Cooperative Fish and Wildlife Research Units Program—

2023

Year-in-Review

Circular 1545

Cooperative Fish and Wildlife Research Units Program—2023 Year-in-Review

By Elise R. Irwin, Caroline E. Murphy, Dawn E. Childs, Donald E. Dennerline, and Jonathan R. Mawdsley

U.S. Geological Survey, Ecosystems Mission Area,
Cooperative Fish and Wildlife Research Units Program

Circular 1545

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

Special Appreciation

We would like to extend special thanks to the leadership of the United States and State and Territorial fish and wildlife agencies whose strong engagement and support are essential for the success of the U.S. Geological Survey (USGS) Cooperative Fish and Wildlife Research Units (CRU) Program. We are especially grateful to our friends at the Association of Fish and Wildlife Agencies (AFWA) for their continued support of the CRU Program, and particularly the AFWA Executive Director Ron Regan for his strong and steady leadership. We also want to extend special recognition to Paul Johansen, Director of Wildlife at the West Virginia Division of Natural Resources, for his enthusiastic support for the CRU Program. State fish and wildlife agencies have been a critically important part of the CRU Program since the formation of the very first Unit in Iowa in 1935, and we greatly value the collaboration, engagement, and support of all of our State agency partners.

Acknowledgments

Multiple U.S. Geological Survey reviewers (David Hu, Colleen Caldwell [retired], Mark Wildhaber, Vicki Blazer, Jason Dunham, Mike Colvin, Julien Martin, and Tim Counihan [deceased]) provided critical feedback on the product, enhancing the quality of this report. Tess McConnell conducted the biological names review. Each project summary was authored by the lead Unit scientist(s) and edited for length by the report authors.

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North Dakota native prairie. Photograph by Rick Bohn, U.S. Fish and Wildlife Service.

Abbreviations

AFS	American Fisheries Society
AFWA	Association of Fish and Wildlife Agencies
AMU	autonomous monitoring unit
BLM	Bureau of Land Management
CFP	ciguatera fish poisoning
CMT	Corridor Mapping Team
COP	community of practice
CRU	Cooperative Fish and Wildlife Research Units
CWD	chronic wasting disease
DAR	Division of Aquatic Resources
DDCSP	Doris Duke Conservation Scholars Program
DNR	Department of Natural Resources
DOI	U.S. Department of the Interior
eDNA	environmental deoxyribonucleic acid
EDRR	early detection and rapid response
ESA	Endangered Species Act
FS	U.S. Department of Agriculture Forest Service
FWC	Florida Fish and Wildlife Conservation Commission
FWS	U.S. Fish and Wildlife Service
FY	fiscal year
GIS	geographic information system
IDFG	Idaho Department of Fish and Game
MNDNR	Minnesota Department of Natural Resources
M.S.	Master of Science
MassWildlife	Massachusetts Division of Fisheries and Wildlife
MTDFWP	Montana Department of Fish, Wildlife and Parks

NAJFM	North American Journal of Fisheries Management
NCWRC	North Carolina Wildlife Resources Commission
NGO	nongovernmental organization
NMDGF	New Mexico Department of Game and Fish
NPS	National Park Service
NWR	National Wildlife Refuge
NYDEC	New York State Department of Environmental Conservation
ODFW	Oregon Department of Fish and Wildlife
PA DCNR	Pennsylvania Department of Conservation and Natural Resources
PFAS	per- and polyfluoroalkyl substances
PGC	Pennsylvania Game Commission
Ph.D.	Doctor of Philosophy
RWO	Research Work Order
SDGFP	South Dakota Department of Game, Fish and Parks
SE CASC	Southeast Climate Adaptation Science Center
SO	Secretarial Order
SSA	Species Status Assessment
TWS	The Wildlife Society
USDA	U.S. Department of Agriculture
USDA APHIS	U.S. Department of Agriculture Animal and Plant Health Inspection Service
USGS	U.S. Geological Survey
WMI	Wildlife Management Institute
WNS	white-nose syndrome
WVDNR	West Virginia Department of Natural Resources
WYOBIRD	University of Wyoming Bird Initiative for Resilience and Diversity

Redhead ducks (*Aythya americana*). Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Dana Winkleman, Cora Schildt, Justin Rogers, Mia Ter Kuile-Miller, and Sam Radosevich. Photograph by U.S. Geological Survey.

Cooperative Fish and Wildlife Research Units

Established in 1935, the U.S. Geological Survey (USGS) Cooperative Fish and Wildlife Research Units (CRU) Program is a unique cooperative partnership among State fish and wildlife agencies, host universities, the Wildlife Management Institute (WMI), USGS, and the U.S. Fish and Wildlife Service (FWS). Designed to meet the scientific needs of natural resource management agencies and to produce trained wildlife management professionals, the program has grown from the original nine wildlife-only Units to a program that, as of 2024, includes 43 Units located on university campuses in 41 States.

Grizzly Bear (*Ursus arctos horribilis*). Photograph by Kari Cieszkiewicz, U.S. Fish and Wildlife Service.

Message from the Chief

It has been another great year for the U.S. Geological Survey (USGS) Cooperative Fish and Wildlife Research Units (CRU) Program. In the summer of 2023, we celebrated the addition of the Indiana Cooperative Fish and Wildlife Research Unit to our CRU family. USGS Director David Applegate participated in a public event launching the new Unit in Connor Prairie, Indiana, along with cooperators (Purdue University, Indiana Department of Natural Resources, and the Wildlife Management Institute), Senator Mike Braun, and over 150 conservation partners from the State. The addition of the Indiana Unit is the result of the tireless efforts of Indiana cooperators and partners, and we are all looking forward to many productive years of collaborative fish and wildlife research at Purdue University.

Throughout the reporting period of Fiscal Year 2023 (October 1, 2022, to September 30, 2023), we hired staff to fill existing vacancies, including the Southeast Regional Supervisor position recently vacated by James (Barry) Grand, who served in the supervisor position for the last 7 of his 35 years in Federal service. Lisa Webb, formerly of the Missouri Cooperative Fish and Wildlife Research Unit, has moved into this important leadership position. Our Deputy Chief, John Thompson, retired at the end of September 2023 after 20 years of Federal service; we are currently working to fill this position. Another important hire is our first-ever Programs and Partnerships Coordinator, Caroline Murphy, who comes to the CRU Program from The Wildlife Society and will be handling a variety of tasks related to external relations and partnerships.

As you will see from this circular, our scientists continue to expand the frontiers of scientific knowledge and provide relevant technical assistance and training to our partners and the broader conservation community. Highlights this year include the continuation of our ongoing work to map migration corridors for large ungulates in the West; conservation of fish species in the Great Plains and elsewhere that are threatened by drought, floods, and climate change; and improvements to our scientific understanding of imperiled species, such as the sage grouse, lesser prairie chicken, and monarch butterfly. We continue to develop new and innovative methods to address ecosystem issues of regional and multistate importance, including the recent formation of a multistate research consortium in the Midwest. On behalf of the CRU, we look forward to continued collaboration with all of our partners—State, Federal, academic, and nongovernmental organizations—to deliver relevant science, training, and technical assistance.

We are extremely grateful to each of our cooperators and partners for their continued support of the CRU Program. Our continued success depends on the active engagement, participation, and support from our cooperators and partners. We thank you for everything that you do for our program, and we look forward to continued collaboration with you in the coming years.

Sincerely,

Jonathan Mawdsley,
Chief, Cooperative Fish and Wildlife Research Units
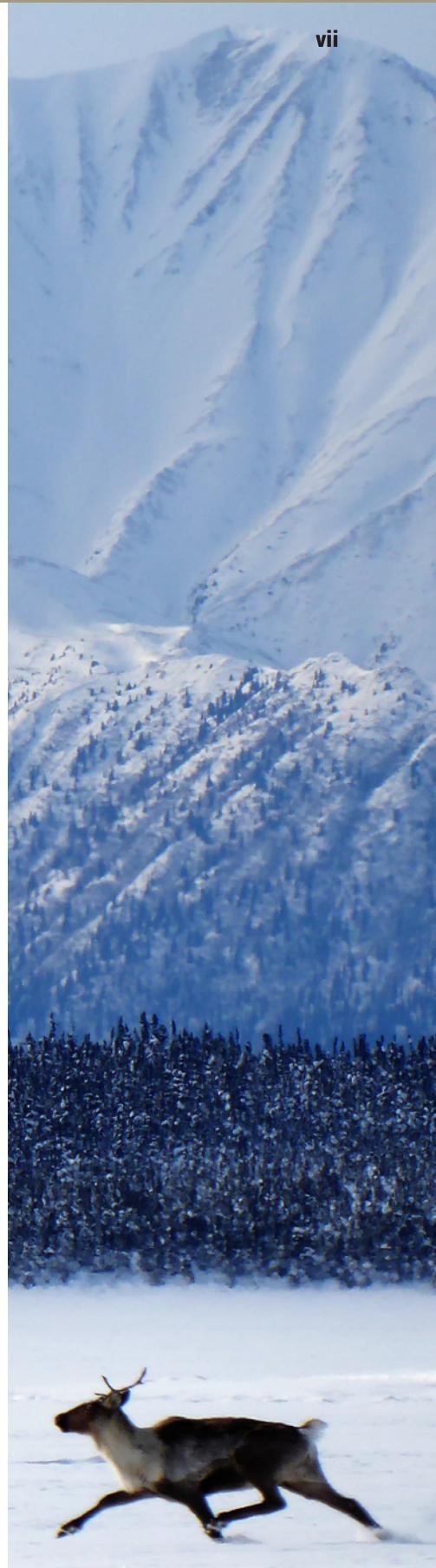
Caribou (*Rangifer tarandus*) on the Tetlin National Wildlife Refuge. Photograph by Chelsea Arnold, U.S. Fish and Wildlife Service.

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Special Products 2023

Pollinator Science Fact Sheets

In collaboration with several U.S. Geological Survey (USGS) Science Centers (Northern Rocky Mountain Science Center, Alaska Science Center, Fort Collins Science Center), the Alaska and Northwest USGS Climate Adaptation Science Centers, the New York Unit, and many cooperating partners, the CRU Program published a fact sheet on pollinator science and climate change (Irwin and Mawdsley, 2023). A second fact sheet was published describing the work at the USGS Bee Lab, which is part of the USGS Eastern Ecological Science Center located at the FWS Patuxent Wildlife Refuge (Droege and others, 2023).

References

Droege, S., Irwin, E.R., Malpass, J., and Mawdsley, J.R., 2023, The bee lab: U.S. Geological Survey Fact Sheet 2023–3023, 2 p., accessed February 15, 2024, at https://doi.org/10.3133/fs20233023.

Irwin, E.R., and Mawdsley, J.R., 2023, Pollinator conservation and climate science at the U.S. Geological Survey: U.S. Geological Survey Fact Sheet 2023–3026, 4 p., accessed February 15, 2024, at https://doi.org/10.3133/fs20233026.
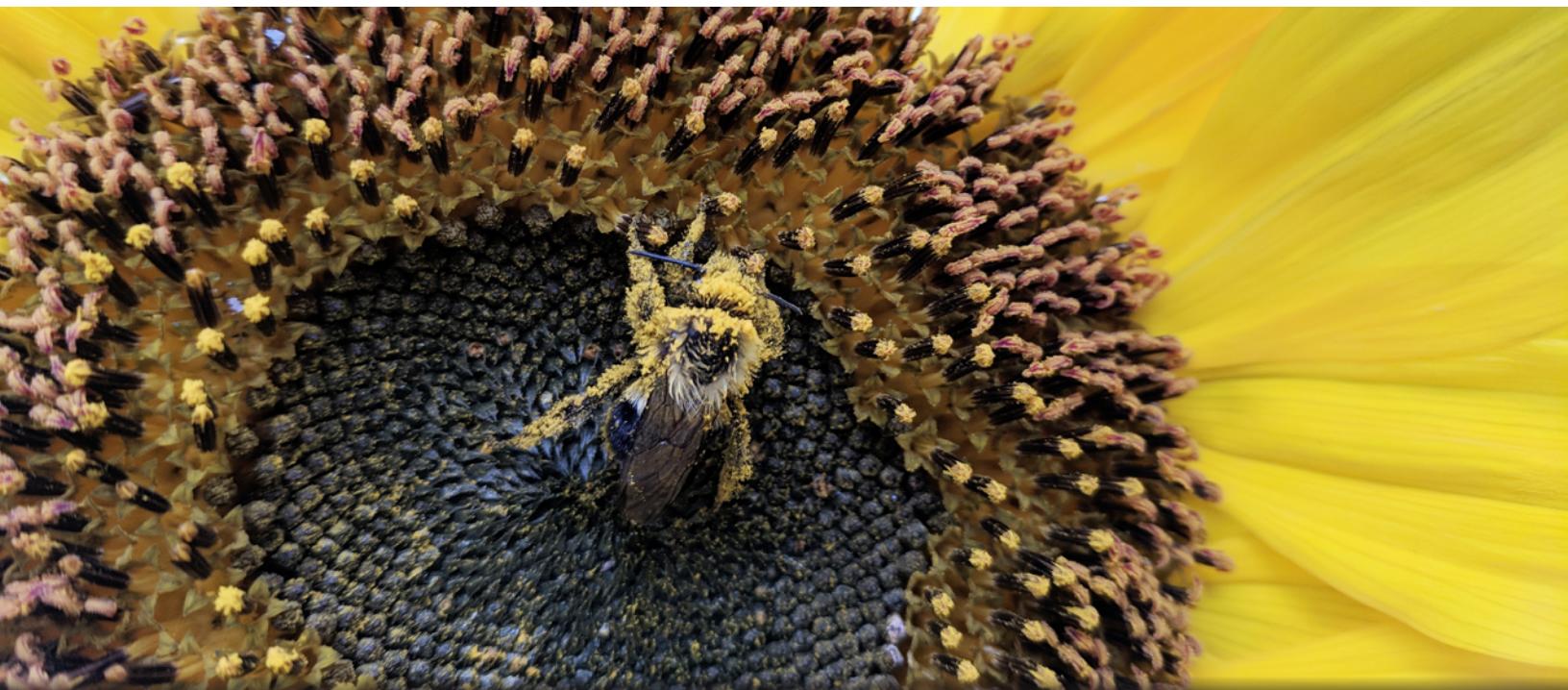
Digger bee (Apinae) collecting pollen. Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Elk (*Cervus canadensis*) migrating from the National Elk Refuge. Photograph by Gannon Castle, U.S. Fish and Wildlife Service.

Western Ungulate Migrations Volume 3

The third volume of "Ungulate Migrations of the Western United States" was published in Fiscal Year (FY) 2023. Many ungulate herds face barriers that impede migration, and wildlife management agencies across the western United States have worked to identify and protect or enhance ungulate migration corridors and seasonal ranges as identified from global positioning system collar data. These efforts to help ungulate migration garnered additional support through the U.S. Department of the Interior Secretarial Order (SO) 3362, which was initiated in 2018 and provided Federal support for enhancing habitat quality of big-game winter ranges and migration corridors across the western States. Further, SO 3362 prompted the USGS to establish the Corridor Mapping Team (CMT), which is a collaboration among USGS and participating State and Federal wildlife management agencies and many Tribal Nations. The CMT works collaboratively to map ungulate migrations and seasonal ranges throughout the western United States and to report results in the "Ungulate Migrations of the Western United States" series.

Citation for "Ungulate Migrations of the Western United States, Volume 3"

Kauffman, M., Lowrey, B., Berg, J., Bergen, S., Brimeyer, D., Burke, P., Cufaude, T., Cain, J.W., III, Cole, J., Courtemanch, A., Cowardin, M., Cunningham, J., DeVivo, M., Diamond, J., Duvuvuei, O., Fattebert, J., Ennis, J., Finley, D., Fort, J., Fralick, G., Freeman, E., Gagnon, J., Garcia, J., Gelzer, E., Graham, M., Gray, J., Greenspan, E., Hall, L.E., Hendricks, C., Holland, A., Holmes, B., Huggler, K., Hurley, M., Jeffreys, E., Johnson, A., Knox, L., Krasnow, K., Lockyer, Z., Manninen, H., McDonald, M., McKee, J.L., Meacham, J., Merkle, J., Moore, B., Mong, T.W., Nielsen, C., Oates, B., Olsen, K., Olson, D., Olson, L., Pieron, M., Powell, J., Prince, A., Proffitt, K., Reddell, C., Riginos, C., Ritson, R., Robatcek, S., Roberts, S., Sawyer, H., Schroeder, C., Shapiro, J., Simpson, N., Sprague, S., Steingisser, A., Tatman, N., Turnock, B., Wallace, C., and Wolf, L., 2022, Ungulate migrations of the western United States, Volume 3: U.S. Geological Survey Scientific Investigations Report 2022–5088, 114 p., accessed February 15, 2024, at https://doi.org/10.3133/sir20225088.

Budget

Indiana Unit Added in Fiscal Year 2023

In FY 2023, the CRU Program had a budget increase, making it the fourth year in a row with an increased budget and bringing the budget to approximately $28.2 million (fig. 1). Part of the congressional budget language for this year's increase was to establish a new Unit in Indiana. That directive was fulfilled with the completion of a Cooperative Agreement establishing a new CRU in the State of Indiana based at Purdue University in West Lafayette, Indiana (fig. 2).

Founding partners include the Indiana Department of Natural Resources (Indiana DNR), Purdue University, FWS, USGS, and WMI. In addition to CRU leadership and staff, gratitude is extended to the many people who supported the establishment of the new Unit, including: Amanda Wuestefeld and David Bortner, Indiana DNR; Elizabeth Flaherty, Karen Plaut, Robert Swihart, and Jessica Gurevitch, Purdue University; Chuck Traxler and Craig Czarnecki, FWS; Bill Moritz, WMI; and Lowell Baier and Jen Mock. Each of these individuals are to be commended for their engagement and support for the new Unit. This latest addition to the CRU Program family will build on newly established productive relationships to deliver solutions to problems using sound science in Indiana.
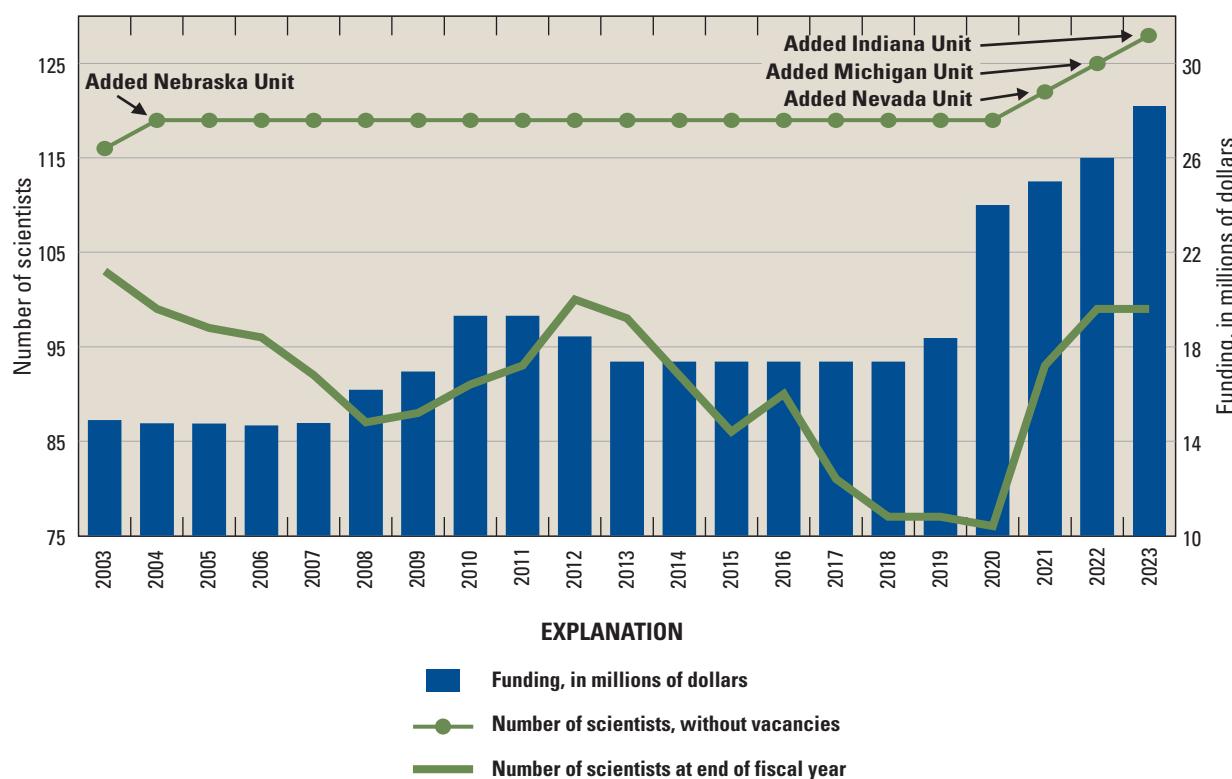
Figure 1.   Graph showing budget and staffing data for the Cooperative Fish and Wildlife Research Units Program during fiscal years 2003–2023. Note that the scale of the left y-axis starts at 75 personnel.

Atlantic puffins (*Fratercula arctica*). Photograph by U.S. Fish and Wildlife Service.

Northern leopard frog (*Rana pipiens*). Photograph by Laurie Averill-Murray, U.S. Fish and Wildlife Service.
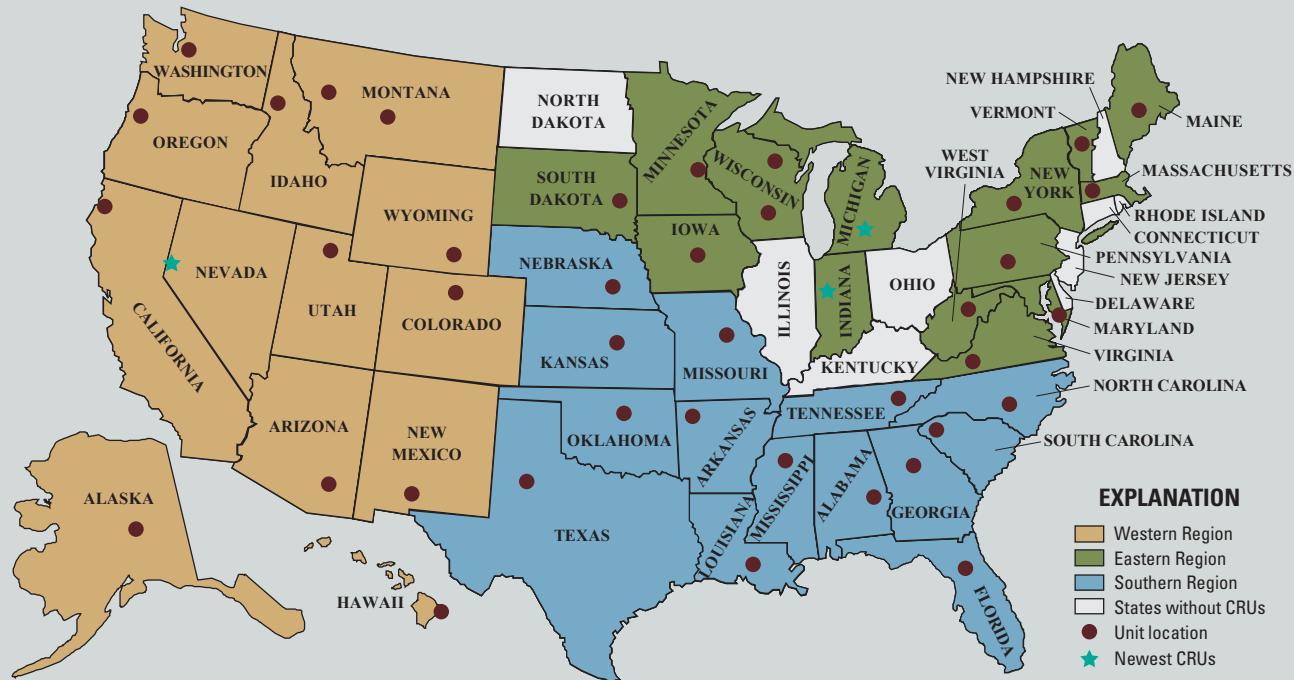
Figure 2. Map of Cooperative Fish and Wildlife Research Units (CRU) locations in 41 States at 44 host universities. The newest CRU locations are indicated by stars: Nevada CRU, established in 2021; Michigan CRU, established in 2022; and Indiana CRU, established in 2023.

Staffing

The recent budget increases have allowed the CRU Program to continue to actively fill positions over the past three years, with 42 new scientists brought on board (26 in FY 2021, 11 in FY 2022, and 5 in FY 2023). The FY 2023 hires included Unit Leader positions at the Nevada and Michigan CRU. However, 29 vacancies remained at the end of FY 2023 because of the loss of 19 scientists (retirements, resignations, death) over the past three years, and the addition of nine new positions at the three new Units. Hiring actions have been initiated to fill ten of these positions, including the Deputy Chief of the CRU Program and the new Unit Leader position at the new Indiana Unit.

Operational Support

Recent budget increases provided needed operational support to the CRU Program for capital investments such as vehicles and safety equipment. Because of an extended period of flat funding during government budget sequestration (FY 2013–18), little to no financial support was available for operational investments, and operational equipment, such as the vehicle fleet, aged without replacement. However, with the 42 new scientists recently brought into the CRU Program and 29 more to come, a large investment in operational items, such as vehicles—including watercraft, all-terrain vehicles, and utility terrain vehicles—and laboratory and safety equipment to support the active and growing field-research programs of potentially 60 or more new scientists, is needed and welcomed.

Candy darter (*Etheostoma osburni*). Photograph by Ryan Hagerty, U.S. Fish and Wildlife Service.

How the CRU Works

Mission

> The mission of the CRU Program has three directives:
>
> (1) conduct research to deliver actionable science to cooperating agencies and organizations,
>
> (2) develop the natural resource conservation workforce of the future through graduate education, and
>
> (3) fulfill the training and technical assistance needs of cooperators related to fisheries and wildlife sciences.

Project Controls

Research Work Orders (RWOs) are how host universities receive Federal financial support to conduct research as provided for in the 1978 amendment to Public Law 86–686. RWOs are an extension of the Cooperative Agreement establishing each Unit. Funds from the USGS, other U.S. Department of the Interior (DOI) Bureaus, or other Federal agencies are obligated via financial assistance into a RWO and awarded to the host university for a specific research project.

The Deputy Chief assures that the project meets the requirements for a RWO, including: (1) the project must be novel research, (2) the project must be consistent with the mission of the USGS and DOI priorities, (3) the project must have an educational component, (4) the budget is complete and appropriate, and (5) no apparent conflicts of interest exist.

Regional Engagement and Coordination

CRU headquarters staff and leadership work closely with key regional partners, including USGS Center Directors, USGS Regional Directors, USGS Ecosystems Mission Area leadership, as well as leadership from other agencies, such as the FWS. The Chief of the CRU Program works closely with USGS Center Directors and USGS Regional Directors on topics of mutual interest. For example, the development of an interagency pollinator science community-of-practice (Pollinator Science COP) is engaging regional USGS staff and center scientists, and external partners, such as the FWS, U.S. Department of Agriculture (USDA), the Northeast Association of Fish and Wildlife Agencies, National Park Service (NPS), and the Smithsonian Institution, in research to inform pollinator conservation activities at State and Federal agencies.

Leveraging Resources and Creating Jobs

Through their research programs, CRU scientists create jobs at the host university. Each CRU scientist supports graduate students, postdoctoral researchers, and research technicians, collectively amounting to approximately 1,000 university positions supported per year (fig. 3). Graduates who participated in the CRU Program go on to obtain professional positions in many different fields (fig. 4).

The CRU Program also leverages the contributions of each cooperator such that Federal salary dollars are matched on a 1:3 basis by State and host university contributions and grant funds. In FY 2023, the CRU budget of $28.2 million brought in approximately $48 million in reimbursable research funds to the host universities, who provided more than $22 million through in-kind support (such as office space or use of university equipment), tuition, and reduced overhead.

Unit scientists garner approximately
$48 million
in State and Federal research funding each year

Federal investment supports about
1,100 students and university staff members
annually

Universities provide more than
$22 million
through in-kind support, tuition, and reduced overhead

76
Graduate degrees awarded (57 M.S. and 19 Ph.D. degrees)

545
Active graduate students (343 M.S. and 202 Ph.D. students

92
Postdoctoral researchers

71
Undergraduate students

327
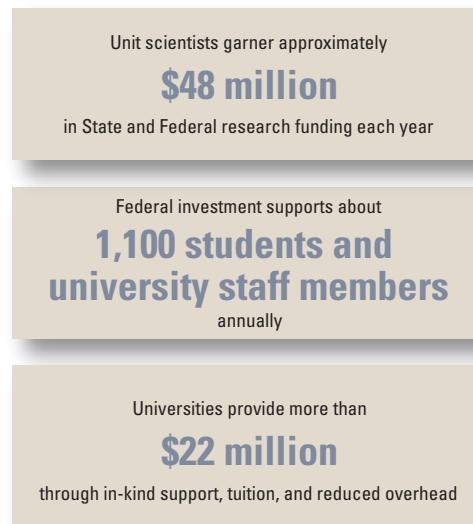Active university research staff

Figure 3.   Number of graduate degrees awarded and active students, postdoctoral researchers, and university research staff during FY 2023 in the Cooperative Research Units Program. M.S., Master of Science; Ph.D., Doctor of Philosophy.
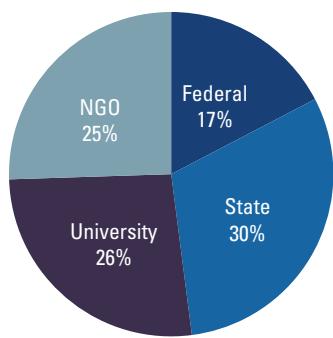
Figure 4. Pie chart showing the major types of professional positions obtained by recent graduates who participated in the Cooperative Fish and Wildlife Research Units Program; 2 percent of other kinds of positions are not accounted for in this chart. Data are averaged for fiscal years 2012–2021. NGO, nongovernment organization, %, percent.

Productivity

Scientists, research staff, and students in the CRU Program are highly productive, publishing 360 scientific papers in FY 2023. Papers were published in 160 peer-reviewed journals, ranging from international journals such as "Nature" to regional journals such as "Southwestern Naturalist." Based on the number of articles per journal, the top 20 scientific journals that CRU scientists, students, and research staff published papers in are reported in table 1. Thirty-nine percent of CRU publications were published in these 20 journals in FY 2023.

More than 88 courses were taught in FY 2023 at host universities to 1,023 graduate students. In addition, many workshops and short courses were delivered and tailored to cooperators' needs for setting conservation objectives and providing collaborative decision-making tools (fig. 5).

Seven CRU scientists and two graduate students received prestigious awards for their publications (table 2). In addition, CRU scientists serve on editorial boards for many journals, lending expertise to scientific review and article selection.
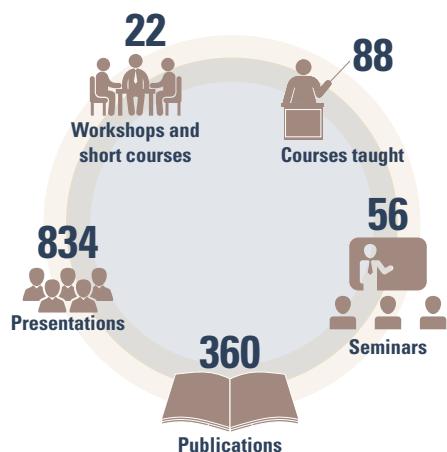
Figure 5. Products delivered from Cooperative Research Units scientists, research staff, and students for fiscal year 2023. Total number of workshops and short courses, invited seminars, presentations, scientific publications, and courses taught are reported.

Table 1. A list of the top twenty journals that Cooperative Research Units scientists, students, and research staff published papers in.

Journal	Number of articles
Journal of Wildlife Management	12
North American Journal of Fisheries Management	12
Ecology and Evolution	11
Ecological Applications	10
Ecosphere	10
Journal of Fish and Wildlife Management	10
PLoS ONE	8
Wildlife Society Bulletin	8
Canadian Journal of Fisheries and Aquatic Sciences	7
Ecology	7
Fisheries	6
River Research and Applications	5
Science of the Total Environment	5
Transactions of the American Fisheries Society	5
Biological Conservation	4
Conservation Science and Practice	4
Journal of Animal Ecology	4
Journal of Applied Ecology	4
Journal of Great Lakes Research	4
Scientific Reports	4

Research Priorities

Following the original legislation that created the CRU Program (Public Law 86–686, 74 Stat. 733), all Unit research priorities are set locally at each Unit in consultation with Federal and State cooperators (fig. 6). Unit scientists and supervisors work with cooperators to help them identify their research needs, and Unit supervisors ensure that all research is aligned with the USGS mission. Unit scientists, associated faculty, staff, and students regularly conduct research projects in coordination with, and to meet the needs of, USGS headquarters, regions, and science centers.

Individual Unit reports herein provide examples of collaborative work with USGS science centers, States, universities, nongovernmental organizations (NGOs), and other Federal cooperators. Final approval for each project is made by CRU headquarters management (Chief or Deputy Chief) to ensure that projects meet the USGS mission and the U.S. Department of the Interior (DOI) priorities.

Table 2.   Awards made to Cooperative Research Units scientists and students for excellence in their publication records.

[AFS, American Fisheries Society; TWS, The Wildlife Society; NAJFM, North American Journal of Fisheries Management]

Scientist	Award	Awarding organization or Journal
Clint Boal	Outstanding Book Award	Texas Chapter TWS

Kim Bonvechio (student) and Andrew Carlson	Feature Article
	    Cover Article
		Fishes
		    Fishes

Andrew Carlson	Top 10 percent most downloaded papers in calendar year 2022	AFS
Katie Dugger	Best Journal Article	TWS

Jeff Falke	Top-cited article
	    Top 10 percent most-downloaded papers in calendar year 2022
		Fisheries
		    Fisheries

Craig Paukert	Top 10 percent most-downloaded papers in calendar year 2022
	    Top 10 percent most-downloaded papers in calendar year 2022
	    Top-cited article
		Fisheries Management and Ecology
		    Fisheries
		    AFS-NAJFM

Craig Paukert and Lyndsie Wszola (student)	Top 10 percent most-downloaded papers in calendar year 2022	AFS-NAJFM

Kevin Pope	Top-cited article
	    Top 10 percent most-downloaded papers in calendar year 2022
		Fisheries
		    AFS-NAJFM

Mark Rogers	Top-cited article
	    Top 10 percent most-downloaded papers in calendar year 2022
		AFS-NAJFM
		    Fisheries
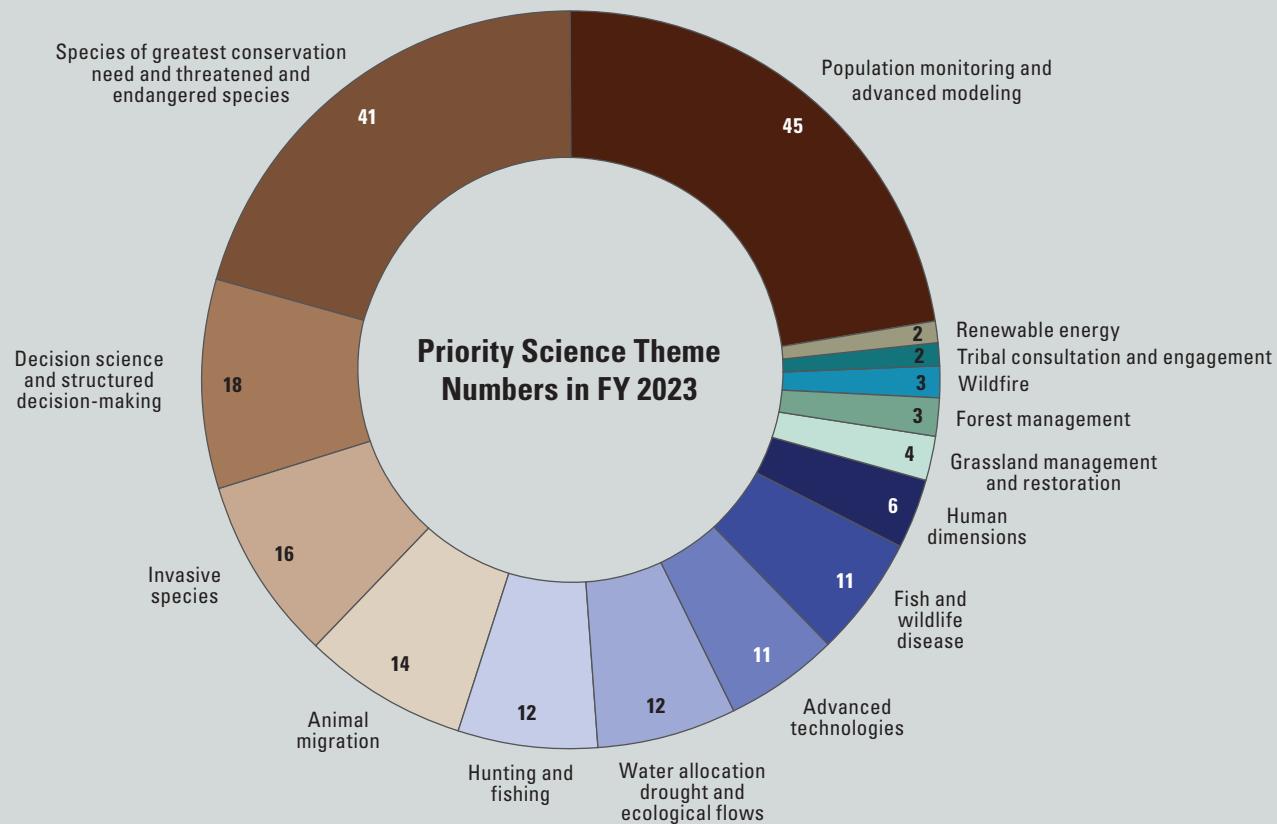
Figure 6.   A modified pie chart showing the top 15 categories of science priority themes as determined by cooperators from a subset of 101 of the highest priority Cooperative Research Units projects. Themes for the 101 high-priority projects, a subset of more than 800 total projects in fiscal year 2023, could be reported in multiple categories.

Applied Research to Meet Cooperators′ Science Needs

The CRU Program is a leader in applied research, providing objective science for the management needs of cooperators and informing decision-making. The research priorities for each Unit are established locally in consultation with Federal and State cooperators.

This circular highlights some of the approximately 800 current management-oriented research projects conducted with State, Federal, and university cooperators in FY 2023 in the "Meet the Units" section. The "Meet the Units" section is organized by region (fig. 2), and within each region, each individual Unit reports on FY 2023 projects, products, technical assistance, and other activities. Science themes were identified for each project, demonstrating the depth and breadth of research provided to Unit cooperators and partners and the invaluable decision-based science that it can yield.

More examples of Unit projects are available at https://www1.usgs.gov/coopunits/allProject/all.

CRU scientists have diverse expertise and skillsets that are reported in the CRU Expertise Directory. [https://usgs-cru-department-data.s3.amazonaws.com/headquarters/unit_docs/CRU_Expertise-1.pdf]

White-tailed deer (*Odocoileus virginianus*). Photograph by Gary Eslinger, U.S. Fish and Wildlife Service.

Awards and Accolades

Annual Cooperative Fish and Wildlife Research Units Awards

The Annual CRU individual Scientific Excellence and Leadership Awards were awarded in FY 2023 for FY 2022 accomplishments and represent significant achievements in the CRU Program. Congratulations to each recipient for their scientific excellence and leadership to the CRU Program, to their cooperators, and to natural resource conservation!

In addition to the CRU awards, as a main cooperator of the CRU Program, WMI awarded the Administrative Excellence Award to a deserving Unit Administrative Assistant. Administrative Assistants are university employees assigned to Units to manage various aspects of the Unit's integration and function at the University as well as cooperator interaction, student management, and record-keeping for Unit Headquarters. The contributions of Administrative Assistants to each of the Units are a significant factor in the success of the Unit.

Courtney Conway, Unit Leader, Idaho Unit—Excellence in Leadership

Photograph by U.S. Geological Survey.

Courtney Conway has demonstrated excellence in leadership in all aspects of his career, and his professional conduct is a shining example of leadership within the CRU Program. His excellent leadership with the Idaho Cooperative Fish and Wildlife Research Unit includes outstanding research, including publishing 20 papers over the last two years (2020–2022) with a research focus on population dynamics and recruitment of rare birds and other threatened species. Conway's expertise and leadership are highly valued by both university and resource agency cooperators. His involvement in the flagship Doris Duke Conservation Scholars Program (July 2016–present [2023]) has had a significant influence on enhancing professional diversity. In summary, Conway has exemplified leadership in all aspects of his career and professional conduct, and he is an extraordinary example of a leader.

Joseph Zydlewski, Unit Leader, Maine Unit—Excellence in Leadership

Photograph by U.S. Geological Survey.

Joseph Zydlewski's excellent leadership with the Maine Cooperative Fish and Wildlife Research Unit demonstrates an outstanding level of research, exceptional service, and important scientific leadership to The University of Maine, the Maine Department of Inland Fisheries and Wildlife, the FWS, the USGS, and to the Unit's many other local, regional, national, and international partners. His many important contributions to graduate education through student mentoring, graduate advising, and coordinating the graduate program in the Department of Wildlife, Fisheries, and Conservation Biology are just some of the examples of his leadership in the educational mission of the CRU. He is an important knowledge source for science professionals, as demonstrated by his participation on numerous scientific advisory panels, academic service to The University of Maine, and contributions as an associate editor. Additionally, Zydlewski's willingness to lead and foster new collaborations and to facilitate efforts to resolve critical aquatic systems conservation challenges, particularly with respect to fish passage restoration, has resulted in meaningful, actionable science.

Phaedra E. Budy, Unit Leader, Utah Unit—Excellence in Science

Photograph by U.S. Geological Survey.

Phaedra Budy's research productivity in 2023 was outstanding, as was her support from Unit cooperators. Over the last two years, she published 20 papers, including 11 journal articles in FY 2022. The diversity of her work, including the importance of natural flow regimes to native fish conservation, evaluating the productivity of western reservoirs versus water levels, and groundbreaking experimental whole-lake ecological research in Alaska, is unparalleled in scope and quality. She is a recognized leader in dry climate and desert fish conservation science, and her work has produced critical information for informing the conservation of several imperiled fishes in the Colorado River basin. Budy's contributions to science as well as the applications of her research program are deep and substantial, exemplify the value of the CRU Program, and have greatly enhanced the portfolio and profile of CRU.

Sarah J. Converse, Unit Leader, Washington Unit—Excellence in Science

Photograph by U.S. Geological Survey.

Sarah Converse's research productivity in 2022 was outstanding, as was her support from Unit cooperators. She has published 19 papers over the last two years, focusing on (among other subjects) modeling spatial dynamics, capture-recapture modeling, endangered species conservation science, decision science, and demographic risk assessments of harvested species. Converse's research program is influential in the State of Washington and is recognized at regional, national, and international scales. In addition, she continues to provide technical assistance using her expertise in decision science. Converse's leadership in science and administration of the Unit enables the two Assistant Unit Leaders to prosper both scientifically and as graduate faculty. Her research program has contributed greatly to her cooperators and is focused on the highest regional, national, and international priorities.

Scott Bonar, Unit Leader, Arizona Unit—Excellence in Service

Photograph by U.S. Geological Survey.

Scott Bonar has a long track record of service to the profession with his extensive time invested in leadership for the American Fisheries Society. His work to lead the effort to edit and produce standard sampling and methodology books has had a broad and constructive contribution to the profession and to State and Federal agencies nationwide. He has demonstrated a deep commitment to professional service to his local State and Federal cooperators, always answering the call to provide technical assistance and support on his research endeavors. Lastly, he never hesitates to support the national CRU Program by contributing his expertise on communication methodologies for both new scientist's orientation sessions and our national CRU All-Hands meetings. Bonar's service and research overall have and continue to have a significant positive effect on the conservation of native fishes in Arizona, and regionally in the desert Southwest.

Matthew Kauffman, Unit Leader, Wyoming Unit—Excellence in Service

Photograph by U.S. Geological Survey.

Matthew Kauffman's service to the Unit program, cooperators, and partner agencies is extraordinary. He has been and continues to be highly productive, publishing 16 papers over the last two years, including 11 journal articles in FY 2022, and continues his ground-breaking research and assessment of big game migrations across the West. Currently, he continues to work with 12 western States on assessments of mule deer (*Odocoileus hemionus*) and other ungulates using methods developed in his laboratory. His work is widely supported by State and Federal partners, as well as NGOs that have directly contributed to the migration mapping efforts. This work that he has led is a significant transboundary research and science effort that has had huge positive effects for conserving migratory corridors up to global scales. This award acknowledges Kauffman's exemplary service to the Unit program, cooperators, and partner agencies.

Rena Carey, Administrative Assistant, Maine Unit—Wildlife Management Institute (WMI) Administrative Excellence Award

Photograph by U.S. Geological Survey.

Rena Carey is recognized for her outstanding performance in 2022 and for exceptional service to the Unit, the Maine's Unit cooperator, and the CRU national program. Rena came to The University of Maine, Department of Wildlife, Fisheries, and Conservation Biology in May 2006. She started working with the Maine Unit in December 2008. She regularly juggles a variety of tasks simultaneously, adapts to the changing administrative needs of the Unit and Department, and has the flexibility, patience, and good humor that fosters a welcoming environment and the success of those she supports. This includes departmental faculty, Unit personnel, and the nearly 30 graduate students in the department. Her poise, dedication, knowledge, and deft handling of both delicate and challenging issues have made numerous Unit transitions "work." She continues to improve the function of the Maine Unit within the university system. Rena also supervises two other administrative assistants to coordinate critical functions such as safety training and documentation. Rena excels in her unique, multifaceted administrative position and the responsibilities it requires with distinction. Rena is often recognized for her tremendous and unwavering service, willingness to rise to meet new challenges, and her patience. Her exceptional performance is notable, even against a high baseline pattern of excellence.

Awards and Scholarships

Unit Scientists and Students

It is common for CRU scientists and students to win awards from organizations that we partner with. Awards vary from international accolades to local awards. In FY 2023, 16 CRU scientists and 16 CRU students won a total of 47 awards (table 3). with students receiving 26 awards and scientists receiving 21 awards. These awards attest to the excellence of the CRU scientists and students in the CRU Program.

Table 3.   Scientist and student organizational awards for fiscal year 2023.

[AFS, American Fisheries Society; TWS, The Wildlife Society, FWS, U.S. Fish and Wildlife Service]

Title	Awardee	Award	Given by
Alabama Unit			
Student	Mariaguadalupe Vilchez	Outstanding Service Award Sharon Fitz-Coy Memorial Award	University of Florida
Florida Unit			
Student	Marion Baker	President's Award	Georgia Chapter of the AFS
Student	Kimberly Bonvechio	Best Student Speed Talk	Florida Chapter of the AFS
Student	Tyler Coleman	Outstanding Teaching Award	University of Florida, Department of Wildlife Ecology and Conservation
Student	Bethany Gaffey	Featured Graduate Student	University of Florida
Student	Kyle Miller	Luby Microgrant	University of Florida, Department of Wildlife Ecology and Conservation

Student	Alexandra Scott	University Scholar
		   Study Abroad Scholarship
			University of Florida, Department of
			   Wildlife Ecology and Conservation

Idaho Unit			
Scientist	Courtney Conway	Group Achievement Award	TWS
Scientist	Mike Quist	Outstanding Sport Fish Restoration Program Project	AFS
Massachusetts Unit			
Scientist	Allison Roy	Graduate School Distinguished Mentor Award	University of Massachusetts Amherst
Minnesota Wildlife Unit			

Scientist	David Fulton	Minnesota Award
		   Academy of Excellence Award in Team Science
			TWS
			   University of Minnesota

Mississippi Unit			

Student	Darren Shoemaker	Best Student Poster Award
		   Best Student Poster Presentation
			Mississippi State University
			   AFS: Mississippi Chapter

Student	Joshua Stafford	John Skinner Memorial Travel Award
		   Outstanding Service Award
			AFS
			   AFS: Mississippi Chapter

Missouri Unit			

Student	Hadley Boehm	Best Student Aquatics Presentation
		   Fenske Award Winner
		Missouri AFS Student Achievement Award
		D.L. Hallett Award
		Outstanding Graduate Student (Ph.D. student)
			Missouri Natural Resources Conference
			   North Central Division of the AFS
			   Missouri Chapter of the AFS
			   Missouri Cooperative Fish and Wildlife
			   Research Unit
			   University of Missouri–Columbia, School
			   of Natural Resources

Student	Levi Umland	Best Student Aquatics Presentation	North American Paddlefish and Sturgeon Society

Table 3.   Scientist and student organizational awards for fiscal year 2023.—Continued

[AFS, American Fisheries Society; TWS, The Wildlife Society, FWS, U.S. Fish and Wildlife Service]

Title	Awardee	Award	Given by
Montana Fisheries Unit			
Student	Keith Wellstone	Best Student Presentation	Montana Chapter AFS
Nebraska Unit			
Scientist	Kevin Pope	Gary L. Hill Watercraft Safety group award	U.S. Geological Survey
New Mexico Unit			
Scientist	James Cain III	Honor Plaque	Desert Bighorn Council
New York Unit			

Scientist	Angela Fuller	Distinguished Service Award
		  Distinguished Wildlife Alum Award
			Society for Conservation Biology
			  The University of Maine

North Carolina Unit			

Scientist	Corey Dunn	Regional Director's Honor Award for At-Risk
		  Species Conservation
		Outstanding Service Award
			FWS: Southeast Region
			  AFS: Mississippi Chapter

Oklahoma Unit			
Scientist	Rob Lonsinger	Alumni Achievement Award	University of Idaho, College of Natural Resources
Pennsylvania Unit			
Scientist	Duane Diefenbach	Henry S. Mosby Award	National Wild Turkey Federation
Tennessee Fisheries Unit			
Scientist	Mark Rogers	Wings Up 100 Award	Tennessee Tech University
Scientist	Amanda Rosenberger	Wings Up Research Achievement	Tennessee Tech University
Student	Katelynn Sallack	Best Student Poster	Tennessee Tech University Tennessee Chapter of the AFS
Texas Unit			

Scientist	Clint Boal	College of Agricultural Sciences and Natural
		  Resources Dean's Research Grant Award
		Outstanding Educator
			Texas Tech University, College of
			  Agriculture Sciences and Natural
			  Resources
			Texas Chapter of TWS, Texas Tech
			  University

Student	Cienna Hanson	Travel Award	Texas Chapter of the AFS
Student	Mary Mousumi	Doctoral Dissertation Completion Fellowship Graduate Student Research Support Award	Texas Tech University Graduate School
Utah Unit			
Student	Chad Teal	Best Dissertation	The University of Arizona - School of Natural Resources
Washington Unit			
Scientist	Alex McInturff	Faculty Member of the Year	School of Environmental and Forest, University of Washington
West Virginia Unit			
Scientist	Stuart Welsh	Recovery Champion Award	FWS
Wyoming Unit			
Scientist	Annika Walters	Max Award of Merit	University of Wyoming

Tribal Engagement

In the U.S. Department of the Interior's initiative, "Vision for the Future," is an objective to support Tribal Nations. USGS CRU Program scientists, staff, and students support Tribal Nations through collaborative research, technical assistance, and graduate student training. Units are assisting Tribal Nations with solving natural resource problems ranging from walleye (*Sander vitreus*) stock management to decision analysis for lake whitefish (*Coregonus clupeaformis*) harvest limits to mule deer (*Odocoileus hemionus*) fawn monitoring. Some examples of ongoing projects with and for Tribes include:

- The Montana Wildlife Unit mentors graduate students from local Tribes to build partnerships and capacity with indigenous partners in the state.

- The Wisconsin Fishery Unit works with an interagency planning committee to design telemetry-based research to better understand movements of lake whitefish in Lake Michigan.

- The Arizona Unit incorporates traditional ecological knowledge and molecular scatology for wildlife surveys on ancestral lands.

Kaylie Durglo of the Confederated Salish and Kootenai Tribes with a telemetry collared grizzly bear (*Ursus arctos horribilis*). Photograph by Payton Adams, Confederated Salish and Kootenai Tribes.

- The Vermont Unit collaborates with Tribes and other partners in the Northeast to coordinate assessments of multiple components of monitoring programs.

- The Utah Unit evaluates tui chub (*Siphateles bicolor*) populations as forage for the listed Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*) in Pyramid Lake, Nevada.

Alphabetical List of Tribal Partners and Partner Cooperative Unit

- Kootenai Tribe of Idaho (Idaho)

- Little Traverse Bay Bands of Odawa Indians, Michigan (Wisconsin Fishery)

- Non-Removable Mille Lacs Band of Ojibwe (Minnesota)

- Penobscot Nation (Vermont)

- Pyramid Lake Paiute Tribe of the Pyramid Lake Reservation, Nevada (Utah)

- Red Cliff Band of Lake Superior Chippewa Indians of Wisconsin, and Bay Mills Indian Community, Michigan (Wisconsin Fishery)

- Sault Ste. Marie Tribe of Chippewa Indians, Michigan, and Little Traverse Bay Bands of Odawa Indians, Michigan (Montana Wildlife)

- The Great Lakes Indian Fish and Wildlife Commission (Wisconsin Fishery)

- Yurok Tribe of the Yurok Reservation, California (Arizona)

Doris Duke Conservation Scholars Program

The Doris Duke Conservation Scholars Program (DDCSP) Collaborative is a two-year undergraduate conservation field program designed to provide students with an experiential introduction to a career in natural resources. The Arizona, Florida, Idaho, Massachusetts, and North Carolina Units are members of the DDCSP collaborative. Students in the DDCSP attend leadership training, work with scientists and graduate students on research projects, and are mentored by current CRU Program graduate students and Federal scientists. The Doris Duke Conservation Scholars Program scholars participate in paid summer internships with local, State, Federal, and Tribal agencies, as well as nongovernmental organizations.

Doris Duke Conservation Scholars Program Spotlights

Mariaguadalupe Vilchez—Auburn University, Alabama Unit

Maria participated in the DDCSP during her undergraduate studies at the University of Florida, where she majored in Natural Resource Conservation. Her time in the DDCSP was formative and rewarding as she participated in various aspects of Everglades research to support restoration efforts, such as studying mammal communities in the Picayune Strand State Forest, surveying the beaches of Cape Sable for sea turtles, and working with invasive species such as the Burmese python (*Python bivittatus*). Maria became involved with the Florida Unit, and was advised by Andrew Carlson and Ph.D. student Tyler Coleman, to investigate the social responses of restoring the headwaters of the St. Johns River in Florida. Her involvement with the DDCSP has allowed Maria to present her research at a variety of conferences, including the Ecological Society of America meeting (2021), American Fisheries Society meetings (2021–2023), and the Florida Chapter of The Wildlife Society (TWS) meeting (2023).

Maria is a first-year master's student at Auburn University in the School of Fisheries, Aquaculture and Aquatic Sciences and is advised by Shannon Brewer. Her thesis examines the role of altered flows and thermal variability on the reproductive success of riverine fishes. After graduate school, Maria hopes to work with a Federal government agency conducting research in aquatic systems and working collaboratively with State agencies and universities to provide science that will help inform management decisions for biodiversity.

Mariaguadalupe Vilchez sampling fish on the Tallapoosa River, Alabama. Photograph by Mariaguadalupe Vilchez, University of Florida.

Doris Duke Conservation Scholars Program scholars Hunter Henry and Madison Diaz and mentor Kaitlyn Gahl carry hoop nets. Photograph by Kaitlyn Gahl, University of Arizona.

Doris Duke Conservation Scholars Program scholars Isa Ross and Syd Ingham, mentor Kaitlyn Gahl, and Scott Bonar prepare to hike out of upper Wet Beaver Creek canyon after a multiday trip to locate fish and measure stream habitat. Photograph by Kaitlyn Gahl, University of Arizona.

Annie Vaage—University of Idaho, Idaho Unit

Annie is a senior majoring in Wildlife Sciences with a minor in Ecology at the University of Idaho. She grew up near the small town of Orofino, Idaho, where she developed a deep passion and respect for wildlife through hunting many game species with her father. During her first summer (2022) with the DDCSP, she worked alongside a graduate student mentor studying six species of forest owls in the Chiricahua Mountains in southeastern Arizona. Annie conducted her own research project that summer, examining the effects of habitat features on nest cavity presence. Annie has shared her owl research in a promotional video for the College of Natural Resources at the University of Idaho, on local television, and on a public radio podcast. She recently presented a poster on her research at TWS's 30th annual conference in Louisville, Kentucky. During summer 2023, Annie completed an internship in the Valles Caldera National Preserve in New Mexico, where she worked with black bears (*Ursus americanus*) and mountain lions (*Puma concolor*).

Annie Vaage holding a whiskered screech owl (*Megascops trichopsis*). Photograph by Day Scott, University of Idaho.

Doris Duke Conservation Scholars Program Students, University of Massachusetts, Massachusetts Unit

In the summer of 2023, DDCSP scholars conducted research on river herring and freshwater mussels under the direct supervision of Unit graduate-student mentors at the University of Massachusetts Amherst. Scholars Adamarias Agosto and Grace Davis participated in river herring (*Alosa* spp.) field-data collection with master's student Julian Burgoff, including purse seining for river herring in lakes at night, seining in estuaries, zooplankton sampling, and water-quality sampling in eastern Massachusetts. In the laboratory on the Mt. Ida campus, DDCSP scholars extracted fish otoliths. Scholars Estela Garcia (from North Carolina State University) and Julia Hatzis participated in a variety of freshwater mussel field and lab work under the supervision of Ph.D. students Stefanie Farrington and Alexa Hershberger while stationed at the FWS Cronin Aquatic Resource Lab in Sunderland, Massachusetts. Field work included side-scan sonar habitat-mapping, mussel snorkel surveys, sediment-trap deployment, and water-quality sampling. In the laboratory, the scholars mapped habitat characteristics in a geographic information system (GIS) and assisted with a host fish trial for yellow lampmussel (*Lampsilis cariosa*). The four scholars will present posters at the Society for Freshwater Science Annual Meeting in Philadelphia, Pennsylvania. in June 2024.

Scholars Owen Blacker and Anjali Shukla presented a poster with master's student Andrew Gordon at the Ecological Society of America Conference in Portland, Oregon, in August 2023 that was based on their research conducted in Summer 2022. Their project involved quantifying the effects of a parasitic fly, *Cistudinomyia cistudinis*, on the movement and shell temperature of the Eastern box turtle (*Terrapene carolina carolina*) at Camp Edwards Military Training Reservation located on Joint Base Cape Cod, Massachusetts.

Julia Hatzis, Doris Duke Conservation Scholars Program (DDCSP) scholar (left), Stefanie Farrington Cooperative Fish and Wildlife Research Unit (CRU) graduate student (middle), Hannah Davis, CRU undergraduate technician (front), and Estela Garcia, DDCSP scholar (back right) in the Connecticut River. Photograph by Hannah Davis, University of Massachusetts.

Doris Duke Conservation Scholars Program Students, University of Florida, Florida Unit

In FY 2023, the Year 1 cohort of DDCSP Collaborative students at the University of Florida assisted their graduate-student mentors on projects ranging from studying snail kites (*Rostrhamus sociabilis*) to invasive tegus (Teiidea). The Year 2 cohort presented their research results in November at TWS annual meeting in Louisville, Kentucky:

- Otto Alvarez presented "Climate change-induced reduction in the size of Alabama barrier islands."

- Jesus Rodriguez-Riverol presented "Parasite infection and antipredator behavior in freshwater snails."

- Spencer Zeitoune presented "Prey naiveté or pre-adaptation in cotton rats facing invasive pythons (*Python* spp.)."

- Logan D. Stratton presented "Food provisioning and juvenile survival in the fishing spider (*Dolomedes triton*)."

Five years after completing the program, more than two-thirds of the scholars are pursuing careers in environmental science and conservation. More than 25 percent of Doris Duke Conservation Scholars have completed or are pursuing graduate degrees related to conservation.

Doris Duke Conservation Scholars Program scholar Otto Alvarez records gas efflux measurements on a Florida panhandle beach. Photograph by J. Serano, University of Florida.

Doris Duke Conservation Scholars Program scholar Logan Stratton assists with tracking brown tree snakes (*Boiga irregularis*) in Guam. Photograph by U.S. Geological Survey.
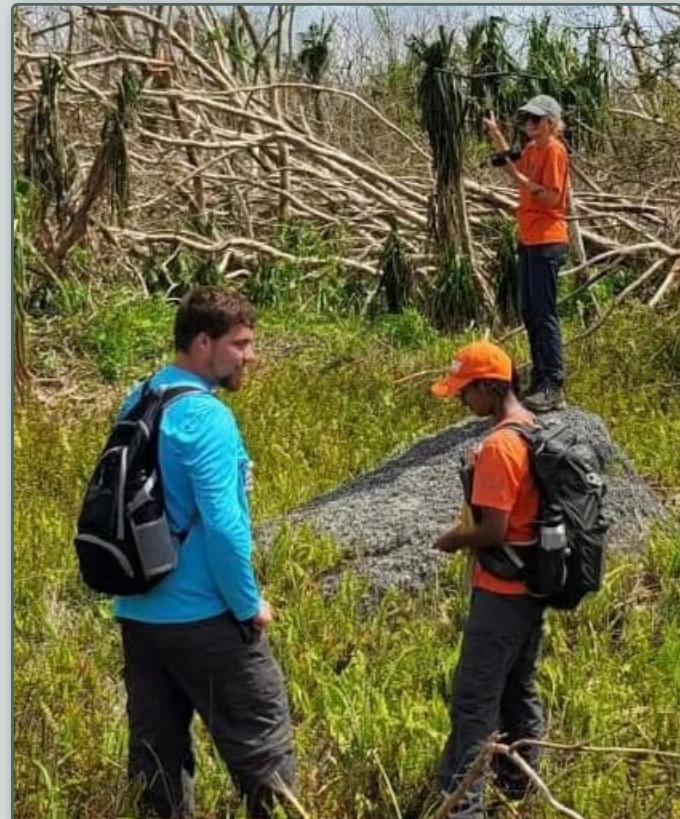
Introductions are in Order—Fiscal Year 2023 and a Little Beyond

CRU Headquarters added critical staff in FY 2023 in an effort to expand the program's ability to support the Units and their staff. Staff contact information is listed on the CRU Headquarters contacts page: https://www1.usgs.gov/coopunits/unit/Headquarters.

Meet the New CRU Headquarters Staff

Lanaia Hughes

Lanaia is an administrative student intern at the USGS. This is her first time in a professional administrative position. She is currently a full-time college student pursuing a degree in business administration at Northern Virginia Community College. In her free time, she enjoys activities such as drawing and making music.

Lanaia Hughes. Photograph by U.S. Geological Survey.

Caroline Murphy

Caroline Murphy, Associate Wildlife Biologist, joined the CRU headquarters team in August 2023 to serve as the CRU's first programs and partnerships coordinator. Over the past year, Caroline has worked to elevate opportunities for engagement between the CRU Program and Federal decision-makers, agencies, and nongovernment stakeholders. Caroline holds a bachelor's degree in wildlife ecology from the University of Delaware and has nearly a decade of experience in government relations and public affairs. From 2019 to 2023, Caroline worked as the government relations manager for The Wildlife Society, interfacing with Federal decision-makers on behalf of wildlife professionals. Caroline lives in Washington, D.C., and enjoys yoga, cooking, jigsaw puzzles, and hikes with her fiancé and their dog.

Caroline Murphy. Photograph by U.S. Geological Survey.

John Withers

John Withers joined USGS as a Pathways intern. This is the start of his career in the Federal Government, and he is learning and developing a wide variety knowledge and skills. John is also a full-time student at George Mason University working towards his bachelor's degree in business in management information systems. He has always had a passion for computers, which is why he decided to pursue this degree. John holds an associate's degree in general education from Germanna Community College, Virginia, and has prior experience in administrative work as an executive assistant for a sheet-metal company.

John Withers. Photograph by U.S. Geological Survey.

Zachary (Zack) Holcomb

Zachary Holcomb. Photograph by U.S. Geological Survey.

Zack joined the CRU Headquarters team as a Safety and Occupation Health Specialist and comes to the program with years of experience. He began his Federal career with the U.S. Department of Agriculture Forest Service in the Allegheny National Forest (Pennsylvania) directly after getting his bachelor's degree in environmental biology. Next, he joined the USGS as a hydrologic technician in the Baton Rouge office within the Lower Mississippi Gulf Center, where he became interested in watercraft safety. At his next duty station at the USGS Kansas Water Science Center, he became the local Collateral Duty Safety Program Coordinator, and also started training employees on nonmotorized watercraft safety and subsequently became a motorboat operators certification course instructor. Zack has also worked on and organized facility safety plans, chemical hygiene plans, internal facility audits, watercraft/trailer inspections, and job hazard analyses. He resides in Kansas with his wife and is an avid hunter and fisher and enjoys conversations about any outdoor adventure.

Brent Sigafus

Brent Sigafus. Photograph by U.S. Geological Survey.

Brent moved from the USGS Southwest Biological Science Center to the CRU Program. In 2000, Brent worked with Cecil Schwalbe as a University of Arizona science technician studying Chiricahua leopard frogs and bullfrogs. At the University of Arizona, Brent became aware of the Arizona Unit, which was located near the Schwalbe lab. Brent was then hired by the USGS as a biologist, and his work focused on amphibians of the Southwest under the Amphibian Research and Monitoring Initiative. He studied threatened and endangered amphibians, aquatic invasive species, habitat change and alteration, population dynamics, and drought. In 2009, Brent became an instructor in the USGS Firearms Safety Program instructing the classes "Specimen Collection" and "Defense Against Wild Animals." He held the joint positions of Southwest and Northwest-Pacific Islands Regional Firearms Safety Manager, Collateral Duty Safety Program Coordinator, and the Collateral Duty Environmental Management Program Coordinator for the USGS Southwest Biological Science Center, while doing "a little science on the side." The transition to his current position with the CRU Program allows Brent to instruct courses such as "Wilderness First Aid," "CPR [cardiopulmonary resuscitation]/AED [automated external defibrillator]," "Off Road Driving," "Bear Spray," "Animal Awareness," "Heat/Cold Stress," "Field Communication," and other safety courses. In his spare time, he is the Scoutmaster of a Boy Scout troop and Assistant Scoutmaster of a Girl Scout troop; loves to be in the outdoors camping, hunting, and fishing; doing projects around the house; and enjoying the empty-nester life.

University and State Cooperators

The Cooperative Fish and Wildlife Research Units Program is a unique cooperative partnership among State fish and wildlife agencies, universities, WMI, FWS, and USGS. The signed cooperating universities and State fish and wildlife agencies for each of the 43 Units are listed below.

https://www1.usgs.
gov/coopunits/
allCooperator/all

Alabama

Auburn University
Alabama Department of Conservation and
    Natural Resources

Alaska

University of Alaska Fairbanks
Alaska Department of Fish and Game

Arizona

The University of Arizona
Arizona Game and Fish Commission

Arkansas

University of Arkansas
Arkansas Game and Fish Commission

California

California State Polytechnic University, Humboldt
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
Hawaii Department of Land and Natural Resources

Idaho

University of Idaho
Idaho Department of Fish and Game

Indiana

Purdue University
Indiana Department of Natural Resources

Iowa

Iowa State University
Iowa Department of Natural Resources

Kansas

Kansas State University
Kansas Department of Wildlife and Parks

Louisiana

Louisiana State University
Louisiana Department of Wildlife and Fisheries

Maine

The 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

Michigan

Michigan State University
Michigan Department of Natural Resources

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

Nevada

University of Nevada, Reno
Nevada Department of Wildlife

New Mexico

New Mexico State University
New Mexico Department of Game and Fish

New York

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 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 & Wildlife Department

Virginia

Virginia Polytechnic Institute and State University
Virginia Department of Wildlife Resources

Washington

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

West Virginia

West Virginia University
West Virginia Division of Natural Resources

Wisconsin—Fishery

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

Cooperative Fish and Wildlife Research Unit Program

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Meet the Units—Cooperative Fish and Wildlife Research Units Program Highlights by Unit

In the following regional sections (fig. 7), accomplishments of individual Cooperative Fish and Wildlife Research Units Program are highlighted for Fiscal Year 2023–24.
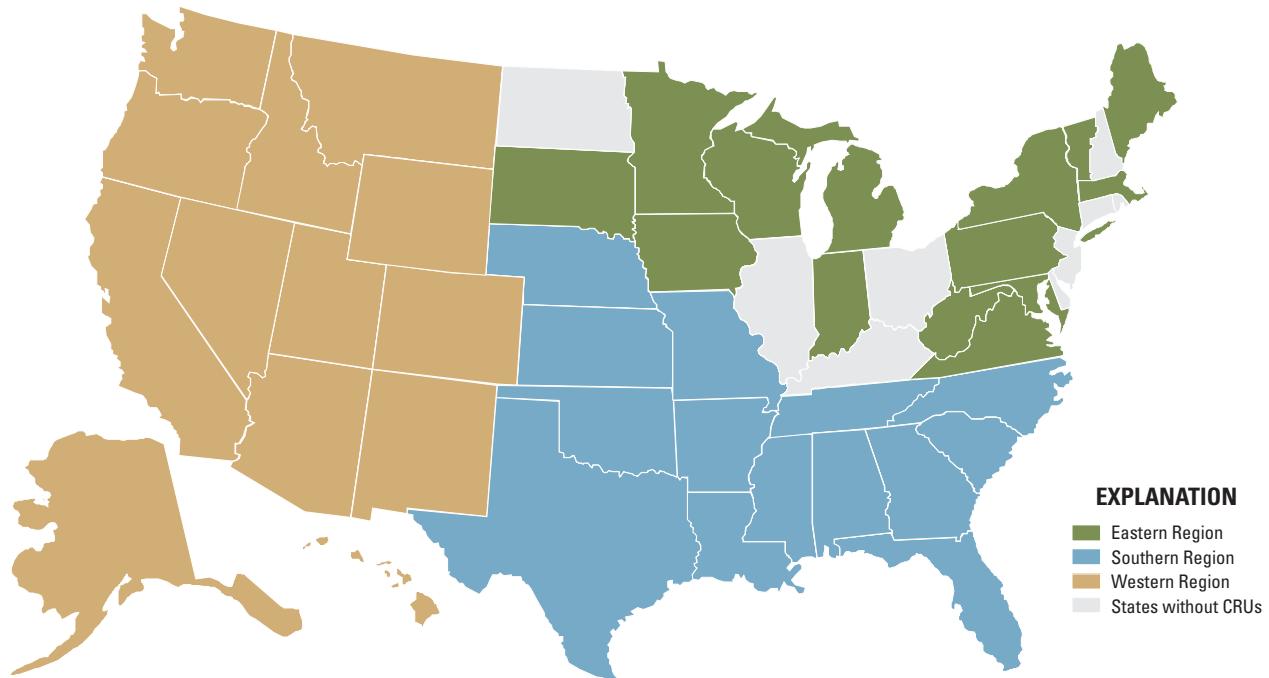

Figure 7. Map of the United States showing the three administrative regions for the Cooperative Fish and Wildlife Research Units Program. Colors used to denote the three administrative regions correspond to the Unit pages that follow: Eastern Region, green; Western Region, brown; Southern Region, blue.

Green River, Wyoming. Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Indiana

Cooperative Fish and Wildlife Research Unit

Scientists

New Unit; currently hiring for three vacancies

About the Unit

The Indiana Cooperative Fish and Wildlife Research Unit is the 43rd of the U.S. Geological Survey (USGS) Cooperative Research Units (CRU) added since the nationwide program began in 1935. The CRU Program's goal is to increase opportunities for graduate education in fisheries and wildlife science and to facilitate research and technical assistance between natural resources agencies and universities. Although the Indiana Unit will be focused on natural-resource management needs in the State of Indiana, many of these State needs are also regional needs, and the U.S. Fish and Wildlife Service (FWS) will advise and coordinate these regional needs. USGS hiring actions are ongoing: the Indiana Unit will house three Federal scientists and will begin operations once staff are in place at Purdue University in 2024.

Prothonotary warbler (*Protonotaria citrea*) at Patoka River National Wildlife Refuge in Indiana. Photograph by James Kawlewski, U.S. Fish and Wildlife Service.

Bobcat kitten (*Lynx rufus*) at Big Oaks National Wildlife Refuge, Indiana. Photograph by Rob Chapman, U.S. Fish and Wildlife Service.

Quotes from Cooperators

"The creation of this new Unit is another milestone in the highly successful USGS Cooperative Research Units Program, and we are proud to join the State of Indiana, Purdue University, the USGS, Wildlife Management Institute and the others to address conservation questions facing Indiana and the region," said FWS Science Applications Program Assistant Regional Director, Craig Czarnecki. "We look forward to engaging with the students and professionals at Purdue University as we codevelop scientific research and support the next generation of conservationists."

"We look forward to the tremendous opportunity that collaboration with the Indiana CRU will bring to our State and Purdue University," said Karen Plaut, Executive Vice President of research at Purdue University. "It will have a direct impact on graduate education as well as research productivity and innovation."

"Data and research constantly drive our decision-making as we work to wisely manage Indiana's natural, cultural, and recreational resources," said Indiana Department of Natural Resources Director, Dan Bortner. "Through this new partnership, we will gain greater information about supporting stronger ecosystems for wildlife and people alike across the State."

"The addition of Indiana to the USGS Cooperative Units Program is a proud moment for WMI [Wildlife Management Institute], the only national, private cooperator," said Wildlife Management Institute president, Tony Wasley. "WMI was involved in the creation of the CRU Program in 1935, and we applaud the 2023 agreement as this new Unit will serve as a model for researchers to work collaboratively with the conservation community to benefit wildlife and their habitats. It is especially exciting to have this multiagency program bringing together the passion and expertise of partners and resources to open new doors of opportunity and to learn and apply the best available natural resource science to real-world, real-time challenges."

Sunrise at Muscatatuck National Wildlife Refuge in Indiana. Photograph by Alejandro Galvan, U.S. Fish and Wildlife Service.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Purdue University, and Indiana Department of Natural Resources.
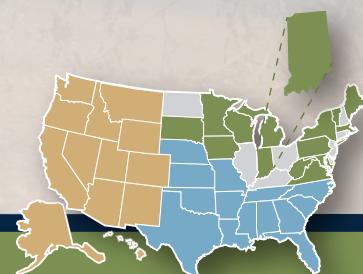
Iowa
Cooperative Fish and Wildlife Research Unit

Scientists

Robert Klaver, Unit Leader; Anna Tucker, Assistant Unit Leader; Michael Moore, Assistant Unit Leader

About the Unit

Founded in 1932, the Iowa Cooperative Fish and Wildlife Research Unit was the nation's first Cooperative Research Unit, preceding the creation of additional Units by three years. The Iowa Unit has a legacy of applied conservation work and continues to foster close relationships with university and agency partners, as well as cooperative work, completing research projects that incorporate multiple State and Federal partners. The community built by the Unit staff shares their complementary skills and knowledge to benefit our university partner and cooperators. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: animal migration, Species of Greatest Conservation Need and threatened and endangered species, grassland management and restoration, population monitoring and advanced modeling, and invasive species.

Research Projects

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

Sandhill cranes (*Antigone canadensis*) have naturally recolonized Iowa. Little is known about their habitat use and movements in this highly agricultural State. The assumption is that cranes in Iowa are part of the Eastern Population of sandhill cranes, but some birds may be associated with the Midcontinent Population. Management of the Eastern Population and the Midcontinent Population of sandhill cranes is different. Hunting of cranes is more common in the Midcontinent Population, which is larger than the Eastern Population. It is critical to understand if sandhill cranes belong to both of these populations or only one population because of the differences in population management. The results from this study are informing Iowa Department of Natural Resources (DNR) which populations of sandhill cranes occupy in the State. Results on movements and habitat use are providing guidance on how cranes may colonize Iowa's landscape in the future.

Sandhill cranes (*Antigone canadensis*). Photograph by Courtney Celley, U.S. Fish and Wildlife Service.

Imperiled Bumble Bee Occupancy and Health Status in Iowa

The rusty patched bumble bee (*Bombus affinis*) is a federally endangered species that was once widespread across the eastern United States and upper Midwest. Little is known about the distribution and status of rusty patched bumble bee populations in Iowa.

Rusty patched bumble bee (*Bombus affinis*). Photograph by U.S. Fish and Wildlife Service.

While *B. affinis* is the only species in this region currently protected under the Endangered Species Act, many other bumble bee species have been documented to be in decline as well, including the American bumble bee (*Bombus pensylvanicus*). Creation, restoration, and maintenance of habitat in the Midwestern region can also support priorities for conservation of pollinators more broadly. The project is contributing samples to several ongoing efforts to monitor *B. affinis* population genetic structure and threats to resilience (for example, pesticides and pathogens). This project is a collaboration between the Iowa Unit, Iowa State University, U.S. Fish and Wildlife Service's Science Applications, Ecological Services, and Partners for Fish and Wildlife programs. This research can help with determining habitat management strategies for the Partners for Fish and Wildlife Program as well as targets for *B. affinis* recovery planning.

Habitat Associations and Biotic Interactions of Invasive Rusty Crayfish to Inform Risk Assessment and Management of Shallow Glacial Lakes at the Invasion Front

The invasive rusty crayfish (*Faxonius rusticus*) has caused tremendous ecological and economic damage in glacial lakes in the Upper Midwest. Following its introduction into Wisconsin in the 1960s, rusty crayfish have decimated aquatic vegetation, preyed on fish eggs and larvae, restructured food webs, and forced the local extinction of native species. This crayfish species also potentially reduces water quality by stirring up nutrients and sediment from deeper waters and lakebeds. Its range has recently expanded south to shallow-eutrophic lakes of the Upper Mississippi Basin. The first lake-dwelling population of rusty crayfish in Iowa was discovered in Storm Lake, Iowa, in 2018, but little is known about its relative abundance and distribution or how these crayfish will interact with native and invasive species. This project is assessing the distribution and habitat and biotic associations of rusty crayfish both within Storm Lake and among lakes using trapping data from surveys within the Upper Mississippi River Basin. The project is analyzing how lake habitat, species community interactions, human socioeconomic factors, and habitat management and restoration practices may regulate the spread of rusty crayfish. This research is informing vulnerability assessments for early detection and management of this species.

Technical Assistance

Robert Klaver assisted the Iowa DNR on wild turkey (*Meleagris gallopavo*) population dynamics, grey fox (*Urocyon cinereoargenteus*) movements, and Canada goose (*Branta canadensis*) population dynamics and movements. Tracking Canada geese to Artic molting areas using global positioning system and global system for mobile communications collars helps determine the length and duration of movements to and from molting areas.

Anna Tucker is working closely with partners in the Iowa DNR to develop an integrated population model for trumpeter swans (*Cygnus buccinator*) in the State to inform recovery planning and reintroduction efforts.

Michael Moore is assisting Iowa DNR in conducting a literature review on the effects of hydropeaking on river fishes as part of an ongoing partnership with Iowa DNR, U.S. Army Corps of Engineers, The Nature Conservancy, and other agencies. This is to better understand how to manage flood control and hydroelectric dams to promote downstream ecosystem health, specifically proposed changes to operations of Red Rock Dam on the Des Moines River.

Selected Publications

Bartelt, P.E., DeVries, A.T., and Klaver, R.W., 2023, Response of tiger salamanders (*Ambystoma t. tigrinum*) to wetland restoration in a Midwestern agricultural landscape, U.S.A: Ichthyology & Herpetology, v. 111, no. 4, p. 571–583, accessed March 19, 2024, at https://doi.org/10.1643/h2020083.

Bouska, K.L., Healy, B.D., Moore, M.J., Dunn, C.G., Spurgeon, J.J., and Paukert, C.P., 2023, Diverse portfolios— Investing in tributaries for restoration of large river fishes in the Anthropocene: Frontiers in Environmental Science, v. 11, article 1151315, 18 p., accessed March 19, 2024, at https://doi.org/10.3389/fenvs.2023.1151315.

Giese, J.C., Agee, M., Campbell, C.G., Hatch, A., Mitsdarfer, C., Poincon, A.-U., Russell, R.C., Chamberlain-Irwin, H.N., Kastner, M., Franklin, D., and Klaver, R.W., 2023, Book review—Restoring the balance—What wolves tell us about our relationship with nature: Journal of Mammalogy, v. 104, no. 2, p. 425–427, accessed March 19, 2024, at https://doi.org/10.1093/jmammal/gyac100.

Moore, M.J., and Hyman, A.A., 2024, What can conservation culturomics tell us about factors driving public interest in aquatic endangered species: Biological Conservation, v. 289, article 110397, 8 p., accessed March 19, 2024, at https://doi.org/10.1016/j.biocon.2023.110397.

Tucker, A.M., McGowan, C.P., Nuse, B.L., Lyons, J.E., Moore, C.T., Smith, D.R., Sweka, J.A., Anstead, K.A., DeRose-Wilson, A., and Clark, N.A., 2023, Estimating recruitment rate and population dynamics at a migratory stopover site using an integrated population model: Ecosphere, v. 14, no. 2, article e4439, 16 p., accessed March 19, 2024, at https://doi.org/10.1002/ecs2.4439.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Iowa State University, and Iowa Department of Natural Resources.

Trabuco Creek in Cleveland National Forest. Photograph by U.S. Fish and Wildlife Service.

Maine
Cooperative Fish and Wildlife Research Unit

Scientists

Joseph Zydlewski, Unit Leader; Christina A. Murphy, Assistant Unit Leader; Tristan Nuñez; Assistant Unit Leader

About the Unit

The Maine Cooperative Fish and Wildlife Research Unit is one of the oldest Units, and is located in a State that is known for its peoples' connection to the land and waters through industry, recreation, and heritage. Unit scientists are dedicated to creating a positive learning environment for graduate students at The University of Maine. Although Unit scientists, research staff, and students study broadly applicable topics, project narratives follow the themes of hunting and fishing, and forest management.

Research Projects

Wild Turkey Population and Harvest Management in Maine

Limiting uncertainty may help to provide accurate information on management decisions. In the case of Maine's goals and methods for wild turkey (*Meleagris gallopavo*) management, this means improving estimates of harvest rate and abundance of turkeys and accounting for spatial variation in these processes. The Maine Unit is integrating leg-band recovery and a population model to try to determine what kind of banding effort could help to achieve lower levels of uncertainty in the population model. This may

Lara Katz (Maine Unit) with an Eastern wild turkey (*Meleagris gallopavo*). Photograph by U.S. Geological Survey.

aid in developing a data-driven approach to managing populations to meet the State's goals to stabilize wild turkey populations below biological carrying capacity and at socially acceptable levels in southern portions of the State while increasing the size and distribution of turkey populations in other areas. By defining how decision-makers quantify and deal with risks associated with uncertainty, there is a greater level of transparency, thus allowing stakeholders to assess decision-maker concerns, which often leads to greater support for the final decisions made to manage these gamebirds.

Wetland Ecology of Northeastern Lowland Forests

Northern Forest lowlands, including seasonally wetted forested swamps and seeps, contain regionally important commercial tree species such as northern white-cedar (*Thuja occidentalis*), balsam fir (*Abies balsamea*), and red spruce (*Picea rubens*). Although these lowland forests are widely harvested, the effects of forestry operations on these ecosystems are poorly understood. Areas of intermittent waters, including seasonally wetted forested swamps and seeps, are increasingly recognized for the important roles these areas play in supporting water quality and biodiversity, and as critical habitat for wildlife of conservation concern. Our project is a collaboration of researchers across multiple agencies and includes the Maine Unit, the U.S. Department of Agriculture Forest Service, The University of Maine, and industry partners. This study may provide baseline information on aquatic forest species and processes. This information may help inform sustainable forest management practices and prepare stakeholders for questions regarding ecological tradeoffs in management of intermittent waters throughout Northern Forest lowlands.

Rena Carey joined a field sampling team at the Maine Unit. Photograph by U.S. Geological Survey.

Technical Assistance

Unit scientists work with the Wabanaki Youth in Science program at The University of Maine to engage and learn with students, researchers, and indigenous teachers about ecosystems.

Christina Murphy presented a keynote address to the Oregon Lakes Association annual meeting on reservoir ecology.

Tristan Nuñez, who reported in late 2023, has been meeting with cooperators and other stakeholders to assess research needs and interests, including the Maine Department of Inland Fisheries and Wildlife, U.S. Fish and Wildlife Service, the Penobscot Nation Department of Natural Resources, and others. Nuñez has also been working to support graduate students from The University of Maine by serving on student committees and offering spatial data-science trainings.

Graduate Student Spotlight

Lara Katz, Master of Science in Wildlife Ecology, The University of Maine

Lara Katz. Photograph by Lara Katz.

Thesis title: "Integrating environmental DNA, traditional fisheries techniques, and species distribution modeling to assess bridle shiner status in Maine."

Lara continues to work with the Maine Unit as she pursues a Ph.D at the University of Maine. Her dissertation will focus on wild turkey population dynamics using modeling techniques.

Selected Publications

Flye, M.E., Sponarski, C.C., McGreavy, B., and Zydlewski, J.D., 2023, Leading the charge—A qualitative case-study of leadership conditions in collaborative environmental governance structures: Journal of Environmental Management, v. 348, article 119203, 9 p., accessed March 19, 2024, at https://doi.org/10.1016/j.jenvman.2023.119203.

Gerth, W.J., Murphy, C.A., and Arismendi, I., 2023, Caddisfly dives for oviposition—Record-shattering depths and poor life choices in a dammed river system: Freshwater Science, v. 42, no. 1, p. 104–117, accessed March 19, 2024, at https://doi.org/10.1086/724053.

Murphy, C.A., Pollock, A.M., Johnson, S.L., and Arismendi, I., 2023, Linked foraging and bioenergetics modeling may inform fish parasite infection dynamics: Environmental Biology of Fishes, v. 106, p. 1345–1356, accessed March 19, 2024, at https://doi.org/10.1007/s10641-023-01420-2.

Zydlewski, J., Coghlan, S., Dillingham, C., Figueroa-Muñoz, G., Merriam, C., Smith, S., Smith, R., Stich, D., Vogel, S., Wilson, K., and Zydlewski, G., 2023, Seven dam challenges for migratory fish—Insights from the Penobscot River: Frontiers in Ecology and Evolution, v. 11, article 1253657, accessed March 19, 2024, at https://doi.org/10.3389/fevo.2023.1253657.

Northern forest and beaver (*Castor canadensis*) pond. Photograph by Keith Ramos, U.S. Fish and Wildlife Service.

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"Thanks for your willingness to tackle this emerging and very challenging new issue."

—Francis Brautigam, Director of Fisheries & Hatcheries, Maine Inland Fisheries and Wildlife.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, The University of Maine, and Maine Department of Inland Fisheries and Wildlife.

Massachusetts
Cooperative Fish and Wildlife Research Unit

Scientists

Allison Roy, Unit Leader; Graziella V. DiRenzo, Assistant Unit Leader; Tammy L. Wilson, Assistant Unit Leader

About the Unit

The Massachusetts Cooperative Fish and Wildlife Research Unit is composed of scientists who have strong quantitative expertise, allowing the Unit to support projects with a wide variety of taxa, ecosystems, and approaches. The Unit's proximity to the U.S. Fish and Wildlife Service (FWS) regional office provides opportunities for recruiting Pathways student interns [see information at https://www.fws.gov/intern], who work at FWS while getting their degree, and several students have been hired by FWS after graduation. The Massachusetts Unit handles diverse management and ecological questions from land to water and from basic experimental designs to complicated hierarchical modeling. The Unit aids Federal, State, and Tribal partners in decision-making processes related to policy and management. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: restoration, Species of Greatest Conservation Need and threatened and endangered species, population monitoring and advanced modeling, diseases of fish and wildlife, and Tribal consultation and engagement.

Prairie warbler (*Setophaga discolor*). Photograph by U.S. Fish and Wildlife Service.

Moose (*Alces alces*) in a lake. Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Research Projects

## Restoring Aquatic Habitats through Dam Removal

There are thousands of small dams in Massachusetts that fragment and impair nearly every stream and river throughout the State, altering fish passage, water flow, and sediment and nutrient movement, making these ecosystems less resilient to natural and anthropogenic disturbances. To date, over 70 dams have been removed in the State, yet only a fraction of these streams has been monitored to assess water quality, habitat, and biotic responses to dam removal. Information on dam removal, including on the watershed and long-term effects of these changes, may help educate the public on expectations following dam removal. Cooperators may also benefit from understanding ecological changes following dam removal in order to address questions from local, regional, and national regulatory communities. This project is a collaborative effort among the Massachusetts Division of Ecological Restoration, Massachusetts Unit, U.S. Department of Agriculture Forest Service (FS), Trout Unlimited, and Massachusetts Division of Fisheries and Wildlife. An assessment of the responses of water quality, macroinvertebrates, and fishes to dam removal may be used to model the collective ecological effects of dam removal statewide. Climate survey results may be used to help inform decision-making around restoration activities to increase watershed resilience under changing climates.
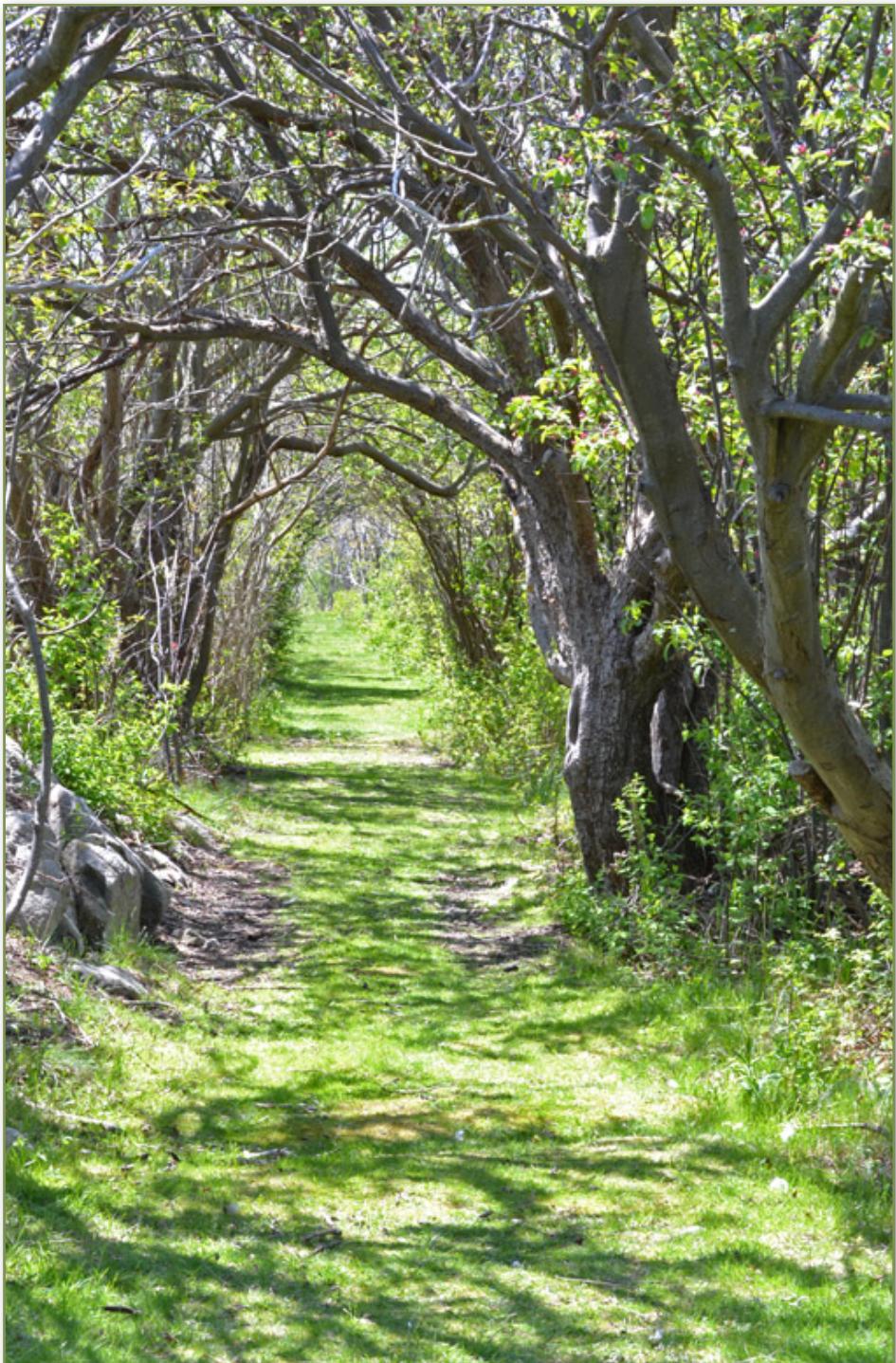
Anne's Way, Thatcher Island National Wildlife Refuge, Massachusetts. Photograph by Matt Poole, U.S. Fish and Wildlife Service.
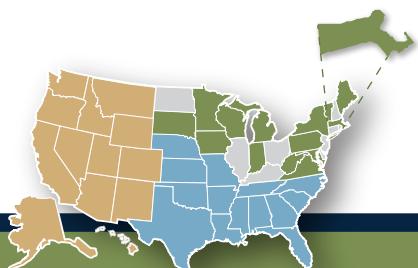
Evaluating the Effect of Management and Stressors on At-risk Species in Pine Barrens

Mandated by the Sikes Act of 1960, natural resource managers work to manage the habitats and wildlife that are found on military installations in the United States and Territories. At Camp Edwards Military Training Reservation (hereafter, Camp Edwards) in Bourne, Massachusetts, wildlife that occupies pine barrens includes the State-protected eastern box turtle (*Terrapene carolina carolina*) and the prairie warbler (*Setophaga discolor*), which is a declining species. In 2020, natural resource managers at Camp Edwards reported that eastern box turtles were being infected by myiasis, which occurs when flesh flies deposit larvae into the living tissue of a vertebrate host. Initial study results suggest that infected turtles may exhibit behavioral fever in response to myiasis, but there was no observed change in body condition or habitat use during a single field season.

It was also reported in the initial study that although prairie warblers are declining throughout their range, prairie warbler abundance increased at Camp Edwards from 2013 to 2022, where point-count estimates show a positive trend. These study results may help inform how prairie warblers respond to long-term management of habitat. Continued habitat management could improve colonization rates and sustain prairie warbler populations. This work on pine barrens species at Camp Edwards was done in collaboration with the FWS and the Natural Resources Program at the Massachusetts Army National Guard, Camp Edwards.

Effects of Habitat, Density, and Climate on Moose and Winter Tick Ecology in the Northeast U.S

Moose (*Alces alces*) in northeast North America are being affected by winter tick (*Dermacentor ablipictus*) epizootics that can affect fecundity and calf survival. However, the main drivers of tick abundance remain uncertain. This project leverages a multiagency partnership (Northeast Wildlife Monitoring Network) to examine regional and local drivers of winter tick abundance. Partners include Dartmouth College, Mass Wildlife, Maine Department of Inland Fisheries and Wildlife, U.S. Geological Survey Northeast Climate Adaptation Science Center, New Hampshire Fish and Game, Penobscot Department of Natural Resources, FWS, FS, Vermont Cooperative Fish and Wildlife Research Unit, and Vermont Fish & Wildlife Department. The research team is improving monitoring methods for both moose and winter ticks that may help to inform habitat and population management decisions.

Eastern box turtle (*Terrapene carolina carolina*). Photograph by Sharon Peregoy, U.S. Geological Survey.

Technical Assistance

Allison Roy led two regional working groups on Atlantic Coast freshwater mussel species—brook floater (*Alasmidonta varicosa*) and yellow lampmussel (*Lampsilis cariosa*). The working groups are made up of Unit scientists and State, Provincial, and Federal biologists and managers in order to foster information-sharing and collaboration for coordinated conservation of these imperiled species.

Graziella DiRenzo helped coordinate an "R Hacky Hour" for graduate students, where students come for coding help and to build community. She also initiated the organization of a structured decision-making workshop around chronic wasting disease management for the Massachusetts Division of Fisheries and Wildlife (MassWildlife).

Tammy Wilson is working with FWS partners to develop a machine-learning model that potentially can be used in conjunction with nest cameras to monitor bald eagle nesting life-cycle and food-provisioning events.

Mill River, Massachusetts. Photograph by Lia McLaughlin, U.S. Fish and Wildlife Service.

Selected Publications

Bartz, K.K., Hannam, M.P., Wilson, T.L., Lepak, R.F., Ogorek, J.M., Young, D.B., Eagles-Smith, C.A., and Krabbenhoft, D.P., 2023, Understanding drivers of mercury in lake trout (*Salvelinus namaycush*), a top-predator fish in southwest Alaska's parklands: Environmental Pollution, v. 330, article 121678, 11 p., accessed March 19, 2024, at https://doi.org/10.1016/j.envpol.2023.121678.

Grant, E.H.C., DiRenzo, G.V., and Brand, A.B., 2023, Abiotic and biotic factors reduce the viability of a high-elevation salamander in its native range: Journal of Applied Ecology, v. 60, no. 8, p. 1684–1697, accessed March 19, 2024, at https://doi.org/10.1111/1365-2664.14431.

Grant, E.H.C., Mummah, R.O., Mosher, B.A., Evans, J., and DiRenzo, G.V., 2023, Inferring pathogen presence when sample misclassification and partial observation occur: Methods in Ecology and Evolution, v. 14, no. 5, p. 1299–1311, accessed March 19, 2024, at https://doi.org/10.1111/2041-210X.14102.

He, X., Andreadis, K., Roy, A.H., Kumar, A., and Butler, C.S., 2023, Developing a stochastic hydrological model for informing lake water level drawdown management: Journal of Environmental Management, v. 345, article 118744, 13 p., accessed March 19, 2024, at https://doi.org/10.1016/j.jenvman.2023.118744.

Sirén, A.P., Berube, J., Clarfeld, L.A., Sullivan, C.F., Simpson, B., and Wilson, T.L., 2024, Accounting for missing ticks—Use (or lack thereof) of hierarchical models in tick ecology studies: Ticks and Tick-Borne Diseases, v. 15, no. 4, 102342, accessed July 12, 2024, at https://doi.org/10.1016/j.ttbdis.2024.102342.

Skorupa, A.J., Roy, A.H., Hazelton, P.D., Perkins, D., and Warren, T., 2022, Evaluation of host fishes for the Brook Floater (*Alasmidonta varicosa*) from populations in Massachusetts and Maine, USA: Freshwater Mollusk Biology and Conservation, v. 25, no. 2, p. 91–102, accessed March 19, 2024, at https://doi.org/10.31931/fmbc-d-21-00011.

Graduate Student Spotlights

Meghna Marjadi, Ph.D. in Organismic and Evolutionary Biology, University of Massachusetts Amherst

Dissertation title: "Timing is everything: Climate change implications for phenological events and reproductive success in river herring."

Meghna Marjadi stands with unit leader Allison Roy in cap and gowns during a graduation ceremony. Photograph by Pamela Narang, used with permission.

Marjadi is a postdoctoral fellow with the School for Marine Sciences & Technology at the University of Massachusetts Dartmouth and part of the National Oceanic and Atmospheric Administration's Cooperative Research Branch at the Northeast Fisheries Science Center, where she is conducting research on offshore wind effects on fisheries.

Andrew B. Gordon, Master of Science in Wildlife, University of Massachusetts Amherst

Thesis title: "Pine barrens wildlife management: exploring the impact of a stressor and active management on two taxa at Camp Edwards."

Andrew Gordon smiles in a forest while holidng an eastern box turtle (*Terrapene carolina carolina*). Photograph by Andrew Gordon, Univeristy of Idaho.

Andrew works as a full-time employee at FWS under the Science Applications division in the Cortland, New York, field office.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Massachusetts, Massachusetts Division of Fisheries and Wildlife, and Massachusetts Division of Marine Fisheries.

Michigan Cooperative Fish and Wildlife Research Unit

Scientists

Brett DeGregorio, Unit Leader; two vacancies

About the Unit

Having been established in 2022, the Michigan Cooperative Fish and Wildlife Research Unit is new and has not even celebrated its first birthday. The Unit leader is in the stage of building relationships and exploring how the Unit will contribute to opportunities for natural resources research in the State of Michigan. Although Brett DeGregorio studies broadly applicable topics, the following project narrative follows these themes: forest management and restoration, and decision science and structured decision-making.

Research Project

Evaluating Outcomes of Oak Forest Management on Southern Michigan State Game Areas

Upland oak ecosystems in the eastern United States are critically important habitats for a wide diversity of game and nongame wildlife species. However, these oak ecosystems are threatened by "mesophication," a process in which tree species that tolerate drier conditions, such as maples, invade and displace oak. Oak displacement can cause a regime shift in the ecosystem that can only be reversed with extremely intensive management intervention. Understanding the efficacy of oak habitat management techniques, such as prescribed fire, mechanical disturbance, and herbicide application, may help to protect intact upland oak ecosystems. Working with partners from the Michigan Department of Natural Resources, Michigan State University, and Michigan Natural Features Inventory, the research team is evaluating the outcomes of oak management at a large number of oak stands (about 75 units) and implementing a Before-After Control-Impact study. Results from this study may assist in understanding (1) the management tools that may be required and (2) how often these tools need to be used in order to combat mesophication. The results may aid in preservation and long-term persistence of valuable oak woodlands.

A raccoon (*Procyon lotor*) meets a river otter (*Lontra canadensis*). Photograph by Emily Johansson, Arkansas State University.

Technical Assistance

Working with partners from the U.S. Fish and Wildlife Service, Brett DeGregorio used camera traps at Shiawassee National Wildlife Refuge to estimate the density of Northern raccoons (*Procyon lotor*), an important nest predator.

Selected Publications

Johansson, E.P., and DeGregorio, B.A., 2023, The effects of landscape and yard features on mammal diversity in residential yards within Northwest Arkansas, USA: Urban Ecosystems, v. 27, no. 1, p. 275–287, accessed March 19, 2024, at https://doi.org/10.1007/s11252-023-01433-w.

Veon, J.T., Lassiter, E.V., Johansson, E., Shaw, M., McTigue, L., Massey, A., Gibson, R., and DeGregorio, B.A., 2023, Influence of human development and predators on patterns of Virginia opossum occupancy, abundance, and activity: Journal of Zoology, v. 321, no. 4, p. 278–288, accessed March 19, 2024, at https://doi.org/10.1111/jzo.13111.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Michigan State University, and Michigan Department of Natural Resources.

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> "The Department of Fisheries and Wildlife and College of Agriculture and Natural Resources at Michigan State University were delighted to welcome the Michigan Unit to campus in 2023. Our Department and College have long-standing relationships with State, Federal, Tribal, and industry natural resources partners, but the addition of the Michigan Unit takes those relationships to a new level and adds critical science capacity. Science-based conservation is legislatively mandated in Michigan, and we look to the Unit for helping us advance actionable science in support of natural resource conservation for the State, region, and Nation."
>
> —Gary Roloff, Chair, Fisheries and Wildlife Department, Michigan State University.

Raccoon (*Procyon lotor*). Photograph by Emily Johansson, Arkansas State University.

Seney National Wildlife Refuge. Photograph by Courtney Celley, U.S. Fish and Wildlife Service.

Minnesota Cooperative Fish and Wildlife Research Unit

Scientists

David E. Andersen, Unit Leader; David Fulton, Assistant Unit Leader; Lynn Waterhouse, Assistant Unit Leader

About the Unit

The Minnesota Cooperative Fish and Wildlife Research Unit is situated near the confluence of the Eastern Deciduous Forest, Boreal Forest, and Tall Grass Prairie biomes. The Unit investigates the intersection of terrestrial and aquatic ecosystems and human interaction. The Minnesota Unit is unique in its disciplinary spread across the human dimensions and quantitative wildlife and fisheries approaches. The Minnesota Unit emphasizes research on effects of human activities on aquatic and terrestrial ecosystems that are of State, regional, and national significance. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: animal migration, invasive species, human dimensions, Tribal consultation and engagement, and population monitoring and advanced modeling.

American goshawk (*Accipiter atricapillus*). Photograph by Karen Laubenstein, U.S. Fish and Wildlife Service.

Research Projects

Minnesota Trumpeter Swan Migration Ecology and Conservation

Trumpeter swans (*Cygnus buccinator*) were locally extinct from the Great Lakes region of North America by the late 1800s and were successfully reintroduced beginning in the late 1960s. These Interior Population birds are now abundant across most of their historical range, but little is known about their movement ecology, particularly migration. Understanding trumpeter swan movement ecology can provide information to help with conservation of a newly abundant member of the regional bird population. This project has a broad range of collaborators across the Great Lakes region, including the U.S. Fish and Wildlife Service; Canadian Wildlife Service; Tribal, State, and Provincial natural resources agencies; and nongovernmental natural resources agencies. Interior Population trumpeter swans have a range of migration strategies, including long-distance (greater than 100 kilometers [60.2 miles]) seasonal movements and local movements, presumably to areas with access to open water and food. This behavioral flexibility will likely result in continued colonization of appropriate habitat beyond their current distribution, and enable trumpeter swans to adapt to changes in distribution and abundance of habitat in the face of climate change.

Genetic Biocontrol of Invasive Species: Understanding Attitudes and Risk Perceptions

Very little is known about public attitudes or risk perceptions concerning the use of genetic modifications for aquatic invasive-species control. To evaluate Minnesotans' attitudes and risk perceptions related to the use of genetic modification techniques for the control of invasive species, a web-based survey is underway to collect these data. The goal is to better describe public understanding and attitudes towards the use of advanced genetic-modification techniques as control tools for invasive species. Specifically, this project's objectives include understanding previous knowledge, attitudes, risk perceptions, and level of support for using genetic techniques in controlling two invasive aquatic species in Minnesota: the common carp (*Cyprinus carpio*) and zebra mussel (*Dreissena polymorpha*). A total of 3,200 surveys were targeted for completion from the Minnesota general public, lakeshore homeowners, anglers, and boaters. Another objective of this project is exploring and gaining an initial understanding of the potential concerns of Tribal communities in Minnesota about using genetic techniques for invasive species control. Results from this project may inform managers about perceptions surrounding genetic techniques and other strategies for invasive species control.

Improving Stock Assessment of Walleye for Mille Lacs Lake

The walleye (*Sander vitreus*) fishery in Mille Lacs Lake, Minnesota, has declined since the 1990s. The decline coincides with a variety of changes, including warming temperatures, increases in smallmouth bass, invasion of zebra mussels in 2005, invasion of spiny waterflea (*Bythotrephes longimanus*) in 2009, changes to northern pike (*Esox lucius*) abundance, and changes to the fishery in both in gear types and management. The walleye fishery has consisted of a recreational and joint Tribal fishery since 1998. Based on legal agreements, this fishery, along with northern pike, yellow perch (*Perca flavescens*), cisco (*Coregonus artedi*), and burbot (*Lota lota*), is comanaged by Tribes that are signatory to the 1837 Treaty and the State through the Minnesota Department of Natural Resources (MNDNR). Previously estimated by a virtual population analysis, the population of walleye is now estimated annually through a statistical catch-at-age model. This project focuses on improving aspects of stock assessment to provide more precise information to better inform management of the fishery by the comanagement team. This project is being performed under a contract with MNDNR in collaboration with the Tribes signatory to the 1837 Treaty.

Walleye (*Sander vitreus*). Photograph by U.S. Fish and Wildlife Service.
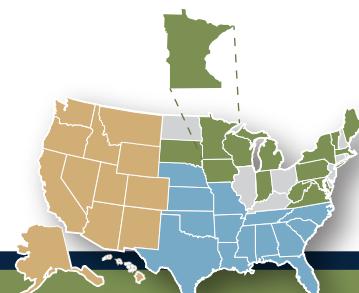
Technical Assistance

David Anderson provides information about individual trumpeter swan movements via a project website that was visited by 18,560 unique users from 60 countries during 29,656 online sessions through December 2023. David Wolfson, a Ph.D. student working on this project, presented research results on the genetics of Interior Population trumpeter swans that were based on tissue samples collected as part of this project at the 2023 Annual Conference of The Wildlife Society.

David Fulton participated in multiple outreach workshops with Tribal partners, including the Leech Lake Band of Ojibwe, Mille Lacs Band of Ojibwe, Red Lake Nation, Shakopee Mdewakanton Sioux Community of Minnesota, and White Earth Nation, to share information about Tribal perceptions and concerns relating to chronic wasting disease and its potential effects.

Lynn Waterhouse served on an expert technical review panel for Monterey Bay Aquarium Seafood Watch for assessment of California yellowtail (*Seriola dorsalis*) white seabass (*Atractoscion nobilis*), and giant sea bass (*Stereolepis gigas*). This assessment informs the Seafood Watch seafood recommendations (formerly the "Pocket Guides"). Waterhouse also participated in the Grouper Moon project, a research collaboration between the Cayman Island Department of Environment and Reef Environmental Education Foundation to conserve and study grouper species, particularly Nassau grouper (*Epinephelus striatus*), in the Cayman Islands, and participated in the Grouper Education program porch chats, which are livestreamed into Caymanian classrooms and beyond.

Trumpeter swans (*Cygnus buccinator*). Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Selected Publications

Bruggeman, J.E., Kennedy, P.L., Andersen, D.E., Deisch, S., and Stukel, E.D., 2023, Declining American goshawk (*Accipiter atricapillus*) nest site habitat suitability in a timber production landscape—Effects of abiotic, biotic, and forest management factors: The Journal of Raptor Research, v. 57, no. 4, p. 595–616, accessed March 19, 2024, at https://doi.org/10.3356/JRR-22-116.

Kramer, G.R., Andersen, D.E., Buehler, D.A., Wood, P.B., Peterson, S.M., Lehman, J.A., Aldinger, K.R., Bulluck, L.P., Harding, S., Jones, J.A., Loegering, J.P., Smalling, C., Vallender, R., and Streby, H.M., 2023, Exposure to risk factors experienced during migration is not associated with recent *Vermivora* warbler population trends: Landscape Ecology, v. 38, p. 2357–2380, accessed March 19, 2024, at https://doi.org/10.1007/s10980-023-01701-2.

Landon, A.C., Smith, K., Cornicelli, L., Fulton, D.C., McInenly, L.E., and Schroeder, S.A., 2023, Examining landowners' preferences for a chronic wasting disease management program: Wildlife Society Bulletin, v. 47, no. 1, article e1401, 19 p., accessed March 19, 2024, at https://doi.org/10.1002/wsb.1401.

Smith, K., Landon, A.C., and Fulton, D.C., 2023, A self-determination approach to understanding leisure identity salience among lapsed hunters: Leisure Sciences, p. 1–26, accessed March 19, 2024, at https://doi.org/10.1080/01490400.2023.2222738.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Minnesota, and Minnesota Department of Natural Resources.

Zebra mussel (*Dreissena polymorpha*). Photograph by Amy Benson, U.S. Geological Survey.

Graduate Student Spotlight

Briana Davis, Master of Science in Conservation Sciences, University of Minnesota

Project title: "Establishing a remote volunteer-based baited remote underwater video survey watching program to aid in conservation: application to sharks in the Bahamas."

Briana Davis holds a garter snake (*Thamnophis spp.*). Photograph by Isabel Pfeiffer, University of Minnesota.

Briana is currently deciding which law school to attend. She will begin her degree program in Fall 2024.
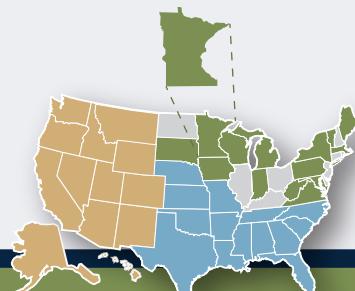
New York
Cooperative Fish and Wildlife Research Unit

Scientists

Angela Fuller, Unit Leader; Steve Grodsky, Assistant Unit Leader; one vacancy

About the Unit

The New York Cooperative Fish and Wildlife Research Unit embodies research productivity and collegiality and contributes to regional to global-scale research. The New York Unit scientists research diverse topics with many collaborators, resulting in variety of solutions for conservation. The New York Unit scientists, research staff, and students mainly focus on four core research areas: quantitative ecological research, decision science, risk assessment and management, and socioecological systems sustainability. The project narratives below fit into these broad research themes: population monitoring and advanced modeling, diseases of fish and wildlife, animal migration, Species of Greatest Conservation Need and threatened and endangered species, advanced technologies, grassland management and restoration, and renewable energy.

Research Projects

Parasitic Threats to Moose and Moose Juvenile Survival

Parasites can function as important regulators of wildlife populations. Natural resource managers face challenges in monitoring wildlife health and incorporating the effects of parasites on wildlife in decision-making. Moose (*Alces alces*) persist in New York at low densities, and population growth has recently slowed. Declines in moose populations in neighboring States due to parasites and the presence of these parasite species in New York prompted the investigation of parasite effects on the local moose population. This project is being conducted by researchers at the New York Unit, Cornell University, and the State University of New York College of Environmental Science and Forestry in conjunction with biologists and managers at the New York State Department of Environmental Conservation (NYDEC). This work aims to quantify previously unknown rates of juvenile moose survival and investigate the effects of internal and external parasites on the moose population to help inform local and regional moose management.

Yellow warbler (*Setophaga petechia*). Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Grassland Birds and Solar Energy

Solar energy provides a way to mitigate climate change, yet it is land intensive and may cause land-use change. Suitable sites for solar energy generation, including agricultural lands, also provide nesting habitat for grassland birds. Little is known about how grassland birds and solar energy infrastructure interact at local and landscape levels. Globally, grassland birds are declining in response to rapid land-use and land-cover changes, among other factors. Given the potential overlap of grassland bird habitat and current (2024) siting for solar energy in the Northeast, there are growing concerns regarding solar energy projects and grassland bird conservation. These concerns are exacerbated by known responses of grassland birds to patch dynamics, including negative responses to habitat fragmentation and edge effects, that may be influenced by solar energy project siting. This project is funded by the NYDEC, and staff at the NYDEC are collaborating on the project. The research team is working with State University of New York Brockport, the Cornell Lab of Ornithology, the U.S. Fish and Wildlife Service, and renewable-energy industry partners. This research may inform solar energy siting and development for grassland bird conservation and guide sustainable solutions for increasing solar energy development to mitigate climate change.

Technical Assistance

Angela Fuller is assisting cooperators with decision-making support for fisher harvest management and a deer-management assistance program.

Steve Grodsky has served on three advisory boards for Department of Energy-funded projects related to solar energy and ecosystems. He also serves as the faculty co-advisor of the Cornell student chapter of The Wildlife Society.

Selected Publications

Grodsky, S.M., Roeder, K.A., and Campbell, J.W., 2023, Effects of solar energy development on ants in the Mojave Desert: Ecosphere, v. 14, no. 10, article e4668, 14 p., accessed March 19, 2024, at https://doi.org/10.1002/ecs2.4668.

Poudel, S., Twining, J.P., Stedman, R.C., Ghimire, S.K., and Fuller, A.K., 2023, Ecological and anthropogenic drivers of leopard (*Panthera pardus fusca*) attack occurrence on humans in Nepal: People and Nature, v. 5, no. 6, p. 1977–1988, accessed March 19, 2024, at https://doi.org/10.1002/pan3.10536.

Riley, S.J., and Fuller, A.K., 2023, Integrating social and environmental science in decision making for endangered species management, chap. 12, *in* Baier, L.E., Organ, J.F., and Segal, C.E., eds., The codex of the Endangered Species Act, volume II—The next fifty years: Lanham, Md., Rowman and Littlefield, p. 232–249.

Wu, D., Grodsky, S.M., Xu, W., Lui, N., Almeida, R.M., Zhou, L., Miller, L.M., Roy, S.B., Xia, G., Agrawal, A.A., Houlton, B.Z., Flecker, A.S., and Xu, X., 2023, Observed impacts of large wind farms on grassland carbon cycling: Science Bulletin, v. 68, no. 23, p. 2889–2892, accessed April 3, 2024, at https://doi.org/10.1016/j.scib.2023.10.016.

"

"Each year of this valuable research increases our understanding of New York's moose population and its vital role in our State's biodiversity."

—Basil Seggos, New York State Department of Environmental Conservation Commissioner

"Let's keep working together."

—Bureau of Land Management Biologist

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Cornell University, and New York State Department of Environmental Conservation.

Moose cow (*Alces alces*) and calf at twilight. Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Scientists

Duane R. Diefenbach, Unit Leader; Tyler Wagner, Assistant Unit Leader; W. David Walter, Assistant Unit Leader

About the Unit

The Pennsylvania Cooperative Fish and Wildlife Research Unit has expertise in quantitative ecology of aquatic and terrestrial species. Each of the Unit scientists are leaders in their respective areas of research and conduct research throughout the United States, not just in their home State. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: decision science and structured decision-making, population monitoring and advanced modeling, forest management, invasive species, emerging contaminants, and diseases of fish and wildlife.

of the Pennsylvania Game Commission (PGC), Pennsylvania Department of Conservation and Natural Resources (PA DCNR), Bureau of Forestry, and the Pennsylvania Unit at The Pennsylvania State University. The research team is monitoring changes in deer density and the response of forest understory vegetation. In addition, the team is conducting experiments to study the relative importance of liming to counter acid deposition and using herbicides to reduce interspecific plant competition. The results of this research may inform the PGC as to how their habitat metrics used to make deer harvest recommendations respond to changes in deer density. In addition, this study can help the Bureau of Forestry refine their monitoring program used to make deer management decisions on State forest lands.

White-tailed deer (*Odocoileus virginianus*) standing in the woods. Photograph by Dawn Childs, U.S. Geological Survey.

Research Projects

White-tailed Deer Abundance and Its Relationship to Factors that Affect Forest Vegetation Conditions

There are problems with tree regeneration and a lack of diversity in understory plant species in forests in Pennsylvania, and white-tailed deer (*Odocoileus virginianus*) herbivory has been identified as a source contributing to these problems. However, other factors such as insect outbreaks, acid rain, competitive effects among plant species, and lack of fire have been identified as other potential causes that inhibit tree regeneration and understory diversity. Deer populations were reduced by about 23 percent during 2002–2005, yet problems with forest plant diversity remains. An important question is whether deer populations require further reduction or if other factors play an important role in affected forested ecosystems. This study is a collaboration

Targeted Surveillance for Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) in Wildlife

Emergence of zoonotic diseases (infections that spread between animals and people) in new wildlife host species occurs globally and poses major health or conservation risks for the hosts involved. Understanding the conditions that lead to emergence and persistence of zoonotic diseases is critical when making resource allocation decisions to protect the health of humans, animals, and ecosystems. Current knowledge of disease emergence in wildlife reservoirs remains weak because of the challenges with collecting enough data for a system-level understanding of what drives disease emergence and with the relative infrequency that these events occur. The project is a collaboration with Colorado

State University, Columbia University, PGC, Southern Illinois University, University of Pennsylvania, The Pennsylvania State University, University of Tennessee, University of Minnesota, Utah State University, U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS), and U.S. Fish and Wildlife Service. The research team is looking at strengths, challenges, and key lessons for best management practices in the surveillance design for understanding disease emergence processes in new animal host species. The project highlights the importance of the continued interplay between surveillance design and a model-based understanding of systems for optimizing risk assessment.

Aquatic Food Web Changes due to Invasive Flathead Catfish Along an Invasion Gradient

Biological invasions have the potential to significantly alter the structure and function of aquatic communities. By changing energy transfer through a food web, invasive species may affect the accumulation of contaminants in other food fish species. This study seeks to understand the effects of an invasive catfish (flathead catfish, *Pylodictis olivaris*) on a riverine food web and the resulting changes in how per- and polyfluoroalkyl substances (PFAS, or "forever chemicals") move and accumulate through the food web (trophodynamics). PFAS have the potential to be harmful to aquatic organisms and the accumulation of PFAS in fish species targeted by recreational anglers raises concerns for human health through consumption. A collaboration between the Pennsylvania Unit, The Pennsylvania State University, and the Pennsylvania Fish and Boat Commission, results of this study may provide important information on the effects of flathead catfish invasion and PFAS trophodynamics on the food web to help fisheries management and risk assessment of invasive flathead catfish.

Flathead catfish (*Pylodictis olivaris*). Photograph by Sam Stukel, U.S. Fish and Wildlife Service.

Technical Assistance

Duane Diefenbach provided technical assistance to the PA DCNR in developing a program for monitoring vegetation conditions on State forest lands and incorporating that information into a decision tool for making deer harvest management recommendations.

Tyler Wagner delivered kindergarten through 5th grade outreach on vernal pool ecology.

W. David Walter was a grant reviewer for USDA APHIS branches of Wildlife Services and of Veterinary Services related to chronic wasting disease (CWD) research. He reviewed competitive proposals that were then selected for funding based on the panel reviews of the study objectives, likelihood of success, and scientific validity of the proposed research. Walter was also elected as Secretary-Vice Chair-Chair for the NC1209: North American interdisciplinary chronic wasting disease research consortium, which involves researchers throughout the United States working together to advance understanding of CWD.

Selected Publications

Bondo, K.J., Montecino-Latorre, D., Williams, L., Helwig, M., Duren, K., Hutchinson, M.L., and Walter, W.D., 2023, Spatial modeling of two mosquito vectors of West Nile virus using integrated nested Laplace approximations: Ecosphere, v. 14, no. 1, article e4346, 15 p., accessed March 19, 2024, at https://doi.org/10.1002/ecs2.4346.

Fameli, A., Edson, J., Banfield, J.E., Rosenberry, C.S., and Walter, W.D., 2022, Variability in prion protein genotypes by spatial unit to inform susceptibility to chronic wasting disease: Prion, v. 16, no. 1, p. 254–264, accessed March 19, 2024, at https://doi.org/10.1080/19336896.2022.2117535.

Gundermann, K.P., Diefenbach, D.R.; Walter, W.D., Corondi, A.M., Banfield, J.E., Wallingford, B.D., Stainbrook, D.P., Rosenberry, C.S., and Buderman, F.E., 2023, Change-point models for identifying behavioral transitions in wild animals: Movement Ecology, v. 11, article 65, 15 p., accessed March 19, 2024, at https://doi.org/10.1186/s40462-023-00430-0.

Navarro, N., Diefenbach, D.R., McDill, M.E., Domoto, E.J., Rosenberry, C.S., and Drohan, P.J., 2023, Species and physiographic factors drive Indian cucumber root and Canada mayflower plant chemistry—Implications for white-tailed deer forage quality: Journal of Environmental Management, v. 326, part A, article 116545, 10 p., accessed March 19, 2024, at https://doi.org/10.1016/j.jenvman.2022.116545.

Smalling, K.L., Romanok, K.M., Bradley, P.M., Morriss, M.C., Gray, J.L., Kanagy, L.K., Gordon, S.E., Williams, B.M., Breitmeyer, S.E., Jones, D.K., DeCicco, L.A., Eagles-Smith, C.A., and Wagner, T., 2023, Per-and polyfluoroalkyl substances (PFAS) in United States tapwater: Comparison of underserved private-well and public-supply exposures and associated health implications: Environment International, v. 178, article 108033, 12 p., accessed March 19, 2024, at https://doi.org/10.1016/j.envint.2023.108033.

Wagner, T., Schliep, E.M., North, J.S., Kundel, H., Custer, C.A., Ruzich, J.K., and Hansen, G.J., 2023, Predicting climate change impacts on poikilotherms using physiologically guided species abundance models: Proceedings of the National Academy of Sciences, v. 120, no. 15, 8. p., accessed March 19, 2024, at https://doi.org/10.1073/pnas.2214199120.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, The Pennsylvania State University, Pennsylvania Fish and Boat Commission, and Pennsylvania Game Commission.
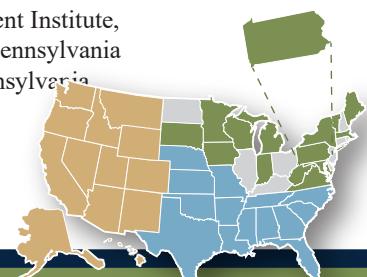
Scientists

Steve Chipps, Unit Leader; Joshua Stafford, Assistant Unit Leader; two vacancies

About the Unit

The South Dakota Cooperative Fish and Wildlife Research Unit is based in the Northern Great Plains ecoregion, and Unit scientists work closely with State and Federal cooperators to address fish and wildlife conservation needs in many habitats, including the Prairie Pothole Region, the Missouri River, and the Black Hills. Unit scientists have established an especially close working relationship with South Dakota Department of Game, Fish and Parks (SDGFP). This cooperative partnership helps solve practical resource management problems and train the next generation of biologists. Because the South Dakota Unit is located in the Northern Great Plains ecoregion, it is in a position to lead the way in fisheries and wildlife research and education in this critical area. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: Species of Greatest Conservation Need and threatened and endangered species; water allocation, drought, and ecological flows; decision science and structured decision-making; wetland management and restoration; and advanced technologies.
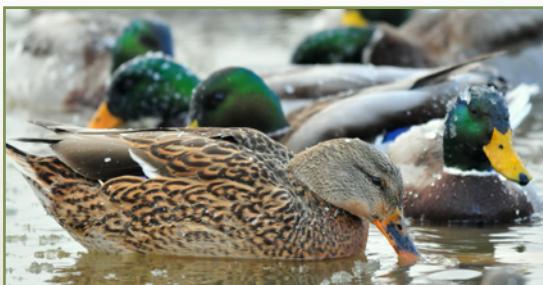
Mallards (*Anas platyrhynchos*). Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Research Projects

Living in a Gradient: The Influence of Water Temperature Variation on Development, Settling Time, and Survival of Pallid Sturgeon Larvae in the Missouri River

The larval drift stage of pallid sturgeon (*Scaphirhynchus albus*) has been identified as a critical stage for reproductive success. Understanding how water temperature variation affects larval development during the drift phase is critical for understanding factors affecting their survival. Release of cold water below Missouri River impoundments can lower downstream water temperature for long distances (over 186 miles [299.3 kilometers]), especially during summer months. Cooler water temperatures may reduce growth and development of sturgeon and can delay an important behavioral transition where pallid sturgeon larvae go from negative (facing away from the current) to positive (facing into the current) rheotaxis. Rheotaxis is an important life history event associated with switching from using their yolk sac as food to external food sources. This project is a collaboration of researchers from the U.S. Geological Survey Columbia Environmental Research Center and the U.S. Fish and Wildlife Service (FWS). Understanding the influence of water temperature changes on larval pallid sturgeon development is crucial for recovery efforts aimed at improving natural recruitment. This information is being used to develop a model for estimating settling time (days post-hatch) and drift distance of sturgeon larvae using temperature and velocity conditions in the Missouri and Yellowstone rivers.

Quantifying Restorable Wetlands in the Prairie Pothole Region of Eastern South Dakota

Wetland loss continues to be a significant issue in the Prairie Pothole Region of North America. Drainage and conversion of wetlands to croplands not only eliminates important wildlife habitats but can affect other ecosystem processes, such as floodwater retention. No database of drained wetland basins exists for South Dakota, yet many State, Federal, and nongovernmental partners have requested this information in a useable format. It is likely that hundreds of thousands of wetlands have been drained in South Dakota during the last century, and restoration and conservation efforts may be far less effective if implemented piecemeal and opportunistically. Identifying restorable wetland basins, their spatial locations and extents, and former wetland types can help promote targeted conservation efforts from local to watershed scales. This project has broad support and interest, with partners including the FWS, Prairie Pothole Joint Venture, U.S. Department of Agriculture Natural Resource Conservation Service, the SDGFP, and the East Dakota Water Development District, among others. Using machine learning techniques to identify and quantify restorable wetland basins in South Dakota may aid in creating tools for use in other regions where wetland restoration is of conservation importance. Understanding where conservation opportunities exist can promote more effective and efficient conservation implementation and wise use of limited restoration funds. Finally, developing an application for drained wetlands data may help with using these data more easily.

Technical Assistance

Unit scientists and staff assisted SDGFP with meeting arrangements and development of the plenary session for the 2024 Midwest Fish and Wildlife Conference in Sioux Falls, South Dakota.

Joshua Stafford regularly consulted with SDGFP personnel regarding issues of waterfowl management in the State and Central Flyway, and on various issues of waterfowl management and regulations. Stafford also served on two faculty search committees at South Dakota State University.

Selected Publications

Gallman, C.W., Arnold, T.W., Michel, E.S., and Stafford, J.D., 2023, Evaluation of fall-seeded cover crops for grassland nesting waterfowl in eastern South Dakota: Wildlife Society Bulletin, Early View [Online Version of Record before inclusion in an issue], posted September 5, 2023, article e1484, accessed March 20, 2024, at https://doi.org/10.1002/wsb.1484.

Lyon, C.A., Davis, J.L., Fincel, M.J., and Chipps, S.R., 2022, Effects of capture depth on walleye hooking mortality during ice fishing: Lake and Reservoir Management, v. 38, p. 334–340, accessed March 19, 2024, at https://doi.org/10.1080/10402381.2022.2130118.

Pearse, A.T., Szymanski, M.L., Anchor, C.A., Anteau, M.J., Murano, R.M., Brandt, D.A., and Stafford, J.D., 2023, Factors influencing autumn–winter movements of midcontinent mallards and consequences for harvest and habitat management: Ecology and Evolution, v. 13, no. 10, article 10605, 18 p., accessed March 20, 2024, at https://doi.org/10.1002/ece3.10605.

Zebro, L.R., Mrnak, J.T., Shaw, S.L., Chipps, S.R., and Sass, G.G., 2022, Density-dependent and environmental influences on juvenile walleye *Sander vitreus* (Mitchill) survivorship in northern Wisconsin lakes: Fisheries Management and Ecology, v. 29, no. 6, p. 897–910, accessed March 20, 2024, at https://doi.org/10.1111/fme.12591.

Graduate Student Spotlight

Maria Erceg, Master of Science in Fisheries Biology, South Dakota State

Title: "Living in a gradient: The influence of water temperature variation on development, settling time and survival of pallid sturgeon larvae in the upper Missouri River."

Maria is currently working as a Fisheries Specialist with the Minnesota Department of Natural Resources.

Cooperators

U.S. Geological Survey; U.S. Fish and Wildlife Service; Wildlife Management Institute; South Dakota State University; and South Dakota Department of Game, Fish and Parks.

Pallid sturgeon (*Scaphirhynchus albus*) larvae. Photograph by Rob Holm, U.S. Fish and Wildlife Service.
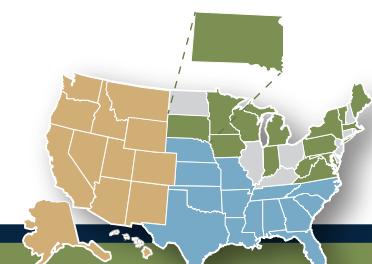
Vermont
Cooperative Fish and Wildlife Research Unit

Scientists

Mark Henderson, Unit Leader; Therese Donovan, Assistant Unit Leader; one vacancy

About the Unit

The Vermont Cooperative Fish and Wildlife Research Unit works closely with its State and university cooperators. Unit scientists attend monthly meetings to discuss projects and management with cooperators and to enhance collaboration. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: diseases of fish and wildlife, and population monitoring and advanced modeling.

Research Projects

Genomic Forensics: Using Bioinformatics to Investigate the Causes of Melanistic Lesions in Brown Bullhead

Over the past decade on Lake Memphremagog, which spans Quebec, Canada, and Vermont, approximately 30 percent of brown bullhead (*Ameiurus nebulosus*) have been observed with an unusual black skin pigmentation that has been identified as either melanistic lesions or melanomas. Potential hypotheses regarding the associated risk factors for fish with these lesions include exposure to environmental contaminants, genetics, viruses, and interactions of these stressors. One hypothesis is that these melanistic lesions are the result of above normal concentrations of contaminants of emerging concern (for example, pharmaceuticals, personal care products, and industrial and household

compounds) introduced to waterbodies from wastewater runoff and landfill leachate. This hypothesis is concerning if proven because Lake Memphremagog is a source of drinking water for approximately 175,000 Canadian residents. The researchers on this project plan to use bioinformatics to determine if there is a relationship between brown bullhead genetics and stressors such as water quality and sample location. This may help managers to identify the source for the melanistics lesions and to take preventative measures to prevent contamination of the lake in the future. Researchers are collaborating with the Vermont Fish & Wildlife Department, University of Vermont, and the U.S. Geological Survey (USGS) on this project.

Brown bullhead (*Ameiurus nebulosus*). Photograph by Uland Thomas, used with permission.

Adaptive Management with AMMonitor

Automated monitoring of wildlife with remote cameras and recording devices is a cost-effective way to monitor species across space and time. However, the data management requirements of an autonomous monitoring unit (AMU)-based monitoring effort can be immense: processing audio/image data to generate detections can be complicated and integrating streams of AMU data

Golden-winged warbler (*Vermivora chrysoptera*). Photograph by Walt Ford, U.S. Fish and Wildlife Service.

into species distribution models or other analyses may appear almost impossible. Land-use change and climate change are shifting the distribution patterns of many wildlife species. Natural resource managers who are tasked with maintaining viable wildlife populations require data to understand changes in species distribution and tools that enable them to act quickly. AMMonitor is an R package/tool for R software that allows agencies monitoring wildlife remotely to easily manage, archive, and analyze data. The project is a collaboration of researchers across multiple agency platforms, including USGS ScienceBase, USGS Cloud Computing, and the National Park Service's Natural Sounds and Night Skies Division.

Technical Assistance

Mark Henderson's brown bullhead project was featured on Vermont Public radio: [https://www.vermontpublic.org/local-news/2023-09-13/brown-bullhead-fish-cancer-melanoma-lake-memphremagog-vermont-genetics-research]. This project is a collaboration with Vermont Fish & Wildlife Department and other USGS scientists to collect fish samples for genomics analyses and histology and pathology. Henderson recruited Mohammad "Habib" Molla, a postdoctoral researcher who plans to conduct bioinformatic analysis for the project.

In an era of big data, there are increasing demands on developing quantitative skills and proficiency, and Therese Donovan conducts training for young ecologists to develop these skills. Donovan also published "occupancyTuts," an open-source, freely available R package [hosted at code.usgs.gov/vtcfwru/occupancyTuts] featuring 28 tutorials that teach occupancy modeling concepts, which is a framework for estimating species abundance and distribution patterns.

Selected Publications

Dick, C., Larson, W.A., Karpan, K., Baetscher, D.S., Shi, Y., Sethi, S., Fangue, N.A., and Henderson, M.J., 2023, Prey ration, temperature, and predator species influence digestion rates of prey DNA inferred from qPCR and metabarcoding: Molecular Ecology Resources, Early View [Online Version of Record before inclusion in an issue], posted August 9, 2023, 17 p., accessed March 20, 2024, at https://doi.org/10.1111/1755-0998.13849.

Donovan, T., Hines, J., and MacKenzie, D., 2024, OccupancyTuts—Occupancy modelling tutorials with RPresence: Methods in Ecology and Evolution, v. 15, no. 3, p. 477–483, accessed March 20, 2024, at https://doi.org/10.1111/2041-210X.14285.

Henderson, M.J., Loomis, C.M., Michel, C.J., Smith, J.M., Iglesias, I.S., Lehman, B.M., Demetras, N.J., and Huff, D.D., 2023, Estimates of predator densities using mobile DIDSON surveys—Implications for survival of Central Valley chinook salmon: North American Journal of Fisheries Management, v. 43, no. 3, p. 628–645, accessed March 20, 2024, at https://doi.org/10.1002/nafm.10873.

Rosenblatt, E., Creel, S., Gieder, K., Murdoch, J., and Donovan, T., 2023, Advances in wildlife abundance estimation using pedigree reconstruction: Ecology and Evolution, v. 13, no. 10, article e10650, 18 p., accessed March 20, 2024, at https://doi.org/10.1002/ece3.10650.

Mark Henderson holding a chinook salmon (*Oncorhynchus tshawytscha*). Photograph by U.S. Geological Survey.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Vermont, and Vermont Fish & Wildlife Department.

Virginia
Cooperative Fish and Wildlife Research Unit

Scientists

W. Mark Ford, Unit Leader; Elizabeth Hunter, Assistant Unit Leader; Paul Angermeier, Assistant Unit Leader

About the Unit

The Virginia Cooperative Fish and Wildlife Research Unit has a long history as one of the original Cooperative Research Units, and is located in a dynamic, biodiverse landscape where the Appalachians, Piedmont and Coastal Plain ecosystems contain both southern and northern affinities. Many of the Unit research projects are in, and focus on, Virginia, but the Unit has a wide reach throughout the country, working with State and Federal agencies across the eastern United States from New York to Florida. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: animal migration, Species of Greatest Conservation Need and threatened and endangered species, advanced technologies, population monitoring and advanced modeling, renewable energy, forest management, and climate change.

Research Projects

Post White-Nose Syndrome (WNS) Bat Ecology in the Eastern United States

This project is a comprehensive investigation of the foraging and roosting ecology and distribution of bats in the mid-Atlantic and Northeast following white-nose syndrome (WNS), with an emphasis on the threatened Northern long-eared bat (*Myotis septentrionalis*) and the endangered Indiana bat (*Myotis sodalis*). The Virginia Unit has been working with several persisting populations, notably in the Washington, D.C., metro area; northeastern North Carolina;

Long Island, New York; and the upper Ohio Valley, with efforts focused on documenting natural ecology and to ascertain what factors allow for population persistence. Data from this work helps to inform a wide array of land management efforts such as forest management, military training, and energy development where these bat species occur or could be recovered. This effort over multiple States and cooperating State, Federal, and private entities is one of the largest and longest-running mist-netting and acoustic surveys for bats in the eastern United States.

Northern long-eared bat (*Myotis septentrionalis*) at Rock Creek Park, Washington D.C. Photograph by John F. Organ, U.S. Geological Survey.

## Marsh Bird Conservation on the Atlantic Shore in the Face of Sea-level Rise

Sea-level rise affects marsh bird habitats through loss and degradation, and also has direct effects on population dynamics through disruptions to nesting habitats. Future habitat may depend on marsh habitats moving into current uplands, but this habitat movement may negatively affect the productivity of working lands. Conserving species in the face of the threat of habitat loss requires an ecological understanding of the effects of habitat loss as well as multidisciplinary collaborations to come up with solutions. The research team is studying species such as the saltmarsh sparrow (*Ammospiza caudacuta*), seaside sparrow (*Ammospiza maritima*), and clapper rail (*Rallus crepitans*), using remote-sensing technology and social science to understand the threats to species habitats and to coastal peoples' livelihoods and potential management actions. Partners on this project include researchers at Virginia Polytechnic Institute and State University, the Virginia Department of Wildlife Resources, and the National Aeronautics and Space Administration. The results from this research could help to inform agency and nonprofit actions regarding land acquisition to prepare for marsh migration and to preserve habitat for at-risk species. The researchers are working to explore equitable solutions that allow for safeguarding coastal peoples' livelihoods.

Development and Application of a Multiscale Model of Habitat Suitability for Candy Darter

The endangered candy darter (*Etheostoma osburni*) has disappeared from about half of its historical range and its range in Virginia is now limited to only four widely separated streams. No comprehensive assessments of which landscape features predict candy darter occurrence (for example, watershed size, land use, channel gradient, network position, connectivity) have been undertaken, so there has been no development of rangewide maps of habitat suitability. Rangewide assessments have been instrumental in advancing conservation of ecologically similar fishes in Virginia, such as Roanoke logperch (*Percina rex*). This project is synthesizing existing rangewide occurrence data on candy darter, building statistical models to assess stream reach-specific probabilities of candy darter occurrence, and conducting field surveys to test model predictions and help with model refinement. Collaborators include the Virginia Department of Wildlife Resources, Virginia Polytechnic Institute and State University, West Virginia Division of Natural Resources, U.S. Fish and Wildlife Service (FWS) Virginia Field Office, FWS West Virginia Field Office, and the U.S. Department of Agriculture Forest Service. The models being developed for the candy darter may assist State and Federal managers in identifying streams and watersheds that are most likely to support undiscovered populations, be suitable reintroduction sites, and provide refugia from variegate darter (*Etheostoma variatum*) invasion.

Clapper rail (*Rallus crepitans*). Photograph by U.S. Fish and Wildlife Service.
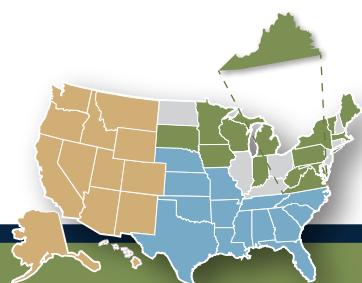
Technical Assistance

"Evaluating Acoustical Bat Surveys for Endangered Species Act Compliance" is an annual FWS National Conservation Training Center course that Mark Ford coteaches at Mammoth Cave National Park. This course provides Federal and State agencies biologists and environmental consultants with a basic understanding of how to apply acoustic sampling methods and post-processing analyses to assess project effects on endangered bats in the post-WNS environment. For many participants, this is their first exposure to working with acoustic methods on the landscape, analyzing real-word data, and seeing bat capture and handling.

Elizabeth Hunter assisted the Virginia Department of Wildlife Resources with analyzing data from the most recent Breeding Bird Atlas to make estimates of population sizes and distributions, and to estimate changes in occupancy since the last State survey for the Breeding Bird Atlas was conducted in the 1980s.

Paul Angermeier is the cochair of the the Science and Technical Advisory Committee for the Albemarle-Pamlico National Estuary Partnership, a consortium of citizens, business leaders, environmental organizations, and local, State, and Federal agencies tasked with managing the Albemarle-Pamlico estuary, which includes approximately 28,000 square miles [72,520 square kilometers] of northeastern North Carolina and southeastern Virginia that drain into the second-largest estuary in the U.S. Angermeier also serves on the editorial boards for "Conservation Biology" and "Freshwater Biology," and reviews manuscripts for other journals and colleagues.

Selected Publications

Barrile, G.M., Augustine, D.J., Porensky, L.M., Duchardt, C.J., Shoemaker, K.T., Hartway, C.R., Derner, J.D., Hunter, E.A., and Davidson, A.D., 2023, A big data–model integration approach for predicting epizootics and population recovery in a keystone species: Ecological Applications, v. 33, no. 4, article e2827, 23 p., accessed March 20, 2024, at https://doi.org/10.1002/eap.2827.

Gorman, K.M., Barr, E.L., Nocera, T., and Ford, W.M., 2023, Network analysis of a northern long-eared bat (*Myotis septentrionalis*) maternity colony in a suburban forest patch: Journal of Urban Ecology, v. 9, no. 1, article juad005, 10 p., accessed March 20, 2024, at https://doi.org/10.1093/jue/juad005.

Hilling, C.D., Jiao, Y., Fabrizio, M.C., Angermeier, P.L., Bunch, A.J., and Orth, D.J., 2023, A size-based stock assessment model for invasive blue catfish in a Chesapeake Bay sub-estuary during 2001–2016: Fisheries Management and Ecology, v. 30, no. 1, p. 70–88, accessed March 20, 2024, at https://doi.org/10.1111/fme.12601.

McBaine, K.E., Angermeier, P.L., and Hallerman, E.M., 2023, Genetic structure across isolated Virginia populations of the endangered candy darter (*Etheostoma osburni*): Fishes, v. 8, no. 10, article 490, 18 p., accessed March 20, 2024, at https://doi.org/10.3390/fishes8100490.

True, M.C., Gorman, K.M., Taylor, H., Reynolds, R.J., and Ford, W.M., 2023, Fall migration, oceanic movement, and site residency patterns of eastern red bats (*Lasiurus borealis*) on the mid-Atlantic Coast: Movement Ecology, v. 11, article 35, 16 p., accessed March 20, 2024, at https://doi.org/10.1186/s40462-023-00398-x.

Whitesell, M.J., Hunter, E.A., Rostal, D.C., and Carroll, J.M., 2022, Direct and indirect pathways for environmental drivers of hatching success in the loggerhead sea turtle: Marine Ecology Progress Series, v. 701, p. 119–132, accessed March 20, 2024, at https://doi.org/10.3354/meps14197.

Roanoke logperch (*Percina rex*). Photograph by North Carolina Wildlife Resources Commission.

Graduate Student Spotlight

Cory Allred, Master of Science in Fisheries and Wildlife Conservation, Virginia Polytechnic Institute and State University

Thesis title: "Using remote sensing data to predict habitat occupancy of Pine Savanna bird species."

Cory is now a Wildlife Biologist working with the Montana Department of Fish Wildlife and Parks and manages a large area of eastern Montana.
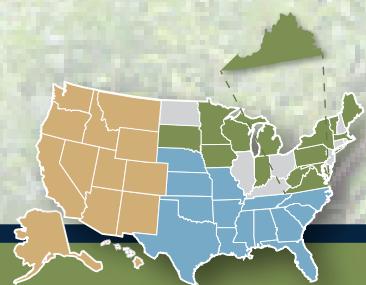
Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Virginia Polytechnic Institute and State University, and Virginia Department of Wildlife Resources.

Smallmouth bass (*Micropterus dolomieu*). Photograph by Sam Stukel, U.S. Fish and Wildlife Service.

The South River, Virginia. Photograph by U.S. Fish and Wildlife Service.

West Virginia

Cooperative Fish and Wildlife Research Unit

Scientists

Patricia M. Mazik, Unit Leader; Laura Gigliotti, Assistant Unit Leader; Stuart Welsh, Assistant Unit Leader

About the Unit

The West Virginia Cooperative Fish and Wildlife Research Unit works closely with its host university and cooperators, and our scientists contribute to a wide variety of research projects in West Virginia. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: diseases of fish and wildlife, population monitoring and advanced modeling, hunting and fishing, invasive species, and Species of Greatest Conservation Need and threatened and endangered species.

Research Projects

Assessment of the Immune Status of Smallmouth Bass

A long-term monitoring approach has been implemented to investigate smallmouth bass (*Micropterus dolomieu*) health issues and mortality in West Virginia. Many factors naturally affect wild fish immunity, so the purpose of this study is to monitor and evaluate changes in immune function in context with other aspects of health and environmental factors, including complex interactions between water quality, contaminants, land use, climatic factors, pathogens and parasites, and genetic changes. Unexplained episodic deaths of smallmouth bass in the Potomac River drainage, particularly the South Branch, has been noted since 2003. Functional immune assays and gene expression can be combined with established fish health-assessment methods that document external and internal abnormalities, histopathology, plasma analyses, and pathogen identification to better understand the relationship between health, land use, and chemical contaminants that may be affecting the health of smallmouth bass. Research partners include the West Virginia Division of Natural Resources and U.S. Geological Survey Eastern Ecological Science Center at the Leetown Research Laboratory.

Diamond darter (*Crystallaria cincotta*). Photograph by U.S. Geological Survey.

Stuart Welsh holding a flathead catfish (*Pylodictis olivaris*). Photograph by U.S. Geological Survey.

A Distributional Atlas and Identification Guide to West Virginia Fishes

This project involves compiling a distributional atlas and identification guide to West Virginia's fishes to help Federal and State agencies, anglers, and the general public understand the distribution, habitat, and conservation needs and concerns for each fish species found in West Virginia. The project is a collaborative effort of the West Virginia Unit and the West Virginia Division of Natural Resources (WVDNR). Information provided from this project may also aid WVDNR in the management of sport- and nongame fishes and their associated habitats and resources.

River Otter Population Dynamics and Spatial Ecology in West Virginia

River otters (*Lontra canadensis*) are native to West Virginia, but experienced population declines in the 19th and 20th centuries because of habitat fragmentation, water pollution, and unregulated trapping. Following reintroduction efforts in the 1980s and 1990s, otter populations in the State are now considered to be stable or increasing. Accurate estimates of otter survival and harvest rates can help to inform future otter management plans in West Virginia. The diet of river otters is primarily composed of various fish species, and the State stocks fish to provide fishing opportunities for anglers. Gathering information on the fine-scale movements of river otters during fish-stocking periods may help to determine potential effects of river otters on the fishing opportunities provided by fish stocking. This project is a collaboration between the West Virginia Unit and WVDNR. This research aims to provide the WVDNR with information on river otter populations in the State to help inform future management decisions about trapping regulations.

River otter (*Lontra canadensis*). Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Technical Assistance

West Virginia Unit scientists, staff, and students were invited to the WVDNR annual research project meeting in Canaan Valley, West Virginia, to present their research results for projects funded by the WVDNR.

Laura Gigliotti participated in a panel discussion as part of the West Virginia University Women in Natural Resources spring research symposium.

Stuart Welsh conducted a workshop on the fishes of the Cacapon River drainage at the Cacapon Riverfest, Capon Bridge, West Virginia, and also conducted a workshop on fish ecology of the Central Appalachians at the Wilderness Rangers Boy Scout camp in Elkins, West Virginia.

Selected Publications

Gigliotti, L.C., Atwood, M.P., Cole, E.K., Courtemanch, A., Dewey, S., Gude, J.A., Hurley, M., Kauffman, M., Kroetz, K., Leonard, B., MacNulty, D., Maichak, E., McWhirter, D., Mong, T.W., Proffitt, K., Scurlock, B., Stahler, D.R., and Middleton, A.D., 2023, Multi-level thresholds of residential and agricultural land use for elk avoidance across the Greater Yellowstone Ecosystem: Journal of Applied Ecology, v. 60, no. 6, p. 1089–1099, accessed March 20, 2024, at https://doi.org/10.1111/1365-2664.14401.

Gigliotti, L.C., Keener, L., Swanepoel, L.H., Sholto-Douglas, C., Hunnicutt, A., and Curveria-Santos, G., 2023, Positive but un-sustained wildlife community responses to reserve expansion and mammal reintroductions in South Africa: Biological Conservation, v. 287, article 110277, 10 p., accessed March 20, 2024, at https://doi.org/10.1016/j.biocon.2023.110277.

Siegel, J.V., Welsh, S., Taylor, N., and Phelps, Q., 2023, Size structure, age, growth, and mortality of flathead catfish in the Robert C. Byrd Pool of the Ohio and Kanawha Rivers: Journal of the Southeastern Association of Fish and Wildlife Agencies, v. 10, p. 10–16, accessed March 20, 2024, https://seafwa.org/sites/default/files/journal-articles/J10_02_Siegel%20et%20al%2010-16.pdf.

Smith, C.R., Ottinger, C.A., Walsh, H.L., Mazik, P.M., and Blazer, V.S., 2023, Application of a lipopolysaccharide (LPS)-stimulated mitogenesis assay in smallmouth bass (*Micropterus dolomieu*) to augment wild fish health studies: Fishes, v. 8, no. 3, article 159, 18 p., accessed March 20, 2024, at https://www.mdpi.com/2410-3888/8/3/159.

Smith, C.R., Ottinger, C.A., Walsh, H.A., Mazik, P.M., and Blazer, V.S., 2023, Immune function of wild smallmouth bass collected from sites within the Chesapeake Bay watershed, 2016–2021: U.S. Geological Survey data release, accessed March 24, 2024, at https://doi.org/10.5066/P9FTUPPX.

Smith, D.M., Welsh, S.A., and Hilling, C.D., 2023, Environmental correlates of walleye spawning movements in an Appalachian hydropower reservoir: Journal of the Southeastern Association of Fish and Wildlife Agencies, v. 10, p. 36–44, accessed March 20, 2024, https://seafwa.org/journal/2023/environmental-correlates-walleye-spawning-movements-appalachian-hydropower-reservoir.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, West Virginia University, and West Virginia Division of Natural Resources.
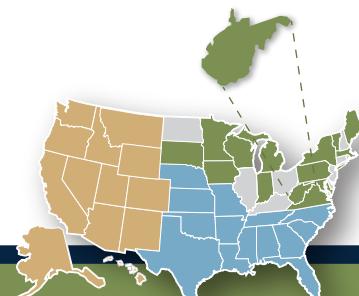
Wisconsin
Cooperative Fishery Research Unit

Scientists

Dan Isermann, Unit Leader; Jared Homola, Assistant Unit Leader

About the Unit

The Wisconsin Cooperative Fishery Research Unit works closely with multiple Tribal, Provincial, State, and Federal natural resource agencies. Unit scientists and the Wisconsin Department of Natural Resources (DNR) meet at least weekly and collaborate on almost all grants and papers. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: animal migration, hunting and fishing, population monitoring and advanced modeling, invasive species, and advanced technologies.

Smallmouth bass (*Micropterus dolomieu*). Photograph by U.S. Geological Survey.

Research Projects

Understanding Smallmouth Bass Recruitment in Relation to Nest Fishing along Wisconsin's Door Peninsula

Smallmouth bass (*Micropterus dolomieu*) are an important fishery, and along Wisconsin's Door Peninsula, there have been recent declines in catch rates for smallmouth bass greater than or equal to 18 inches (45.7 centimeters), prompting concerns among fisheries stakeholders. Determining reasons for declining catch rates for this size class of smallmouth bass is difficult because the Wisconsin DNR lacks a method for indexing smallmouth bass recruitment before bass enter the fishery at ages 3 and 4 years old. This research may help fishery managers determine a sampling method to index recruitment before smallmouth bass enter the fishery and may address concerns regarding the effects of nest fishing on recruitment. This project is a collaboration of researchers across multiple agencies, and includes the Wisconsin DNR, University of Wisconsin–Stevens Point, and University of Wisconsin–Milwaukee.

Smallmouth bass (*Micropterus dolomieu*). Photograph by U.S. Geological Survey.

Graduate student collecting fish samples. Photograph by U.S. Geological Survey.

Development of Point-Of-Use Invasive Species Environmental Deoxyribonucleic Acid (eDNA) Screening Approaches

Invasive species are ecologically damaging, economically costly, and increasingly prevalent throughout the world. Eradicating invasive species is notoriously difficult; therefore, it is better to prevent the introduction of invasive species. Many invasive species originate via trade and commerce, such as through the ballast water of shipping vessels or through the food trade. Enabling invasive species surveillance using environmental deoxyribonucleic acid (eDNA) at discrete points of entry is a promising avenue to detecting and preventing new invasions before they begin. Developing eDNA tools may allow port agents to detect invasive species before they enter the country, reducing the likelihood of establishment of new invasive species. This work is a collaboration between the Wisconsin Fishery Unit and the U.S. Geological Survey Upper Midwest Science Center.

Technical Assistance

Dan Isermann was asked by the Wisconsin DNR to serve as a member of a forum designed to outline future management directions for walleye (*Sander vitreus*) in northern Wisconsin.

Jared Homola is performing an assessment of brook trout (*Salvelinus fontinalis*) genetic diversity for the Wisconsin DNR Nevin Fish Hatchery to inform management of the genetic wellbeing of brook trout stocked in Wisconsin's waterways.

Selected Publications

Dembkowski, D.J., Shrovnal, J.S., Parks, T.P., Sass, G.G., Lyons, J., and Isermann, D.A., 2023, Cisco population characteristics in Wisconsin lakes in relation to lake- and landscape-level factors: Transactions of the American Fisheries Society, v. 153, no. 1, p. 93–111, accessed March 20, 2024, at https://doi.org/10.1002/tafs.10449.

Homola, J.J., Larson, W.A., and Albosta, P., 2023, An amplicon genotyping panel suitable for species identification and population genetics in sauger (*Sander canadensis*) and walleye (*Sander vitreus*): Conservation Genetics Resources, v. 16, p. 103–110, accessed March 20, 2024, at https://doi.org/10.1007/s12686-023-01329-z.

Izzo, L.K., Dembkowski, D., Hayden, T., Binder, T., Vandergoot, C., Hogler, S., Donofrio, M., Zorn, T., Krueger, C.C., and Isermann, D., 2023, Spawning locations, movements, and potential for stock mixing of walleye in Green Bay, Lake Michigan: North American Journal of Fisheries Management, v. 43, no. 3, p. 695–714, accessed March 20, 2024, at https://doi.org/10.1002/nafm.10883.
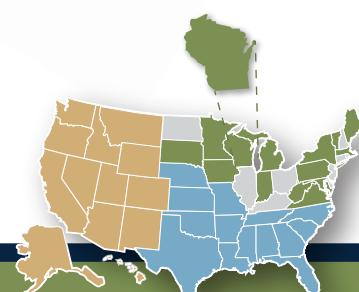

Graduate student collecting fish samples. Photograph by U.S. Geological Survey.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Wisconsin–Stevens Point, and Wisconsin Department of Natural Resources.

Sauger (*Sander canadensis*). Photograph by Sam Stukel, U.S. Fish and Wildlife Service.

Wisconsin

Cooperative Wildlife Research Unit

Scientists

Wendy Turner, Unit Leader; Christian Che-Castaldo, Assistant Unit Leader

About the Unit

The Wisconsin Cooperative Wildlife Research Unit scientists are leaders in the fields of wildlife disease and quantitative ecology. The Wisconsin Wildlife Unit is also committed to providing graduate education in wildlife and natural resource management. The Unit scientists have and continue to build productive and collaborative research programs in their respective fields and are dedicated to assisting their State and Federal cooperators. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narrative follows the theme of diseases of fish and wildlife.

White-tailed deer (*Odocoileus virginianus*). Photograph by Alena Rinaldi, U.S. Geological Survey.

Research Projects

Transmission and Evolution of a Persistent Pathogen: Anthrax Infection Dynamics Comparing Two Natural Systems

Anthrax is a globally distributed disease of wildlife, livestock, and humans that is caused by the bacterium *Bacillus anthracis*. Successful prediction of and responses to outbreaks of anthrax are limited by a lack of understanding of the geographic differences in the ecology of the pathogen and the pattern of disease outbreaks. This project is investigating the roles of host, pathogen, and environment to understand how the pathogen-host interaction evolves and contributes to the differences in anthrax occurrence in two national parks in southern Africa. Researchers are building landscape-level models of epidemiology and population dynamics incorporating host movement, transmission routes, pathogen virulence, and host resistance across ecosystems. In a broader sense, this research is facilitating the development of predictive tools to better manage public health and related policies for complex, multihost zoonotic diseases such as anthrax. The project is a collaboration between the Wisconsin Wildlife Unit, the University of Wisconsin–Madison, The University of Maine, University of Pretoria, University of Namibia, South African National Parks, and the Namibian Ministry of Environment, Forestry and Tourism.

Technical Assistance

Wendy Turner developed a prion laboratory on campus at the University of Wisconsin–Madison to meet State cooperator needs for prion research for chronic wasting disease in deer.

Christian Che-Castaldo provided analytical and technical support to the U.S. Fish and Wildlife Service (FWS) by sharing R code for compiling and processing National Agriculture Imagery Program aerial imagery data for the Inyo rockdaisy (*Perityle inyoensis*) Species Status Assessment. He has also met with Wisconsin Department of Natural Resources and FWS to develop multiple research projects addressing cooperator data science and statistical modeling needs.

Selected Publications

Barandongo, Z.R., Dolfi, A.C., Bruce, S.A., Rysava, K., Huang, Y-H., Joel, H., Hassim, A., Kamath, P.L., van Heerden, H., and Turner, W.C., 2023, The persistence of time—the lifespan of *Bacillus anthracis* spores in environmental reservoirs: Research in Microbiology, v. 174, no. 6, article 104029, 9 p., accessed March 20, 2024, at https://doi.org/10.1016/j.resmic.2023.104029.

Inzalaco, H.N., Bravo-Risi, F., Morales, R., Walsh, D.P., Storm, D.J., Pedersen, J.A., Turner, W.C., and Lichtenberg, S.S., 2023, Ticks harbor and excrete chronic wasting disease prions: Scientific Reports,.v. 13, article 7838, 13 p., accessed March 20, 2024, at https://doi.org/10.1038/s41598-023-34308-3.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Wisconsin–Madison, and Wisconsin Department of Natural Resources.

Necedah National Wildlife Refuge in Wisconsin. Photograph by Katie Goodwin, U.S. Fish and Wildlife Service.
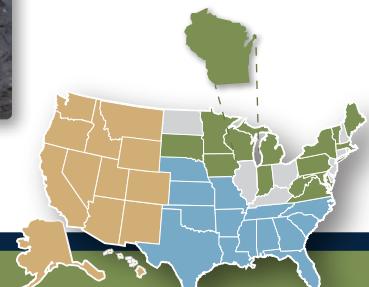
Alabama
Cooperative Fish and Wildlife Research Unit

Scientists

Shannon Brewer, Unit Leader; Jonathon Valente, Assistant Unit Leader; one vacancy

Meet the Unit

The Alabama Cooperative Fish and Wildlife Research Unit is located in one the most diverse ecological areas in the United States, and works cooperatively with agencies tasked with managing the many species and habitats in this area. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives include the following themes: hunting and fishing, animal migration, Species of Greatest Conservation Need and threatened and endangered species, and decision science and structured decision-making.

Research Projects

Movement, Recruitment, and Exploitation of Shoal Bass in the Lower Flint River Basin

Black basses (*Micropterus* spp.) contribute to important recreational fisheries, but different species respond differently to landscape changes. Shoal bass (*Micropterus cataractae*) is a popular sportfish that, like many bass with a limited distribution, has been affected by human disturbances on the riverscape. Alternatively, largemouth bass (*Micropterus salmoides*) has a broad distribution and is well-studied in reservoir ecosystems, but riverine populations are rarely studied. Both species are important to recreational fisheries and offer interesting comparisons as to how they use the riverscape and the levels of exploitation in the lower Flint River. The lower Flint River supports strong populations of both

bass species, although recruitment by shoal bass is a concern. Examination of movement and recruitment dynamics together with exploitation levels may be useful for making management decisions in this region. The Unit is improving understanding of how bass populations use the river seasonally, how recruitment varies spatially and temporally, and population exploitation management regulations are also being evaluated. Collectively, a management agency may use this information for making decisions on water use, dam operations (where applicable), and designated take and length regulations. This project is a collaboration of the Alabama Unit, Auburn University, The Jones Center at Itchauway, and the Georgia Department of Natural Resources.

Shoal bass (*Micropterus cataractae*). Photograph by Shannon Brewer, U.S. Geological Survey.

Conciliation in the Habitat Fragmentation and Biodiversity Debate

For nearly 50 years, ecologists have disagreed about whether habitat fragmentation has a negative effect on biodiversity after accounting for habitat loss. Landscape-scale conservation planning can help to inform land-use decisions given the extent of human land-use change and its pervasive effects on Earth's biodiversity. This continued disagreement among ecologists regarding habitat fragmentation has created confusion in how to approach broad-scale planning for habitat conservation. Our work sets the stage for a unified set of principles regarding conservation in fragmented landscapes and identifies potential reasons for differing conclusions in fragmentation research. Current efforts are developing a path forward for the ecological community by reconciling different views and advancing conservation planning within a landscape ecology framework. This research was conducted in partnership with Oregon State University, University of Florida, University of Wisconsin–Madison, Cornell Lab of Ornithology, Carleton University, and Arizona State University.

Technical Assistance

Brewer and Valente meet with U.S. Fish and Wildlife Service personnel quarterly to discuss technical assistance needs.

Valente is working with biologists in Oregon to develop an experiment that examines effects of forest management practices on the endangered marbled murrelet (*Brachyramphus marmoratus*) in the Elliott State Research Forest. He is also assisting with the analysis of nest monitoring, bird-banding, and point-count survey data to compare these approaches for quantifying bird population changes.
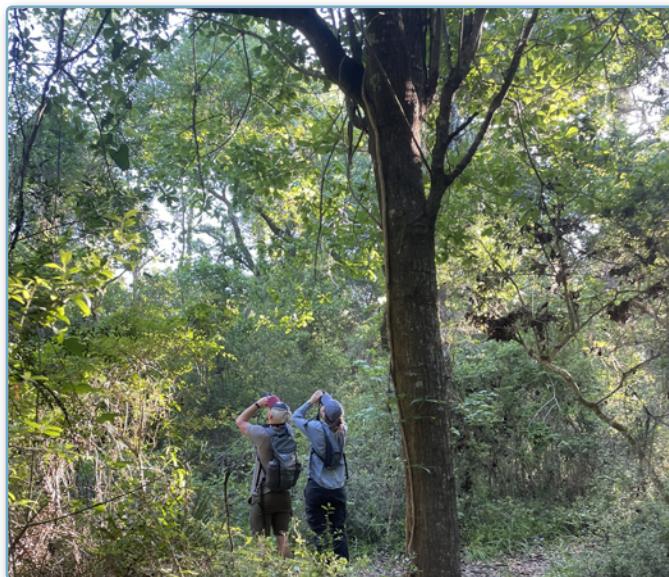
Two students survey birds. Photograph by Jonathan Valente, U.S. Geological Survey.

Selected Publications

Galbraith, S.M., Valente, J.J., Dunn, C.J., and Rivers, J.W., 2023, Both Landsat- and LiDAR-derived measures predict forest bee response to large-scale wildfire: Remote Sensing in Ecology and Conservation, v. 10, no. 1, p. 24–38, accessed March 13, 2024, at https://doi.org/10.1002/rse2.354.

Swedberg, D., Mollenhauer, R., and Brewer, S.K., 2023, The context dependency of fish-habitat associations in separated karst ecoregions: Ecology and Evolution, v. 13, no. 12, article e10701, 18 p., accessed March 13, 2024, at https://doi.org/10.1002/ece3.10701.

Valente, J.J., Gannon, D.G., Hightower, J., Kim, H., Leimberger, K.G., Macedo, R., Rousseau, J.S., Weldy, M.J., Zitomer, R.A., Fahrig, L., Fletcher, R.J., Wu, J., and Betts, M.G., 2023, Toward conciliation in the habitat fragmentation and biodiversity debate: Landscape Ecology, v. 38, p. 2717–2730, accessed March 13, 2024, at https://doi.org/10.1007/s10980-023-01708-9.

Wedgeworth, M., Mollenhauer, R., and Brewer, S.K., 2022, Variation in prairie chub hatch relationships across wet and dry years in the upper Red River basin: North American Journal of Fisheries Management, v. 43, no. 5, p. 1246–1259, accessed March 13, 2024, at https://doi.org/10.1002/nafm.10842.

Graduate Student Spotlight

Paul Ramsey, Master of Science, School of Fisheries, Aquaculture, and Aquatic Sciences, Auburn University

Thesis title: "Nursery habitat and hatch dates of large river fishes of the lower Red River catchment."

Paul is now a freshwater fisheries biologist with the Florida Fish and Wildlife Conservation Commission. He works in the Fish and Wildlife Research Institute where he assesses competition between Nile tilapia (*Oreochromis niloticus*) and Florida bass (*Micropterus floridanus*), thermal suitability of Florida's rivers for fish, and assists with long-term monitoring of Florida's fish assemblages.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Auburn University, and Alabama Department of Conservation and Natural Resources.
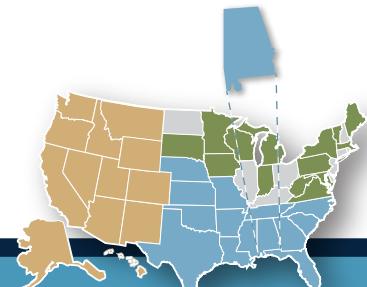
Arkansas
Cooperative Fish and Wildlife Research Unit

Scientists

Caleb Roberts, Unit Leader; Dan Magoulick, Assistant Unit Leader; one vacancy

About the Unit

The Arkansas Cooperative Fish and Wildlife Research Unit scientists work closely with cooperators to identify problems, create a shared vision, and conduct science directly applicable to conservation at local, State, and national scales. The Unit is housed in the Department of Biological Sciences at the University of Arkansas rather than in a Fisheries and Wildlife or Natural Resources program. This arrangement makes the Unit unusual and creates the opportunity for diverse perspectives. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: invasive species; wildfire; population monitoring and advanced modeling; Species of Greatest Conservation Need, threatened and endangered species; water allocation, drought, and ecological flows; and advanced technologies.

Research Projects

A National-Scale Early Detection and Ecosystem Service Effect Assessment Tool for Invasive Terrestrial Plants

Globally, invasive species cause trillions of dollars in damages to ecosystem services, including agricultural production and biodiversity, and these damages may increase as the climate changes. The United States has adopted early detection and rapid response (EDRR) policies to prevent spread and establishment of invasive species, but implementing a consistent, national-scale EDRR approach has been difficult. Challenges include accurately predicting where and when invasive species will spread and consistently estimating the effects of invasive species on ecosystem services, which are benefits that wildlife or an ecosystem provides. To help overcome these challenges, the goals of this project are to develop and implement a consistent, national-scale EDRR tool that can be adapted to most terrestrial invasive plants. The team hopes to: (1) develop new early-detection methods that predict the spread of invasive species and overcome modeling limitations; (2) implement these early-detection methods on a model system of cogongrass (*Imperata cylindrica*), one of the "world's worst weeds" and current invader in the United States; (3) estimate cogongrass effects on ecosystem services across a gradient of invasion; (4) use early-detection model predictions to map losses in ecosystem services driven by cogongrass invasion under different climate-change scenarios; and (5) publish computer code and instructional vignettes to help with application of the EDRR tool for other terrestrial invasive plant species. By combining early-detection models and ecosystem service effects, the project results may aid stakeholders and private landowners in prioritizing proactive management actions at local, regional, and national scales, and in conserving ecosystem services such as biodiversity, timber, and livestock production.

Bush honeysuckle (*Lonicera tatarica*). Photograph by National Park Service.

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

Despite the critical role of hydrology and water temperature in sustaining native aquatic biodiversity, few studies have examined the across-scale influence of these factors on freshwater biota using a multispecies and flow-regime analytical framework. The Ozark and Ouachita Interior Highlands and Gulf Coastal Plain regions are characterized by high biological diversity, species that are unique to the area, and a rapidly growing human population that is dependent on freshwater resources. This project is using high-performance computing resources at the University of Arkansas to quantify the influence of hydrology, temperature, and landscape changes on fish and aquatic macroinvertebrate assemblages. Researchers plan to link large, species-level taxonomic and functional trait databases with hydrologic metrics derived from the U.S. Geological Survey's national streamgage network, and with satellite remote-sensing data, including precipitation measurements and daily land-surface temperature and emissivity. The researchers plan to use a new machine-learning approach to examine nonlinear environmental thresholds. Results will describe significant hydrologic, temperature, and land-use thresholds for individual fish species and functional traits. This approach can focus on entire assemblages, Species of Greatest Conservation Need, or species of management concern. This approach may be implemented and expanded to address important natural-resource questions at local, regional, and national scales.

Technical Assistance

Caleb Roberts and student Lauren Berry met with Arkansas Game and Fish Commission and U.S. Fish and Wildlife Service (FWS) personnel at Bald Knob National Wildlife Refuge (NWR) to discuss how findings from their project "A rapid mapping tool for quantifying grassland restoration outcomes" could be applied to statewide grassland restoration and management. FWS managers of the Big Oaks NWR in Marion, Indiana, asked Roberts to design a Before-After Control-Impact study for their planned aerial herbicide treatment of invasive shrubs such as privet (*Ligustrum* spp.) and bush honeysuckle (*Lonicera tatarica*). Roberts also coplanned and led a Cooperative Research Units All-Hands meeting session on "Big Data" in March 2023 in Tampa, Florida.

Selected Publications

Annaratone, B., Larson, C., Prater, C., Dowling, A., Magoulick, D.D., and Evans-White, M.A., 2023, Predicting habitat and distribution of an Interior Highlands regional endemic winter stonefly (*Allocapnia mohri*) in Arkansas using random forest models: Hydrobiology, v. 2, no. 1, p. 196–211, accessed March 13, 2024, at https://doi.org/10.3390/hydrobiology2010013.

Longing, S.D., and Magoulick, D.D., 2023, Flight capacity and response to habitat drying of endemic diving beetles (Coleoptera—Dytiscidae) in Arkansas (USA): Hydrobiology, v. 2, no. 2, p. 354–362, accessed March 13, 2024, at https://doi.org/10.3390/hydrobiology2020023.

Morford, S.L., Allred, B.W., Twidwell, D., Jones, M.O., Maestas, J.D., Roberts, C.P., and Naugle, D.E., 2022, Herbaceous production lost to tree encroachment in United States rangelands: Journal of Applied Ecology, v. 59, no. 12, p. 2971–2982, accessed March 13, 2024, at https://doi.org/10.1111/1365-2664.14288.

Roberts, C.P., Doser, J.W., Berry, L.L., Fowler, A., Marshall, P.M., Middaugh, C., Rowe, K., Schmidt, J.M., Shaw, M., and Wilson, K., 2024, Scenario planning and multispecies occupancy models reveal positive avian responses to restoration of afforested woodlands: Restoration Ecology, v. 32, no. 1, article e13998, 10 p., accessed March 13, 2024, at https://doi.org/10.1111/rec.13998.

> "
>
> "The Arkansas Game and Fish Commission has enjoyed a long-tenured relationship with the Arkansas Cooperative Fish and Wildlife Research Unit. By working together, we have increased the State's scientific knowledge to move conservation forward in Arkansas. In addition, and just as importantly, we strongly believe that the investment in the students as future conservation professionals is fundamental and crucial to the future of wildlife and fisheries management. A close working relationship and partnership is the key to our success!"
>
> —Cory Gray, Chief of the Research Division, Arkansas Game and Fish Commission

Graduate Student Spotlight

Emily Johansson, Master of Science in Biology, University of Arkansas-Fayettville

Thesis title: "Effects of landscape and yard features on mammals in residential yards in Northwest Arkansas."

Emily Johansson works with a barred owl, Arkansas State University. Photograph by Emily Johansson.

Emily currently is a Doctor of Veterinary Medicine candidate at Iowa State University where she is studying Zoo, Exotics, and Wildlife veterinary medicine. Brett Degregorio, now at the Michigan Unit, directed her studies at the Arkansas Unit.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Arkansas, and Arkansas Game and Fish Commission.
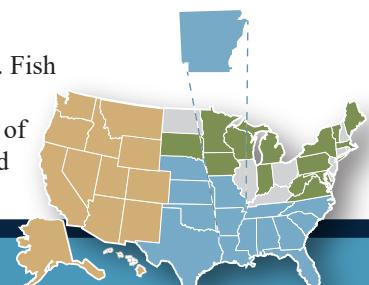
Scientists

Abby Powell, Unit Leader; Andrew K. Carlson, Assistant Unit Leader; Raymond R. Carthy, Assistant Unit Leader; Conor McGowan, Assistant Unit Leader

About the Unit

The Florida Cooperative Fish and Wildlife Research Unit has wide-ranging expertise in avian ecology and conservation, endangered species monitoring and assessment, coastal ecosystems, population and ecological modeling, decision analysis, fisheries ecology and management, and coupled human and natural systems. Research in the Florida Unit is taxonomically diverse, including terrestrial and water birds, terrestrial herpetofauna and marine turtles, and freshwater and marine fishes. The Florida Unit has a strong legacy of close ties and productive collaborations with its State agency and university partners, as well as other Federal resource management entities. The level of support and engagement the Florida Unit receives is highlighted by the well-attended annual Coordinating Committee meeting, where the research team provides programmatic summaries and graduate students showcase their research. Although the scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: animal migration, Species of Greatest Conservation Need and threatened and endangered species, invasive species, decision science and structured decision-making, hunting and fishing, human dimensions, and population monitoring and advanced modeling.

Florida scrub-jay (*Aphelocoma coerulescens*). Photograph by James Lyon, U.S. Fish and Wildlife Service.

Research Projects

Colonial Nesting Wading Bird Tracking and Habitat Use Assessment

This study is designed to inform and enhance future restoration planning for key colonial nesting wading bird species along the Alabama coast that were affected by the Deepwater Horizon oil spill in 2010. Overall research objectives include determining daily and seasonal movements, home-range size, and habitat use by several species of colonial-nesting wading birds, specifically tricolored heron (*Egretta tricolor*), little blue heron (*Egretta caerulea*), and possibly white ibis (*Eudocimus albus*), in Mobile Bay, Mississippi Sound, and Perdido Bay, Alabama. Partners include U.S. Fish and Wildlife Service (FWS) and Alabama Department of Conservation and Natural Resources. The goals of the project are to better understand 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.

Lessons From a Long-Term Fisheries Monitoring Program—The Florida Experience

Fisheries managers depend on consistent, reliable information on fish populations across space and time to make informed management decisions. However, developing and sustaining long-term monitoring programs is inherently challenging for fisheries management agencies because of limited time, money, and personnel. This dichotomy—the value of fisheries monitoring on the one hand and the difficulty of monitoring on the other—makes it critical for fisheries agencies to formally evaluate their monitoring programs to ensure data reliability and maximize program efficiency. Partners from the Florida Unit and the State of Florida are collaborating to analyze data from a long-term monitoring fisheries program initiated in 2006 to track trends in freshwater fish population distribution and community structure in numerous water bodies throughout Florida. The evaluation of the long-term fisheries monitoring program for this project encompasses factors such as sampling design and statistical rigor, ecological insights, and program delivery, and is providing important information about changes in Florida fish communities. This information may allow managers to make decisions for fisheries management amid human-caused or aided environmental stressors such as climate change, land-use alteration, and species invasion.

Gulf sturgeon (*Acipenser oxyrhynchus desotoi*). Photograph by John Knight, Florida Fish and Wildlife Conservation Commission.

Green sea turtle (*Chelonia mydas*). Photograph by U.S. Fish and Wildlife Service.
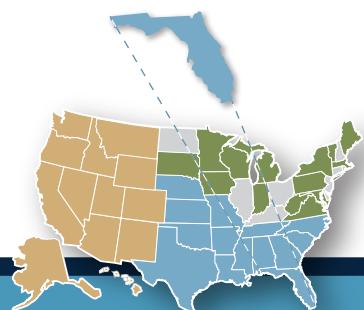
Assessing Effects of Anthropogenic and Climate-Induced Change on the Health of Coastal Ecosystems

Florida's coastline is constantly reworked by long and short-term climate cycles. Shifts in the frequency and intensity of those cycles due to global change, in conjunction with human-caused alterations, are affecting the resilience of coastal habitats and the species that rely on them, such as sea turtles. Sea turtles nest in a variety of beach environments, and the success of an individual nest is influenced by its location on the beach and the resulting incubation microenvironment. Recent research indicates that the incursion and retreat of saltwater wedges during the tidal cycle causes substantial movement of gases through the beach, and that alterations such as beach nourishment have the potential to suppress this natural gas-pumping effect. The effects of tide-driven gas exchange on sea turtle nest incubation, beach microbial communities, and dune stabilization have received little attention. The research team is evaluating how nest incubation dynamics and productivity respond to altered gaseous environments. Additionally, the project is investigating the role of beach nourishment in shifting offshore/onshore organic matter budgets, and implications for greenhouse gas emissions. The results of this work are helping to identify how and where habitat suitability issues might arise, and informing sound conservation planning measures and beach nourishment practices, including mitigation and alternative actions.

Southwestern and Northwestern Pond Turtle Viability Analysis to Support Species Status Assessment

Northwestern pond turtles (*Actinemys marmorata*) and southwestern pond turtles (*Actinemys pallida*) are proposed for listing under the Endangered Species Act (ESA). To determine if protections are warranted, FWS needs to assess the status of existing populations of these species and to predict the future status of these species. The researchers worked with FWS to devise and complete analysis that supported the Species Status Assessment (SSA) and the listing decision for both turtle species. Listing a species under the ESA precipitates legal protection for that species and its habitat. The ESA serves as the primary regulatory mechanism for protecting species that have an intolerably high risk of extinction now or in the foreseeable future. To determine if the species needs protection, FWS must first assess the current status and predict future trajectories to decide if extinction risk is too high. The research team worked with the FWS Region 8, California, Oregon, and Washington Divisions of Fish and Wildlife, U.S. Geological Survey, and University of California, Santa Barbara. Northwestern and Southwestern pond turtles were proposed for listing under the ESA. The SSA work that this project supported directly informed the decision process and decision-makers used the results of the predictive models to determine that "Threatened status" was warranted for both species.
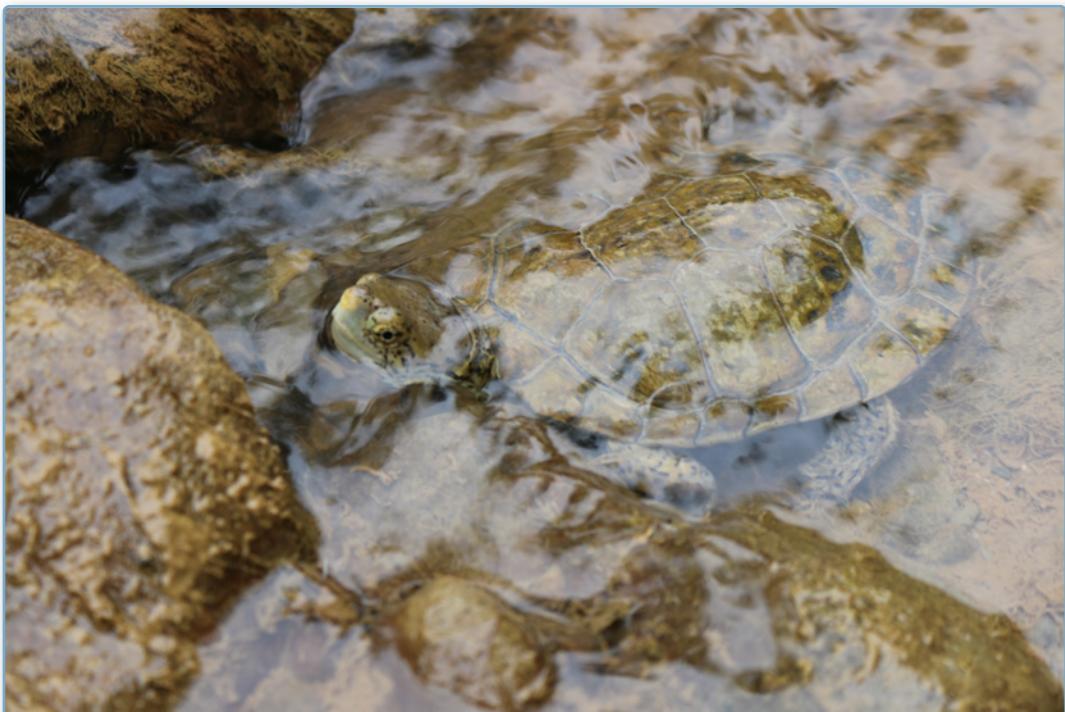
Western pond turtle (*Actinemys marmorata*). Photograph by Hazel Rodriguez, U.S. Fish and Wildlife Service.

White ibis (*Eudocimus albus*). Photograph by Jeremy Smith, U.S. Fish and Wildlife Service.

Technical Assistance

Abby Powell is a member of the Coastal Connections Planning Group for the East Gulf Coastal Plain Joint Venture.

Andrew Carlson provided technical assistance with research on sport fish and nongame fish throughout Florida in collaboration with the Florida Fish and Wildlife Conservation Commission (FWC). Carlson also worked with other Florida Unit scientists to plan and participate in a virtual meeting between the Unit and the FWS Florida Classification and Recovery Division. The scientists presented an overview of the Florida Unit and discussed research capabilities and areas of expertise.

Raymond Carthy coordinated a "Drones for sea turtle research and conservation" workshop at the 41st International Sea Turtle Symposium in Cartagena, Colombia.

Conor McGowan assisted with facilitating an objective-setting workshop for the FWC freshwater lake-monitoring program.

Selected Publications

Cardas, A., Hewett Ragheb, E.L., Miller, K.E., and Powell, A.N., 2023, Evidence of a load-lightening helper effect in Florida Scrub-Jays—Implications for translocation: Avian Conservation and Ecology v. 18, no. 2, article 17, 15 p., accessed March 13, 2024, at https://doi.org/10.5751/ACE-02552-180217.

Coleman, T.S., Eckelbecker, R.W., Carlson, A.K., DeVries, D.R., Wright, R.A., Staton, B.A., Parker, S.W., Chittam, C.R., Lovell, R.G., and Catalano, M.J., 2023, Evaluation of shoreline rotenone application to control largemouth bass recruitment in small impoundments: North American Journal of Fisheries Management, v. 44, no. 1, p. 57–69, accessed March 13, 2024, at https://doi.org/10.1002/nafm.10953.

Goode, A.B., Rivenbark, E., Gilbert, J.A., and McGowan, C.P., 2023, Prioritization of species status assessments for decision support: Decision Analysis, v. 20, no. 4, p. 243–344, accessed March 13, 2024, at https://doi.org/10.1287/deca.2023.0026.

Hirama, S., Witherington, B., Hirsch, S., Sylvia, A., and Carthy, R., 2023, Accuracy and precision of sea-finding orientation as a function of dune proximity in hatchlings of two species of sea turtles: Marine and Freshwater Research, v. 74, no. 11, p. 994–1001, accessed March 13, 2024, at https://doi.org/10.1071/mf23052.

Manes, C., Carthy, R.R., and Hull, V., 2023, A coupled human and natural systems framework to characterize emerging infectious diseases—The case of fibropapillomatosis in marine turtles: Animals, v. 13, no. 9, article 1441, 16 p., accessed March 13, 2024, at https://doi.org/10.3390/ani13091441.

Maslovsky, K.S., Maleko, P.N., Pronkevich, V.V., Slaght, J.C., and Powell, A.N., 2023, First nests of endangered Nordmann's Greenshank (*Tringa guttifer*) found in over 40 years indicate nesting plasticity: Bird Conservation International, v. 33, article e43, 6 p., accessed March 13, 2024, at https://doi.org/10.1017/S095927092200051X.

Parker, S.W., Coleman, T.S., Carlson, A.K., and Fischer, J.R., 2023, Characterization of fish assemblages in eleven multi-use reservoirs from North Carolina, USA: Journal of Freshwater Ecology, v. 38, no. 1, article 2241494, 21 p., accessed March 13, 2024, at https://doi.org/10.1080/02705060.2023.2241494.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Florida, and Florida Fish and Wildlife Conservation Commission.
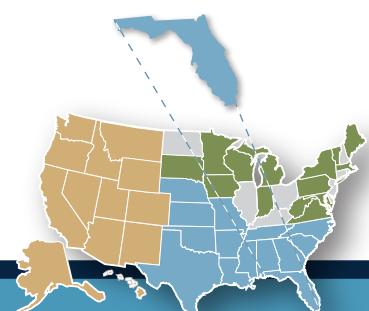
Georgia
Cooperative Fish and Wildlife Research Unit

Scientists

Brian Irwin, Unit Leader; Kelly Robinson, Assistant Unit Leader; one vacancy

About the Unit

The Georgia Cooperative Fish and Wildlife Research Unit is positioned to provide field, laboratory, quantitative, and decision support for diverse stakeholders. Some of the Unit's specific strengths include fish sampling, dissection, and aging; creating statistical models, and facilitating workshops with collaborators. The Unit is housed within the School of Forestry and Natural Resources, providing many opportunities for collaboration. Although the scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: animal migration, Species of Greatest Conservation Need and threatened and endangered species, population monitoring and advanced modeling, and decision science and structured decision-making.

Research Projects

Movement and Distribution of Lake Sturgeon in the Coosa River

Efforts to restore lake sturgeon (*Acipenser fulvescens*) to northwest Georgia began nearly 20 years ago. These large, prehistoric-looking fish were historically present in the Coosa River basin but were thought to be locally extinct by the late 1970s due to overfishing and degraded water quality. Following improvements in water quality after passage of the Clean Water Act of 1972 (33 U.S.C. §1251 et seq.), the Georgia Department of Natural Resources began a lake sturgeon reintroduction program that included annual stocking of fish to produce a self-sustaining population, and the initial cohorts have theoretically reached sexual maturity. The objective of this study is to determine seasonal habitat use and movement of lake sturgeon in the Coosa River basin using radio telemetry. The project goal is to target 40 lake sturgeon for tagging. New information about reproductive status and behaviors, movement, and habitat use may aid in recovery efforts and to inform managers of the status of the lake sturgeon population.

View of the Conasauga River, Georgia. Photograph by U.S. Fish and Wildlife Service.

Developing a Holistic Approach to Evaluate and Communicate Natural Resource Assets and Management Actions for Michigan's Large Rivers: Focus on the Au Sable River

Cold-water streams support important fisheries, including native brook trout (*Salvelinus fontinalis*). These streams are threatened by climate and land-use changes, leading to increased concern about these cold-water ecosystems by managers and stakeholders. New management strategies may help increase resilience in these important ecosystems. Collaborating with the Michigan Department of Natural Resources and many stakeholders, such as State and local chapters of Trout Unlimited, anglers, and property owners, the Unit is looking at a case-study system in the Au Sable River to help develop an adaptive management strategy for resilience in this cold-water stream system. This adaptive management plan may provide a decision-making framework for the Au Sable River, and a framework for implementing adaptive management for other cold-water streams in Michigan and in other parts of the world.

Technical Assistance

Georgia Unit scientists attended the 2023 Georgia Department of Natural Resources Fisheries Section Meeting at the Go Fish Education Center in Perry, Georgia.

Brian Irwin was the coeditor for "Analysis and interpretation of freshwater fisheries data, 2nd edition" published by the American Fisheries Society, Bethesda, Maryland.

In 2023, Kelly Robinson was asked to serve as the chair of the Sea Lamprey Research Board, which is part of the Great Lakes Fishery Commission. Robinson also collaborates with other U.S. Geological Survey researchers on a structured decision-making process for supplemental sea lamprey control.

Selected Publications

Baker, M.A., Ingram, E.C., Higginbotham, D.L., Irwin, B.J., and Fox, A.G., 2023, Refining capture-recapture recruitment estimation methods for Atlantic sturgeon: Endangered Species Research, v. 51, p. 203–214, accessed March 13, 2024, at https://doi.org/10.3354/esr01250.

Robinson, K.F., Baker, E., Ewing, E., Hemming, V., Kenney, M.A., and Runge, M.C., 2023, Decision analysis to advance environmental sustainability: Decision Analysis, v. 20, no. 4, p. 243–251, accessed March 13, 2024, at https://doi.org/10.1287/deca.2023.intro.v20.n4.

Robinson, K.F., DuFour, M.R., Fischer, J.L., Herbst, S.J., Jones, M.L., Nathan, L.R., and Newcomb, T.J., 2023, Lessons learned in applying decision analysis to natural resources management for high-stakes issues surrounded by uncertainty: Decision Analysis, v. 20, no. 4, p. 326–342, accessed March 13, 2024, at https://doi.org/10.1287/deca.2023.0015.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Georgia, and Georgia Department of Natural Resources.

Brook trout (*Salvelinus fontinalis*). Photograph by U.S. Fish and Wildlife Service.

Lake sturgeon (*Acipenser fulvescens*). Photograph by U.S. Fish and Wildlife Service.
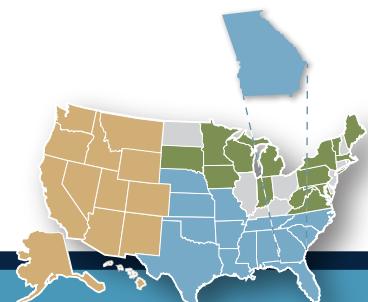
Kansas
Cooperative Fish and Wildlife Research Unit

Scientists

David Haukos, Unit Leader; Martha Mather, Assistant Unit Leader

About the Unit

The Kansas Cooperative Fish and Wildlife Research Unit is uniquely positioned to address landscape-scale issues in the Great Plains. The Unit conducts research across multiple environmental gradients on populations, resource selection, and movements in response to landscape changes, climate variability, and conservation strategies. The Unit combines diverse expertise related to traditional species-management projects and strategic-planning perspectives at local and landscape scales. This allows the Kansas Unit to be effective in conservation problem-solving now, and to enhance future conservation success by proposing innovative ways to negotiate a changing environment. Cooperators and graduate students also benefit from the diverse expertise in the Unit. Although the scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: Species of Greatest Conservation Need and threatened and endangered species; grassland management and restoration; population monitoring and advanced modeling; water allocation, drought, and ecological flows; human dimensions; and decision science and structured decision-making.

Lesser prairie-chicken (*Tympanuchus pallidicinctu*) on a lek. Photograph by Greg Kramos, U.S. Fish and Wildlife Service.

Research Projects

Reconstruction of Landscape Composition and Vegetation Characteristics in the Sand Sagebrush Prairie Ecoregion

Historically, the Sand Sagebrush Prairie Ecoregion supported the greatest population density of lesser prairie-chickens (*Tympanuchus pallidicinctus*). Currently, this species is nearly extinct in the ecoregion. Potential reasons for the rapid population decline include changes in land cover, vegetation composition, and vegetation structure. Lesser prairie-chickens depend on quality habitat, primarily specific vegetation structure, and secondarily vegetation composition, to persist. Conservation planning requires information on the current vegetation structure and composition relative to historical conditions. Landscape-scale changes in land cover composition and configuration and increasing occurrence of human-built structures are likely interacting to limit movements and habitat use by lesser prairie-chickens. These changes may be contributing to the rapid decline of lesser prairie-chickens in the Sand Sagebrush Prairie Ecoregion. Project partners are the U.S. Geological Survey, the Kansas Unit, Kansas State University, Kansas Department of Wildlife and Parks, Colorado Parks and Wildlife, and the U.S. Department of Agriculture Forest Service. Results from this research may provide managers and conservation planners with a framework for determining landscape features that may be influencing lesser prairie-chicken population demography.

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

Natural resource agencies are charged with conserving native species. Freshwater biodiversity is decreasing rapidly even though protecting freshwater is a priority for human security and environmental management. State natural resource agencies require new tools in their conservation toolboxes to address the increasing number of obstacles that impede successful conservation of native freshwater biodiversity. The overarching issue that researchers are focusing on is how to extract clearer and more actionable ecological insights from "messy" biodiversity monitoring data. At present, only partial solutions exist for this challenge of translating real-world data into environmental protection. The adaptive management process for conserving native species threatened by adverse human effects uses an iterative step framework to address this challenge. Researchers are working with a variety of Unit cooperators and the project is funded by State cooperators. The research team has expanded university collaboration to include geographic information systems experts, a statistician, and experts on spatial data analysis using R computer code. By systematically and repeatedly using the adaptive management process framework, teams can cumulatively integrate insights, address relevant gaps, and propose testable predictions that connect present understanding to future information needs for conservation. This innovative team approach is transforming the analysis of monitoring data into a series of iterative hypothesis tests that connect present and future analyses, direct upcoming data collections, and guide impending restoration initiatives.

Technical Assistance

David Haukos served as co-chair representing the Central Mountains and Plains Section of The Wildlife Society on the Certification Review Board.

Martha Mather taught a graduate course "Biologically-involved Sustainability: A New Direction for Successful Resource Conservation and Management" in Spring 2023. This class was designed to help future fisheries and wildlife students to understand traditional management missions and to navigate future challenges. Mather also collaborated with the State cooperators and served on the Steering Committee for the 83rd Midwest Fish and Wildlife Conference in Overland Park, Kansas.

Selected Publications

Gehrt, J.M, Sullins, D.S., Verheijen, B.H.F., and Haukos, D.A., 2023, Lesser prairie-chicken incubation behavior and nest success most influenced by nest vegetation structure: Ecology and Evolution, v. 13, no. 9, article e10509, 12 p., accessed March 13, 2024, at https://doi.org/10.1002/ece3.10509.

Mather, M.E., and Dettmers, J.M., 2022, Adaptive problem maps (APM)—Connecting data dots to build increasingly informed and defensible environmental conservation decisions: Journal of Environmental Management, v. 312, article 114826, 10 p., accessed March 13, 2024, at https://doi.org/10.1016/j.jenvman.2022.114826.

Mather, M.E., Granco, G., Bergtold, J.S., Caldas, M.M., Heier-Stamm, J.L., Sheshukov, A.Y., Sanderson, M.R., and Daniels, M.D., 2023, Achieving success with RISE—A widely implementable, iterative, structured process for mastering interdisciplinary team science collaborations: Bioscience, v. 73, no. 12, p. 891–905, accessed March 13, 2024, at https://doi.org/10.1093/biosci/biad097.

Teige, E.C., Berigan, L.A., Aulicky, C.S.H., Reitz, J.H., Haukos, D.A., Sullins, D.S., Fricke, K.A, Schultz, K.A., and Rossi, L.G., 2023, Assessment of lesser prairie-chicken translocation through survival and lek surveys: Wildlife Society Bulletin, v. 47, no. 4, article e1493, 20 p., accessed March 13, 2024, at https://doi.org/10.1002/wsb.1493.

Graduate Student Spotlight

Olivia Rode, Master of Science in Biology, Kansas State University

Thesis title: "How a monitoring dataset, an adaptive management framework, and ecological comparisons of thoughtfully-selected fish groups can aid aquatic conservation and native fish restoration."

Olivia graduated in December and is currently employed as a biologist with Olsson Environmental. She continues to consult with the cooperator-sponsored project that funded her degree as we build on her results.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Kansas State University, and Kansas Department of Wildlife and Parks.

A prairie stream. Photograph by Shannon Brewer, U.S. Geological Survey

Louisiana Cooperative Fish and Wildlife Research Unit

Scientists

Sammy King, Unit Leader; Megan La Peyre, Assistant Unit Leader; Drew Fowler, Assistant Unit Leader; one vacancy

About the Unit

The Louisiana Cooperative Fish and Wildlife Research Unit is focusing on conducting cutting-edge research on wetlands and wetland-dependent organisms. Louisiana Unit scientists study Gulf of America [Mexico] coastal habitats and dependent species, working closely with State cooperators to help address coastal land loss and in other research areas. The Louisiana Unit conducts applied research connecting patterns of fish and wildlife to underlying ecological processes that drive habitat systems. Although scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: ecological restoration, coastal restoration, animal migration, and population monitoring and advanced modeling.

Research Projects

Comparison of Avian Communities and Hydrological Characteristics on Restored and Natural Marshes in Coastal Louisiana

Louisiana has embarked on a $50 billion coastal restoration program. Numerous marshes have been restored under previous funding mechanisms, but little evaluation has been conducted to determine the effects of restoration on bird communities. Secretive marshbirds are common inhabitants of coastal marshes in Louisiana, but there is a lack of information about specific habitat needs for these species. Also,

Whooping cranes (*Grus americana*). Photograph by Steve Gifford, U.S. Fish and Wildlife Service.

there has been no evaluation of the newly created marshes to determine how effective they are in providing adequate marshbird habitat. The research team is developing models for each secretive marshbird species to determine how multiscale hydrologic processes and vegetation structure affect marshbird abundance. This project is a collaboration among multiple agencies, including the Louisiana Technical Implementation Group and Louisiana Department of Wildlife and Fisheries.

Exploring Louisiana's Oyster Populations: Examining Population Tolerances to Salinity

Louisiana and Gulf coast estuarine conditions are changing rapidly due to climate change and river and coastal management. These changing conditions affect the survival and growth of commercially and ecologically valuable bottom-dwelling organisms, including the eastern oyster (*Crassostrea virginica*), and complicate management and conservation of this ecosystem engineer. Loss of oyster reefs due to changing estuarine conditions results in the loss of ecosystem services provided by oysters and the reefs they create, such as water filtration, habitat provision, and shoreline protection. In addition, oyster deaths from changing conditions reduce production of this commercially valuable species. Survival of eastern oysters might be helped by inclusion of oyster stocks that are more tolerant of changing conditions. This research is being conducted in close collaboration with State partners, including the Louisiana Department of Wildlife and Fisheries regarding oyster production,

and the Louisiana Coastal Protection and Restoration Authority regarding overall coastal restoration and protection. Results from this work are being used to model oyster growth, mortality, and reef connectivity, and to determine which oysters tolerate change best so these specific oysters can be used to produce seed oysters for the oyster industry and for restoration projects.

Collecting Eastern oysters (*Crassostrea virginica*) for research. Photograph by U.S. Geological Survey.

Linking Annual Waterfowl Productivity and Louisiana Hunter-Harvest to Natal/Molt Origins Using Stable Isotope Ecology

Identifying links between where waterfowl are hatched and where they migrate to winter is important for developing sustainable waterfowl harvest-management strategies. However, traditional methods for determining migratory connectivity require a capture-mark-recovery framework, and current capture locations may not represent the entire breeding range of a species because of limited accessibility. Stable isotopes found in feathers can indicate where a bird developed its flight feathers. This research compares estimates of where harvested waterfowl originate using banding data and stable isotope analyses of flight feathers in harvested blue-winged teal (*Spatula discors*), green-winged teal (*Anas carolinensis*), gadwall (*Mareca strepera*), mallard (*Anas platyrhynchos*), northern pintail (*Anas acuta*), and lesser scaup (*Aythya affinis*). Project collaborators are the Louisiana Unit, University of Western Ontario, Louisiana Department of Wildlife and Fisheries, and Arkansas Game and Fish Commission. Data acquired in this study may inform biologists on how well the capture-mark-recovery method represents where

Blue-winged teal (*Spatula discors*). Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Mallard (*Anas platyrhynchos*). Photograph by Alena Rinaldi, U.S. Geological Survey.

waterfowl originate and the migratory connectivity of managed waterfowl species. This study may also demonstrate the utility of incorporating source-origins estimates using stable isotope analyses into long-term monitoring programs of harvested waterfowl used to track hunter harvest and population productivity.

Technical Assistance

Sammy King served as an invited wetland expert in a formal wetland review of wet meadows for Malheur National Wildlife Refuge.

Megan La Peyre is serving as subject matter expert on a Louisiana Trustee Implementation Group-funded project to develop an oyster metapopulation model to identify sites for oyster restoration and oyster aquaculture development. La Peyre also provided map products and analyses to support Louisiana Sea Grant Alternative Oyster Culture grant program.

Drew Fowler provided technical support to the Lower Mississippi River Valley Joint Venture in a collaborative effort to develop a decision support tool for identifying wetland habitat complexes that are important for wintering and migratory waterfowl.

Selected Publications

Coxe, N., Casas, S.M., Marshall, D.A., La Peyre, M.K., Kelly, M.W., and La Peyre, J.F., 2023, Differential hypoxia tolerance of eastern oysters from the northern Gulf of Mexico at elevated temperature: Journal of Experimental Marine Biology and Ecology, v. 559, article 151840, 11 p., accessed March 13, 2024, at https://doi.org/10.1016/j.jembe.2022.151840.

Coxe, N., Mize, G., Casas, S., La Peyre, M.K., Lavaud, R., Callam, B., Rikard, S., and La Peyre, J.F., 2023, Hypoxia and anoxia tolerance in diploid and triploid eastern oysters at high temperature: Journal of Shellfish Research, v. 42, no. 1, p. 29–43, accessed March 13, 2024, at https://doi.org/10.2983/035.042.0104.

Vasseur, P.L., King, S.L., and Kaller, M.D., 2023, Diurnal time-activity budget and habitat use of whooping cranes (*Grus americana*) in the reintroduced Louisiana nonmigratory population: The Wilson Journal of Ornithology, v. 135, no. 1, p. 31–45, accessed March 13, 2024, at https://doi.org/10.1676/22-00039.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Louisiana State University, and Louisiana Department of Wildlife and Fisheries.

Scientists

Leandro Miranda, Unit Leader; Francisco Vilella, Assistant Unit Leader; one vacancy

About the Unit

The Mississippi Cooperative Fish and Wildlife Research Unit borders the alluvial valley of the lower Mississippi River, the Tennessee River, and the Coastal Plains. The Unit works closely with State and regional cooperators, and also conducts research in the Caribbean. Although scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: invasive species, Species of Greatest Conservation Need and threatened and endangered species, and decision science and structured decision-making.

Research Projects

Bracing for the Long Term: A Conceptual Framework to Facilitate Coexistence With Invasive Carp

Invasive bighead carp (*Hypophthalmichthys nobilis*) have spread and become established throughout the Mississippi River and its tributaries. The responses to this expansion of this invasive species' range have included surveillance, harvesting, mass removals, deterrence systems, and various eradication approaches to keep bighead carp from entering waterbodies where they are not wanted. Despite extensive efforts by conservation agencies, it is likely that carp will not be eradicated. Management plans for this species may need to consider refocusing conservation efforts toward facilitating coexistence with native biotic communities. The Mississippi Unit is collaborating on this

research project for carp management with the U.S. Fish and Wildlife Service (FWS) and several State agencies bordering the Tennessee and Cumberland rivers. This research is developing a conceptual framework that represents our current understanding of bighead carp effects in aquatic systems, identifies deficiencies in knowledge, and pinpoint system drivers, with the goal to inform solutions that facilitate coexistence with carp in aquatic systems.

Bighead carp (*Hypophthalmichthys nobilis*). Photograph by U.S. Geological Survey.

Modeling Species at Risk to Support Species Status Assessments (SSAs) in the Southeast

Planning for conservation requires accurate knowledge of the distribution of organisms that is frequently lacking for many species, especially uncommon ones. Species distribution models are helpful in identifying vital habitats for at-risk species. Even though these models have become widely available over the last 20 years, some management programs rely on expert knowledge

to find existing populations, rather than embracing use of distribution models to inform species surveys. The FWS's Species Status Assessment (SSA) is a significant framework that might benefit from species distribution models. There are no set standards for estimating species distributions, but the SSA takes a variety of factors into account related to the assessed species, including distributions. The project goal is to identify the best species-distribution modeling strategy for at-risk species for comparable-species monitoring initiatives such as the SSA. Collaborators include FWS; State natural heritage programs in Arkansas, Georgia, South Carolina, Florida, and Missouri; Florida Native Plant Society; National Council for Air and Stream Improvement; and the Weyerhaeuser Company. An ensemble species distribution model was developed for seven species of insects, plants, and animals, including rattlesnake-master borer (moth) (*Papaipema eryngii*), Ocmulgee skullcap (*Scutellaria ocmulgee*), purpledisk honeycombhead (*Balduina atropurpurea*), hairy-peduncled beaked-rush (*Rhynchospora crinipes*), Florida nutmeg (*Torreya taxifolia*), Carolina birds-in-a-nest (*Macbridea caroliniana*), and Red Hills salamander (*Phaeognathus hubrichti*). These models help support planning and aid in measurement of success across multiple metrics. This research is projected to deliver a suite of species distribution models to support the FWS Southeast Region's at-risk species efforts.

Technical Assistance

Leandro Miranda developed software for the Mississippi Department of Wildlife, Fisheries, and Parks that field biologists can use to generate management plans based on survey data and ecological knowledge about an aquatic system. Miranda also worked with a panel of experts nationwide to establish procedures for sampling warmwater fish in standing waters.

Francisco Vilella provided technical assistance to the Puerto Rico Department of Natural and Environmental Resources on restoration and management of coastal wetlands.

Selected Publications

Miranda, L.E., 2023, Aging, climate, and invasions threaten threaten reservoirs in the Mississippi River Basin: Fisheries (Bethesda, Md.), v. 48, no. 12, p. 499–514, accessed March 13, 2024, at https://doi.org/10.1002/fsh.10990.

Miranda, L.E., 2023, Facing our freshwater crisis via fluid and agile communication—A grand challenge: Frontiers in Freshwater Science, v. 1, article 1068115, 6 p., accessed March 13, 2024, at https://doi.org/10.3389/ffwsc.2023.1068115.

Ramirez-Reyes, C., Vilella, F.J., Evans, K.O., Street, G., Pacheco, C., Monzon, O., and Morales, A., 2023, Geographic distribution of the Puerto Rican harlequin butterfly (*Atlantea tulita*)—An ensemble modeling approach: Caribbean Journal of Science, v. 53, no. 1, p. 37–44, accessed March 13, 2024, at https://doi.org/10.18475/cjos.v53i1.a3.

Vilella, F.J., and González, R., 2023, Multi-resolution habitat models of the Puerto Rican nightjar *Antrostromus noctitherus*: Bird Conservation International, v. 33, article e74, 10 p., accessed March 13, 2024, at https://doi.org/10.1017/S0959270923000278.

Graduate Student Spotlight

Nicky Faucheux, Ph.D. in Forest Resources, Mississippi State University

Dissertation title: "Assessing the legacy of erosion and flood control management efforts on the fish assemblages and physical conditions of Yazoo Basin bluff hill streams."

Nicky is currently employed by the U.S. Army Corps of Engineers at the Engineering Research and Development Center Waterways Experiment Station in Vicksburg, Mississippi, and conducts fish research across the United States, principally in the lower Mississippi River.

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"The Coop Unit is our agency's research arm."

—Mississippi Department of Wildlife, Fisheries, and Parks

Cooperators

U.S. Geological Survey; U.S. Fish and Wildlife Service; Wildlife Management Institute; Mississippi State University; and Mississippi Department of Wildlife, Fisheries, and Parks.

Missouri Cooperative Fish and Wildlife Research Unit

Scientists

Craig Paukert, Unit Leader; Jacob Westhoff, Assistant Unit Leader; Lisa Webb, Assistant Unit Leader; one vacancy

About the Unit

The Missouri Cooperative Fish and Wildlife Research Unit focuses on water-related conservation and management. The Unit has unique expertise in a wide range of aquatic science issues related to climate change and adaptation, aquatic organism passage, invasive species, and conservation priority planning, and studies a wide range of organisms, including freshwater fish, crayfish, and mussels. The Missouri Unit is different from other Units because all Unit scientists conduct research in aquatic ecosystems, allowing the Unit to develop many collaborative projects. The Unit scientists facilitate weekly Unit-wide laboratory discussions, and encourage students to think collaboratively and to consider themselves as part of a collective Missouri Unit rather than members of individual laboratories. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: population monitoring and advanced modeling, hunting and fishing, invasive species, Species of Greatest Conservation Need and threatened and endangered species, animal migration, and decision science and structured decision-making.

St. Francis River crayfish (*Faxonius quadruncus*). Photograph by Chris Lukhaup, Missouri Department of Conservation.

Research Projects

Developing Adaptation Strategies and Replacement Costs for Recreational and Tribal Fisheries

Recreational fisheries are popular in the upper Midwest, but there is concern that fish communities may be altered from climate change, resulting in recreational anglers leaving the fishery. Understanding how climate change may affect walleye (*Sander vitreus*) recruitment and how fishery managers can develop strategies for adapting to these changes is important to recreational fishers. The researchers plan to quantify the replacement cost of recreational angling in lakes in Wisconsin and identify approaches that help glacial lakes managers integrate climate adaptation into current fisheries management. The project is a collaboration of researchers across multiple agencies and includes the U.S. Geological Survey (USGS) Cooperative Research Units in Missouri, Minnesota, and Wisconsin (Fishery Unit), USGS Great Lakes Science Center, USGS Climate Adaptation Science Center, Wisconsin Department of Natural Resources, and the University of Minnesota. A model that predicts how walleye recruitment may change because of climate has been developed and is currently being implemented by the Wisconsin Department of Natural Resources (DNR). The model is also being incorporated into Wisconsin DNR databases to allow managers to view current and future conditions to inform decision-making on stocking and walleye management.

Distribution of Threatened Endemic Crayfishes of the St. Francis River Drainage, Missouri and Spread of the Invasive Woodland Crayfish

The St. Francis River crayfish (*Faxonius quadruncus*) and the Big Creek crayfish (*Faxonius peruncus*) were listed as federally threatened under the Endangered Species Act in 2023. Both species are stream-dwelling crayfish that only live in portions of the upper St. Francis River drainage in Missouri, and their primary threat is

displacement by the invasive woodland crayfish (*Faxonius hylas*). The researchers are sampling throughout the upper St. Francis River drainage to determine the current distribution of all three species. Using these data, the team is creating a species distribution model to predict the probability of species presence in unsampled stream segments. Intensive sampling of the leading edges of the invasion of the woodland crayfish to estimate their spread is also being conducted. Study results are anticipated to provide current and comprehensive distributional records for the invasive and two listed native crayfish, define the leading edges of the invasion in all known invaded streams, and produce more accurate estimates of invasion rates and native crayfish declines. These data may inform recovery planning and identify potential refuges where there are native crayfish populations and no invasive crayfish. This is a cooperative project among FWS, Missouri Department of Conservation, and the Missouri Unit.

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

Landscape management for waterfowl conservation depends on evaluating waterfowl responses to habitat conditions. Managing landscapes for waterfowl conservation combines determining how complex behavioral, environmental, and human-caused factors affect waterfowl populations. So-called agent-based models offer an approach that can simulate and evaluate the response of waterfowl populations to different conservation scenarios. The goal of this project is to develop a tool to model different amounts, configurations, and conditions of waterfowl management units under a range of differing management and predicted future environmental conditions. This tool may be used to test the suitability of alternative conservation allotments that sustain and promote mallard (*Anas platyrhynchos*) populations during the nonbreeding season.

Mallards (*Anas platyrhynchos*) in flight.

Photograph by Tom Koerner, U.S. Fish and Wildlife Service.

Technical Assistance

Craig Paukert is the coordinating lead author for an international team for a global assessment of the interlinkages among biodiversity, water, food, and health (Nexus assessment) for the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services.

Jacob Westhoff assisted State and Federal partners with data, advice, and review of Species Status Assessments for the Ozark shiner (*Notropis ozarcanus*), and the Statewide Strategic Mussel Conservation Plan, Statewide Strategic Crayfish Conservation Plan, and recovery planning for

Niangua darter (*Etheostoma nianguae*). Westoff also participated in a series of short videos produced and shared by FWS on crayfish conservation issues.

Lisa Webb contributed to an article "A million migrating birds expecting Kansas wetlands will find dust" that was published in Newsweek, November 2022 [https://www.new sweek.com/migrating-birds-affected-drying-wetlands-kansas-drought-1761001]. Webb also delivered an invited presentation titled, "Are wintering waterfowl distributions changing?" to the Waterfowl Webinar Series hosted by FWS Southeast Region Waterfowl Working Group in May 2023, with over 100 virtual attendees.

Selected Publications

Bouska, K.L., Healy, B.D., Moore, M.J., Dunn, C.G., Spurgeon, J.J., and Paukert, C.P., 2023, Diverse portfolios—Investing in tributaries for restoration of large river fishes in the Anthropocene: Frontiers in Environmental Science, v. 11, article 1151315, 18 p., accessed March 19, 2024, at https://doi.org/10.3389/fenvs.2023.1151315.

Huber, A.F., Fitzsimmons, W.A., and Westhoff, J.T., 2023, The smaller, the better? First evaluation of growth and mortality in crayfish internally tagged with p-Chips: Journal of Crustacean Biology, v. 43, no. 4, article ruad071, 10 p., accessed March 13, 2024, at https://doi.org/10.1093/jcbiol/ruad071.

Malone, K.M., Webb, E.B., Mengel, D.C., Kearns, L.J., McKellar, A.E., Matteson, S.W., and Williams, B.R., 2023, Wetland management practices and secretive marsh bird habitat in the Mississippi Flyway—A review: Journal of Wildlife Management, v. 87, no. 7, article e22451, 20 p., accessed March 14, 2024, at https://doi.org/10.1002/jwmg.22451.

Sievert, N., Paukert, C. Whittier, J., Daniel, W., Infante, D., and Stewart, J., 2022, Projected stream fish community risk to climate impacts in the Northeastern and Midwestern United States: Ecological Indicators, v. 144, article 109493, 15 p., accessed March 13, 2024, at https://doi.org/10.1016/j.ecolind.2022.109493.

Weller, F.G., Beatty, W.S., Webb, E.B., Kesler, D.C., Krementz, D.G., Asante, K., and Naylor, L.W., 2022, Environmental drivers of autumn migration departure decisions in midcontinental mallards: Movement Ecology v. 10, article 1, 13 p., accessed March 14, 2024, at https://doi.org/10.1186/s40462-021-00299-x.

Westhoff, J.T., Abdelrahman, H.A., and Stoeckel, J.A., 2023, Upper thermal tolerances of two native and one invasive crayfish in Missouri, USA: Freshwater Crayfish, v. 28, no. 1, p. 27–36, accessed March 13, 2024, at https://doi.org/10.5869/fc.2023.v28-1.27.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Missouri–Columbia, and Missouri Department of Conservation.
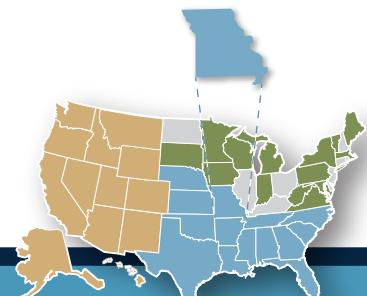
Nebraska
Cooperative Fish and Wildlife Research Unit

Scientists

Kevin Pope, Unit Leader; Jonathan Spurgeon, Assistant Unit Leader; Sarah Sonsthagen, Assistant Unit Leader

About the Unit

The Nebraska Cooperative Fish and Wildlife Research Unit is committed to interdisciplinary and cross-boundary teamwork in support of the North American Model of Wildlife Conservation. The Nebraska Unit scientists interact almost daily in team settings with their cooperators while developing future natural resource managers and researchers, conducting innovative research, and transferring novel science practices. The relationships and mutual trust among cooperators enables an environment where research, teaching, and technical service provided by the Nebraska Unit contribute to conservation and management of natural resources across the State and region. The Unit scientists also collaborate with partners to help meet the Unit's mission. Although scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: outreach and habitat protection, Species of Greatest Conservation Need and threatened and endangered species, population monitoring and advanced modeling, and advanced technologies.

Two anglers fishing on the bank of a river. Photograph by Sam Stukel, U.S. Fish and Wildlife Service.

Research Projects

### Wetlands of Nebraska: An Outreach and Education Project

Outreach and education materials relating to Nebraska's wetland resources may support the public, schools, conservation partners, and community organizations. Informing people about Nebraska's wetland resources and the important ecosystem services that they provide may help to develop and refine Nebraska's wetland resource programs. This project is a collaboration of researchers across multiple organizations and includes the U.S. Geological Survey, Nebraska Game and Parks Commission, University of Nebraska–Lincoln, and the Platte Basin Timelapse Project. The project objective is to produce and distribute a series of integrated outreach and education products to increase awareness of wetlands in Nebraska, and to develop an understanding of wetland conservation across many audiences. These products provide up-to-date information about Nebraska's wetlands, align with the Nebraska statewide education standards, and deliver information in a format that is understandable and approachable to current audiences.

Multi-Scale Habitat Needs of At-Risk Fishes in Nebraska

The distribution and abundance of prairie-river fishes is maintained through processes that occur over multiple scales and embedded within a habitat matrix. Degradation of the habitat matrix in rivers, however, can limit recruitment and movement of fish, and may lengthen the time needed for recolonization or permanently reduce fish distribution and abundance. A knowledge gap remains in defining habitat features at different spatial scales that may help populations of Species of Greatest Conservation Concern stabilize and recover. Our current study is testing the relative influences of stream reach, segment, and basin-scale variables on native fishes throughout the Nebraska Sandhills. This study is also assessing potential fish habitat relations by identifying locations most likely to contain species of interest. This research is being conducted with support from and in collaboration with the Nebraska Game and Parks Commission. This study will provide data to the Nebraska Conservation and Environmental Review Tool, which is commonly used to review proposed projects and the potential effects these projects might have within areas that contain at-risk species.

Gray-headed chickadee (*Poecile cinctus*). Photograph by Aaron Lang, U.S. Fish and Wildlife Service.
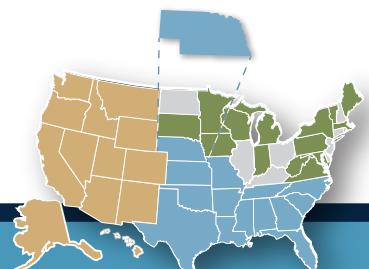
Investigating Hybridization Between the Declining Gray-Headed Chickadee and a Recent Colonizer, the Boreal Chickadee

Gray-headed chickadees (*Poecile cinctus*) were historically common in Alaska and northwestern Canada, and in recent years, populations have gone extinct locally or are in decline, and have been replaced with boreal chickadees (*Poecile hudsonicus*). There is not enough information to identify threats to gray-headed chickadees in North America with confidence. Two mechanisms are thought to be playing a role in the decline of gray headed chickadees: interspecific competition and loss of genetic traits through hybridization with boreal chickadees. This project is a collaboration across multiple agencies, including the U.S. Fish and Wildlife Service, Alaska Department of Fish and Game, U.S. National Park Service, and Canadian Wildlife Service. Understanding what role, if any, hybridization has on the decline of the gray-headed chickadee may help inform the prioritization of conservation recovery actions.

Technical Assistance

Kevin Pope and Jonathan Spurgeon participated in the University of Nebraska's East Campus Discovery Days, which provided an opportunity to talk to members of the public about ongoing activities within the Unit.

Sarah Sonsthagen offered experiential learning opportunities for undergraduate students in conservation genomics by providing technical assistance to multiple partner agencies studying migration patterns and seasonal or periodic life-cycle events (phenology) of shorebirds. Because assigning the sex of many shorebird species by plumage or other characters is not always possible, students determined the sex of individual birds through molecular approaches, providing information to partners while gaining fundamental experience in methods and the scientific process.

Selected Publications

Bouska, K.L., Healy, B.D., Moore, M.J., Dunn, C.G., Spurgeon, J.J., and Paukert, C.P., 2023, Diverse portfolios—Investing in tributaries for restoration of large river fishes in the Anthropocene: Frontiers in Environmental Science, v. 11, article 1151315, 18 p., accessed March 19, 2024, at https://doi.org/10.3389/fenvs.2023.1151315.

Franz, M., Whyte, L., Atwood, T.C., Menning, D., Sonsthagen, S.A., Talbot, S.L., Laidre, K.L., Gonzalez, E., and McKinney, M.A., 2023, Fecal DNA metabarcoding shows credible short-term prey detections and explains variation in the gut microbiome of two polar bear subpopulations: Marine Ecology Progress Series, v. 704, p. 131–147, accessed March 14, 2024, at https://doi.org/10.3354/meps14228.

Kane, D.S., Pope, K.L., Koupal, K.D., Pegg, M.A., Chizinski, C.J., and Kaemingk, M.A., 2023, Waterbody size predicts bank-and boat-angler efforts: Fisheries Research, v. 267, article 106801, 5 p., accessed March 14, 2024, at https://doi.org/10.1016/j.fishres.2023.106801.

Melstrom, R.T., Kaemingk, M.A., Cole, N.W., Whitehead, J.C., Chizinski, C.J., and Pope, K.L., 2023, Valuing angling on reservoirs using benefit transfer: North American Journal of Fisheries Management, v. 43, no. 2, p. 400–416, accessed March 14, 2024, at https://doi.org/10.1002/nafm.10802.

Spurgeon, J., Kaiser, J., Graham, C., and Lochmann, S., 2022, Trout responses to stocking rates and river discharge within a southeast U.S. hydropeaking tailwater: North American Journal of Fisheries Management, v. 42, no. 4, p. 926–938, accessed March 14, 2024, at https://doi.org/10.1002/nafm.10779.

Wilson, R.E., Sonsthagen, S.A., DaCosta, J.M., Sorenson, M.D., Fox, A.D., Weaver, M., Skalos, D., Kondratyev, A.V., Scribner, K.T., Walsh, A., Ely, C.R., and Talbot, S.L., 2022, As the goose flies—Migration routes and timing influence patterns of genetic diversity in a circumpolar migratory herbivore: Diversity, v. 14, no. 12, article 1067, 23 p., accessed March 14, 2024, at https://doi.org/10.3390/d14121067.

Lone angler at sunset. Photograph by Krista Lundgren, U.S. Fish and Wildlife Service.

Graduate Student Spotlight

Kyle Hansen, Master of Science, Natural Resource Sciences, University of Nebraska–Lincoln

Thesis title: "Understanding avidities of recreational activities for people possessing fishing licenses and residing in urban environments."

Kyle is currently enrolled in the Nebraska Law Enforcement Academy and will soon be employed by the Nebraska Game and Parks Commission as a Conservation Officer.

Graduate Student Spotlight

Joseph Spooner, Master of Science in Natural Resource Science, School of Natural Resouces, University of Nebraska–Lincoln

Thesis title: "Population demography of a glacial-relict stream fish mediated via anthropogenic alteration."

Joe is currently a fisheries biologist with the Nebraska Game and Parks Commission, where his work is focused on monitoring stream fish of greatest conservation need across the State.
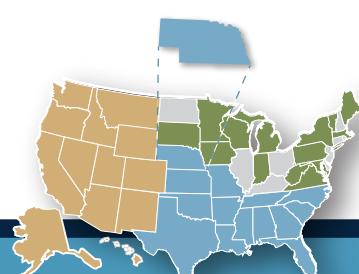
> "The Nebraska Cooperative Fish and Wildlife Research Unit has served as a catalyst for growth in our School of Natural Resources in the last two decades. Beyond their impactful research and graduate training, the Unit scientists have a tradition of collaboration and engagement that directly benefits their colleagues within the School."
>
> —Larkin Powell, Director of the School of Natural Resources, University of Nebraska–Lincoln

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Nebraska–Lincoln, and Nebraska Game and Parks Commission.

Scientists

Corey Dunn, Unit Leader; Jaime A. Collazo, Assistant Unit Leader; Nathan J. Hostetter, Assistant Unit Leader; one vacancy

About the Unit

The North Carolina Cooperative Fish and Wildlife Research Unit is a leader in developing geospatial approaches for advancing landscape-scale conservation and management. Research at the North Carolina Unit spans a variety of taxa and ecosystems, including marine and freshwater fishes, harvested wildlife species, and nongame species of conservation concern. Unit scientists support cooperators by providing tools and science with tangible results. The Unit is home to the national Gap Analysis Program [https://www.usgs.gov/programs/gap-analysis-project] and is in a partnership with the U.S. Geological Survey Southeast Climate Adaptation Science Center (SE CASC) in North Carolina and Puerto Rico. Unit scientists assist with developing analyses to support U.S. Fish and Wildlife Service (FWS) Species Status Assessments (SSAs) for southeastern species. The Unit also addresses methodological development and research on climate adaptation in temperate and tropical environments, primarily in the United States Caribbean. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: Species of Greatest Conservation Need and threatened and endangered species; decision science and structured decision-making; advanced technologies; water allocation, drought, and ecological flows; population monitoring and advanced modeling; climate adaptation; hunting and fishing; human dimensions; and urban ecology.

Canada lynx (*Lynx canadensis*). Photograph by Lisa Hupp, U.S. Fish and Wildlife Service.

Research Projects

Using a Bayesian Belief Network to Structure Species Status Assessments of Data-Deficient Species: A Case Study with Piebald Madtom

The southeastern United States supports hundreds of freshwater mussels, fishes, and crayfishes, but many are at risk of imperilment because of rarity, limited distributions, and declining populations. Currently, there is no standardized quantitative framework for evaluating imperilment of certain southeastern freshwater fishes. Therefore, researchers are using the piebald madtom (*Noturus gladiator*) as a case study for implementing a SSA using a Bayesian belief network and elicitation techniques from experts with FWS, Tennessee Wildlife Resources Agency; Mississippi Department of Wildlife, Fisheries, and Parks; U.S. Army Corps of Engineers; Mississippi State University; University of Tennessee at Martin; and Austin Peay State University. This research is helping to predict current and future conditions of piebald madtom for this SSA to help inform conservation measures under the Endangered Species Act.

Advancing Climate-Change Adaptation Strategies for High-Elevation and Endangered Lowland Amphibian Species in the United States Caribbean

Coquí frogs (*Eleutherodactylus coqui*) are represented by 17 species in the genus *Eleutherodactylus* in Puerto Rico, and are threatened by extreme heat and drying, and coastal saltwater intrusion. Recent investigations have determined how global climate change may affect the local climate of the United States Caribbean, and how sensitive coquí species are to local climate and habitat conditions. This research

has two main two objectives: (1) measuring key microclimate variables along multiple habitat and climate gradients to identify habitats that are resilient to climate change for at-risk and endangered amphibian species; and (2) expanding previous work to distinguish between the interactive effects of moisture and temperature on occurrence and abundance of coquí species. Results from this study include an islandwide evaluation of potential refuge sites for

Rock frog (*Eleutherodactylus cooki*) from Puerto Rico. Photograph by Alberto Puente, U.S. Fish and Wildlife Service.

temperature- and moisture-sensitive *Eleutherodactylus* species, and criteria for decision-makers to determine when and where to engage in either in-place management or to manage translocations of amphibian species in the face of climate change.

White-tailed Deer Ecology Across an Urban–Rural Continuum

Urban and suburban areas continue to spread into previously rural areas, increasing the need to understand deer ecology and assess the cultural effects of white-tailed deer (*Odocoileus virginianus*) and white-tailed deer hunting across the urban–rural continuum. The North Carolina Wildlife Resources Commission (NCWRC) is faced with an increased number of interactions between humans and deer in areas of high human or white-tailed deer density, and these interactions often have negative outcomes, such as vehicle collisions. There is limited understanding across this continuum of public perceptions and desires of white-tailed deer and white-tailed deer hunting, along with little data on deer movements, density, recruitment, survival, causes of mortality, or how hunting (the primary herd management tool) affects deer populations. Additionally, harvest and survey trends used to monitor herds across county or management zones are confounded by unknown hunter effort and success in these expanding urban and suburban areas. This project aims to increase the understanding of spatial and temporal variation in white-tailed deer ecology across an urban–rural continuum in North Carolina and how harvest regulations affect white-tailed deer herds across these landscapes. Results are available to help evaluate current NCWRC programs (Urban Archery Season, Community Deer Management Assistance Program, depredation permits) and adjust or create new programs. Information may also be used to provide technical guidance to municipalities, landowners, and hunters. Results may be applicable to areas across North Carolina and may have implications for other urban–rural areas across the State and country.

Technical Assistance

Corey Dunn led annual monitoring to evaluate success of a reintroduced population of Yoknapatawpha darter (*Etheostoma faulkneri*) in Mississippi. The multiagency and organization team that performed this evaluation was awarded the FWS Southeast Region Regional Director's Honor Award for At-Risk Species Conservation. Dunn was invited by FWS to serve as technical expert during a two-day workshop on implementing a SSA for southeastern species.

Jaime Collazo participated in a SE CASC workshop sponsored by FWS in the United States Caribbean, and assisted SE CASC in developing a project to increase professional capacity to research climate adaptation challenges in Puerto Rico.

Nathan Hostetter coordinated with over 100 private landowners in North Carolina to expand research activities into suburban and urban landscapes, including research on black bear (*Ursus americanus*) abundance, and white-tailed deer survival, movement, and abundance. In collaboration with the FWS and U.S. Department of Agriculture Forest Service, Hostetter also analyzed, summarized, and updated Canada lynx (*Lynx canadensis*) occupancy models for the FWS Canada lynx SSA revision process.

Selected Publications

Besson, J.C., Neary, J.J., Stafford, J.D., Dunn, C.G., and Miranda, L.E., 2023, Fish functional gradients along a reservoir cascade: Freshwater Biology, v. 68, no. 6, p. 1079–1091, accessed March 14, 2024, at https://doi.org/10.1111/fwb.14087.

Bouska, K.L., Healy, B.D., Moore, M.J., Dunn, C.G., Spurgeon, J.J., and Paukert, C.P., 2023, Diverse portfolios—Investing in tributaries for restoration of large river fishes in the Anthropocene: Frontiers in Environmental Science, v. 11, article 1151315, 18 p., accessed March 19, 2024, at https://doi.org/10.3389/fenvs.2023.1151315.

Hostetter, N.J., Evans, A.F., Payton, Q., Roby, D.D., Lyons, D.E., and Collis, K., 2023, A review of factors affecting the susceptibility of juvenile salmonids to avian predation: North American Journal of Fisheries Management, v. 43, no. 1, p. 244–256, accessed March 14, 2024, at https://doi.org/10.1002/nafm.10862.

Rivera, D., Zegarra, J.P., Figuerola-Hernández, C.E., Herrera-Giraldo, J.-L., Arocho-Hernández, N., Hostetter, N.J., Collazo, J.A., and Bell, R.C., 2023, Contemporary record and photographs of the rarely seen and poorly known Mona blindsnake, *Antillotyphlops monensis* (Schmidt, 1926), with comments on its ecology and conservation: Herpetology Notes, v. 16, p. 915–918, accessed March 14, 2024, https://www.biotaxa.org/hn/article/view/82175.

Ruzi, S.A., Youngsteadt, E., Cherveny, A., Kettenbach, J., Levenson, H.K., Carley, D.S., Collazo, J.A., and Irwin, R.E, 2023, Bee species richness through time in an urbanizing landscape of the southeastern USA: Global Change Biology, v. 30, no. 1, article e17060, 18 p., accessed March 14, 2024, at https://doi.org/10.1111/gcb.17060.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, North Carolina State University, and North Carolina Wildlife Resources Commission.
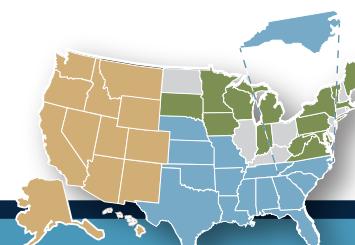
Scientists

Jim Long, Unit Leader; Robert Lonsinger, Assistant Unit Leader; one vacancy

About the Unit

The Oklahoma Cooperative Fish and Wildlife Research Unit celebrated its 75th anniversary in October 2022, highlighting the Unit's long-standing relationships with the Unit cooperators. Oklahoma's diverse landscape increases the scope and relevance of projects conducted by Unit scientists and cooperators. The Unit's research is problem-oriented and designed to provide cooperators with actionable science on contemporary natural resource issues. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: Species of Greatest Conservation Need and threatened and endangered species, advanced technologies, and population monitoring and advanced modeling.

Research Projects

Quantifying Freshwater Mussel Abundance and Composition in Two Prairie Rivers of Northern Oklahoma with the Aid of Side-Scan Sonar to Identify Novel Habitat Patches

Prairie rivers of northern Oklahoma, such as the Verdigris and Caney Rivers, harbor a diverse assemblage of freshwater mussels, but drivers of mussel abundance and composition are not well known. Previous research has focused on proportional abundance using timed searches, which do not give much information about temporal trends in mussel populations. Moreover, recent studies have documented increases in rare species, suggesting some species may be more prevalent than previously documented or are locally abundant. This project partners with biologists from the Oklahoma Department of Wildlife Conservation and U.S. Fish and Wildlife Service to identify freshwater mussel habitats within the Verdigris and Caney Rivers of northern Oklahoma. Mussels are then quantitatively sampled to estimate density and community composition in these habitats. Calculation of detection and occupancy estimates among habitat types can aid in the development of future monitoring efforts.

Factors Influencing Detection and Occurrence of Plains Spotted Skunks in Oklahoma

Spotted skunks (*Spilogale* spp.) were historically widespread across much of North America, but long-term harvest trends and anecdotal evidence suggested notable population declines, leading to a petition to list the plains spotted skunk (*S. interrupta*) under the Endangered Species Act. Although the plains spotted skunk was determined to be "not warranted" for protection, information regarding the distribution and ecology of plains spotted skunk is lacking across much of its distribution. The plains spotted skunk is difficult to monitor because it is rare and elusive. Trail cameras have become the predominant monitoring approach for spotted skunks, but low detection rates have limited the success of monitoring programs. Consequently, evaluating factors influencing camera-based detections may help to improve monitoring and generate robust population assessments. This

project engages collaborators from the Oklahoma Department of Wildlife Conservation, Oklahoma State University, and the U.S. Department of Agriculture Forest Service. The project designed a robust study to assess camera-based sampling strategies for the plains spotted skunk and determine factors influencing spotted skunk occurrence. By addressing both detection and occurrence, this project may help to inform future monitoring strategies and management actions for the elusive plains spotted skunk.

Spotted skunk (*Spilogale* spp.). Photograph by U.S. Geological Survey.

Technical Assistance

Jim Long organized the Unit's 75th anniversary celebration with a gathering of over 100 attendees, including alumni spanning 50 years. A collection of photos and links to articles celebrating the Unit's history is available at https://www.kudoboard.com/boards/9HKUdRRS#view.

Robert Lonsinger conducted a week-long workshop "Occupancy Modeling for Fisheries and Wildlife Management," which explored the role of occupancy modeling for natural resource management and provided practitioners with the knowledge, skills, and ability to design occupancy-based studies, analyze occupancy data, and interpret study results. The workshop included biologists from State and Federal agencies and graduate students from four universities.

Lonsinger also served as a subject-matter expert to assist in the planning and implementation of a prairie dog (*Cynomys* spp.) trapping and translocation event to move prairie dogs from the City of Lawton onto the Wichita Mountains Wildlife Refuge. In this capacity, Lonsinger assisted with capture approaches, methods for handling and transport, and acclimation and release strategies.

Threehorn wartyback (*Obliquaria reflexa*) mussels (center and right), and pimpleback (*Quadrula pustulosa*) mussel (left). Photograph by Hunter Torolski, Oklahoma State University.

Selected Publications

Dart, M.M., Perkins, L.B., Jenks, J.A., Hatfield, G., and Lonsinger, R.C., 2023, The effect of scent lures on detection is not equitable among sympatric species: Wildlife Research, v. 50, no. 3, p. 190–200, accessed March 14, 2024, at https://doi.org/10.1071/wr22094.

Long, J.M., Snow, R.A., Shoup, D.E., and Bartnicki, J.B., 2023, Validation and comparison of age estimates for smallmouth buffalo (*Ictiobus bubalus*) in Oklahoma based on otoliths, pectoral fin rays, and opercula: North American Journal of Fisheries Management, v. 43, no. 3, p. 618–627, accessed March 14, 2024, at https://doi.org/10.1002/nafm.10865.

Lonsinger, R.C., Dart, M.M., Larsen, R.T., and Knight, R.N., 2023, Efficacy of machine learning image classification for automated occupancy-based monitoring: Remote Sensing in Ecology and Conservation, v. 10, no. 1, p. 56–71, accessed March 14, 2024, at https://doi.org/10.1002/rse2.356.

Wolfenkoehler, W., Long, J.M., Gary, R., Snow, R.A., Schooley, J.D., Bruckerhoff, L.A., and Lonsinger, R.C., 2023, Viability of side-scan sonar to enumerate paddlefish, a large pelagic freshwater fish, in rivers and reservoirs: Fisheries Research, v. 261, article 106639, 9 p., accessed March 14, 2024, at https://doi.org/10.1016/j.fishres.2023.106639.

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"The Oklahoma Cooperative Fish and Wildlife Research Unit is a long-trusted research partner of the Oklahoma Department of Wildlife Conservation. Through dozens of Federal grant program partnerships, the Oklahoma Unit provides robust scientific expertise, ecological knowledge, and the dedicated human capital essential to addressing research needs for the benefit of conservation action delivery to Oklahoma's passionate outdoor enthusiasts. We rely on this critical partnership to answer difficult questions which guide our fish and wildlife management and conservation, and to help foster stewardship with those who care for natural resources."

—Wade Free, Interim Director, Oklahoma Department of Wildlife Conservation.
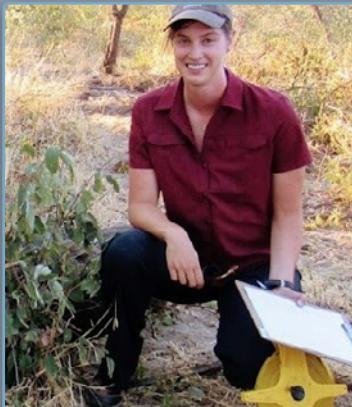
Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Oklahoma State University, and Oklahoma Department of Wildlife Conservation.
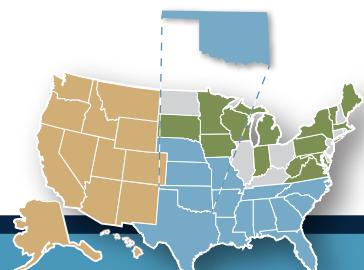
Scientists

Patrick Jodice, Unit Leader; Erin Buchholtz, Assistant Unit Leader; Luke Bower, Assistant Unit Leader

About the Unit

The South Carolina Cooperative Fish and Wildlife Research Unit is engaged in science and conservation efforts in terrestrial, freshwater, and marine systems that extend from studies of fine-scale life processes to large-scale movement ecology. The research is conducted on local to international scales, and the species studied include fish, seabirds, mammals, and herpetofauna. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: Species of Greatest Conservation Need and threatened and endangered species; invasive species; and water allocation, drought, and ecological flows.

Research Projects

An Atlas and Registry for Seabird Colonies and Associated Habitats in the Northern Gulf of America [Mexico]

The northern Gulf of America [Mexico] supports a diverse community of nearshore seabirds and waterbirds that breed in colonies of different sizes. Although returning to the same nest site is common, the dynamic nature of the coastal zone in the northern Gulf can result in shifts in the locations of bird colonies and in the existence, size, or stability of the islands or habitats that support them. There is a stakeholder network responsible for management of these species and their breeding habitat that includes natural resource agencies in Alabama, Florida, Louisiana, Mississippi, Texas, multiple Federal agencies, and numerous private organizations. To date, there is no single place where data on the size, composition, occupancy, and status of these bird colonies for monitoring purposes or to respond to a critical need can be accessed. In order for these data to be accessible to stakeholders, an "Atlas" Team is being created by the Gulf Coast Joint Venture's Bird Nesting Island Cooperative, with stakeholders from each Gulf State and regional nongovernmental organizations also participating in the team. The Atlas Team supports bird inventory, monitoring, management, disaster response, and research. The Atlas itself and associated bird colony register are assisting with marine spatial planning decisions, including siting wind turbines, scheduling and siting sand-dredging and beach nourishment operations, managing recreation and access, and land and marine conservation planning.

Brown pelican (*Pelecanus occidentalis*) and royal terns (*Thalasseus maximus*), Breton National Wildlife Refuge, Louisiana. Photograph by Greg Thompson U.S. Fish and Wildlife Service.

Wild Pig Spatial Ecology in Mixed-Use Landscapes of South Carolina

The wild pig (*Sus scrofa*) is an invasive species found across North America, and as wild pig populations increase, so does the damage these animals cause to natural, agricultural, and developed landscapes. South Carolina has seen a recent and dramatic increase in the distribution and abundance of wild pigs; however, it is unclear how wild pigs use mixed-use landscapes in the upstate region. A habitat-use model is being developed to investigate how wild pigs are moving through the landscape and using different areas in upstate South Carolina. This project is a collaboration that includes Clemson University and the Clemson University Experimental Forest, the South Carolina Unit, the South Carolina Department of Natural Resources, and a team of undergraduate and graduate students with the Creative Inquiry program at Clemson University. The model integrates wild pig global positioning system tracking and demographic data with environmental and habitat data. The results may inform management actions for targeted wild pig mitigation in this region of South Carolina.

Wild pigs (*Sus scrofa*). Photograph by Steve Hillebrand, U.S. Fish and Wildlife Service.

Using Flow-Ecology Relationships to Inform State Water Planning in South Carolina

The need for appropriation of water resources is continually increasing with the rapidly growing human population in South Carolina. Protecting instream flows for ecosystem services may be one of society's greatest challenges this century. South Carolina is a water-rich State that faces unique challenges and opportunities as demand for water increases. Protecting instream flow from human alterations and maintaining ecosystem services of water resources requires an understanding of the relationship between aquatic organisms and instream flow. Accordingly, the goals of this project are to identify key relationships between flow metrics and biotic response (flow-ecology relationships) in the State's eight major river basins, and to use these relationships to predict the response of aquatic organisms to changes in streamflow and water withdrawals. Results may then inform river basin planning across the State. The research team is providing technical assistance to, and works in cooperation with, Clemson University, South Carolina Department of Natural Resources, River Basin Councils, the River Basin Council Facilitator, and the River Basin Council Surface Water Technical Support Contractor. The flow-ecology relationships identified by this project are informing river basin planning processes.

Technical Assistance

Luke Bower serves as a technical advisor for the River Basin Councils in South Carolina to place water modeling results into a biological context, thereby informing State water planning.

Selected Publications

Bower, L.M., Stoczynski, L., Peoples, B.K., Patrick, C.J., and Brown, B.L., 2023, Multiple dimensions of functional diversity affect stream fish taxonomic β-diversity: Freshwater Biology, v. 68, no. 3, p. 437–451, accessed March 18, 2024, at https://doi.org/10.1111/fwb.14036.

Buchholtz, E.K., Kreitler, J., Shinneman, D.J., Crist, M., and Heinrichs, J., 2023, Assessing large landscape patterns of potential fire connectivity using circuit methods: Landscape Ecology, v. 38, p. 1663–1676, accessed March 14, 2024, at https://doi.org/10.1007/s10980-022-01581-y.

Buchholtz, E.K., O'Donnell, M.S., Heinrichs, J.A., and Aldridge, C.L., 2023, Temporal patterns of structural sagebrush connectivity from 1985 to 2020: Land, v. 12, no. 6, article 1176, 13 p., accessed March 14, 2024, at https://doi.org/10.3390/land12061176.

Jodice, P.G.R., Lamb, J.S., Satgé, Y.G., and Perkins, C., 2023, Spatial and individual factors mediate the tissue burden of polycyclic aromatic hydrocarbons in adult and chick brown pelicans in the northern Gulf of Mexico: Frontiers in Ecology and Evolution, v. 11, article 1185659, 18 p., accessed March 14, 2024, at https://doi.org/10.3389/fevo.2023.1185659.

Satgé, Y.G., Keitt, B.S., Gaskin, C.P., Patteson, B.J., and Jodice, P.G.R., 2023, Spatial segregation between phenotypes of the diablotin black-capped petrel *Pterodroma hasitata* during the non-breeding period: Endangered Species Research, v. 51, p. 183–201, accessed March 14, 2024, at https://doi.org/10.3354/esr01254.

Winemiller, K.O., Andrade, M.C., Arantes, C.C., Bokhutlo, T., Bower, L.M., Cunha, E.R., Keppler, F.W., Lopez-Delgado, E.O., Quintana, Y., Saenz, D.E., Mayes, K.B., and Robertson, C.R., 2023, Can spatial food web subsidies associated with river hydrology and lateral connectivity be detected using stable isotopes?: Food Webs, v. 34, article e00264, 18 p., accessed March 15, 2024, at https://doi.org/10.1016/j.fooweb.2022.e00264.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Clemson University, and South Carolina Department of Natural Resources.
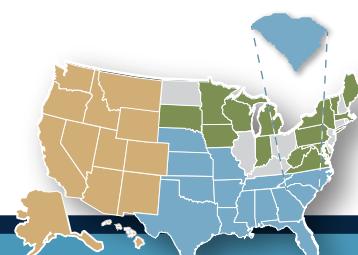
Tennessee
Cooperative Fishery Research Unit

Scientists

Mark Rogers, Unit Leader; Amanda Rosenberger, Assistant Unit Leader


About the Unit

The Tennessee Cooperative Fishery Research Unit is located in central Tennessee, an aquatic biodiversity hotspot of North America. For over 50 years, the Unit has cooperated with State, Federal, and other partners to conduct science and education that contributes to the management and conservation of Tennessee's aquatic resources. The Unit is situated on a rural college campus, and any other resources that may be needed are easily accessed. Unit scientists work closely with State and Federal agencies in the region. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: invasive species; Species of Greatest Conservation Need and threatened and endangered species; decision science and structured decision-making; and water allocation, drought, and ecological flows.

Research Projects

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

Invasive species create risks to ecological communities. In 2018, walking catfish (*Clarias batrachus*) were discovered in Puerto Rico as a new invasive species. This project is using environmental deoxyribonucleic acid (eDNA) to sample streams and help inform where physical removal efforts of this invasive species could best be allocated. The research team is working with the U.S. Fish and Wildlife Service (FWS) and the University of Puerto Rico to identify removal and monitoring locations. The outcome of the project may help to inform control needs for an invasive species in Puerto Rico.
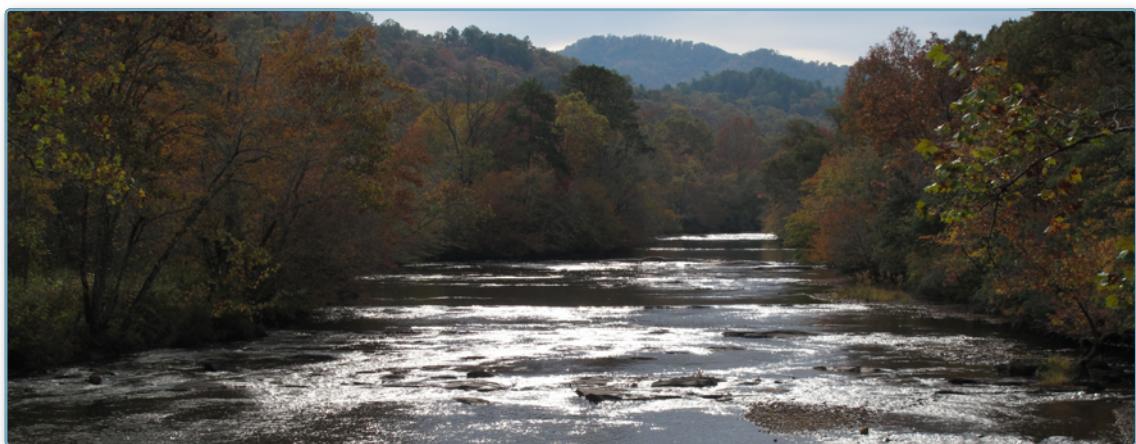
Little Tennessee River, Tennessee. Photograph by U.S Fish and Wildlife Service.

A Comprehensive Understanding of Mussel Populations in the Duck River, Tennessee, for Conservation and to Establish Ecological Flows for Ongoing Water Withdrawals and Water Management

The Duck River in Tennessee has a high species biodiversity, with 151 species of fishes, 60 mussel species, and 22 snail species, and many are federally listed as threatened or endangered. The river provides drinking water for about 250,000 people but faces increasing pressure as Nashville grows. Water withdrawals strain supplies during summer and drought, and supplies are projected to worsen. Multiple agencies regulate the Duck River and require transparent, evidence-based planning to ensure sufficient clean water supplies despite development and climate change. This project aims to identify how Duck River instream flows affect freshwater mussel habitat. Agencies may incorporate results to help model consequences of proposed water withdrawals using an adaptable, decision-support framework that can expand into a comprehensive assessment tool for environmental flows. The research team is collecting data on physical habitat and ecological conditions that are anticipated to change with flows to better understand these effects on mussel populations. These data can help in an assessment approach to balancing water withdrawals with species protection. The project also plans to consider traditionally underserved, rural communities that are adversely affected by drought, examine biotic and human resilience to water scarcity, and promote stewardship of local natural resources that provide essential ecosystem services. The project is funded by FWS, the Tennessee Wildlife Resources Agency, and The Nature Conservancy.
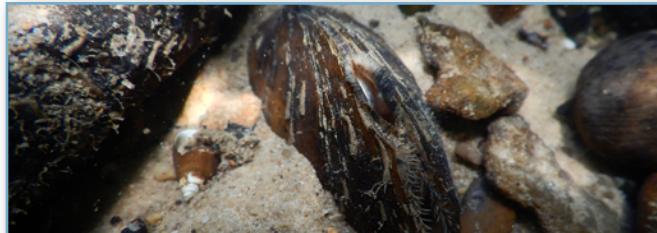
Unionid mussel (Unionidae). Photograph by Jack Fetters, Tennessee Tech University.

Technical Assistance

Mark Rogers was invited by Tennessee Wildlife Resources Agency to assist with outreach at their information booth at the Bassmaster Classic, and is a member of the Tennessee-Cumberland Rivers Data Analysis Working Group on invasive carps.

Amanda Rosenberger and one of the Unit graduate students, Katelynn Sallack, participated in the Library Speaker Series in Columbia, Tennessee, to talk about freshwater mussel ecology and conservation. Their presentation was titled "Freshwater Mussels of the Duck River: Why the Fuss?"

and Sallack showed participants shells of different mussel species and shared information about identification, status, and ecology of mussels.

Selected Publications

Hartman, J.N., Rosenberger, A.E., Key, K.N., and Lindner, G., 2023, Assessing potential habitat for freshwater mussels by transferring a habitat suitability model within the Ozark Ecoregion, Missouri: Freshwater Mollusk Biology and Conservation, v. 26, no. 1, p. 32–44, accessed March 18, 2024, at https://doi.org/10.31931/fmbc-d-21-00005.

Roberts, A.D., Besser, J., Hundley, J., Mosby, D.E., Rosenberger, A., Bouska, K.L., Simmons, B.R., McMurray, S.E., Faiman, S., and Lueckenhoff, L., 2023, An assessment of the relation between metal contaminated sediment and freshwater mussel populations in the Big River, Missouri: Science of the Total Environment, v. 876, article 162743, 15 p. accessed March 18, 2024, at https://doi.org/10.1016/j.scitotenv.2023.162743.

Graduate Student Spotlight

Jack Fetters, Master of Science in Biology, Tennessee Tech University

Thesis title: "Mussels of the Wolf River, Tennessee: A resurvey of Unionids in an inundated Cumberland tributary."

Jack works as a Conservation Biologist with the Xerces Society, an international nonprofit focused on invertebrate conservation through programs on pollinators, endangered species, and pesticide effects. He specializes in freshwater mussel conservation.

"The Tennessee Cooperative Fishery Research Unit continues to be the research branch for the Tennessee Wildlife Resources Agency."

—Mark Thurman, Chief of Fisheries, Tennessee Wildlife Resources Agency

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Tennessee Tech University, and Tennessee Wildlife Resources Agency.
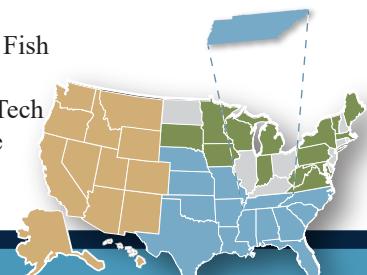
Scientists

Reynaldo Patino, Unit Leader; Jane Rogosch, Assistant Unit Leader; Clint Boal, Assistant Unit Leader

About the Unit

The Texas Cooperative Fish and Wildlife Research Unit works closely with cooperators, specifically with university faculty members, agency managers, and biologists. These relationships make for strong research collaborations. The Unit addresses terrestrial and aquatic natural resource information needs in what is the second-largest and one of the most ecologically diverse States in the nation. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow the theme of Species of Greatest Conservation Need and threatened and endangered species.

Research Projects

Assessing Texas Kangaroo Rat Habitat Connectivity, Management, and Monitoring Protocols

The Texas kangaroo rat (*Dipodomys elator*) is a rare species that is endemic to the Central Great Plains and Southwest Tablelands ecoregions in north-central Texas. Because of substantial reduction in distribution and suspected population declines, this species has been petitioned for Federal protection under the Endangered Species Act, and is ranked as a G2—imperiled (NatureServe Globally Ranked Species Richness) and a S1—critically imperiled (State ranking) species. This research addresses three important steps in the effort to conserve the Texas kangaroo rat. The team plans to conduct experimental vegetation manipulations

to determine feasibility and effectiveness of restoring, enhancing, or creating usable habitat for Texas kangaroo rats. Movement patterns and dispersal of Texas kangaroo rats are being assessed, especially whether or not individuals move into restored areas from nearby occupied areas. Connectivity and environmental resistance to dispersal of Texas kangaroo rats within and among the known occupied clusters is being modeled, which may help with targeted application of habitat restoration or creation. Other objectives are to identify landowners who will allow access and habitat manipulations for this study, and to monitor movements of tagged animals to assess their response to habitat restoration efforts. The researchers are evaluating use of passive integrated transponder tags for tracking movements of kangaroo rats rather than much heavier and larger radio collars.

Texas kangaroo rat (*Dipodomys elator*). Photograph by Tritia Matsuda, U.S. Geological Survey.

Food Habits of Species of Greatest Conservation Need Fishes to Inform Habitat Assessment and Restoration in the Red River Basin

The ecology of many prairie-stream fishes is not well understood, despite the knowledge that these fishes are negatively affected by stream flow alterations, habitat degradation and fragmentation, and invasive species. River flow regulation and riverside habitat that has been degraded due to increasing salt levels and invasive species may diminish the diverse resources that support riverine food-webs of prairie fishes. The primary objectives of this study are to (1) characterize where and when Red River fish find food, (2) determine the degree to which aquatic and terrestrial resources are utilized, and (3) describe age and growth of selected fish populations. This research is a collaboration with Lubbock Christian University and the Texas Parks and Wildlife Department. Information from this project is aiding conservation efforts by identifying and describing broad habitat types (instream, riverside) that support Red River shiner (*Notropis bairdi*) and other prairie fish in the Upper Red River. This fundamental ecological information is describing baseline conditions and identifying species-specific traits that can be used to evaluate the consequences of habitat change and for predictive modeling.

Red River shiner (*Notropis bairdi*). Uland Thomas, used with permission.

Technical Assistance

Reynaldo Patino engaged residents of the community of Abernathy, Texas, who were concerned about harmful algal blooms in their community lake, and met with Polish academics and government officials in Warsaw to discuss causes and solutions to harmful algal blooms.

Jane Rogosh participated in the Southwest Regional Horizon Scan to identify potential new aquatic invasive species to the Southwest United States with the goal of expanding Federal leadership and capacity for early detection and rapid response activities.

Clint Boal co-organized and taught a workshop on identification of raptor species, determination of different stages of the nesting cycle, and the balance between gathering data and disturbing nesting birds for the annual meeting of the Texas Master Naturalist program. Boal also co-organized a symposium focused on the history, changes, contemporary needs, and challenges of applied management of birds of prey, held at the 2023 Annual Meeting of The Raptor Research Foundation.

Selected Publications

Boal, C.W., Bibles, B.D., and Gicklhorn, T.S., 2023, Patterns of water use by raptors in the Southern Great Plains: The Journal of Raptor Research, v. 57, no. 3, p. 444–455, accessed March 18, 2024, at https://doi.org/10.3356/JRR-21-70.

Durboraw, T.D., Boal, C.W., Fleck, M.S., and Gill, N.S., 2022, Long-term recovery of Mexican spotted owl nesting habitat after fire in the Lincoln National Forest, New Mexico: Fire Ecology, v. 18, article 31, 20 p., accessed March 18, 2024, at https://doi.org/10.1186/s42408-022-00158-z.

Messager, M.L., Olden, J.D., Tonkin, J.D., Stubbington, R., Rogosch, J.S., Busch, M.H., Little, C.J., Walters, A.W., Atkinson, C.L., Shanafield, M., Yu, S., Boersma, K.S., Lytle, D.A., Walker, R.H., Burrows, R.M., and Datry, T., 2023, A metasystem approach to designing environmental flows: Bioscience, v. 73, no. 9, p. 643–662, accessed March 18, 2024, at https://doi.org/10.1093/BIOSCI/BIAD067.

Patiño, R., Christensen, V.G., Graham, J.L., Rogosch, J.S., Rosen, B.H., 2023, Toxic algae in inland waters of the conterminous United States—A review and synthesis: Water, v. 15, no. 15, article 2808, 40 p., accessed March 18, 2024, at https://doi.org/10.3390/w15152808.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Texas Tech University, and Texas Parks and Wildlife Department.

Barn owls (*Tyto alba*). Photograph by U.S. Fish and Wildlife Service.

Scientists

Jeffrey Muehlbauer, Unit Leader; Shawn Crimmins, Assistant Unit Leader; 3 vacancies

Meet the Unit

The Alaska Cooperative Fish and Wildlife Research Unit conducts research throughout the massive State of Alaska, spanning from the ocean to the highest peaks in the Nation, and from the tundra of the North Slope to the rainforests of the Alexander Archipelago. The Units' research is just as varied, including everything from microscopic parasites and insects to salmon, caribou, and moose. The Alaska Unit conducts research in the unique boreal and arctic systems that characterize Alaska. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: climate change, biodiversity, ecosystem health, water quality, and population monitoring and advanced modeling.

Research Projects

Central Alaska Aquatic Inventory and Monitoring Data Synthesis

Streams and rivers on public lands in central Alaska are subject to acute and increasing ecological stress from climate change and in-stream mining. This project is focused on identifying long-term trends in water quality and biomonitoring of relevant species. Insights from this work are helping managers to better understand how ecological stressors are affecting the function of aquatic ecosystems. The objective of this project is to assess the status and trends of freshwater communities and habitats in streams on Alaskan public lands using a long-term water-quality dataset. These data originate from

within central Alaska national parks managed by the National Park Service (NPS) as well as other lands in the region managed by the Bureau of Land Management (BLM). This project is a collaboration of researchers and partners within the U.S. Department of the Interior, including the U.S. Geological Survey, NPS, and BLM. Data synthesis is aimed at delivering results that help predict habitat and species population changes related to ecological stressors in central Alaskan freshwaters.

Sockeye salmon (*Oncorhynchus nerka*). Photograph by U.S. Geological Survey.

Moose Population Expansion in Togiak National Wildlife Refuge

Moose populations in portions of Togiak National Wildlife Refuge (NWR) have been expanding in recent years, potentially following the expansion of shrub habitat. This expansion

is likely driven by changing climatic conditions, meaning that future climate change could result in further expansion of shrub habitat and, potentially, moose populations. Understanding the driving factors behind moose population dynamics on the refuge is critical; however, most studies and resources are directed at baseline population monitoring only. We are using existing monitoring data to build an integrated population model for moose on Togiak NWR as a monitoring tool and to explore demographic changes in the population. This project may help to determine the demographic patterns behind moose population expansion while also improving monitoring programs and their utility.

Caribou (*Rangifer tarandus*) grazing. Photograph by U.S. Fish and Wildlife Service.

Technical Assistance

Jeffrey Muehlbauer conducted "Climate Change in My Community," a workshop at the University of Alaska Fairbanks with thirty participants. Muehlbauer also conducted a workshop for the Global Learning and Observation to Benefit the Environment program. He also demonstrated water quality devices and stream and river sampling methodologies and gears for a group of educators nationally as well as Alaska Native community leaders interested in developing science-based monitoring approaches for their local waterways.

Shawn Crimmins assisted NPS with the development of habitat selection models for brown bears in interior Alaska. He also delivered a public presentation about bear viewing sites to the general public at the 2023 Alaska Bearfest in Wrangell, Alaska.

Bald eagle (*Haliaeetus leucocephalus*). Photograph by Brian Uher-Koch, U.S. Geological Survey.

Selected Publications

Cruz, J., Windels, S., Thogmartin, W.E., Crimmins, S.M., and Zuckerberg, B., 2023, Survival of common loon chicks appears unaffected by bald eagle recovery in northern Minnesota: Avian Conservation and Ecology, v. 18, no. 1, article 7, 10 p., accessed March 21, 2024, at https://doi.org/10.5751/ACE-02395-180107.

Metcalfe, A.N., Fritzinger, C.A., Weller, T.J., Dodrill, M.J., Muehlbauer, J.D., Yackulic, C.B., Holton, P.B., Szydlo, C.M., Durning, L.E., Sankey, J.B., and Kennedy, T.A., 2023, Insectivorous bat foraging tracks the availability of aquatic flies (Diptera): Journal of Wildlife Management, v. 87, no. 5, article e22414, 15 p., accessed March 21, 2024, at https://doi.org/10.1002/jwmg.22414.

Ward, N.K., Lynch, A.J., Beever, E.A., Booker, J., Bouska, K.L., Embke, H., Houser, J.N., Kocik, J.F., Kocik, J., Lawrence, D.J., Lemon, M.G., Limpinsel, D., Magee, M.R., Maitland, B.M., McKenna, O., Meier, A., Morton, J.M., Muehlbauer, J.D., Newman, R., Oliver, D.C., Rantala, H.M., Sass, G.G., Shultz, A., Thompson, L.M., and Wilkening, J.L., 2023, Reimagining large river management using the Resist-Accept-Direct (RAD) framework in the Upper Mississippi River: Ecological Processes, v. 12, no. 1, article 48, 20 p., accessed March 21, 2024, at https://doi.org/10.1186/s13717-023-00460-x.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Alaska Fairbanks, and Alaska Department of Fish and Game.
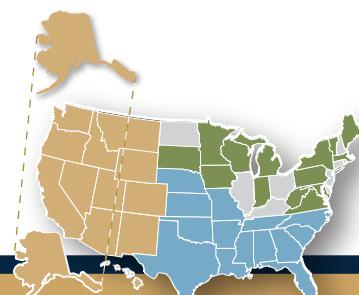
Arizona
Cooperative Fish and Wildlife Research Unit

Scientists

Scott Bonar, Unit Leader; Melanie Culver, Assistant Unit Leader; Javan Bauder, Assistant Unit Leader

Meet the Unit

The Arizona Cooperative Fish and Wildlife Research Unit focuses on fish and wildlife management in arid lands. Fish and wildlife living in deserts, grasslands, dry forests, and the waterbodies within these ecosystems often have unique conservation requirements and management needs. The Arizona Unit's expertise is in fisheries, genetics, and landscape modeling, so the team has a unique combination of disciplines. The Arizona Unit also collaborates on projects with students who work with two Unit Leaders or Assistant Unit Leaders depending on the project. This kind of collaborative work involves multiple perspectives and enhances the research and the student experience. The Arizona Unit also contributes towards managing and conserving southern Arizona's biodiversity in ecosystems found nowhere else in the United States. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: water allocation, drought, and ecological flows; population monitoring and advanced modeling; diseases of fish and wildlife; and Species of Greatest Conservation Need and threatened and endangered species.

Research Projects

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

Fishes that only live in the arid southwestern United States have rapidly declined due to human-caused stressors. Identifying the habitat conditions needed by these fish species is critical for their successful management. Habitat suitability criteria are commonly used in planning how to conserve species of interest. Therefore, developing habitat suitability criteria for native fish species across multiple rivers allows for better understanding of how different river environments are occupied under varying conditions. The research team developed stream-specific and generalized criteria for longfin dace (*Agosia chrysogaster*), speckled dace (*Rhinichthys osculus*), and desert sucker (*Pantosteus clarkii*) across five central Arizona streams. Fish were sampled using prepositioned electrofishing devices during summer low-flow periods to identify relationships among fish presence and habitat variables of water depth, water velocity, and what the streambed was made of. The optimal (the central 50 percent of range used) and suitable (the central 95 percent of range used) ranges for each habitat variable were calculated for each stream based on the occurrence of each species. Partners include U.S. Fish and Wildlife Service and the U.S. Department of Agriculture Forest Service (FS). Results are being used to inform decisions for conservation of these native fish species.

Emerging Viral Diseases in At-Risk Populations of Felids and Ungulates

Wildlife pathogens and disease are rarely monitored, yet modern tools provide new and effective ways to monitor viruses, microbiomes, diet, and disease pathogens in wildlife, even using noninvasive fecal samples to gain valuable data. Information from monitoring wildlife, environments, and domestic/human populations

Ocelot (*Leopardus pardalis*). Photograph by U.S. Geological Survey.

for pathogens and disease can benefit wildlife conservation and public health. As environmental changes occur, disease transmission and pathogens can change for wildlife and humans. This project is funded by the National Science Foundation; U.S. Department of Agriculture Animal and Plant Health Inspection Service (USDA APHIS), which has long been interested in monitoring wildlife diseases that have potential to spillover to human or domestic animals; and the University of Arizona, which provided the initial funding for felid virus monitoring. Knowledge of viral biodiversity in endangered and nonendangered wildlife species, viral diversity on the landscape from environmental deoxyribonucleic acid (eDNA) monitoring, and disease prevalence in human and domestic populations can inform decisions regarding managing habitats or wildlife populations for the benefit of species conservation and for the benefit of public health.

Mexican spotted owls (*Strix occidentalis lucida*). Photograph by Amie Smith, U.S. Fish and Wildlife Service.

Evaluating the Effects of Nest Management on Bald Eagles in Arizona

Arizona's breeding population of bald eagles (*Haliaeetus leucocephalus*) is mostly isolated from other bald eagle breeding populations in North America, so the current and future status of this population needs to be evaluated separately. The breeding population of bald eagles in Arizona has steadily increased in recent decades, and the likelihood of future population growth needs to be determined. There are multiple nest-level management programs in place, and it is important to determine if continuing these programs is necessary to sustain population growth. This project is being conducted in collaboration with Arizona Game and Fish Department and the Arizona Unit. The research team is using multiple long-term datasets for bald eagles in Arizona, including band-resight data, nest occupancy surveys, global positioning system telemetry data, and nest productivity surveys to create an integrated population model. This model uses information from all datasets to estimate population demographic parameters and to simulate future population projections under different management scenarios.

Technical Assistance

Scott Bonar provided technical support and data to the FS and the U.S. Department of Justice for protection and management of flows in desert streams containing fish species at risk and listed species.

Melanie Culver worked with 40 citizen-scientists in southern Arizona on a trail camera project to monitor endangered wildlife, such as jaguar (*Panthera onca*), ocelot (*Leopardus pardalis*), and Mexican spotted owl (*Strix occidentalis lucida*), and overall biodiversity in 18 mountain ranges. The project included continuing education for the citizen scientists. Culver also provided interviews to the media on topics such as large carnivore movement and gene flow with respect to the border wall, and detections of rare, endangered cats (jaguar and ocelot) in Arizona.

Selected Publications

Bolt, M.R., Bauder, J.M., Legare, M.L., Jenkins, C.L., Rothermel, B.B., and Breininger, D.R., 2023, Eastern indigo snake (*Drymarchon couperi*) shelter site use in peninsular Florida, USA, and implications for habitat conservation: Herpetological Conservation and Biology, v. 18, no. 2, p. 362–373, accessed March 21, 2024, https://www.herpconbio.org/Volume_18/Issue_2/Bolt_etal_2023.pdf.

Erwin, J.A., Logan, K.A., Trumbo, D.R., Funk, W.C., and Culver, M., 2023, Effects of hunting on mating, relatedness, and genetic differentiation in a puma population: Molecular Ecology, Early View [Online Version of Record before inclusion in an issue], posted December 12, 2023, article 17237, accessed March 24, 2024, at http://doi.org/10.1111/mec.17237.

Jenney, C.J., Bauder, J.M., and Bonar, S.A., 2024, Native fish abundance and habitat selection changes in the presence of nonnative piscivores: Ecology of Freshwater Fish, v. 33, no. 1, article e12742, 14 p., accessed March 21, 2024, at https://doi.org/10.1111/eff.12742.

Payne, N., Erwin, J.A., Morrison, J.L., Dwyer, J.F., and Culver, M., 2023, Genomic insights into isolation of the threatened Florida crested caracara (*Caracara plancus*): The Journal of Heredity, v. 115, no. 1, p. 45–56, accessed March 21, 2024, at https://doi.org/10.1093/jhered/esad057.

Teal, C.N., Schill, D.J., Fogelson, S.B., Roberts, C.M., Fitzsimmons, K., Bauder, J.M., Stewart, W.T., and Bonar, S.A., 2023, The effects of estradiol-17β on the sex reversal, survival, and growth of green sunfish *Lepomis cyanellus*: Aquaculture, v. 562, article 738853, 10 p., accessed March 21, 2024, at https://doi.org/10.1016/j.aquaculture.2022.738853.

Graduate Student Spotlight

Chad Teal, Ph.D., University of Arizona, School of Natural Resources and the Environment

Dissertation title: "The development of Trojan sex chromosome carrying green sunfish (*Lepomis cyanellus*) and red shiner (*Cyprinella lutrensis*) to control their nuisance populations."

Chad Teal is now the Assistant Unit Leader at the Utah Cooperative Fish and Wildlife Research Unit.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, The University of Arizona; and Arizona Game and Fish Commission.

California
Cooperative Fish and Wildlife Research Unit

Scientists

Nicholas Som, Unit Leader; one vacancy

Meet the Unit

The California Cooperative Fish and Wildlife Research Unit is located at California State Polytechnic University, Humboldt in Arcata, California. The California Unit is situated in the redwoods and serves the needs of partners across the State of California. The Unit Leader, Nicholas Som, reported in November 2023 and is developing productive research, graduate-student mentoring, and technical-assistance programs. Som's projects focus on fish conservation research, but also include other animals such as mammals and amphibians. Themes for current research and technical assistance include water allocation, drought, and environmental flows; Species of Greatest Conservation Need and threatened and endangered species; population monitoring and advanced modeling; and diseases of fish and wildlife.

Research Projects

Research and Development of a Suitable Method for Estimating Weekly-Stratified Abundances of Migrating Juvenile Salmonids in the Absence of Mark-Recapture Experiments

This project aims to develop new methods for computing statistically valid abundance estimates without mark-recapture data. Many fish monitoring projects rely upon mark-recapture data to track various population metrics, such as long-term trends in abundance, fish health, and outmigration timing. However, marking and recapturing fish are invasive processes that stress fish. Marking and recapturing fish becomes more difficult as populations decline and may become threatened and endangered. The objective of this study is to develop new methods for estimating fish abundances that does not depend on mark-recapture data. These methods must be biologically and technically sound because these monitoring data are often scrutinized and relied on for setting fish population objectives.

Coho salmon (*Oncorhynchus kisutch*). Photograph by U.S. Fish and Wildlife Service.

Effects of Dam Removal on the Survival and Migratory Behavior of Salmonids

Dr. Som is working with a multipartner team to establish a monitoring and research program in the Klamath Basin to isolate the effects of the largest dam removal project in the United States to date. Projects in this program include fish abundance estimation, speciation for sonar monitoring stations (remote-sensing sampling), and telemetry applications to investigate thermal barriers and refuge for migrating salmonids.

Coho salmon (*Oncorhynchus kisutch*). Photograph by Roger Tabor, U.S. Fish and Wildlife Service.

Technical Assistance

Nicholas Som coproduced a research proposal with U.S. Fish and Wildlife Service cooperators to investigate co-occupancy of martens (*Martes americana*) and fishers (*Pekania pennanti*). Som also provided technical assistance to California Department of Fish and Wildlife cooperators on study designs for salmon disease experiments and a project to reduce predation on threatened frogs. Som is also teaching a graduate research seminar on the science of dam removal.

Selected Publication

Som, N.A., Hetrick, N.J., Perry, R.W., and Alexander, J.D., 2019, Estimating annual *Ceratonova shasta* mortality rates in juvenile Scott and Shasta River Coho Salmon that enter the Klamath River mainstem: Arcata, Calif., U.S. Fish and Wildlife Service, Arcata Fish and Wildlife Office, Arcata Fisheries Technical Report Number TR 2019-38, accessed on April 4, 2024, at https://pubs.usgs.gov/publication/70206402.

Cooperators

U.S. Geological Survey; U.S. Fish and Wildlife Service; Wildlife Management Institute; California State Polytechnic University, Humboldt; and California Department of Fish and Wildlife.

Humbolt marten (*Martes caurina*). Photograph by U.S. Fish and Wildlife Service.

Colorado
Cooperative Fish and Wildlife Research Unit

Scientists

Dana Winkelman, Unit Leader; Brian Gerber, Assistant Unit Leader; William Kendall, Assistant Unit Leader

Meet the Unit

The Colorado Cooperative Fish and Wildlife Research Unit has a long history of expertise in quantitative ecology and remains a leader in this field. Additionally, the Colorado Unit works closely with Colorado State University and Colorado Parks and Wildlife. The Unit includes scientists with diverse but overlapping expertise for pursuing collaborations with partners to address a variety of aquatic and terrestrial population-management problems. The Unit is also known for its proximity to diverse montane ecosystems. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: Species of Greatest Conservation Need and threatened and endangered species; animal migration; water allocation, drought, and ecological flows; and population monitoring and advanced modeling.

Whooping cranes (*Grus americana*). Photograph by Klaus Nigge, U.S. Fish and Wildlife Service.

Research Projects

Development of Protective Temperature Criteria for Bluehead Sucker, Flannelmouth Sucker and Roundtail Chub Larvae

Climate change, water demand, and extensive urbanization influence stream water temperature and thermal inputs; therefore, temperature is becoming an increasingly challenging regulatory pollutant in Colorado. Water temperature is one of the most important abiotic factors for fish survival, and streams used by many fish species across Colorado are experiencing high and low water-temperature extremes. These extreme rates of temperature change are contributing to low fish survival rates. Appropriate water temperatures for fish species are dependent on fish life stage, and larval and adult stages may exhibit large differences in temperature tolerance. This study evaluates several metrics of temperature tolerance for flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*Catostomus discobolus*), and roundtail chub (*Gila robusta*) larvae, and may determine if temperature tolerance tests should be conducted in the field as compared to testing in controlled laboratory experiments.

Carli Baum with a johnny darter (*Etheostoma nigrum*). Photograph by U.S. Geological Survey.

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

The Rocky Mountain population of greater sandhill cranes (*Antigone canadensis tabida*) and a portion 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 crane 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 can help to determine the future needs of these populations and inform refuge management decisions. This project is a collaboration among the Colorado Unit, U.S. Fish and Wildlife Service Regions 6 and 2, the Intermountain West Joint Venture, Colorado Parks and Wildlife, and Colorado Open Lands. Results from these analyses are being used to build a decision model to assist Monte Vista National Wildlife Refuge in making water and grain management decisions for crane habitat.

Wolverine (*Gulu gulu*). Photograph by William Warby, used with permission.

Technical Assistance

Dana Winkelman consulted with Colorado Parks and Wildlife on temperature monitoring and criteria for Great Plains and Westslope streams and rivers. Winkelman also consulted with Environmental Protection Agency and wastewater utilities on ongoing monitoring of effluent effects on Great Plains fish populations.

Brian Gerber was invited to be an external reviewer of a wolverine (*Gulo gulo*) recovery plan to provide comments on the general approach and layout, and to consider any additional aspects that might affect wolverine recovery in Colorado that should be included in the plan.

William Kendall provided a workshop on the use of structured decision-making to staff of one of our cooperators, Colorado Parks and Wildlife. Kendall also served on a review team to evaluate the National Oceanic and Atmospheric Administration's comprehensive plan for in-water sea-turtle data collection in the U.S. Gulf of America [Mexico].

Selected Publications

Adams, C.M., Winkelman, D.L., and Fitzpatrick, R.M., 2023, Impact of wastewater treatment plant effluent on the winter thermal regime of two urban Colorado South Platte tributaries: Frontiers in Environmental Science, v. 11, article 1120412, 10 p., accessed March 21, 2024, at https://doi.org/10.3389/fenvs.2023.1120412.

Adams, C.M., Winkelman, D.L., Schaffer, P.A., Villeneuve, D.L, Cavallin, J.E., Ellman, M., Rodriguez, K.S., and Fitzpatrick, R.M., 2022, Elevated winter stream temperatures below wastewater treatment plants shift reproductive development of female johnny darter (*Etheostoma nigrum*)—A field and histologic approach: Fishes, v. 7, no. 6, 22 p., accessed March 21, 2024, at https://doi.org/10.3390/fishes7060361.

Cannell, B.L., Kendall, W.L., Tyne, J., Bunce, M., Hetzel, Y., Murray, D., and Radford, B., 2023, Marine heatwaves affect breeding, diet and population size but not body condition of a range-edge little penguin colony: Marine Ecology Progress Series, article HEATav11, Advance View [Online Version of Record before inclusion in an issue], posted November 23, 2023, accessed March 21, 2024, at https://doi.org/10.3354/meps14425.

Hyde, M., Payán E., Barragan, J., Stasiukynas, D., Rincón, S., Kendall, W.L., Rodríguez, J., Crooks, K.R., Breck, S.W., and Boron, V., 2023, Tourism-supported working lands sustain a growing jaguar population in the Colombian Llanos: Scientific Reports, v.13, article 10408, 11 p., accessed March 21, 2024, at https://doi.org/10.1038/s41598-023-36935-2.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Colorado State University, and Colorado Parks and Wildlife.
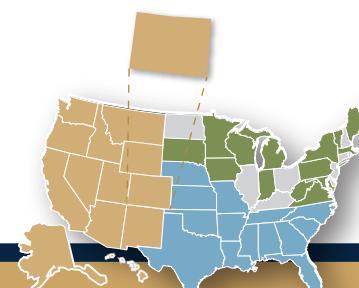
Hawai'i Cooperative Fishery Research Unit

Scientists

Tim Grabowski, Unit Leader; Lillian J. Tuttle Raz, Assistant Unit Leader

Meet the Unit

The Hawai'i Cooperative Fishery Research Unit is the most geographically isolated Unit and serves one of the most biologically and culturally diverse States in the Nation. The issues that the Hawai'i Unit addresses are familiar: overfishing, human-caused climate change, pollution, and balancing cultural and socioeconomic needs of the public with the needs of the State's natural resources. The Hawai'i Unit is the only Unit in the tropics and is situated in one of the most isolated places on the planet with a long heritage of indigenous resource stewardship pre-dating modern management practices. The habitats and species that the Unit's cooperators manage are complex and biodiverse, with relatively high rates of endemism; vulnerability to overextraction and nonnative species; and have great ecological, economic, and cultural value. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: invasive species, diseases of fish and wildlife, decision science and structured decision-making, advanced technologies, and hunting and fishing.

Pacific coral reef and fish. Photograph by Tim Grabowski, U.S. Geological Survey.

Research Projects

How Will Changing Reefscapes Affect the Prevalence of Ciguatera on Hawaiian Reefs?

Ciguatera fish poisoning (CFP) is considered the most common marine-toxin-related illness affecting humans in the tropics and subtropics. However, CFP has started to occur outside of these regions because of fish exports and climate change so the public health and economic effects are underestimated. CFP is caused when reef fishes contain toxins from a reef-dwelling organism that they ate, then humans eat the now-toxic reef fish. These toxins are produced by organisms called dinoflagellates that are in the genus *Gambierdiscus*. Changing reefscapes due to climate change and overfishing may alter the risk of ciguatera poisoning in communities dependent upon reef fishes for food security. This study evaluates the relationship between human reef alterations and the prevalence of ciguatoxic fishes, and assesses the effectiveness of the risk-management practices of local communities in a changing ocean. This work was conducted in collaboration with the Hawaii Department of Land and Natural Resources-Division of Aquatic Resources, U.S. Fish and Wildlife Service, The Nature Conservancy, U.S. Geological Survey Pacific Island Climate Adaptation Science Center, local community groups, local spearfishers, and the Federal Institute of Risk Assessment in Berlin, Germany. The results of this study indicate that changing temperature regimes and fishing pressure influence the prevalence of ciguatoxic fishes, but

in unexpected ways. Also, practices and beliefs local fishers use to mitigate CFP risk are likely to lose effectiveness as conditions on reefs in Hawai'i continue to degrade. These results may inform decisions about when and how public outreach and monitoring efforts are implemented to lessen chances of CFP.

Analysis and Review of Fishery-Dependent Data for Hawaiian Nearshore Noncommercial Fisheries

The State of Hawaii's Division of Aquatic Resources (DAR) routinely collects survey data to monitor the catch and effort of nearshore noncommercial fisheries. These data are used to justify management actions and regulatory decisions taken by DAR and the State government, yet these data from island or county-based monitoring have not been collated, analyzed, or used as effectively as they might be.

Green sea turtle (*Chelonia mydas*). Photograph by U.S. Geological Survey.

Unit researchers worked with DAR scientists to assemble a statewide creel survey dataset that was analyzed for spatial and temporal patterns in fishing effort and quantified potential bias in survey methods. The research team also reviewed the potential for incorporating emerging technologies, such as electronic data entry and processing systems with geospatial and image capabilities, field cameras, drones, smart buoys, citizen-science apps, data-mining social media, and artificial intelligence and machine learning, that can improve, augment, and evolve creel survey data collection, especially for spearfishing. Researchers synthesized the most detailed information to date about noncommercial shore-based fisheries of Hawai'i. The project involved close collaboration between Unit researchers and many partners within the State government, especially at the O'ahu, Kaua'i, and Maui DAR field offices where data were collected. The extensive coverage of the DAR's dataset revealed the value of their survey efforts over the last decade to address fishery management needs. The researchers also highlighted areas for improvement to make these efforts a more effective tool for future decision-making processes in resource management and conservation in Hawai'i's fisheries.

Technical Assistance

Tim Grabowski leads the adaptive management team for the management of Achilles tang or Pāku'iku'i (*Acanthurus achilles*) along the west side of Hawai'i Island. The Hawai'i Unit also has served as a data collection and clearinghouse for invasive species removal events around the State.

Lillian Tuttle Raz continues to provide technical assistance to State cooperators by leading them through the structured decision-making–adaptive resource management process and providing critical life history information, both for an imperiled population of coral-reef fish.

Grabowski and Tuttle Raz participated in data collection and fisher engagement at an invasive species removal event on Kaua'i, and organized an outreach booth at the Queen Lili'uokalani Festival of Hilo, where they engaged hundreds of members of the public.

Selected Publications

Acre, M.R., Grabowski, T.B., Leavitt, D.J., Smith, N.G., Pease, A.A., Bean, P.T., and Geeslin, D., 2022, Mismatch between temperature and discharge disrupts spawning cues in a fluvial specialist, blue sucker *Cycleptus elongatus*: Ecology Freshwater Fish, v. 32, no. 2, p. 305–321, accessed March 21, 2024, at https://doi.org/10.1111/eff.12687.

Grabowski, T., Benedum, M.E., Curley, A., Dill De-Sa, C., and Shuey, M., 2023, Pandemic-driven changes in the nearshore non-commercial fishery in Hawai'i—catch photos posted to social media capture changes in fisher behavior: PeerJ, v. 11, article e14994, 18 p., accessed March 21, 2024, at https://doi.org/10.7717/peerj.14994.

Nalley, E.M., Tuttle, L.J., Conklin, E.E., Barkman, A.L., Wulstein, D.M., Schmidbauer, M.C., and Donahue, M.J., 2023, A systematic review and meta-analysis of the direct effects of nutrients on corals: Science of the Total Environment, v. 856, article 159093, 13 p., accessed March 21, 2024, at https://doi.org/10.1016/j.scitotenv.2022.159093.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Hawai'i; and Hawaii Department of Land and Natural Resources.

Kaloko Fishpond, Hawai'i.
Photograph by U.S. Geological Survey.

Scientists

Courtney Conway, Unit Leader; **Michael Quist**, Assistant Unit Leader; **David Ausband**, Assistant Unit Leader; **Matt Falcy**, Assistant Unit Leader

Meet the Unit

The Idaho Cooperative Fish and Wildlife Research Unit scientists have a combined 75 years of experience in the Cooperative Research Units Program, including experience at six different Units. Unit scientists have expertise in fish, wildlife, and quantitative ecology and because of the strong relationships with agency partners, research results are applied to management problems and have a direct, measurable influence on natural resource conservation. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: Species of Greatest Conservation Need and threatened and endangered species, wildfire, grassland management and restoration, hunting and fishing, population monitoring and advanced modeling, and invasive species.

Graduate student Luke Anderson holds a northern pike (*Esox lucius*) captured during a sampling trip on Lake Pend Oreille, Idaho. Photograph by U.S. Geological Survey.

Research Projects

Effectiveness of Forest Restoration Treatments on Demography of a Federally Listed Ground Squirrel

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 (*Urocitellus brunneus*) are federally threatened and have a very small range in central Idaho. The researcher team is comparing the effects of two forest treatments on northern Idaho ground squirrels: (1) mechanical thinning followed by a fall-season burn (past prescription used by the U.S. Department of Agriculture Forest Service (FS); and (2) no treatment (control). We are using a Before-After-Control-Impact design with field sampling to be done for more than five years before treatment and for more than four years after treatment. The project is a collaboration between the Idaho Unit, FS, U.S. Fish and Wildlife Service (FWS), and Idaho Department of Fish and Game (IDFG). Results may help determine whether thinning and fire treatments can be used to improve habitat suitability for northern Idaho ground squirrels.

Northern Idaho ground squirrel (*Urocitellus brunneus*). Photograph by Day Scott, University of Idaho, used with permission.

Trophic Ecology of Walleyes in Lake Pend Oreille

Walleye (*Sander vitreus*) are an ecologically and recreationally important fish species in their native range. A nonnative population of walleye has been established recently in the Lake Pend Oreille system in northern Idaho. Walleye eat other fish, and this new population raises concerns about their potential effect on the lake system, particularly in regard to eating salmonids. The research team worked closely with IDFG to evaluate the ecology of walleye in the lake system, identify factors related to growth of walleye, and relate growth variability to variability in isotopic values of walleye that help to determine where a fish lives during its life stages. The results suggest that walleye will likely have negative effects on the kokanee salmon (*Oncorhynchus nerka*) population. This research provides information that can be used to support and direct walleye management efforts in the Lake Pend Oreille system.

Determining the Vulnerability of Wolves to Harvest

Much of the scientific results showing how hunting affects gray wolf (*Canis lupus*) populations is from the core of the species range in Canada and Alaska, where populations are connected and robust, and wolves are numerous. Less is known about how hunting and trapping might affect wolves in smaller populations such as those found in the Rockies. This project is a collaboration between the Idaho Unit, The University of Idaho, The University of Montana, and IDFG. Insights into how human-caused wolf deaths affect wolf pack and long-term population structures are critical to understanding the potential effects of humans on gray wolves and their population management.

Gray wolf pups (*Canis lupus*). Photograph by U.S. Geological Survey.

Gray wolf adult (*Canis lupus*) and pups. Photograph by U.S. Geological Survey.

Mule Deer in Changing British Columbia Forests

Humans have direct and indirect effects on wildlife behavior, habitat, and communities. The complex nature of the links between humans to wildlife make it difficult to understand and predict effects of management and conservation actions on wildlife. This project is coupling large datasets with statistical models to assess human influence on wildlife behavior. Data were used from motion-sensing trail cameras that were deployed from 2019 to 2022 at 250 sites across gradients of human disturbance, including logging, fires, road density, and human presence. The research team developed mathematical and statistical models to link image data to research objectives. The objectives were to (1) assess the effects of human disturbance on daily activity patterns of mule deer (*Odocoileus hemionus*), and to quantify whether mule deer responses to human disturbance alters exposure to predator and competitor species; (2) quantify the cumulative effects of landscape disturbance and human presence on the occurrence of mule deer, including both direct and indirect effects; and (3) quantify the influence of human disturbance on species richness in the Southern Interior British Columbia mammal community. This work can provide new insight into wildlife conservation and management in Southern Interior British Columbia.

Technical Assistance

Courtney Conway was invited by FWS to serve on Species Status Assessment teams for two listed species to help guide management and recovery: the Yuma Ridgway's rail (*Rallus longirostris yumanensis*) and the northern Idaho ground squirrel.

Michael Quist and Unit staff and students regularly conduct training for State and Federal agency fisheries scientists in their laboratory on standard techniques for evaluating age and growth of fishes.

David Ausband presented a talk "Fifteen years of wolf hunting and trapping in Idaho, USA: What do we know?" at the Wolves Across Borders Conference in Stockholm, Sweden.

Matt Falcy is working with IDFG staff on a decision-making tool for salmonid hatcheries.

Selected Publications

Allison, A.Z.T., Conway, C.J., and Morris, A.E., 2023, Why hibernate? Tests of four hypotheses to explain intraspecific variation in hibernation phenology: Functional Ecology, v. 37, no. 6, p. 1580–1593, accessed March 21, 2024, at https://doi.org/10.1111/1365-2435.14322.

Ausband, D.E., and Mech, L.D., 2023, The challenges of success—Future wolf conservation and management in the United States: Bioscience, v. 73, no. 8, p. 587–591, accessed March 21, 2024, at https://doi.org/10.1093/biosci/biad053.

Black, A.R., Walrath, J.D., Willmes, M., and Quist, M.C., 2023, Natal contributions of kokanee salmon to Flaming Gorge Reservoir, Wyoming–Utah—An evaluation using otolith microchemistry: Journal of Fish and Wildlife Management, v. 14, no. 1, p. 90–107, accessed March 21, 2024, at https://doi.org/10.3996/JFWM-22-009.

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Klein, Z.B., Quist, M.C., and Guy, C.S., 2023, Suppression of invasive fish in the West—Synthesis and suggestions for improvement: North American Journal of Fisheries Management, v. 43, no. 2, p. 369–383, accessed March 21, 2024, at https://doi.org/10.1002/nafm.10827.

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Voss, N.S., Bowersox, B.J., and Quist, M.C., 2023, Reach-scale associations between introduced brook trout and juvenile and stream-dwelling bull trout in Idaho: Transactions of the American Fisheries Society, v. 152, no. 6, p. 835–848, accessed March 21, 2024, at https://doi.org/10.1002/tafs.10443.

Graduate Student Spotlight

Nolan Helmstetter, Master of Science in Wildfire Sciences, University of Idaho

Thesis title: "Effects of livestock grazing and habitat on predator-specific nest mortality and spatiotemporal activity patterns of sage-grouse nest predators."

Nolan is now a first-year Ph.D. student at Montana State University.

"The Idaho Department of Fish and Game has long relied on the Idaho Cooperative Fish and Wildlife Research Unit as an extension of research capacity to address key fisheries and wildlife management questions in Idaho."

—Lance Hebdon, Idaho Department of Fish and Game Fisheries Bureau Chief, and Shane Roberts, Idaho Department of Fish and Game Wildlife Bureau Chief

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Idaho, and Idaho Department of Fish and Game.

Greater sage grouse (*Centrocercus urophasianus*). Photograph by Tom Koerner, U.S. Fish and Wildlife Service.
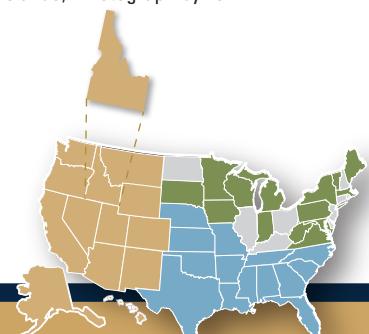
Montana Cooperative Fishery Research Unit

Scientists

Alexander Zale, Unit Leader; Christopher Guy, Assistant Unit Leader

Meet the Unit

The Montana Cooperative Fishery Research Unit conducts applied research aimed at addressing fisheries problems identified by State and Federal cooperators in the northern United States Rocky Mountains and Great Plains. Unit scientists investigate complicated and unique fisheries questions in Montana and the surrounding areas. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: population monitoring and advanced modeling, invasive species, Species of Greatest Conservation Need and threatened and endangered species, and keystone species in National Parks.

Research Projects

Evaluation of the Management Actions Taken in the Lamar River Watershed

Introduction of nonnative fish species has negatively affected native fishes throughout the United States and the world. Yellowstone National Park is no exception to this trend, with negative effects from nonnative fish species cascading through aquatic and terrestrial food webs. Beginning in 1889, over 16 million nonnative fish were stocked into Yellowstone's waters, with almost 3 million stocked in the Lamar River watershed. The Lamar River watershed is considered the most important riverine stronghold

Katie Furey holds a western toad (*Anaxyrus boreas*). Photograph by Chris Guy, U.S. Geological Survey.

for Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*) by the Yellowstone Cutthroat Trout interagency workgroup, which is made up of researchers from the National Park Service (NPS), U.S. Department of Agriculture Forest Service, U.S. Geological Survey, and from the States of Montana, Wyoming, Idaho, Utah, and Nevada. Over the decades, introduced rainbow trout (*Oncorhynchus mykiss*) have continued to migrate farther upstream in the Lamar River watershed, displacing and hybridizing with native Yellowstone cutthroat trout. Many efforts have been made to suppress the spread of nonnative rainbow and hybrid trout and to protect and restore Yellowstone cutthroat trout and its ecological function to preinvasion conditions. Long-term monitoring and independent data analysis may help to evaluate the progress of management actions. This project is conducting an analysis of how populations of Yellowstone cutthroat trout, rainbow trout, and hybrid trout respond to the institution of a mandatory harvest angling regulation coupled with selective mechanical removal of nonnative trout within the watershed. The research team is conducting statistical analysis of new and historic fisheries assessment work and creel surveys and interviews of anglers in the watershed. The project objectives are to (1) develop population estimates of Yellowstone cutthroat, rainbow, and hybrid trout populations in different regions of the Lamar River watershed; and (2) determine if management actions being undertaken by the NPS (selective removal of nonnatives, angling regulations) are having the desired effect on native and nonnative fish populations.

Evaluate and Refine Benchmarks for Lake Trout and Cutthroat Trout Populations in Yellowstone Lake

In Yellowstone Lake, Wyoming, the largest inland population of nonhybridized Yellowstone cutthroat trout (hereafter cutthroat trout), declined throughout the 2000s because of predation from invasive lake trout (*Salvelinus namaycush*), drought, and whirling disease (*Myxobolus cerebralis*). To maintain ecosystem function and conserve cutthroat trout, a lake trout gill-netting program was established in 1995 to suppress and decrease lake trout abundance and biomass. However, the response of cutthroat trout to varying lake trout suppression levels and the influence of disease and climate is unknown.

We developed an ecosystem model calibrated to historical data to forecast (2020–2050) whether cutthroat trout would achieve recovery benchmarks given disease, varying suppression efforts, and climate change. Lake trout suppression influenced cutthroat trout recovery, with current suppression effort levels resulting in cutthroat trout recovering from historical lows in the early 2000s. However, cutthroat trout did not achieve conservation benchmarks when incorporating the influence of disease and climate. Therefore, the NPS intends to incorporate age-specific abundance, spawner biomass, or both in conservation benchmarks to provide a better indication of how a combination of management actions and environmental conditions influence cutthroat trout. Our results show how considering complex interactions within an ecosystem simultaneously may help to establish and achieve realistic benchmarks for species of conservation concern.

Michelle Briggs shows an angler how to measure a fish. Photograph by Chris Guy, U.S. Geological Survey.

Technical Assistance

Alexander Zale is collaborating with the Montana Department of Fish, Wildlife and Parks (MTDFWP) to understand the reasons for declines in abundances of popular recreational fisheries for trout in southwest Montana. The work involves comprehensive assessment of survival, recruitment, disease, and fishing pressure components.

Christopher Guy and Zale, along with MTDFWP and MountainWorks, updated the "Fishes of Montana" phone app, which can be downloaded for free for Android and Apple devices. The "Fishes of Montana" app replaces the outdated "Fishes of Montana" book. The app allows users to identify fishes in real time and to have easier access to the biology and ecology of Montana fishes. The app also allows the developers to update species information more easily, such as when there are changes in species names and distributions.

Selected Publications

Cox, T.L., Guy, C.S., Holmquist, L.M., and Webb, M.A.H., 2023, Spawning locations of pallid sturgeon in the Missouri River corroborate the mechanisms for recruitment failure: Fishes, v. 8, no. 5, article 243, 22 p., accessed March 22, 2024, at https://doi.org/10.3390/fishes8050243.

Glassic, H.C., Chagris, D.D., Guy, C.S., Tronstad, L.M., Lujan, D.R., Briggs, M.A., Albertson, L.K., Brenden, T.O., Walsworth, T.E., and Koel, T.M., 2023, Yellowstone cutthroat trout recovery in Yellowstone Lake—Complex interactions among invasive species suppression, disease, and climate change: Fisheries (Bethesda, Md.), v. 49, no. 2, p. 55–70, accessed March 22, 2024, at https://doi.org/10.1002/fsh.10998.

Koel, T.M., Doepke, P.D., MacDonald, D.J., Thomas, N.A., Vender, C.W., Glassic, H.C., Poole, A.S., Guy, C.S., and Zale, A.V., 2023, Aerial application of organic pellets eliminates lake trout recruitment from a primary spawning reef in Yellowstone Lake: North American Journal of Fisheries Management, v. 43, no. 2, p. 505–516, accessed March 22, 2024, at https://doi.org/10.1002/nafm.10872.

Poole, A.S., Koel, T.M., Zale, A.V., and Webb, M.A.H., 2023, Rotenone induces mortality of invasive lake trout and rainbow trout embryos: Transactions of the American Fisheries Society, v. 152, no. 1, p. 3–14, accessed March 22, 2024, at https://doi.org/10.1002/tafs.10394.

Cooperators

U.S. Geological Survey; U.S. Fish and Wildlife Service; Wildlife Management Institute; Montana State University; and Montana Department of Fish, Wildlife and Parks.

Yellowstone cutthroat trout. Photograph by Chris Guy, U.S. Geological Survey.

Scientists

Daniel Walsh, Unit Leader; Sarah Sells, Assistant Unit Leader

Meet the Unit

The Montana Cooperative Wildlife Research Unit is uniquely poised to assist cooperators by providing rigorous science and decision support to address some of the most challenging wildlife issues in the country, including chronic wasting disease management, grizzly bear (*Ursus arctos horribilis*) restoration and conservation, gray wolf (*Canis lupus*) management, and promotion of ecosystem health. The Montana Unit is involved in high-profile conservation challenges, including recovery of grizzly bears in the northern Rocky Mountains, and proactive decision-making for wildlife disease management in the United States. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: diseases of fish and wildlife, Species of Greatest Conservation Need and threatened and endangered species, population monitoring and advanced modeling, and connectivity.

Research Projects

Highlands Bighorn Sheep Herd Project

Many bighorn sheep (*Ovis canadensis*) populations across the West are struggling, with population numbers that are unchanging to decreasing. The cause of this poor population performance is mainly because of the effects of bighorn sheep respiratory disease. The primary cause of respiratory disease in bighorn sheep is *Mycoplasma ovi pneumoniae* (*M. ovi*). This disease usually expresses itself as an all-ages die-off

in a newly infected herd followed by years to decades of poor lamb survival, with lambs dying of pneumonia. This lamb mortality prevents a herd of bighorn sheep from rebounding after the initial infection of the herd, and is a concern for managers trying to restore herd vigor. The purpose of this project, in collaboration with Montana Department of Fish, Wildlife and Parks (MTDFWP), is to test management actions that are designed to increase lamb survival and, ultimately, ensure the conservation of the species. Specifically, the research team is evaluating the effects of testing and removal of *M. ovi*-positive animals on the survival rates of lambs. This management strategy is based on the theory that only a few individuals within the herd harbor *M. ovi* and maintain and pass the pathogen on to doomed lambs born each year. By identifying these few infected individuals and removing them, lamb survival should improve. This strategy has been successful in free-ranging and captive herds across the West, and this project will test this approach in the Highlands sheep herd in Montana. Because many bighorn herds have a trace mineral deficiency (based on domestic sheep reference standards), the research team is also investigating the effects of mineral supplementation on lamb survival and population growth. Of particular interest is selenium, which has been linked to immune function. The research team plans to test the hypothesis that access to mineral supplements will increase lamb survival by helping to provide a more robust immune response to *M. ovi* and other respiratory pathogens. The overarching goal of these research projects is to explore whether management actions to improve the health of bighorn sheep herds will be successful.

Bighorn sheep (*Ovis canadensis*). Photograph by Paul Cross, U.S. Geological Survey.

Grizzly Bear Space Use in the U.S. Northern Rocky Mountains

Over the past two centuries, persecution and habitat loss caused grizzly bears (*Ursus arctos horribilis*) to decline from a population of approximately 50,000 individuals to only four fragmented populations within the contiguous United States. An understanding of habitat selection by grizzly bears within these existing populations may help to predict potential linkage zones among these populations and suitable habitats. Other conservation challenges are to identify areas where grizzly bears are likely to disperse among recovery ecosystems, and proactive efforts to reduce human-grizzly bear conflicts. This project is a close collaboration across multiple partners, including the University of Montana, MTDFWP, the U.S. Fish and Wildlife Service (FWS), and the U.S. Geological Survey Northern Rocky Mountain Science Center. The project is delivering models of grizzly bear movement, habitat use, and population connectivity. Results are directly informing conservation challenges by identifying specific areas that are important for habitat use and natural connectivity among recovery ecosystems, which will help identify where to prioritize habitat conservation, human-bear conflict mitigation, and transportation planning.

Grizzly bear (*Ursus arctos horribilis*). Photograph by Frank van Manen, U.S. Geological Survey.

Technical Assistance

Daniel Walsh provided training on wildlife health management in Warsaw, Poland, for National Focal Points for Wildlife from the countries composing the European Region of the World Organisation for Animal Health.

Sarah Sells continues to help the FWS and other collaborators with grizzly bear conservation through research, consultation, and invited talks.

Selected Publications

Ketz, A.C., Storm, D.J., Barker, R.E., Apa, A.D., Oliva-Aviles, C., and Walsh, D.P., 2023, Assimilating ecological theory with empiricism—Using constrained generalized additive models to enhance survival analyses: Methods in Ecology and Evolution, v. 14, no. 3, p. 952–967, accessed March 22, 2024, at https://doi.org/10.1016/j.biocon.2023.110206.

Sells, S.N., Costello, C.M., Lukacs, P.M., van Manen, F.T., Haroldson, M., Kasworm, W., Teisberg, J., Vinks, M.A., and Bjornlie, D., 2023, Grizzly bear movement models predict habitat use for nearby populations: Biological Conservation, v. 279, article 109940, 11 p., accessed March 22, 2024, at https://doi.org/10.1016/j.biocon.2023.109940.

Sells, S.N., Costello, C.M., Lukacs, P.M., Roberts, L.L, and Vinks, M.A., 2023, Predicted connectivity pathways between grizzly bear ecosystems in Western Montana: Biological Conservation v. 284, article 110199, 14 p., accessed March 22, 2024, at https://doi.org/10.1016/j.biocon.2023.110199.

Yao, K., Zhu, J., O'Brien, D.J., and Walsh, D., 2023, Bayesian spatio-temporal survival analysis for all types of censoring with application to a wildlife disease study: Environmetrics, v. 34, no. 8, article e2823, 13 p., accessed March 22, 2024, at https://doi.org/10.1002/env.2823.

Cooperators

U.S. Geological Survey; U.S. Fish and Wildlife Service; Wildlife Management Institute; University of Montana; and Montana Department of Fish, Wildlife and Parks.

Nevada
Cooperative Fish and Wildlife Research Unit

Scientists

Jeff Falke, Unit Leader; two vacancies

Meet the Unit

The Nevada Cooperative Fish and Wildlife Research Unit was established in 2021 and is located in the heart of the Great Basin. Jeff Falke reported as the Unit Leader shortly after the Unit was established, and is initiating productive research, graduate-student mentoring, and technical-assistance activities with Unit cooperators. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narrative follows this theme: Species of Greatest Conservation Need and threatened and endangered species.

Lower Rainbow Canyon, Nevada. Photograph by U.S. Geological Survey.

Research Projects

Habitat Suitability for Big Spring Spinedace (*Lepidomeda mollispinis pratensis*) in Meadow Valley Wash, Nevada

The Big Spring spinedace (*Lepidomeda mollispinis pratensis*) is a federally threatened minnow (Cyprinidae) with a distribution limited to a single 5-km (3.2 mile)-long stream reach in Meadow Valley Wash, Lincoln County, Nevada. Little is known about the life history, habitat requirements, or demographics of this species. In 1994, the U.S. Fish and Wildlife Service (FWS) set goals and objectives for recovery of Big Spring spinedace that included selection and establishment of refuge populations due to the vulnerability of the existing population to catastrophic events, human-induced habitat modification, and nonnative species introduction. FWS indicated that information collected on life history and habitat requirements could be used to evaluate potential refuges. This project is a collaboration among the Nevada Unit, FWS, and the Nevada Department of Wildlife. The research team is establishing criteria to evaluate Big Spring spinedace habitat suitability via a literature review and preassessment analysis. To assess habitat, the project plans to conduct flow permanence surveys, monitor water levels and temperatures, and survey occupied and potential reintroduction sites for habitat suitability. The research outcome may inform a prioritized list of sites that could be used as refuges for Big Spring spinedace in and around Meadow Valley Wash, Nevada.

Selected Publications

Bellmore, J.R., Sergeant, C.J., Bellmore, R.A., Falke, J.A., and Fellman, J.B., 2023, Modeling coho salmon (*Oncorhynchus kisutch*) population response to streamflow and water temperature extremes: Canadian Journal of Fisheries and Aquatic Sciences, v. 80, no. 2, p. 243–260, accessed March 22, 2024, at https://doi.org/10.1139/cjfas-2022-0129.

Sergeant, C.J., Bellmore, J.R., Bellmore, R.A., Falke, J.A., Mueter, F.J., and Westley, P.A.H., 2023, Hypoxia vulnerability in the salmon watersheds of Southeast Alaska: Science of the Total Environment, v. 896, article 165247, 12 p., accessed March 22, 2024, at https://doi.org/10.1016/j.scitotenv.2023.165247.

Cooperators

U.S. Geological Survey; U.S. Fish and Wildlife Service; Wildlife Management Institute; University of Nevada, Reno; and Nevada Department of Wildlife.

Pyramid Lake, Nevada. Photograph by U.S. Fish and Wildlife Service.

New Mexico
Cooperative Fish and Wildlife Research Unit

Scientists

James Cain, Unit Leader; Kasey Pregler, Assistant Unit Leader; Abby Lawson, Assistant Unit Leader

Meet the Unit

The New Mexico Cooperative Fish and Wildlife Research Unit is based in a culturally and ecologically diverse region of the United States. Ecosystems spanning from the Chihuahuan Desert to alpine tundra provide a wealth of research opportunities for scientists at the New Mexico Unit. Kasey Pregler joined the New Mexico Unit last year, and her laboratory uses genetic and modeling tools to improve fitness and aid in the conservation of imperiled freshwater fish populations. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: population monitoring and advanced modeling, hunting and fishing, predator-prey dynamics, Species of Greatest Conservation Need and threatened and endangered species, and decision science and structured decision-making.

Research Projects

Elk Demography, Movements, and Habitat Selection in the Mexican Wolf Recovery Area in Arizona and New Mexico

Elk (*Cervus canadensis*) population declines have been observed following wolf reintroduction or recolonization events. These population declines were attributed to the combined effects of hunter harvest, predation, and interactions with climatic events that lowered adult survival and recruitment. In addition, changes in the predator community composition have led to other nonlethal effects, such as changes in elk behavior and habitat selection, that may influence elk demographic rates. Baseline data on elk survival rates, cause-specific mortality, and habitat selection is limited for periods before the reintroduction of Mexican wolves (*Canis lupus baileyi*) in New Mexico and Arizona. The effects of Mexican wolf reintroduction on elk behavior, habitat selection, and demography are unknown due to a lack of data. This lack of data makes development of the most-informed management plans for elk in the Mexican wolf recovery area challenging. This study is a collaboration between the New Mexico Unit, Arizona Game and Fish Department, New Mexico Department of Game and Fish (NMDGF), and the U.S. Fish and Wildlife Service (FWS). In order to inform management plans for elk in Arizona and New Mexico, the research team plans to: (1) estimate cause-specific mortality and survival rates for juvenile and adult females, (2) estimate kill rates and prey composition of Mexican wolves, (3) assess effects of wolf activity on elk behavior and habitat selection, and (4) model elk populations with varying cause-specific mortality rates from predators and other mortality sources such as harvesting.

Mexican wolf (*Canis lupus baileyi*). Photograph by Julie Olson, New Mexico State University.

Identifying Environmental and Demographic Drivers of American Kestrel Population Declines to Inform Conservation Actions

American kestrels (*Falco sparverius*) have been steadily declining across their North American range for several decades. Kestrels are primarily associated with open country and grasslands, and grassland birds are among the most rapidly declining avian groups in North America. Although kestrels are among the most studied raptor species, previous studies on localized demographics have failed to identify broader causes of population declines. Continental-scale population analyses that use more data may offer insights into causes of kestrel population declines that can inform conservation actions. This project is a collaboration of researchers across multiple agencies, and includes the New Mexico Unit, FWS programs (National Raptor Program, Migratory Bird Management Southwest Region, and Migratory Birds), and the Cornell Lab of Ornithology. This research can be used to identify potential conservation actions to address causes of kestrel population declines as identified by the population models. The research team is using decision-analysis tools to identify regional-scale research priorities that could test the effectiveness of conservation actions and to help understand American kestrel population dynamics.

American kestrel (*Falco sparverius*). Photograph by Natalie Karouna-Renier, U.S. Geological Survey.

Technical Assistance

James Cain is a member of the U.S. Geological Survey (USGS) Corridor Mapping Team. The New Mexico Unit is leading efforts to map migration routes, stopovers, and seasonal ranges for migratory elk, mule deer (*Odocoileus hemionus*), and pronghorn (*Antilocapra americana*) populations in New Mexico.

In collaboration with the NMDGF, Kasey Pregler is coordinating the development of a GT-seq (genotyping-in-thousands by sequencing) marker panel to support future YY-brown trout (*Salmo trutta*) implementation efforts in New Mexico. These YY-brown trout have been genetically modified to only create male trout when reproducing.

Abby Lawson is working with a team of USGS scientists in the Southeast Climate Adaptation Science Center, Energy and Minerals Mission Area, and Wetland and Aquatic Research Center to develop an evaluation framework to inform National Park Service infrastructure investment decisions in relation to agency objectives, including mitigating risk against threats from climate change and other coastal hazards.

Selected Publications

Dunham, K.D., Devers, P.K., Lawson, A.J., Lyons, J.E., McGowan, C.P., and Royle, J.A., 2023, Strategic monitoring to minimize misclassification errors from conservation status assessments: Biological Conservation, v. 286, article 110260, 12 p., accessed March 22, 2024, at https://doi.org/10.1016/j.biocon.2023.110260.

Karish, T., Roemer, G.W., Delaney, D.K., Reddell, C.D., and Cain, J.W., III, 2023, Habitat selection and water dependency of feral burros in the Mojave Desert, California, USA: Journal of Wildlife Management, v. 87, no. 6, article e22429, 24 p., accessed March 22, 2024, at https://doi.org/10.1002/jwmg.22429.

Reddell, C.D., Roemer, G.W., Delaney, D.K., Karish, T., and Cain, J.W., III, 2023, Anthropogenic subsidies influence resource use during a mange epizootic in a desert coyote population: Oecologia, v. 201, p. 435–447, accessed March 22, 2024, at https://doi.org/10.1007/s00442-023-05328-7.

Stantial, M.L., Lawson, A.J., Fournier, A.M.V., Kappes, P.J., Kross, C.S., Runge, M.C., Woodrey, M.W., and Lyons, J.E., 2023, Qualitative value of information provides a transparent and repeatable method for identifying critical uncertainty: Ecological Applications, v. 33, no. 4, article e2824, 15 p., accessed March 22, 2024, at https://doi.org/10.1002/eap.2824.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, New Mexico State University, and New Mexico Department of Game and Fish.
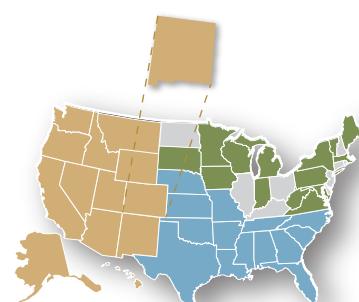
Scientists

Jim Peterson, Unit Leader; Melanie Davis, Assistant Unit Leader; Katie M. Dugger, Assistant Unit Leader; Megan Jones, Assistant Unit Leader

Meet the Unit

The Oregon Cooperative Fish and Wildlife Research Unit is located near many highly diverse ecosystems, from the Pacific Coast to the Cascade Mountains and from the lush landscape of the Willamette Valley to the high desert of the Great Basin. The wide assortment of projects conducted at the Unit reflects this proximity to diverse ecosystems and highlights the broad range of ecological skillsets Unit scientists have. As a four-person Unit that covers a wide spectrum of research expertise, the Unit can help with the many needs of its cooperators and provide research opportunities for graduate students. The Oregon Unit combines social, ecological, and biological sciences to explore questions about natural resource management from the ocean to the desert, and from rural to urban areas. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: diseases of fish and wildlife; decision science and structured decision-making; population monitoring and advanced modeling; invasive species; Species of Greatest Conservation Need and threatened and endangered species; wildfire; water allocation, drought, and ecological flows; and human dimensions.

Coho salmon (*Oncorhynchus kisutch*). Photograph by U.S. Fish and Wildlife Service.

Research Projects

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

Most natural resource problems are complex, and decision-makers and stakeholders often disagree on what the best decision might be to solve a problem. How decision-makers traditionally arrive at the decisions they make also may be difficult to explain and communicate to stakeholders and the general public, resulting in miscommunication and conflicts. A structured, adaptive approach to problem-solving can help by fostering better communication and knowledge transfer and with integration of new information for improved decision-making. This project is a collaboration with researchers and managers in multiple State and Federal agencies, including the U.S. Fish and Wildlife Service, the Bureau of Reclamation, the National Marine Fisheries Service, California Department of Fish and Wildlife, California Department of Water Resources, nongovernmental organizations, and local municipalities operating in the Central Valley of California. By using a structured decision-making process, decision-makers can develop and evaluate restoration strategies and identify factors that drive restoration decision-making. This approach can help focus and prioritize research and monitoring to reduce critical uncertainties and improve decision-making in restoration of systems in the Central Valley.

Native Fish Species Distribution and Population Status in Goose Lake Basin, Oregon

The Goose Lake basin is located in a desert valley that runs north-south on the border of Oregon and California. The basin's watersheds drain into Goose Lake, which is slightly alkaline and has historically dried up during severe drought years, such as 2015. Goose Lake drains into the Pit River to the south during very high-flow years. There are several endemic fish species that occupy Goose Lake and its adjacent rivers, marshes, and riparian areas: redband trout (*Oncorhynchus mykiss*), Goose Lake lamprey (*Entosphenus* spp.), Goose Lake tui chub (*Siphateles bicolor*), and Goose Lake sucker (*Catostomus occidentalis lacusanserinus*). These endemic species coexist with a variety of native and nonnative species. Because Goose Lake and its surrounding watershed are highly sensitive to drought conditions, an increased frequency of drought events in the region may limit the accessibility, quantity, and quality of available habitat for native fishes and putting stress on vulnerable species. The goal of this project is to aid agency partners in conducting a population assessment for at-risk native fish species in Oregon's closed lake-basin ecosystems, and to determine which ecosystems are most at risk of declining

fish populations due to disturbances such as drought or invasive species. This research is timely because consistent surveys have not been conducted in many of Oregon's high desert basins for more than a decade. Updated abundance and distribution estimates may inform State and Federal managers as to the population status of at-risk native species, while the population risk assessment can support actionable management outcomes.

Habitat Use and Survival of Ringtail in Southwest Oregon

The ringtail (*Bassariscus astutus*) is a small, secretive, omnivorous, nocturnal relative of the raccoon (*Procyon lotor*) that occurs in southwestern Oregon, which is the most northerly portion of the species range. Ringtail are listed as "Sensitive" and a Conservation Strategy species in Oregon, but relatively little is known about the demographics and ecology of this species in the State. Knowledge gaps for ringtail in Oregon include assessments of species distribution and abundance, demographics, and habitat use and selection across all life stages. This project was conducted in collaboration with researchers from the Oregon Department of Fish and Wildlife (ODFW). This research may aid in the development of a large-scale monitoring program for ringtail in Oregon, and will add to the basic understanding of ringtail ecology and demographics at the most northerly edge of their distribution.

Investigating Practitioner Organization Communication with Landowners About Human-Beaver Coexistence

American beavers (*Castor canadensis*) are landscape engineers. They create habitat for other species and change the landscape in ways that often help buffer ecosystems and people from the damaging effects of climate change, including drought, flood, and wildfire risks. In part because of these benefits, there is a movement to restore beaver and associated beaver-modified habitat on the landscape in Oregon. However, beaver introduction can also be controversial because of the damage they can cause to human structures and crops. As such, beavers are a useful case study for how to engage Oregonians in wildlife habitat restoration efforts while simultaneously trying to minimize human-wildlife conflict and promoting coexistence. In situations like these, social science can support engagement programs that are tailored to key audiences' needs, coordinated across organizations and agencies, and targeted at the specific moment when action is taken.
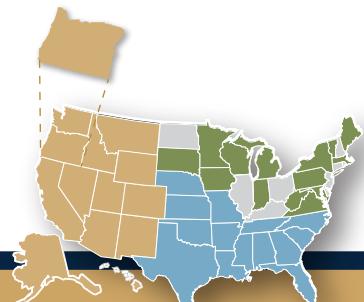
This project is working to answer the question: How can private landowners be supported to take coexistence actions that are mutually beneficial for their needs as well as those of beaver populations in Oregon? The research team is assembling a community of practice comprising groups to work with private landowners on human-beaver conflict management and beaver-modified habitat restoration. Collaborators are identifying best practices for landowner engagement (both tried and true strategies and creative new approaches), places in the process that are limiting landowner engagement, and opportunities to coordinate future outreach and engagement campaigns. Social science methods are being used to execute this project, combining baseline and follow-up interviews, facilitated workshops, and pre-post social network analysis. Results from this project may aid in wider discussion and adoption of human-beaver coexistence strategies among ODFW, the community of practice, other stakeholders and rightsholders, and the broader conservation science community. Results may also inform strategic implementation of ODFW's Beaver Habitat Action Plan in the future.

Technical Assistance

Jim Peterson created and hosts a bimonthly Oregon State University ODFW lunchtime seminar where students, faculty, and staff share their completed and ongoing research findings with State cooperators.

Melanie Davis assisted with an assessment of ODFW's Oregon Coast Coho 27-year monitoring program.

Adélie penguins (*Pygoscelis adeliae*). Photograph by Katie Dugger, U.S. Geological Survey.

Goose Lake redband trout (*Oncorhynchus mykiss* ssp.). Photograph by U.S. Geological Survey.

Megan Jones testified as part of a panel before the Oregon House Agriculture, Land Use, Natural Resources and Water Committee during Legislative Days. Panel testimony was intended to inform future policy-making related to funding nonlethal human-beaver conflict management and beaver habitat restoration.

Graduate Student Spotlight

Lindsay Somers, Master of Science in Wildlife Science, Oregon State University

Thesis title: "Ringtail (*Bassariscus astutus*) survival, home range size, and rest site use in southwest Oregon."

Lindsay Somers holds a ringtail (*Bassariscus astutus*). Photograph by Max McClarnon, used with permission.

Lindsay was hired by the Oregon Department of Fish and Wildlife almost a year before she graduated, and she works as the Regional Habitat Biologist in the John Day Watershed based in Pendleton, Oregon.

Selected Publications

Couch, C.E., Neal, T.W., Herron, C.L., Kent, M.L., Schreck, C.B., and Peterson, J.T., 2023, Gut microbiome composition associates with corticosteroid treatment, morbidity, and senesence in chinook salmon (*Oncorhynchus tshawytscha*): Scientific Reports, v.13, article 2567, 11 pp., accessed March 22, 2024, at https://doi.org/10.1038/s41598-023-29663-0.

Cronin, M.R., Zavaleta, E.S., Beltran, R.S., Payne, A., Termini, V., and Jones, M.S., 2024, Testing the effectiveness of interactive training on sexual harassment and assault in field science (Registered Report Stage 1 protocol): Scientific Reports [prepublication], posted January 8, 2024, accessed March 22, 2024, at https://doi.org/10.6084/m9.figshare.21770165.v1.

Davis, M.J., Anthony, J., Ward, E.J., Firman, J., and Lorion, C., 2023, Coherence among Oregon Coast coho salmon populations highlights increasing relative importance of marine conditions for productivity: Fisheries Oceanography, v. 32, no. 3, p. 293–310, accessed March 22, 2024, at https://doi.org/10.1111/fog.12630.

Jennings, S., Dugger, K.M., Ballard, G. and Ainley, D.G., 2023, Faster growth and larger size at crèche onset are associated with higher offspring survival in Adélie penguins: Ornithology, v. 140, no. 2, 11 p., accessed March 22, 2024, at https://doi.org/10.1093/ornithology/ukad006.

Jones, M.S., 2024, Integrating the human dimensions into fish and wildlife management depends on increasing managers' social science fluency: Human Dimensions of Wildlife, 8 p., accessed March 22, 2024, at https://doi.org/10.1080/10871209.2024.2301965.

Mikkelsen, A.J., Lesmeister, D.B., O'Reilly, K.M., and Dugger, K.M., 2023, Juvenile northern spotted owls with higher mass and intermediate levels of corticosterone have greater long-term survival: Ornithological Applications, v. 125, no. 3, article duad015, 13 p., accessed March 22, 2024, at https://doi.org/10.1093/ornithapp/duad015.

Steen, V.A, Duarte, A., and Peterson, J.T., 2023, An evaluation of multistate occupancy models for estimating relative abundance and population trends: Ecological Modelling, v. 478, article 110303, 9 p., accessed March 22, 2024, at https://doi.org/10.1016/j.ecolmodel.2023.110303.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Oregon State University, and Oregon Department of Fish and Wildlife.
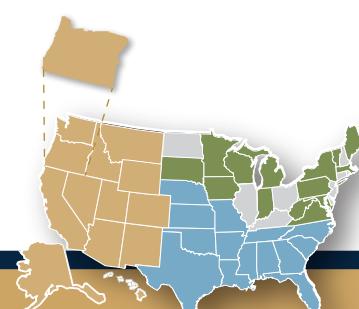
Utah

Cooperative Fish and Wildlife Research Unit

Scientists

Phaedra Budy, Unit Leader; Erica Stuber, Assistant Unit Leader; Chad Teal, Assistant Unit Leader

Meet the Unit

The Utah Cooperative Fish and Wildlife Research Unit is located in a State that is nearly 75 percent public land, and Unit cooperators include five Federal land and resource management agencies. The Utah Unit covers nine very different biomes, requiring both depth and breadth in ecological knowledge and expertise. The Utah Unit is nested in the Watershed Sciences Department (Phaedra Budy and Chad Teal) and Wildland Resources Department (Erica Stuber) at Utah State University. These departments have a diverse faculty who specialize in how physical drivers of aquatic habitats relate to individual behavior and genome research. The Utah Unit's scientists collaborate with faculty to deliver comprehensive research products to our State and other stakeholders. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: Species of Greatest Conservation Need and threatened and endangered species; water allocation, drought, and ecological flows; animal migration; population monitoring and advanced modeling; and invasive species.

Research Projects

Effects of Lake-Level Elevation Decline on Tui Chub, a Critical Forage Species for Lahontan Cutthroat Trout in Pyramid Lake, Nevada, USA

Lake-elevation decline is a global phenomenon with many consequences for lake ecosystems, including altering critical nearshore habitat used by animals that spawn in the lake and increasing total dissolved solids in the water. Changes to nearshore habitat resulting from lake-elevation decline are dependent on many factors,

although generally, nearshore habitat is simplified and shrinks in size as lake level declines. To understand the relationship between lake elevation and Tui chub (*Siphateles bicolor*) spawning potential, the research team investigated chub use of nearshore habitat during spawning, and quantified nearshore habitat available at lake elevations from a maximum elevation to desiccation. Based on the elevation model, it was determined that if Pyramid Lake elevation declines by an additional 26.2 feet (7.9 meters), the lake will contain the minimum quantity of nearshore habitat for Tui chub spawning, which is 40 percent less than a realistic theoretical maximum. Project results suggest further lake elevation decline would have negative consequences for Tui chub and consequently, the federally threatened Lahontan cutthroat trout (*Oncorhynchus clarkii henshawi*). Understanding other controls on Tui chub abundance provided in this study (for example, predation pressure) also may allow managers to alter Lahontan cutthroat trout hatchery supplementation in response to anticipated changes in Tui chub abundance based on lake-elevation fluctuations. Collaborators for this project include the U.S. Fish and Wildlife Service, Lahontan National Fish Hatchery Complex, Pyramid Lake Paiute Tribe of the Pyramid Lake Reservation, Nevada, and Desert Fishes Council.

Demography, Movement, and Population Dynamics of White Pelicans on Great Salt Lake

Despite recent apparent population rebounds, American White pelican (*Pelecanus erythrorhynchos*) are still considered a sensitive species across the Pacific Flyway, including in Utah. This project aims to continue deploying global positioning system transmitters on white pelicans to fill gaps in understanding of white pelican movement and space-use, including connectivity between

Lahonton cutthroat trout (*Oncorhynchus clarkii henshawi*). Photograph by Chad Melllison, U.S. Fish and Wildlife Service.

regional colonies, critical migratory routes, high-use breeding and foraging habitat, and airspace use within airport property. In the face of regional drought, climate uncertainty, and development affecting Great Salt Lake and other regionally imperiled habitats, filling these knowledge gaps may provide information to managers and researchers, thus aiding in conservation of white pelicans and other waterbird species. This project is a partnership among Utah State University, the University of Georgia, Utah Division of Wildlife Resources, the Salt Lake City International Airport, and the U.S. Geological Survey. The population dynamics model is informing environmental scenario planning for maintaining the Gunnison Island pelican population, and analyses of pelican airspace use can inform management plans to lower airstrikes in the airport airspace.

American white pelican (*Pelecanus erythrorhynchos*). Photograph by Steve Hillebrand, U.S. Fish and Wildlife Service.

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

Nonnative fishes can affect native fishes through competition for resources such as food, and by predation. Targeted removal of the most harmful nuisance species of nonnative fishes has always been challenging. However, advancing technology shows promise in manipulating the sex of fishes using hormones to produce all-male offspring with a YY chromosome complement ("supermales"). These supermales spawn with existing nuisance fishes and over time, can reduce or even eliminate their populations because all of their offspring are males. While supermales have been developed for several different species, efforts to develop supermales of some of the most damaging invasive fishes in the southwestern United States have not yet been established. The research team is examining feasibility of producing supermales of a common, short-lived, invasive nonnative species to the southwestern United States, the red shiner (*Cyprinella lutrensis*). Researchers are also examining the feasibility of creating supermales of some common, long-lived, invasive nonnative species to the southwestern United States, such as channel catfish (*Ictalurus punctatus*) or green sunfish (*Lepomis cyanellus*), to be selected in collaboration with sponsors. The team is also modeling the feasibility of integrated control of red shiner, channel catfish, and green sunfish, and other nonnative species using mechanical removal to reduce the population first, then stocking different rates of supermales to the population. This project is supported by the Bureau of Reclamation.

Technical Assistance

Phaedra Budy was an invited scientific expert for the Utah Wildlife Action Plan revision 2023–2024, providing external academic technical expertise. Budy also served as an invited scientific expert reviewer for the U.S. Fish and Wildlife Service, Species Status Assessment for the Rio Grande cutthroat trout (*Oncorhynchus clarkii virginalis*).

Erica Stuber has been active in supporting the 2025 revision of Utah's State Wildlife Action Plan through contributions to the Species of Greatest Conservation Need, Conservation Opportunity Areas, Landscape & Regional Focus, and Integration of Plants and Insects committees. Stuber is actively developing a novel data integration technique that leverages the strengths of structured surveys and semistructured citizen-science observations to improve spatial data coverage for Utah's avian Species of Greatest Conservation Need.

Chad Teal is assisting the Western Association of Fish and Wildlife Agencies to implement YY eradication strategies for invasive species that are affecting native species of high conservation concern. He is collaborating with State, Federal, and private companies to obtain Food and Drug Administration approvals by providing data and consulting on the novel use of exogenous hormone treatments for the development of YY fishes being released on the landscape.

Selected Publications

McLaren, J.S., Van Kirk, R.W., Budy, P., and Brothers, S., 2023, The scale-dependent role of submerged macrophytes as drift-feeding lotic fish habitat: Canadian Journal of Fisheries and Aquatic Sciences, v. 80, no. 9, p. 1533–1546, accessed March 22, 2024, at https://doi.org/10.1139/cjfas-2022-0182.

Remiszewski, T.T., Budy, P., and Macfarlane, W.W., 2023, Expansive, positive changes to a fish habitat diversity following the formation of a valley plug in a degraded desert river: River Research and Applications, v. 40, no. 1, p. 116–128, accessed March 22, 2024, at https://doi.org/10.1002/rra.4213.

Stillman, A.N., Howell, P.E., Zimmerman, G.S., Bjerre, E.R., Millsap, B.A., Robinson, O.J., Fink, D., Stuber, E.F., and Ruiz-Gutierrez, V., 2023, Leveraging the strengths of citizen science and structured surveys to achieve scalable inference on population size: Journal of Applied Ecology, v. 60, no. 11, p. 2389–2399, accessed March 22, 2024, at https://doi.org/10.1111/1365-2664.14512.

Teal, C.N., Schill, D.J., Bauder, J.M., Fogelson, S.B., Fitzsimmons, K., Stewart, W.T., Culver, M., and Bonar, S.A., 2023, The effects of estradiol-17β on the sex reversal, survival, and growth of red shiner and its use in the development of YY individuals: North American Journal of Aquaculture, v. 86, no. 1, p. 110–129, accessed March 22, 2024, at https://doi.org/10.1002/naaq.10314.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, Utah State University, and Utah Division of Wildlife Resources.
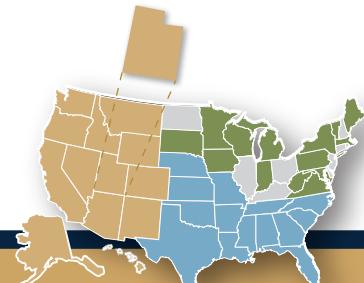
Scientists

Sarah Converse, Unit Leader; Alex McInturff, Assistant Unit Leader; Mark Scheuerell, Assistant Unit Leader

Meet the Unit

The Washington Cooperative Fish and Wildlife Research Unit has support from three State agency cooperators and two university cooperators. The Unit has a unique range of expertise in marine and terrestrial environments, including in population ecology, decision science, and social science, and in modeling and statistical analysis of spatial and temporal data. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: Species of Greatest Conservation Need and threatened and endangered species, decision science and structured decision-making, population monitoring and advanced modeling, human dimensions, and advanced technologies.

Research Projects

Assessing Threats to Cascade Red Foxes in Washington

The Cascade red fox (*Vulpes vulpes cascadensis*) is one of the rarest and most genetically distinct carnivores in North America. Currently, Cascade red fox appear to be absent from the North Cascades and are found primarily in Washington's South Cascades, including Mount Rainier National Park and the surrounding wilderness areas. A lack of information about threats to Cascade red fox and of a process for identifying and evaluating potential conservation actions is complicating efforts to conserve this State-endangered species. In this collaborative effort with partners, including the National Park Service and Washington Department of Fish and Wildlife, researchers are combining existing data and new radio-tracking data to understand the effects of threats on Cascade red fox movements and demography. Based on these results, the Unit is engaging partners

in a decision-making process to identify and evaluate management actions. This work is informing the ongoing conservation of Cascade red fox throughout their range in Washington, including development of a recovery plan.

Integrating Social Tolerance into Wolf Habitat Suitability Models

As gray wolves (*Canis lupus*) recolonize Washington State, their reintroduction to their historic range provokes strong, polarized responses in people living in the State. While many studies have investigated the reactions of people to wolves and wolf management, managing wolves and human-wolf interactions remains challenging. New methods in the environmental social sciences offer promise in revealing patterns in people's reactions to wolves and wolf management. In this study, the research team is working with the Washington Department of Fish and Wildlife using three social sciences methodological domains that are rarely applied in other science fields. These methodological domains are (1) studies of attitudes and perspectives over time in an area experiencing wolf recolonization, (2) mapping social phenomena to complement ecological understandings of habitat suitability and connectivity, and (3) including robust understandings of attitudes and values in science communication. Taken together, these methods may offer insights to human behavior and reaction to wolf recolonization at local and broad scales and may help identify systems under stress and to prioritize management. Support provided by this funding is helping to educate a graduate student investigator in these understudied research domains as part of their dissertation research.

Cascade red fox (*Vulpes vulpes cascadensis*). Photograph by U.S. Geological Survey.

Habitat of Shellfish Aquaculture Ecosystems: Developing New Technology to Understand Species Use of Nearshore Habitats

Washington is the nation's leading producer of farmed clams, oysters, and mussels, including Manila clam (*Ruditapes philippinarum*), Pacific oyster (*Magallana gigas*), and Pacific blue mussel (*Mytilus trossulus*). Farming shellfish contributes approximately $184 million to the Washington State economy, supports over 1,900 jobs, and supplies fresh shellfish to consumers around the globe. With such high cultural, economic, and ecological value, there is substantial demand for growth within the shellfish aquaculture industry. A key impediment to the sustainable expansion of shellfish aquaculture is understanding the ecological implications of converting nearshore habitats to shellfish production. Understanding how shellfish aquaculture functions in nearshore habitats relative to uncultivated areas may help resource managers overcome this barrier to expansion and to assess potential tradeoffs when planning sustainable expansion of shellfish aquaculture. The research team is collaborating with the National Marine Fisheries Service to examine feeding behavior of these species by using an extensive dataset of underwater video, and by determining trophic ecology (diet and isotopic analyses) from sampling sites in the Salish Sea. Results from this work may inform decisions about the introduction of aquaculture into a system composed of a diversity of seascapes, and where considerable management attention is invested in conserving species that rely on nearshore waters and these essential habitats.

Pacific oysters (*Crassostrea gigas*). Photograph by U.S. Geological Survey.

Technical Assistance

Sarah Converse and Alex McInturff teach an annual, two-day structured decision-making course to staff at the Washington Department of Fish and Wildlife; in 2023, this included the agency's Executive Management Team. In addition to providing decision science skills, this training provided a venue for important conversations about how science contributes to decision-making within the State agency.

Mark Scheuerell presented an informational seminar, "An overview of salmon conservation issues in the Pacific Northwest," to a group from the National Fisheries Institute, whose mission is to ensure that the media, consumers, and regulators have facts about seafood.

Selected Publications

Abrahms, B., Carter, N.H., Clark-Wolf, T.J., Gaynor, K.M., Johansson, E., McInturff, A., Nisi, A.C., Rafiq, K., and West, L., 2023, Climate change as a global amplifier of human–wildlife conflict: Nature Climate Change, v. 13, p. 224–234, accessed March 22, 2024, at https://doi.org/10.1038/s41558-023-01608-5.

Jaeger, W.K., and Scheuerell, M.D., 2023, Return(s) on investment—Restoration spending in the Columbia River Basin and increased abundance of salmon and steelhead: PLoS ONE, v. 18, no. 7, article e0289246, 21 p., accessed March 22, 2024, at https://doi.org/10.1371/journal.pone.0289246.

Kurz, D.J., Middleton, A.D., Chapman, M., Huber, B.R., McInturff, A., Sorgen, J., Van Houtan, K.S., Wilkinson, C.E., Withey, L., and Brashares, J., 2023, Including rural America in academic conservation science: Frontiers in Conservation Science, v. 4, article 1227227, 6 p., accessed March 22, 2024, at https://doi.org/10.3389/fcosc.2023.1227227.

Petracca, L.S., Gardner, B., Maletzke, B.T., and Converse, S.J., 2023, Merging integrated population models and individual-based models to project population dynamics of a recolonizing species: Biological Conservation, v. 289, article 110340, 12 p., accessed March 22, 2024, at https://doi.org/10.1016/j.biocon.2023.110340.

Warlick, A.J., Himes Boor, G.K., McGuire, T.L., Shelden, K.E.W., Jacobson, E.K., Boyd, C., Wade, P.R., Punt, A.E., and Converse, S.J., 2023, Identifying demographic and environmental drivers of population dynamics and viability in an endangered top predator using an integrated model: Animal Conservation, Early View [Online Version of Record before inclusion in an issue], posted October 6, 2023, 13 p., accessed March 22, 2024, at https://doi.org/10.1111/acv.12905.

Graduate Student Spotlight

Karl Veggerby, Master of Science, School of Aquatic and Fishery Sciences, University of Washington

Thesis title: "Shellfish aquaculture farms as foraging habitat for nearshore fishes and crabs in Puget Sound."

Karl is currently a consulting biologist with Anchor QEA in Seattle, Washington.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Washington, Washington State University, Washington State Department of Ecology, Washington Department of Fish and Wildlife, and Washington State Department of Natural Resources.

Scientists

Matt Kauffman, Unit Leader; Annika Walters, Assistant Unit Leader; Anna Chalfoun, Assistant Unit Leader

Meet the Unit

The Wyoming Cooperative Fish and Wildlife Research Unit is situated in a State with a high proportion of public lands and many fish and wildlife management issues. With only one university in the State, the Wyoming Unit plays a large role in training young professionals who go on to manage the State's fish and wildlife. The Wyoming Unit has developed close relationships with its collaborators and has a strong commitment to graduate education. Currently, the Wyoming Game and Fish Department does not have a research branch, so the Wyoming Unit works closely with the department to develop, implement, and communicate sound research and results. Although Unit scientists, research staff, and students study broadly applicable topics, the following project narratives follow these themes: animal migration, Species of Greatest Conservation Need and threatened and endangered species, population monitoring and advanced modeling, and diseases of fish and wildlife.

Research Projects

Mapping and Conserving Big Game Migration Corridors in Wyoming and Other Western States

In 2018, the U.S. Geological Survey (USGS) assembled a Corridor Mapping Team (CMT) to work with individual State wildlife agencies and other U.S. Department of the Interior partners to facilitate mapping of wildlife migration corridors and to develop a mapping report. The CMT is based out of the Wyoming Unit and includes key biologists in participating State agencies who provide expertise, statistical code, troubleshooting, metadata, and map templates as well as overall direction for this large-scale mapping effort. This collaborative effort includes the State wildlife agencies from 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. The CMT is developing products to address science and management needs related to understanding big-game use of corridor habitat, winter ranges, and stopover areas. A primary goal is to create a standardized inventory of big-game migration corridors in the western United States that can be used to inform conservation and management.

Evaluating the Role of Spring-fed Streams to Yellowstone Cutthroat Trout

Yellowstone cutthroat trout (*Oncorhynchus clarkii bouvieri*) populations have gone extinct locally or are in decline throughout most of their range because of habitat degradation, hybridization with nonnative species, and climate change. The need for diverse stream habitats—specifically, stable, spring-fed streams—for Yellowstone cutthroat trout survival in the Snake River watershed is not well-understood. Evaluating the role spring-fed streams play in maintaining Yellowstone cutthroat trout populations may help in directing and focusing conservation efforts in an era of global and regional environmental change. By developing a better understanding of the factors underlying Yellowstone cutthroat trout success in the upper Snake River watershed, this research may inform best approaches to

maintaining successful populations and population recovery in areas where Yellowstone cutthroat trout are in decline. The project is a collaborative effort among multiple agencies, including Grand Teton National Park, the Wyoming Game and Fish Department, the Wyoming Unit, and the University of Wyoming. The research team is also mapping predicted groundwater input to streams, estimated juvenile growth and production, and tributary contribution to the mainstem Yellowstone cutthroat trout population across the upper Snake River watershed. The results of this research may help prioritize habitat management strategies by highlighting streams where habitat work will have the most effect.

Infection Rates and Effects of Ectoparasites on Declining Sagebrush Songbirds

Sagebrush steppe ecosystems throughout western North America have been altered extensively by human activities, and many species that need sagebrush to survive have experienced significant population declines, such as many sagebrush songbirds. We are quantifying the rate of infection by parasitic bird blow flies (*Protocalliphora* spp. and *Trypocalliphora braueri*) in nestlings of declining sagebrush songbirds in relation to weather patterns and proximity to human disturbance. The project team is determining the extent to which parasite loads may be contributing to songbird declines by measuring nestling growth rate, offspring condition, rates of fledging, and post-fledging survival. The project is collaborative in nature, with funding from the U.S. Fish and Wildlife Service, USGS, Wyoming Landscape Conservation Initiative, and Wyoming Game and Fish Department. Results may inform the management and conservation of declining sagebrush-obligate songbirds for numerous State and Federal management agencies, with implications for land use and the effects of a changing climate.

Technical Assistance

Matt Kauffman worked with Grand Teton National Park to design and produce a 10-minute-long film highlighting ungulate migrations that move in and out of the Park. The film can be seen online here: https://vimeo.com/841366409.

Annika Walters led an alpine-lake ecology workshop at the Native American Summer Institute at the University of Wyoming. She also was an instructor for the Year-1 Teacher Research Knowledge Exchange that was focused on exploring the implications of changing flows in the Upper Snake River.

Anna Chalfoun helped initiate a new small grants program through the Conservation Committee of the American Ornithological Society that awards Latin American or Caribbean-based scientists conducting research related to avian conservation south of the United States border. Chalfoun also helped spearhead a new initiative at her host university, called University of Wyoming Bird Initiative for Resilience and Diversity (WYOBIRD), that focuses on avian research excellence, student education, and outreach.

Selected Publications

Baldock, J.R., Al-Chokhachy, R., Walsworth, T.E., and Walters, A., 2023, Redd superimposition mediates the accuracy, precision, and significance of redd counts for cutthroat trout: Canadian Journal of Fisheries and Aquatic Sciences, v. 80, no. 5, p. 825–839, accessed March 22, 2024, at https://doi.org/10.1139/cjfas-2022-0267.

Carlin, M., and Chalfoun, A.D., 2023, Congruence among multiple indices of habitat preference for species facing human-induced rapid environmental change—A case study using the Brewer's sparrow: Ecological Solutions and Evidence, v. 3, no. 4, article e12175, 10 p., accessed March 22, 2024, at https://doi.org/10.1002/2688-8319.12175.

Carlisle, J.D., Smith, K.T., Beck, J.L., Murphy, M.A., and Chalfoun, A.D., 2023, Beyond overlap—Considering habitat preference and fitness outcomes in the umbrella species concept: Animal Conservation, Early View [Online Version of Record before inclusion in an issue], posted September 12, 2023, 14 p., accessed March 22, 2024, at https://doi.org/10.1111/acv.12899.

Combrink, L.L., Rosenthal, W.C., Boyle, L.J., Rick, J.A., Mandville, E.G., Krist, A.C., Walters, A.W., and Wagner, C.E., 2023, Parallel shifts in trout feeding morphology suggest rapid adaptation to alpine lake environments: Evolution, v. 77, no. 7, p. 1522–1538, accessed March 22, 2024, at https://doi.org/10.1093/evolut/qpad059.

Ortega, A.C., Aikens, E.O., Merkle, J.A., Monteith, K.L., and Kauffman, M.J., 2023, Migrating mule deer compensate en route for phenological mismatches: Nature Communications, v. 14, article 2008, 10 p., accessed March 22, 2024, at https://doi.org/10.1038/s41467-023-37750-z.

Cooperators

U.S. Geological Survey, U.S. Fish and Wildlife Service, Wildlife Management Institute, University of Wyoming, and Wyoming Game and Fish Department.

Sagebrush sparrow (*Artemisiospiza nevadensis*). Photograph by Tom Koerner, U.S. Fish and Wildlife Service.
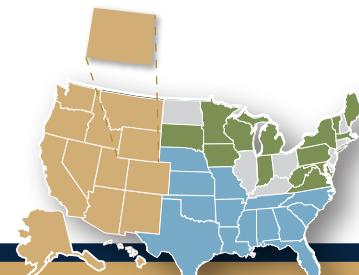
Doris Duke Conservation Scholars Program scholars Matthew Mayer and Woods Nystedt, Forest Service interns Malik Scott and Catrina Alberts, mentor Kaitlyn Gahl, and Scott Bonar pose after conducting snorkeling and habitat surveys in West Clear Creek, Arizona. Photograph by Kaitlyn Gahl, University of Arizona.

Graduate students, technicians, and Doris Duke Conservation Scholars Program scholars working on a fish trial for yellow lampmussel (*Lampsilis cariosa*). Photograph by Stefanie Farrington, University of Massachusetts.