, and movements among States; and to integrate with the other monitoring programs for this population. The banding data, along with abundance surveys and harvest surveys, could be integrated in a population model to inform future monitoring and mottled duck management decisions. This project is a collaboration with USFWS Regions 2 and 9, Division of Migratory Birds and Refuges; Texas Parks and Wildlife; and the Louisiana Department of Fisheries and Wildlife.

Breeding Ecology of Cinnamon Teal Within the San Luis Valley, Colorado

Colorado Cooperative Fish and Wildlife Research Unit

The USFWS Service Regulations Committee in 2009 requested an assessment of the harvest potential of three North American teal species, one of which was the cinnamon teal. The assessment, as envisioned by the Service Regulations Committee, included five areas of interest, one of which was a description of the population dynamics of each species. The cinnamon teal is one of the least studied waterfowl species in North America, and reliable, accurate demographic information, including reproductive parameters, is needed to determine population status and responses to harvest and habitat management. Results could provide baseline demographic data for this population of teal and could inform

Mottled duck. Photograph by the U.S. Fish and Wildlife Service.

Male and female cinnamon teal. Photograph by Neil Mishler, U.S. Fish and Wildlife Service.

refuge managers about the effects of conditions created by refuge management and water availability on cinnamon teal. This project is a collaboration with the USFWS Region 6, Migratory Birds, Colorado Parks and Wildlife, and the USFWS Monte Vista National Wildlife Refuge.

Publications

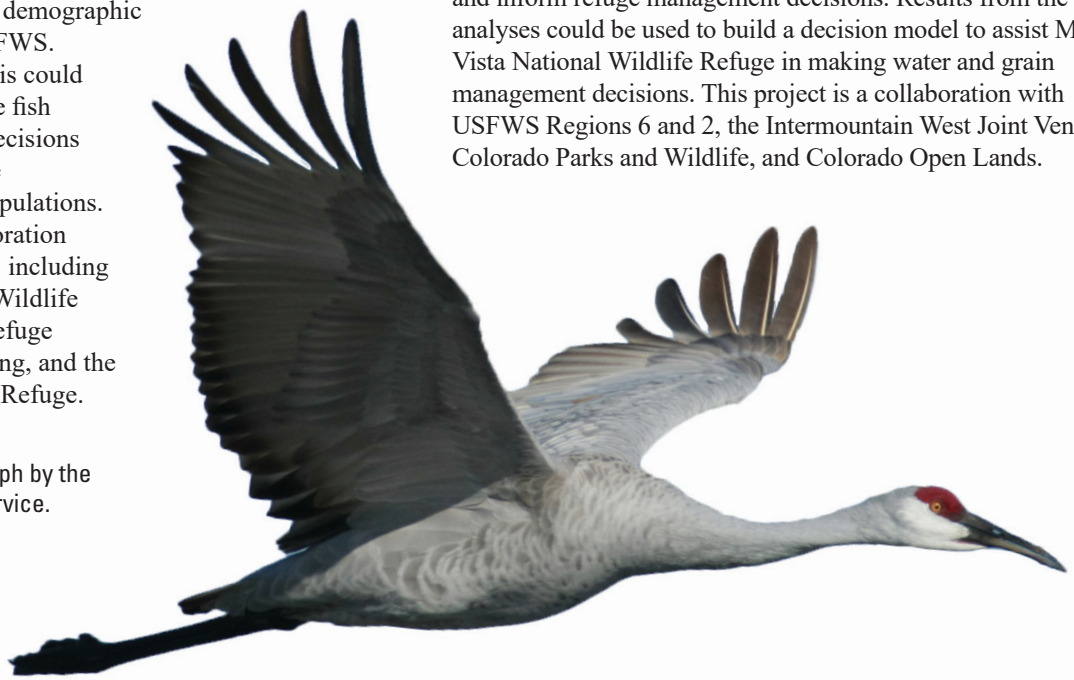
Setash, C.M., Kendall, W.L., and Olson, D., 2020, Factors influencing cinnamon teal nest attendance patterns: Ibis, v. 163, no. 1, p. 125–136, https://doi.org/10.1111/ibi.12838.

Setash, C.M., Kendall, W.L., and Olson, D., 2020, Nest site selection influences cinnamon teal nest survival in Colorado: The Journal of Wildlife Management, v. 84, no. 3, p. 542–552, https://doi.org/10.1002/jwmg.21818.

Estimating Population Size and Demographic Parameters for Rio Grande Sucker and Rio Grande Chub at Baca National Wildlife Refuge

Colorado Cooperative Fish and Wildlife Research Unit

The Baca National Wildlife Refuge is home to one of only two aboriginal populations of Rio Grande sucker and Rio Grande chub in Colorado, the conservation of which is part of their Comprehensive Conservation Plan. These fish have been PIT tagged and redetected by capture and remote antennas for the past few years as part of a program to improve fish passage on the refuge. An evaluation and analysis of these data for population size and vital rates is needed to assess the status of these native fish and their response to passage improvements. Training is also needed to increase capacity for demographic analyses within the USFWS. Results from the analysis could be used to inform future fish passage management decisions and the design of future monitoring for these populations. This project is a collaboration with USFWS Region 6, including the Colorado Fish and Wildlife Conservation Office, Refuge Inventory and Monitoring, and the Baca National Wildlife Refuge.



Sandhill crane. Photograph by the U.S. Fish and Wildlife Service.

Rocky Mountain Elk Recruitment and Habitat

Colorado Cooperative Fish and Wildlife Research Unit

The Rocky Mountain elk is an iconic species that has high recreational value to hunters, photographers, artists, and other wildlife enthusiasts. Although recruitment in elk is naturally variable, during the past 10 years recruitment has declined in some populations within Colorado because of unknown causes. An assessment is needed on the timing of the loss of calves between birth and the following winter, and to identify the causes, including predators, habitat quality, and anthropogenic factors. Results from this study can be used to inform Colorado Parks and Wildlife management decisions for mitigating this decline. This project is a collaboration with Colorado Parks and Wildlife and the Rocky Mountain Elk Foundation.

Spring and Fall Stopover Food Resources and Land-Use Patterns for Rocky Mountain Population Sandhill Cranes in the San Luis Valley, Colorado

Colorado Cooperative Fish and Wildlife Research Unit

The Rocky Mountain population of greater sandhill cranes and a part of the Mid-Continent Population of cranes use the San Luis Valley of Colorado as an important migration stopover area each spring and fall. Declines in water availability for roosts and in important food sources such as barley, could have negative effects on these populations. An assessment of available roost habitat and grain, the use of these habitats by cranes, and the carrying capacity of the San Luis Valley for cranes is needed to determine the future of these populations and inform refuge management decisions. Results from the analyses could be used to build a decision model to assist Monte Vista National Wildlife Refuge in making water and grain management decisions. This project is a collaboration with USFWS Regions 6 and 2, the Intermountain West Joint Venture, Colorado Parks and Wildlife, and Colorado Open Lands.

Temperature and Winter Duration Requirements for Reproductive Success in Johnny Darter in the South Platte River Basin, Colorado

Colorado Cooperative Fish and Wildlife Research Unit

Historically, the South Platte River Basin naturally experienced a wide range of seasonal temperatures. However, urbanization and development of wastewater treatment plants have contributed to warmer and more consistent water temperatures throughout the year, particularly in winter months. Less variation in seasonal temperatures could have adverse effects on native fishes that previously relied on temperature fluctuations for important biological processes, such as reproduction. Assessing the thermal requirements of warmwater fishes can provide valuable information toward establishing protective winter water temperature standards in effluent-dominated streams. This project is being conducted with Colorado Parks and Wildlife, the Colorado Department of Public Health and the Environment, and several municipal wastewater treatment plants.

Field Examination of Wastewater Treatment Effluent Thermal Regimes and Effects on the Reproduction of Johnny Darter

Colorado Cooperative Fish and Wildlife Research Unit

Historically, the South Platte River Basin naturally experienced a wide range of seasonal temperatures. However, urbanization and development of wastewater treatment plants have contributed to warmer and more consistent water temperatures throughout the year that may negatively affect fish reproduction. Collaborating with Colorado Parks and Wildlife, the goal of this project is to assess the thermal requirements of warmwater fishes by placing temperature loggers above and below wastewater treatment facilities along the Front Range to determine potential thermal alterations. The assessment will also include an evaluation of how altered thermal regimes are affecting reproduction of Johnny darter. Results could provide guidance on thermal regimes to conserve transition zone native fishes and hence establish protective winter water temperature standards in effluent-dominated streams.

Productivity of American Oystercatchers Nesting on Spoil Islands at the Cross Florida Greenway State Recreation and Conservation Area

Florida Cooperative Fish and Wildlife Research Unit

American oystercatchers breed at about 50 sites within Florida, but 90 percent of the population is concentrated on the Gulf coast. The Cross Florida Greenway State Recreation and Conservation Area spoil islands along the Gulf coast support the largest concentration of nesting oystercatchers along the Nature Coast Region of the Gulf and the fourth largest concentration in Florida. The goal of this project is to use existing data and collect additional field data to determine causes of mortality and disturbance and to estimate annual productivity and its responses to disturbance, predators, and food supply. Results could be used to develop management actions to increase annual productivity of oystercatchers nesting on spoil islands in the Cross Florida Greenway State Recreation and Conservation Area.

Tracking of Colonial Wading Birds and Habitat Use Assessment

Florida Cooperative Fish and Wildlife Research Unit

Restoring habitats along the Gulf coast for colonial wading birds has been a focus of mitigation actions after the *Deepwater Horizon* oil spill. Such actions require, however, a detailed understanding of habitat use and movement patterns of focal species. The goal of this research is to determine the extent to which declines in colonial nesting wading bird populations result from habitat limitation versus other potential population-limiting factors, and, in turn, which restoration approaches and techniques are most appropriate to effectively target and restore wading bird populations. Results could be used to inform and enhance future restoration planning for key colonial nesting wading bird species along the Gulf coast. Partners include the USFWS and the Alabama Department of Conservation and Natural Resources.

Assessing Actively Poached Beetleweed Populations to Inform Restoration and Law Enforcement

Georgia Cooperative Fish and Wildlife Research Unit

The southern Appalachians are a hotspot of biodiversity, and some local species may be harvested to the point of overexploitation. In recent years, illegal harvest of beetleweed, an herbaceous perennial used in background foliage and floral decorations, has increased to a point that it may be contributing to population declines. There is a growing need to understand the scope of poaching in protected areas and to study the effect of harvest on nontimber forest products. This research could support decisions on beetleweed management within the Blue Ridge Parkway, including law enforcement activity and identifying further research needs to assess the status of beetleweed in the park. This project is a collaboration with the NPS, the Appalachian Highlands Monitoring Network, the University of Georgia, and the USGS.

Environmental Stressors and Priority Plant Communities on Jekyll Island, Georgia

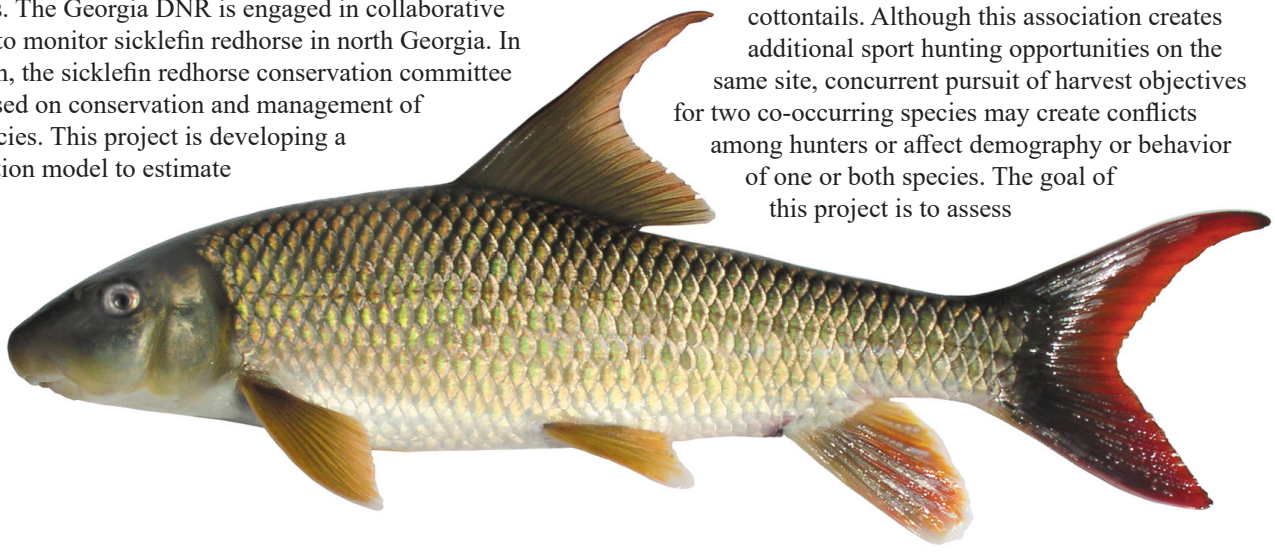
Georgia Cooperative Fish and Wildlife Research Unit

Jekyll Island is a Georgia barrier island that supports developed tourism amenities and a residential community, but it is also a State park that is committed to conserving and managing most of the island's area as natural habitat. Formulating natural area management strategies is a complex challenge because of simultaneous multiple stressors that affect plant communities and the diverse range of ecological and social objectives—from biodiversity conservation and climate resilience to tourism amenities and educational opportunities—that the Jekyll Island Authority's mission seeks to balance. This work will have relevance to the management of other barrier islands faced with similar threats. This work is expected to deliver relevant, novel ecological information on the consequences of ecological stressors on high-priority natural areas, contextualized in terms of management options, to facilitate the Jekyll Island Authority in conservation planning. Collaborators include the USGS, the University of Georgia, and the Jekyll Island Authority.

Estimating Population Size of Sicklefin Redhorse in the Hiwassee River System

Georgia Cooperative Fish and Wildlife Research Unit

Sicklefin redhorse is a native freshwater fish whose range includes the Hiwassee River Basin in North Carolina and Georgia and the Little Tennessee River Basin in North Carolina. The fish is rare within its range and is facing potential threats such as habitat degradation and migratory barriers. The Georgia DNR is engaged in collaborative efforts to monitor sicklefin redhorse in north Georgia. In addition, the sicklefin redhorse conservation committee is focused on conservation and management of the species. This project is developing a population model to estimate important parameters to evaluate the status of the sicklefin redhorse population in Brasstown Creek, Georgia, including survival probability, recruitment, and spawning population abundance. Data can be used to inform monitoring and management decisions.



Sicklefin redhorse. Photograph by Steve Fraley, North Carolina Wildlife Resources Commission.

Forestry Best Management Practices for Sensitive Aquatic Species in the Southeastern United States

Georgia Cooperative Fish and Wildlife Research Unit

In the southeastern United States, forestry is a major land use and an important component to the economy. Generally, forestry best-management practices (BMPs) are implemented at high rates, but information on the degree to which BMPs might support conservation of at-risk aquatic species is lacking. The goal of this research is to clarify which BMPs are of interest to forest managers and aquatic biologists and subsequently determine which BMPs offer conservation benefits to imperiled aquatic species in the region. Results could fill critical information gaps and provide a better understanding of the effectiveness of BMPs for protecting sensitive aquatic species and their habitat. Collaborators include the USGS, the USFWS, land managers, and stakeholders in aquatic conservation.

Effects of Rabbit Hunting on Northern Bobwhite Demographics and Behavior

Georgia Cooperative Fish and Wildlife Research Unit

Management of early successional habitat for northern bobwhites may provide as a byproduct habitat suitable for other early successional species, such as eastern cottontails. Although this association creates additional sport hunting opportunities on the same site, concurrent pursuit of harvest objectives for two co-occurring species may create conflicts among hunters or affect demography or behavior of one or both species. The goal of this project is to assess

strategies that may provide added opportunity (for example, opportunity to hunt two species) for the same management effort and whether such strategies can have deleterious consequences if hunting activities directed at one species disrupts populations of the other species, ultimately leading to decreased satisfaction among hunters of that species. Research results could inform the Georgia DNR on costs—in terms of population performance and hunter satisfaction—for the perceived benefits of coincidental habitat and harvest management for two co-occurring species. This research is conducted in collaboration with Georgia DNR and the University of Georgia.

Improving and Field Testing Novel Methods to Estimate White-Tailed Deer Density Using Camera Traps

Georgia Cooperative Fish and Wildlife Research Unit

Reliable methods for estimating deer abundance and for monitoring temporal trends in density are important components of effective deer management. A cost-effective, camera-based survey method would be useful for assessing the effects of management practices on trends in density and recruitment rates. Customary camera-based survey approaches for estimating population quantities at the degree of accuracy and precision needed for decision making are cost-prohibitive. This research could produce a camera-based survey approach that is cost effective to apply at large scales and is free of the estimation assumptions that encumbered previous approaches. Deer managers for Georgia will be able to make population and habitat management decisions using more robust demographic information. This study is a collaborative effort between the University of Georgia and the Georgia DNR.

Estimating Detection and Occupancy Coefficients for the Pacific Islands Coral Reef Fish Species

Hawai´i Cooperative Fishery Research Unit

Data-limited stock assessment models are used to determine the status of the coral reef fish species in the western Pacific. Estimates of standing stock biomass are based on an expansion of the species biomass density with known hard bottom substrate from 0 to 30 meters deep from underwater visual census surveys. The expansion to generate estimates of standing stock biomass includes implicit assumptions of uniform distribution and perfect detection, which are rarely met. The overall aim of this project is to analyze the National Marine Fisheries Service Coral Reef Ecosystem Program Reef Fish Dataset to estimate detection and occupancy coefficients for species listed in the Western Pacific Regional Fishery Management Council's Fishery Ecosystem Plans. Results could be used to refine the standing stock biomass estimates used in stock assessments throughout the region.

A Comprehensive Framework for Monitoring and Adaptively Managing Deer Harvest in North Dakota

Idaho Cooperative Fish and Wildlife Research Unit

Mule deer and white-tailed deer are popular game animals that provide outdoor recreation and organic venison for many families. State agencies are tasked with managing populations to ensure that the annual harvest is sustainable. This project is developing a removal model that incorporates observations of deer hunter harvest and effort data into a capture-recapture modeling framework to estimate deer abundance in North Dakota. The results could help collaborators set optimal and responsible harvest regulations. The project is a collaboration between the USGS and the North Dakota Game and Fish Department.

Assessing the Importance of Wetlands on Department of Defense Installations for the Persistence of Wetland-Dependent Birds

Idaho Cooperative Fish and Wildlife Research Unit

DoD lands offer many opportunities for conservation and management of wildlife species throughout the Nation. The goal of this project is to develop detailed habitat models for rare and endangered wetland birds and subsequently use the models to rank the importance of over 600 DoD installations to wetland birds. Models can be verified by conducting surveys for wetland birds on a random subset of DoD installations, and surveys also can provide estimates of abundance for these rare species. This project could contribute to a large partnership of agencies and organizations in North America that are conducting marsh bird surveys following a standardized protocol. The project could produce a first-of-its-kind inventory of the biological value of wetlands on DoD lands, detailed habitat models for each species, and baseline survey data of secretive marsh birds at a large subset of DoD installations.

Biotic and Abiotic Factors Affecting Population Dynamics of Yellowstone Cutthroat Trout and Utah Chubs in Henrys Lake, Idaho

Idaho Cooperative Fish and Wildlife Research Unit

Henrys Lake is a shallow lake in southeast Idaho that has long supported a renowned trophy salmonid fishery for Yellowstone cutthroat trout. Although the fishery remains popular, a number of concerning trends have been observed in the Yellowstone cutthroat trout population (for example, reduced body condition and growth). The USGS is working with the Idaho Department of Fish and Game to identify abiotic (for example, water temperature) and biotic (for

example, invasive Utah chub) factors related to Yellowstone cutthroat trout population structure and dynamics. Results of this research can be used to identify options and actions associated with management of Yellowstone cutthroat trout and Utah chub in the system.

Catch-and-Release Mortality in Idaho Steelhead Fisheries

Idaho Cooperative Fish and Wildlife Research Unit

Steelhead is one of the most ecologically and economically important species in the Pacific Northwest, particularly in Idaho. Because hatchery fish use the same waters as wild fish, which are protected under the ESA, Idaho's fisheries are permitted and managed such that impact rates on wild steelhead populations are not exceeded. The USGS is partnering with the Idaho Department of Fish and Game to estimate the rate that wild fish are encountered in the fishery and the catch-and-release mortality of steelhead. Results of this research can be used to refine estimation techniques and provide managers with critical information for managing wild and hatchery steelhead in the region.

Determining the Vulnerability of Wolves to Harvest

Idaho Cooperative Fish and Wildlife Research Unit

Much of the available science regarding how hunting affects gray wolf populations is from the core of the wolf's range in Canada and Alaska, where populations are contiguous and robust and wolves are quite numerous. Less is known about how hunting and trapping might affect wolves in smaller populations such as those found in the Rocky Mountains. Insights into how human-caused mortality affects wolf pack structure and long-term demography are critical to understanding the potential effects of humans on gray wolves and their population management. This project is a collaboration among the USGS, the University of Idaho, the University of Montana, and the Idaho Department of Fish and Game.

Evaluation of Natural and Hatchery-Produced Kokanee in Flaming Gorge Reservoir

Idaho Cooperative Fish and Wildlife Research Unit

Kokanee is one of the most important recreational species in western North America, and it is also an important prey species for other species of recreational or conservation importance. Flaming Gorge Reservoir, Wyoming-Utah, receives a substantial part of Wyoming's hatchery production of kokanee. The USGS is working with the Wyoming Game and Fish Department and the Utah Division of Wildlife Resources to better understand the role of hatchery kokanee in the system. Results of this research can provide managers with information that can be used to efficiently allocate hatchery resources and provide insight on factors related to the survival, growth, and ultimate recruitment of hatchery and wild kokanee to the population in Flaming Gorge Reservoir.

Evaluation of White Sturgeon Monitoring Practices

Idaho Cooperative Fish and Wildlife Research Unit

White sturgeon is an important species in the Sacramento-San Joaquin River Basin. Unfortunately, little is known about their population ecology and whether current monitoring metrics are adequate for evaluating management and conservation success. The USGS is working with the USFWS to evaluate white sturgeon populations in the basin. Results of this research could examine whether current conservation targets are reasonable and whether monitoring efforts are providing data that are adequate for tracking changes in the population dynamics of white sturgeon.

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

Idaho Cooperative Fish and Wildlife Research Unit

Monitoring of forage availability, use, and residual biomass is the primary basis for making livestock management decisions in grazing land systems. New technologies can improve field measures and provide new perspectives on grazing effects at landscape scales. This research is assessing grazing effects at ranch scales and integrating plot-based field use measurements with livestock GPS collar data and remotely sensed measures of grazing intensity. The resulting estimates of grazing intensity across pastures could improve understanding of livestock effects on greater sage-grouse populations and could be integrated into the RangeSat online tool to analyze and visualize forage availability and grazing intensity. The project is a collaboration among the USGS, the University of Idaho, the NRCS, The Nature Conservancy, and ranchers.

Kokanee Population Dynamics, Mysid-Kokanee Interactions, and Sampling Techniques in Idaho Lakes

Idaho Cooperative Fish and Wildlife Research Unit

Despite considerable research during the past 60 years, numerous questions remain regarding appropriate management of kokanee in Idaho. Numerous hypotheses have been posited as causing kokanee declines in Idaho including water development, the introduction of opossum shrimp, predation, and exploitation. To supplement or maintain kokanee populations, the Idaho Department of Fish and Game has instituted large-scale hatchery supplementation of the species. Underlying research questions associated with understanding the management of kokanee in Idaho is the need to address uncertainty surrounding common sampling techniques (for

example, midwater trawls and hydroacoustics). The goals of this research are to evaluate the biases of midwater trawling, to investigate interspecific competition between mysids and kokanee, and to evaluate the performance of kokanee breeding groups (early run or late run) in Idaho. Results could inform hatchery supplementation plans in Idaho by improving understanding of the ecology of kokanee and the comparative success of different breeding groups (for example, early run or late run).

Monitoring Black Bear Populations

Idaho Cooperative Fish and Wildlife Research Unit

Black bears occur in a variety of habitats throughout Idaho, are a popular game species, and potentially are a major predator of ungulate neonates. To improve inference regarding population health and growth, the goal of this study is to establish a link between recruitment and habitat productivity for black bears in Idaho. Individual tracking and remote cameras can be used to estimate recruitment and density and to model habitat use. Results could provide managers with a cost-effective, replicable way to estimate bear population size and inform management decisions. This project is a collaboration between the USGS and the Idaho Department of Fish and Game.

Production of Wild Bonneville Cutthroat Trout in Bear Lake—Evaluating a Harvest Fishery

Idaho Cooperative Fish and Wildlife Research Unit

Bear Lake is an oligotrophic, dimictic lake in southeast Idaho and northeast Utah. The system supports popular fisheries for Bonneville cutthroat trout. The USGS is working with the Idaho Department of Fish and Game and the Utah Division of Wildlife Resources to better understand how the Bonneville cutthroat trout population is functioning in the system. Results of this work can provide insight on movement dynamics and habitat associations of Bonneville cutthroat trout in tributary streams. Population models also could be developed that could be used to evaluate different management options for the Bonneville cutthroat trout fishery in Bear Lake.

Trophic Ecology of Walleye in Lake Pend Oreille

Idaho Cooperative Fish and Wildlife Research Unit

Walleye are among the most popular sport fishes in North America. However, they are a concern in areas where they are nonnative and have been introduced. Walleye have been introduced to Lake Pend Oreille, Idaho, and are likely a threat to species of recreational and conservation importance. The USGS is working closely with the Idaho Department of Fish and Game to better understand the potential effect of walleye on fishes in the system. Results of this work can provide a comprehensive understanding of the population dynamics of walleye and their food habits in Lake Pend Oreille. This information could be used to develop population models and bioenergetics models that, in turn, can be used to evaluate different management actions.

An Index of Oxbow Restoration Quality for Topeka Shiners Based on the Fish Assemblage

Iowa Cooperative Fish and Wildlife Research Unit

Restored oxbows are important habitats for the endangered Topeka shiner, but because of their rarity, the "signal" associated with the presence of Topeka shiners in restored oxbows is weak. Although the value of restored oxbows is increasingly recognized and the pace of oxbow restoration programs is accelerating, difficulty in accurately assessing restoration effectiveness poses a substantial roadblock for evaluating restoration methods. The purpose of this study is to develop an index of oxbow restoration quality for the conservation of endangered Topeka shiners based on characteristics of the fish assemblage. The index could enable evaluation of oxbow restorations when direct methods, such as documenting presence or increased abundance of Topeka shiners, are not possible.

Topeka shiner individual included in a USGS experimental study, fall 2020. Photograph by U.S. Geological Survey.

Boone River Watershed Stream Fish and Habitat Monitoring in Iowa

Iowa Cooperative Fish and Wildlife Research Unit

Fish assemblages and habitat conditions in two streams in the Boone River watershed, White Fox Creek and Eagle Creek, could be monitored to evaluate their potential as Topeka shiner population sources and conduits for associated oxbow habitats. Eagle Creek and associated natural oxbows support the only known remnants of the Topeka shiner distribution in the Boone River watershed. Topeka shiners are presumed extirpated from the White Fox Creek subwatershed, but five oxbows have been restored there for Topeka shiners. The success of

restored oxbows for Topeka shiners depends on the existence of populations in associated streams with suitable habitat. The monitoring and assessment results from this research could help guide present and future oxbow restorations and inform potential future Topeka shiner reintroduction to the Boone River watershed.

Developing Capture Techniques and Monitoring the Movement of Sandhill Cranes Breeding in Iowa

Iowa Cooperative Fish and Wildlife Research Unit

Sandhill cranes were extirpated from Iowa in the late 19th century because of habitat loss and overharvest. Nearly 100 years passed before sandhill cranes began recolonizing Iowa; the first breeding effort since 1894 was documented in 1992. Information regarding the population, such as trends, dynamics, and affiliations, consist of anecdotal reports or are entirely unknown. The USGS is working with the Iowa DNR to gather data that can greatly improve the understanding of how sandhill cranes use the modern-day (2020) Iowa landscape, define suitable habitat for cranes, and provide evidence on the migration routes and wintering grounds of Iowa's breeding cranes.

Ecology of Canada Geese in an Urban Area of Iowa

Iowa Cooperative Fish and Wildlife Research Unit

Iowa's Canada goose population has gone from near zero to spring population estimates that occasionally exceed 100,000. This project partners with the Iowa DNR to ascertain movements of urban geese to determine their susceptibility to hunting and to estimate annual harvest and survival rates of Canada geese captured in urban areas. Results could be used to ensure that monitoring and management keep pace with the changes in population.

Monitoring Protocol for Otter and Bobcat in Iowa

Iowa Cooperative Fish and Wildlife Research Unit

Two native species, the bobcat and the North American river otter, have returned to Iowa and reestablished their roles as predators and furbearers. Harvest information, tooth age, and reproductive tract data have been gathered annually by the Iowa DNR since 2006, but this information has not been used to its full extent. The goal of this project is to create an efficient modeling framework for monitoring Iowa otter and bobcat populations using the Iowa DNR's existing data sources and augmenting it with additional auxiliary information. Results could allow managers to evaluate the role and effectiveness of the annual bow hunter survey in monitoring these species because bobcats are better represented on this survey than otters.

Assessment of Temperate-Breeding Canada Goose Management in Kansas

Kansas Cooperative Fish and Wildlife Research Unit

Resident Canada geese are a wildlife management success story but are exceeding societal thresholds of tolerance in many areas. Management strategies are needed to address this conflict. The goals of this research are to assess translocation as a management strategy for overabundant geese and to seek to resolve conflicts with resident Canada geese by obtaining accurate counts and determining the effect of various management strategies. Results could be used to improve the precision of population estimates and, hence, management plans. This research is a collaborative effort between the USGS and the Kansas Department of Wildlife, Parks and Tourism.

Dispersal, Reproductive Success, and Habitat Use by Translocated Lesser Prairie-Chickens

Kansas Cooperative Fish and Wildlife Research Unit

Lesser prairie-chickens are a species of conservation concern because of declining populations and occupied range. Managers are developing strategies, including translocation, to restore populations. Assessing habitat quantity and quality at release locations is necessary to determine the success of the strategy. Results indicate that initial release sites may provide little quality habitat for translocated birds. Thus, long-distance movements by translocated birds requires an assessment of the potential for a much larger area to support lesser prairie-chickens than previously thought. This research is a collaborative effort among the USGS; the USFS; the Kansas Department of Wildlife, Parks and Tourism; and Colorado Parks and Wildlife.

Publication

Berigan, L.A., 2019, Dispersal, reproductive success, and habitat use by translocated lesser prairie-chickens: Manhattan, Kans., Kansas State University, Master's thesis, 61 p., http://hdl.handle.net/2097/40279.

Fawn Survival and Bed-Site Selection of Mule and White-Tailed Deer in Western Kansas

Kansas Cooperative Fish and Wildlife Research Unit

Mule deer are declining throughout their range, including western Kansas. The expansion of white-tailed deer may be affecting population demography and space use by mule deer. Fawn survival is a driving force in population trends of deer; therefore, determining factors that affect fawn survival could provide insight on population trends of white-tailed and mule deer in western Kansas. Results could be used to inform management actions for mule deer by providing insights into differential fawn survival in mule and white-tailed deer and by assessing the effect of coyote predation on fawn mortality. This project is a collaboration of the USGS, the Wildlife and Enterprise Management Department at Kansas State University; the Kansas Department of Wildlife, Parks and Tourism; the Kansas Bowhunters Association; and the Mule Deer Foundation.

Publication

Kern, M.J., 2019, Fawn survival, cause-specific mortality, and bed-site selection of white-tailed deer and mule deer in western Kansas: Manhattan, Kans., Kansas State University, Master's thesis, 101 p., http://hdl.handle.net/2097/40277.

Ring-Necked Pheasant Survival, Nest Habitat Use, and Predator Occupancy in Kansas Spring Cover Crops

Kansas Cooperative Fish and Wildlife Research Unit

Ring-necked pheasant populations are declining across the midwestern United States, and pheasant hunting contributes to the economy in many of these areas. Developing alternative management strategies is important for management of pheasants. Use of spring cover crops can potentially benefit pheasants and producers. Use of spring cover crops by pheasants is related to distance from Conservation Reserve Program tracts. Therefore, strategic placement of spring cover crops is necessary to maximize use by pheasants. This research is a collaborative effort between the USGS and the Kansas Department of Wildlife, Parks and Tourism.

Publication

Annis, A.C., 2019, Ring-necked pheasant survival, nest habitat use, and predator occupancy in Kansas spring cover crops: Manhattan, Kans., Kansas State University, Master's thesis, 129 p., http://hdl.handle.net/2097/39372.

Survival, Movement, and Resource Selection of Male Mule Deer and White-Tailed Deer in Western Kansas

Kansas Cooperative Fish and Wildlife Research Unit

Mule deer have been decreasing in abundance and occupied range in Kansas for the past three decades. Increasing numbers and expanding white-tailed deer may be contributing to trends in mule deer population. Mule deer are highly prized game animals that generate considerable revenue for the Kansas Department of Wildlife, Parks and Tourism and private landowners. Understanding how the presence of male white-tailed deer affect space use and movements by male mule deer can inform landscape-scale management strategies. Relating the effect of harvest on male deer survival could contribute to developing harvest strategies. The project is a collaboration among the USGS; the Wildlife Enterprise and Outdoor Management Program at Kansas State University; the Kansas Department of Wildlife, Parks and Tourism; the Kansas Bowhunters Association; and the Mule Deer Foundation.

Determining Optimal Elevation for Restoration of an Island Used by Rare Colonial Nesting Waterbirds

Louisiana Cooperative Fish and Wildlife Research Unit

Several rare species of colonial nesting waterbirds nest at Rabbit Island, Louisiana. However, the island floods frequently and causes nest failure. Restoring the island is being considered, and therefore data are needed on the optimal target elevation for restoration that minimizes flood risk and occupancy of the islands by mammalian predators. Data could be used to minimize costs of island restoration and maximize benefits by optimizing island height to limit nest failure because of flooding and mammalian predation. Cooperators include the USGS and the Louisiana Department of Wildlife and Fisheries.

Changes in Patterns of Estuarine Use by Diadromous Fishes Such as American Shad

Maine Cooperative Fish and Wildlife Research Unit

Since the early 20th century, passage of American shad past Veazie Dam in the Penobscot River was biologically trivial and spawning habitat for the population was restricted to the tidal estuary. Two dam removals (Veazie and Great Works) and upstream fish passage modifications at other dams are anticipated to reconnect American shad to most of their historical freshwater habitat upstream from Milford Dam.

To assess how this change in access may affect estuarine use, researchers sampled adult and juvenile shad from 2013 to 2017. Otoliths were taken from all fish for age analysis, and scales were taken from adults to assess spawning history. Adults were dominated by older age classes (4–8 years) with a high incidence of repeat spawning. Otolith microchemistry (strontium and barium) suggests that many juveniles were reared in elevated salinities, often moving into freshwater before fall migration. The general pattern of salinity use by juveniles has remained qualitatively unchanged the first few years after dam removal, likely reflective of low upstream recruitment. Continued monitoring could assess whether the lack of an immediate response is indicative of a time lag in the population response or a lack of spawning or rearing potential of the upstream habitat.

Changing Fish Communities in the Penobscot River After Dam Removal

Maine Cooperative Fish and Wildlife Research Unit

Dam removals re-establish natural flow regimes and increase connectivity, profoundly affecting fish assemblages throughout a watershed. In Maine, the Penobscot River Restoration Project removed the two lowermost dams on the river and improved fish passage at other dams to help recover declining sea-run fishes and increase resilience of entire ecosystems. To quantify spatial and temporal changes associated with river rehabilitation efforts, fish assemblages are being assessed using boat electrofishing surveys (3 years each, spring and autumn) before dam removal, shortly after removal, and 6 years after removal (in progress as of 2020). Together with NOAA and The Nature Conservancy, researchers have described distinct fish assemblages present before the dam and followed how these communities have changed to more riverine assemblages. These changes, and their timeline, are important for understanding the management outcomes of dam removal.

Development of Predictive Models for Identifying Priority Atlantic and Gulf of Mexico Coastal North America Migratory Stopover Areas Used by Monarch Butterflies

Maine Cooperative Fish and Wildlife Research Unit

The annual migration of monarch butterflies to breeding areas that span from southern Canada across the United States and back to overwintering habitat in central Mexico was designated as a threatened phenomenon by the International Union for Conservation of Nature in 1983 in recognition of the importance of coordinated habitat conservation across North America. Although the need for monarch butterfly conservation action has been recognized through development of cooperative agreements among Canada, the United States, and Mexico to conserve and restore habitat in these recently documented migratory pathways, threats to the species' persistence continue. The goals of this research are to develop spatially explicit predictions of monarch butterfly coastal stopover habitat based on identification of important environmental characteristics (including habitat and climate variables) and to use these stopover habitat predictions to inform conservation or restoration of these areas for migrating monarchs and other pollinators. Study results could be distributed in a variety of formats appropriate for use by land managers as well as citizen groups (including information sheets, maps, and an interactive mapping tool) and could provide information about land management actions for conservation and enhancement of nectaring and roosting habitat for migrating monarch butterflies and insect pollinator populations. This project is a collaboration of the USGS, the Maine Department of Inland Fisheries and Wildlife, the University of Maine, and Tennessee State University.

Monarch butterfly. Photograph by Emily Weiser, U.S. Geological Survey.

Early Life-History Metabolism in Atlantic Salmon

Maine Cooperative Fish and Wildlife Research Unit

The energetic costs of migrating Atlantic salmon are high, and high energy demands likely affect gonadal development (egg size), spawning performance, and probability of surviving to spawn again. Because the size of an egg can be a good predictor of survival probability, how egg size relates to embryo physiology is of interest for conservation and aquaculture. Working with partners at the University of Maine, researchers are developing techniques to quantify energy expenditure during embryonic development. Moving forward, the respirometer trials will be expanded to include temperature acclimation treatments of embryos in conjunction with later-life metabolic patterns. This information could help to better understand the combined roles of dams and climate change in the restoration of Atlantic salmon.

Laying the Groundwork for Science-Based Management of Colonial Waterbirds

Maine Cooperative Fish and Wildlife Research Unit

Colonial nesting seabirds and long-legged wading birds (inclusively waterbirds) of the eastern United States span geographic boundaries and jurisdictions of conservation agencies in 19 States, as well as adjacent provinces in maritime Canada. Despite many management concerns for colonial nesting waterbirds, broad, coordinated annual surveys similar to those for waterfowl, American woodcock, and sandhill crane are not conducted, and colonial seabirds were singled out explicitly as poorly sampled by the creators of the Breeding Bird Survey. The goals of this project are to increase knowledge on the current limitations in survey and monitoring, to determine associated data storage needs for colonial waterbirds in the Atlantic and Gulf coasts, and to better understand distributions, population trends, and threats to these species in this area. In addition, the project aims to resurrect and improve the Colonial Waterbirds Database for improving data archiving and accessibility for informing species conservation and management across the area. The researchers can evaluate contents of the USGS-managed Colonial Waterbirds Database and update it with data collected within the eastern United States because the database became inactive, display species trends for select focal species graphically within the revised Colonial Waterbirds Database user interface, and evaluate trends and conservation goals of the species with a sufficient data archive. This project is a collaboration of the USGS, the USFWS, and the University of Maine.

Phenology and Survival of Migrating American Eel

Maine Cooperative Fish and Wildlife Research Unit

Historically, the American eel was the target species of a lucrative fishery, but this fishery has collapsed over the past few decades and eels are in decline worldwide. Because eels play an integral role in maintaining biotic integrity in fish communities, eel conservation has become a high priority of fishery managers and conservationists in many freshwater ecosystems. One well documented source of mortality for eels is passage through hydroelectric facilities encountered during downstream migration where high losses of sexually mature adults can result in a substantial, negative effect on eel population dynamics. Decreasing mortality at dams is therefore an important conservation goal. Management options such as shutting down turbines during migration might satisfy conservation goals but potentially come at an unacceptable operational cost. Fortunately, eels migrate during a relatively short period in the fall associated with episodes of high precipitation and high flow events. Further, eels tend to migrate at night and during specific lunar phases. Consequently, the goal is to develop a comprehensive model predicting the timing and magnitude of eel migration to identify discrete periods of peak migration that would minimize mortality and maximize passage while being short enough in duration to be appealing and cost effective to hydropower operators.

Comparative Ecology and Conservation of Bears in North and South America

Massachusetts Cooperative Fish and Wildlife Research Unit

The spectacled bear and American black bear are considered to be representative landscape species, meaning that large-scale conservation benefits can result from conservation efforts for these species and the areas they inhabit. However, the general lack of information about spectacled bears, particularly their distribution in Peru, makes it difficult to develop conservation plans. This research aims to create a spectacled bear distribution model and verify the species' presence in areas without current records to obtain reliable distribution predictability. In contrast, distribution, ecology, and management strategies for the American black bear are well known and can serve to inform the same topics for the somewhat similar spectacled bear, for which relatively little is known. Results could contribute to the national plan for the conservation of spectacled bears being implemented by the Peruvian Forest and Wildlife Service (Servicio Nacional Forestal y de Fauna Silvestre), and allow a comparative study between these two bear species.

Estimating Black Bear Density, Abundance, and Source-Sink Dynamics in Massachusetts

Massachusetts Cooperative Fish and Wildlife Research Unit

In the 1970s, black bears existed as a small and isolated population in the Berkshire Mountains of Massachusetts. Since then, the black bear population has increased and expanded eastward across the State. However, current black bear density and population estimates in different parts of the State are lacking. This information is required for informed and successful management of this important game species across the State. A capture-recapture survey for black bears using hair snares and molecular techniques can be used to estimate density and abundance and understand how density and abundance changes with different land-cover types and levels of human influence. This project could also identify black bear population sources and sinks to determine areas of population growth and decline. Results from this research could provide information on black bear population dynamics and estimate the population size of bears across the State. This information could be used in developing a comprehensive management plan for black bears in Massachusetts. The Massachusetts Division of Fisheries and Wildlife, Amherst College, and the Massachusetts Department of Conservation and Recreation are project collaborators.

Effects of Winter Lake Drawdowns on Downstream Flows and Stream Ecosystems

Massachusetts Cooperative Fish and Wildlife Research Unit

Water-level management in lakes and reservoirs not only affects those ecosystems but also affects the downstream ecosystems. Winter drawdowns result in higher streamflow in fall during drawdown and lower streamflow in spring during refill relative to lakes not managed for drawdown; however, the effects of this management strategy on downstream ecosystems are unknown. Quantifying the hydrologic alterations and the associated effects to habitat and biota are critical for developing comprehensive water-level management strategies that benefit in-lake and downstream ecosystems. Consequently, results from this study could be used to set recommendations for lake water-level management that meets in-lake human needs while minimizing effects to downstream ecosystems. This project is a collaboration among the USGS, the Massachusetts Division of Fisheries and Wildlife, and the Massachusetts Division of Ecological Restoration.

Investigating Effects of Winter Lake Drawdowns on Littoral Ecosystems

Massachusetts Cooperative Fish and Wildlife Research Unit

Anthropogenic alteration of water levels in lakes is a major stressor to the ecological integrity of littoral zones, which provide critical heterogenous resources that support diverse biological communities. Annual winter drawdowns have been used in Massachusetts for several decades as a macrophyte control technique, among other purposes; however, few studies have estimated effects to littoral zone habitat and biological communities, particularly at relatively mild magnitudes. The goals of this collaborative project with the Massachusetts Division of Fisheries and Wildlife are to characterize winter drawdown hydrological regimes and to estimate responses of physical habitat (macrophytes, sediment texture, and coarse wood), macroinvertebrate assemblages, and mussel assemblages to variable levels of drawdown magnitude. Results are critical for understanding the scope of drawdowns in Massachusetts and could more broadly assist agencies in evaluating lake management techniques and determining management options that minimize losses to lake ecosystem integrity.

Modeling Black Bear Habitat Use, Movement, and Connectivity in Massachusetts

Massachusetts Cooperative Fish and Wildlife Research Unit

The black bear population in Massachusetts has been increasing and expanding into human-dominated areas because of conservative management and increasing availability of human food resources. Quantifying seasonal black bear habitat use and movement in relation to land cover in natural and human-dominated areas is necessary for understanding black bear behavior and creating effective black bear management programs. This research intends to use GPS telemetry collared bears to derive estimates of connectivity, identify important movement corridors, direct wildlife-road mitigation efforts, and predict black bear movements into currently (2020) unoccupied areas of the State. The results could be used to inform management of bears and bear habitat in natural and human-dominated areas of the State. Collaborators on the project include the Massachusetts Division of Fisheries and Wildlife, the Massachusetts Department of Transportation, and the Massachusetts Department of Conservation and Recreation.

Regeneration of Forest Vegetation in Response to Browsing by Moose and Deer—An Experimental Approach Using Exclosures

Massachusetts Cooperative Fish and Wildlife Research Unit

Over the past 200 years as southern New England has become increasingly populated, human distribution, land cover, and wildlife habitats have become more diverse. Development, suburban fragmentation, and landscape degradation concurrent with an increase in the moose population in southern New England in recent decades has led to interest and concern about the interaction between forest management and moose. During the first phase of this research, it was discovered that in logged forests, moose and deer used the cuts at roughly the same frequency despite moose densities being much lower than deer densities. Browsing resulted in greater herbaceous species richness and greater woody species richness than ungulate exclusion and deer alone. These results illustrate the complex interactions that two native browsers can have on forest ecological dynamics and timber management. This ongoing, long-term study is continuing through various stages of forest development and the information could be used by conservation and management agencies to further understand wildlife-forest habitat relations and the role they play in forest ecology, animal community dynamics, watershed management, and production of timber and other forest products. The Massachusetts Department of Conservation and Recreation, the Massachusetts Division of Fisheries and Wildlife, Harvard University, the Highstead Foundation, and the USFS collaborated on this research.

The Ecological Value of Spruce Plantations in Massachusetts

Massachusetts Cooperative Fish and Wildlife Research Unit

The planting of exotic Norway spruce plantations to supplement native forest stock has been common practice

throughout the northeastern United States over the past century. These plantations, however, were frequently created without much consideration to the effect they would impose on local wildlife diversity. Recent shifts in conservation priorities toward increasing biodiversity have raised new questions on whether habitat provided by exotic plantations can support an adequate level of biodiversity. This study aims to examine the comparative ecological value of spruce plantations to surrounding native forest stands in Massachusetts using birds as indicators of biodiversity. In addition to using avian occupancy and abundance, researchers plan to weight relative species values by incorporating Partners in Flight Conservation scores to provide a more objective estimate of overall ecological importance. This research could better inform land managers and conservationists on how Norway spruce plantations are contributing to conservation goals in Massachusetts. This project is being conducted in partnership among the USGS, the USFS, the University of Massachusetts Amherst, and the Massachusetts Department of Conservation and Recreation.

Using Genomics to Understand Population Dynamics and Enhance the Management of Canada Lynx Populations in the Contiguous United States

Massachusetts Cooperative Fish and Wildlife Research Unit

Management of Canada lynx populations occurring at the edge of the species' range has been informed by limited regional studies focused mostly on demographics and ecology. Tools are needed to provide baseline metrics of population health and an understanding of landscape dynamics to inform regional and range-wide management and monitoring strategies. Next-generation sequencing produces a high density of genetic markers (for example, single nucleotide polymorphisms, structural variants, and mutations) that enhance the precision and reliability of population demographic parameter estimates relevant to conservation practitioners. In 2018, this research produced the first-ever reference genome for the Canada lynx, which can serve as a publicly available community resource and a powerful tool for population-level assessments. Ultimately, this work could provide baseline metrics for managing Canada lynx populations in the lower 48 States and management recommendations that conserve or enhance population fitness and resiliency. This project is a multidisciplinary collaboration including the USGS, the University of Massachusetts Amherst, the Vertebrate Genomes Laboratory at Rockefeller University, the State of Maine Department of Inland Fisheries and Wildlife, and the Smithsonian Institution.

Evaluating Nest-Site Selection of Arctic Peregrine Falcons in the Colville River Special Area

Minnesota Cooperative Fish and Wildlife Research Unit

One-fourth of Alaska's Arctic peregrine falcons, a formerly federally threatened species, nest along the Colville River on Alaska's North Slope. Since their recovery and removal from the endangered species list, the Colville River Arctic peregrine population has increased substantially, although there is considerable variation in reproductive success and reproduction. Researchers used historical survey data and models related to productivity to assess where this population would be most and least susceptible to perturbation. Results of this study could be used to refine management strategies for Colville River Arctic peregrines that minimize potential population effects from anthropogenic factors. Collaborators included the BLM and the USFWS.

Peregrine falcon. Photograph by the U.S. Fish and Wildlife Service.

Publication

Bruggeman, J.E., Swem, T., Andersen, D.E., Kennedy, P.L., and Nigro, D., 2018, Incorporating productivity as a measure of fitness into models of breeding area quality of Arctic peregrine falcons: Wildlife Biology, article 475, 12 p., https://doi.org/10.2981/wlb.00475.

Insecticide Exposure Risk for Grassland Wildlife on Public Lands

Minnesota Cooperative Fish and Wildlife Research Unit

Routine application of insecticides in agricultural landscapes has the potential to expose grassland wildlife on public lands to chemicals that could negatively affect survival and reproduction. In particular, application of insecticides to control soybean aphids is thought to potentially affect grassland birds directly and indirectly. Researchers evaluated this risk on Minnesota DNR property in southwestern Minnesota that is managed for wildlife by assessing potential direct and indirect (through food resources) exposure of grassland birds to operational insecticide application and by measuring chemical deposition. Results of this research could help managers better design and manage public grasslands embedded in agricultural landscapes for wildlife. Partners included the Minnesota DNR with support from the State of Minnesota Environmental and the Natural Resources Trust Fund.

Minnesota Trumpeter Swan Migration Ecology and Conservation

Minnesota Cooperative Fish and Wildlife Research Unit

The Interior population of trumpeter swans was re-established through reintroduction efforts beginning in the late 1960s. Since that time, the population has exceeded reintroduction goals and now totals more than 25,000 individuals with an estimated growth rate in Minnesota of circa 1.20 (in other words, a doubling time of about 5 years). As this population moves from rare to abundant across much of the Upper Midwest, a lack of information regarding basic ecology hinders planning for long-term management. This project plans to mark Interior population trumpeter swans. Additionally, the research could evaluate the current genetic structure of this population and assess environmental exposure to lead. Information resulting from this study could help guide future trumpeter swan management across the western Great Lakes region. Partners include the USGS, the USFWS, the University of Minnesota, the Canadian Wildlife Service, Manitoba Conservation, the Minnesota DNR, the Wisconsin DNR, the Michigan DNR, the Iowa DNR, the Great Lakes Indian Fish and Wildlife Commission, and the Trumpeter Swan Society.

Red-Headed Woodpecker—Indicators of Oak Savanna Health

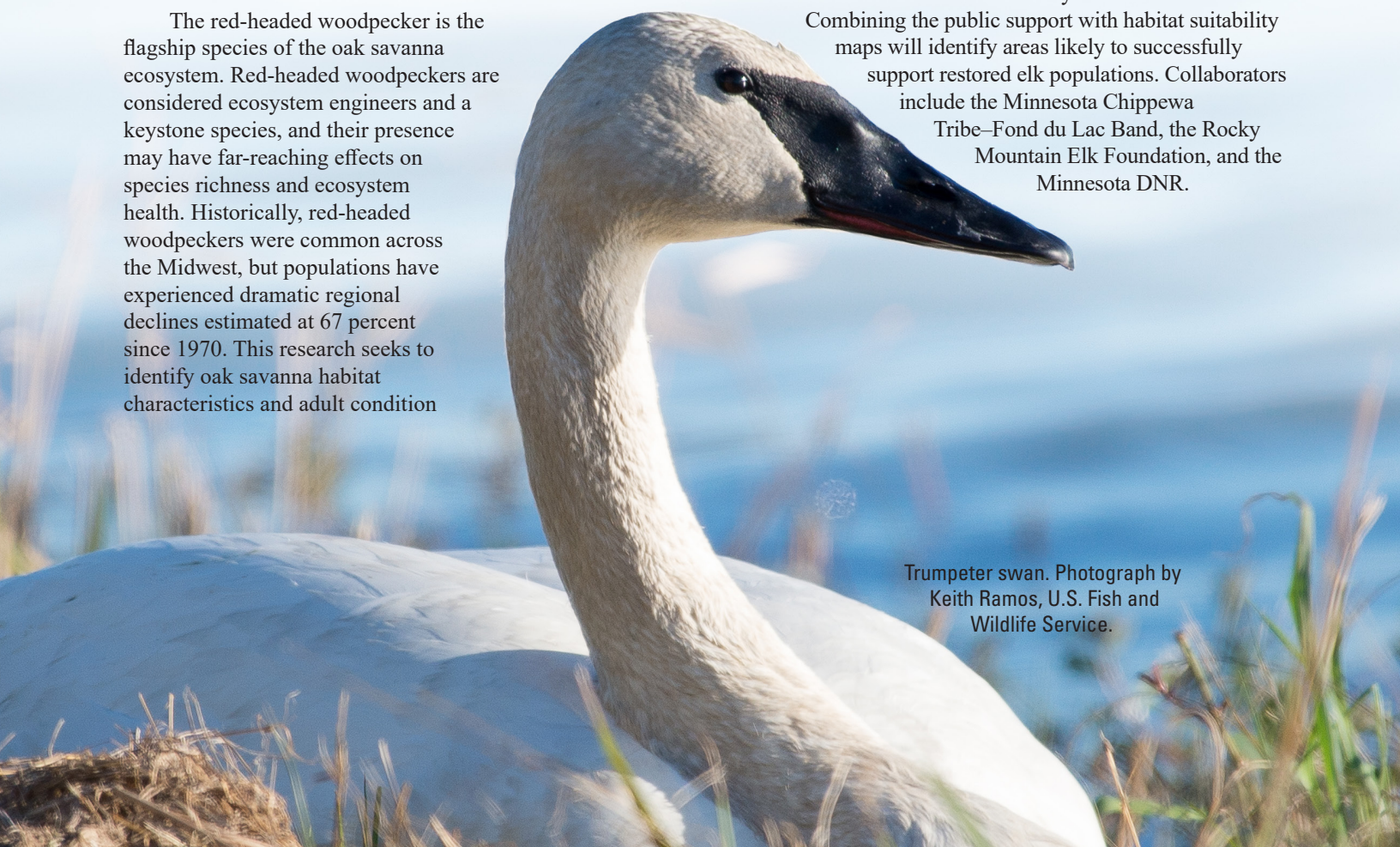
Minnesota Cooperative Fish and Wildlife Research Unit

The red-headed woodpecker is the flagship species of the oak savanna ecosystem. Red-headed woodpeckers are considered ecosystem engineers and a keystone species, and their presence may have far-reaching effects on species richness and ecosystem health. Historically, red-headed woodpeckers were common across the Midwest, but populations have experienced dramatic regional declines estimated at 67 percent since 1970. This research seeks to identify oak savanna habitat characteristics and adult condition and behaviors associated with successful production of young, the factors related to whether and where individuals migrate, and the consequences of migratory status on productivity and survival. Results could provide insight into factors that affect population ecology of red-headed woodpeckers and be used to develop a long-term management plan for restoring oak savanna ecosystems to support red-headed woodpeckers and other oak-savanna habitat specialists in Minnesota and the Midwest. Project partners include the University of Minnesota Cedar Creek Ecosystem Science Reserve, the University of Toledo, and the Minneapolis Chapter of the Audubon Society.

Restoration of Elk to Northeastern Minnesota

Minnesota Cooperative Fish and Wildlife Research Unit

Elk were historically present in Minnesota but were extirpated from the State at the beginning of the 20th century. Successful restoration of elk in Minnesota requires understanding the biological and social habitat necessary for elk to thrive. The goal of this research is to determine areas of suitable habitat and levels of public support for restoring elk to northeastern Minnesota. Research is to be conducted in an area already identified as having local public interest and abundant public forest land (that is, southern St. Louis, Carlton, and northern Pine Counties). The research could build upon existing eastern elk restoration research to identify the amount of public support for a restored elk population by surveying citizens in and around the prospective restoration site and to determine where suitable habitat exists and how many elk it could sustain. Combining the public support with habitat suitability maps will identify areas likely to successfully support restored elk populations. Collaborators include the Minnesota Chippewa Tribe–Fond du Lac Band, the Rocky Mountain Elk Foundation, and the Minnesota DNR.



Trumpeter swan. Photograph by Keith Ramos, U.S. Fish and Wildlife Service.

Avian Abundance and Use Patterns in Fields of Mississippi Managed for the Mourning Dove—A Multiscale Approach

Mississippi Cooperative Fish and Wildlife Research Unit

Dove hunting is a very popular outdoor activity in Mississippi, generating supplemental dollars in revenue for landowners. Research on mourning doves has been relatively limited in Mississippi, but a few studies have been conducted in recent years. Those efforts included research on landscape changes around mourning dove call-count routes and banding studies assessing movements and survival. The goal of this research is to evaluate the relations between abundance patterns and multiscale characteristics of managed fields used by mourning doves on wildlife management areas managed by the Mississippi Department of Wildlife, Fisheries, and Parks. Study sites include wildlife management areas where fields are actively managed using dove-attracting crops and based on records of variable hunting pressure and harvest. Results could be used by the Mississippi Department of Wildlife, Fisheries and Parks for managing mourning doves and for planning activities such as planting crops on wildlife management areas.

Establishing Vegetation in Reservoir Mudflats

Mississippi Cooperative Fish and Wildlife Research Unit

With a median age of 70 years, reservoirs in the United States are showing compelling signs of fish habitat degradation. Habitat losses are often most prominent in littoral zones and are driven by regular and sometimes extreme water-level drawdowns mandated by the operational goals of the reservoir. These fluctuations generally limit successful establishment of aquatic and terrestrial plants. Consequently, expansive mudflats form along the shores of reservoirs that are aesthetically displeasing, promote erosion, increase water turbidity when flooded, and cause various ecological problems in aquatic ecosystems. The goal of this research is to assess the efficacy of establishing agricultural plantings on mudflats to rejuvenate fish habitat and stabilize these highly erodible areas. Results could be compiled into implementation guidelines for managers on successfully establishing agricultural plantings on mudflats. Cooperators in this research include the USGS, Mississippi State University, the Mississippi Department of Wildlife, Fisheries, and Parks, the USACE, and the Reservoir Fisheries Habitat Partnership.

Review, Revision, and Development of New Monitoring Protocols

Mississippi Cooperative Fish and Wildlife Research Unit

The Mississippi Department of Wildlife, Fisheries, and Parks uses a standardized monitoring program to support all statewide fisheries management activities. The monitoring program is reviewed every decade to ensure reliable techniques are being used for obtaining and evaluating data and building models for organizing knowledge. The current research and review focuses on the development of stock assessment methods and could develop new gear; identify approaches for collecting and using data; develop models for evaluating population dynamics and predicting responses of anglers to management actions; and develop classification systems for organizing fish, fisheries, and environmental data. The results and tools from this project could directly affect the Mississippi Department of Wildlife, Fisheries, and Parks standardized monitoring program but may also be useful to other management agencies as they develop, review, or revise their own sampling programs. Collaborators include the USGS; the Mississippi Department of Wildlife, Fisheries, and Parks; and Mississippi State University.

Assessing the Biotic Community of Wetland Reserve Program Restorations in Western Kentucky and Tennessee

Missouri Cooperative Fish and Wildlife Research Unit

The WRP enrolls private lands in conservation easements and seeks to achieve the greatest wetland functions and values, along with optimum wildlife habitat, on every acre enrolled in the program. Restoration activities on WRP sites often focus on improving wildlife habitat that supports hunted species such as migratory waterfowl, but it is uncertain how restoration methods affect nongame waterbird communities (Charadriiformes, Gruiformes, Ciconiiformes, and Podicipediformes spp.). The objectives of this project are to quantify vegetation, macroinvertebrate, and avian communities on WRP restorations and to evaluate the potential for waterfowl to serve as umbrella taxa for wetland ecosystems. The results could allow managers to assess tradeoffs of different restoration strategies to maximize benefits in terms of waterfowl and nongame waterbird communities.

Determining Electrofishing Immobilization Thresholds of Smallmouth Bass, Blue Catfish, and Flathead Catfish—A Critical Step to Develop a Standardized Sampling Protocol

Missouri Cooperative Fish and Wildlife Research Unit

Electrofishing is a common sampling technique to collect fish, but biologists may use different settings that may create bias in the collections. There has been very little research on what electrofishing waveforms are best to collect popular sportfish like smallmouth bass, flathead catfish, and blue catfish. This research is providing managers needed information on what waveforms produce the fish response that will most likely collect these species and is being used to refine standardized sampling methods to help managers account for detection probability, minimize bias, improve sampling efficiency, and make better informed decisions on the status and management of fish populations. This work is in collaboration with the USFWS and several State agencies.

Smallmouth bass. Photograph by Gretchen Hansen, Wisconsin Department of Natural Resources.

Developing Adaptation Strategies and Replacement Costs for Recreational and Tribal Fisheries

Missouri Cooperative Fish and Wildlife Research Unit

Recreational and Tribal fisheries are popular in the Upper Midwest, but there is concern that fish communities may change in the future and result in recreational and Tribal fishers leaving the fishery. Understanding how climate change may affect walleye recruitment and how fishery managers can develop strategies for adapting to these changes is important to recreational and Tribal fishers. The goals of this research are to quantify the replacement cost of recreational and Tribal angling in lakes in Wisconsin and to identify approaches that help glacial lakes managers integrate climate adaptation into current fisheries management. Results from this study could be used to update models that predict walleye recruitment and subsequently presented to agency and Tribal biologists to develop adaptation scenarios that weigh costs associated with retaining fisheries in these glacial lakes against the benefits or costs to anglers. The updated models could allow agency biologists in the glacial lakes region to identify management strategies that are available to them and determine to what extent these strategies can maintain fisheries important to their stakeholder group (for example, walleye).

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Evaluation of Striped Bass Stocking in Bull Shoals Lake

Missouri Cooperative Fish and Wildlife Research Unit

Striped bass are an important sportfish in Missouri, and a goal of reservoir stocking programs is to create a unique angling opportunity to catch a trophy fish. However, there is concern among fishery managers and anglers that stocked striped bass may compete with or prey upon other sport fishes like crappie and bass. The goal of this project is to use telemetry to evaluate dispersal and habitat use of stocked striped bass and stable isotope analysis to document striped bass food habits and diet overlap with other sport fishes. An improved understanding of diet and habitat overlap between striped bass and other reservoir sport fishes could be used by the MDC to develop stocking strategies for striped bass in Bull Shoals Lake and other reservoirs throughout the State.

Habitat Selection and Dispersal of Lake Sturgeon in Missouri Tributaries

Missouri Cooperative Fish and Wildlife Research Unit

Several States have instituted reintroduction programs for lake sturgeon. Researchers partnered with the Missouri Department of Conservation to determine movement and identify the flow and temperature metrics affecting migrations of 100 lake sturgeon in the hydrologically altered Osage and the free-flowing Gasconade Rivers. Distinct thermal regimes affected timing in each river with spring migrations beginning 17 days earlier and ending 29 days earlier on average in the Gasconade River than the Osage River. Spring upstream migrations were positively associated with daily discharge at warmer temperatures in the Osage and 1-day flow rise at cooler temperatures in the Gasconade River. This research could be used by the MDC to predict movement of lake sturgeon in other tributaries and help to locate other river habitats to be conserved.

Habitat Use and Distribution of Gravel Spawning Fishes

Missouri Cooperative Fish and Wildlife Research Unit

Declines in substrate downstream from dams is a major concern for fishes that require certain size gravel and cobble to spawn. This project determined the habitat characteristics of spawning hornyhead chubs and the habitat characteristics associated with fish communities within riffles and runs in the East Fork of the Black River, Missouri. Hornyhead chub preferred depths of 0.20–0.35 meter, velocities of 0.10–0.30 meter per second, wetted widths of 7–10 meters, the presence of velocity shelters, and increased amounts of small substrate. In addition, smaller substrate size was the most important habitat characteristic for increased diversity in the overall fish community and fishes commonly found with hornyhead chub. Riffle-run habitats were deprived of substrate sizes between 8 and 32 millimeters, and this knowledge can guide the Missouri Department of Conservation's substrate augmentation efforts to help conserve native fish below dams.

Prevalence of Neonicotinoid Insecticides on Intensively Managed Wetland Areas and Surrounding Landscapes with a Focus on Effects to Aquatic Invertebrates

Missouri Cooperative Fish and Wildlife Research Unit

Neonicotinoid insecticides are commonly used as seed treatments on major agricultural row crops and are often planted directly in flood-plain wetlands managed for wildlife, specifically waterfowl. Given the high use of neonicotinoid insecticides in the Midwest and their inherent characteristics (that is, acute toxicity to insects, relatively long half-lives in soil, and high water solubility), land managers need to know if these chemicals are present in Missouri wetlands in concentrations that may cause harm to beneficial, nontarget aquatic invertebrates and other taxa. This study investigated invertebrate community response to planting of neonicotinoid-treated seed in managed wetland ecosystems in Missouri and found an overall decrease in aquatic invertebrate diversity and abundance with increasing neonicotinoid insecticides in wetland water and sediments. Research results could be useful to wetland managers in making decisions regarding use of neonicotinoid seed treatments, specifically, and potentially provide broader considerations of the role agriculture may play in future wetland management and conservation plans.

Quantifying Secretive Marshbird Habitat Use Across the Full Annual Cycle—A Meta-Analysis

Missouri Cooperative Fish and Wildlife Research Unit

The group of birds known, collectively, as secretive marshbirds includes some hunted species, as well as species of greatest conservation need, within the Midwest region and the Mississippi Flyway. Unfortunately, there is limited basic ecological information to evaluate whether wetland habitats available on public lands, and management actions directed toward other wetland-dependent taxa within the Mississippi Flyway, are meeting annual life cycle needs for this diverse suite of birds. Consequently, the goal of this project is to better understand habitat requirements of secretive marshbirds across their full annual cycle (that is, migration, breeding, and wintering periods) throughout the Midwest and the Mississippi Flyway and to evaluate how wetland management practices on public lands affect secretive marshbirds' species distribution and habitat use. This project could further understanding of seasonal interactions for secretive marshbird species throughout the Midwest, identify critical information gaps of secretive marshbirds' habitat needs throughout their full annual cycle, and meet technical information needs identified by the Midwest Marshbird Working Group and the Mississippi Flyway Nongame Technical Section.

Which Geese are Being Harvested?—Body Condition of Snow and Ross's Geese Harvested by Different Methods During the Light Goose Conservation Order

Missouri Cooperative Fish and Wildlife Research Unit

The increase of midcontinent light goose populations over the past 30 years and subsequent effects to Arctic and sub-Arctic habitats has been well documented. However, uncertainty exists on whether there have been changes in species composition, sex ratios, or overall condition of light goose populations as these populations have increased. Scientists plan to assess body condition of light geese harvested by various methods and to examine species, sex,

and age composition. The resulting information could be useful for evaluating tradeoffs when considering alternative management scenarios, including potential strategies to reduce light goose populations.

Ross's geese and snow geese. Photograph by Steve Emmons, U.S. Fish and Wildlife Service.

Assess the Recovery of Westslope Cutthroat Trout and Arctic Grayling In Yellowstone National Park

Montana Cooperative Fishery Research Unit

Native populations of Westslope cutthroat trout and Arctic grayling in Yellowstone National Park were reduced or eliminated through competition, predation, and hybridization with nonnative fishes that were historically stocked by managers, ostensibly to enhance sportfishing. NPS fisheries managers carried out conservation actions aimed at restoring Westslope cutthroat trout and Arctic grayling populations in two watersheds in Yellowstone National Park, including East Fork Specimen Creek in the Gallatin River drainage basin and Grayling Creek in the Madison River drainage basin. NPS fisheries managers plan to continue restoration efforts of Westslope cutthroat trout and Arctic grayling in additional park watersheds but first want to understand how past conservation efforts performed to guide future restoration actions. Moreover, similar management actions are being conducted or contemplated worldwide. Therefore, the goal of this research project is to assess the recovery and status of the reintroduced populations of Westslope cutthroat trout and Arctic grayling in East Fork Specimen Creek and Grayling Creek. Results could provide fisheries managers with information needed to better manage such populations and to guide future restoration efforts elsewhere.

Bull Trout Emigration Study

Montana Cooperative Fishery Research Unit

Additional research is needed to understand whether juvenile bull trout emigrate from the Montana streams during the spring. This lack of knowledge hampers decision making on the appropriate allocation of limited resources, on when to sample (for example, just fall or fall and spring), and trap designs needed for those specific water conditions. Thus, the goal of this study is to evaluate the timing and extent of juvenile bull trout emigration and the capture efficiency of tributary traps in Graves Creek and East Fork Bull River. Results could allow managers to improve efficiency of sampling designs and trap designs, which has implications in terms of cost and the footprint of future traps.

Bull trout. Photograph by Shannon Downey, U.S. Fish and Wildlife Service.

Efficacy of the Nature-Like Fish Bypass Channel at Huntley Diversion Dam, Yellowstone River, Montana

Montana Cooperative Fishery Research Unit

The Huntley Diversion Dam on the Yellowstone River limits movements and distributions of fish. A nature-like fish bypass channel designed to resemble a natural stream or side channel was constructed around the dam to enhance fish movements around it in 2015, but its hydraulics and efficacy for fish passage have not been evaluated. The gradient of nature-like bypasses is lower than that of typical fish ladders and their sinuosity and inherent substrate roughness provide diverse water velocities, especially along their margins, thereby ostensibly facilitating passage for a variety of species

and sizes. Nature-like bypasses are still rare, and only a few evaluations of them have been conducted, although none at a dam as large as Huntley. Researchers are evaluating the Huntley fish bypass by estimating fish passage rates through the bypass and measuring and modeling the hydraulics of the bypass channel to determine its passability by various species under different river stages. Results could determine how well the fish bypass works, ascertain the causes of any deficiencies, and identify corrective measures, if needed. Partners are the Montana Department of Fish, Wildlife and Parks and the Civil Engineering Program at Montana State University.

Evaluating Sediment and Nutrient Contributions from Unpaved Forest Roads to Headwater Streams

Montana Cooperative Fishery Research Unit

Unpaved forest roads remain a pervasive disturbance on public lands. Restoring roaded landscapes is becoming increasingly important for many native coldwater fishes that disproportionately rely on public lands for persistence. Researchers are conducting an in-depth field study in the Southwestern Crown of the Continent to monitor and refine understanding of how roads and sediment delivery from increased use (and other activities and disturbances) affect sediment and water quality in aquatic habitat. A comprehensive understanding of the effects of roads across different ecosystems can enhance forest restoration opportunities. Partners are the USFS and the USGS Northern Rocky Mountain Science Center.

Lake Roosevelt Burbot Maturation Study

Montana Cooperative Fishery Research Unit

Male and female burbot cannot be easily distinguished from one another. Burbot spawn over a relatively short period and only once during the spawning year. Reliable information regarding gonad development is required for population status assessments and harvest modeling. This research described gonad development and the endocrine profile in adult Lake Roosevelt burbot; developed noninvasive (ultrasound) and less-invasive (plasma sex steroids) tools to determine sex and stage of maturity; and developed noninvasive (egg diameter via ultrasound) and nonlethal invasive (collection of gametes through catheterization) tools to predict spawning readiness and successful spawning. Results provide information and tools needed to conduct accurate reproductive assessments for burbot that could improve understanding of population dynamics and increase accuracy of harvest models.

Preliminary Analysis of Paddlefish Data from the Missouri River Above Fort Peck Reservoir Focusing on Population Abundance and Survival

Montana Cooperative Fishery Research Unit

The paddlefish fisheries in Montana are important recreational fisheries that are highly valued by the Montana Department of Fish, Wildlife and Parks and anglers within and outside Montana. Paddlefish are long-lived and late maturing, so managing the species for sustainable harvest requires precise and accurate information about their population dynamics because they are particularly susceptible to overharvest. The goal of this project is to evaluate whether the current paddlefish database contains the appropriate data structure to estimate population vital rates. These vital rates are needed to develop harvest models, which are used by fisheries biologists to establish harvest regulations that ensure a sustainable population. Documenting the robustness of the paddlefish database and corresponding estimates of vital rates could give fisheries biologists confidence that management actions are prudent and not allowing the population to be overharvested or underharvested (that is, denying angling opportunities). Partners include the Montana Department of Fish, Wildlife and Parks.

Quantifying Spawning Locations and Habitat Use by Adult Lake Trout in Swan Lake, Montana

Montana Cooperative Fishery Research Unit

Novel experimental approaches to suppress lake trout have focused on the early life stages because lake trout spawning behavior and the physiology of lake trout embryos provide an opportunity for embryo suppression with limited bycatch. Increasing mortality beyond gillnetting and in lieu of gillnetting (the most preferred option) is probably feasible because of the vulnerability of lake trout embryos. Much of the consternation in continuing the lake trout suppression effort in Swan Lake is related to cost and associated bycatch of bull trout in a gillnetting approach. Use of novel approaches, such as those being evaluated in Yellowstone Lake, may provide a tool for use in Swan Lake. However, for these methods to be effective, the exact locations of lake trout spawning sites need to be determined. Thus, the goals of this project are to identify lake trout spawning locations and the habitat associated with those areas when gillnetting suppression is not operational. The results from this project could provide locations where embryo suppression is deemed most feasible in Swan Lake. Partners are the USFWS and the Montana Department of Fish, Wildlife and Parks.

Reproductive Indices of Hatchery-Origin White Sturgeon in the Lower Columbia River, Canada

Montana Cooperative Fishery Research Unit

Conservation aquaculture has become a critical component of recovery programs, including for white sturgeon in the lower Columbia River where extirpation has largely been avoided because of the success of hatchery-origin juveniles released into the wild. There is an urgent need to determine when the hatchery population will mature and begin contributing to natural spawning because genetic swamping of the existing wild population is at risk given low numbers of estimated annual breeders. Several methods to assess sex and stage of maturity in sturgeons are available, but direct comparisons among all methods (ultrasound, endoscopy, measurement of plasma sex steroids, and biopsy) in their efficiency and reliability in assigning sex and stage of maturity are few. The goal of this research is to conduct comparative assessments between available methods for females and males to determine the accuracy of the different methods for establishing sex and stage of maturity in hatchery-origin and wild populations; to determine if gametogenesis occurs homogenously across the gonadal tissue in male and female hatchery-origin white sturgeon; and to determine how biological (that is, age, sex, and size) and environmental characteristics (that is, discharge rate and water temperature) could affect the stage of maturity in hatchery-origin white sturgeon in the lower Columbia River, Canada. Results from this study could improve the accuracy and efficiency of deriving sex and stage of maturity in sturgeons, which could improve stocking strategies and restoration efforts.

Spawning Characteristics and an Assessment of Juvenile Sampling Methods and Habitat for Mountain Whitefish in the Green River, Wyoming

Montana Cooperative Fishery Research Unit

Mountain whitefish are an important ecological and recreational component of streams and lakes in Wyoming, such as the Upper Green River. Historically, mountain whitefish were likely one of the most abundant sport fishes in the Intermountain West, including States such as Montana and Wyoming. Despite the putative abundance of mountain whitefish in the water bodies of western Wyoming and their availability as a sport fish, relatively little is known about the ecology of mountain whitefish in Wyoming. This project is identifying the factors that may limit production of mountain whitefish at various life history stages (such as spawning success, abundance of spawning individuals, movement, and early life-history survival). Understanding the ecology of mountain whitefish and the mechanisms for potential population declines could allow managers to develop management plans to mitigate limiting factors and increase production. Partners include the Wyoming Game and Fish Department.

Using Carcass and Carcass-Analog Material to Increase Lake Trout Suppression Efficiency in Yellowstone Lake

Montana Cooperative Fishery Research Unit

Introduced, invasive lake trout have greatly reduced the abundance of Yellowstone cutthroat trout in Yellowstone Lake and disrupted aquatic and terrestrial food webs. The dramatic, negative effect of lake trout prompted the NPS to start a lake trout suppression program in 1995, which has evolved over the past 25 years. Currently, the most efficient and cost-effective alternative suppression method has been to suppress lake trout embryos using whole and ground lake trout carcass material and carcass-analog pellets on spawning substrates causing hypoxic conditions unsuitable for developing lake trout embryos. The potential effect of the lake trout carcass or carcass-analog pellet nutrients on the food-web dynamics in Yellowstone Lake is unknown. Consequently, the goal of this study is to determine how this novel suppression method affects nutrient cycling and food-web dynamics in Yellowstone Lake. Results can be used by NPS managers to decide whether to implement lake-wide embryo suppression using lake trout carcass or carcass-analog pellet deposition because implementing the carcass program would result in considerable cost savings to the lake trout suppression program. Partners include Yellowstone National Park.

Moose Ecology in Colorado

Montana Cooperative Wildlife Research Unit

Moose populations are decreasing throughout the southern part of their range in the continental United States. Factors that may be negatively affecting moose populations include climate change, predation, disease, parasitism, and habitat change; however, many questions remain as to the ultimate drivers of declining populations. Moose populations in Colorado, which occur at the southern extent of the range, have been stable or increasing and recently experienced large-scale habitat disturbance caused by mountain pine beetles. This research intends to document the effects of moose landscape use and diet quality on population productivity and calf recruitment in Colorado and to provide a better understanding of the mechanistic drivers of moose population

changes. Results could provide biologists with a set of key habitat metrics that can be monitored through time to inform moose habitat and population management decisions. The research could also be used by moose researchers throughout the United States and Canada to better understand how nutrition and habitat affect moose population dynamics at broader scales. This project involves a collaboration of researchers and management biologists from the University of Montana and Colorado Parks and Wildlife.

Population Dynamics and Modeling—Cougars

Montana Cooperative Wildlife Research Unit

Solitary predators are notoriously difficult to monitor because they occur at low densities and are elusive. New techniques for estimating abundance using camera surveys offer a solution to this problem because they do not depend on many of the assumptions required (for example, identification of individual animals) by traditional estimation techniques. To be useful for monitoring carnivores, this new methodology requires confirming that typical behaviors of carnivores (for example, territoriality) do not bias estimates and a test on carnivores under field conditions. Results of this work may allow the University of Montana and the Idaho Department of Fish and Game managers an unprecedented opportunity to reliably estimate abundance for a variety of carnivores in Idaho. This information could also allow managers to defensibly evaluate and demonstrate carnivore management in the State. Collaborators include the University of Montana and the Idaho Department of Fish and Game.

Sage-Grouse and Grazing Study

Montana Cooperative Wildlife Research Unit

Greater sage-grouse populations have been declining in the western United States. Emulating the historical, positive effect of native bison on sage-grouse habitat, alternative regimes of grazing domestic cattle have the potential to improve habitat for sage-grouse. Domestic livestock grazing is a newly founded conservation tool used in parts of the western United States to benefit sagebrush-steppe systems. Notably, conservation efforts to protect declining greater sage-grouse populations have implemented various grazing management strategies. The efficacy of these strategies needs to be evaluated to set long-range strategies for sage-grouse conservation. The project seeks to determine how greater sage-grouse respond to managed grazing strategies. Results could inform land managers on how and when conservation-based livestock grazing benefits sage-grouse populations. The project is a collaboration of resource managers and biologists across multiple agencies and NGOs and includes the USFWS; the BLM; the University of Montana; the Montana Department of Fish, Wildlife and Parks; and the Safari Club International Foundation.

Assessment of Angler Use and Catch at Sutherland Reservoir, Nebraska

Nebraska Cooperative Fish and Wildlife Research Unit

Sutherland Reservoir is the first canal reservoir downstream from Lake McConaughy and is used for the cooling of Nebraska Public Power District's Gerald Gentleman Station. Permitting requires ongoing monitoring of activities, including recreational fishing. The purpose of this study is to estimate angler use and catch at Sutherland Reservoir, Nebraska. Information gained on angler behavior can be important for increased effectiveness of fishery management, as well as increased effectiveness of plant operations. This project is a collaboration of researchers across multiple agencies and includes the University of Nebraska-Lincoln and the Nebraska Public Power District.

Climatic Constraints on Bobwhite Quail Populations Along Their Northern Extent

Nebraska Cooperative Fish and Wildlife Research Unit

Northern bobwhite quail are among the most popular game birds in North America; however, the loss of suitable habitat has led to precipitous population declines throughout their range. Nebraska has the potential to maintain viable quail populations, but climatic conditions imposed by harsh winters and periodic wet springs make quail populations highly variable from year to year. Local habitat management may be capable of overcoming some environmental constraints, but effective management strategies necessitate a comprehensive understanding of the effects of large-scale climatic conditions on Nebraska's quail resources. The goal of this study is to identify the mechanisms by which climatic conditions affect quail and the means by which management may overcome climatic constraints. Results could provide an understanding of how severe climatic events alter quail physiology, behavioral decisions, and subsequent population stability and could provide the basis for developing management strategies to offset these costs. Cooperators include the Nebraska Game and Parks Commission.

Northern bobwhite quail. Photograph by the U.S. Fish and Wildlife Service.

The Social Ecology of an Intensively Managed Ecosystem—Pheasants and Pheasant Hunters in Southwest Nebraska

Nebraska Cooperative Fish and Wildlife Research Unit

Ring-necked pheasants are a culturally and economically important game species. Across the Midwest, agroecosystems have historically served as important habitat for pheasants, but the intensification of agriculture has significantly altered the landscape, resulting in a long-term decline in pheasant populations. Given the importance of pheasants to Nebraska, managers are interested in developing programs that will continue to support pheasant populations while ensuring hunting opportunities. This research monitored pheasants and pheasant hunters in the region to better understand how pheasants use managed agroecosystems, how hunters perceive and use public access, and how pheasants and pheasant hunters interact. Results provide insight into how the complex dynamics among uncontrollable factors—such as weather—and habitat and harvest affect pheasant population dynamics in an intensively managed ecosystem. This information may be used to guide program development to increase pheasant populations throughout Nebraska.

Publications

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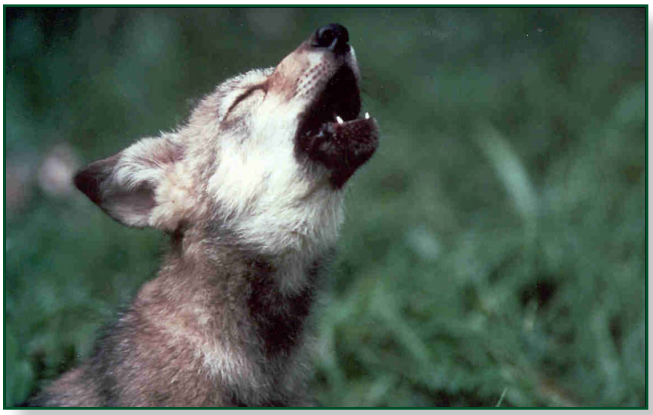
Elk Demography, Movements, and Habitat Selection in the Mexican Wolf Recovery Area in Arizona and New Mexico

New Mexico Cooperative Fish and Wildlife Research Unit

Baseline data on elk survival rates, cause-specific mortality, and habitat selection is scanty for periods before the reintroduction of Mexican wolves in New Mexico and Arizona. Whether Mexican wolves are reducing elk population growth or if wolf predation is compensatory, additive, or partially compensatory is unknown because of a lack of appropriate data. The goal of this study is to assess variability in survival, cause-specific mortality, movements, and habitat selection of elk across the Mexican wolf recovery area in Arizona and New Mexico. Results from this study can fill key data gaps and provide a basis for development of a comprehensive management plan for elk in the Mexican wolf recovery area. This study is a collaboration between the USGS, the USFWS, the Arizona Game and Fish Department, and the New Mexico Department of Game and Fish.



Mexican wolf. Photograph by the U.S. Fish and Wildlife Service.

Estimation of Mountain Lion Density in New Mexico

New Mexico Cooperative Fish and Wildlife Research Unit

Estimating large carnivore population size and density at scales most relevant for management is arguably one of the most challenging issues in wildlife management. Despite substantial advances in methodological and analytical approaches for estimating common game species, estimating low-density predator populations remains challenging for State and Federal management agencies. Researchers are currently estimating the abundance of mountain lions in New Mexico in collaboration with the New Mexico Department of Game and Fish. This study could provide relevant, precise, and unbiased population and density data for mountain lions in New Mexico that could drive management plans including harvest.

Mountain lion. Photograph by the U.S. Fish and Wildlife Service.

Kirtland Air Force Base Mountain Lion Study

New Mexico Cooperative Fish and Wildlife Research Unit

Wildlife management on DoD lands is often hampered by a lack of data on certain wildlife species. The goal of this study is to provide information on basic life history and ecological attributes of mountain lions occupying Kirtland Air Force Base, New Mexico. The specific objectives are to determine mountain lion territory locations, home range and areas, and dens sites; to identify puma kill sites and determine prey composition; to estimate survival and determine cause-specific mortality; and to develop resource selection models for mountain lions on Kirtland Air Force Base. Results from this study could be used to develop management strategies for the mountain lion population and other species on Kirtland Air Force Base.

Natal Source and the Influence of Environmental Bottlenecks on Largemouth Bass Recruitment in Elephant Butte Reservoir

New Mexico Cooperative Fish and Wildlife Research Unit

Largemouth bass is the most sought-after sportfish in New Mexico. However, population abundance of largemouth bass in Elephant Butte Reservoir remains well below the statewide target objective of 20–40 fish per hectare. As such, largemouth bass fingerlings have been stocked into the reservoir to augment the bass population. This project retrospectively characterized the contribution of stocked versus natal (hatched in the reservoir) largemouth bass to assess if stocking practices were successful. A nonlethal collection of dorsal spines in conjunction with strontium isotopes in the spines was used to characterize the origin of fish and discover that stocking was successful. In addition, this project evaluated how the rate of water level change within the reservoir affected spawning of the bass population. Results could be used to develop and implement a stocking strategy that includes the appropriate timing, size, and number of fingerling largemouth bass to stock and to time the delivery of water throughout the middle Rio Grande Basin to increase bass spawning habitat in Elephant Butte Reservoir.

Density Estimation of Moose in New York State—Investigations Into the Apparent Decline

New York Cooperative Fish and Wildlife Research Unit

Moose were extirpated from New York during the 1800s, but the population expanded back into New York in the 1980s. Current population estimates suggest that the New York population has not increased at the same rate as the rest of the northeastern United States (estimates of moose abundance range from 500 to 1,000 individuals). The goal of this project is to implement a spatial capture-recapture study of moose in New York to estimate population density and model processes such as resource selection, movement, space usage, and landscape connectivity to provide inference on the effects of land-use patterns, climate, disease, and interspecific interactions. Results could be used to develop efficient survey designs that incorporate occupancy-level survey data and noninvasive genetic sampling so that rigorous range-wide surveys can be conducted to estimate abundance and density. Future surveys could provide additional information needed for developing broader management and population goals for moose in New York, including the characterization of stakeholder concerns for population-level thresholds. Collaborators include the New York State Department of Environmental Conservation and the Wildlife Conservation Society.

Great Lakes Cisco Spawning Habitat Assessment

New York Cooperative Fish and Wildlife Research Unit

Great Lakes cisco once dominated Great Lakes forage fish communities, yet overharvest, invasive species, and habitat loss led to the widespread collapse of these native fish by the mid-1900s. As Great Lakes ecosystems continue to change, restoring these native forage species is a top priority for increasing the resilience of fishery resources across the Great Lakes Basin. This project is assessing cisco spawning habitat preferences in the Great Lakes. Initial results indicate cisco use a wide range of nearshore habitats across their Great Lakes range but, within lakes, exhibit only a subset of life histories. These findings indicate biodiversity across the species range is still high and identifies research priorities to understand whether within-lake life-history diversity has been lost. Results from this study may be used to develop and prioritize coregonid population restoration efforts.

Quantifying Coregonid Habitat Use Across Space and Time to Inform Assessment and Restoration

New York Cooperative Fish and Wildlife Research Unit

Coregonines once dominated the Lake Ontario fish communities, yet historical overharvest, invasive species introductions, and changing lake conditions have collapsed many native fish stocks in the Great Lakes. Presently, interest is burgeoning on restoring native Coregonine populations to increase Great Lakes ecosystem resilience. This research project is assessing early-life stage ecology of cisco to facilitate native restoration in the Great Lakes. Information from this project could inform fish community restoration efforts and contribute to stabilizing fishery resources throughout the Great Lakes Basin. Collaborators include the USGS, the USFWS, the New York State Department of Environmental Conservation, and Cornell University.

Restoring Fish Community Resilience to Support Ecosystem Stability in the Great Lakes—Cisco Restoration in Keuka Lake

New York Cooperative Fish and Wildlife Research Unit

As inland lakes in the northeastern United States evolve under changing climate and variable nutrient inputs, maintaining fish community biodiversity has been identified as a key ecosystem management strategy to promote resilient fishery resources. Cisco were once abundant throughout the Great Lakes Basin; however, many inland lake populations were lost by the mid-1900s. Managers are now looking to restore these populations and increase lake forage fish diversity. This study intends to pioneer whole-lake monitoring and novel acoustic tagging technology to reintroduce cisco in Keuka Lake. The results could provide survival and food web information that could guide cisco restoration across the Great Lakes Basin and contribute vital empirical evidence to inform species restoration efforts. Collaborators include the USGS, Cornell University, and the New York State Department of Conservation.

Fishery Population and Habitat Assessment in Puerto Rico Streams

North Carolina Cooperative Fish and Wildlife Research Unit

Much information on the life history, distribution, identification, biology, ecology, conservation, and management of Puerto Rico fishes exists in the literature; however, a readily accessible, synthetic collection of the information is not available to fisheries managers. The goals of this project are to compile and synthesize the most relevant information on the freshwater and diadromous fishes of Puerto Rico and to publish it in a comprehensive book. These research findings could be supplemented by previous research and investigations published in the primary literature, and various agency reports on the relevant species and habitats could also be included.

Assessing the Distribution and Habitat Needs of the Least Darter and Sympatric Species of the Ozark Highlands and Arbuckle Mountain Ecoregions

Oklahoma Cooperative Fish and Wildlife Research Unit

Isolated populations may benefit from different conservation and management activities. The least darter is a species of conservation concern that has two isolated populations occupying parts of the Arbuckle Mountain and Ozark Highlands ecoregions. The goal of this research is to assess different environmental factors at multiple spatial scales to determine the relations among microhabitats, reaches, and stream segments and occurrence of least darter and sympatric species. Results from this study could include identification of likely populations that can be used as the foundation for a targeted monitoring program and stream segments that likely contain spring locations.

Graduate student conducts snorkel surveys for least darter study. Photograph by the U.S. Geological Survey.

Assessing the Effects of Stocked Rainbow Trout on Native Fishes

Oklahoma Cooperative Fish and Wildlife Research Unit

Rainbow trout are native only to the western United States but are stocked widely throughout the country to increase fishing opportunities for anglers. Competitive interactions have been shown to be condition specific (for example, water temperature) and, thus, may only occur seasonally or under certain environmental conditions. Understanding these differences is beneficial if there is interest in identifying conditions where stocking may be problematic for native fishes. The goal of this research is to determine how native fishes respond to the presence of trout via resource use and growth in field and controlled laboratory settings. These data could provide information useful to agencies making future decisions about trout stocking in riverine systems. This project is a collaborative effort involving the Arkansas Game and Fish Commission and the Oklahoma Department of Wildlife Conservation.

Rainbow trout. Photograph by the Bureau of Land Management.

Assessing the Spawning Movement and Habitat Needs of Riverine Neosho Smallmouth Bass

Oklahoma Cooperative Fish and Wildlife Research Unit

Limited information is available about the movements of riverine smallmouth bass in landscapes with prevalent river-reservoir interfaces. This lack of information is especially problematic for the Neosho subspecies of smallmouth bass, given that the distribution covers an interwoven landscape of rivers and reservoirs. This research focuses on the movement and habitat use of the Neosho smallmouth bass with an emphasis on the reproductive and juvenile development periods. Project results could identify areas across the landscape that contribute substantially to reproduction and recruitment. Identifying the environmental conditions that support high yield could aid decision-based protective regulations or enhancements, as needed, by the management agencies.

Assessment of Prey Consumption and Body Condition of Missouri River Age-0 Shovelnose Sturgeon

Oklahoma Cooperative Fish and Wildlife Research Unit

The lower Missouri River has been highly modified for navigation, affecting resident sturgeon populations. Researchers are working with the USACE and the Nebraska Game and Parks Commission to study the effect of habitat on prey use and lipid content of juvenile shovelnose sturgeon. Results of this study can be used in an adaptive management process that is evaluating how habitat modifications in the river are affecting juvenile sturgeon.

Shovelnose sturgeon. Photograph by Eli Cureton, U.S. Fish and Wildlife Service.

Black Bass Angler Harvest and Opinions in Relation to Stream Size, Access, and Fish Diversity

Oklahoma Cooperative Fish and Wildlife Research Unit

The diversity of anglers' perceptions and valuation of fishing in Oklahoma streams are important attributes for managers to understand. How anglers value the quality and experience of fishing in the Illinois River and how they compare it with other tributaries of Lake Tenkiller (Baron Fork and Caney Creek) may help in understanding and managing the expectations of anglers in these, and similar-sized, streams in the Ozark region of Oklahoma. The research findings could help fishery managers to develop sound management strategies for the black bass fisheries in these systems.

Determining Factors Associated with Paddlefish Restoration Success in Reservoirs

Oklahoma Cooperative Fish and Wildlife Research Unit

Paddlefish support several high-profile fisheries in the Oklahoma reservoirs and have been the focus of several restoration efforts. However, restoration efforts are hampered by a lack of knowledge on the amount of suitable spawning substrate for successful reproduction. Working with Oklahoma Department of Wildlife Conservation biologists, this project intends to use side-scan sound navigation and ranging to quantify the proportional availability of suitable spawning substrate in major rivers of reservoirs where paddlefish are self-sustaining (Keystone and Oologah Rivers), not self-sustaining (Kaw and Texoma Rivers), recently restored (Eufaula River), or slated to be restored (Tenkiller River). The project could also characterize the zooplankton communities at these rivers and reservoirs in relation to paddlefish needs at juvenile and adult life stages. This study could be used by the managers to better understand the factors affecting restoration success of paddlefish in Oklahoma reservoirs.

Researcher measuring a paddlefish from Keystone River. Photograph by the U.S. Geological Survey.

Effects of Sucker Gigging on Riverine Fish Populations

Oklahoma Cooperative Fish and Wildlife Research Unit

Sucker gigging is a cultural method of fish harvest throughout the Ozarks. Harvest during sucker gigging tournaments can be substantial (for example, >1,200 fish harvested in a weekend). Little is known about the effect of these fishing activities, but life history characteristics of suckers (relatively long-lived and highly migratory) suggest these tournaments have the potential to affect fish communities over a large distance from the tournament locations. The goals of this study are to evaluate the effects of sucker harvest on population dynamics in Spavinaw Creek and to determine the harvest level at which overfishing would occur. This information is necessary to evaluate the possible need for harvest regulations on this cultural fishery to ensure sustainability of the fishery and ecosystem integrity.

Lake Spavinaw is home to numerous gigging tournaments targeting sucker species. Photograph by the U.S. Geological Survey.

Evaluating Striped Bass Exploitation in the Arkansas River Basin

Oklahoma Cooperative Fish and Wildlife Research Unit

Striped bass is an economically important sportfish that often congregates in tailwater habitats, where they are potentially vulnerable to overharvest. The goal of this study is to evaluate the current population demographics, exploitation rate, and movement patterns of striped bass from tailwater habitats of the Lower Illinois and Canadian Rivers and the main-stem Arkansas River to determine the potential for overfishing of tailwater fisheries. A delayed hooking mortality study could also be conducted to evaluate the mortality rate of fish that are captured but not harvested to allow better predictions of the effectiveness of restrictive bag limits. The results could be evaluated with a population harvest model and used to determine the optimum harvest regulations for sustaining a quality fishery.

Habitat Use and Survival of Columbian Black-Tailed Deer in Western Oregon

Oregon Cooperative Fish and Wildlife Research Unit

Black-tailed deer populations and hunter harvest trends have declined in Oregon since 1994. The Oregon Department of Fish and Wildlife is concerned with this decline and has identified current knowledge gaps regarding black-tailed deer ecology in Oregon that are necessary to facilitate their management of this species. To address these knowledge

gaps, the Oregon Department of Fish and Wildlife started a large-scale, long-term black-tailed deer research project that included tracking GPS radio-collared adult female deer. The goal of this research is to use the radio telemetry data to generate seasonal resource selection functions and estimate seasonal and annual survival rates of black-tailed deer relative to habitat use. Information on habitat selection and its effect on key vital rates like adult survival could fill a primary knowledge gap for black-tailed deer in Oregon, which could improve population models and facilitate more effective management by the Oregon Department of Fish and Wildlife.

Changes in Forest Composition Through Time Due to Charcoal Production for the Iron Industry, Tree Harvest, and Deer Browse

Pennsylvania Cooperative Fish and Wildlife Research Unit

Abrupt changes in a forest ecosystem, whether natural or anthropogenic, are changes that occur over short periods; such disturbance has the potential to drive state changes and alter forest resilience. Understanding how present-day abrupt forest change may alter ecosystem services is becoming more important because of ever-growing anthropogenic stresses. Historical charcoal production is an example of abrupt change across northern Appalachian forest ecosystems that is hypothesized to have had a lasting effect on forests, and forest managers can be better prepared to adapt to future abrupt change by studying this model system of past abrupt change. Forest managers trying to adapt to anthropogenic stress can benefit from the study and quantification of past abrupt changes in forests, especially when the legacy of past disturbance is still evident. This project is a collaboration of researchers at The Pennsylvania State University with expertise in soils, forests, and white-tailed deer.

Deer Abundance and Its Relationship to Factors that Affect Forest Vegetation Conditions

Pennsylvania Cooperative Fish and Wildlife Research Unit

The forests of Pennsylvania have problems with tree regeneration and a lack of diversity in understory plant species. White-tailed deer herbivory has been identified as one problem source. However, other factors such as insect outbreaks, acid deposition, competitive effects among plant species, and lack of fire have been identified as other potential causes. Deer populations were reduced by about 23 percent during 2002 to 2005, yet problems with forest plant diversity remains. An important question is whether deer populations require further reduction or other factors may be playing an important role in affecting forested ecosystems. Researchers are monitoring changes in deer density and the response in forest understory vegetation and are conducting experiments to study the relative importance of liming and using herbicide to reduce interspecific plant competition. The results of this research could inform the Pennsylvania Game Commission on how their habitat metrics used to make deer harvest recommendations respond to changes in deer density. In addition, this study could help the Bureau of Forestry refine their monitoring program on State forest lands used to make deer management decisions. This study is a collaboration of the Pennsylvania Game Commission, the Pennsylvania Bureau of Forestry, and the USGS.

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Determining the Consequences of Land Management Actions on Fish Population Dynamics and Distributions

Pennsylvania Cooperative Fish and Wildlife Research Unit

Better understanding the drivers and stressors affecting fish health, fish habitat, and aquatic conditions remains a substantial management need in coolwater and warmwater rivers. Quantifying the effects of land management activities on aquatic ecosystems plays an important role in environmental management and decision making. The goal of this research is to address stakeholder needs related to understanding the effects of land-management actions on stream and river habitat conditions—habitat that is critical for supporting socioeconomically and ecologically important fish communities throughout the Chesapeake Bay watershed. Through the development of several modeling frameworks, this research intends to focus on quantifying the effects of land management actions on population-level outcomes that are relevant to managers, including effects on abundance, recruitment, the number of spawners, and size structure. The project is a collaboration of researchers across multiple agencies and includes the USGS and State fisheries management agencies across the Chesapeake Bay watershed.

Fawn Survival and Predator Abundance in Pennsylvania

Pennsylvania Cooperative Fish and Wildlife Research Unit

Predation is the primary cause of white-tailed deer fawn mortality and is of concern to the hunting public. In this study, researchers monitored survival and cause-specific mortality of fawns and the distribution and abundance of predators (black bear, coyote, and bobcat). Results from this study provided insights into how predators and prey are distributed in space and time and how human changes to landscapes affected these interactions.

Deer fawn. Photograph by Christine L. Densmore, U.S. Geological Survey.

Publication

Gingery, T.M., Diefenbach, D.R., Wallingford, B.D., and Rosenberry, C.S., 2018, Landscape-level patterns in fawn survival across North America: The Journal of Wildlife Management, v. 82, no. 5, p. 1003–1013, https://doi.org/10.1002/jwmg.21456.

Quantifying the Roles of Changing Watershed Conditions and Biotic Interactions in Structuring Pennsylvania Stream Fish Communities

Pennsylvania Cooperative Fish and Wildlife Research Unit

Understanding and predicting fish community interactions and their response to environmental stressors is of utmost importance for fisheries and water-resource management. State agencies and other water-resource agencies rely on knowledge of stream and river fish communities for assessment programs, many of which have regulatory ramifications and implications for water and fisheries management and aquatic resource use activities. However, traditional fish community studies fail to accommodate potential interactions that exist among the entire fish assemblage and, therefore, represent an overly simplistic view of community dynamics. This is important because treating species independently when quantifying and predicting their responses to changing watershed conditions ignores potential dependencies between species because of biotic interactions and can lead to erroneous predictions. The goal of this research is to help inform fisheries and water-resource management and conservation by improving understanding of the relative roles of fish species interactions, environmental factors, and how species traits affect a species' response to changing watershed conditions in Pennsylvania streams and rivers. The project is in collaboration with the Pennsylvania Fish and Boat Commission, the Pennsylvania Department of Environmental Protection, the Susquehanna River Basin Commission, and The Pennsylvania State University.

Snowshoe Hare Habitat Relations in Response to Prescribed Burn and Northern Forest Management

Pennsylvania Cooperative Fish and Wildlife Research Unit

In the face of climate change, land development, and the ephemeral nature of early successional habitats, the Pennsylvania Game Commission wants to develop a comprehensive spatial understanding of snowshoe hare habitat relations to better understand factors affecting snowshoe hare abundance and distribution in Pennsylvania. The snowshoe hare is classified as a game animal and was listed as a species of maintenance concern on Pennsylvania's 2005 SWAP because of sensitivity to habitat alteration, apparent decline, and potential importance of Pennsylvania's population for gene flow between States to the north and south. Currently, the distribution is thought to be limited to mountainous sections of the northern half of Pennsylvania and in small, isolated populations in higher elevations of southern parts of the State in areas where suitable habitats exist. The findings from this research could help to develop guidelines for habitat managers to consider and implement when managing northern forest habitats, for habitats managed with prescribed fire, and for protecting critical habitat features to conserve and expand sustainable snowshoe hare populations.

A Multispecies Approach to Managing the Effects of Weather and Land Use on Upland Game Birds

South Carolina Cooperative Fish and Wildlife Research Unit

Management for upland gamebirds is commonly focused on managing habitat for a single species. The goal of this project is to determine optimal ways to manage habitat across several upland gamebirds in Kansas. This research

could be used to better inform placement and type of habitat management for multiple species of gamebirds. This project is a partnership with the NRCS Lesser Prairie-Chicken Initiative and Pheasants Forever.

Publication

Schindler, A.R., Haukos, D.A., Hagen, C.A., and Ross, B.E., 2020, A decision-support tool to prioritize candidate landscapes for lesser prairie-chicken conservation: Landscape Ecology, v. 35, p. 1417–1434, https://doi.org/10.1007/s10980-020-01024-6.

Effects of Forest Management on Early-Successional Avian Species in South Carolina

South Carolina Cooperative Fish and Wildlife Research Unit

South Carolina contains the southernmost extent for several early-successional avian species in the Appalachian Region, yet it is often not included when monitoring or surveying for these species. As several of these species are in decline, more information is needed to determine how they are using habitats in the southern part of the range as well as more information on their occupancy rates across suitable habitats. The goal of this project, in collaboration with the South Carolina DNR, is to assess the response of ruffed grouse, golden-winged warblers, and other early-successional forest species to habitat management in upstate South Carolina. Information from the study may help to inform management practices and conservation needs of species in the State as well as general ecological information about habitat use of these avian species at the edge of their range.

Tracking Atlantic and Caribbean Seabirds

South Carolina Cooperative Fish and Wildlife Research Unit

Many species of seabirds breeding in the Caribbean occupy waters off the Atlantic and Gulf coasts of the United States during some part of the annual cycle. As marine spatial planning becomes a pressing issue in the region, data are needed to enhance understanding of the seabird community in the South Atlantic Bight and the Gulf of Mexico. Although current ship-based and aerial surveys are the standard methods used to measure abundance and distribution of birds at sea, each is a population-based survey that provides information without regard to individual variability or colony of origin. Researchers are deploying tracking devices to measure movement patterns of seabirds in the Caribbean, Gulf of Mexico, and western north Atlantic. Data from individual tracking efforts could allow researchers to assess variability in movements and use patterns, fidelity to specific marine locations, and the relation between marine use areas and breeding locations and population trends at the breeding grounds. The project is a collaboration with the USFWS and also with local NGOs and universities throughout the Caribbean.

Publications

Ramos, R., Paiva, V.H., Zajková, Z., Precheur, C., Fagundes, A.I., Jodice, P.G.R., Mackin, W., Zino, F., Bretagnolle, V., and González-Solís, J., 2020, Spatial ecology of closely related taxa—The case of the little shearwater complex in the North Atlantic Ocean: Zoological Journal of the Linnean Society, v. 191, no. 2, p. 482–502, https://doi.org/10.1093/zoolinnean/zlaa045.

Satgé, Y.G., Rupp, E., and Jodice, P.G.R., 2019, A preliminary report of ongoing research of the ecology of black-capped petrel (*Pterodroma hasitata*) in Sierra de Bahoruco, Dominican Republic—I, GPS tracking of breeding adults: Clemson, S.C., Clemson University, USA, https://doi.org/10.5066/P9UHASY4.

Wilkinson, B.P., Haynes-Sutton, A.M. Meggs, L. and Jodice, P.G.R., 2020, High spatial fidelity among foraging trips of masked boobies from Pedro Bank, Jamaica: PLOS ONE, v. 15, no. 4, article e0231654, https://doi.org/10.1371/journal.pone.0231654.

Zaluski, S., Soanes, L.M., Bright, J.A., George, A., Jodice, P.G.R., Meyer, K., Woodfield-Pascoe, N., and Green, J.A., 2019, Potential threats facing a globally important population of the magnificent frigatebird *Fregata magnificens*: Tropical Zoology, v. 32, no. 4, p. 188–201, https://doi.org/10.1080/03946975.2019.1682352.

Black-capped petrel. Photograph by the U.S. Geological Survey.

Variation of Chronology of Wild Turkey Gobbling in Upstate South Carolina

South Carolina Cooperative Fish and Wildlife Research Unit

Wild turkeys are an important game species but are potentially declining in the southeastern United States. Information about the timing of harvest relative to their breeding season is needed to better determine the effects of harvest on survival and reproduction. This study is comparing gobbling chronology in upstate South Carolina to other locations as well as looking at variation in gobbling related to date, hunting pressure, and elevation to better inform management decisions about harvest seasons and ecology of wild turkeys in upstate South Carolina. The research could inform management decisions related to the harvest of turkeys in this region relative to other regions in South Carolina. This project is in collaboration with the South Carolina DNR.

Ecology of Breeding Canvasbacks in Southwestern Manitoba

South Dakota Cooperative Fish and Wildlife Research Unit

Depredation is the most common cause of nest failure in waterfowl; however, nearly all studies on the topic have focused on upland nesting ducks. Several species of diving ducks nest overwater and cause-specific nest failure of these species is less understood. Managers who wish to increase nest survival and, hence, diving duck populations lack information to make decisions or understand best practices. This project endeavors to compare nest survival of canvasbacks and other overwater-nesting species between areas where predators have been lethally removed and those where no removal has taken place. Results of this work could allow managers to understand if predator removal is effective at increasing survival of overwater nests, as well as understand the various factors influencing nest survival. The role of redhead parasitism on canvasback nests is of particular interest. This project is supported by the Delta Waterfowl Foundation with field work in Manitoba, Canada, and is in collaboration with researchers at the University of Minnesota and Louisiana State University.

Canvasback. Photograph by the U.S. Fish and Wildlife Service.

Ecology of Postbreeding Mallards in North Dakota and South Dakota

South Dakota Cooperative Fish and Wildlife Research Unit

Mallards are one of the most heavily studied waterfowl species, yet few studies have investigated their ecology during the postfledging period before fall migration. The behavior and physiology of young mallards during this time may be unique as they learn to fly and navigate, exploit new forage and wetland types, develop settling and social cues, molt, avoid predators, change social status and bonds, and anticipate migration. This project intends to use the recent technology of implantable transmitters to investigate the ecology of hatching-year mallards. Because survival of juvenile mallards during the autumn is an integral component of recruitment to the breeding population, understanding the ecology of hatch-year mallards during this sensitive time could provide critical information to inform management decisions, such as habitat acquisition and harvest regulation in North and South Dakota. The work is a collaboration among the USGS, South Dakota State University, the North Dakota Game and Fish Department, and the South Dakota Department of Game, Fish, and Parks.

Evaluating Avian Use of Cover Crop Fields in the Corn Belt

South Dakota Cooperative Fish and Wildlife Research Unit

Fall-seeded cover crops are a re-emerging technology in the Upper Midwest, intended to improve soil health, increase crop yields, and reduce erosion. Wildlife benefits may also be realized from the planting of cover crops, but because a row crop is planted and harvested, often during the avian nesting season, the effect on wildlife, and birds in particular, is largely unknown. The goal of this study is to evaluate breeding bird use and, to a smaller extent, nest survival of grassland nesting songbirds in cover crops in Iowa. Results from this work could provide managers with critical information about the avifaunal benefits—or detriments—of incentivizing fall-seeded cover crops. Should this practice end up being an ecological trap for birds, managers can focus on complementary programs to offset cover cropping, which has clear soil health and water-quality implications.

Evaluation of Cover Crops for Grassland Nesting Waterfowl in Eastern South Dakota

South Dakota Cooperative Fish and Wildlife Research Unit

With continuing grassland losses throughout the Prairie Pothole Region, alternative methods of providing nesting cover for birds are warranted. Fall-seeded cover crops may provide such an alternate habitat type, but because a row crop is planted and harvested, often during the waterfowl nesting season, the effect on wildlife, and nesting waterfowl in particular, is largely unknown. The goal of this study is to evaluate the efficacy of fall-seeded cover crops to benefit nesting waterfowl in eastern South Dakota. Results of this work can help managers understand if this cover crop program is beneficial to nesting waterfowl. If not, managers can target their efforts at compensatory habitats or alter the timing of agricultural practices to maximize the benefits to breeding waterfowl. The work is a collaboration among the USGS, South Dakota State University, Ducks Unlimited, and the NRCS.

Influence of Mink Predation on Brown Trout in Rapid Creek, South Dakota

South Dakota Cooperative Fish and Wildlife Research Unit

Wild brown trout represent an important fishery in Rapid Creek, South Dakota. The catch-and-release section of Rapid Creek, below Pactola Dam, is particularly notable among anglers and is considered a “Blue Ribbon” trout fishery. Since the early 2000s, the abundance of adult brown trout has declined appreciably and remains low compared to historical estimates. Understanding the cause of this decline is important because of the importance of this catch-and-release fishery and the implications for recruitment of larger fish. Recent work has shown that predation by mink may account for significant mortality of brown trout. Understanding the magnitude of mink predation on brown trout could have important implications for future management decisions in Rapid Creek. Working in collaboration with South Dakota Department of Game, Fish, and Parks and the USFS, the purpose of this project is to assess effects of mink predation on brown trout populations in Rapid Creek, South Dakota. Data gathered in this study could provide insight into the effectiveness of management techniques such as instream habitat improvements or predator block management, or both, on trout populations.

Poststocking Survival of Rainbow Trout in Black Hills Reservoirs

South Dakota Cooperative Fish and Wildlife Research Unit

Harvest rate of stocked rainbow trout in small lakes and reservoirs of the Black Hills, South Dakota, is often well below management objectives. Low harvest of put-and-take fisheries raises concerns about the costs (trout production) and benefits (angler use) of the rainbow trout stocking program. To improve the costs and benefits of the rainbow trout stocking program, a better understanding is needed of factors affecting survival of poststocked trout. This project, in collaboration with the South Dakota Department of Game, Fish, and Parks, is evaluating the effect of stocking density, food availability, water quality, and catch-and-release fishing on survival of stocked rainbow trout in the Black Hills. To better understand the reasons for poor return rates to anglers, the goals of this study are to provide information to inform the development of recommendations that enhance South Dakota’s put-and-take trout stocking program.

Predator Cascade and Nest Success—Changes in Foraging Patterns as a Function of Grassland Patch Dynamics and Vegetation Composition

South Dakota Cooperative Fish and Wildlife Research Unit

Predator-prey interactions affect vital rates, and predation is a major cause of nest failure of ground-nesting birds (for example, waterfowl). With continued grassland loss associated with conversion to row-crop agriculture, and changing predator communities (for example, declines in red fox and active coyote control), this project seeks to understand how habitat dynamics affect predator-prey interactions and nest success of ground-nesting birds. Results from this study could help improve development of comprehensive management recommendations for remaining grasslands, for restoration or reclamation efforts, and for active management programs that wish to modify grassland regimes or predator communities to improve nesting habitat and nest survival.

Red fox. Photograph by John J. Mosesso, U.S. Geological Survey.

Angler Responses to State Management Stocking

Tennessee Cooperative Fishery Research Unit

Stocking fish is an intensive effort, and one of the highest budget items, for State agencies. This study is using a long-term database to explore how angler effort and catches relate to agency stocking efforts across the Tennessee landscape. The project could also evaluate how angler effort and catch rates might inform State management decisions. The project is a cooperative effort between the USGS and the Tennessee Wildlife Resources Agency.

Assessing Sampling Gear and Seasonal Effects on Evaluations of Florida Bass Introgression in Chickamauga Reservoir, Tennessee

Tennessee Cooperative Fishery Research Unit

Largemouth bass fisheries are very popular in Tennessee, and Chickamauga Reservoir has very high angler effort and several tournaments. The Tennessee Wildlife Resources Agency began stocking Florida largemouth bass to improve size structure. Researchers are using genetic techniques to characterize the genetic profile of the population and if sampling gear or sampling season affect that profile. Identifying and characterizing introgression of Florida largemouth bass alleles into populations informs the agency if they are meeting their goals in their management plan. Evaluating if genetics information could be biased depending on sampling time and sampling method helps understand if past samples were robust and informs planning for future sampling.

Contributions of Hatchery Fish to Tailwater Trout Fisheries

Tennessee Cooperative Fishery Research Unit

Tailwater trout fisheries, below dams, are popular with anglers in Tennessee. The Tennessee Wildlife Resources Agency and the USFWS highly invest in hatcheries and stocking to enhance fisheries. However, the contribution of stocked fish to a tailwater fishery is not well understood. The goal of this project is to evaluate the contribution of hatchery versus wild fish to the fishery. For this project, all stocked fish are being marked using PIT tags to understand how many hatchery fish recruit to the fishery. An extensive mark-recapture sampling can indicate stocking success, and individual marks using PIT tags can provide information on growth after stocking. Information from this study could inform hatchery management and stocking practices.

Population Characteristics of Three Important Commercial Fish Species in Tennessee—Skipjack Herring, Smallmouth Buffalo, and Silver Carp

Tennessee Cooperative Fishery Research Unit

Commercially harvested species require population dynamics information for stock assessment. Critical information includes age structure, growth, and recruitment that helps understand how much harvest can be allowed for sustainable populations. The objectives of this study include gaining information for three commercially harvested species in Tennessee: skipjack herring, smallmouth buffalo, and silver carp. All species in the study are harvested in Kentucky, Tennessee, Alabama, and Mississippi; however, demographic information and models are lacking. Results could help inform population status for States to make management decisions.

A Multifaceted Reconstruction of the Population Structure and Life-History Expressions of a Remnant Metapopulation of Bonneville Cutthroat Trout

Utah Cooperative Fish and Wildlife Research Unit

Fishes that evolutionarily demonstrated a fluvial life-history expression and migrated to spawning and rearing habitat using lotic corridors are increasingly affected by fragmentation. The overall goal of this study was to identify the contemporary importance of main-stem connectivity and tributaries to maintaining life-history expression, population structure, and viability of a large metapopulation of Bonneville cutthroat trout persisting in the Weber River in Utah. Researchers used a multifaceted approach including active sampling, mark-recapture, passive PIT-tag detection, otolith microchemistry, and genetics. Results suggest a surprising degree of fluvial life-history expression and very complex movement patterns. Average apparent survival (33 percent) was within the range estimated in similar studies for Bonneville cutthroat trout, and resight rate was best explained by angler management regulations. The fact that Bonneville cutthroat trout in the Weber River and tributaries still reproduce successfully in most years and are still able to grow into large, fluvial fish, suggests connectivity must be occasionally available despite considerable fragmentation. Therefore, this metapopulation may need little further human intervention, although it may benefit from improved connectivity; as such, it represents a high-priority metapopulation for conservation. This project was a collaboration between the USGS, the Utah Division of Wildlife Resources, Trout Unlimited, and Utah State University.

Assessing the Effect of Nutrient Enrichment in the Henrys Fork Headwaters

Utah Cooperative Fish and Wildlife Research Unit

Rivers in the western United States are experiencing changes in nutrient loading because of rapid urban development, but the effects of changing nutrient loading on the structure and function of stream ecosystems, especially fish habitat, are not fully understood. The Henrys Fork of the Snake River in east Idaho is a wide, shallow, clear, spring-fed river whose fish habitat is primarily provided by nutrient-sensitive macrophytes and is experiencing nutrient loading changes from commercial and residential development in its watershed. The goal of this study is to investigate connections between nutrient availability, ecosystem structure, and fish habitat in the Henrys Fork.

Researchers collecting water samples at Henrys Fork. Photograph by the U.S. Geological Survey.

Understanding the Dynamics of Beaver Reintroduction for Passive Desert River

Utah Cooperative Fish and Wildlife Research Unit

American beavers are absent from or in low abundance in many river systems because of historic and current anthropogenic activity. Reintroduction of beavers, sometimes coupled with the addition of structural features (for example, beaver dam analogs), to restore degraded systems is becoming more popular, but outcomes are variable and standardized best practices are lacking, especially in desert rivers. Beavers can serve as a cost-effective, natural restoration tool because of their dam-building behavior (which promotes heterogeneity and drought resiliency in rivers), and translocating nuisance beavers to restoration areas offers an alternative to lethal removal of problem beavers. Consequently, evaluating the efficacy of translocated beavers is imperative to improving beaver-assisted restoration techniques. The project could help to understand the complexities of translocation and its effect on vital rates, space use, and activity patterns of wildlife, which in turn could inform best practices for establishment of dam-building beavers in desert river restoration areas. The project is a collaboration of researchers across multiple agencies and includes the USGS, the BLM, Utah State University, the USDA National Wildlife Research Center, Reclamation, and the Utah Division of Wildlife Resources.

Unintended Fragmentation—Fish Community Effects and Conservation Implications of the Piute Farms Waterfall on the San Juan River

Utah Cooperative Fish and Wildlife Research Unit

Stream fragmentation and nonnative species introductions shape the structure and function of freshwater ecosystems and contribute to the decline of stream fish biodiversity. On the San Juan River, Utah, a novel waterfall poses a barrier to upstream movement of ESA-listed migratory fishes and invasive predatory species from Lake Powell. The goal of this project is to provide a quantitative assessment of the waterfall's emerging effects on species interactions and endangered fish population dynamics. Describing and predicting effects of this barrier on native fish populations could inform management decisions (that is, should fish passage be considered, and if so, what type?) regarding the waterfall and analogous features emerging as reservoir levels decline in the Colorado River Basin, such as the Pearce Ferry Rapid in lower Grand Canyon. This project is a collaborative effort by researchers from the USGS, the Utah Division of Wildlife Resources, and Reclamation.

Utah State Lands—Improving the Success Rate of Beaver Translocation Efforts to Benefit Stream Management and Restoration on Public Lands

Utah Cooperative Fish and Wildlife Research Unit

American beavers are a keystone species and ecosystem engineer. They are especially important to water storage, increasing livestock forage, and creating native fish habitat in arid western ecosystems. For these reasons, beaver translocations are becoming a popular method to enhance stream restoration projects. However, using beaver to scale up restoration efforts to the actual scope of stream degradation may sound promising, but the reality is that the logistics of doing so are not simple. The goal of this study is to provide critical information on beaver space use and behavioral ecology to increase the effectiveness of future stream restoration projects using beaver translocations. This research could aid directly in the management of public lands, help evaluate beaver-based restoration project success, aid in the conservation of species, provide information on beaver ecology and movement, and demonstrate how beaver

restoration can be a creative, cost-effective approach to integrate management of private, State, and Federal lands in Utah.

Estimating Elk Abundance and Herd Demographics

Virginia Cooperative Fish and Wildlife Research Unit

After being extirpated in Virginia in the late 1960s, elk have been reintroduced to the southwest coal fields. Efforts are underway to understand movements and habitat use, develop monitoring techniques, and assess areas for herd expansion. Using GPS-collared animals, this project is showing the reliance of elk on reclaimed surface mines as the primary habitat, although forest cover that provides thermal protection in the summer and escape cover in the fall also are important. The herd is slowly growing and expanding in distribution because of annual recruitment and immigration from surrounding States. Efforts to develop Virginia-specific censusing techniques are underway. Information from this study could help wildlife managers in Virginia effectively manage the elk herd.

Evaluating Efficacy of Agricultural Best-Management Practices in the Upper Clinch, Powell, and Holston River Drainages

Virginia Cooperative Fish and Wildlife Research Unit

Agricultural BMPs are implemented widely, and at great taxpayer expense, to mitigate adverse effects of nutrient and sediment pollution in streams. However, the efficacy of most BMPs for reducing biophysical effects of pollution is poorly documented. BMP assessments are needed to inform land-management decisions by agencies and landowners. Such decisions are especially important in watersheds supporting many imperiled species, such as the Upper Tennessee River Basin. This project seeks to characterize spatial patterns of BMP implementation and predicted sediment and nutrient loading in the Upper Clinch-Powell River drainage upstream from the Norris Reservoir and in the Holston River drainage upstream from the Virginia-Tennessee line; analyze the effects of BMPs, relative to other watershed features, on predicted sediment and nutrient loads across the Upper Clinch, Powell, and Holston River drainages; quantify relations among BMP implementation, observed instream water quality and habitat quality, and observed biotic assemblages; and quantify the cost-effectiveness of BMP implementation across the Upper Clinch, Powell, and Holston River drainages. Results from field-based data analysis and computer models could be synthesized to provide guidelines to farmland managers regarding how to implement BMPs cost effectively. The project is a collaboration among the USGS, the NRCS, the USFWS, the Virginia Department of Game and Inland Fisheries, and the Tennessee Wildlife Resources Agency.

Assessing the Fish Community in the Chehalis River With Occupancy Models

Washington Cooperative Fish and Wildlife Research Unit

Salmon- and steelhead-focused restoration efforts are common in river systems of the Pacific Northwest, but their effects on overall stream communities are not well understood. Understanding these effects can help managers to target restoration efforts appropriately. The goals of this project are to define a baseline for monitoring changes in native fish occupancy after restoration actions in the Chehalis River Basin of Washington and to describe the relation between native freshwater fish occupancy and habitat and landscape metrics. This project aims to develop a multisite occupancy model to describe how the fish community is affected by habitat and landscape metrics. This information could inform the design and location of future restoration projects. The project is a collaboration among the USGS, the University of Washington, and the Washington Department of Fish and Wildlife.

Evaluating Sea Duck Detectability in the Puget Sound Ambient Monitoring Program

Washington Cooperative Fish and Wildlife Research Unit

The Washington Department of Fish and Wildlife annually conducts a survey to monitor sea ducks in Puget Sound. This survey, the Puget Sound Ambient Monitoring Program, is critical to understanding status and trends of sea ducks on this continentally important wintering area and to informing management of the Washington sea duck hunting season. Although relative abundance has been available from the survey, a lack of information on detection rates has made estimating absolute abundance untenable, but a 2012 effort led to collection of digital imagery to inform the estimation of detection. The purpose of this project is to complete analysis of these data to produce a correction factor for sea duck detection. Results of the research could inform the design and analysis of the Puget Sound Ambient Monitoring Program to better inform the status of sea ducks in Puget Sound. This project is a collaboration among the USGS, the USFWS, and the Washington Department of Fish and Wildlife.

Integrated Abundance and Movement Models for Marine Mammals

Washington Cooperative Fish and Wildlife Research Unit

There is an increasing need to identify population- and individual-level responses to rapid physical and biological changes in Arctic marine ecosystems. For Arctic marine mammals that range over large areas, reliable and efficient methods to estimate movement and demographic parameters are vital to evaluating ecosystem-level changes, population status, and subsistence harvest, and to minimizing conflicts with humans and resource development. Advanced statistical models that accommodate the particular challenges of studying wide-ranging marine mammals are needed. The goal of the work is to provide recommendations to management agencies such as the USFWS regarding data collection and analysis methods to improve knowledge of marine mammal, particularly polar bear, demography. This project is a collaboration among researchers with the USGS, the USFWS, and the University of Washington Applied Physics Laboratory.

Publication

Regehr, E.V., Hostetter, N.J., Wilson, R.R., Rode, K.D., St. Martin, M., and Converse, S.J., 2018, Integrated population modeling provides the first empirical estimates of vital rates and abundance for polar bears in the Chukchi Sea: Scientific Reports, v. 8, article 16780, 12 p., https://doi.org/10.1038/s41598-018-34824-7.

Integrated Population Model for Black Bears in Maine

Washington Cooperative Fish and Wildlife Research Unit

Integrated population models unite data from multiple sources that are informative about demographic variables. Integrated population models offer several important advantages over analyzing single datasets by themselves: they can estimate parameters that are inestimable from single datasets and do so more precisely, and multiple datasets can overcome biases present in individual datasets, thus leading to more accurate estimates. The goal of this project is to develop an integrated model that estimates spatially explicit population size, movement patterns, and demographic rates for the Maine black bear population. An integrated modeling framework could lead to identification of a cost-efficient monitoring program to inform Maine black bear management. This project is a collaboration between the USGS New York Cooperative Fish and Wildlife Research Unit and the Maine Department of Inland Fisheries and Wildlife.

Long-Term Seabird Monitoring Data Analysis to Update Channel Islands National Park Seabird Inventory and Monitoring Program and Inform Management and Conservation

Washington Cooperative Fish and Wildlife Research Unit

Established in 1980, California's Channel Islands National Park contains essential breeding grounds for at least 14 seabirds and shorebirds. These species were collectively identified as one of the park's monitoring vital signs, but staff turnover and funding gaps have led to an inconsistent monitoring effort. The purpose of this project is to advance Channel Islands National Park's Seabird Monitoring Program by compiling all known datasets for eight prioritized species and conducting species-specific in-depth program and status reviews. The results of the research could inform status reviews and identify threats for seabirds at Channel Islands National Park and could inform the development of updated monitoring plans to make best use of monitoring funds. This project is a collaboration among the USGS, Channel Islands National Park, and the NPS Inventory and Monitoring Program.

Cerulean Warbler and Associated Species Response to Silvicultural Prescriptions in the Central Appalachian Region

West Virginia Cooperative Fish and Wildlife Research Unit

Cerulean warblers benefit from forest management practices that promote a heterogeneous canopy structure based on an experimental study that resulted in cerulean warbler management guidelines. This project studied application of the guidelines through operational silviculture under a broad set of conditions and harvest types. Kentucky, Pennsylvania, Virginia, and West Virginia conducted timber harvests that incorporated the recommendations of the guidelines, and researchers quantified the response of cerulean warbler and associated avian species. Results suggest that the guidelines are effective under broader topographic conditions, and the study identified specific management targets for the preferred tree species basal area to better guide management practices.

Publications

Nareff, G.E., 2019, Cerulean warbler (*Setophaga cerulea*) and associated species response to operational silviculture in the central Appalachian region: Morgantown, West Virginia University, Ph.D. dissertation, 153 p., https://researchrepository.wvu.edu/etd/7485/.

Nareff, G.E., Wood, P.B., Brown, D.J., Fearer, T., Larkin, J.L., and Ford, W.M., 2019, Cerulean warbler (*Setophaga cerulea*) response to operational silviculture in the central Appalachian region: Forest Ecology and Management, v. 448, p. 409–423, https://doi.org/10.1016/j.foreco.2019.05.062.

Corridor H Stream Monitoring Project

West Virginia Cooperative Fish and Wildlife Research Unit

An environmental impact assessment is required for the construction of Corridor H, a four-lane highway under construction in eastern West Virginia. Specifically, the West Virginia Department of Transportation was required to establish a long-term investigation focused on providing community-level information on stream ecosystems. This study is a long-term monitoring effort with analyses of macroinvertebrate communities in streams affected by Corridor H road construction, including assessments before, during, and after road construction efforts. Study results should provide the West Virginia Department of Transportation with biological impact information relative to the road construction project and can be specifically used by West Virginia Department of Transportation to meet their Federal permit requirements for continued advancement toward project completion. The study is a collaborative effort among the USGS, West Virginia University, and the West Virginia Department of Transportation.

Effects of Imidacloprid on Soil Macrofauna Within Riparian Hemlock Forests

West Virginia Cooperative Fish and Wildlife Research Unit

Hemlock-dominated forests create unique microclimates that provide favorable habitats for certain animals and affect understory plant species composition, biomass, and productivity among various hemlock stands. Hemlocks cover 11,690 acres in the Gauley River, New River, and Bluestone River lands of the NPS, but hemlocks are threatened by an exotic insect pest, the hemlock woolly adelgid. Although the effectiveness of imidacloprid on hemlock woolly adelgid is well documented, the long-term effects of the insecticide on soil-dwelling organisms and the ecology of forest soils and water resources are poorly understood in the National Park System. This research is designed to determine the richness and diversity of soil and benthic macroinvertebrates and salamander species associated with imidacloprid treatment and to assess species' risk. Synthesis of this information could culminate in the reassessment of hemlock woolly adelgid treatment programs.

Assessing Abundance of Centrarchids and Juvenile Yellow Perch in Northern Wisconsin Lakes With Different Walleye Recruitment Histories

Wisconsin Cooperative Fishery Research Unit

Walleye are an important ecological component in many lakes in Wisconsin, where they are one of the most sought-after fishes by anglers and provide an important Tribal subsistence fishery. Walleye recruitment has declined in many northern Wisconsin lakes that historically supported natural recruitment. Declines in recruitment may be related to increased abundance of small centrarchid fishes, but current standardized sampling does not sample these small fish effectively. Identifying potential causes for walleye recruitment declines may help in developing management strategies to mitigate these declines. The goal of this research is to determine if lakes with different walleye recruitment histories differ in terms of various metrics of centrarchid abundance and juvenile yellow perch abundance. This information may lead to changes in management strategies that may help mitigate declines in walleye recruitment. This project is a collaboration with the Wisconsin DNR and helps to address management concerns of the Great Lakes Indian Fish and Wildlife Commission who share management responsibilities for walleye fisheries in much of northern Wisconsin.

Combining Genetics, Otolith Microchemistry, and Vital Rate Estimation to Inform Restoration and Management of Fish Populations in the Upper Mississippi River

Wisconsin Cooperative Fishery Research Unit

Understanding demographic and population structure is important for informing fisheries management, but little research has been conducted on this topic for species in the Mississippi River. This project intends to use three techniques—genetics, otolith microchemistry, and age and growth estimation—to understand structure in multiple fish species within the Upper Mississippi River. The resulting data could be vital for developing new management strategies for fish population restoration in this region. The project is a collaboration among the USGS, the Wisconsin DNR, and multiple universities.

Determining Spawning Locations of Green Bay Walleye

Wisconsin Cooperative Fishery Research Unit

Management of walleye in Green Bay is complicated because walleye spawn in many locations within Green Bay and its tributaries, but the importance of these different locations or regions to the overall population and fishery is unknown. Understanding spatiotemporal dynamics of walleye stock contributions in Green Bay is needed to help fisheries managers develop spatially relevant management strategies. A goal of this project is to determine if the walleye population in Green Bay is largely composed of (that is, greater than or equal to 90 percent) fish spawning in the Fox, Oconto, Peshtigo, and Menominee Rivers or if fish spawning in other locations within southern or northern Green Bay are important components. Additionally, the project could determine if walleye spawning in Wisconsin waters contribute to the walleye population in Michigan waters because the population as a whole is jointly managed by the Wisconsin and Michigan DNRs. Determining the extent to which walleye spawn within certain tributaries or open-water habitats could help the Michigan DNR biologists determine where habitat protection is needed to maintain spawning stocks and where habitat improvement and restoration might be used to increase abundance of some stocks. This work may also help identify spawning habitats that were not previously known to biologists. The project is a collaboration among the USGS, the Wisconsin DNR, the Michigan DNR, and research scientists with the Great Lakes Acoustic Telemetry Observation System.

Developing a DNA-Based Tool to Estimate the Number of Salmon Consumed by Piscivores in the Sacramento Delta

Wisconsin Cooperative Fishery Research Unit

Predation is a major source of mortality for salmonids emigrating from the Sacramento River. This project is using a newly developed tool (DNA mixtures) to estimate the number of salmon that are consumed by piscivores as they exit the river. This project is a collaboration between USGS offices in Wisconsin and California, and the results can be used to better estimate predation, which could inform salmon management in the Sacramento River.

Developing a High-Throughput Single Nucleotide Polymorphism Panel for Walleye in Wisconsin and Minnesota

Wisconsin Cooperative Fishery Research Unit

Walleye are one of the most highly sought after and harvested fish species in the Upper Midwest. Walleye abundances have recently decreased in many northern lakes including those in Wisconsin and Minnesota. Genetic tools can be used to define management units for walleye, to design more effective propagation programs for restoration, and to conduct parentage analysis to understand walleye biology. The goal of this research is to develop novel genetic tools and resources for walleye populations in Minnesota and Wisconsin. The genetic resources and tools developed here could be used to improve resolution of walleye management units and inform future stocking programs. For example, these data could be used to refine management units in the Upper Wisconsin, Upper Chippewa, and Upper Mississippi River drainages. This project is a collaboration between the USGS and the Wisconsin and Minnesota DNRs.

Estimating Mortality of Lake Sturgeon in the Lake Winnebago System Using Traditional Age-Based Approaches and Capture-Recapture Models

Wisconsin Cooperative Fishery Research Unit

The lake sturgeon population in the Lake Winnebago System supports a culturally and economically important spear fishery that is managed by the Wisconsin DNR. Current estimates of mortality used to manage this population may be biased because ages are estimated from fin rays, and these estimates are not accurate for older fish. Researchers intend to develop mark-recapture-based models for estimating mortality of Lake Winnebago lake sturgeon based on recovery of fish marked with PIT tags and then compare those data with mortality estimated from fin ray ages providing biologists with guidance on whether current estimates of mortality are appropriate for management purposes. The project is a collaboration with the Wisconsin DNR.

Evaluation of Muskellunge Habitat Use and Suitability in Green Bay and Tributaries

Wisconsin Cooperative Fishery Research Unit

The Lower Fox River and Green Bay muskellunge population is largely supported by stocking because natural recruitment is small, possibly because of habitat limitations. Although previous work has identified potential spawning locations, it is unknown whether muskellunge hatch at these locations, and habitat attributes associated with successful hatching have not been determined. Identifying habitat conditions that result in the successful production of offspring is important for developing habitat improvement projects that aim to restore critical spawning habitat. Understanding muskellunge behavior could also help develop stocking strategies that aim to increase use of restored spawning habitat. The goals of this study are to determine the proportion of muskellunge spawning in tributaries to lower Green Bay or in Green Bay proper, to determine if adults return to stocking locations to spawn, to define habitat conditions that result in successful hatching, and to quantify the availability of viable spawning habitat in tributaries. Study results should lead to better application of habitat improvement and restoration and of stocking efforts

designed to increase muskellunge abundance. This project is a collaboration among the USGS, the Wisconsin DNR, the Universities of Wisconsin-Stevens Point and Green Bay, and many local musky fishing clubs.

Food Web Interactions Among Walleye, Lake Whitefish, and Yellow Perch in Green Bay, Lake Michigan

Wisconsin Cooperative Fishery Research Unit

Green Bay currently supports one of the most economically important recreational fisheries for walleye in North America. Lake whitefish and yellow perch also support economically important recreational and commercial fisheries within Green Bay. Because of substantial ecosystem changes, including water quality and invasive species, all three species have experienced a tenuous history and collapse in Green Bay; and yellow perch numbers remain at historically low levels. The goal of this research is to address the following research questions: What is the status of the predator-prey balance, food web, and aquatic habitat in Green Bay, and can tools and models be developed to better understand this complex food web while also engaging angling and commercial fishing stakeholders? The study represents an important step in a research plan that could help improve management of walleye, lake whitefish, and yellow perch in Green Bay. The study results can provide fishery managers in Wisconsin and Michigan information on interactions among these three economically important species, which could guide management decisions, because changes in population status of one species will likely affect fisheries for all three species. This project is a collaboration with the Wisconsin DNR, the University of Wisconsin-Green Bay, the Center for Limnology, and the Michigan DNR.

Genetic Assessment of Boardman River Fish Populations Before Dam Removal

Wisconsin Cooperative Fishery Research Unit

Fragmentation caused by dams can fundamentally alter population structure and genetic diversity of fish species that once had access to a continuous river system. Fish populations above the Union Street Dam on the Boardman River have been isolated from Traverse Bay in Michigan since the dam's construction in 1867, but fish passage will soon be implemented on the river. Collecting baseline genetic data from fish species as well as eDNA water samples from sites above and below the dam can allow scientists to determine the genetic effect of fish passage on fish populations above the dam and investigate distribution patterns of species that are being passed. Results could help determine the effects of fish passage on genetic structure and species diversity and could be used to inform fish passage strategies at the Union Street Dam and beyond. This research is part of the FishPass project, a collaborative effort involving multiple State and Federal agencies including the USGS, the USFWS, the Great Lakes Fishery Commission, and the Michigan DNR.

Historical and Contemporary Genetic Diversity of Cisco from Lake Michigan

Wisconsin Cooperative Fishery Research Unit

Cisco are an important component of the Great Lakes food web and are a prime target for restoration and reintroduction efforts. This study is using a recently developed genomic tool to investigate the historic structure of cisco in Lake Michigan. The results could provide important baseline data that can be used to develop management and restoration strategies for cisco. This project is a collaboration between the USGS and the University of Wisconsin-Stevens Point.

Identifying Recruitment Bottlenecks for Walleye in Northern Wisconsin Lakes

Wisconsin Cooperative Fishery Research Unit

Recruitment failure has been observed in some northern Wisconsin walleye populations that formerly supported moderate to high levels of recruitment. Recruitment failure could be linked to a variety of factors, including changes in habitat availability and fish communities, within these lakes. In collaboration with the Wisconsin DNR, researchers have undertaken an intensive study of walleye early life history. This work could encompass a range of walleye populations, including those that have exhibited recent recruitment failure and populations that exhibit high levels of recruitment on a relatively consistent basis. Primary study objectives are to determine if larval and juvenile walleye abundance, survival, foraging success, diet composition, and growth vary among

Lake whitefish. Photograph by the U.S. Geological Survey.

populations; if predation by northern pike, black crappies, bluegill, and yellow perch could affect walleye recruitment; if availability of suitable optical and thermal habitat varies among lakes in relation to walleye recruitment patterns; and if zooplankton abundance, community composition, and size structure vary in relation to larval growth and survival and subsequent recruitment. Results from this study could be used to develop better management techniques to support improved walleye recruitment.

Population Characteristics and Movements of Smallmouth Bass in the Menominee River

Wisconsin Cooperative Fishery Research Unit

The Menominee River supports popular, high-quality fisheries for smallmouth bass that attract anglers from all over North America, and the popularity of these fisheries has continued to increase, leading to increased fishing effort. Maintaining these fisheries is an important goal of the Wisconsin and Michigan DNRs, but little information is available to help guide management decisions. Population characteristics and movement patterns of smallmouth bass could vary among impoundments on the Menominee River, such that the effectiveness and feasibility of additional management actions (for example, changes to harvest regulations and fish passage) could also vary among river segments. The primary goal of this study is to use mark-recapture population assessments to describe population characteristics and movements of smallmouth bass in multiple segments of the Menominee River to determine if current harvest regulations are sufficient to maintain the quality of these fisheries. A secondary goal is to use acoustic telemetry to determine if seasonal movements could result in increased vulnerability to angling or suggest that future fish passage is warranted. This study is a collaboration among the USGS, the University of Wisconsin-Stevens Point, and the Michigan and Wisconsin DNRs.

Predicting Abundance of Adult Muskellunge in Northern Wisconsin

Wisconsin Cooperative Fishery Research Unit

In the Ceded Territory of northern Wisconsin, muskellunge support important mixed fisheries consisting of a recreational muskellunge populations are based on population abundance estimates that are considered valid for 2 years. Muskellunge typically have lower rates of recruitment and mortality than walleye, and populations may be stable for more than 2 years. If muskellunge populations are temporally stable, safe harvest levels may be developed from population abundance estimates conducted on a basis less frequent than every 2 years, and resources may be allocated to other priority research and management needs. Determining the temporal stability in adult muskellunge populations may allow for more efficient fisheries management in that safe harvest levels could be developed, and resources could be allocated to other research and management needs. Additionally, growth and survival information gathered in this study could be used to inform management decisions that promote the sustainability of muskellunge populations in northern Wisconsin. This project is a collaboration with fishery managers of the Wisconsin DNR.

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

Wisconsin Cooperative Fishery Research Unit

The lake whitefish fishery in northwestern Lake Michigan consists of multiple stocks, and the movements of fish within those stocks is not well understood. Previous studies suggested lake whitefish show relatively high spawning site fidelity, but determining whether stocks are functionally discrete remains an important question for fishery managers. This project is using acoustic telemetry coupled with genomics to test current understanding of lake whitefish stock structure and describe stock-specific movements and spatial distribution relative to fishing effort. Use of telemetry and high-reward tags could also allow scientists to estimate mortality rates for these stocks, which are needed for determining safe harvest levels. This project is a collaboration among multiple agencies including the USGS, the University of Wisconsin-Stevens Point, the Wisconsin DNR, the Michigan DNR, and Michigan State University.

Using Genetic Tools to Inform Conservation of Wisconsin's Native Brook Trout

Wisconsin Cooperative Fishery Research Unit

Brook trout are native to Wisconsin and provide a culturally valuable resource as well as substantial support to recreational fisheries. Many populations of brook trout have been threatened by overfishing, stocking, and variable thermal regimes. Stocking has been used to supplement native brook trout populations, but often little consideration was given to the genetic suitability and fitness of stocked fish. The project is a collaboration between the USGS, the University of Wisconsin-Stevens Point, and the Wisconsin DNR.

Using Genomic Tools to Investigate Adaptive Diversity in Great Lakes Cisco

Wisconsin Cooperative Fishery Research Unit

Cisco are an important forage fish species in the Great Lakes that have experienced substantial population declines because of various factors such as changes in lake productivity and introductions of invasive species. Cisco species vary in several morphological characteristics, but it is unclear whether this variation corresponds to heritable genetic differences. Understanding the landscape of adaptive variation in cisco could help to inform future management and restoration efforts. The overall goal of this research is to develop a genetic management plan for Great Lakes cisco that can include definition of conservation units based on neutral and adaptive differentiation as well as identification of suitable broodstock sources and stocking locations. The genetic data obtained could be combined with the genetic linkage map being developed to improve understanding of adaptive genetic differentiation in cisco across the Great Lakes. These data could help resource managers prioritize populations for conservation and choose broodstock for restoration efforts. This project is a collaboration among the USGS, the University of Wisconsin-Stevens Point, the Michigan DNR, the Little Traverse Bay Bands of Odawa Indians, and Université Laval.

Using Genomics to Delineate Stock Structure and Create a Standardized Genetic Resource for Great Lakes Walleye

Wisconsin Cooperative Fishery Research Unit

Walleye support important commercial and recreational fisheries in the Great Lakes region, especially in Lake Erie. The goals of this project are to use genomic tools to help define stock boundaries and to develop a low-cost genetic screen to assign walleye caught in mixed-stock fisheries to their stock of origin. This research could be used to design new management strategies with the goal of protecting each stock of walleye and preserving the important portfolio of population diversity in this species. This project is a collaboration among multiple agencies and universities including the USGS, the Ohio DNR, the University of Wisconsin-Stevens Point, and Ohio State University.

Using Genomics to Improve Stock Structure Resolution and Assess Recruitment Dynamics of Lake Whitefish in Lake Michigan

Wisconsin Cooperative Fishery Research Unit

Lake whitefish support one of the largest commercial fisheries in the Great Lakes, but populations are declining in several areas. The goal of this project is to use genomic tools to help define stock boundaries and to develop a low-cost genetic screen to assign lake whitefish caught in mixed-stock fisheries to their stock of origin. This research could be used to design new management strategies with the goal of protecting each stock of lake whitefish and preserving the important portfolio of population diversity in this species. This project is a collaboration among several State and Tribal agencies including the Wisconsin and Michigan DNRs, the Little Traverse Bay Bands of Odawa Indians, and the Sioux Tribe.

Using Parentage Analysis to Investigate the Spawning and Recruitment Dynamics of Walleye in Northern Wisconsin

Wisconsin Cooperative Fishery Research Unit

Walleye recruitment has declined substantially in the Upper Midwest but finding causal mechanisms for these declines has remained elusive. The goal of this study is to use genetic techniques to reconstruct pedigrees for walleye to investigate walleye spawning biology and recruitment. The results could be used to guide future fishing regulations and to develop conservation plans that protect important habitat features. This project is a collaboration between the USGS and the Wisconsin DNR.

Wild Juvenile Salmonid Abundance and Outmigration in Wisconsin Tributaries to Lake Michigan

Wisconsin Cooperative Fishery Research Unit

Introduced salmonids (that is, Chinook salmon, Coho salmon, rainbow trout, and brown trout) support important recreational fisheries within the Lake Michigan ecosystem. These fisheries are primarily supported by stocking; however, some natural reproduction occurs within some tributary systems. Specifically, anadromous rainbow trout (that is,

steelhead) stocked into Lake Michigan are known to exhibit an adfluvial life history, migrating up tributaries for spawning. Wild offspring have been present in some of these tributaries, but it is not known whether these fish successfully emigrate from these streams into larger tributaries or Lake Michigan. The primary objectives of this study are to determine if abundance of wild age-0 salmonids (primarily steelhead) varies among selected streams in relation to available habitat, if wild age-0 salmonids successfully emigrate from Wisconsin tributaries into Lake Michigan or into larger tributaries, and what potential bottlenecks related to stream temperature or annual flow regimes prevent successful emigration from some streams. This research is in collaboration with the Wisconsin DNR, which could use study results to better manage salmonid populations.

Wyoming Mule Deer Project

Wyoming Cooperative Fish and Wildlife Research Unit

Although such environmental variables as weather and plant phenology are thought to be the main drivers of migration, new evidence suggests that anthropogenic disturbances, such as hunting, as well as intrinsic factors, such as age and sex, can also affect ungulate migrations. However, critical gaps in understanding how intrinsic and extrinsic factors affect migratory behaviors abound. This project is using 3 years (2016–18) of GPS-collar data for a herd of migratory mule deer in south-central Wyoming to compare key migratory behaviors between sexes, identify factors that affect the potential and timing of migration, and evaluate habitat selection in and around the autumn hunting season. Results demonstrate that during hunting season, males found security by using habitats far from roads, whereas females used habitats through the hunting season that retained higher forage quality longer. This collaborative study with the Wyoming Game and Fish Department suggests that mule deer mitigate disturbance from hunting season by moving to roadless security habitats. Overall, these findings contribute to a broader understanding of migration ecology and the factors that affect migration and habitat selection of wild ungulates in western landscapes.

Bighorn Moose

Wyoming Cooperative Fish and Wildlife Research Unit

Moose are not native to the Bighorn Mountains. They populated the Bighorn Mountains from translocated moose from Jackson, Wyoming, in the mid-1900s. This study is using GPS telemetry to evaluate moose demography and habitat use. The demographic data collected can aid in estimating population dynamics of the herd. The spatial data could be used to develop a resource selection function to identify preferred moose habitat. An integrated population model could be developed to estimate population trends, including demographic data from other Wyoming moose herds. Overall, this study could advance understanding of how moose can endure in varying habitats across Wyoming with different movement strategies. This study is being conducted in collaboration with the Wyoming Game and Fish Department to advance the management of this unique moose herd.

Deer-Elk Ecology Project (DEER Project)

Wyoming Cooperative Fish and Wildlife Research Unit

Mule deer are an integral part of the outdoor heritage of western North America, a relished species of pursuit among big game hunters throughout the country, and a key component of the landscape of the West. Nevertheless, mule deer populations have declined across much of their range during the past two decades, potentially because of several factors. Coincident with waning populations of mule deer, populations of elk have burgeoned throughout much of their range through growth in abundance and range expansion. The opposite trajectories of these two species that overlap throughout much of their range have spawned the hypothesis that competition between elk and mule deer may contribute to declining mule deer populations. This study seeks to quantify the net effects of competition on nutritional condition, survival, productivity, and ultimately population growth of these species. To better understand factors regulating growth of struggling mule deer populations, identifying what, if any, effect elk have on mule deer is key to knowing what management and conservation actions will enhance mule deer populations while maintaining robust elk populations in the future.

Evaluating the Effect of Beetle Kill on Sierra Madre Elk

Wyoming Cooperative Fish and Wildlife Research Unit

The goal of this project is to provide information on how hunters and elk change their use of the forest as trees die, as dead trees begin to fall, and beetle kill management is implemented. Most of the beetle-killed trees in this study area of the Sierra Madre Mountains are infected and dying but have not yet fallen over. The goal of this study is to assess elk movement and forest use before, during, and after massive tree fall. The research could also document how hunters change their use of the forest and where they choose to hunt elk throughout all stages of the beetle kill and tree fall. This information could be useful to managers for predicting elk distributions and setting harvest regulations in beetle-kill areas in the future.

Evaluating the Use of Redd Counts in Monitoring Snake River Cutthroat in Snake River Tributaries

Wyoming Cooperative Fish and Wildlife Research Unit

Redd counts are a commonly used management tool for monitoring spawning salmonid population status and trends. The validity of redd count data as an index of population size is based on two key assumptions: redd counts are representative of actual redd numbers, and redd counts reflect population status. These assumptions may not always be met, especially when there is substantial redd superimposition, leading to biased redd counts. In partnership with the Wyoming Game and Fish Department, scientists are evaluating the relations between redd count data and spawning populations, spawning success, and fry emergence in spring creeks in the Upper Snake River drainage. The results of this project could allow managers to better interpret redd counts to population status (spawner numbers and fry production). This better interpretation could inform the development of recommendations on how to most effectively conduct redd counts.

Exploring Mechanisms Underlying the Persistence of Yellowstone Cutthroat Trout Despite Hybridization in the North Fork Shoshone River Drainage

Wyoming Cooperative Fish and Wildlife Research Unit

Cutthroat trout populations are declining across the western United States. Hybridization with introduced rainbow trout, and backcrossing with parental species and other hybrids, has led to genetic introgression and the presence of hybrid individuals with a mix of ancestry. A recent study on the extent of cutthroat trout hybridization in the North Fork Shoshone watershed found no allopatric genetically unaltered streams. However, in a subset of North Fork Shoshone tributaries, pure cutthroat trout remain, raising the question of what mechanisms are allowing these cutthroat trout to persist. This project is a collaboration with the Wyoming Game and Fish Department and the USFS to identify and evaluate mechanisms that maintain cutthroat trout in the North Fork Shoshone River drainage despite potential for hybridization. If mechanisms are found (for example, temporal segregation in spawn timing), management actions can be modified to promote cutthroat trout population growth.

Greater Yellowstone Ecosystem Mule Deer Project

Wyoming Cooperative Fish and Wildlife Research Unit

Increasingly, scientists and wildlife managers are recognizing that the productivity of western herds of mule deer depend on their ability to migrate seasonally across vast expanses of public and private lands. Mule deer are especially important to the ecology and economy of northwest Wyoming, part of the Greater Yellowstone Ecosystem. Along the eastern front of Wyoming's Wind River Mountains, mule deer herds migrate from higher elevations in summer to lower elevation wintering habitats. Although a comprehensive map of the elk migrations of the Greater Yellowstone Ecosystem is soon to be completed, mule deer migration corridors have never been mapped comprehensively. Studying the movements and nutritional ecology of five Greater Yellowstone Ecosystem herds over 2 years can provide essential information to State partners (the Wyoming Game and Fish Department) to manage these herds through identifying crucial habitats—including migration corridors, stopover sites, parturition areas, and winter concentration areas—for conservation and improvement projects.

Harvest Records—Implications for Understanding Factors Affecting Horn and Antler Size in Ungulates

Wyoming Cooperative Fish and Wildlife Research Unit

All harvested bighorn and Dall's (thinhorn) sheep are required to be inspected and have their horns permanently marked with a small identification plug. Consequently, most western natural-resource management agencies maintain harvest records that include size and age of all sheep harvested. These agency harvest records represent a valuable resource to assess trends in size and factors responsible for those patterns on a more regional basis and, thus, also to provide a more robust test of hypotheses and effects of specific management practices. The goal of this project is to use two sources of sheep harvest data to document long-term trends in horn size and age of bighorn sheep, Dall's sheep, and Stone's sheep at a regional level. This information could be used to better manage sheep populations and to potentially increase the number of trophy sheep.

Interstate 80 Pronghorn in Wyoming

Wyoming Cooperative Fish and Wildlife Research Unit

Movement barriers challenge the ability of species to make long-distance movements such as migrations. Along southern Wyoming, pronghorn migrations are severed by Wyoming Interstate 80 (I–80), a nearly impermeable barrier to movement. The ecological consequences of this movement barrier have garnered interest in using wildlife crossing structures to ameliorate this barrier effect to pronghorn and other wildlife. This research uses a novel application of connectivity models to identify potential movement corridors across the I–80 barrier. Analytical techniques can be used to model pronghorn movements across I–80 and to identify the locations that best facilitate movement and predict the optimal locations for a wildlife crossing structure. These methods could have

applied value to managers in southern Wyoming and in other systems where there is interest in how to restore movement across nearly impermeable barriers similar to I–80. This study is a collaborative effort among the USGS, the Wyoming Game and Fish Department, and the Wyoming Department of Transportation.

LaBarge Creek Cutthroat Trout Investigations

Wyoming Cooperative Fish and Wildlife Research Unit

Colorado River cutthroat trout populations have declined across their range. Currently (2020), the major threats are habitat degradation, nonnative species, and climate change. Because of concern about nonnative species, one management strategy is the removal of nonnative fish species and stocking from a captive brood source. Translocation success rates for cutthroat trout are often less than 50 percent, and increased knowledge of stocked fish survival and movement poststocking is needed to understand why cutthroat trout are failing to establish and to improve translocation success rates. This project is a collaboration with the Wyoming Game and Fish Department and is taking place in LaBarge Creek, Wyoming, the site of a large-scale restoration project where hatchery-reared Colorado River cutthroat trout have failed to establish or reproduce. This study could provide useful insight into the causes of establishment failure. It could also provide information on the best time, size, and habitat in which to stock fish to maximize translocation success.

Mapping and Conserving Big Game Migration in Wyoming

Wyoming Cooperative Fish and Wildlife Research Unit

In 2018, the USGS assembled a big game Corridor Mapping Team to work with individual State wildlife agencies and U.S. Department of the Interior partners to facilitate mapping of migration corridors and develop a mapping report. The team has been in place since the beginning of 2019 and includes key biologists in participating State agencies. The Corridor Mapping Team is providing expertise, statistical code, troubleshooting, metadata, and map templates as well as overall direction for this west-wide mapping effort. This collaborative effort includes the State wildlife agencies of all 11 public lands States in the West and is closely integrated with the corridor mapping goals of the Western Association of Fish and Wildlife Agencies. Through this effort, the collaborative team is developing numerous products to address science and management needs related to understanding big game use of corridor habitat, winter ranges, and stopover areas. A primary goal of this effort is to create a standardized inventory of big game migration corridors in the Western United States that can be used to guide conservation and management.

Migration Assessment

Wyoming Cooperative Fish and Wildlife Research Unit

For ungulate migration corridors to be effectively managed, they must first be mapped with detailed movement data. This project is a multiyear effort to map migration corridors of elk and other big game in Wyoming and to develop tools to facilitate the identification and prioritization of threats and opportunities for conservation along migration corridors. The analytical team has produced the migration corridor maps currently being incorporated into the Wyoming Game and Fish Department's vital habitat program. Initial corridor maps have also formed the scientific basis of multiple efforts to conserve private lands that intersect with migration corridors in northwest Wyoming. These products represent a new way of managing elk and other big game herds in Wyoming. They are already increasing awareness and interest in Wyoming's elk migrations while also acting as tools to guide on-the-ground management and conservation projects now and for years to come.

Mule Deer Fawn Survival on the Wyoming Range

Wyoming Cooperative Fish and Wildlife Research Unit

This research is part of the larger Wyoming Range Mule Deer Project that is investigating the nutritional relations among mule deer population dynamics, energy development and disturbance, habitat conditions, and climate to provide a mechanistic approach to monitoring and management of mule deer. This specific research component is designed to quantify the effects of predation on fawn survival, a study objective that is often cost prohibitive to achieve or to measure properly. Examining survival and cause-specific mortality of a Wyoming ungulate is unprecedented and could be a valuable addition to the larger Wyoming Range Mule Deer Project.

Nutritional Carrying Capacity and Interactions With Disease in Bighorn Sheep

Wyoming Cooperative Fish and Wildlife Research Unit

The "Wyoming Plan" by the Wyoming Game and Fish Department's Statewide Bighorn/Domestic Sheep Interaction Working Group expressed the need to monitor habitat selection and habitat nutritional carrying capacity (NCC) for bighorn sheep, evaluate if poor nutrition contributes to disease susceptibility, and determine if habitat improvements affect the nutritional status of populations and thus the NCC. The goal of this study is to identify and calibrate nutritional levels that correspond with the NCC for bighorn sheep. In doing so, scientists could evaluate the proximity of three key sheep herds to their NCC and shed light on the interactions

among density dependence, nutrition condition, chronic stress, demography, and disease susceptibility. Study results could aid in understanding how herd density, environmental conditions, and harvest management interact to affect populations' NCC and their susceptibility to pneumonia. This understanding could assist managers in ensuring that sheep do not exceed the capacity of their habitat and also help them understand how habitat improvements modify nutrition and subsequently affect performance.

Population Dynamics in Moose in the Snowy Range

Wyoming Cooperative Fish and Wildlife Research Unit

Snowy Range moose are at a crossroads. Managers have considered the population to be performing well because it was recently introduced and has had abundant forage; however, the current status of the population and the effect of harvest remain uncertain. This has created considerable uncertainty in how these moose should be managed (that is, harvest levels) over the long term and what can be done to maintain productivity and reduce the probability of a population decline, which has become the norm for Shiras moose across much of their range. The overall goal of this project is to characterize the population trajectory of moose in the Snowy Range to determine if the population is increasing or decreasing under current management. Researchers also seek to understand the primary factors affecting population performance (especially nutrition) and to develop cost-effective tools to aid in the long-term monitoring and management.

Sediment and Fisheries—An Assessment to Inform Sediment Management Practices at Wyoming Dams

Wyoming Cooperative Fish and Wildlife Research Unit

Sediment accumulation behind dams presents managers with a substantial challenge. Allowing sediment to accumulate behind dams can impair dam operations, compromise structural integrity, and increase maintenance costs, but large sediment releases can harm downstream uses such as fisheries. The goal of this project is to provide insight into the relation between sediment and fisheries to provide managers with the tools and information to effectively address fisheries management below dams. This study could be directly applicable to Willwood Dam near Powell, Wyoming, and could also assist in evaluating Wyoming's water-quality criteria for suspended sediment and turbidity. The project is a collaboration of researchers across multiple agencies and includes the USGS, the Wyoming Department of Environmental Quality, Reclamation, and the Wyoming Game and Fish Department.

Snowy Range Moose II

Wyoming Cooperative Fish and Wildlife Research Unit

Although moose are relatively new to the Snowy Range of southwestern Wyoming after translocations in the 1980s, the herd harbors some of the most-coveted moose hunting permits in the State because of the production of world-class moose. Nevertheless, given the difficulty in surveying and monitoring this herd, current levels of herd performance and the sustainability of current harvest practices have been largely unknown. Moreover, the striking alterations to habitat caused by the bark-beetle epidemic has resulted in increased concern for herd performance. This study seeks to assess survival and cause-specific mortality of adult female moose, to evaluate patterns of habitat use of female moose as a function of habitat conditions, to survey for recruitment of young from radiomarked females, to evaluate seasonal patterns of adult survival, to assess riparian communities, and to determine the effects of snow compaction by recreational snowmobiling. Study results could help managers better manage the population by providing them with a more comprehensive understanding of the factors contributing to the high rates of mortality for adult female moose, along with continued monitoring of habitat and range conditions.

The Red Desert to Hoback Mule Deer Migration

Wyoming Cooperative Fish and Wildlife Research Unit

Although migration is the most profitable foraging strategy for animals in numerous environments, many migratory populations contain individuals that do not migrate—a phenomenon known as partial migration. Three different migratory strategies have been observed in a mule deer herd wintering in Wyoming's Red Desert. These include long-distance migrants that travel 150 miles to the Hoback Basin for the summer (the longest recorded mule deer migration, named the Red Desert to Hoback migration), medium-distance migrants that migrate nearly 70 miles to the southern Wind River Range for the summer, and short-distance migrants that either migrate less than 30 miles north for the summer or live all year in the Red Desert. Although these different types of migration have been observed for several years, little is known about the costs or benefits associated with each migratory strategy, and how varying environmental conditions (in other words, annual precipitation and mean temperature) or landscape changes (in other words, fire and fencing) may affect each strategy or how a diversity of migratory tactics benefits the productivity of the overall herd. The primary objective of this study is to compare the costs and benefits of each migratory strategy (long-, medium-, and

short-distance migration). Evaluating different migratory tactics in the Sublette mule deer herd is an important step in understanding factors maintaining variability in migration behavior and will aid in future conservation and management efforts. This study is being conducted as a collaborative project among the USGS, the BLM, and the Wyoming Game and Fish Department.

Ungulate Migrations of the Wind River Indian Reservation

Wyoming Cooperative Fish and Wildlife Research Unit

The Wind River Indian Reservation provides vast and intact winter range for at least 10,000 elk and 4,000 to 5,000 mule deer on the Owl Creek and Wind River Mountain winter ranges in northwest Wyoming. As such, the Wind River Indian Reservation is of high importance to the sustainability of elk and mule deer within northwest Wyoming. Despite the numerous benefits of elk and mule deer to the local community and hunters of Wyoming, the location of their migration corridors or stopover areas is unknown. Understanding the location and use of these areas is critical to conserving and managing the elk and mule deer populations for future generations. Further, there is a limited understanding of the demography of elk (adult survival and pregnancy rates), and how diseases such as Brucellosis could be affecting population growth. This project seeks to gather this information, working in collaboration with the Eastern Shoshone and Northern Arapahoe Tribal Fish and Game Department and the USFWS. This migration study could provide new maps of migration corridors, stopover areas, and winter ranges for these herds, thereby advancing population and land management to keep corridors open.

Wyoming Range Mule Deer Project

Wyoming Cooperative Fish and Wildlife Research Unit

The Wyoming Mule Deer Working Group is one of the most active and productive working groups sponsored by the Western Association of Fish and Wildlife Agencies. The overall goal of the Wyoming Range mule deer project is to address important research and management needs identified by the Mule Deer Working Group. For this project, researchers intend to investigate the nutritional relations among mule deer population dynamics, energy development and disturbance, habitat conditions, and climate to provide a mechanistic approach to monitoring and management of mule deer.

Mule deer migrate across the half-frozen Fremont Lake. Photograph by Mark Thonhoff, Bureau of Land Management.

Species of Greatest Conservation Need

Productivity of Black Oystercatchers in Southwest Alaska

Alaska Cooperative Fish and Wildlife Research Unit

The black oystercatcher, a keystone species in nearshore ecosystems, plays an important role in structuring nearshore systems and is highly vulnerable to human disturbance. Current inventory and monitoring efforts may not adequately address the information needs for estimating long-tveterm trends for this species. To address these issues, the goal of this research is to examine black oystercatcher nests, diet, and chick provisioning to ensure robust interpretation of trends observed in long-term monitoring data. Evaluations of current and alternative methods for monitoring black oystercatcher reproductive success may be used to develop recommendations for management of the species. The project is a collaborative effort with the NPS and the University of Alaska Fairbanks.

Black oystercatcher chick. Photograph by Abby Powell, U.S. Geological Survey.

Publications

Robinson, B.H., Coletti, H.A., Phillips, L.M., and Powell, A.N., 2018, Are prey remains accurate indicators of chick diet? A comparison of diet quantification techniques for black oystercatchers: Wader Study, v. 125, no. 1, p. 20–32, https://doi.org/10.18194/ws.00105.

Robinson, B.H., Phillips, L.M., and Powell, A.N., 2019, Energy intake rate influences survival rates of black oystercatcher *Haematopus bachmani* broods: Marine Ornithology, v. 47, p. 277–283.

Assessing Occurrence and Effects of Neonicotinoid Pesticides on Loggerhead Shrike Body Condition, Immunocompetence, Survival, and Reproduction

Arkansas Cooperative Fish and Wildlife Research Unit

The loggerhead shrike is a grassland associated avian species that is one of the fastest declining passerines in North America and in Arkansas. Mechanisms underlying the decline are unclear, but one area of concern is environmental stressors related to agricultural practices. To improve the ability to conserve this species of greatest conservation need, this project is evaluating the occurrence and impact of neonicotinoid pesticides on individual shrikes. Researchers intend to capture shrikes (adult and nestlings) from a variety of row-crop habitats as well as more natural grassland and pasture habitat. Blood and fecal samples can be collected and analyzed to determine how pesticide concentrations and potential effects vary between growing and nongrowing seasons. Results could inform management by State and Federal agencies by providing insight as to how best to conserve shrikes in human-modified habitats. Partners include the USGS, Arkansas State University, and the Arkansas Game and Fish Commission.

Loggerhead shrike. Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Effect of Current and Future Climate on Endangered Yellowcheek Darter Growth, Survival, and Refuge Use

Arkansas Cooperative Fish and Wildlife Research Unit

Yellowcheek darter has been identified as an obligate riffle dweller and is endemic to the Little Red River watershed in Arkansas. As a result of threats, geographic isolation, and declining abundance, the species was listed as endangered in 2011. Seasonal drought is typical in this region, and as drying occurs, darters must move from riffles into neighboring pools, move into the hyporheic zone, migrate large distances to a persistent riffle, or perish. This project examines the patterns of yellowcheek darter refuge selection and how this may affect bioenergetics and population dynamics. The effects of current and future climate on yellowcheek darter population dynamics are also being studied. Results could be used by stakeholders to manage and conserve this endangered species and may be readily transferable to other aquatic species in the Southeast Region and nationally. Partners include the USGS, the USFWS, and the University of Arkansas.

Hydrologic Alteration and Geomorphic Instability in the Illinois River Watershed and Potential Effects on Mussel Species of Greatest Conservation Need and Associated Fish Communities

Arkansas Cooperative Fish and Wildlife Research Unit

The Illinois River watershed has been substantially altered because of recent land-use and land-cover changes associated with rapid urbanization in northwest Arkansas. This project intends to quantify and assess how impervious surface area, and other natural and anthropogenic land-use factors, affect hydrologic alteration and geomorphic instability of gaged and ungaged streams in the Illinois River watershed. How these hydrologic alterations and land-use and land-cover changes impact the distribution of freshwater mussels, classified as species of greatest conservation need (SGCN), and associated fish communities may also be evaluated. Results could be communicated to the public through stakeholder workshops, Government forums, and an online data portal. Partners include the USGS, the Arkansas Game and Fish Commission, the Illinois River Watershed Partnership, and the University of Arkansas.

Population Demography and Connectivity of Spotted Turtles on an Urban Military Installation

Arkansas Cooperative Fish and Wildlife Research Unit

Spotted turtles are considered endangered by the International Union for Conservation of Nature and are an SGCN in all 21 States in which they occur. One area where they are still abundant, however, is on the protected Fort Belvoir, which is located in northern Virginia—a region that is one of the fastest developing areas of the country and where spotted turtle habitat has been rapidly lost. Working with the USACE, this project examines the population demography, population structure, and movement patterns of turtles using capture-mark-recapture techniques as well as radio telemetry. Results could determine if Fort Belvoir is acting as a source population for other nearby natural areas and, therefore, could directly inform management activities on Fort Belvoir. Data also could be used to assist the installation biologists in consultation with the USFWS if the species is listed.

Rangewide Giant Kangaroo Rat Surveys and Monitoring Optimization

California Cooperative Fish and Wildlife Research Unit

The status of the giant kangaroo rat in many parts of its range is unknown, and the most recent surveys of satellite colonies occurred in the late 1980s. Furthermore, because of an ongoing drought and concerns over long-term permanent changes in climate within its habitat, there is a critical need to understand population dynamics within all colonies of this species across their range. Therefore, acquiring baseline data throughout the range of this species is necessary for long-term management and recovery of the species as well as for assessing the potential effects of development projects. The goal of this project is to determine the current range and status of the State and federally endangered giant kangaroo rat by examining remotely sensed imagery and developing habitat models. Results could be used to develop monitoring methods

Giant kangaroo rat. Photograph by George Harrison, U.S. Fish and Wildlife Service.

based on existing demographic data and aerial surveys of population extent and optimized to detect changes as described in the recovery criteria for the species.

Roost Site Selection in Townsend's Big-Eared Bat

California Cooperative Fish and Wildlife Research Unit

Townsend's big-eared bat has been identified as an SGCN by the California Department of Fish and Wildlife within their SWAP. A critical data gap for this species, as well as for other bats in the region, includes habitat information as it pertains to roosting behavior. The goal of this project is to determine how much bats use basal hollows of trees. Results could provide land managers with specific criteria to identify and protect roosting habitat for Townsend's big-eared bat. This project is a collaboration with the USGS, the California Department of Fish and Wildlife, and Humboldt State University.

Control of Sucker Spawning Migrations in a Major Tributary of the Gunnison River to Increase the Production of Native Sucker Larvae

Colorado Cooperative Fish and Wildlife Research Unit

Nonnative suckers in the Upper Colorado River are a major threat to the persistence of native suckers. This project seeks to manage that threat by removing nonnative suckers during the spawning migration by precluding entry of nonnative and hybrid suckers to the native spawning run and by studying the spawning tributary fidelity of bluehead sucker, flannelmouth sucker, and roundtail chub. If these fishes exhibit spawning system fidelity, the opportunity for long-term success via exclusion of nonnative is possible. The research is being conducted in collaboration with Colorado Parks and Wildlife. Data could be used to inform management decisions regarding native suckers in the Upper Colorado River Basin.

Townsend's big-eared bat. Photograph by Ann Froschauer, U.S. Fish and Wildlife Service.

Demography of Black-Footed and Laysan Albatrosses—Kilauea Point and Tern Island Populations

Colorado Cooperative Fish and Wildlife Research Unit

Black-footed and Laysan albatrosses are long-lived seabirds of conservation concern to the USFWS, and a petition to list black-footed albatrosses under the ESA has recently been submitted to USFWS. Furthermore, >65 percent of the world population of these albatross species nest on remote low island refuges in the Pacific and in smaller numbers in the main Hawaiian Islands. Relatively little is known about the life history, survival, and breeding frequency of Northern Hemisphere albatross species and how this compares between the low islands of the northwestern Hawaiian Islands and the main Hawaiian Islands. A model for annual survival and breeding probability for the albatrosses could be developed for Kilauea Point National Wildlife Refuge and Tern Island, allowing these processes to be connected with threats such as overlap with long-line fishing and other environmental factors. A vetted banding database could be provided for future analyses and used to help develop recommendations for future monitoring intensity. The project is a collaboration among the USGS, the USFWS Region 1 Migratory Bird and Habitat and Inventory and Monitoring programs, the Marine National Monuments of the Pacific, and the USGS Bird Banding Laboratory.

Demography of Black-Footed and Laysan Albatrosses—Vital Rates in Support of the Surrogate Species Approach to Strategic Habitat Conservation

Colorado Cooperative Fish and Wildlife Research Unit

Black-footed and Laysan albatrosses are long-lived seabirds of conservation concern to the USFWS, and a petition to list black-footed albatrosses under the ESA has recently been submitted to USFWS. Furthermore, >65 percent of the world population of these albatross species nest on remote low island refuges in the Pacific and in smaller numbers in the main Hawaiian Islands. Relatively little is known about the life history, survival, and breeding frequency of Northern Hemisphere albatross species of the northwestern Hawaiian Islands and the main Hawaiian Islands. A model for annual survival and breeding probability for the albatrosses could be developed for Midway Atoll and Laysan Island, allowing these processes to be connected with threats such as overlap with long-line fishing and other environmental factors. A vetted banding database could be provided for future analyses and used to help develop recommendations for future monitoring intensity. The project is a collaboration with the USFWS Region 1 Migratory Bird and Habitat and Inventory and Monitoring programs, the Marine National Monuments of the Pacific, and the USGS Bird Banding Laboratory.

Black-footed albatross and chick. Photograph by Wieteke Holthuijzen, U.S. Geological Survey.

Evaluating the Status and Distributions of Bats in White-Nose Syndrome-Free Areas Using Data from the North American Bat Monitoring Program—Acoustic Data Processing and Analysis

Colorado Cooperative Fish and Wildlife Research Unit

The NABat was established to provide standardized monitoring protocols and a continental-scale collaborative framework to evaluate the status and distributions of bat species in areas unaffected by WNS. This survey is multispecies and based on detections by stationary and mobile acoustic receivers. An integration of data from each type of receiver—one that uses statistical methods for species occupancy that accounts for errors in species identification—is needed to extract maximum information from this monitoring program. Results from the analysis could be used to define NABat monitoring in the future, and species distributions from the analysis could be used as a baseline for assessing WNS effects. This project is a collaboration of the USGS, the NPS, and the Colorado Natural Heritage Program.

Hibernating little brown bat with white muzzle typical of white-nose syndrome. Photograph by Greg Turner, Pennsylvania Game Commission.

Assessing Effects of Anthropogenic and Climate-Induced Change on Health of Coastal Ecosystems

Florida Cooperative Fish and Wildlife Research Unit

Sea turtles nest in a variety of beach environments, and the success of an individual nest is affected by its location on the beach and the resulting incubation microenvironment. However, shifts in the frequency and intensity of short- and long-term climate cycles because of global change, in conjunction with anthropogenic alterations, are affecting the resilience of coastal habitats where sea turtles nest. This research can integrate existing approaches with novel techniques to examine the coupling of oceanographic and onshore processes and their effects on sea turtle nest incubation and dune stabilization. The results of this work could identify how and where habitat suitability issues might arise and inform sound conservation planning measures and better practices for beach nourishment, including mitigation and alternative actions.

Composition, Distribution, and Ecology of the Nature Coast Sea Turtle Assemblage

Florida Cooperative Fish and Wildlife Research Unit

There has been a recent increase in anecdotal reports of sea turtles being present in coastal areas of the Nature Coast of the Florida Gulf. It is unclear, however, what factors may be affecting prey and forage availability and habitat selection. The goals of this research are to identify areas of high occurrence via vessel-based surveys and aerial surveys conducted from unmanned aerial systems and to interview fishers and recreationists to assess local knowledge to identify turtle hotspots. Current and historical observation data could be overlayed with climatic data to investigate the role of environmental factors on species distribution and dominance over time. Results could distinguish between the competing hypotheses of localized increases in turtle sightings being caused by changing conditions versus an increase in population size.

Evaluation of the Effect of Artificial Lighting on Sea Turtle Hatchling Orientation

Florida Cooperative Fish and Wildlife Research Unit

Light pollution disorients sea turtle hatchlings. Although management actions to reduce artificial lighting are underway, the quantified spatial data on hatchling orientation accuracies and measurements to show the progress of the management efforts are limited. This project provides information on the threats of artificial lighting that can be directly reduced in the North Atlantic Ocean and the Gulf of Mexico. This project could produce models to predict hatchling orientation accuracies using light intensity data that can be easily collected by the stakeholders. The partners of the study include the Florida Fish and Wildlife Conservation Commission and several counties in the State of Florida that support nesting sea turtles.

Sea turtle hatchlings. Photograph by the U.S. Geological Survey.

Publication

Hirama, S., 2018, Evaluation of the impact of artificial lighting on sea turtle hatchling orientation: Gainesville, University of Florida, Ph.D. dissertation, 127 p.

Green Sea Turtle Spatial Distribution, Abundance, and Habitat Models in the Northeastern Gulf of Mexico

Florida Cooperative Fish and Wildlife Research Unit

Threatened juvenile green sea turtles recruit to shallow lagoons, bays, and estuaries in Florida, yet, in many areas, key information about their distribution, abundance, and specific habitat requirements is lacking. Although some indicators suggest green sea turtles are recovering in the North Atlantic, the nearshore habitats they depend upon are rapidly changing through human-induced regime shifts and climate change. The Sea Turtle Conservancy is collaborating with the University of Florida and the USGS to develop a habitat model that predicts green sea turtle abundance and to understand their health, diet, and movement patterns in the region. This work could inform Federal and State wildlife managers on the important link between juvenile green sea turtles and their habitat in one of the largest remaining seagrass beds in the Gulf of Mexico.

Effects of Translocation on a Cooperatively Breeding Bird in Ocala National Forest

Florida Cooperative Fish and Wildlife Research Unit

Translocation has been considered as a conservation tool to increase the population numbers of Florida scrub-jays, especially in areas that have been recently restored and where small, isolated populations reside and are unlikely to increase naturally through dispersal. Most translocation research has focused on the success at recipient sites, whereas the effects associated with the donor population have not been monitored. This study will focus on the effects that translocation could place on the donor population through monitoring of nesting success and productivity and is a collaboration with State, Federal, and university scientists and wildlife managers. Monitoring nests in groups with and without helpers could increase the understanding of how this cooperative breeder benefits from the presence of nonbreeding individuals. If data show evidence that helpers do not increase productivity or nest success, then future translocations can focus on removing helpers as opposed to entire family groups.

Florida scrub-jay. Photograph by Alexis Cardas; used with permission.

Overwintering Survival of Shorebirds on Florida's Panhandle

Florida Cooperative Fish and Wildlife Research Unit

The beaches and coastal bayside wetlands along Florida's panhandle are important to migrant and resident shorebirds, including species of conservation concern such as piping plovers and red knots. Human disturbance and development,

dredged and hardened inlets, and sea-level rise have affected much of the natural beach habitat in this region. The project can use existing data and collect additional field data to summarize and analyze regional data on nonbreeding shorebirds using public lands along Florida's Panhandle region and, where data on banded birds permits, determine overwintering survival of select species (for example, piping plover and red knot) at targeted sites along northwest Florida beaches. This work could inform managers of areas that may need additional protection or alternative management to enhance survival of migrating and overwintering shorebirds. This work is collaborative among the USFWS, Audubon, and the University of Florida.

Identifying Migratory Routes and Wintering Grounds of Burrowing Owls that Breed on Department of Defense Installations in the Western United States

Idaho Cooperative Fish and Wildlife Research Unit

Burrowing owls were once a common breeder in grasslands throughout North America but are now listed as an SGCN in the United States. Despite population declines, burrowing owls are present on many DoD installations throughout the Western United States. The goal of this project is to identify wintering grounds and migratory routes of burrowing owls nesting on DoD lands through the use of geolocators. Identifying migratory routes and wintering grounds for burrowing owls that breed on DoD installations could help determine shared management responsibility and allow for the development of the most cost-effective management plans for recovery. The results could identify priority management needs for this declining species and help reduce conflict with the military mission on DoD installations. The project represents a large collaborative partnership among 17 organizations including the USGS, the DoD, the Canadian Department of Defense, and the Canadian Wildlife Service.

Burrowing owls. Photograph by Douglas Barnum, U.S. Geological Survey.

Evaluating Restored Mussel Population Genetics and Survivorship

Iowa Cooperative Fish and Wildlife Research Unit

In Iowa and Minnesota, 60 to 70 percent of the known species of mussels are considered SGCN. Reintroducing mussel SGCN where the cause of extirpation has been reduced or eliminated can minimize risks to these species from locally catastrophic events and increase species and river biota resilience to climate change. This project could assess if mussels that are released at reintroduction sites survive and grow to reproductive age. This assessment could take 3 to 6 years, depending on each species' life history traits, and data could inform management plans for these SGCN.

Translocation of the Lesser Prairie-Chicken to the Sand Sagebrush Prairie Ecoregion

Kansas Cooperative Fish and Wildlife Research Unit

Lesser prairie-chickens are a species of conservation concern because of declining populations and occupied range. Managers are developing strategies, including translocation, to restore populations. Assessing the fate and movements of translocated birds is therefore necessary to determine the success of the strategy. Results indicate translocated birds have a low initial survival rate and tend to leave release locations, which makes targeted restoration unlikely. However, translocated birds do nest and reproduce, providing evidence that the conservation strategy may have merit. This research is a collaborative effort among the USGS; the USFS; the Kansas Department of Wildlife, Parks and Tourism; and Colorado Parks and Wildlife.

Effects of Forest Management Practices in the Acadian Northern Hardwood and Conifer Forests of Maine on Forest Bird Communities, With Emphasis on Species of Regional Conservation Priority and Concern

Maine Cooperative Fish and Wildlife Research Unit

The effects of Maine's forest harvest practices, in the northern deciduous and coniferous forest, on the diversity and abundance of the forest bird community of selected species of conservation interest (for example, Bay-breasted warbler, Blackburnian warbler, Cape May warbler) are unknown. The goal of this research is to document bird communities in manipulated stands compared to reference stands and within the larger landscape context. The information learned in this study could provide insight on avian responses to stand age and structure as it relates to habitat quality and in the context of changing land-use practices in the northern forest landscape. This project is a collaborative effort between the USFWS and the University of Maine.

Publication

Rolek, B.W., Harrison, D.J., Loftin, C.S., and Wood, P.B., 2018, Regenerating clearcuts combined with postharvest forestry treatments promote habitat for breeding and post-breeding spruce-fir avian assemblages in the Atlantic Northern Forest: Forest Ecology and Management, v. 427, p. 392–413, https://doi.org/10.1016/j.foreco.2018.05.068.

The Gulf of Maine Coastal Ecosystem Survey—An Integrated, Multidisciplinary Effort to Map Biological Hotspots in the Waters of Maine, New Hampshire, and Massachusetts

Maine Cooperative Fish and Wildlife Research Unit

The Gulf of Maine coastal marine ecosystem is one of the most ecologically and economically productive ecosystems in the world and currently faces threats on multiple levels, including climate change, wind energy development, and numerous competing uses of the system's natural resources. This study is collecting data needed to inform immediate management needs and to increase understanding of the Gulf of Maine coastal marine ecosystem. A multidisciplinary Gulf of Maine coastal marine ecosystem survey combined with focal research on life-history parameters of target species can acquire needed detailed measurements of the physical characteristics of the system and the distribution and abundance of organisms across all trophic levels. Research could provide habitat use models for SGCN in the coastal zone and calculate overall biological hotspot index values for locations throughout the coastal zone, which will collectively support spatial planning efforts and on-the-ground habitat management by delineating ecologically important areas. Detailed and repeatable measures of physical and biological factors within the coastal zone could also provide critical baseline data for monitoring and evaluating future changes to the region archived in open-source existing databases, to be used in long-term monitoring, as well as for evaluating the effects of future changes. The project is a collaboration of the USGS, the University of Maine, the Maine Department of Inland Fisheries and Wildlife, the Biodiversity Research Institute, and the Gulf of Maine Research Institute.

Publications

McKnight, A., 2017, Common threads in seabird productivity patterns across two systems, chap. 2 *of* Population ecology of colonially breeding seabirds—How intrinsic processes, mediating influences, and individual heterogeneity affect population vital rates: Orono, Maine, University of Maine, Ph.D. dissertation, p. 6–37, https://digitalcommons.library.umaine.edu/cgi/viewcontent.cgi?article=3731&context=etd&httpsredir=1&referer=.

McKnight, A., Blomberg, E.J., Irons, D.B., Loftin, C.S., and McKinney, S.T., 2019, Survival and recruitment dynamics of black-legged kittiwakes *Rissa tridactyla* at an Alaskan colony: Marine Ornithology, v. 47, no. 2, p. 209–222, https://www.marineornithology.org/content/get.cgi?rn=1319.

McKnight, A., Irons, D.B., Loftin, C.S., McKinney, S.T., and Olsen, B.J., 2020, Combined influence of intrinsic and environmental factors in shaping productivity in a small pelagic gull, the black-legged kittiwake *Rissa tridactyla*: Marine Ecology Progress Series, v. 633, p. 207–223, https://doi.org/10.3354/meps13162.

Quantifying Brown Trout and Lake Trout Predation on Burbot and Mountain Whitefish

Montana Cooperative Fishery Research Unit

Burbot and mountain whitefish are important native sportfish species in Wyoming, and burbot is classified as an SGCN. Additionally, because of genetic differentiation among Wind River tributary drainage burbot stocks, the Torrey Creek drainage burbot stock is a high conservation priority. Declines in burbot and mountain whitefish abundance have been documented in this drainage, but the causes of the declines are unknown. A potential cause of the noted declines is predation by introduced brown trout and lake trout. The goal of this project is to estimate the predatory effect of brown trout and lake trout on the burbot and mountain whitefish populations in the Torrey Creek drainage. The results could be used to develop management strategies to control brown trout and lake trout to conserve the native burbot and mountain whitefish populations in the Torrey Creek drainage.

An Assessment of the Genetic Structure of an Urban Cooper's Hawk Population

New Mexico Cooperative Fish and Wildlife Research Unit

The USFWS has been coordinating a study of the population ecology of an urban population of Cooper's hawks in Albuquerque, New Mexico, since 2011. That study detailed the demography and population ecology of a model raptor population (Cooper's hawks) to obtain insights into the population ecology of harder to study species of management concern, such as golden eagles. The researchers on the project are conducting an analysis of genetic material and stable isotopes of feathers from the Albuquerque Cooper's hawk study population to gain additional insights into their mating system, behavioral ecology, and population genetic structure. Results of the current project present a valuable opportunity to compare and contrast genetic estimates of population attributes

(for example, estimates of paternity certainty and of effective population size) with direct measures obtained through banding and radio telemetry. This project is a collaboration with the USFWS and the Department of Fish, Wildlife and Conservation Ecology at New Mexico State University.

Cooper's hawk. Photograph by the U.S. Fish and Wildlife Service.

Habitat Suitability for Gila Chub Reintroduction in the Upper San Francisco River Drainage

New Mexico Cooperative Fish and Wildlife Research Unit

Gila chub, an SGCN, has not been collected from the San Francisco River in New Mexico since 1948. Federal and State management agencies have expressed interest in reintroducing Gila chub to ensure representation, resiliency, and redundancy of Gila chub throughout its historical range. The goal of this research is to catalog and characterize (in terms of habitat and hydrology) rivers and tributaries that have suitable habitat for potential reintroduction of the species. The results could be used by Federal and State managers to develop a comprehensive management and reintroduction plan for Gila chub in the San Francisco River.

Response of Bachman's Sparrow to Habitat Management

South Carolina Cooperative Fish and Wildlife Research Unit

Bachman's sparrow is a species of conservation concern that typically inhabits open forest systems with wiregrass; however, little is known about how the species responds to wiregrass-free ecosystems such as those in South Carolina. This research focuses on quantifying abundance, nest success, and survival of Bachman's sparrow in these special ecosystems to provide insights into the management of wiregrass-free habitats. The results could help managers understand optimal burn frequencies and vegetation needs for Bachman's sparrow and also provide additional information about the ecology of the species. This project is in collaboration with the South Carolina DNR.

Spatial Ecology of Brown Pelicans in the South Atlantic Bight

South Carolina Cooperative Fish and Wildlife Research Unit

Brown pelicans have been understudied in the southeastern United States, and the sparse availability of data for pelicans (as well as other nearshore seabirds in the region such as royal tern, sandwich tern, and black skimmer) has resulted in a relatively incomplete picture of pelican ecology in a baseline environment. As such, understanding of habitat use at sea, population trends, and reproductive success for pelicans is limited. Furthermore, the potential for an overlap between use areas of brown pelicans in the marine environment and proposed or existing offshore energy activities may be substantial in the region. Researchers are collaborating with State agencies (South Carolina, Georgia, and Florida), the Bureau of Ocean Energy Management, and the USGS Outer Continental Shelf Program to study spatial and reproductive ecology of pelicans in the region. Data could be used to generate distribution maps and movement models showcasing breeding ranges, migratory pathways, wintering locations, and site fidelity. This information could greatly expand knowledge of this charismatic species in the Atlantic and complement prior research recently conducted on brown pelicans in the Gulf of Mexico.

Publication

Wilkinson, B.P., Satgé, Y.G., Lamb, J.S., and Jodice, P.G.R., 2019, Tropical cyclones alter short-term activity patterns of a coastal seabird: Movement Ecology, v. 7, article 30, 11 p., https://doi.org/10.1186/s40462-019-0178-0.

Black skimmer. Photograph by Douglas Barnum, U.S. Geological Survey.

Validation and Transferability of Fundamental Niche Models of Mussel Communities and Assessment of Risks to Mussel Populations in Ozark River Drainages

Tennessee Cooperative Fishery Research Unit

Missouri is developing a comprehensive monitoring framework for freshwater mussels that maximizes the probability of species detection and distributional changes in mussel species while minimizing costs and man hours dedicated to monitoring purposes. The goals of this project are to transfer fundamental niche models of mussel concentrations (that is, reaches of rivers with features that allow establishment of dense concentrations of multiple species of native unionid mussels) that have been developed in the Meramec River drainage to two contrasting Ozark Plateau river systems, the Gasconade and Little Black Rivers, and to determine baseline occupancy of these areas for model validation. Hydrogeomorphic characteristics that allow establishment of mussel beds have been identified and intend to be tested in the Gasconade River and Little Black River systems.

Avian Community Response to Brush Control on the Welder Wildlife Refuge—Phase II

Texas Cooperative Fish and Wildlife Research Unit

Grassland obligate birds are experiencing widespread population declines across North America. Despite widespread prairie restoration efforts, little evaluation has been made as to the success of coastal prairie restoration in terms of avian community structure. The coastal prairie of the Texas coast has experienced extensive brushland encroachment and prairie loss. Efforts to restore coastal prairie grasslands and the natural avian communities have been overlooked. Data could provide insights as to the success of different brush control methods to restore prairie, whether or not natural avian communities can be restored, and if so, what the lag periods for avian community restoration may be. This study is a partnership with the Welder Wildlife Foundation.

Toward a Better Understanding of Blue Suckers—Validating Age Determination Methods and Estimating the Effect of Temperature on Aerobic Scope and Swimming Performance

Texas Cooperative Fish and Wildlife Research Unit

Blue suckers are listed as SGCN or threatened by most States throughout their range. Proper management of these riverine, migratory species requires knowledge of their life history, which is at present (2020) poorly understood. More specifically, knowledge of the association between cohort (year class) strength and hydrology is needed for proper instream flow recommendations. The goal of this study is to provide data that address two critical needs: validating age estimation techniques and characterizing swimming performance under various environmental simulations. Validating yearly annulus formation and evaluating the accuracy of various structures used for aging blue suckers could provide a greater level of confidence in age estimates generated from wild-caught blue suckers. Assessments of swimming performance under various environmental conditions could improve habitat suitability models for blue suckers, particularly as they relate to discharge, current velocity, and temperature. The project is a collaboration of researchers across multiple agencies and includes the USGS Texas and Hawai´i Cooperative Fish and Wildlife Research Units, Texas Parks and Wildlife Department, and Texas Tech University.

Assessing Distribution and Occupancy Patterns of Riparian Avifauna in the Trans Pecos Region of Texas

Texas Cooperative Fish and Wildlife Research Unit

Riparian areas in the Chihuahuan Desert Ecoregion are identified as a priority for conservation in the Trans Pecos region of Texas. Southwest riparian zones create nesting and foraging habitat for an estimated 166 bird species and support an estimated 10.6 times more migratory birds compared to the surrounding upland desert. Among these species of conservation concern are the federally threatened western yellow-billed cuckoos and the State-threatened common black-hawk, gray hawk, and zone-tailed hawk. It is also an objective of the Texas Parks and Wildlife Department to work toward the recovery of threatened, endangered, and high-priority species associated with riparian systems. However, little quantitative data are available for riparian obligate birds in the region. This study, in partnership with the Texas Parks and Wildlife Department, is designed to assess the distribution, site occupancy, and community structure of birds among different riparian systems of the Trans Pecos region, and to estimate nesting abundance and productivity of three State-threatened raptor species. Results could provide the Texas Parks and Wildlife Department with data to make informed decisions for identifying priority areas for conservation and restoration and for assessing the status of species of concern.

Habitat Modeling of Rare Plant Species in the Intermountain West

Utah Cooperative Fish and Wildlife Research Unit

Utah is the home of about 340 endemic plant taxa. Many of these are considered species of concern at both State and Federal levels; the USFWS has responsibility for reviewing the species of concern for possible listing under the ESA. Of special interest are identifying, mapping, and modeling known and possible locations of the species on BLM lands. The flora element of the Utah Natural Heritage Program, now

housed in the Quinney College of Natural Resources, Utah State University, could be surveyed for plants considered for review by the USFWS, along with other species where little information is available.

Demographic Status and Population Genetic Differentiation of Candy Darter Populations in Virginia

Virginia Cooperative Fish and Wildlife Research Unit

Candy darter are narrowly restricted to medium-sized streams with cold-cool temperatures, high-velocity riffles, and silt-free substrates. Absences in fish surveys during the past half century indicate that the species has declined or is extirpated from many former localities, probably because of warming water temperatures or excessive siltation. This study is designed to document spatiotemporal shifts in occupancy and suitability of riffles in Stony Creek and Cripple Creek; to monitor populations to estimate relative population size for use in demographic projections and assessment of population viability; to estimate life history attributes such as fecundity, age-specific survival, annual recruitment, and age structure; and to analyze molecular and life history data to define demographic and evolutionarily significant units for the species and to estimate genetic diversity and effective population size. Enhanced understanding of the viability and dynamics of extant populations and evaluating biologically defensible options for translocation of individuals or augmentation of populations could inform management planning for the species, could enhance cost effectiveness of management actions, and may obviate the need to formally list the species as imperiled.

Distribution and Ecology of the Eastern Spotted Skunk

Virginia Cooperative Fish and Wildlife Research Unit

Rare throughout the Appalachians, the eastern spotted skunk is occasionally encountered, but limited information exists relative to population size or distribution. This study is designed to survey for distribution, habitat use, and genetic status of eastern spotted skunks in Virginia and West Virginia. The goal of this project is to gather enough information so managers can determine whether the species should be designated either a game or sensitive species. Project cooperators include the USGS, the USFS, the Virginia Department of Game and Inland Fisheries, the West Virginia Division of Natural Resources, and the Virginia Master Naturalist Program.

Fox Squirrel Presence and Distribution in Eastern Virginia

Virginia Cooperative Fish and Wildlife Research Unit

Southeastern fox squirrels is a declining subspecies of fox squirrel associated with pine savanna habitats in the Southeast. Formerly reaching its northernmost distribution in east-central and coastal Virginia, the subspecies is largely absent in the State. As valued small game, managers need information on current distribution and habitat correlates to effect change on public land and to advise private landowners interested in pine savanna restoration and management. Concomitant with this decrease and land-use changes from pine plantation culture and fire suppression that favors hardwood forest development, the eastern fox squirrel subspecies seems to be colonizing the lower Piedmont and upper Coastal Plain in Virginia, potentially excluding or integrating with southeastern fox squirrels. The researchers of this study, in cooperation with the Virginia Department of Game and Inland Fisheries, the Virginia Department of Military Affairs, and The Nature Conservancy are currently conducting passive camera surveys and live-trapping and radio-telemetry research efforts to define current occupancy and habitat use of eastern and southeastern fox squirrels in the region. Data from this effort could be used by the Virginia Department of Game and Inland Fisheries to decide if southeastern fox squirrel reintroductions are needed and (or) if they would be successful in light of the eastern fox squirrel range expansion.

Phenology and Habitat Use of Larval Percina in the Upper Roanoke River Basin—Phase 2

Virginia Cooperative Fish and Wildlife Research Unit

North American darters are a widely threatened subfamily of freshwater fishes, and little is known about their larval ecology. A key hurdle to better understanding the population ecology and early life history of imperiled darters is the lack of standard methods for identifying darter larvae to species. Research documenting when and where larval darters occur, especially for imperiled species, can provide new insights into when and where to apply management actions to ensure those actions are cost effective. This project seeks to provide new information on how to distinguish co-occurring larval darter species and on how their abundances vary across time and space. Project results could provide methods useful to other researchers and inform managers about when and where actions to conserve darters would be most effective. The project

is a collaboration among the USGS, Virginia Polytechnic Institute and State University (Virginia Tech), and the Virginia Department of Game and Inland Fisheries.

Publication

Buckwalter, J., Angermeier, P.L., Argentina, J., Wolf, S., Floyd, S., and Hallerman, E.M., 2019, Drift of larval darters (family Percidae) in the Upper Roanoke River Basin, USA, characterized using phenotypic and DNA barcoding markers: Fishes, v. 4, no. 4, article 59, 16 p., https://doi.org/10.3390/fishes4040059.

Integrating Data Sources to Characterize Demographic Responses of Columbia River Salmon and Steelhead to Threats and Management Actions

Washington Cooperative Fish and Wildlife Research Unit

Much of the historical abundance and diversity of Chinook salmon and steelhead trout have been lost in the Columbia River Basin, which led to the listing of many populations under the ESA. Recovery goals have not been achieved despite substantial efforts, and there is a need to better understand the effects of various threats and ecosystem drivers on population dynamics. Three factors are of particularly high interest: (1) the effect of the quality of freshwater habitats used for egg incubation and juvenile rearing; (2) the effect of broad-scale ocean conditions on marine survival; and (3) the effect of predation by marine mammals. The goal of this project is the development of an integrated population modeling framework for spring-summer Chinook salmon, built by combining count and mark-recapture data, and designed to allow for evaluation of the effects of management and threats on Chinook salmon. The resulting model could facilitate evaluation of the benefits of past habitat restoration actions, could support decisions about future actions, and could provide an assessment of population viability. This project is a collaboration among the USGS, the University of Washington, the NOAA Northwest Fisheries Science Center, the Washington Department of Fish and Wildlife, and the Yakama Nation.

Chinook salmon. Photograph by the U.S. Geological Survey.

Understanding Common Loon Distribution and Abundance in Washington

Washington Cooperative Fish and Wildlife Research Unit

The common loon is a State species of concern in Washington. The species was once thought to be fairly common in eastern and western Washington but likely declined in the early decades of the 20th century. Planning conservation efforts for the species is complicated by lack of information on the abundance and distribution of the species in Washington. An objective of this project is to understand the factors affecting site occupancy of loons in Washington based on existing State survey data and citizen science (eBird) data. Additionally, the researchers seek to design a sampling strategy and conduct a simulation study that could describe expected precision in occupancy estimates as a function of sampling effort and spatial coverage. Improved information on distribution of common loons, along with study design recommendations to improve data in the future, could produce more robust information to guide status assessment and recovery of common loons in Washington.

Publication

Sipe, H.A., 2019, Multi-state occupancy modeling and optimal allocation of survey resources for common loons in Washington State: Seattle, University of Washington, Master's thesis, 78 p., http://hdl.handle.net/1773/45270.

Creation and Development of Early Successional Habitat and Wildlife Use

West Virginia Cooperative Fish and Wildlife Research Unit

Wildlife species that depend on young forest conditions are declining. At the same time, linear features in the landscape (for example, powerlines, pipelines, and roads) are increasing and creating hard forest edges within forested landscapes. This study examined creation of young forest habitat along linear edges by softening hard edges to benefit early successional-dependent species (specifically birds and terrestrial salamanders). Results provided land managers with information on intensity and width of harvest treatment to optimize management activities for young forest species while minimizing negative effects on mature forest species with a focus on SGCN.

Developing a Long-Term Paddlefish Monitoring Program on the Ohio River in West Virginia

West Virginia Cooperative Fish and Wildlife Research Unit

The paddlefish is a unique, long-lived, and large-bodied fish of the Mississippi River drainage. This species has undergone dramatic population declines owing to anthropogenic alterations of large river ecosystems. Many State natural-resource agencies, including West Virginia, are conducting stocking programs toward recovery of paddlefish populations. A long-term monitoring effort is needed to evaluate the success of this program. The goal of this study is to evaluate population status, movement patterns, and reproductive success of paddlefish in the Ohio River of West Virginia. Information from this study could inform management decisions for this species, helping the West Virginia Division of Natural Resources toward their goal of a re-established population of paddlefish in the Ohio River. This research is a collaborative effort involving the USGS, West Virginia University, the West Virginia Division of Natural Resources, and Missouri State University.

Pre- and Post-Treatment Monitoring on Working Lands for Wildlife and Regional Conservation Partnership Program Sites in West Virginia

West Virginia Cooperative Fish and Wildlife Research Unit

Cerulean warbler and golden-winged warbler are two high-priority species for conservation on private lands in West Virginia through NRCS conservation practices. The effectiveness of these conservation practices for increasing cerulean warbler and golden-winged warbler populations on private lands has not been examined. This project, in partnership with the West Virginia Division of Natural Resources and the NRCS, is quantifying avian populations before and after implementing NRCS conservation practices. Focal species for the research also include blue-winged warblers and other species in need of conservation in the region. Results could help to improve future habitat management actions for these species.

Developing eDNA Metabarcoding Methods for Freshwater Mussels

Wisconsin Cooperative Fishery Research Unit

Mussels are an important component of river ecosystems but have undergone substantial declines throughout their range. Information is needed on mussel diversity and distribution so populations can be managed effectively. This project intends to leverage genetic techniques (eDNA metabarcoding) to improve estimates of mussel diversity in Michigan rivers. The techniques developed here can be used to conduct research that could inform mussel conservation strategies in the future. This project is a collaboration between the USGS and the USFWS.

Evaluating Methodologies for Estimating Age and Growth of Lake Sturgeon

Wisconsin Cooperative Fishery Research Unit

Use of accurate age data is critical to effective fisheries management because age data are incorporated into population dynamics models to assess growth and mortality. Age estimates from pectoral fin spines can underestimate the age of lake sturgeon, the use of otoliths requires the fish to be sacrificed, and age estimates have been variable. Application of other methods to evaluate age and growth through correction factors and mark-recapture data have been limited, but a rich dataset exists for lake sturgeon on the Lake Winnebago System to evaluate these techniques. The goal of this study is to evaluate four different methodologies (otoliths, pectoral fin spines, corrected spines, and Fabens-Wang models) for assessing age and growth of lake sturgeon on the Lake Winnebago System. The use of otoliths to augment the pectoral fin spine correction factor for lake sturgeon allows for a nonlethal method of estimating age in the future on a more globalized scale. This research is a collaboration with the Wisconsin DNR.

Identifying Sources of Lake Sturgeon Recruitment in the Lake Winnebago System With an Assessment of Reproductive Success in Relation to Size and Sex

Wisconsin Cooperative Fishery Research Unit

Lake sturgeon spawn in many locations within the Lake Winnebago System, and many fish make extensive spawning migrations into the Fox and Wolf Rivers and their tributaries. The contribution of different spawning locations to the overall lake sturgeon population is unknown at this time, and this information is critical in developing management strategies. Identifying the contribution of different spawning locations to spearing harvest would allow managers to determine if this harvest differentially affects certain spawning groups or stocks. Furthermore, little is known about the relative number of recruits that are produced at different spawning locations, and this information could help guide efforts to increase recruitment at some locations through habitat improvement. Information from this study could have important implications for harvest management if the probability of producing offspring varies among fish of different sizes. This project is a collaboration among the USGS, the University of Wisconsin-Stevens Point, and the Wisconsin DNR.

Maximizing the Capture of Lake Sturgeon and Other Species in the Fish Elevator on the Menominee River

Wisconsin Cooperative Fishery Research Unit

Populations of lake sturgeon have decreased drastically over the past two centuries. This is due to a suite of factors including overfishing, habitat loss and fragmentation, and water-quality degradation. Dams impede historic travel corridors and, because of the physiology and benthic orientation of lake sturgeon, make conventional fish passage (for example, fish ladders) inaccessible for these fish. The Menominee Dam on the Menominee River, Michigan and Wisconsin, is only 3.9 kilometers upriver from Green Bay; therefore, a fish elevator was constructed in 2014 to capture, sort, and trap-and-transfer lake sturgeon upstream from the two lowest dams. This is the first elevator specifically targeting lake sturgeon. The goals of this study are to provide guidelines for operating the elevator that will optimize lake sturgeon captures and offer information on behaviors near dams that may benefit other managers considering passage. This project is a collaboration among the USGS, the USFWS, the University of Wisconsin-Stevens Point, the Michigan DNR, and the Wisconsin DNR.

Landscape-Scale Management of Grassland Birds in Wisconsin

Wisconsin Cooperative Wildlife Research Unit

It is widely recognized that grassland obligate birds are declining faster than any other bird community in the Upper Midwest. Recently, conservation delivery has changed from focusing on individual sites at the local scale to focusing on landscape-scale conservation areas. This project intends to estimate State-level densities for a suite of grassland birds in the Midwest. This information could be used to evaluate the importance of current landscape-scale conservation areas in Wisconsin for grassland bird populations. This project is a collaboration among the USGS, the USFWS, and State natural resource managers in the Midwest.

Strategies for Reducing the Vulnerability of Grassland Birds to Climate Change Within the Central Flyway

Wisconsin Cooperative Wildlife Research Unit

The management and conservation of grassland birds often focuses on habitat protection and restoration, but there is growing recognition that grassland birds are sensitive to climate variability such as drought, heat waves, and flooding. A synthesis of climate change vulnerability for grassland birds is needed in the Central Flyway to identify information gaps and management strategies useful for developing climate adaptation plans for grassland birds and their habitats. The goal of this project is to develop a report documenting adaptation strategies and information gaps needed for implementing those strategies to inform managers in the Central Flyway. The project is a collaboration of managers and researchers across multiple agencies and includes the USGS, the USFWS Habitat and Population Evaluation Team, and State, Federal, and NGO natural resource managers in the Central Flyway.

Black Rosy-Finch Distribution, Abundance, and Habitat Selection During the Breeding Season

Wyoming Cooperative Fish and Wildlife Research Unit

The black rosy-finch has a fairly restricted geographic range within the Intermountain West and is one of the most understudied species in North America. The black rosy-finch has been designated an SGCN in Wyoming, reflecting the lack of information available on this species. As a high elevation obligate nester, range contraction and habitat changes resulting from warming weather trends could lead to local extirpation of the species. The goals of this project are to obtain data currently lacking on breeding habitat selection and requirements and to identify key characteristics of summer breeding habitat to build a predictive model. This study addresses conservation actions as identified in the SWAP, including the establishment of optimal long-term monitoring sites, which could be used for tracking population trends and changes in habitat use given changing weather conditions in the alpine. The primary project cooperator is the Wyoming Game and Fish Department.

Great Gray Owl Habitat Selection and Home Range Characteristics During the Breeding and Postfledging Periods

Wyoming Cooperative Fish and Wildlife Research Unit

The great gray owl is a species of conservation concern in Wyoming and is associated with older-aged boreal forest habitats, which are affected by wildfire, disease and beetle outbreaks, drought, climate change, logging, and development. Very little is known, however, about great gray owl habitat requirements and territory size during the nesting and postfledging periods. Information generated from the study could substantially enhance the State's ability to address

the unknown aspects of the species' biology, update the species' account in the SWAP, and provide insight for the implementation of future monitoring efforts and management strategies. The primary project partners are the NPS, the USFS, the Wyoming Game and Fish Department, and the Teton Raptor Center.

Habitat Selection and Quality of Wood Frogs in the Bighorn Mountains

Wyoming Cooperative Fish and Wildlife Research Unit

Wyoming contains the most disjunct populations of wood frogs in the species' North American range. A glacial relict species, the wood frog occurs as two isolated populations in Wyoming, including one in the Medicine Bow Range. Because of their limited distribution, isolation, and lack of data on habitat use and population status, the wood frog is listed as an SGCN in the Wyoming SWAP. In addition, the chytrid fungus, which is responsible for the chytridiomycosis disease and amphibian declines and extirpations worldwide, is present in the Medicine Bow, rendering information about ideal habitat characteristics necessary and timely. The main project cooperator is the Wyoming Game and Fish Department, with cooperation from the Medicine Bow National Forest.

Seasonal Movement of Roundtail Chub in the Blacks Fork Drainage

Wyoming Cooperative Fish and Wildlife Research Unit

Freshwater fishes are threatened because of water diversion, habitat alteration, and nonnative species. The roundtail chub is a fish species endemic to the Colorado River Basin that currently occupies only 45 percent of its historic range. The Blacks Fork population constitutes the largest

Wood frog. Photograph by Gary Eslinger, U.S. Fish and Wildlife Service.

Great gray owl. Photograph by Brian Uher-Koch, U.S. Geological Survey.

contiguous (that is, not fragmented by barriers) population of roundtail chub remaining in Wyoming, but very little is known about their current status and life history. The goal of this study is to determine general movement patterns of all roundtail chub life stages, timing of movements, how populations are connected, and whether they are using tributaries. The results of this study could provide information necessary for managers to conserve roundtail chub populations in the Blacks Fork drainage and across their range. This project is a collaboration with the Wyoming Game and Fish Department.

Spatiotemporal Pattern of Hybridization With Walleye and Genetic Divergence in Sauger Life Histories in the Bighorn River Sauger Population

Wyoming Cooperative Fish and Wildlife Research Unit

Sauger are listed as an SGCN in Wyoming because of habitat fragmentation, competition with nonnative fish, and potential loss of genetic integrity because of coexistence and hybridization with walleye. These species hybridize in locations where they are sympatric, and experimental crosses have confirmed viability of hybrid offspring. There is a need to understand hybridization and the degree of threat it poses to native sauger populations. In conjunction with the Wyoming Game and Fish Department, researchers are determining the extent of hybridization and describing the genetic structure of sauger. This project could provide essential information for management and conservation of sauger in the Bighorn River system by identifying frequency and extent of hybridization. Characterizing genetic divergence among life histories could also help to prioritize conservation actions if hybridization is detected in one or more of the life history forms of sauger.

Sauger. Photograph by the U.S. Fish and Wildlife Service.

Survival of Boreal Toads Across Multiple Life Stages in Relation to Habitat, Grazing, Disease, and Climate

Wyoming Cooperative Fish and Wildlife Research Unit

The boreal toad was once widespread and common but has suffered substantial population declines in the Rocky Mountain region. As a result, the boreal toad is an SGCN in Wyoming. Factors believed to be contributing to boreal toad decline include disease, habitat loss and alteration, pollution, and changing weather. The overall project objective is to develop a better understanding of boreal toad survival at multiple life stages in relation to habitat, grazing management practices, disease, and climatic variables. Study results could clarify risks to the population sustainability of boreal toads in Wyoming and beyond and the specific mechanisms underlying survival across life stages. Project partners include the USGS, the USFS, and the Wyoming Game and Fish Department.

Boreal toad with transmitter. Photograph by the U.S. Geological Survey.

Boreal toad on a burned log. Photograph by Blake Hossack, U.S. Geological Survey.

Threatened and Endangered Species

Captive Rearing and Propagation of Critically Endangered Moapa Dace

Arizona Cooperative Fish and Wildlife Research Unit

Highly endangered fishes are threatened by habitat loss and competition by introduced species. Moapa dace is an endangered cyprinid endemic to the Warm Springs area of Clark County, Nevada. Managers needed to develop techniques to propagate and rear Moapa dace in captivity. Moapa dace were successfully transported and reared using slow acclimation and aggressive prophylactic treatment and were successfully spawned after 14 different trials of propagation techniques. Currently, the Nevada Department of Wildlife is using these techniques to rear and spawn the only Moapa dace population in captivity. This project was a collaboration among the USGS, the USFWS, the Nevada Department of Wildlife, the University of Arizona, and the Southern Nevada Water Authority.

Publications

Ruggirello, J.E., Bonar, S.A., Feuerbacher, O.G., Simons, L.H., and Powers, C., 2018, Propagation of endangered Moapa dace: Copeia, v. 106, no. 4, p. 652–662, https://doi.org/10.1643/OT-18-036.

Ruggirello, J.E., Bonar, S.A., Feuerbacher, O.G., and Simons, L.H., 2020, Use of underwater videography to quantify conditions utilized by endangered Moapa dace while spawning: North American Journal of Fisheries Management, v. 40, no. 1, p. 17–28, https://doi.org/10.1002/nafm.10356.

Environmental Conditions Used by Endangered Moapa Dace While Spawning

Arizona Cooperative Fish and Wildlife Research Unit

Knowledge of habitat use of all life stages of fish is important for their conservation. Needed spawning habitat can be difficult to ascertain for many fishes, especially rare species. Moapa dace is a critically endangered cyprinid endemic to the Warm Springs area of Clark County in southeastern Nevada. Spawning by Moapa dace had never been documented; consequently, the environmental conditions they require for this critical aspect of their life history were unknown. New methods of underwater videography technology were deployed in the uppermost reach of a Nevada desert stream to capture Moapa dace spawning activity and describe the conditions under which that occurred. Knowledge of Moapa dace spawning ecology provided vital data for managers to manage habitat and to identify factors that induce spawning in captivity. This information was used to spawn Moapa dace successfully for the first time in captivity. This project was a collaboration among the USGS, the USFWS, the Nevada Department of Wildlife, the University of Arizona, and the Southern Nevada Water Authority.

Publication

Ruggirello, J.E., Bonar, S.A., Feuerbacher, O.G., and Simons, L.H., 2020, Use of underwater videography to quantify conditions utilized by endangered Moapa dace while spawning: North American Journal of Fisheries Management, v. 40, no. 1, p. 17–28, https://doi.org/10.1002/nafm.10356.

Monitoring Chinook Salmon in Redwood Creek to Assess the Effects of a Modified Estuary

California Cooperative Fish and Wildlife Research Unit

Effective fisheries management relies on understanding how populations respond to habitat modifications resulting from environmental changes and restoration efforts. Pacific salmon rely on freshwater and marine habitats during different phases of their life history; thus, it is necessary to monitor adult and smolt abundances to differentiate how conditions in these different habitats affect demographic rates. The goals of this project are to monitor adult and juvenile salmonids in Redwood Creek, California, and to build a life-cycle model for the Chinook salmon population. Monitoring data could be used to parameterize a life-cycle model to assess the effect of restoration efforts and climate change on the abundance of the Chinook salmon population in Redwood Creek. This is a collaborative effort, which includes the USGS, the California Department of Fish and Wildlife, and Humboldt State University.

Monitoring the Endangered Tidewater Goby Using eDNA in Water Samples—Phase II

California Cooperative Fish and Wildlife Research Unit

eDNA is a cost-effective and noninvasive technique that can be used to assess the presence of organisms in aquatic systems and has been successfully applied to a broad range of taxonomic groups, including fishes. Studies show that eDNA can closely track presence and absence and can be useful for monitoring species that cannot be detected using conventional field approaches. This project assesses the potential of using eDNA in water samples as a tool for monitoring the endangered

tidewater goby in lagoon and bay habitats. Surveys could be conducted in 15 water bodies in northern California using traditional field surveys for tidewater goby while simultaneously collecting water samples from each site to test for the presence of DNA of tidewater goby. Results could allow for the evaluation of eDNA as a tool to determine the presence and (or) relative abundance of endangered tidewater goby. Research partners include the USGS, the USFWS, and Humboldt State University.

Tidewater goby. Photograph by the U.S. Fish and Wildlife Service.

Monitoring Threatened Coho Salmon Populations in Humboldt Bay Tributaries

California Cooperative Fish and Wildlife Research Unit

Continuing the long-term monitoring of adult abundance of Coho salmon in Humboldt Bay tributaries is essential for status and trends assessments of regional salmon stocks. The goal of this project is to provide annual estimates of juvenile and adult abundance for the Coho salmon population in Freshwater Creek, California. The project also intends to incorporate juvenile tagging and detection efforts in streams adjacent to Freshwater Creek to characterize dispersal among tributaries. Researchers plan to use these parameters, in combination with estimates of population synchrony across basins from the time series of escapement data, to evaluate potential metapopulation dynamics of Humboldt Bay tributaries. In addition, the expanded tagging and detection efforts could allow for the comparison of life-history diversity that has been characterized in Freshwater Creek across basins that differ in habitat and restoration status. As habitat restoration and enhancement projects proceed in the Humboldt Bay watershed, ongoing monitoring could provide insight into the response of Coho salmon populations to these conservation efforts. This project is a cooperation with the USGS; the California Department of Fish and Wildlife; Humboldt Fish Action Council; Humboldt State University; the Pacific Coast Fish, Wildlife and Wetlands Restoration Association; the Pacific States Marine Fisheries Commission; and the Redwood Community Action Agency.

Prairie Creek Coho Salmon Life-Cycle Monitoring

California Cooperative Fish and Wildlife Research Unit

Within the Prairie Creek Basin, it is unclear if changes in salmonid numbers are caused by recovery from improvements in freshwater habitat conditions or by changes in ocean conditions. Therefore, data are needed to accurately identify factors limiting the recovery of Coho salmon and to identify restoration needs in the basin. The goal of this project is to determine baseline and status and trend population information for Coho salmon and other anadromous salmonids in the study area by estimating freshwater survival and emigration timing of tagged juvenile Coho salmon; population sizes of emigrating Coho salmon and other salmonids; and numbers of live adult fish, redds (nests), and carcasses of Coho salmon and other anadromous salmonids that are returning to Prairie Creek to spawn. The adult counts and emigrant smolt counts can be used to provide relative estimates of freshwater and marine survival. The freshwater survival and abundance and size of yearling Coho salmon smolts emigrating from Prairie Creek can be used as the benchmark for other streams because much of Prairie Creek is in pristine condition. Cooperating organizations include the USGS, the California Department of Fish and Wildlife, the National Marine Fisheries Service, Redwood National and State Parks, and Humboldt State University.

Tracking Coho Salmon Using eDNA

California Cooperative Fish and Wildlife Research Unit

Coho salmon in northern California are valuable ecologically and culturally, and they compose a fundamental component of redwood forest ecosystems. Coho salmon within northern California have been listed as threatened under the ESA. Recovery of these populations requires effective management actions that depend on collecting reliable and timely survey information on Coho salmon abundance and distribution. Further, the success of restoration efforts is contingent upon the ability to effectively measure the response of salmon populations after restoration. This project examines the potential of using eDNA to assess salmon populations. The existing fish monitoring infrastructure in Prairie Creek can be used to compare daily measurements of abundance and biomass of emigrating Coho salmon with eDNA concentrations taken from water samples at the trap site. Results could be used to improve population management and assess the effectiveness of restoration efforts.

Fish Population Models

Colorado Cooperative Fish and Wildlife Research Unit

Challenges to monitoring the population status and dynamics of endangered humpback chub include remote locations (the Colorado and Little Colorado Rivers), periodic capture, difficulty tagging early life stages, and optimal accessibility for capture during spawning. Recently, arrays of PIT tag readers have been installed to increase the chance of tagged chub being detected. A model that integrates PIT tag detections with traditional recapture data is needed to better understand the population size and dynamics of humpback chub. The results of the model of population size and vital rates could be used to better inform proposed management actions that affect the chub. This project is a collaboration of the USGS, the USGS Grand Canyon Monitoring and Research Center, and the USFWS.

Preliminary Evaluation of Santa Ana Sucker Responses to Wastewater Treatment Plant Effluent in the Santa Ana River

Colorado Cooperative Fish and Wildlife Research Unit

The Santa Ana sucker is a federally threatened fish native to the larger streams of southern California's Los Angeles Basin. Within the Santa Ana River, the Santa Ana sucker population exists in an effluent-dominated system, and current habitat restoration efforts may not be sufficient to overcome the negative consequences of wastewater treatment plant effluent exposure. The goal of this project is to provide a preliminary assessment of potential negative effects of exposure to wastewater effluent, particularly exposure to estrogenic compounds. Understanding the potential effect of water quality on Santa Ana suckers is a high priority for the recovery and management of this endangered species. The project is being conducted with the USFWS, the San Bernardino Valley Municipal Water District, the University of Colorado, and the U.S. Environmental Protection Agency.

Ecology of the Endangered Nordmann's Greenshank

Florida Cooperative Fish and Wildlife Research Unit

The Nordmann's greenshank is a critically endangered shorebird that breeds in far eastern Russia and migrates through and overwinters in east and southeast Asia. Little is known about this critically endangered species. The USGS is working with Russian collaborators and the Wildlife Conservation Society to find and describe breeding areas and capture and mark birds. In 2019, the first Nordmann's greenshank nest since the 1970s was discovered. Information on basic life history of the species can assist in making management decisions that will protect important breeding areas. Resightings of marked birds can assist in determining migratory pathways and overwintering areas in the East Asian-Australasian Flyway.

Movements and Overwinter Survival of Juvenile Red Knots in the Southeast United States—Information Needs for Recovery Planning

Florida Cooperative Fish and Wildlife Research Unit

Much of the focus of red knot research and conservation over the past 20 years has largely focused on a few sites along the Atlantic Flyway, primarily in the mid-Atlantic region. The distribution of juvenile red knot is not yet fully known. The primary goals of this project are to identify the main area where juvenile red knot occur during their first 2 years of life, to estimate survival rates, and to estimate recruitment rates. Results could be used by listing biologists to better understand conservation threats during the juvenile life stage of red knots. Partners for this study include the USFWS, the Florida Fish and Wildlife Conservation Commission, the Georgia DNR, and the South Carolina DNR.

Nutritional Ecology and Husbandry of the Central American River Turtle

Florida Cooperative Fish and Wildlife Research Unit

The Central American river turtle is a critically endangered freshwater turtle endemic to Central America, although only a few scientific studies have been conducted that focus on the unique biology and ecology of this species. Captive breeding programs for wild release have been identified as an important component of conservation efforts for the Central American river turtle, but relatively little is known about their biology and ecology. Knowledge gained from this study could address the long-term conservation goals by informing husbandry practices, captive breeding protocols, and management of the Central American river turtle. This project is collaborating with the Belize Foundation for Research and Environmental Education and the Turtle Survival Alliance.

Benefit-Cost Analysis for the Threatened and Endangered Species Program of the Bureau of Land Management

Georgia Cooperative Fish and Wildlife Research Unit

Determining the potential benefits of proactive conservation is an important step toward being able to implement operational cost savings or other programmatic benefits for the management of threatened and endangered species. The USGS is partnering with applied economists at the University of Georgia to quantify and monetize the resulting beneficial outputs stemming from a selection of BLM programs. They intend to evaluate the benefits of avoiding the listing of a species or the delisting of a previously listed species. Project tasks include producing an annotated bibliography with a narrative discussion related

to economics of endangered species and ESA programs and seeking additional Federal case-study examples to document restrictions, expenditures, transaction costs, or benefits related to delisting or avoiding listing. Results could be used by BLM in their assessment of management programs for threatened and endangered species on lands they manage.

Comparing Recruitment Estimation Methods for Age-1 Atlantic Sturgeon in the Altamaha River, Georgia, from 2008 to 2020

Georgia Cooperative Fish and Wildlife Research Unit

The Atlantic sturgeon is an anadromous fish species that was once of great commercial importance in many of the coastal rivers of the eastern United States. As a result of multiple centuries of overharvest and habitat degradation, this species is now listed as endangered over most of its range. Three abundance estimation methods, which consider different components of the capture data including spatial information, environmental covariates, and varying effort, are intended to be used to estimate age-1 abundance of Atlantic sturgeon in the Altamaha River, Georgia. Comparing the precision of these methods could improve future population estimates as well as give insight into the abiotic factors affecting recruitment variability within Atlantic sturgeon populations. The project is a collaboration among the USGS, the University of Georgia, the National Marine Fisheries Service, and the Georgia DNR.

Head-Starting as a Recovery Strategy for the Desert Tortoise

Georgia Cooperative Fish and Wildlife Research Unit

The Mojave Desert tortoise population, classified as threatened under the ESA, is in decline and in need of active management for population recovery. The rearing of neonate tortoises until they are more likely to survive (head starting) is one strategy for population augmentation. Although head starting has intuitive appeal as a conservation strategy, the strategy is expensive, and its success depends on how soon and how successfully head-started animals reproduce in the wild compared to wild-reared animals. The goal of this research is to evaluate the function and performance of head-started tortoises once released in the wild. This research could be used by conservation agencies and their partners to weigh tradeoffs between the costs of head starting against the expected benefit of head starting to enhance tortoise population growth and persistence. This research is conducted in collaboration with the University of Georgia's Savannah River Ecology Laboratory, the University of California-Davis, and the NPS.

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Restoring a Relict Population of Gopher Tortoises Through Translocation of Waif Animals

Georgia Cooperative Fish and Wildlife Research Unit

The gopher tortoise has declined over most of its range and is currently a candidate for listing under the ESA. Active conservation management is being used, including the translocation of waif tortoises (animals temporarily in human custody that cannot be returned to the point of origin in the wild) in some efforts to augment existing populations. The efficacy of translocating waif animals for the purpose of population augmentation is unknown, both with respect to the demographic performance of released tortoises and the health of the population into which they are released. The goal of this research is to provide needed information on the benefits and risks of translocating waif tortoises. This research could be used by conservation agencies and their partners to weigh the risks of using waif animals for reintroduction stock to augment existing populations. This research was conducted in collaboration with the University of Georgia's Savannah River Ecology Laboratory and the South Carolina DNR.

Publication

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Dispersal Behavior of Yuma Ridgway's Rail

Idaho Cooperative Fish and Wildlife Research Unit

Since 2005, the number of Yuma Ridgway's rail detected through standardized surveys across its range has decreased by 52 percent. Reasons for the decline are unclear, and most of this decline has occurred at managed wetlands near the Salton Sea, California. Currently, the species is restricted to small patches of emergent wetland vegetation affected by multiyear drought. These isolated patches are separated by stretches of farmland and open desert with solar facilities, which may attract dispersing rails that mistake the solar array reflection for water. This research could determine the dispersal distances, dispersal direction, and dispersal behavior of juvenile Yuma Ridgway's rail via individual tracking. Data could be used to inform monitoring strategies for fatalities at renewable energy facilities to evaluate total species effects.

Effectiveness of Forest Restoration Treatments on Demography of a Federally Listed Ground Squirrel

Idaho Cooperative Fish and Wildlife Research Unit

Fire suppression over the past century has caused widespread changes to the structure and function of coniferous forests in the western United States. Forest restoration efforts to reverse these changes must ensure that restoration prescriptions will not adversely affect federally listed species. Northern Idaho ground squirrels are federally threatened and have a very small range in central Idaho. This project is comparing the effects of two forest treatments on northern Idaho ground squirrels. The results could help determine whether thinning and fire treatments can be used to improve habitat suitability for northern Idaho ground squirrels. The project is a collaboration among the USGS, the USFS, the USFWS, and the Idaho Department of Fish and Game.

Northern Idaho ground squirrel. Photograph by the U.S. Fish and Wildlife Service.

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Effects of Spring Cattle Grazing on Demographic Traits of Greater Sage-Grouse

Idaho Cooperative Fish and Wildlife Research Unit

The greater sage-grouse was once widespread within sagebrush-grassland ecosystems of western North America, but populations declined substantially during the 20th century. Given the ubiquity of livestock grazing within sage-grouse habitat and the lack of rigorous scientific data to inform the debate regarding the effects of grazing on sage-grouse populations, the goal of this project is to experimentally evaluate the effects of cattle grazing on demographic traits and habitat characteristics of greater sage-grouse over a 10-year period. The results could help guide management actions and inform policy and litigation decisions throughout the western United States. The project is a collaboration among the USGS, the USFWS, the BLM, the University of Idaho, the Public Lands Council, and the Idaho Department of Fish and Game.

Energetic Effects of Passage Delays in Migrating Adult Atlantic Salmon

Maine Cooperative Fish and Wildlife Research Unit

Atlantic salmon, including those that spawn in the Penobscot and Kennebec Rivers of Maine, are federally endangered, and their numbers remain low. Inefficient fishways at dams in Maine continue to slow and prevent upstream migrations to spawning habitat, and delays of weeks to months are common. These delays expose fish to elevated water temperatures, resulting in increased metabolic demands. These energetic costs have not been quantified, nor have fitness outcomes been characterized, but energy loss may affect gonadal development, spawning performance, and probability of surviving to spawn again. Consequently, the goal of this research is to characterize specific energetic costs of the delays to upstream migrating adult salmon using bioenergetics modeling. Understanding tradeoffs in overall fitness with respect to migration delays could inform development of dam passage criteria standards. This project is a collaboration between NOAA and the Maine Department of Marine Resources.

Optimizing Strategies to Hydraulically Plant Atlantic Salmon Eggs Based on Fry Dispersal Patterns

Maine Cooperative Fish and Wildlife Research Unit

The Gulf of Maine Distinct Population Segment of Atlantic salmon has suffered from habitat loss and exploitation over the past century. Hatchery supplementation has played an important role in the management and population persistence of Atlantic salmon over the past decades. Stocking older life-history stages minimizes early life-history mortality but does so at a cost of limiting exposure to a natural freshwater environment. Egg planting is a process by which fertilized eggs from the hatchery are injected into the gravel in the fall to replicate the natural spawning process in streams and provide a natural experience for larvae and fry, which can be important for adaptation. Egg planting has been used experimentally within the region, but substantial uncertainties exist in implementing this approach at a larger scale. The goal of this research is to characterize the dispersal pattern of egg-planted Atlantic salmon as a function of habitat and subsequently use that pattern to construct a geographic information system-based tool to inform stocking and help to optimize the application of egg planting at a functional management level. Project partners include the USFWS, NOAA, the Maine Department of Marine Resources, and the Penobscot Nation.

Passage of Adult Atlantic Salmon in the Penobscot River Before and After Dam Removal

Maine Cooperative Fish and Wildlife Research Unit

The Penobscot River has experienced two main-stem dam removals and other engineering changes, including the installation of a fish lift at Milford Dam (the lowest dam in the system) to improve fish passage upstream, aiding restoration efforts of Atlantic salmon (a federally endangered fish). Acoustic, radio telemetry, and PIT tag technology were used to characterize migration patterns and passage efficiency of adult Atlantic salmon through the system. Characterizing migration patterns and passage efficiency in the Penobscot River could inform restoration strategies for Atlantic salmon into the future. The research was conducted in collaboration with the USFWS, NOAA, the Penobscot Nation, the Maine Department of Marine Resources, Brookfield Power, The Nature Conservancy, and the Penobscot River Restoration Trust.

Atlantic salmon. Photograph by the U.S. Geological Survey.

Publication

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Understanding Downstream Migratory Survival of Atlantic Salmon Smolts in the Penobscot River Maine—Effects of Dams and Restoration

Maine Cooperative Fish and Wildlife Research Unit

The downstream migration of Atlantic salmon juveniles is a critical stage in their life cycle. During this stage, individuals undergo a series of morphological, physiological, and behavioral changes that prepare them for the migration and for life at sea. Acoustic and radio telemetry surveys were used to study survival of emigrating juveniles in the Penobscot River and identified two areas of high concern, namely dams and the estuary. The system-wide survival of smolts in the Penobscot River has been consistently low throughout the years, but the effect of stocking timing, flow, and delays are being revealed. These data are being used to inform stocking strategies and stimulate innovative restoration techniques. Together with NOAA, the USFWS, and the Penobscot Nation, researchers are working to understand how the range of conditions in the river can affect the odds of restoration success.

Brook Floater Research and Conservation

Massachusetts Cooperative Fish and Wildlife Research Unit

The brook floater is a stream-dwelling freshwater mussel native to the Atlantic slope of the United States and Canada that has experienced large population declines during the past 50 years and is at high risk of extinction. The species' distribution has been restricted to about 50 percent of its historical sites; the species is listed as threatened or endangered by most States where it occurs and has been petitioned for listing under the ESA. This project aims to reduce further population losses and restore the brook floater throughout its range through cooperative conservation efforts and strategic planning. Population augmentation and reintroduction have been identified as critical components of a recovery plan, and this research will develop methods to propagate the brook floater. In addition, the goal of this project is to develop and implement a rapid assessment protocol and a long-term monitoring protocol that can be used throughout the range of the brook floater to create comparable datasets and develop a species distribution model. This research is a collaboration among the USGS, the USFWS, the Massachusetts Division of Fisheries and Wildlife, the Connecticut River Conservancy, several State agencies along the east coast from Maine to Georgia, mussel biologists, and consultants; the project also includes citizen science involvement in mussel and habitat surveys and numerous restoration and outreach efforts.

Dwarf Wedgemussel Propagation and Restoration in the Mid-Atlantic and Northeastern United States

Massachusetts Cooperative Fish and Wildlife Research Unit

The dwarf wedgemussel is a small, freshwater mussel historically known from at least 15 Atlantic slope drainages from New Brunswick, Canada, to North Carolina; however, population declines throughout its range resulted in Federal listing of the species in 1990. The decline of dwarf wedgemussel in areas previously thought to have the most viable and largest populations leads to substantial concerns about the long-term The the develop in-vitro propagation techniques, to conduct laboratory experiments to assess different culture methods, to compile data on dwarf wedgemussel populations and habitat requirements, to collect and synthesize data on host fish populations, and to assess population genetics. These data could be used to identify management units, develop broodstock genetic guidelines, develop criteria and a decision tree to select ideal locations for reintroduction and augmentation, and, ultimately, inform recovery and management decisions of this species. This project is a collaboration between the USGS and the USFWS.

Environmental Factors Controlling Juvenile River Herring Productivity and Emigration

Massachusetts Cooperative Fish and Wildlife Research Unit

River herring, collectively alewife and blueback herring, have been valued by human societies since precolonial times, but populations have undergone a dramatic coast-wide decline over the past five decades. Information on factors affecting freshwater productivity of juvenile river herring, emigration timing, and early seawater survival are needed to understand, predict, and mitigate population declines. The goal of this research is to examine the effects of abiotic and biotic factors on juvenile river herring growth, survival, physiology, and emigration rates. Results of this research could be used to inform population models for river herring stock assessments and decisions related to Federal listing of river herring under the ESA and management decisions toward restoring river herring in the northeast. This project is a collaboration among the USGS, the University of Massachusetts Amherst, the USFWS, Woods Hole Oceanographic Institution, the Connecticut Department of Energy and Environmental Protection, and the Massachusetts Division of Marine Fisheries.

Yellow Lampmussel Restoration Initiative

Massachusetts Cooperative Fish and Wildlife Research Unit

In North America, 72 percent of freshwater mussel species are endangered, threatened, or of special concern because of factors such as habitat loss and degradation, biological invasion, and land-use change. Propagation of freshwater mussels has been considered a necessary conservation strategy for population restoration where threats have been mitigated, but small population sizes limit population viability. Developing and refining culture methods for target mussel species is a critical step toward population restoration. Research on the effects of probiotic supplements and secondary rearing designs are critical for developing effective culture methods for the State-listed yellow lampmussel and could more broadly add to the limited literature on probiotic use and secondary rearing designs in freshwater mussel culture. This project is a collaboration of the USFWS and the Massachusetts Division of Fisheries and Wildlife.

A Geographic Information System-Based Rapid Assessment of Geographic Distribution and Habitat Conditions of the Endangered Puerto Rico Plain Pigeon After Hurricane Maria

Mississippi Cooperative Fish and Wildlife Research Unit

The plain pigeon is a large arboreal columbid of open woodlands of the Greater Antilles. The subspecies of plain pigeon in Puerto Rico is considered rare and is listed as endangered. Hurricane Maria moved across the island of Puerto Rico and across the center of the region occupied by plain pigeon, including the municipalities of Cidra, Aguas Buenas, Comerio, and Naranjito. This research used a spatial modeling approach to assess hurricane effects to plain pigeon habitat and to quantify damage to forest cover, including defoliation and loss of canopy. Plain pigeon numbers were negatively affected by Hurricane Maria, and surveys conducted for this rapid assessment by project personnel and cooperators suggest plain pigeon detections were reduced by more than 50 percent after the storm. Damage to plain pigeon habitat in the municipalities encompassing the study area was widespread with varying intensity depending on particular sectors in each municipality. The results could be instrumental for informing the next phase of research on posthurricane geographic distribution, movement, and dispersal to fully assess the effects of Hurricane Maria to the long-term recovery of the plain pigeon.

Rapid Assessment of Geographic Distribution and Habitat Conditions of the Critically Endangered Puerto Rico Sharp-Shinned Hawk After Hurricane Maria

Mississippi Cooperative Fish and Wildlife Research Unit

The Puerto Rican sharp-shinned hawk is an endangered woodland raptor of Puerto Rico. Individual populations are small and mostly known to occur on montane forest reserves on the island. Information is lacking on sharp-shinned hawk population status and use of private lands, particularly the coffee growing regions of the Cordillera Central. In 2017, Hurricane Maria hit Puerto Rico and caused extensive damage and alteration of forest structure, including loss of tree branches (for example, nesting structures), the opening of the forest canopy (about 90 percent of canopy loss), and a consequent increase in understory and midstory cover. Consequently, posthurricane forest conditions resulted in less available suitable habitat for the sharp-shinned hawk. This rapid assessment project quantified and documented initial damage to the vegetation structure of the Maricao, Guilarte, and Toro Negro Forests. As a result of the documented physical and structural damage, many basic ecological processes such as microclimates, rainfall patterns, nutrient cycling, and litter fall could be altered. Given the precarious situation of this endangered island raptor, the results could be critical for identifying sharp-shinned hawk survival and movements after Hurricane Maria to avoid the extinction of this critically endangered species.

Enhancing Survival and Condition of First-Feeding Larval Pallid Sturgeon through Diet

Montana Cooperative Fishery Research Unit

Conservation propagation facilities in the Upper Missouri River Basin are currently experiencing variable survival of first-feeding larval pallid sturgeon. This type of hatchery-induced selection can ultimately have unintended, negative consequences on genetic representation of pallid sturgeon returned to the Missouri and Yellowstone Rivers, and managers are now investigating potential sources of mortality in the hatchery. This study seeks to determine if survival and condition of first-feeding larval pallid sturgeon and successful weaning to a formulated diet can be enhanced by a diet more like the dietary options in the wild. The results of this study could be used to develop a feeding regimen to enhance survival and condition of larval pallid sturgeon in conservation propagation facilities. This project is in collaboration with the USFWS.

Prairie Stream Inventory

Montana Cooperative Fishery Research Unit

The pearl dace and the northern redbelly × finescale dace hybrid (hereafter hybrid dace) are designated as sensitive species by the BLM and as species of special concern by the Montana Department of Fish, Wildlife and Parks. These two species are facing existing threats, seem to have undergone substantial range contractions, and are at risk of extirpation from the State of Montana. Inventory surveys are needed to enable land managers to identify and prioritize potential areas and opportunities for long-term conservation of these species. This proposed research could benefit land-management agencies and the general public by identifying current distribution, threats, and habitat conditions of pearl dace and hybrid dace. Moreover, researchers are working with BLM land managers to identify and prioritize conservation areas, potential management actions, land-management practices, and inform National Environmental Policy Act analysis to ensure continued existence of pearl and hybrid dace and enhance the biotic integrity of prairie streams.

Conservation and Management of Andean Bears from Regional to Local Scales—Occupancy, Density, Connectivity, and Threats

New York Cooperative Fish and Wildlife Research Unit

The Andean bear is the only extant species of bear in South America and is considered threatened across its range because of habitat loss, fragmentation, and illegal hunting. In Colombia, Andean bear populations are isolated and exposed to a diverse degree of human-related threats, including human-bear conflict in the form of retaliatory hunting. Monitoring changes in the Andean bear population and relating those changes to threats and environmental variables is necessary for informing management decisions. The goal of this study is to evaluate farmers' attitudes about bears; the landscape factors and threats that contribute to regional occupancy of Andean bears; and the relation between density and occupancy of Andean bears. The results could be used to develop management strategies for Andean bears in the Colombia region that minimize human-bear conflicts and maximize occupancy objectives.

Optimal Sampling of Animal Communities

North Carolina Cooperative Fish and Wildlife Research Unit

The USFWS has about 2.4–2.5 million acres of private lands enrolled in the Safe Harbor Program for red-cockaded woodpeckers across the Southeast. Viewing the red-cockaded woodpeckers as a surrogate species, the USFWS is interested in quantifying and evaluating the conservation benefits of red-cockaded woodpecker practices on nonsurrogate species. The goal of this research is to develop a sampling scheme that can help USFWS quantify the benefits of Safe Harbor Management Agreements on nonsurrogate species across the southeastern United States. Because Safe Harbor Management Agreements affect present and future habitat conditions, the sampling scheme would be geared toward estimating parameters that quantify species richness and the dynamics of single species or avian communities over time (for example, occupancy, extinction and colonization rates, and inference about interactions). This work could use occupancy-based models and develop extensions, if needed, to deliver a robust and flexible sampling design for implementation across the Southeast.

Red-cockaded woodpecker. Photograph by the U.S. Fish and Wildlife Service.

Assessing Distribution of Yaqui Catfish in the Rio Yaqui Drainage, United States-Mexico

Oklahoma Cooperative Fish and Wildlife Research Unit

Yaqui catfish is a federally threatened species, extirpated from its native range in the wild in the United States and threatened in the remainder of its range in the Yaqui, Mayo, and Fuerte River Basins of Mexico. The Rio Yaqui drainage basin is the largest of the three basins and is the only shared basin between the two countries where Yaqui catfish occur. A major threat to Yaqui catfish is hybridization with nonnative Ictalurid species, particularly channel catfish, that have been stocked. Researchers are working with the USFWS Southwest Region using existing data and surveys of eDNA samples to model distribution of Yaqui catfish and nonnative channel catfish. This research could help identify factors affecting the occurrence of Yaqui catfish and identify new areas that might support Yaqui catfish recovery efforts.

Determining the Distribution of State-Endangered Longnose Darter through Niche Model Transferability

Oklahoma Cooperative Fish and Wildlife Research Unit

The longnose darter is a rare fish species, designated as endangered, in Oklahoma. Efforts to recover the species are hampered by poor information on the current distribution and abundance of the species. The goals of this study are to develop an environmental niche model and to determine the presence of longnose darter in the Poteau River system, particularly in the streams where the species has previously been documented (Poteau River and Brazil Creek) or translocated (Blackfork Creek). The model could be used to identify novel locations where longnose darter might occur and to strategically direct restoration efforts for the species.

Using eDNA to Assess the Presence of Cave Crayfish Populations in Caves of the Ozark Highlands

Oklahoma Cooperative Fish and Wildlife Research Unit

Several cave crayfish species occur within the Ozark region including several federally listed endangered or petitioned species. The distribution and abundances of these cave crayfish are largely unknown, and a few species are thought to be very rare and endemic to only one or a few caves. The goal of this research is to assess the usefulness of eDNA sampling to determine the presence of these rare cave crayfish populations in the Ozark Highlands ecoregion of Missouri, Arkansas, and Oklahoma. Results from this research could include estimates of detection probability for traditional cave surveys along with the use of eDNA. The study could provide surveillance data for more than 30 caves, springs, and wells across the area that the USFWS and partner agencies could use to develop protection and recovery actions. This project is a collaborative effort across multiple agencies including the USFWS, the USFS, the MDC, the Oklahoma Department of Wildlife Conservation, and The Nature Conservancy.

Avian Predation on Juvenile Salmonids in the Lower Columbia River

Oregon Cooperative Fish and Wildlife Research Unit

Avian predation on juvenile salmonids has been identified as a limiting factor for restoration of a number of ESA-listed salmonid species in the Columbia River Basin. In particular, several species of piscivorous colonial waterbirds, including Caspian terns, double-crested cormorants, California gulls, and ring-billed gulls, have been found to consume more than 2 percent of emigrating smolts in some listed populations. The goals of this project are to quantify the magnitude of smolt losses to avian predators, to design management actions to reduce avian predation rates on ESA-listed salmonids, and to evaluate the efficacy of management actions for enhancing survival of juvenile salmonids. Results have been used to design and implement three different management plans to reduce avian predation rates on Columbia Basin salmonid smolts, including two management plans in the Columbia River estuary and one in the Columbia Plateau region. These management plans have substantially reduced predation rates by Caspian terns and double-crested cormorants on some populations of Columbia Basin salmonids. This project is a partnership among the Bonneville Power Administration, the Northwest Power and Conservation Council, the USACE, NOAA Fisheries, and the USFWS.

California gull. Photograph by Josh Ackerman, U.S. Geological Survey.

Caspian tern. Photograph by Crystal Shore, U.S. Geological Survey.

Conservation of the Critically Endangered Chinese Crested Tern—Restoration of a Lost Breeding Colony

Oregon Cooperative Fish and Wildlife Research Unit

Chinese crested terns are likely the most endangered seabird species in eastern Asia and a flagship species for seabird conservation in China. The estimated global population of breeding adult Chinese crested terns is barely 100. The main threats to the species are illegal egg harvest and the increasing intensity and frequency of typhoons in the East China Sea. This project seeks to identify those factors currently limiting the reproductive success and population size of Chinese crested terns, their migratory routes, and overwintering range using a combination of satellite telemetry and field-readable leg band technologies. The information could be used to establish a dispersed network of safe, protected breeding colony sites for the common colony associate species for Chinese crested terns, the greater crested tern, as a means to provide nesting habitat and enhance reproductive success of Chinese crested terns. The project is a collaboration with the Zhejiang Museum of Natural History in Hangzhou, China, and a variety of bird conservation NGOs in China.

Evaluating Caspian Tern Management to Reduce Predation on Endangered Species Act-Listed Salmonids in the Columbia Plateau Region

Oregon Cooperative Fish and Wildlife Research Unit

Avian predation on juvenile salmonids in the Columbia River is a major natural resource management issue pitting migratory bird managers and advocates in a contentious policy debate over the role of water bird management in efforts to restore juvenile salmonids. Information is needed on the magnitude of smolt losses to avian predation, quantifying the effect of those losses to the demography of salmonid stocks, and evaluating the potential benefits to ESA-listed salmonid stocks from the Columbia River Basin of reducing avian predation through management. This research is using state-of-the-art GPS and satellite tracking devices to assess the effect of predation by Caspian terns nesting at Goose Island near the City of Moses Lake, Washington, on survival of juvenile salmonids belonging to ESA-listed evolutionarily significant units from the Upper Columbia River. This information is critical to resource management agencies and stakeholder groups wanting to reduce the effect of avian predation on ESA-listed salmonids.

The Demography of Northern Spotted Owls in Oregon and Washington

Oregon Cooperative Fish and Wildlife Research Unit

The northern spotted owl is listed as threatened under the ESA, primarily because of the loss of old growth forest habitat because of timber harvest. The Northwest Forest Plan was developed in the mid-1990s to conserve the owl and other old growth species while allowing greatly reduced levels of commercial timber harvest on Federal land. The plan required the implementation of a regional effectiveness monitoring program for the spotted owl. This research project collects and analyzes data from five of the seven spotted owl effectiveness monitoring program study areas across the owl's range. Results from this work are used to regularly evaluate population trends of spotted owls, as well as increase understanding of owl ecology, including dispersal, diet, nest site selection, behavior, genetics, and response to a recent, congeneric invader, the barred owl.

Northern spotted owl. Photograph by the U.S. Fish and Wildlife Service.

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Bobcat Population Dynamics on Cumberland Island National Seashore

Pennsylvania Cooperative Fish and Wildlife Research Unit

Bobcats were reintroduced to Cumberland Island National Seashore, Georgia, in 1988–89 to restore a native predator. The reintroduction of bobcats has reduced the deer population and allowed natural regeneration of live oaks and other plant species. Although bobcat populations are secure throughout their range, most felid species are threatened or endangered. The population on Cumberland Island can be considered equivalent to an endangered population (less than 30 individuals) because natural immigration is extremely rare. This project is studying the population dynamics and monitoring the genetic status of bobcats on the island to better understand when this population undergoes genetic bottlenecks and whether conservation actions are warranted to ensure the sustainability of the population on the island. This research is supported by the Pennsylvania Game Commission and the NPS.

Monitoring of Rock Gnome Lichen Populations

South Carolina Cooperative Fish and Wildlife Research Unit

Rock gnome lichen is an endangered species of lichen currently occupying the Southern Appalachians. Population monitoring for the species has occurred twice previously, but a consistent survey methodology is needed to monitor populations for 5-year status updates and potential delisting of the species in the future. Researchers are working with the USFWS to develop a monitoring protocol to provide a status and assessment tool for rock gnome lichen. The survey design could be implemented for future population monitoring efforts as well as inform ecology of the species related to the effects of hemlock woolly adelgid on rock gnome lichen populations through vegetation changes.

Hemlock woolly adelgid. Photograph by Jodi French-Burr, National Park Service.

Effect of Water Velocity and Temperature on Energy Reserves of Larval Pallid Sturgeon

South Dakota Cooperative Fish and Wildlife Research Unit

The larval phase of freshwater fishes is often characterized by high mortality. As with many fishes, the recruitment bottleneck for pallid sturgeon is believed to occur during their early life history. Recent work in the Upper Missouri River has shown that the amount of riverine drift habitat may be insufficient for larval development to transition to the fry stage. Moreover, cooler summer water temperatures in downstream reaches can prolong larval ontogeny, delaying their ontogenetic development. Given current conditions in the river, pallid sturgeon larvae develop at slower rates and require longer migration distances compared to historic conditions. The objective of this study is to quantify the effects of water temperature and water velocity on larval ontogeny (activity, growth, and energy depletion) and mortality. Results from this study highlight the importance of an autecological approach aimed at understanding transitional life-history attributes that affect recruitment success in pallid sturgeon. This project is a collaboration with the USFWS and the U.S. Department of Energy.

Structure and Connectivity of Midcontinental Snowy Plovers in the Great Plains

Texas Cooperative Fish and Wildlife Research Unit

Recent work in the Southern High Plains of Texas has documented continued declines of adult snowy plovers on saline lakes. Currently, no reliable estimates of survival, recruitment, connectivity, or philopatry exist for any other part of the midcontinental snowy plover population. About 28 percent of snowy plovers occur in the Great Plains emphasis area, and population declines approached 80 percent in saline lakes of the Southern High Plains of Texas over a 10-year period. Researchers are working with partners from the USFWS to obtain reliable estimates of survival and population connectivity. These data are important to provide decision makers with reliable information with which to evaluate the species status and develop conservation measures if warranted.

Snowy plover. Photograph by the U.S. Fish and Wildlife Service.

Bureau of Reclamation and the National Park Service—Efficacy of Conservation Actions for Native Fishes in Tributaries of the Colorado River, Grand Canyon

Utah Cooperative Fish and Wildlife Research Unit

The predominantly endemic fishes of the American Southwest are highly imperiled because of pervasive hydrologic alteration of aquatic habitats through river regulation and human water use, compounded by the widespread introduction

of nonnative competitors and predators. In the Grand Canyon, conservation actions, including nonnative fish suppression and flow experiments designed to benefit nearshore habitats and encourage juvenile fish recruitment, have been underway to recover the endangered humpback chub. Yet the responses in the population dynamics of native and nonnative fishes to these conservation actions have been equivocal. The objectives of this study are to assess the efficacy of these efforts in restoring native fish communities and establishing reproducing populations of humpback chub by quantifying the effects of nonnative suppression and environmental variability on demographic vital rates (that is, survival, recruitment, and mortality) of native fishes and introduced salmonids; assessing factors contributing to the likelihood of establishing self-sustaining humpback chub populations in small Colorado River tributaries; and developing an integrated population model for brown trout to quantify future levels of suppression necessary to reduce or eradicate the population in the Grand Canyon and beyond. Through detailed evaluations of humpback chub vital rates in translocated populations, plans for the reestablishment of the species in the Upper Colorado River Basin may be more informed. The project is a collaboration of researchers across multiple agencies and includes the USGS and State and Federal natural resource managers in the Pacific Northwest.

Publication

Healy, B.D., Schelly, R.C., Yackulic, C.B., Omana Smith, E.C., and Budy, P., 2020, Remarkable response of native fishes to invasive trout suppression varies with trout density, temperature, and annual hydrology: Canadian Journal of Fisheries and Aquatic Sciences, v. 77, no. 9, p. 1446–1462, https://doi.org/10.1139/cjfas-2020-0028.

Bureau of Reclamation—Understanding and Quantifying Potential Movement Patterns of Rio Grande Silvery Minnow in the Middle Rio Grande, New Mexico

Utah Cooperative Fish and Wildlife Research Unit

The Rio Grande silvery minnow is listed as endangered under the ESA and remains critically imperiled in the Middle Rio Grande. Although there is existing information on their basic habitat and life histories, there are many critical data gaps. These pelagic spawners release semibuoyant eggs in the water column and rely on flood-plain connectivity for rearing, after drifting downstream and being retained in available habitats. Habitat alteration, loss of inundated flood plains, and alteration and dampening of the hydrograph have negatively affected the species through reduction in flood-plain connectivity; and in the absence of flood-plain connectivity, the eggs drift farther causing upstream persistence of the species to become reliant on the ability of these fish to move upstream to recolonize areas above. This project aims to describe and quantify the ability to move and drivers of Rio Grande silvery minnow movement in its contemporary fragmented habitat. PIT-tagged Rio Grande silvery minnow were released into the Middle Rio Grande River and tracked during differing environmental conditions and seasons with a combination of stationary and mobile PIT-tag antennas. This critical information is relevant to designing and implementing future modifications to dams in the Middle Rio Grande aimed at allowing fish movement in the upstream direction. The project is a collaboration of researchers across multiple agencies and includes the USGS, Reclamation, and the USFWS.

Publications

Stout, J.B., Conner, M.M., Budy, P., Mackinnon, P.D., and McKinstry, M.C., 2019, We ain't afraid of no ghosts—Tracking habitat interactions and movement dynamics of ghost tags under differing flow conditions in a sand-bed river: North American Journal of Fisheries Management, v. 39, no. 6, p. 1337–1347, https://doi.org/10.1002/nafm.10371.

Stout, J.B., Conner, M., Budy, P., Mackinnon, P., and McKinstry, M., 2020, Keeping it classy—Classification of live fish and ghost PIT tags detected with a mobile PIT tag interrogation system using an innovative analytical approach: Canadian Journal of Fisheries and Aquatic Sciences, v. 77, no. 9, p. 1564–1573, https://doi.org/10.1139/cjfas-2019-0403.

Bureau of Reclamation—Hydrologic Controls on Abundance and Distribution of the Endangered Rio Grande Silvery Minnow in the Middle Rio Grande

Utah Cooperative Fish and Wildlife Research Unit

Rio Grande silvery minnow have experienced dramatic reductions in range and abundance, ultimately being listed as endangered under the ESA. The species' range is currently restricted to the Middle Rio Grande in New Mexico, where habitat degradation and hydrologic alterations present continuing challenges to silvery minnow conservation. Wa8ter managers are tasked with meeting many different and sometimes competing objectives with a limited supply of water in the basin. This project is examining the relation between annual hydrologic conditions and silvery minnow productivity. Using the model developed in this project could help managers determine how likely silvery minnow conservation goals are to be met under alternative management options, informing decisions to benefit this endangered species in the presence of great uncertainty. This project is a collaboration with researchers and managers across multiple agencies and stakeholder groups, including Reclamation, the USFWS, the USACE, the Middle Rio Grande Conservancy District, and the New Mexico Interstate Stream Commission.

U.S. Forest Service—Uinta-Wasatch-Cache Rare Plants

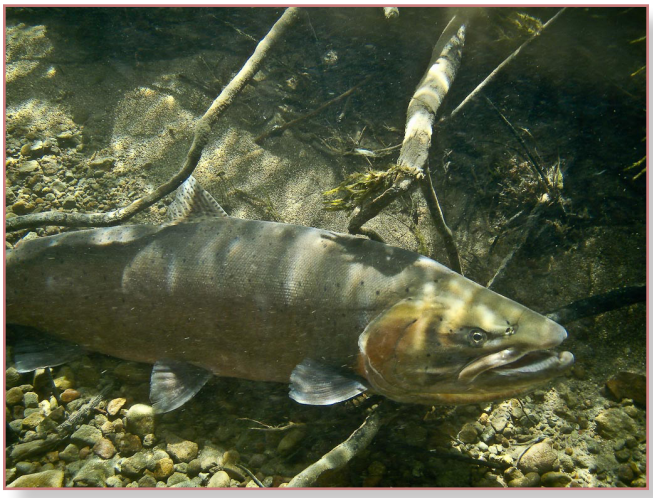
Utah Cooperative Fish and Wildlife Research Unit

The Uinta-Wasatch-Cache National Forest has 35 plant species on its threatened and endangered, sensitive, and watch lists. Many of the locations of these species are from herbarium records and have not been revisited since originally recorded. For this project, researchers revisited all documented field locations as part of a research effort to develop species distribution and habitat models for the plant species of concern. Models were next used to generate field sample designs that checked high likelihood plant locations. Of the 35 species, distributions of 12 were highly localized, and no extrapolative models could be constructed. Results varied among the remaining 23 species; some models resulted in minor range expansions, whereas others resulted in increased observed locations (abundance). Results are being used by the USFS to refine plant distributions as part of internal forest management plans.

U.S. Fish and Wildlife Service—Pyramid Lake Fishery Evaluation to Evaluate Lahontan Cutthroat Trout Performance and Identify Limiting Factors for the Native Fish Community

Utah Cooperative Fish and Wildlife Research Unit

Most large lake populations of lacustrine Lahontan cutthroat trout have undergone population declines or extirpation because of habitat degradation, overharvest, and water diversions, all compounded by the stocking of nonnative species. Pyramid Lake, Nevada, is one of the last remaining strongholds of Lahontan cutthroat trout. Researchers have been engaged in a multiyear, multipart study to evaluate the Lahontan cutthroat trout population in Pyramid Lake. In 2015, researchers completed a comprehensive research project driven by critical uncertainties surrounding the performance of the fishery and stocked Lahontan cutthroat trout across space and time, the effect of exotic Sacramento perch on Lahontan cutthroat trout, the potential for native forage fish recovery, and the link between fish performance and lake productivity and carrying capacity. The goals of this current study are to analyze and to synthesize all available data possible (primarily mark-recapture, creel, and stocking data) to estimate critical performance and vital rates for Lahontan cutthroat trout. The overall goal of this part of the study is to provide a draft framework for adaptive management of the fishery and ecosystem of Pyramid Lake.



Lahontan cutthroat trout. Photograph by the U.S. Geological Survey.

Publication

Heredia, N.A., and Budy, P., 2018, Trophic ecology of Lahontan cutthroat trout—Historical predator-prey interaction supports native apex predator in a unique desert lake: Transactions of the American Fisheries Society, v. 147, p. 842–854, https://doi.org/10.1002/tafs.10066.

U.S. Fish and Wildlife Service—Adaptive Management and Monitoring of Pyramid Lake, Nevada

Utah Cooperative Fish and Wildlife Research Unit

Pyramid Lake, Nevada, is one of the last remaining strongholds for lacustrine Lahontan cutthroat trout; almost all other large lake populations have undergone population declines or extirpation as a result of habitat degradation, overharvest, and water diversions, all compounded by the stocking of nonnative species. The population depends almost entirely on stocking programs and efficient management. Researchers developed a three-tiered monitoring approach, in which tier 1 represents the most critical and includes monitoring Lahontan cutthroat trout and their primary forage base, tui chub. Lahontan cutthroat trout and tui chub abundance could be monitored annually using two sampling sessions, and the management plan could be adapted as necessary to inform management decisions. This is a collaborative effort with the USFWS (Lahontan National Fish Hatchery Complex) and the Pyramid Lake Paiute Tribe.

Researcher setting a larval drift net in Pyramid Lake, Nevada. Photograph by the U.S. Geological Survey.

Developing Methods to Assess Lake Sturgeon Populations in Lake Champlain

Vermont Cooperative Fish and Wildlife Research Unit

Lake sturgeon populations have declined throughout its range because of several factors, including habitat loss and overfishing, and the species is listed as extirpated, endangered, threatened, or of special concern in 12 States. The State of Vermont listed the species as endangered in 1975 because of low abundances in Lake Champlain. Since 1998, the Vermont Fish and Wildlife Department has conducted sampling that documented adult spawners, eggs, and larvae in the Winooski, Lamoille, and Missisquoi Rivers. The goal of this study is to evaluate adult and juvenile movements in the lake and adult spawning movements in the Winooski River using remote technologies and novel methods to estimate the abundance of lake sturgeon in Lake Champlain. Results could provide more detailed information that can be used in managing this State-endangered fish.

Development of a Landscape Model to Predict Reach-Level Sources of Roanoke Logperch Larvae in the Upper Roanoke River System

Virginia Cooperative Fish and Wildlife Research Unit

The Roanoke logperch is an endangered fish found only in two drainages in Virginia and North Carolina. The goal of this project is to provide new knowledge about early life history of Roanoke logperch and which habitats and periods are crucial for the species' recruitment. The study builds on previous work in the Upper Roanoke River system showing that Roanoke logperch larvae can be effectively sampled, and then accurately identified, on a multiscale model of habitat suitability based on occurrences of adult Roanoke logperch. The project could quantify reach-specific physical features correlated with production of Roanoke logperch larvae; develop a spatially explicit model to predict which Upper Roanoke River system reaches are likely larval sources for Roanoke logperch; characterize spatiotemporal patterns of emergence and development for Roanoke logperch larvae; and summarize linkages among water temperature, river discharge, day length, and emergence of Roanoke logperch larvae. More complete knowledge of larval habitat associations and spatiotemporal patterns of emergence and dispersal regarding Roanoke logperch could help managers identify areas and periods crucial to recruitment, potentially making recovery actions more effective. The project is a collaboration among the USGS, the National Fish and Wildlife Foundation, and Virginia Polytechnic Institute and State University (Virginia Tech).

Publication

Buckwalter, J., Angermeier, P.L., Argentina, J., Wolf, S., Floyd, S., and Hallerman, E.M., 2019, Drift of larval darters (family Percidae) in the Upper Roanoke River Basin, USA, characterized using phenotypic and DNA barcoding markers: Fishes, v. 4, no. 4, article 59, 16 p., https://doi.org/10.3390/fishes4040059.

Effects of Surveying and Habitat Characteristics of the Endangered Spruce-Fir Moss Spider

Virginia Cooperative Fish and Wildlife Research Unit

The endangered spruce-fir moss spider is restricted to a few high elevation forests with colluvial boulder fields in the southern Appalachians of North Carolina, Tennessee, and Virginia. Determining presence of the species, necessary for National Environmental Policy Act and ESA clearance for land-management activities in these sites, often required destruction of the moss habitat where the spider resides. Accordingly, surveys are limited in scope and scale, thereby frustrating attempts to adequately map the full distribution of the spider or create robust predictive habitat models to be used in lieu of surveys. This study, a collaboration with the USFWS North Carolina Field Office, is researching various nondestructive and destructive—but with microsite mitigation techniques—to overcome this problem. Results to date suggest that moss reattachment to rock occurs in some microsite settings far more often than previously believed, meaning spider surveys probably can be expanded.

Farm Bill Conservation Practice Efficacy in Mitigating Livestock Effects in the Copper Creek Watershed

Virginia Cooperative Fish and Wildlife Research Unit

The Copper Creek drainage and associated aquatic habitats host 11 federally protected fishes and mussels but are severely affected by fine sediments, likely resulting from intensive cattle-pasturing in riparian zones. State and Federal agencies commonly promote and implement BMPs (for example, afforestation and cattle-exclusion fences) to protect and restore riparian zones to aid recovery of imperiled aquatic species, but the efficacy of such BMPs is largely undocumented in the region. To aid in filling this knowledge gap, model- and field-based studies were used to establish links between watershed-scale sediment dynamics and

instream habitat conditions relevant to priority aquatic species. The efficacy of selected BMP implementation scenarios was assessed with respect to outcomes for benthic habitat quality. Results suggest benefits to benthic habitats can occur even at low adoption rates of BMPs such as afforestation and cattle-exclusion fences. This work could inform conservation planning for at-risk aquatic species by providing baseline data, validating protocols for water quality monitoring, helping to prioritize implementation of future BMPs, and helping to set targets for instream habitat improvement. Partners include the USFWS, the NRCS, the Virginia Department of Game and Inland Fisheries, Virginia Polytechnic Institute and State University (Virginia Tech), and local soil and water conservation districts.

Post White-Nose Syndrome Bat Ecology in the Eastern United States

Virginia Cooperative Fish and Wildlife Research Unit

This project is a comprehensive investigation of the foraging and roosting ecology and distribution of bats in the mid-Atlantic and Northeast after WNS with emphasis on the threatened northern long-eared bat and the endangered Indiana bat. Building on previous efforts, this work is expanding to encompass Coastal Plain bat ecology in the Northeast and mid-Atlantic for these species. Scientists have been working with several persisting populations, notably in the District of Columbia and the surrounding metropolitan areas, northeastern North Carolina, Long Island, New York, and the upper Ohio Valley; efforts are focused on documenting natural ecology and on ascertaining what factors allow for persistence. Data from this work could help inform a wide array of land management efforts such as forest management, military training, and energy development where these species occur or could be recovered. This effort over multiple States and cooperating State, Federal, and private entities composes one of the largest and longest running continuation of mist-netting and acoustic surveys in the East.

Publications

Austin, L.V., Silvis, A., Ford, W.M., and Powers, K.E., 2019, Effects of historic wildfire and prescribed fire on site occupancy of bats in Shenandoah National Park, Virginia, USA: Journal of Forestry Research, v. 31, p. 1255–1270, https://doi.org/10.1007/s11676-019-00923-y.

Austin, L.V., Silvis, A., Muthersbaugh, M.S., Powers, K.E., and Ford, W.M., 2018, Bat activity following repeated prescribed fire in the central Appalachians, USA: Fire Ecology, v. 14, article 10, 11 p., https://doi.org/10.1186/s42408-018-0009-5.

Muthersbaugh, M.S., Ford, W.M., Powers, K.E., and Silvis, A., 2019, Activity patterns of bats during the fall and spring along ridgelines in the central Appalachians: Journal of Fish and Wildlife Management, v. 10, no. 1, p. 180–195, https://doi.org/10.3996/082018-JFWM-072.

Muthersbaugh, M.S., Ford, W.M., Silvis, A., and Powers, K.E., 2019, Activity patterns of cave-dwelling bat species during pre-hibernation swarming and post-hibernation emergence in the central Appalachians: Diversity, v. 11, no. 9, article 159, 24 p., https://doi.org/10.3390/d11090159.

Nocera, T., Ford, W.M., Dobony, C., and Silvis, A., 2020, Temporal and spatial changes in *Myotis lucifugus* acoustic activity before and after white-nose syndrome on Fort Drum Army Installation, New York, USA: Acta Chiropterologica, v. 22, no. 1, p. 121–134, https://doi.org/10.3161/15081109ACC2020.22.1.011.

Nocera, T., Ford, W.M., Silvis, A., and Dobony, C.A., 2019, Let's agree to disagree—Comparing auto-acoustic identification programs for northeastern bats: Journal of Fish and Wildlife Management, v. 10, no. 2, p. 346–361, https://doi.org/10.3996/102018-JFWM-090.

Refining Survey Efforts and Distributional Modeling for the Endangered Carolina Northern Flying Squirrel

Virginia Cooperative Fish and Wildlife Research Unit

The Carolina northern flying squirrel is an endangered subspecies that occurs in the highly imperiled spruce-fir ecosystems of the Southern Appalachians. This study is using data from radio telemetry, camera surveys, acoustic surveys, and nest-box surveys to refine predictive habitat and occupancy models for the species. Efforts to remap potential habitat using remotely sensed imagery, in conjunction with understanding the necessary level of survey effort from a variety of techniques, are being used to inform management efforts for State and Federal partners. Data are being used to update species assessment plans and continuation of listing status. Moreover, because the squirrel is a sentinel species in this ecosystem, being able to track its status helps with assessing spruce-fir ecosystem integrity.

Relating Fine Sediment Dynamics and Best-Management Practices to Instream Habitat Conditions for Priority Fishes and Mussels in the Copper Creek Drainage

Virginia Cooperative Fish and Wildlife Research Unit

The aquatic habitats in the Copper Creek drainage host 11 federally protected fishes and mussels but are severely affected by fine sediments, likely resulting from cattle access to streams and scarce woody vegetation in riparian zones. Relating sediment dynamics to instream habitat conditions in the Copper Creek drainage is critical to identifying the habitat available for priority species and to prioritizing restoration actions. State and Federal agencies commonly promote and implement BMPs to protect and restore riparian zones to aid recovery of imperiled aquatic species, but the efficacy of such

BMPs is largely undocumented in the region. This study used a combination of model- and field-based studies to map and establish links between watershed-scale sediment dynamics and instream habitat conditions relevant to recovery of priority fishes and mussels. Findings suggest benthic habitat quality is low in numerous stream segments across the Copper Creek drainage because of excess fine sedimentation and streambed instability and that riparian zones strongly affect benthic habitat quality. This research could inform conservation planning and implementation of future BMPs (for example, fencing to exclude cattle from streams) in the Copper Creek drainage and other watersheds in the region. Partners include the USFWS, the NRCS, the Virginia Department of Game and Inland Fisheries, Virginia Polytechnic Institute and State University (Virginia Tech), and local soil and water conservation districts.

Wood Turtle Ecology on Army Installations

Virginia Cooperative Fish and Wildlife Research Unit

Wood turtles are of high conservation concern, and with riparian and terrestrial habitat use, their presence may conflict with training exercises on military installations. Efforts to delineate current distributions of turtles are needed so management practices can be developed to conserve this species. This study uses habitat surveys and radio telemetry to map locations of actual or possible wood turtle habitat and informs management recommendations for future management of this species and its habitat. Preliminary results on Fort Drum, New York, and Fort George Meade, Maryland, suggest that a high level of shrub-scrub riparian habitats could be beneficial.

Wood turtle. Photograph by the U.S. Geological Survey.

Restoration Tools for Oregon Silverspot Butterfly

Washington Cooperative Fish and Wildlife Research Unit

The endangered Oregon silverspot butterfly is slated for reintroduction on two National Wildlife Refuges in Oregon and Washington, but maintaining suitable habitat for the Oregon silverspot after reintroduction is challenging. Oregon silverspot larvae need high densities of their host plant, early blue violet, to develop into adult butterflies, and the violets are an early successional species that is outcompeted by invasive plants. The goal of this project is to support refuge managers in deciding whether two selective herbicides should be used to maintain native prairie in the presence of Oregon silverspot butterflies. As part of the project, laboratory research could be conducted, and a management model could be developed to inform managers of the effects of treatment with herbicides on Oregon silverspot butterfly viability. This project is a collaboration among the USGS, the USFWS, and Washington State University.

Oregon silverspot butterfly. Photograph by the U.S. Fish and Wildlife Service.

Summarizing Current Knowledge of the Factors Affecting Juvenile Salmonid Susceptibility to Avian Predation in the Columbia River Basin

Washington Cooperative Fish and Wildlife Research Unit

Avian predation has been identified as a factor that limits the survival of juvenile salmonids in the Columbia River Basin and addressing predation concerns is a component of biological opinions and associated with the management of the Columbia River power system. Over the past two decades, numerous avian predation research, monitoring, and evaluation studies have been conducted to assess the effect of predation by Caspian terns, double-crested cormorants, and other colonial waterbirds on the survival of ESA-listed juvenile salmonids in the Columbia River. The goal of this project is to summarize results from past studies regarding tern and cormorant nesting ecology, intercolony movements, dispersal, and predation effects on juvenile salmonids. A specific emphasis of this work is to summarize current knowledge of the factors affecting juvenile

salmonid susceptibility to avian predation in the Columbia River Basin including factors such as fish rear type (hatchery, wild), run timing, and size. The project is a collaboration between the USGS and the University of Washington.

Genetic and Landscape-Level Threat Assessments and Status Review of the Candy Darter

West Virginia Cooperative Fish and Wildlife Research Unit

The candy darter, an endemic fish of the New River drainage of Virginia and West Virginia, has experienced range reduction and introgressive hybridization with the introduced variegate darter. The candy darter was listed as an endangered species in November 2018. This study is documenting the extent of introgressive hybridization, and the existing threat of extinction for this species. The goals of this study are to provide current data on the introgressive hybridization issue, data on genetic diversity and population genetic structure, a review and compilation of published and unpublished literature on the ecology of the species and on range reduction based on historic and recent data, and a landscape-level threat assessment for the historic and current range of the candy darter using geographic information system-based methods. Study results could have direct management and conservation implications for the candy darter. The project is a collaborative effort of the USGS, the USFWS, and the West Virginia Division of Natural Resources.

Conservation of the Kirtland's Warbler

Wisconsin Cooperative Wildlife Research Unit

The population of the federally endangered Kirtland's warbler has stabilized over the past 5 years at about 1,800 singing males, nearly double the population goal of 1,000 males targeted in the 1976 Recovery Plan. As a result of this biological recovery, the species has expanded into new breeding areas and the USFWS is compiling information for potentially delisting this conservation-reliant species. However, evaluating how the species is using these new habitats and assessing how climate change might affect conservation of Kirtland's warbler has not been done. A population viability assessment could be developed by linking how Kirtland's warbler survivorship and productivity can be altered from changing climate conditions (that is, drought) and changing habitat availability and distribution. This project is a collaboration across the USGS, the USFWS, the USFS Northern Research Station, and State natural resource managers in the Midwest.

Publications

Donner, D.M., Brown, D.J., Ribic, C.A., Nelson, M., and Greco, T., 2018, Managing forest habitat for conservation-reliant species in a changing climate—The case of the endangered Kirtland's warbler: Forest Ecology and Management, v. 430, p. 265–279, https://doi.org/10.1016/j.foreco.2018.08.026.

Wolcott, D.M., Donner, D.M., Brown, D.J., and Ribic, C.A., 2018, Kirtland's warbler winter habitat changes across the Bahamian Archipelago in response to future climate-condition scenarios: Caribbean Naturalist, v. 49, p. 1–20.

Habitat Attributes of Northern Long-Eared Bat Maternity Roosts in Wyoming

Wyoming Cooperative Fish and Wildlife Research Unit

The northern long-eared bat has suffered catastrophic population losses in parts of its range with the arrival of

Kirtland's warbler. Photograph by Joel Trick, U.S. Fish and Wildlife Service.

white-nose syndrome and is currently listed as a threatened species under the ESA. Protections for the northern long-eared bat are partly centered on limiting disturbance to summer day roost trees, which are critical because they provide shelter for females to raise their offspring. The habitat attributes preferred for female northern long-eared bats for their roost sites, however, remain unknown for many parts of the range including within Wyoming. Results from this study could contribute vital information for forest management practices geared toward forestalling further population declines of a threatened bat species. This project is in cooperation among the USFS, the State of Wyoming, and the University of Wyoming.

Research and Monitoring of Wyoming Toad Reintroductions—Linking Survival, Behavior, and Genetics to Inform Species Recovery

Wyoming Cooperative Fish and Wildlife Research Unit

The Wyoming toad, which rapidly declined in the 1970s because of unknown causes, is one of the most endangered amphibians in North America. A small population at Mortenson Lake National Wildlife Refuge sustained by captive release is now one of the only known, noncaptive populations of Wyoming toads. The USFWS recently improved captive facilities to allow regular release of adult Wyoming toads into the wild to foster increased reproduction and survival. This improvement resulted in notable increases in reproduction, as evidenced by regular wild breeding, but changes in survival are questionable because the released animals are being observed less frequently than expected. Collaborating with USFWS, scientists are tracking the fate of Wyoming toads at reintroduction sites across the Laramie Basin to assess the interaction among individual survival, behavior (for example, habitat selection and hibernacula selection), genetics, and disease, to identify how these linkages can be used to facilitate recovery of the species. Data collected could provide valuable information for the reintroduction and recovery of the Wyoming toad. This information could be used to inform release strategies, monitoring, and potential captive breeding.

Wyoming toad. Photograph by Ryan Moehring, U.S. Fish and Wildlife Service.

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

Hawai'i—Fishery
- University of Hawai‘i
- Hawai‘i Department of Land and Natural Resources

Idaho
- University of Idaho
- Idaho Department of Fish and Game

Iowa
- Iowa State University
- Iowa Department of Natural Resources

Kansas
- Kansas State University
- Kansas Department of Wildlife, Parks and Tourism

Louisiana
- Louisiana State University
- Louisiana Department of Wildlife and Fisheries

Maine
- University of Maine
- Maine Department of Inland Fisheries and Wildlife

Maryland
- University of Maryland, Eastern Shore
- Maryland Department of Natural Resources

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

Minnesota
- University of Minnesota
- Minnesota Department of Natural Resources

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

Missouri
- University of Missouri Columbia
- Missouri Department of Conservation

Montana—Fishery
- Montana State University
- Montana Department of Fish, Wildlife and Parks

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

Nebraska
- University of Nebraska Lincoln
- Nebraska Game and Parks Commission

New Mexico
- New Mexico State University
- New Mexico Department of Game and Fish

New York State
- Cornell University
- New York State 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
The Pennsylvania State University
Pennsylvania Fish and Boat Commission
Pennsylvania Game Commission

South Carolina
Clemson University
South Carolina Department of Natural Resources

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

Tennessee—Fishery
Tennessee Tech University
Tennessee Wildlife Resources Agency

Texas
Texas Tech University
Texas Parks and Wildlife Department

Utah
Utah State University
Utah Division of Wildlife Resources

Vermont
University of Vermont
Vermont Fish and Wildlife Department

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

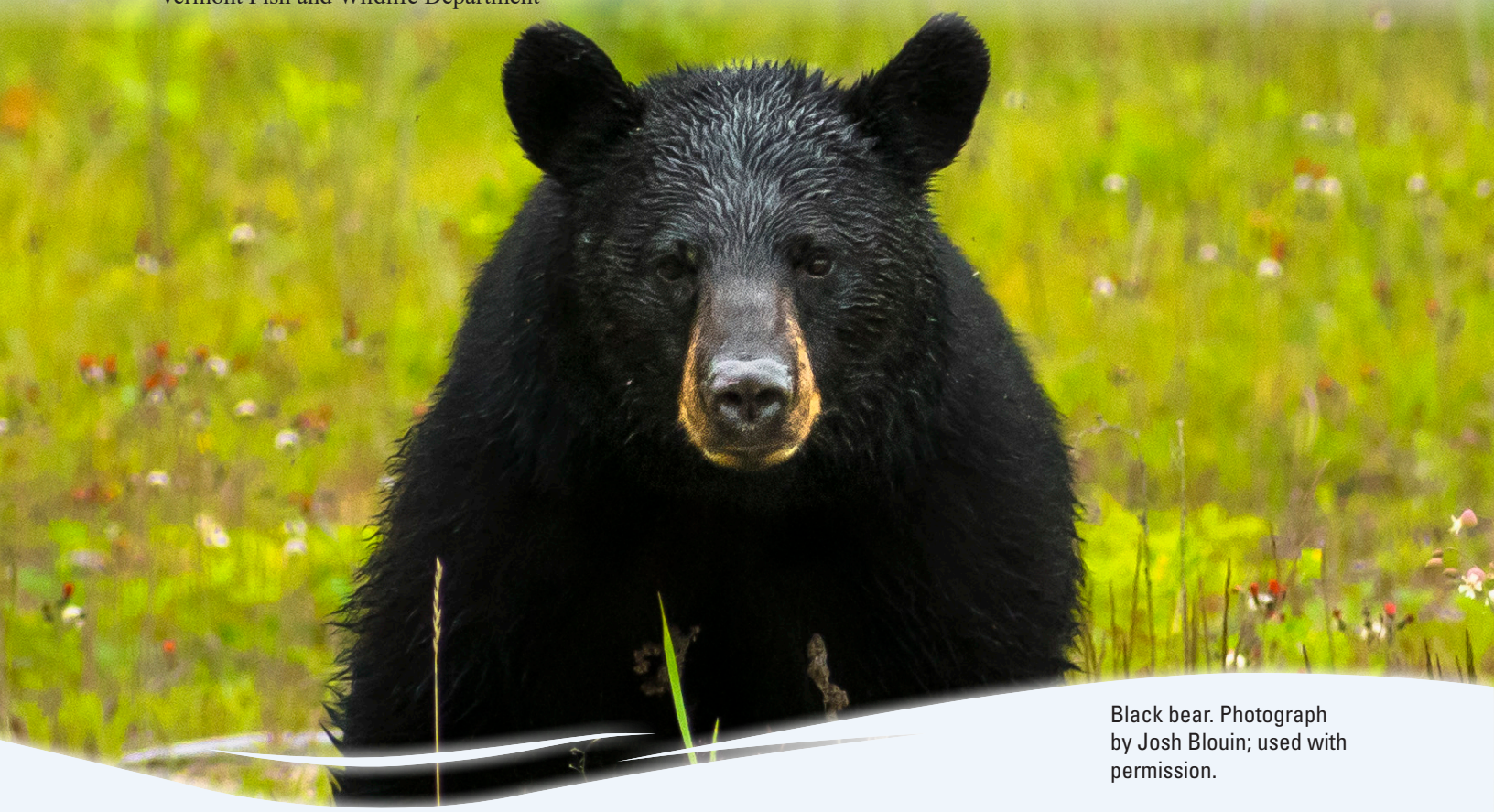
Washington
Washington State University
University of Washington
Washington State Department of Ecology
Washington State Department of Fish and Wildlife
Washington State Department of Natural Resources

West Virginia
West Virginia University
West Virginia Division of Natural Resources

Wisconsin—Fishery
University of Wisconsin-Stevens Point
Wisconsin Department of Natural Resources

Wisconsin—Wildlife
University of Wisconsin Madison
Wisconsin Department of Natural Resources

Wyoming
University of Wyoming
Wyoming Game and Fish Department



Black bear. Photograph by Josh Blouin; used with permission.

List of Species

Common name	Scientific name
Adélie penguin	*Pygoscelis adeliae* (Hombron and Jacquinot, 1841)
alewife	*Alosa pseudoharengus* (Wilson, 1811)
American alligator	*Alligator mississippiensis* (Daudin, 1802)
American beaver	*Castor canadensis* (Kuhl, 1820)
American eel	*Anguilla rostrata* (Lesueur, 1817)
American marten	*Martes americana* (Turton, 1806)
American oystercatcher	*Haematopus palliatus* (Temminck, 1820)
American shad	*Alosa sapidissima* (Wilson, 1811)
American turkey vultures	*Cathartes aura aura* (Linnaeus, 1758); *C. a. meridionalis* (Swann, 1921); *C. a. septentrionalis* (Wied-Neuwied, 1839)
American woodcock	*Scolopax minor* (Gmelin, 1789)
Andean bear	*Tremarctos ornatus* (F. G. Cuvier, 1825)
Apache trout	*Oncorhynchus apache* (Miller, 1972)
Arctic grayling	*Thymallus arcticus* (Pallas, 1776)
Arctic peregrine falcon	*Falco peregrinus tundrius* (C. M. White, 1968)
Asian swamp eel	*Monopterus albus* (Zuiew, 1793)
Atlantic salmon	*Salmo salar* (Linnaeus, 1758)
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus* (Mitchill, 1815)
Bachman's sparrow	*Peucaea aestivalis* (M. H. K. Lichtenstein, 1823)
bald eagle	*Haliaeetus leucocephalus* (Linnaeus, 1766)
barley	*Hordeum vulgare* (L.)
barred owl	*Strix varia* (Barton, 1799)
barren-ground caribou	*Rangifer tarandus groenlandicus* (Borowski, 1780)
Bay-breasted warbler	*Setophaga castanea* (A. Wilson, 1810)
beetleweed	*Galax urceolata* ((Poir.) Brummitt)
bighead carp	*Hypophthalmichthys nobilis* (Richardson, 1845)
bighorn sheep	*Ovis canadensis* (Shaw, 1804)
bison	*Bison bison* (Linnaeus, 1758)
black basses	*Micropterus* spp. (Lacepède, 1802)
black bear	*Ursus americanus* (Pallas, 1780)
Blackburnian warbler	*Setophaga fusca* (Statius Müller, 1776)
black crappie	*Pomoxis nigromaculatus* (Lesueur in Cuvier and Valenciennes, 1829)
black-footed albatross	*Phoebastria nigripes* (Audubon, 1839)
black-footed ferret	*Mustela nigripes* (Audubon and Bachman, 1851)
black oystercatcher	*Haematopus bachmani* (Audubon, 1838)
black rail	*Laterallus jamaicensis* (Gmelin, 1789)
black rosy-finch	*Leucosticte atrata* (Ridgway, 1874)
black scoter	*Melanitta nigra* (Linnaeus, 1758)
black skimmer	*Rynchops niger* (Linnaeus, 1758)
black-tailed deer	*Odocoileus hemionus hemionus* (Rafinesque, 1817)
black-tailed prairie dog	*Cynomys ludovicianus* (Ord, 1815)
blueback herring	*Alosa aestivalis* (Mitchill, 1814)

List of Species—Continued

Common name	Scientific name
blueberries	*Vaccinium* spp. (L.)
bluebirds	*Sialia* spp. (Swainson, 1827)
blue catfish	*Ictalurus furcatus* (Valenciennes in Cuvier and Valenciennes, 1840)
bluegill	*Lepomis macrochirus* (Rafinesque, 1819)
bluehead sucker	*Catostomus discobolus* (Cope, 1871)
blue sucker	*Cycleptus elongatus* (Lesueur, 1817)
blue-winged warbler	*Vermivora cyanoptera* (Olson & Reveal, 2009)
bobcat	*Lynx rufus* (Schreber, 1777)
bobwhite	*Colinus virginianus* (Linnaeus, 1758)
Bonneville cutthroat trout	*Oncorhynchus clarkii utah* (Suckley, 1874)
boreal toad	*Anaxyrus boreas* (Baird and Girard, 1852)
Brewer's sparrow	*Spizella breweri* (Cassin, 1856)
broad whitefish	*Coregonus nasus* (Pallas, 1776)
brook floater	*Alasmidonta varicosa* (Lamarck, 1819)
brook stickleback	*Culaea inconstans* (Kirtland, 1840)
brook trout	*Salvelinus fontinalis* (Mitchill, 1814)
brown pelican	*Pelecanus occidentalis* (Linnaeus, 1766)
brown treesnake	*Boiga irregularis* (Bechstein, 1802)
brown trout	*Salmo trutta* (Linnaeus, 1758)
bull trout	*Salvelinus confluentus* (Suckley, 1859)
burbot	*Lota lota* (Linnaeus, 1758)
burrowing owl	*Athene cunicularia* (Molina, 1782)
California gull	*Larus californicus* (Lawrence, 1854)
Canada goose	*Branta canadensis* (Linnaeus, 1758)
Canada lynx	*Lynx canadensis* (Kerr, 1792)
candy darter	*Etheostoma osburni* (Hubbs and Trautman, 1932)
canvasback	*Aythya valisineria* (A. Wilson, 1814)
Cape May warbler	*Setophaga tigrina* (J. F. Gmelin, 1789)
caracara	Falconidae sp. (Leach, 1820)
caribou	*Rangifer tarandus* (Linnaeus, 1758)
Caspian tern	*Hydroprogne caspia* (Pallas, 1770)
cave crayfish	*Cambarus aculabrum* (Hobbs and Brown, 1987)
Central American river turtle	*Dermatemys mawii* (Gray, 1847)
cerulean warbler	*Setophaga cerulea* (A. Wilson, 1810)
channel catfish	*Ictalurus punctatus* (Rafinesque, 1818)
cheatgrass	*Bromus tectorum* (L.)
Chinese crested tern	*Thalasseus bernsteini* (Schlegel, 1863)
Chinook salmon	*Oncorhynchus tshawytscha* (Walbaum in Artedi, 1792)
Chipola slabshell	*Elliptio chipolaensis* (Walker, 1905)
chytrid fungus	*Batrachochytrium dendrobatidis* (no known reference)
cinnamon teal	*Anas cyanoptera* (Vieillot, 1816)

List of Species—Continued

Common name	Scientific name
cisco	*Coregonus artedi* (Lesueur, 1818)
Coho salmon	*Oncorhynchus kisutch* (Walbaum, 1792)
common black-hawk	*Buteogallus anthracinus* (Deppe, 1830)
common eider	*Somateria mollissima* (Linnaeus, 1758)
common loon	*Gavia immer* (Brunnich, 1764)
common reed	*Phragmites australis* ((Cav.) Trin. ex Steud.)
Cooper's hawk	*Accipiter cooperii* (Bonaparte, 1828)
cougar	*Puma concolor* (Linnaeus, 1771)
coyote	*Canis latrans* (Say, 1823)
crappies	*Pomoxis* spp. (Rafinesque, 1818)
cutthroat trout	*Oncorhynchus clarkii* (Richardson, 1836)
Dall's sheep	*Ovis dalli* (Nelson, 1884)
desert sucker	*Catostomus clarkii* (Baird and Girard, 1854)
double-crested cormorant	*Phalacrocorax auritus* (Lesson, 1831)
dwarf wedgemussel	*Alasmidonta heterodon* (Lea, 1829)
early blue violet	*Viola palmata* (L.)
eastern collared lizard	*Crotaphytus collaris* (Say in James, 1823)
eastern cottontail	*Sylvilagus floridanus* (J. A. Allen, 1890)
eastern fox squirrel	*Sciurus niger vulpinus* (Gmelin, 1788)
eastern oyster	*Crassostrea virginica* (Gmelin, 1791)
eastern red bat	*Lasiurus borealis* (Müller, 1776)
eastern red cedar	*Juniperus virginiana* (L.)
eastern spotted skunk	*Spilogale putorius* (Linnaeus, 1758)
eastern wild turkey	*Meleagris gallopavo silvestris* (Vieillot, 1817)
elk	*Cervus elaphus* (Linnaeus, 1758)
fat threeridge	*Amblema neislerii* (Lea, 1858)
finescale dace	*Chrosomus neogaeus* (Cope, 1867)
fisher	*Pekania pennanti* (Erxleben, 1777)
flannelmouth sucker	*Catostomus latipinnis* (Baird and Girard, 1853)
flathead catfish	*Pylodictis olivaris* (Rafinesque, 1818)
Florida sandhill crane	*Grus canadensis pratensis* (F. A. A. Meyer, 1794)
Florida scrub-jay	*Aphelocoma coerulescens* (Bosc, 1795)
giant kangaroo rat	*Dipodomys ingens* (Merriam, 1904)
gibbons	Hylobatidae spp. (Gray, 1871)
Gila chub	*Gila intermedia* (Girard, 1856)
Gila trout	*Oncorhynchus gilae* (Miller, 1950)
gizzard shad	*Dorosoma cepedianum* (Lesueur, 1818)
golden alga	*Prymnesium parvum* (N. Carter)
golden eagle	*Aquila chrysaetos* (Linnaeus, 1758)
golden-winged warbler	*Vermivora chrysoptera* (Linnaeus, 1766)
gopher tortoise	*Gopherus polyphemus* (Daudin, 1801)

List of Species—Continued

Common name	Scientific name
grass carp	*Ctenopharyngodon idella* (Valenciennes in Cuvier and Valenciennes, 1844)
gray hawk	*Buteo nitidus* (Latham, 1790)
gray wolf	*Canis lupus* (Linnaeus, 1758)
great gray owl	*Strix nebulosa* (J. R. Forster, 1772)
Great Lakes cisco	*Coregonus artedi* (Lesueur, 1818)
greater crested tern	*Thalasseus bergii* (Lichtenstein, 1823)
greater prairie-chicken	*Tympanuchus cupido* (Linnaeus, 1758)
greater sage-grouse	*Centrocercus urophasianus* (Bonaparte, 1827)
greater sandhill crane	*Grus canadensis* (Linnaeus, 1758)
green sea turtle	*Chelonia mydas* (Linnaeus, 1758)
greenback cutthroat trout	*Oncorhynchus clarkii stomias* (Cope, 1871)
ground squirrels	*Marmotini* spp. (Pocock, 1923)
Gulf moccasinshell	*Medionidus penicillatus* (Lea, 1857)
harbor seal	*Phoca vitulina* (Linnaeus, 1758)
hemlock	*Conium maculatum* (L.)
hemlock wooly adelgid	*Adelges tsugae* (no known reference)
Henslow's sparrow	*Ammodramus henslowii* (Audubon, 1829)
hoary bat	*Lasiurus cinereus* (Palisot de Beauvois, 1796)
hornyhead chub	*Nocomis biguttatus* (Kirtland, 1840)
horseshoe crabs	Limulidae spp. (no known reference)
humpback chub	*Gila cypha* (Miller, 1946)
Indiana bat	*Myotis sodalis* (Miller and G. M. Allen, 1928)
invasive carp	*Hypophthalmichthys* spp. (Bleeker, 1860)
jaguar	*Panthera onca* (Linnaeus, 1758)
johnny darter	*Etheostoma nigrum* (Rafinesque, 1820)
juniper titmouse	*Baeolophus ridgwayi* (Richmond, 1902)
Kanawha darter	*Etheostoma kanawhae* (Raney, 1941)
king eider	*Somateria spectabilis* (Linnaeus, 1758)
Kirtland's warbler	*Setophaga kirtlandii* (S. F. Baird, 1852)
kokanee	*Oncorhynchus nerka* (Walbaum in Artedi, 1792)
Lahontan cutthroat trout	*Oncorhynchus clarkii henshawi* (Gill and Jordan, 1878)
lake sturgeon	*Acipenser fulvescens* (Rafinesque, 1817)
lake trout	*Salvelinus namaycush* (Walbaum in Artedi, 1792)
lake whitefish	*Coregonus clupeaformis* (Mitchill, 1818)
largemouth bass	*Micropterus salmoides* (Lacepède, 1802)
Laysan albatross	*Phoebastria immutabilis* (Rothschild, 1893)
least darter	*Etheostoma microperca* (Jordan and Gilbert in Jordan, 1888)
leoncita false-foxglove	*Agalinis calycina* (Pennell)
leopard	*Panthera pardus* (Linnaeus, 1758)
lesser prairie-chicken	*Tympanuchus pallidicinctus* (Ridgway, 1873)
loggerhead sea turtle	*Caretta caretta* (Linnaeus, 1758)

List of Species—Continued

Common name	Scientific name
loggerhead shrike	*Lanius ludovicianus* (Linnaeus, 1766)
longfin dace	*Agosia chrysogaster* (Girard, 1856)
longhorn bee	*Melissodes opuntiellus* (Cockerell, 1911)
longleaf pine	*Pinus palustris* (Mill.)
longnose darter	*Percina nasuta* (Bailey, 1941)
Louisiana waterthrush	*Parkesia motacilla* (Vieillot, 1809)
mallard	*Anas platyrhynchos* (Linnaeus, 1758)
Mammoth Spring crayfish	*Faxonius marchandi* (Hobbs, 1948)
marbled murrelet	*Brachyramphus marmoratus* (Gmelin, 1789)
masked bobwhite	*Colinus virginianus ridgwayi* (Brewster, 1885)
Mexican wolf	*Canis lupus baileyi* (Nelson and Goldman, 1929)
mink	*Mustela vison* (Schreber, 1777)
minnow	*Phoxinus phoxinus* (Linnaeus, 1758)
Moapa dace	*Moapa coriacea* (Hubbs and Miller, 1948)
Mojave Desert tortoise	*Gopherus agassizii* (Cooper, 1861)
monarch butterfly	*Danaus plexippus* (Linnaeus, 1758)
moose	*Alces alces* (Linnaeus, 1758)
mottled duck	*Anas fulvigula* (Ridgway, 1874)
mountain lion	*Puma concolor* (Linnaeus, 1771)
mountain pine beetle	*Dendroctonus ponderosae* (Hopkins, 1902)
mountain whitefish	*Prosopium williamsoni* (Girard, 1856)
mourning dove	*Zenaida macroura* (Linnaeus, 1758)
mule deer	*Odocoileus hemionus* (Rafinesque, 1817)
muskellunge	*Esox masquinongy* (Mitchill, 1824)
mussels	Dreissenidae spp. (Gray, 1840)
Neosho madtom	*Noturus placidus* (Taylor, 1969)
Nordmann's greenshank	*Tringa guttifer* (Nordmann, 1835)
North American darter	*Etheostoma caeruleum* (Storer, 1845)
North American river otter	*Lontra canadensis* (Schreber, 1777)
northern bobwhite	*Colinus virginianus* (Linnaeus, 1758)
northern flying squirrel	*Glaucomys sabrinus* (Shaw, 1801)
northern Idaho ground squirrel	*Urocitellus brunneus* (A. H. Howell, 1928)
northern long-eared bat	*Myotis septentrionalis* (Trouessart, 1897)
northern pike	*Esox lucius* (Linnaeus, 1758)
northern redbelly dace	*Chrosomus eos* (Cope, 1861)
northern spotted owl	*Strix occidentalis caurina* (Merriam, 1898)
Norway spruce	*Picea abies* ((L.) Karst.)
Not applicable (type of bacteria)	*Ceratonova shasta* (no known reference)
Not applicable (type of bacteria)	*Flavobacterium psychrophilum* (Bernardet and Grimont, 1989; Bernardet and others, 1996)
Not applicable (type of bacteria)	*Renibacterium salmoninarum* (Sanders and Fryer, 1980)
Not applicable (type of bacteria)	*Yersinia pestis* (Lehmann and Neumann, 1896; van Loghem, 1944)

List of Species—Continued

Common name	Scientific name
ocelot	*Leopardus pardalis* (Linnaeus, 1758)
opossum shrimp	*Mysis diluviana* (Loven, 1862)
Oregon silverspot butterfly	*Speyeria zerene hippolyta* (W. H. Edwards, 1879)
oval pigtoe	*Pleurobema pyriforme* (Lea, 1857)
Pacific salmon	*Oncorhynchus* spp. (Suckley, 1861)
paddlefish	*Polyodon spathula* (Walbaum, 1792)
pallid sturgeon	*Scaphirhynchus albus* (Forbes and Richardson, 1905)
pearl dace	*Margariscus margarita* (Cope, 1867)
Pecos sunflower	*Helianthus paradoxus (*Heiser)
pinyon jay	*Gymnorhinus cyanocephalus* (Wied-Neuwied, 1841)
piping plover	*Charadrius melodus* (Ord, 1824)
plain pigeon	*Patagioenas inornata* (Vigors, 1827)
polar bear	*Ursus maritimus* (Phipps, 1774)
prairie chub	*Macrhybopsis australis* (Hubbs and Ortenburger, 1929)
prairie dogs	*Cynomys* spp. (Rafinesque, 1817)
pronghorn	*Antilocapra americana* (Ord, 1815)
puma	*Puma concolor* (Linnaeus, 1771)
purple bankclimber	*Elliptoideus sloatianus* (Lea, 1840)
purple cat's paw pearly mussel	*Epioblasma obliquata* (Rafinesque, 1820)
rainbow trout	*Oncorhynchus mykiss* (Walbaum, 1792*)*
red-cockaded woodpecker	*Picoides borealis* (Vieillot, 1809)
red fox	*Vulpes vulpes* (Linnaeus, 1758)
red-headed woodpecker	*Melanerpes erythrocephalus* (Linnaeus, 1758)
red knot	*Calidris canutus* (Linnaeus, 1758)
red tree vole	*Arborimus longicaudus* (True, 1890)
ring-billed gull	*Larus delawarensis* (Ord, 1815)
ring-necked pheasant	*Phasianus colchicus* (Linnaeus, 1758)
Rio Grande chub	*Gila pandora* (Cope, 1872)
Rio Grande cutthroat trout	*Oncorhynchus clarkii virginalis* (Girard, 1856)
Rio Grande silvery minnow	*Hybognathus amarus* (Girard, 1856)
Rio Grande sucker	*Catostomus plebeius* (Baird and Girard, 1854)
river herring	*Alosa chrysochloris* (Rafinesque, 1820)
Roanoke logperch	*Percina rex* (Jordan and Evermann in Jordan, 1889)
robust redhorse	*Moxostoma robustum* (Cope, 1870)
rock gnome lichen	*Gymnoderma lineare* (no known reference)
Rocky Mountain elk	*Cervus elaphus nelsoni* (no known reference)
Ross's goose	*Chen rossii* (Cassin, 1861)
round goby	*Neogobius melanostomus* (Pallas, 1814)
roundtail chub	*Gila robusta* (Baird and Girard, 1853)
royal tern	*Thalasseus maximus* (Boddaert, 1783)
ruffed grouse	*Bonasa umbellus* (Linnaeus, 1766)

List of Species—Continued

Common name	Scientific name
rusty crayfish	*Faxonius rusticus* (Girard, 1852)
Sacramento perch	*Archoplites interruptus* (Girard, 1854)
sagebrush sparrow	*Artemisiospiza nevadensis* (Ridgway, 1874)
sage thrasher	*Oreoscoptes montanus* (J. K. Townsend, 1837)
sandhill crane	*Grus canadensis* (Linnaeus, 1758)
sandwich tern	*Thalasseus sandvicensis* (Latham, 1787)
Santa Ana sucker	*Catostomus santaanae* (Snyder, 1908)
sauger	*Sander canadensis* (Griffith and Smith, 1834)
sea ducks	Anatidae spp.
semipalmated sandpiper	*Calidris pusilla* (Linnaeus, 1766)
sharp-shinned hawk	*Accipiter striatus* (Vieillot, 1808)
shinyrayed pocketbook	*Hamiota subangulata* (Lea, 1840)
Shiras moose	*Alces americanus americanus* (Clinton, 1822)
shorthead redhorse	*Moxostoma macrolepidotum* (Lesueur, 1817)
shovelnose sturgeon	*Scaphirhynchus platorynchus* (Rafinesque, 1820)
sicklefin redhorse	*Moxostoma* sp. (Rafinesque, 1820)
silver carp	*Hypophthalmichthys molitrix* (Valenciennes in Cuvier and Valenciennes, 1844)
silver-haired bat	*Lasionycteris noctivagans* (Le Conte, 1831)
skipjack herring	*Alosa chrysochloris* (Rafinesque, 1820)
smallmouth bass	*Micropterus dolomieu* (Lacepède, 1802)
smallmouth buffalo	*Ictiobus bubalus* (Rafinesque, 1818)
snow goose	*Chen caerulescens* (Linnaeus, 1758)
snowshoe hare	*Lepus americanus* (Erxleben, 1777)
snowy plover	*Charadrius nivosus* (Cassin, 1858)
snuffbox	*Epioblasma triquetra* (Rafinesque, 1820)
southeastern fox squirrel	*Sciurus niger niger* (Linnaeus, 1758)
speckled dace	*Rhinichthys osculus* (Girard, 1856)
spectacled bear	*Tremarctos ornatus* (F. G. Cuvier, 1825)
spotted bass	*Micropterus punctulatus* (Rafinesque, 1819)
spotted turtle	*Clemmys guttata* (Schneider, 1792)
spruce-fir moss spider	*Microhexura montivaga* (Crosby and Bishop, 1925)
steelhead	*Oncorhynchus mykiss* (Walbaum, 1792)
Stone's sheep	*Ovis dalli stonei* (J. A. Allen, 1897)
striped bass	*Morone saxatilis* (Walbaum, 1792)
suckers	Catostomidae spp. (no known reference)
Swainson's hawk	*Buteo swainsoni* (Bonaparte, 1838)
sweat bees	Halictidae spp.
swift fox	*Vulpes velox* (Say, 1823)
tidewater goby	*Eucyclogobius newberryi* (Girard, 1856)
Topeka shiner	*Notropis topeka* (Gilbert, 1884)
Townsend's big-eared bat	*Corynorhinus townsendii* (Cooper, 1837)

List of Species—Continued

Common name	Scientific name
trumpeter swan	*Cygnus buccinator* (Richardson, 1831)
tui chub	*Siphateles bicolor* (Girard, 1856)
Utah chub	*Gila atraria* (Girard, 1856)
variegate darter	*Etheostoma variatum* (Kirtland, 1840)
walleye	*Sander vitreus* (Mitchill, 1818)
walking catfish	*Clarias batrachus* (Linnaeus, 1758)
westslope cutthroat trout	*Oncorhynchus clarkii lewisi* (Girard, 1856)
White Sands pupfish	*Cyprinodon tularosa* (Miller and Echelle, 1975)
white sturgeon	*Acipenser transmontanus* (Richardson, 1836)
white-tailed deer	*Odocoileus virginianus* (Zimmermann, 1780)
wild turkey	*Meleagris gallopavo* (Linnaeus, 1758)
winter tick	*Dermacentor albipictus* (Packard, 1869)
wood frog	*Lithobates sylvaticus* (LeConte, 1825)
wood turtle	*Glyptemys insculpta* (Le Conte, 1830)
wolf	*Canis lupus* (Linnaeus, 1758)
Wright's marsh thistle	*Cirsium wrightii (A*. Gray)
Wyoming toad	*Anaxyrus baxteri* (Porter, 1968)
Yaqui catfish	*Ictalurus pricei* (Rutter, 1896)
yellow-billed cuckoo	*Coccyzus americanus* (Linnaeus, 1758)
yellow lampmussel	*Lampsilis cariosa* (Say, 1817)
yellow perch	*Perca flavescens* (Mitchill, 1814)
yellow-billed loon	*Gavia adamsii* (G. R. Gray, 1859)
yellowcheek darter	*Etheostoma moorei* (Raney and Suttkus, 1964)
yelloweye rockfish	*Sebastes ruberrimus* (Cramer, 1895)
Yellowstone cutthroat trout	*Oncorhynchus clarkii bouvieri* (Jordan and Gilbert, 1883)
Yuma Ridgway's rail	*Rallus obsoletus yumanensis* (Dickey, 1923)
zone-tailed hawk	*Buteo albonotatus* (Kaup, 1847)

Sea turtle. Photograph by Ethan Whitecotton; used with permission.

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Laysan albatross at Ka'ena Point, Hawai´i. Photograph by Ethan Whitecotton; used with permission.

Beaver. Photograph by Josh Blouin; used with permission.

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