MISSOURI COOPERATIVE
FISH & WILDLIFE RESEARCH UNIT REPORT

July 2012-October 2014

Cooperating Agencies:

U. S. Geological Survey
U. S. Fish and Wildlife Service
Missouri Department of Conservation
University of Missouri
Wildlife Management Institute

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MISSOURI COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

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The Unit Annual Report has been produced for over 30 years and includes information from Unit Scientists and projects through the Unit to other scientists, and also includes the Department of Fisheries and Wildlife Sciences. If you desire any additional information, please contact Niki Fuemmeler at our address.

Above: Portrait of Aldo Leopold to Rudolf Bennitt (acting leader of the Missouri Unit, 1947-1948): “With high hopes for the Missouri Unit.”
Front cover: Fountain Grove Conservation Area sunrise.

The Tradition of the Missouri Unit

Amanda Rosenberger (AUL-Fish) | Lisa Webb (AUL-Wildlife) | Craig Paukert (UL) | Niki Fuemmeler (Admin Officer)

Conservation and management of natural resources has changed since the Missouri Unit first became established in 1937. Our long history is linked with the Missouri Department of Conservation and the fish and wildlife program at the University of Missouri. This will be the first report in over 10 years that the Unit is fully staffed and all Unit scientists have well-established research programs. In these lean times, filling vacancies in the Unit Program has been difficult, and being fully staffed is a testament to the cooperators push to fill our vacancies.

The first Unit Quarterly Report, dated April 19, 1938 showed a strong research focus on game management, particularly quail, turkey, and whitetail deer (and even a survey on wolf and coyote damage in Missouri). In the 2014 report there are Unit research projects related to climate change, endangered and invasive species, amphibian sampling protocols, mussel and crayfish conservation, in addition to more traditional management such as evaluation light goose harvest, methods to determine waterfowl abundance, and habitat improvements in reservoirs. In addition, some funding sources for our research are different now than in years past. We currently have several projects meeting the needs of US Fish and Wildlife Service Landscape Conservation Cooperatives and the US Geological Survey Climate Change and Wildlife Science Centers. The diversity of research with more emphasis on non-game species, species diversity, and landscape-level planning demonstrates how we adapt to meet the needs of the cooperators. Although the projects may be different than the projects from 75 years ago, the themes of conducting applied research to meet the needs of the cooperators remains the same.

These are also changing times within the University of Missouri. Budgets remain tight with no intention to fill retirements or other vacancies in applied conservation and management. There is also a strong emphasis to attract faculty that increase our American Association of Universities status, which typically means faculty linked to National Science Foundation and/or National Institute of Health funding. The University of Missouri is not unique with these challenges and other universities follow similar trends. What does this mean to the Missouri Unit? For now it means our role in the Fisheries and Wildlife Sciences Department will remain substantial. Unit scientists currently supervise about 40% of all graduate students in the Department, and Unit scientist are the only faculty with graduate students in fisheries. This trend will likely continue in the future, as the Unit continues to serve the cooperators by conducting applied research, mentoring students, and teaching courses relevant to cooperator needs.

THE MISSOURI COOP UNIT

The Cooperative Research Units program is comprised of 40 Units in 38 states. Each Unit is a formal partnership among the U.S. Geological Survey, a State natural resource agency, a host university, the Wildlife Management Institute, and the U.S. Fish and Wildlife Service. The structure of the program provides Federal and State agencies access not only to Unit scientists, but also to facilities and expertise available at the cooperating universities. Because Unit scientists and university faculty members possess diverse areas of expertise, the program collectively embraces a wide variety of disciplines related to fish, wildlife, and natural resource management.

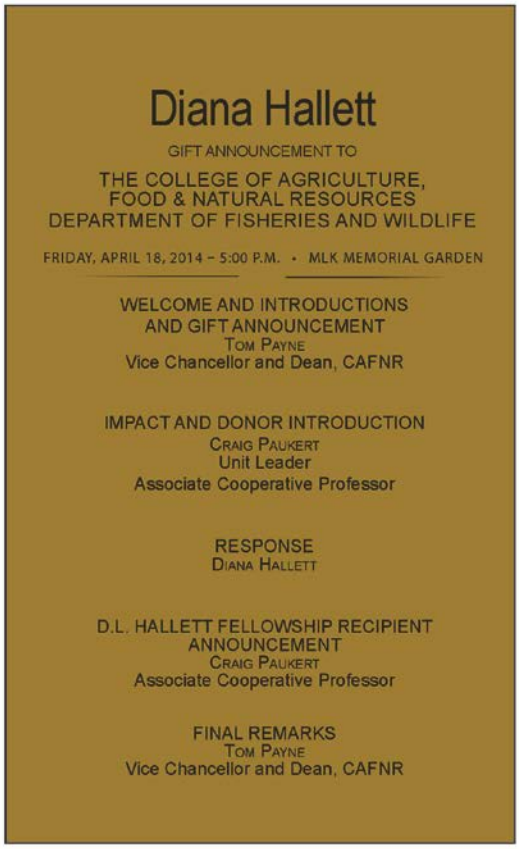
The Missouri Unit is a productive member of the Unit program. Our history began in 1936 when the citizens of Missouri voted to amend the State's constitution to create a politically independent Conservation Commission. The first official act of the Conservation Commission was to establish a Cooperative Wildlife Research Unit at the University of Missouri. Objectives were settled upon quickly and were "*to conduct scientific research on the wildlife of Missouri"* and "*to educate students, both in technical phases of wildlife management and general aspects of wildlife conservation.*" We have grown by adding a Fishery Unit in 1962, consolidated by becoming a single Fish and Wildlife Unit in 1985, and moved from the U.S. Fish and Wildlife Service to the National Biological Survey to the U.S Geological Survey. Through it all we have remained true to these early guiding principles.

Projects conducted by our Unit address the expressed information needs of the Missouri Department of Conservation, the U.S. Geological Survey, and other state and federal agencies. The needs of the University of Missouri, also a primary cooperator, are met by assisting with the education mission of the University at the graduate level. The Unit assists University cooperators in various ways, including sharing Unit resources and by administering USGS and other federal funds through the Research Work Order process.

The diversity of fish and wildlife resources in Missouri requires the Unit to pursue a broad focus for research studies, although waterfowl ecology, big river ecology and management, and stream fishery resources have long been emphasized. An attempt is made to complement and strengthen existing research thrusts of state and federal agencies. The concern of all cooperators is that Unit research be productive, of high quality, and ultimately useful to the management of fish and wildlife resources of the state and region.

The D. L. Hallett Fellowship Fund

In 2013, the Missouri Unit was honored when former Unit student, Diana Hallett developed a fellowship fund specifically for students affiliated with the Missouri Unit conducting wildlife research. This fellowship shows that the reputation of the Missouri Unit is strong, and is a testament to our long legacy of providing quality students that become very successful members of the conservation community. It is also a reminder to current Unit students and staff that we have an obligation to continue to conduct quality research and produce students that will be future leaders in conservation. We sincerely thank Diana Hallett and her husband, Larry Hall, for their contributions and trust in the Missouri Unit and the University of Missouri.



Diana Hallett and husband Larry Hall

Diana is giving back to her alma mater with a planned gift to the D.L. HallettFellowship Fund for graduate students in the Missouri Cooperative Fish and Wildlife Research Unit in The School of Natural Resources. She received the Bachelor of Arts in Biological Sciences from MU in 1973, and the Master of Science in Fisheries and Wildlife Sciences from MU in 1977. Diana had a career in conservation that spanned several states. She also served her professional organization-The Wildlife Society-for over two decades and was the first woman to be elected president. Diana retired after a career with the Missouri Department of Conservation and is currently a floral designer in Ashland.

D.L. Hallett Fellowship

One or more annual awards shall be made to wildlife graduate students in the MissouriCooperative Fish and Wildlife Research Unit, in the School of Natural Resources. This/these students must be member(s) of either the Missouri or Student Chapter of the Wildlife Society.

UNIT AND COOPERATOR PERSONNEL ROSTER

Permanent Unit Personnel

Craig Paukert, Unit Leader
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Niki Fuemmeler, Administrative Officer
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University of Missouri Collaborators

Fisheries and Wildlife Sciences Faculty

David Diamond
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*John R. Jones
*Joshua J. Millspaugh
Douglas B. Noltie
Mark R. Ryan
*Joanna Whittier
*John Faaborg
Robert S. Hayward
*Dylan Kesler
*Charles H. Nilon
Robert A. Pierce II
*Frank R. Thompson III

*Projects and activities in this report

Faculty From Other Departments

*Lori Eggert, Biological Sciences
Rico Holdo, Biological Sciences
*Ray Semlitsch, Biological Sciences
*Fred vom Saal, Biological Sciences
Jason Hubbart, Forestry
Cheryl Kelley, Geological Sciences
Mike Urban, Geography
Sonja Wilhelm-Stanis, Parks, Rec., & Tourism
Keith Goyne, Soil, Env., & Atmos. Sciences
*Scott Holan, Statistics
Chris Wilke, Statistics

Unit Coordinating Committee

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COURSES TAUGHT BY MISSOURI UNIT STAFF AND AFFILIATES

One aspect of the Cooperative Agreement that established the Missouri Cooperative Fish and Wildlife Research Unit is that each Unit Scientist teaches up to one graduate course in their area of expertise each year. Below is a summary of the courses taught by Unit Scientists and affiliates from fall 2012 to fall 2014. In addition to these courses, Unit scientists and staff guest lectured eight times in Fish and Wildlife Colloquium, Wetland Ecology, Ecosystem Management, Fisheries Management, and Advanced Fisheries Science from 2012-present.

Course	Credits	Instructor	Semester	Undergrad. Enroll.	Grad. Enroll.
FW 8460: Wetland Ecology	3	L. Webb	Fall 2014	1	10
FW 8520: Stream Ecology	3	A. Rosenberger	Spr 2014	0	6
FW 8001: Advanced Fisheries Science	3	C. Paukert	Spr 2014	3	5
FW 4880/7880: Waterfowl Ecology	3	L. Webb	Spr 2014	16	3
FW 8001: Movement Ecology	1	*W. Beatty	Spr 2014	0	9
FW 8001: Applied Conservation Genetics	1	*K. Klymus	Fall 2013	0	8
FW 4880/7880: Waterfowl Ecology	3	L. Webb	Spr 2012	7	0
FW 8001: Crayfish and mussel ecology	1	*J. Westhoff	Fall 2012	0	4
FW 8085: Quantitative Fish Assessment	1	C. Paukert	Fall 2012	0	1
FW 4950: Undergraduate research	1-2	Paukert/Webb	multiple	3	0
Total				30	46

*Post doctoral research associates advised by Unit Scientists

Field trip to Otter Slough Conservation Area for the Waterfowl Ecology course.

GRADUATE STUDENTS

2012 TO PRESENT

ADVISED BY UNIT SCIENTISTS

**Student received degree during the report period.*

Name	Research Project	Previous Education	Advisor
Leslie Crawford, M.S.	Development of standardized visual sampling methods for assessing community metrics of unionoid mussel species and tribal groups in Missouri.	B.S. University of Missouri	Dr. Rosenberger
Jackie Dearborn, M.S.	Habitat use for roosting and foraging by maternity colonies of Indiana bats (*Myotis sodalist*).	B.S. Muhlenberg College	Drs. Webb and Amelon
*Andy Dinges, M.S.	Effects of the Light Goose Conservation Order on Waterfowl Distribution and Behavior in the Rainwater Basin.	B.S. University of Nebraska	Dr. Webb
Corey Dunn, Ph.D.	Development of sampling protocols for mid-sized rivers.	B.S. and M.S. Virginia Tech University	Dr. Paukert
Jake Faulkner, M.S.	Seasonal habitat selection of Niangua darters.	B.S. University of Missouri	Dr. Paukert
Drew Fowler, PhD.	Body condition of harvested snow geese during the Light Goose Conservation Order.	B.S. Texas A&M University M.S. Louisiana State University	Dr. Webb
Julia Guyton, M.S.	Development of fish and amphibian rapid assessment protocol for wetlands: linking management to wetland processes.	B.A. Birmingham-Southern College	Drs. Paukert and Webb
*Jason Harris, M.S.	Movement and habitat selection of largemouth bass in Table Rock Lake.	B.S. South Dakota St. University	Dr. Paukert
Brian Hidden, M.S.	Linking waterfowl distribution and abundance to spatial and temporal distribution and abundance of wetland habitat.	B.S. Oklahoma State University	Dr. Webb
Evan Hill, M.S.	Linking wetland management	B.S. Gustavus Adolphus	Dr. Webb

	decisions to distribution, habitat use and nesting efforts of secretive marsh birds in Missouri.	College	
Ethan Kleekamp, M.S.	Identifying reference reaches for MO streams.	B.S. Truman State University	Dr. Paukert
Meagan Montgomery, M.S.	Fish use of passage facility and seasonal wetland pools at Eagle Bluffs Conservation Area (EBCA).	B.S. University of Missouri	Dr. Galat
Rory Mott, M.S.	Thermal Preferences and water quality tolerances of the endangered Topeka shiner.	B.S. Eastern Illinois University	Dr. Rosenberger
Sean O'Daniels, M.S.	Ultraviolet vision in woodpeckers.	B.S. Graceland College	Drs. Kesler and Webb
Emily Pherigo, M.S.	Role of tributaries for large river fish recovery.	B.S. Knox College	Dr. Paukert
Landon Pierce, Ph.D.	Conservation planning of fishes in the Colorado River basin.	B.S. University of Nebraska M.S. South Dakota St. University	Dr. Paukert
Travis Schepker, M.S.	Food resource availability for spring migratory waterfowl at mid-latitudinal wetlands.	B.S. University of Missouri, Columbia	Dr. Webb
Matthew Schrum, M.S.	Development of standardized and validated visual sampling methods for assessing population metrics and recruitment of rare and threatened mussels species in Missouri.	B.S. University of Missouri	Dr. Rosenberger
Jacob Schwoerer, M.S.	Assessment of climate change vulnerability to aquatic biota in National Parks.	B.S. University of Wisconsin-Stevens Point	Dr. Paukert
Nick Sievert, M.S.	Assessing protected areas in conserving biodiversity in the face of climate change.	B.S. University of Wisconsin-Madison	Dr. Paukert
*Jessi Tapp, M.S.	Waterbird use and food availability on Wetland Reserve Program sites enrolled in the Migratory Bird Habitat Initiative.	B.S. Murray State University	Dr. Webb

POST DOCTORAL RESEARCH ASSOCIATES AND RESEARCH STAFF

**Staff moved on during the report period.*

Name	Research Project	Previous Education	Advisor
*Dr. William Beatty	Movements and habitat selection of mid-continent Mallards.	B.S. University of Missouri M.S. Eastern Illinois University PhD. Purdue University	Drs. Webb and Kesler
Dr. Kristen Bouska	Importance of floodplains under climate change; modeling native in the Meramec River drainage.	B.S. University of Wisconsin – La Crosse M.S. Kansas State University PhD. Southern Illinois University	Drs. Paukert and Rosenberger
*Dr. Katy Klymus	Validation of eDNA as a tool for Asian carp detection.	B.S., University of Texas Ph.D. University of Missouri	Dr. Paukert
*Dr. Damon Krueger	Effects of climate change on stream fish in the Northeast US.	B.S. University of Wisconsin-Madison M.S. University of Minnesota-Duluth Ph.D. University of Michigan	Dr. Paukert
Dr. Garth Lindner	Modeling of channel stability in the Meramec River drainage to inform niche models of mussel concentrations; Importance of floodplains under climate change.	B.A. Indiana University M.S. Indiana University PhD. University of Maryland	Drs. Paukert and Rosenberger
Ryan Lueckenhoff	Effects of DO on aquatic biota.	B.S. University of Missouri M.S. University of Nebraska	Dr. Paukert
Ruth Ann Martin	Thermal Preferences and Water Quality Tolerances of the endangered Topeka shiner.	B.S. University of Missouri	Dr. Rosenberger
Emily Tracy-Smith	Evaluation of ecological flows for Missouri.	B.S. University of Florida M.S. University of Missouri	Dr. Paukert

*Dr. Michelle Staudinger	Effects of climate change on biodiversity.	B.S., Boston University M.S., Stony Brook University Ph.D. University of Massachusetts	Dr. Paukert
Dr. Jacob Westoff	Life history of the freckled crayfish, *Cambrus maculatus*.	B.S. University of Missouri M.S. Tennessee Technological University PhD. University of Missouri	Dr. Rosenberger
Dr. James Whitney	Effects of climate change on fishes.	B.S. Emporia St. University M.S. Kansas St. University Ph.D. Kansas St. University	Dr. Paukert

Corey Dunn, PhD student, with a shovelnose sturgeon from the Gasconade River.

GRADUATE STUDENTS

2012 TO PRESENT

ADVISED BY FISH AND WILDLIFE DEPARTMENT FACULTY

**Student received degree during the report period*

Name	Thesis Project	Previous Education	Advisor
Andrew Alba, M.S.	Captive breeding of Micronesian Kingfishers.	B.S. St. John Fisher College	Drs. Kesler and Strauch
*Amy Bleisch, M.S.	Ecology of elk reintroduced to Missouri.	B.S. Cornell University	Dr. Millspaugh
Thomas Bonnot, PhD.	Large scale population viability modeling.	B.S. University of Missouri M.S. University of Missouri	Drs. Millspaugh and Thompson
Michael Burfield, PhD.	Biodiversity and campus planning.	B.S. University of Cincinnati M.S. University of Missouri	Dr. Nilon
Wesley Buchheit, M.S.	Land management and resilience to climate change.	B.S. Southeast Missouri State University	Drs. Nilon and Pierce
* Kaylan Carrlson, M.S.	Survival, habitat use, and movement of resident and translocated greater prairie-chickens.	B.S. Cornell University	Dr. Kesler
* Jenny Cunningham, M.S.	Nest site selection in arctic breeding shorebirds: effects of habitat, social factors, and experience	B.S. University of New England	Dr. Kesler
Michael Farber, M.S.	Tallgrass prairie restoration in Forest Park.	B.S. Northern Michigan University	Dr. Nilon
Eric Fischel, M.S.	Land management and resilience to climate change.	B.S. Johns Hopkins University	Drs. Nilon and Pierce
Aleshia Fremgen, M.S.	Sage-grouse and wind energy in Wyoming.	B.S. Western State College of Colorado	Dr. Millspaugh
Lianne Hibbert, PhD.	Cultural aspects of conservation in St. Lucia.	B.S. Grambling State University M.S. University of Missouri	Dr. Nilon

*Jonathan Hogg, M.S.	Ecology of urban raptors.	B.S. University of Idaho	Dr. Nilon
*David Jachowski, PhD.	Movements and physiology of translocated elephants.	B.S. University of Montana M.S. University of Missouri	Dr. Millspaugh
Barbara Keller, PhD.	Forage production and overlap of ungulates.	B.S. Northland College M.S. New Mexico State University	Dr. Millspaugh
Jesse Kolar, PhD.	Effects of energy development on mule deer in North Dakota.	B. S. University of Montana M.S. University of Missouri	Dr. Millspaugh
Jaymi LeBrun, PhD.	Managing wildlife in the face of a changing climate.	B.S. University of Wisconsin (Madison) M.S. Iowa State University	Drs. Millspaugh and Thompson
Elizabeth Matseur, M.S.	Black-backed woodpecker density.	B.S. University of Delaware	Drs. Millspaugh and Thompson
Matthew McCloud, M.S.	Muskrats in an urban wetland.	B.S. University of Missouri MBA Webster University	Dr. Nilon
* Pablo Olerio, M.S.	Avian population responses to anthropogenic landscape changes in Pohnpei, Federated States of Micronesia.	B.S. University of Minnesota	Dr. Kesler
Sean O'Daniels, M.S.	Ultraviolet vision in woodpeckers.	B.S. Graceland College	Drs. Kesler and Webb
*Christopher Rota, Ph.D.	Population ecology and demographics of black-backed woodpeckers.	B.S. University of Montana M.S. University of Florida	Dr. Millspaugh
*Leslie Schreiber, M.S.	Sage-grouse and wind energy in Wyoming.	B.S., Purdue University	Dr. Millspaugh
Trenton Smith, M.S.	Ecology of elk reintroduced to Missouri.	B.S. Auburn University	Dr. Millspaugh
* Richard Stanton, M.S.	Habitat selection of brown-headed nuthatches at multiple spatial scales.	B.S. State University of New York at Cobleskill	Drs. Kesler and Thompson
*Stephanie Zimmer, M.S.	Effects of commercial harvest on turtles in the Missouri River.	B.S. Michigan State University	Dr. Millspaugh

Kathryn M. Womack, PhD.	Habitat and management effects on foraging activity of Indiana Bats (*myotis sodalis)* in northern Missouri.	M.S. University of Missouri	Dr. Thompson

M.S. student Trent Smith with a reintroduced Missouri elk.

POST DOCTORAL RESEARCH ASSOCIATES AND RESEARCH STAFF

Name	Research Project	Previous Education	Advisor
Dr. Aniruddha Belsare	Modeling chronic wasting disease.	B.S. and A.H., Bombay Veterinary College Ph.D. University of Missouri	Drs. Millspaugh and Gompper
Dr. Kun Cheng	Climate conditions and waterfowl nesting.	B.S. Northeast Forest University M.S. Northeast Forest University PhD. Northeast Forest University	Dr. Kesler
Dr. Robert Gitzen	Development of an inventory and monitoring plan for the Northern Great Plains and MOFEP small mammal and amphibians.	B.S. University of Minnesota M.S. University of Washington PhD. University of Washington	Dr. Millspaugh
Dr. Elizabeth Kalies	Processes affecting wildlife distribution.	B.S., Cornell University M.S., Yale University Ph.D., Northern Arizona University	Dr. Millspaugh and Kays
Dr. Barbara Keller	Ecology of elk reintroduced to Missouri.	B.S., Northland College M.S., New Mexico State University Ph.D., University of Missouri	Dr. Millspaugh
Dr. Ann McKellar	Range-wide analysis of red-cockaded woodpecker habitat and movement.	B.S. Queen's University M.S. McGill University PhD. Queen's University	Dr. Kesler
Dr. Jon McRoberts	White-tailed deer demographics and space use.	B.S. University of Missouri M.S. Texas Tech University Ph.D. Texas Tech University	Dr. Millspaugh
Dr. Robert Montgomery	Processes affecting wildlife distribution.	B.S., University of Minnesota M.S., University of Washington Ph.D., Michigan State University	Dr. Millspaugh
Dr. Christopher Rota	Demographics of wildlife populations.	B.S. University of Montana M.S. University of Florida Ph.D. University of Missouri	Dr. Millspaugh
Dr. Sarah Saalfeld	Climate change effects on arctic breeding shorebirds.	B.S. Thomas More College M.S. Auburn University PhD. Stephen F. Austin State University	Dr. Kesler

RESEARCH PROJECTS

Graduate students Matt Schrum and Leslie Crawford with technicians ready for mussel sampling.

PROJECTS WITH UNIT SCIENTIST AS PRINCIPLE INVESTIGATOR

DR. DAVID GALAT

FISH USE OF PASSAGE FACILITY AND SEASONAL WETLAND POOLS AT EAGLE BLUFFS CONSERVATION AREA

Investigators
Dr. David Galat, MU
Meagan Montgomery, M.S. student, MU

Project Supervisor
Dr. David Galat, MU

Funding
Missouri Department of Conservation

Cooperators
Missouri Department of Conservation
U.S. Geological Survey

Objectives
Predict fish species that potentially access wetland pools based on distribution, habitat-use guilds, spawning temperature ranges, and river water temperature.

Model stage relationship between lower Missouri River and Eagle Bluffs Conservation Area to predict connectivity.

Determine if similar water temperature exist during periods of LMOR-EBCA connectivity and isolation.

Quantify ingress and egress of pooled and selected Missouri River fishes through the fish passage facilities.

Determine how physiochemical variables of the wetland pool compare growth and mortality of riverine fishes.

Estimate growth of selected fish species.

Location
Eagle Bluffs Conservation Area

Expected Completion
May 2015

Status
In Progress

Progress and Results
Restoration projects are being undertaken along many large floodplain rivers, including the lower Missouri River (LMOR), to mitigate past channelization and levee construction that severed river-floodplain connectivity and denied riverine fishes access to seasonally flooded wetlands. As part of the Missouri River Mitigation Program, two wetland pools were constructed with water-control structures designed for controlled passage experiments at Eagle Bluffs Conservation Area (EBCA); these provided our research site. The fundamental objective of our research was to strengthen scientific understanding of relationships among flow dynamics, lateral connectivity, and fish movement and incorporate this knowledge into proposed strategies for enhancing an adaptive, ecosystem management approach to river-floodplain wetlands. This objective was accomplished by collecting hydrologic and ecological data during eleven connectivity events in the spring/summer of flood years 2007 and 2008, then applying that data to sixteen means objectives to address two conceptual models, two management points of interests, and seventeen hydroecological questions. Over 60 species, including both native and invasive fishes, used the pools during the two years. Size structures of the majority of these species were <200 mm during egress events. Export biomass > 1.0 kg/h was recorded for 7 taxa in 2007 and for 12 taxa in 2008, with *Lepisosteus platostomus*, *Hypophthalmichthys* spp., *Dorosoma cepedianum, Cyprinus carpio*, and *Ctenopharyngodon idella* exporting the largest biomasses each year (7-597 kg/h). This is one of the few studies to quantify biomass export to a large river from a floodplain wetland and it clearly demonstrates the importance of such wetlands to annual recruitment. Our results show how river-floodplain connections benefit recruitment of both favored native species and invasive Asian carp. Such knowledge could guide management and conservation efforts to promote and regulate targeted fish species.

DR. CRAIG PAUKERT

MANAGING THE NATIONS FISH HABITAT AT MULTIPLE SPATIAL SCALES IN A RAPIDLY CHANGING CLIMATE

Investigators
Dr. Craig Paukert, MU
Dr. Joanna Whittier, MU
Dr. Allison Pease, post doc, MU
Dr. Dana Infante, Michigan St. U.
Dr. Steve Hostetler, USGS
Dr. Lucinda Johnson, U. of MN-Duluth
Dr. Ty Wagner, Penn St. U.
Dr. Lizhu Wang, Int'l Joint Commission
Dr. Julian Olden, U. of Washington
Dr. Don Pereria, Minnesota DNR
Mr. Pete Jacobson, Minnesota DNR
Mr. Gary Whelan, Michigan DNR
Dr. Bryan Pijanowksi, Purdue U.
Plus 9 post docs and PhD students nationwide

Project Supervisor
Dr. Craig Paukert

Funding
USGS, National Wildlife Climate Change Science Center
RWO 107

Cooperators
National Fish Habitat Initiative

Objectives
What aquatic habitats need conservation as climate and land use changes?

How will climate change affect growth and consumption of smallmouth bass?

Location
Nationwide

Completion
March 2013

Status
Complete

Progress and Results
We used downscaled Atmosphere-Ocean General Circulation Models and projected land use models to identify how future climate and land use will impact the vulnerability of fish and fish habitat at national, regional, and local scales. To project future land uses, we simulated changes in both agricultural and urban areas within stream and river catchments across the conterminous United States using the Land Transformation Model. Changes in land use have been projected to 2040 and climate simulations are complete for much of the conterminous US for 1968 – 1999 and 2010 – 2100. At the regional level, we have sufficient stream temperature and flow data to develop water temperature and flow models for the Midwest Glacial Lakes and Northeast regions but not for the Desert Southwest. Finally, bioenergetics was used to estimate the effects of climate change on smallmouth bass (SMB) growth and consumption in stream s in Oklahoma, Missouri, Iowa, and Minnesota. Growth potential is predicted to increase by 3 to 17% if not limited by food availability with stream warming by 2060, and was most pronounced for southern populations. For each 1°C increase in stream temperature, SMB consumption would be expected to increase by about 27% and growth would increase by about 6%. Due to implications for species interactions, population performance and regulation of local fisheries, a better understanding of how SMB populations will respond to climate change is recommended for effective management and conservation.

Products:
Pease, A.A., and C. P. Paukert. 2013. Potential impacts of climate change on growth and prey consumption of stream-dwelling smallmouth bass in the central United States. Ecology of Freshwater Fish. doi: 10.1111/eff.12084.

MOVEMENT AND HABITAT SELECTION OF LARGEMOUTH BASS: IMPLICATIONS FOR RESERVOIR FISH HABITAT IMPROVEMENTS

Investigators
Dr. Craig Paukert, MU
Jason Harris, M.S. student, MU
Shane Bush, MDC
Mike Allen, MDC
Mike Siepker, MDC

Project Supervisors
Dr. Craig Paukert, MU

Funding
MDC

Cooperators
National Fish Habitat Partnership

Objectives
Determine if use of habitat augmentation structures by largemouth bass differ seasonally in a large reservoir.

Determine if the use of habitat augmentation structures by largemouth bass differs through the different daily time periods (day, night) in a large reservoir.

Location
Table Rock Lake, MO

Completion
June 2013

Deteriorating reservoir fish habitat is a concern throughout the United States so the Missouri Department of Conservation and cooperators placed approximately 2,000 augmentation structures (trees, stumps, and rock piles) throughout Table Rock Lake, Missouri to improve fish habitat for largemouth bass (*Micropterus salmoides)*. Our objectives were to determine habitat selection, movement, and home range of largemouth bass following this enhancement. Seventy largemouth bass (>380 mm total length) were implanted with radio transmitters and relocated monthly for one year. Results from our discrete choice models suggest largemouth bass select intermediate depths (2-7 m) in areas near shore (<25 m) regardless of diel period and season, however structure was only selected during summer and fall. During these seasons, complex (tree) augmentation structures were selected at the same rate as natural woody structure, which suggests the addition of augmentation structures may be able to supplement habitat loss in large reservoirs. Movement rates were higher during day than night across all months, with peak movement rates during June and July (mean=83.5 m/h) when water temperatures were greatest. Annual core (50%) home range estimates averaged 7.9 ha with longer fish having smaller home ranges ($r = -0.64$, $P = 0.03$). However, home range size did not differ in the presence of augmentation structure compared to those without. This project was a pilot program of the National Fish Habitat Partnership and will help identify areas that may be most suitable for habitat augmentation structures to improve reservoir fish populations through reservoir habitat enhancements.

Products:
Harris, Jason. 2013. Thesis: Habitat selection, movement, and home range of largemouth bass following a habitat enhancement project in Table Rock Lake, Missouri. M.S. thesis, University of Missouri.

ECOLOGICAL FLOW LINKAGES: IDENTIFYING RELEVANT LITERATURE AND RECENT ADVANCES

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Project Supervisors
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Funding
MDC

Cooperators
MDC

Objectives
Document the most relevant literature, ongoing studies, and unpublished information related to ecological flows.

Refine the list of flow metrics that can be used in refinement of MOHAT.

Further identify the biological links to stream flow alteration based on the literature, and ongoing and current studies relevant to Missouri streams.

Identify additional available spatial data that could be useful in the assessment of hydrologic alteration and ecological flows.

Recommend for further evaluation a draft classification that uses the additional spatial data to sub-divide the hydrological classification.

Location
statewide

Completion
June 2013

Status
Complete

Progress and Results
Numerous studies have attempted to identify metrics that best represent hydrologic alteration, but there is no consensus on how these hydrologic indices are linked to ecological processes and fishes. We conducted a literature review with the primary objective to identify biological responses of fish, which are linked to stream flow and stream flow alteration metrics. We summarized metrics used to link flow alteration to direct biological responses from over 400 references from peer-reviewed literature, agency reports and flow assessment programs from 1980 to 2011. Completion of our literature review identified less than 100 studies that directly related biological responses to flow. Of these, 42 studies linked biological responses of fish to flow alterations. Our review identified over 300 occurrences of stream flow metrics used and approximately 200 significant biological responses to varying flow components. More common metrics linked to biotic responses included changes in mean annual flow, peak flows, low flows and flow variability. The most common biotic metrics linked to stream flow included abundance and diversity metrics. Our review will help identify future research needs and help managers identify specific stream flow metrics associated with biotic responses that can be incorporated into ecological flow assessments.

INVASIVE BIGHEAD AND SILVER CARPS AND THE GREAT LAKES: EVALUATION OF ALTERNATIVE NATURAL FOOD SOURCES.

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Duane Chapman, USGS

Project Supervisor
Dr. Craig Paukert

Funding
US Geological Survey
RWO 111

Cooperators
US Environmental Protection Agency

Objectives
Evaluate bioenergetic model for juvenile bighead and silver carp in aquaria, using a food of known energetic content consumed by the fish.

Evaluate the bioenergetic model using larger adult or subadult fish in mesocosms.

Location
Great Lakes and Columbia, MO

Completion
July 2013

Status
Complete

Progress and Results
The invasive silver carp (*Hypophthalmichthys molitrix*) now threaten to invade the Great lakes where they may out compete native planktivores for food. A recently developed bioenergetics model for silver carp predicted that the fish could colonize embayments, but not much of the open-water regions of the Great Lakes. However, the models are yet to be validated. The objectives of this study were (i) to validate the carp bioenergetic model and (ii) to identify the sources of model errors. Two growth trials were conducted for silver carp, one for juveniles and the other for subadults. The juvenile model growth prediction was evaluated at 10, 18, and 27 ºC under three feeding regimes (low, moderate and high). The subadult model was validated at three 11, 17, and 26 ºC under high feeding level. Fish were fed a commercial catfish feed daily for 15 (juveniles) or 30 days (subadults). The model for juveniles underestimated growth at low feeding level at 27 ºC and overestimated growth at moderate and high feeding levels for the three different temperatures. However, no differences were found between the predicted and the observed fish weights at low feeding level for 11 and 17 ºC rearing temperatures. Error rates in the model increased with the temperature for low and high feeding levels and with consumption levels across all the three temperatures. Model predictions for subadults showed over estimation of weight gain and under estimation of consumption for all the three temperatures. Error rates were detected in the prediction of consumption, basal metabolic cost and egestion cost for both juveniles and subadults. Our study recommends the use of energy density of silver carp determined in the current study and the need of improving model parameters for consumption (CA and CB), and the importance of using specific egestion cost for different food types.

THERMAL CONDITIONS AND STREAM HABITAT ASSOCIATIONS FOR FISHES AT OZARKS NATIONAL SCENIC RIVERWAYS

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Project Supervisors
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Funding
U.S. Geological Survey, NRPP Program
RWO 115

Cooperators
MDC

Objectives
Test the feasibility of rapidly and inexpensively monitoring local temperature conditions throughout the entire Riverways.

Link the information to a physical habitat classification system in a GIS.

Use this information to assess habitat selection of smallmouth bass.

Location
Current and Jack's Fork rivers, MO

Completion
September 2014

Status
Complete

Progress and Results
Our objectives were to determine movement of smallmouth bass that use thermal refuge and project differences in growth and consumption among smallmouth bass exhibiting different thermal-use patterns, and model the effect of climate change on the thermal regime of a groundwater fed system. We implanted radio transmitters in 29 smallmouth bass captured in Alley Spring on the Jacks Fork River, Missouri during the winter of 2012. Most radio tagged fish (69%) departed Alley Spring when daily maximum river water temperature first exceeded that of the spring (14°C) and during increased river discharge. Bioenergetic modeling predicted that a 350 g migrating smallmouth bass that used cold-period thermal refuge would grow 16% slower at the same consumption level as a fish that did not seek thermal refuge. Growth scope extrapolation produced contrasting results, which suggest migrating fish grow 29% more than fish using areas of stream with little groundwater influence. Springs that contributed less than 5% of the main stem discharge did not affect river temperatures beyond a few hundred meters downstream. A multiple regression model using variables related to season, mean daily air temperature, and a spatial influence factor (metric to account for groundwater influence) was a strong predictor of mean daily water temperature ($r^2 = 0.98$; RMSE = 0.82). By 2080, peak numbers of optimal growth temperature days for smallmouth bass are expected to shift to areas with more spring influence, largemouth bass are expected to experience more optimal growth days (21 – 317% increase) regardless of spring influence, and Ozark hellbenders may experience up to a 20% reduction in the number of optimal growth days in areas with the highest spring influence.

Products:

Westhoff, J., et. al. In press. Behavioral thermoregulation and bioenergetics of riverine smallmouth bass associated with ambient cold-period thermal refuge. Ecology of Freshwater Fish.

Westhoff, J. T., and C. Paukert. In press. Climate change simulations predict altered biotic response in a thermally heterogeneous stream system. PloS ONE.

EFFECTS OF CLIMATE CHANGE ON BIODIVERSITY

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Project Supervisors
Dr. Craig Paukert, MU

Funding
U.S. Geological Survey, National Climate Change and Wildlife Science Center

Cooperators
Over 60 stakeholders nationwide

Objectives
Coordinate the Biodiversity sector of the 2013 National Climate Assessment.

Identify the key data and knowledge gaps related to how climate change will affect biodiversity.

Location
Nationwide

Completion
September 2014

Status
Complete

Progress and Results
Ecosystems around the world already are threatened by land use and land cover change, extraction of natural resources, biological disturbances, and pollution. These environmental stressors have been the primary source of ecosystem degradation to date, and climate change is now exacerbating some of their effects. When ecosystems are stressed, they are likely to have faster and more acute reactions to climate change; it is therefore useful to understand how multiple stresses will interact, especially as the magnitude of climate change increases. Understanding these interactions could be critically important in the design of climate adaptation strategies, especially because climate change responses employed by other sectors (for example, energy, agriculture, transportation) may create new ecosystem stresses.

Products
M. D. Staudinger, N. B. Grimm, A. Staudt, S. L. Carter, F. S. Chapin III, P. Kareiva, M. Ruckelshaus, B. A. Stein. 2012. *Impacts of Climate Change on Biodiversity, Ecosystems, and Ecosystem Services: Technical Input to the 2013 National Climate Assessment.* Cooperative Report to the 2013 National Climate Assessment. 296 p. Available at: http://assessment.globalchange.gov

Staudt, A., A. K. Leidner, J. Howard, K. A. Brauman, J. S. Dukes, L. Hansen, C. Paukert, J. Sabo, and L. A. Solórzano. 2013. The added complications of climate change: understanding and managing biodiversity, ecosystems, and ecosystem services under multiple stressors. Frontiers in Ecology and the Environment 11(9):494-501.

EVALUATION OF HUMPBACK CHUB TRANSLOCATIONS IN GRAND CANYON TRIBUTARIES

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Project Supervisor
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Funding
Grand Canyon National Park
US Bureau of Reclamation
U.S. Geological Survey
RWO 108

Cooperators
National Park Service
US Bureau of Reclamation
US Fish and Wildlife Service
Arizona Game and Fish Dept.

Objectives
How does the fish abundance and community differ in Grand Canyon tributaries?

How many humpback chub remain following translocations?

What is the survival and growth of translocated humpback chub?

Do humpback chub or other species fill a niche vacated by non-natives?

Location
Grand Canyon, Arizona

Completion
September 2013

Status
Complete

Progress and Results
Diet interactions between native and non-native fishes may influence the establishment of native species within their historical range (i.e., reintroduction). Therefore, we illustrated the food web structure of and followed the transition of the federally endangered humpback chub *Gila cypha* into a novel food web following translocation, and determined the potential for a non-native species, rainbow trout *Oncorhynchus mykiss*, to influence translocation success. Humpback chub and rainbow trout used resources high in the food web and assimilated similar proportions of native fishes suggesting non-native rainbow trout may occupy an ecological role similar to humpback chub. Subsequently, humpback chub may be well suited to colonize tributaries because of their ability to consume resources high in the food web. Additionally, diet partitioning may occur between all members of the fish community as indicated by separation in trophic niche space and little trophic overlap; although all species, particularly bluehead sucker *Catostomus discobolus*, used a broad range of food resources. Rainbow trout stomach content analysis corroborated stable isotope analysis and suggested rainbow trout diet consisted of aquatic and terrestrial macroinvertebrates while larger rainbow trout (>120 mm total length) consumed a greater proportion of fish (incidence of piscivory = 5.3%). Trophic interactions may reveal an underutilized niche space or biotic resistance to the establishment of translocated native fishes. Continued translocation of humpback chub into tributaries appears to be one option for conservation. However, successful establishment of humpback chub may depend on continued removal of non-native trout increasing availability of diet sources at higher trophic levels.

Products
Spurgeon, J. J., C. P. Paukert, B. D. Healy, C. A. Kelley, and D. P. Whiting. *In press*. Can translocated native fishes retain their trophic niche when confronted with a resident invasive? Ecology of Freshwater Fish. DOI: 10.1111/eff.12160

FOOD WEB DYNAMICS IN BRIGHT ANGEL CREEK, GRAND CANYON: IMPLICATIONS FOR NATIVE FISH CONSERVATION

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Funding
Grand Canyon National Park
U.S. Bureau of Reclamation
U.S. Geological Survey
RWO 108

Cooperators
National Park Service
U.S. Fish and Wildlife Service
Arizona Game and Fish Dept.

Objectives
Determine seasonal fish communities and food habits of fishes in Bright Angel Creek.

Determine if competition for food exists between native and non-native fishes.

Estimated consumption of invertebrates and fish by non-native fishes.

Location
Grand Canyon, Arizona

Completion
September 2013

Status
Complete

Progress and Results
Non-native fishes have been linked to the decline of native fishes and may impact aquatic food webs through direct and indirect pathways. Non-native brown and rainbow trout are abundant in tributaries of the Colorado River within the Grand Canyon, and these concerns have initiated removal efforts to enhance native fish communities. To assess resource availability and evaluate the effects non-native brown and rainbow trout have in a tributary of the Grand Canyon, we sampled fish, benthic, and drifting macroinvertebrates in November 2010, January 2011, June 2011, and September 2011. Trout diets were evaluated from stomach samples collected during macroinvertebrate sampling periods, and annual consumption was estimated using bioenergetics models. Potential diet overlap between native and non-native fishes was examined using ^{13}C and ^{15}N stable isotopes. Contributions to benthic biomass varied between megalopterans (16-35%), trichopterans (19-28%), and ephemeropterans (9-32%), whereas ephemeropterans dominated biomass (44-64%) in drift samples. Ephemeropterans were dominant in small (< 150 mm total length) trout diets, whereas *Corydalus* and native fish dominated large (> 150 mm total length) brown trout diets and *Corydalus* and algae dominated large rainbow trout stomachs. Annual resource consumption was 6 times higher for large trout compared to small trout. Stable isotopes suggested diet overlap occurs between native and non-native fishes and large non-native trout occupied the highest trophic positions. Our results suggest tributaries may provide diverse and abundant prey that is not found in the mainstem, and native fishes will likely benefit from trout removal efforts, which may reduce piscivory and diet overlap.

Products:
Whiting, D. P., C. P. Paukert, B. D. Healy, and J. J. Spurgeon. *In press*. Macroinvertebrate prey availability and food web dynamics of non-native trout in a Colorado River tributary, Grand Canyon. Freshwater Science. DOI: 10.1086/676915

CONSERVATION PLANNING FOR FISHES IN THE UPPER COLORADO RIVER BASIN

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Dr. Craig Paukert, MU

Funding
U.S. Geological Survey, National Gap Analysis Program
U.S. Geological Survey, Cooperative Research Units
RWO 109

Cooperators
Colorado Department of Wildlife
Wyoming Game and Fish
Utah Department of Natural Resources
Arizona Game and Fish Department

Objectives
Identify landscape habitat metrics linked to native and non-native fishes in the Upper Colorado River Basin.

Identify areas of conservation value that captures habitat for native species.

Provide stakeholders with conservation assessment to inform conservation and adaptive management decisions.

Location
Upper Colorado River Basin

Expected Completion
December 2015

Status
In progress

Progress and Results
Many large river fishes have declined in abundance or distribution due to habitat alteration and introduced species. Tributaries have gained attention for their potential importance to large river fish conservation, but generally are not included in landscape-level evaluations of fish-habitat associations. We used Canonical Correspondence Analysis to identify associations between fish assemblage structure and tributary, mainstem, and catchment environmental factors for 268 large river segments in the Colorado River Basin. Mainstem characteristics explained 7.3% of assemblage structure in the Colorado River, 18.0% in the Green River, and 14.0% in the San Juan River. Mainstem watershed area accounted for 100%, 50%, and 82% of this association for the Colorado, Green and San Juan Rivers, respectively. Catchment factors explained 5.4% of assemblage structure in the Colorado River and 2.6% in the San Juan River, but were not associated with assemblage structure in the Green River. Tributary characteristics were not significantly associated with assemblage structure in the Colorado or San Juan Rivers, but explained 1.5% of the variability in the Green River fish assemblage. Tributaries likely had negligible effects on fish assemblage structure in our study because 92% of tributaries were < 1% of mainstem watershed area. However, the association between assemblage structure and mainstem watershed area suggests that large tributaries affect fish assemblages indirectly by altering the longitudinal position of the river along this gradient. Our results suggest that the role of tributaries in structuring fish assemblages may depend on the spatial scale of interest and tributary size.

THE ROLE OF TRIBUTARIES ON ECOSYSTEM RECOVERY OF THE MISSOURI RIVER

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Project Supervisors
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Funding
U.S. Geological Survey, SSP Program
RWO 116

Cooperators
U.S. Fish and Wildlife Service

Objectives
Determine how the fish assemblage differs seasonally from the mouth of the Missouri River upstream on the Osage River, and a reference river, the Gasconade River.

Determine the contribution of large river fish larvae from the Osage River to the Missouri River.

Location
Osage and Gasconade rivers

Expected Completion
June 2015

Status
In progress

Progress and Results
Tributaries provide important habitat for spawning, rearing, feeding and refuge of big river fishes but river alteration may affect how and when fish use these systems. This study investigates longitudinal patterns of fish abundance, species richness, and big river fish presence in the Osage River, a tributary of the Lower Missouri River. The Osage River is altered by a hydroelectric dam resulting in modified discharges and water temperatures. Additionally, a dilapidated low head dam 19 river kilometers (rkm) upstream of the Missouri River confluence acts as a semi-permeable barrier to fish movement. Sampling with boat electrofishing, benthic trawls, and seines in the lower 30 rkm of the Osage River from June 2012 to August 2013 resulted in the capture of 70 species, 59% of which were found both above and below the low head dam while 24% were found only below the low head dam. One species of conservation concern, the skipjack herring (*Alosa chrysochloris*) was captured downstream of the low head dam but not upstream of the structure in the Osage River. Twelve big river species, only one of which was caught upstream of the low head dam, comprised 3% of the total fish caught. As large-scale ecosystem restoration continues in the Missouri River basin, understanding the use of tributaries by big river fishes will contribute to the planning of future restoration efforts.

EVALUATION AND VALIDATION OF ENVIRONMENTAL DNA AS A TOOL FOR ASIAN CARP DETECTION

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Project Supervisors
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Funding
US Geological Survey
Environmental Protection Agency
RWO 118, 119

Cooperators
US Geological

Objectives
Determine the amount and stochasticity of eDNA given off by bighead and silver carp of different sizes under different temperature, feeding, and densities.

Estimate amount of eDNA in sex products released and the degradation rate of the eDNA.

Develop a model to estimate eDNA concentrations under different environmental conditions and biomass or abundance of bigheaded carps.

Location
Columbia, MO

Expected Completion
May 2015

Status
In Progress

Progress and Results
Management can most effectively mitigate the impacts of invasive species before the species becomes established in a new area, and thus survey methods that can detect only a few individuals are required. Due to its high sensitivity, environmental DNA (eDNA) surveys holds promise as an early detection method for aquatic invasive species. Quantification of actual eDNA amounts may also provide data on species abundance and timing of an organisms presence, allowing managers to more effectively combat the spread of ecologically damaging species. To better understand the link between eDNA and an organism's presence, it is crucial to know how eDNA is shed into the environment. Our study used quantitative PCR (qPCR) and controlled laboratory experiments to measure the amount of eDNA that two species of invasive bigheaded carps (*Hypophthalmichthys nobilis and Hypophthalmichthys molitrix)* shed into the water. We first measured how much eDNA a single fish sheds and the variability of these measurements. Then, in a series of manipulative lab experiments, we studied how temperature, density (g fish/ L), and diet affect the shedding rate of eDNA by these fish. We found that eDNA amounts were positively correlated with fish density, and that feeding could increase the amount of eDNA shed by ten-fold, whereas water temperature did not have an effect. Our results demonstrate that quantification of eDNA may be useful for predicting carp density, and possibly other rare or invasive species.

Products:
Klymus, K. E., C. A., Richter, D. C. Chapman, and C. P. Paukert. Accepted. Quantification of eDNA shedding rates from invasive bighead carp *Hypophthalmichthys nobilis* and silver carp *Hypophthalmichthys molitrix*. Biological Conservation.

EVALUATION OF CONSERVATION NETWORKS TO PROTECT AQUATIC BIODIVERSITY IN MISSOURI

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Funding
U.S. Geological Survey, National Climate Change and Wildlife Science Center

Cooperators
MDC

Objectives
Develop and evaluate methods to assess vulnerability of aquatic biota to climate change.

Assess the potential role that existing protected lands has on the protection of aquatic biodiversity at smaller spatial scales.

Location
Missouri

Expected Completion
December 2014

Status
In progress

Progress and Results
We developed a framework to assess stream fish vulnerability to global climate and land use change that is transferable to many stream fish communities worldwide. Two indices were developed based on species environmental tolerances (habitat degradation, and changes in thermal habitat and flows from climate change), rarity, range size, dispersal ability, and connectivity. Our first index identified species responses to the components of environmental tolerance, while the second index used associations between species traits and the components of environmental tolerance. Vulnerability scores were calculated with the trait-based index for 133 species from the central United States while only 99 species were able to be evaluated using the response based index. The trait based index was unable to evaluate many rare species, which also happened to have many of the highest vulnerability scores based on the species response index. A comparison of our indices revealed they were consistent in classifying vulnerability to habitat degradation, but varied for vulnerability to increases in stream temperature and flow alteration. Both indices showed higher mean vulnerability scores for threatened or endangered species compared to unlisted species, which provided a coarse validation measure for our indices. Regions with heavily forested watersheds had more vulnerable species than regions dominated by agriculture. This vulnerability assessment is highly adaptable to any suite of species where life history traits, or responses to temperature and flows are known, and can be applied to biological assessments anywhere identifying biota vulnerable to land use and climate may be a concern.

ASSESSMENT OF AVAILABLE ECOLOGICLA FLOW DATA

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Del Lobb, MDC
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Project Supervisors
Dr. Craig Paukert, MU

Funding
MDC

Objectives
Develop a comprehensive geodatabase to determine the state of knowledge on where biologic, hydrologic, stream temperature, land-use, flow alterations, Integrated Aquatic Database, and fish community data exists, as well as data from ongoing and recent research on projected land use, stream temperature models, climate change variables, and precipitation and temperature patterns from climate change.

Use the Geodatabase to identify data gaps in occurrences of biological data, gage station data, and alteration data, to prioritize monitoring of biologic or hydrologic data, and determine where to concentrate potential research and management efforts.

Determine software needs to move forward with developing flow alteration – ecological response relationships

Location
Missouri

Expected Completion
June 2015

Status
In progress

Progress and Results
MDC has worked hard to stay at the forefront of ecological flow science and made understanding how flow alterations affect riverine systems and their biota a priority. MDC has established an Ecological Flow Working Group to develop a department policy for how the agency will address ecological flow issues. In addition, one of Fisheries Division's Stretch Goals is establishing adequate ecological flows in Missouri streams in advance of increasing water demands and associated water supply projects and potential energy development projects. To protect fish, forest, and wildlife resources it is crucial to determine appropriate ecological flows as accurately as possible using the best available science. However, the science related to ecological flows is evolving rapidly. Ongoing work at the University of Missouri (funded by MDC) has shown that the number of research studies evaluating ecological flows has quadrupled in the last 10 years (Figure 1). In recent decades the science of ecological flows has shifted from a focus on minimum flows to a range of flows that account for seasonal and inter-annual variation in the magnitude, timing, frequency, duration, and rate of change of stream flows. This natural flow paradigm recognizes that aquatic and water-dependent ecosystems evolved with, and depend upon, naturally variable flows. As a result flow recommendations now typically use a framework for determining appropriate ecological flows across different seasons and years in an attempt to represent the intra- and inter-annual variability of flow. This project will examine the available biological data that could be useful in developing ecological response relationships, Missouri's existing flow data, known flow alterations to streams, expected alterations to streams, least altered or potential reference streams, and the results of the Ecological Flow Linkages in Missouri work that will help identify metrics that are successful in documenting ecological responses to hydrologic alterations. This information will be linked together to determine information needs that will be addressed at a later phase in order to develop the flow alteration – ecological response relationships for Missouri stream types.

A DECISION SUPPORT MAPPER FOR CONSERVATION OF STREAM FISH HABITATS OF THE NORTHEAST CLIMATE SCIENCE CENTER REGION

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Funding
U.S. Geological Survey, Northeast Climate Change and Wildlife Science Center
RWO 124

Cooperators
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Dr. Ty Wagner, Penn St. Univ.
Jana Stewart, USGS
Dr. Wes Daniel, Michigan St. Univ.

Objectives
Characterize current condition of stream fish habitats throughout the NE CSC region based on responses of target fish species to a diverse set of landscape-scale disturbances.

Identify stream reaches predicted to change with climate and likely to change distributions of target fish species throughout the region.

Develop a spatially-explicit web-based decision support viewer showing measures of current landscape condition along with estimates of changes in habitat that may occur with changes in climate.

Location
Northeast U.S.

Expected Completion
December 2015

Status
In progress

Progress and Results
Changes in climate are anticipated to lead to additional changes in stream habitats and the fish assemblages they support via multiple pathways, including changing stream thermal regimes. Accounting for current condition of and future changes in streams and understanding specific mechanisms by which streams are or may become impaired are essential for managing and conserving stream fishes and their habitats. To effectively manage streams of the NE CSC from current impacts and future threats, managers require region-wide information to aid in decision-making and implementation of proactive management strategies. Ideally, this information should identify current condition of stream habitats based on specific disturbances that limit stream fishes, future conditions that could result from changes in climate, and where possible, specific mechanisms (including changes in water temperature) by which streams may change with climate. With such information presented in an integrated, spatially-continuous, and scalable format for the entire NE CSC region, managers can more effectively conserve, protect, and restore stream fish and their habitats. Our project will meet that need by integrating results of a current condition assessment of stream habitats that accounts for fish response to human land use, water quality impairment, and fragmentation by dams with estimates of future stream habitats that may change with climate. Tailored current and future condition assessments for target species will be available for all stream reaches in the U.S. portion of the NE CSC via a web-based viewer.

DEVELOPMENT OF REFERENCE REACHES FOR MISSOURI STREAMS

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Funding
Missouri Department of Natural Resources

Cooperators
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Karen Bataille, MDC

Objectives
Identify candidate reference stream reaches of wadeable streams in Missouri using existing landscape-level data.

Develop a quantitative, scientifically-defensible method to determine candidate reference site conditions in Missouri wadeable streams for each MORAP stream size classification.

Validate reference site methodology and selection using on-site physical habitat and biological sampling.

Location
Missouri

Expected Completion
June 2016

Status
In progress

Progress
Streams and their biota are influenced by in-stream habitat alterations, as well as disturbances occurring at a landscape level. The past two centuries have seen immense growth in urban and agricultural development, resulting in highly degraded stream conditions and subsequent losses in aquatic biodiversity. We summarized landscape-level disturbance metrics for 92,500 headwater stream segments in Missouri, a size class greatly underrepresented in our existing stream biota databases. We selected metrics detrimental to water quality and habitat condition (e.g., agricultural land cover, urban land cover, stream crossing density, confined animal feeding operations density). Streams showed substantial variation in disturbance type and intensity within and across major physiographic boundaries. While headwater drainages in the Mississippi Alluvial Basin had the least amount of urbanization (1.7% impervious surfaces), they exhibited the highest percentage of agricultural crop cover (68.7%), followed by the Central Plains (37.4%) and Ozark (3.9%) Regions. Although Ozark catchments generally showed the least amount of landscape alteration, lead mine densities were the highest within the Ozarks (.015/Km^2), and confined animal feeding operation densities were greatest within the Ozark's Neosho drainage (.021/Km^2). These marked differences in land-use support the conclusion to establish stream reference criteria at the subregion level or smaller.

DEVELOPING MEASURES OF VULNERABILITY TO CLIMATE CHANGE AND DISTIRBANCE OF AQUATIC COMMUNITIES IN HEARTLAND NETWORK NATIONAL PARKS

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Project Supervisors
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Funding
USGS, NRPP Program
NPS I and M Program
RWO 123

Objectives
What is the best combination of sampling gears that will determine the status of fish communities in mid-sized rivers throughout Missouri?

Does detection probability for select species differ by gear type, season, or river type?

How many samples of each gear are needed to detect 75% and 95% of the species estimated to be in a 2-10 km segment?

What is the distribution of fishes in selected mid-sized rivers and does that differ seasonally?

Location
Midwest U.S.

Expected Completion
December 2016

Status
In progress

Progress
The NPS Inventory & Monitoring Program is designed (in part) to elucidate the current variability in biotic metrics typically encountered within parks. These results can be used with climate and land use scenarios to determine the vulnerability of aquatic biota to these changes. We will leverage efforts by the NPS, USGS, and universities to identify 1) areas with stable aquatic communities, 2) aquatic communities vulnerable to climate and land use change, and 3) whether vulnerability to climate and land use change differs by stream size or geographic region (plains to Ozarks) and how vulnerability may be affected by landscape-level factors. Fish and aquatic invertebrate community structure and stability will be assessed using several metrics (e.g., IBI and its subcomponents, EPT, etc.) developed for each site and each year; variability will be determined using the coefficient of variation (cv) of these metrics and non-metric multi-dimensional scaling among sites and years. An index of aquatic biota vulnerability to climate and land use change will be developed using findings from ongoing projects linking temperature and flow to fish abundances, a literature review of fish and invertebrates guilds sensitive to climate change, and a study comparing methods to index fish community vulnerability. The final index developed will be used to assess whether vulnerability to climate and land use change varies by stream size and region. Geo-referenced datasets of predicted air temperature and precipitation to 2100 and predicted changes in landcover to 2040 for each park will be used to identify parks that will experience the greatest climate and land use changes. This study will provide park managers with tools to identify rivers sensitive to climate and land use change and of those which ones will most likely experience changes in climate and landcover. An initial analysis is ongoing and project is on schedule.

CONSERVATION AND MANAGEMENT OF MISSOURI'S MID-SIZED RIVERS: DEVELOPMENT OF SAMPLING PROTOCOLS AND APPLICATION TO PRIORITY WATERSHED RIVERS

Investigators
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Dave Herzog, MDC
Dr. Vince Travnichek, MDC
Matt Combes, MDC
Corey Dunn, Ph.D. student, MU

Project Supervisors
Dr. Craig Paukert, MU

Funding
MDC

Objectives
What is the best combination of sampling gears that will determine the status of fish communities in mid-sized rivers throughout Missouri?

Does detection probability for select species differ by gear type, season, or river type?

How many samples of each gear are needed to detect 75% and 95% of the species estimated to be in a 2-10 km segment?

What is the distribution of fishes in selected mid-sized rivers and does that differ seasonally?

Location
Missouri

Expected Completion
June 2018

Status
In progress

Progress
Substantial monitoring and research has and is currently conducted on mainstem big rivers but little information exists for the mid-sized rivers in Missouri (e.g., tributaries of the Missouri and Mississippi Rivers and other non or semi-wadebale rivers). However, these rivers can be important for fisheries management and conservation as they may 1) provide refuge and inter-basin movement corridors for smaller-stream fishes during drought, 2) possess unique habitats and resources for larger-river fishes moving into these systems during floods, and 3) offer buffer capacity because their floodplains may be less modified than big rivers and thus create substantial productivity and refuge for downstream systems. Understanding these dynamics would be especially important in relation to watershed-scale patterns of disturbance that may increase in the future (e.g., land use and/or climate change). Mid-sized rivers also provide angling opportunities for fish such as channel catfish in northern Missouri and smallmouth bass, goggle eye, and suckers in the Ozarks. Knowing how mid-sized rivers are used by big river and smaller-stream fishes, and to what degree these rivers have their own unique fish communities, will help MDC identify important rivers to target for conservation and restoration. The methods developed and data collected by this project would provide a tool for developing standardized sampling protocols for fish communities in rivers from MDC priority watersheds and other watersheds, and help DNR in the development of fish biocriteria for large rivers. These protocols are the critical first step that can be used to test further hypotheses related to the conservation and management of fishes in these rivers. Field sampling to refine gear selection began in summer 2014 and will continue seasonally for at least one year, before applying these methods to additional rivers in future years.

LINKING HABITAT FEATURES TO DISSOLVED OXYGEN AND RIVER FLOW IN THE LOWER OSAGE RIVER, MISSOURI

Investigators
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Ryan Lueckenhoff, Sr. Research Associate, MU

Project Supervisors
Dr. Craig Paukert, MU

Funding
MDC

Objectives
Document long-term trends in fish community health and sport fish populations in response to flow management.

Help determine at what flows and under what conditions key habitat availability becomes a limiting factor in the lower Osage River.

Empirically demonstrate lower Osage River fish community response, including response of sport fish forage species and YOY sport fish, to dam operations.

Develop knowledge to manage dam releases to maximize fisheries benefits.

Refine knowledge of fish community and sport fish response to flow management for application to other riverine systems

Location
Osage River, Missouri

Expected Completion
June 2018

Status
In progress

Progress

Numerous flow management decisions are being made on rivers throughout the world and these decisions are increasingly incorporating consideration of the physical habitat needs of fish and other aquatic life. However, long term monitoring studies to detect response of fish species to new flow regimes are few, and there is little information to substantiate ecological response to flow alteration, and empirical models predicting ecological responses to various types and degrees of flow alteration are not readily available. Stream flow regimes that meet the ecological needs (including sufficient dissolved oxygen; DO) for the entire aquatic community are vital in supporting healthy, sustainable sport fisheries in flow regulated systems. The upstream presence of several large reservoirs and hydropower facilities imposes a highly artificial flow regime on the lower Osage River. The magnitude, frequency, duration, timing, and rate of change of flow events in the lower Osage River vary spatially due to downstream attenuation of flow fluctuations. These parameters also vary temporally with precipitation and water management for flood control and power generation by Bagnell Dam and Truman Dam, which is immediately upstream of Lake of the Ozarks. Successful management of the lower Osage River's often heavily exploited fisheries resource depends on a healthy and diverse fish community, which in turn depends on deriving the maximum ecological benefit possible under the river's highly artificial flow regime. Therefore, we will use ongoing fish community sampling from MDC and link to field studies that measure water temperature, dissolved oxygen, channel use designation (e.g., riffle, pool) and other water quality parameters throughout the lower Osage River under different seasons and hydrologic regimes. Water quality will be measured continuously with data sondes, and couple with spot-checking during field sampling throughout the entire study period. We will develop a series of *a priori* models to help identify the factors list likely to influence fish communities in the lower Osage River.

DEVELOPMENT OF A FISH AND AMPHIBIAN RAPID ASSESSMENT PROTOCOL FOR WETLANDS: LINKING MANAGEMENT TO WETLAND SYSTEM PROCESSES

Investigators
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Frank Nelson, MDC
Doreen Mengel, MDC
Andy Raedeke, MDC
Julia Guyton, M.S. student

Project Supervisors
Dr. Craig Paukert, MU
Dr. Lisa Webb, MU

Funding
MDC

Cooperators
Multiple wetland managers statewide

Objectives
Assess efficiency and effectiveness of a variety of sampling methods to determine probability of presence and species richness of amphibians and fish in MDC wetlands

Quantify effects of region, season, and habitat complexity on detection probability for amphibians and fish in MDC wetlands

Recommend standardized assessment protocol for use by MDC wetland area managers to evaluate amphibian and fish response to wetland management decisions

Location
Missouri

Expected Completion
June 2017

Status
In progress

Progress
Manipulating water levels within wetland complexes mimics wetland ecosystem processes to ensure habitat conditions vary both in time and space to benefit a wide range of wetland-dependent species. Although providing seasonally flooded habitats to accommodate the needs of migratory water birds is a priority on Missouri's actively managed wetland areas, these floodplain conditions are also used by a wide-variety of other wetland dependent species. Wetland dependent taxa such as fish and amphibians are much more difficult to detect, resulting in management decisions made with the assumption that an action beneficial to one suite of species will also benefit a wider range of species. However, there is uncertainty associated with this assumption. Monitoring to reduce the associated uncertainty allows managers to weigh the needs of a variety of species' life history requirements and increasing awareness of the biological trade-offs inherent in their management decisions. Better informed management decisions based on monitoring could result in certain management actions that are delayed or expedited to benefit an alternate taxonomic group without sacrificing the primary management objective. Fish and amphibians are ideal target taxa to monitor in wetlands due to the perceived conflict of among taxonomic groups and certain wetland conditions. Many fish benefit from having access to the floodplain for foraging, spawning, migration corridors, and refugia. Amphibians benefit from having access to seasonal wetlands for breeding and larval development. Information regarding seasonal fish and amphibian species composition and use of floodplain habitats would help inform wetland management decisions. This would provide managers with a better understanding of how needs of lesser-known species can be incorporated into management actions without detrimental effects to more traditional management activities. Therefore, we will conduct a 2-year study to determine the best sampling methods to determine the presence of fish and amphibians in wetland in different regions of the state.

ASSESSING THE IMPACT OF CLIMATE CHANGE ON GLOBAL INLAND FISHERIES

Investigators
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Dr. James Whitney, post doc, MU

Project Supervisors
Dr. Craig Paukert, MU
Dr. Abigail Lynch, USGS

Funding
U.S. Geological Survey, National Climate Change and Wildlife Science Center
RWO 129

Cooperators
Dr. Doug Beard, USGS
Dr. Dan Isaak, US Forest Service
Dr. Steve Cooke, Carlton Univ.
Dr. Bill Taylor, Michigan St. Univ.
Dr. Bo Bunnell, USGS

Objectives
Synthesize how climate change may affect inland fisheries.

Identify the key data and knowledge gaps related to how climate change will affect inland fisheries.

Identify climate change drivers for inland fisheries.

Location
Global

Expected Completion
December 2016

Status
In progress

Progress and Results
Aquatic biota is particularly vulnerable to climate change and its associated effects, but these effects, both distributional and physiological, will differ by species and region. Approximately 50 percent of available cold and cool water fish habitats are expected to disappear with projected doubling of atmospheric CO_2, while warm water fish habitat is expected increase by 31 percent. Inland fish species, and their associated fisheries, are especially vulnerable to climate changes, both distributional and physiological, because they have limited habitat availability and a more direct link with terrestrial systems, land use patterns, and water use than marine systems. Climate change impacts on these inland systems may be magnified as a result of climate impacts to terrestrial systems and human interventions. To date, little research has investigated climate change effects on inland fisheries at a global scale. Therefore, we will coordinate a workshop in 2015 composed of inland fisheries experts from around the world to provide input on how climate change will affect inland fisheries. Invitations to the workshop will be based on demonstrated experience with research and activities related to climate change and inland fisheries. To lead this workshop and manage the related scientific synthesis, we will first select a post-doctoral researcher (post doc) and several (~5) key participants. This "core working group" will identify broad objectives and select the remainder of the team for the larger workshop. This core working group will help develop the workshop and take the lead at writing up the results for publication, which is slated to appear in a special climate change issue of *Fisheries*.

SCIENCE TO INFORM MANAGEMENT OF FLOODPLAIN CONSERVATION LANDS UNDER NON STATIONARY CONDITIONS

Investigators
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Robb Jacobson (CERC)
Dr. Kristen Bouska, post doc, MU
Dr. Garth Lindner, post doc, MU

Project Supervisors
Dr. Craig Paukert, MU
Robb Jacobson (CERC)

Funding
U.S. Geological Survey, Northeast Climate Change and Wildlife Science Center
RWO 127

Cooperators
Floodplain Science Network

Objectives

Identify information needs in an interactive setting wherein stakeholders will discuss floodplain-management challenges and develop conceptual models relating external drivers, climate change projections, management needs and adaptation strategies, and ecosystem responses.

Apply existing datasets to conceptual models and apply existing datasets and simulation models to the management problems identified in the first component.

Identify data and modeling gaps, and development of consensus for a way forward to address remaining information gaps.

Location
Midwest U.S.

Expected Completion
September 2016

Status
In progress

Progress and Results
The objective of this project is to formalize understanding of science information needs for management of conservation lands on large-river floodplains under non-stationary climatic and land-use conditions. The work is necessary to establish a firm foundation for development of cost-effective, relevant floodplain science to inform management. The work is expressly focused on understanding and addressing managers' information needs in dynamic floodplain environments. In natural systems floodplains owe their high biodiversity and productivity to their dynamic interactions with rivers, yet because floodplains provide productive soils, level land, and abundant water resources they have been subject to intensive agricultural, urban, and industrial development. Recently, large tracts of Missouri and Mississippi River floodplains have been converted to conservation status through purchase or easements, and questions have arisen about how these lands can best be managed under the joint uncertainties of continued land use and climate change. Managers face uncertainties ranging from site-specific designs for water infrastructure to long-term land-acquisition strategies. In the first component of this project we will identify information needs in an interactive setting wherein invited stakeholders (managers and scientists) will discuss specific floodplain-management challenges and develop conceptual models relating external drivers, climate change projections, management needs and adaptation strategies, and ecosystem responses. Project scientists will then take the conceptual models and apply existing datasets and simulation models to the management problems identified in the first component. We will focus on the chain of causality from non-stationary drivers, to abiotic processes, to biotic responses. Project scientists will report back (15 months later) to engage stakeholders in critical evaluation of the models, identification of data and modeling gaps, and development of consensus for a way forward to address remaining information gaps.

DR. AMANDA ROSENBERGER

DEVELOPMENT OF STANDARDIZED AND VALIDATED METHODS FOR SAMPLING FRESHWATER MUSSELS IN MISSOURI

Investigators
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Stephen McMurray
Leslie Crawford, M.S. Student
Matthew Schrum, M.S. Student

Project Supervisor
Dr. Amanda Rosenberger, MU

Funding
Missouri Department of Conservation
Love Foundation

Cooperators
Missouri Department of Conservation

Objectives
Determine the three most common visual methods for sampling mussels in the Meramec River in Missouri. And establish sampling design and protocols in known sites of mussel diversity within the Meramec drainage.

Conduct paired sampling in at least thirty sites within the Meramec drainage, pairing visual methods with bulk sediment collection.

Determine the effect of method, habitat conditions, and species on the accuracy of metrics using visual methods.

Recommend standardized approaches for sampling mussels in the Meramec drainage based on sampling objectives.

Location
Meramec River

Expected Completion
June 2016

Status
In progress

Progress and Results
We have conducted a pilot season and a full field season in sites within the Meramec River drainage. Using these data, we have developed standardized sampling protocols for common visual methods, including bank surveys, timed visual snorkeling, transect snorkeling, and direct collection via sediment sampling. This project assesses the sampling efficiency of common methods used to sample unionoid mussels in Missouri using a double-sampling design (e.g., pairing low-efficiency, low-costs methods with high-efficiency, high-costs methods as baseline measures of animal presence, abundance, and the community composition of mussels). We concentrate on areas with known mussel presence: areas of high diversity in the Meramec River drainage in Missouri.

Products:
Crawford, L. K. and A. E. Rosenberger. 2014. Development of validated standard methods for assessing unionoid mussel communities. Missouri Natural Resources Conference, Osage Beach, MO.

Crawford, L. K. and A. E. Rosenberger. 2014. Effectiveness of visual sampling methods for assessing unionoid mussel communities. 74th Annual Midwest Fish and Wildlife Conference, Kansas City, MO.

Schrum, M. C., L. K. Crawford, A. E. Rosenberger, and S. E. McMurray. 2014. Development of standardized and validated methods for sampling freshwater mussels in Missouri: Evaluation of factors affecting estimation of community and population metrics using visual survey approaches. Final proposal presentation to Missouri Department of Conservation, Columbia, MO.

DETERMINATION OF GEOMORPHOLOGICAL AND LANDSCAPE FACTORS CONTRIBUTING TO DIVERSE UNIONOID MUSSEL COMMUNITIES IN MISSOURI RIVER SYSTEMS, WITH PARTICULAR EMPHASIS ON THE MERAMEC RIVER DRAINAGE

Investigators
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Stephen McMurray
Dr. Kristen Bouska, Postdoctoral Associate
Dr. Garth Lindner Postdoctoral Associate

Project Supervisor
Dr. Amanda Rosenberger, MU

Funding
Missouri Department of Conservation

Cooperators
Missouri Department of Conservation
U.S. Fish and Wildlife Service

Objectives
Identify sites in the Meramec Drainage to produce community metrics of mussel assemblages.

Use existing data to identify core areas in the state for mussel diversity with particular emphasis on the Meramec drainage.

Analyze physical characteristics of mussel beds to identify habitat requirements, that support diverse mussel assemblages, with particular emphasis on landscape metrics.

Location
Meramec River

Expected Completion
June 2017

Status
In progress

Progress and Results
Our intent is to conduct occupancy modeling to identify characteristics of the landscape most likely to lead to areas of high abundance and diversity of unionoid mussels. We have hired two postdoctoral researchers with the expertise to complete this project: one, a habitat modeler, the other, a geomorphologist, who will be splitting their time between this project and another with the cooperative research unit.

The final outcome for this project will be a model that identifies the 'fundamental niche' of mussels in the Meramec drainage and beyond, particularly within the Ozark region. It is not, however, intended to identify all areas where they are present (the realized niche). Model verification, validation, and field studies will identify the differences between where they are predicted to have fundamental habitat requirements met and are not present, versus those areas where fundamental habitat requirements are met and they are present.

PHYSIOLOGY, BEHAVIOR, AND TOLERANCES OF MISSOURI FISHES OF CONSERVATION CONCERN WITH A FOCUS ON THE TOPEKA SHINER

Investigators
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Douglas Novinger
Rory Mott, M.S. Student

Project Supervisor
Dr. Amanda Rosenberger, MU

Funding
Missouri Department of Conservation

Cooperators
Missouri Department of Conservation
Missouri Department of Natural Resources

Objectives

Establish standardized methods for examining physiological ecologies of small, native Missouri fishes.

Determine physiological endpoints for target species related to a subset of acclimation temperatures.

Conduct experiments that vary concentrations of dissolved oxygen, ammonia, chloride, or other parameters to investigate tolerance levels and interactive and cumulative effects that these factors have with temperature on physiological endpoints.

Location
University of Missouri

Expected Completion
June 2017

Status
In progress

Progress and Results
The M.S. student has been selected for the project, and the fish growth laboratory at the University of Missouri is almost completely set up for intended experiments.

Managers whose primary objectives are recovering rare and threatened species of Missouri need to understand the capacity of unoccupied environments to support reintroduction or range expansion of target organisms. Further, it is crucial to understand basic physiological preferences, sensitivities, and tolerances of these species given projected changes in environmental conditions throughout the state related to land use and climate change. Unfortunately, the physiological ecology of most small, native fishes is poorly understood and limits conservation management.

We propose to use facilities available at the University of Missouri to investigate physiological preferences, capacities, and tolerances related to water temperature, oxygen content, and nutrients of the Topeka Shiner and related species. Existing habitat models for these species could be refined or calibrated with this information and ongoing and future reintroductions and recovery efforts would be better informed.

LIFE HISTORY OF THE FRECKLED CRAYFISH *CAMBARUS MACULATUS* IN TWO MISSOURI OZARK STREAMS

Investigators
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Dr. Jacob Westhoff, Post doctoral associate
Robert DiStefano

Project Supervisor
Dr. Amanda Rosenberger, MU

Funding
Missouri Department of Conservation

Cooperators
Missouri Department of Conservation

Objectives
Describe freckled crayfish populations' life cycles.

Document trait patterns important to population management.

Estimate representative summer densities of *C. maculatus* populations and relative densities as compared to other crayfish species at several stream locations.

Location:
Mill and Fourche Renault creeks

Location
University of Missouri

Expected Completion
June 2016

Status
In progress

Progress and Results
The goal of the proposed study is to document life history traits of C. maculatus populations in two streams to account for possible variation due to local environmental conditions, and for two years to detect interannual differences in timing of life cycle events.
We conducted monthly life cycle sampling for May 2013 through April 2014. Diel sampling typically occurred during the middle of every month.

We are presently analyzing data on timing of reproductive-related events, size/age at sexual maturity, realized fecundity, egg size, and timing of recruitment of juveniles. In addition, we are gathering information on frequency/timing of molting, sex ratios, size structure, maximum body size, longevity and growth. We also have preliminary data on population densities of freckled crayfish and other species at the site.

Products:
DiStefano, R., J. Westoff, C. Ames, and A.E. Rosenberger. 2014. Life history of the freckled crayfish *Cambrus maculatus* in two Missouri Ozark streams. FY14 Annual Project Report to the Wildlife Diversity Funding Program.

DR. ELISABETH WEBB

MOVEMENTS AND HABITAT SELECTION OF MID-CONTINENT MALLARDS

Investigators
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Dr. Dylan Kesler, MU
Dr. Elisabeth Webb, MU

Project Supervisors
Dr. Dylan Kesler, MU
Dr. Elisabeth Webb, MU

Funding
Arkansas Game and Fish Commission
Ducks Unlimited
Missouri Department of Conservation
Natural Resource Conservation Service

Cooperators
Arkansas Game and Fish Commission
Ducks Unlimited
Missouri Department of Conservation
Natural Resource Conservation Service

Objectives
Test for differential selection of private wetlands compared to publicly managed areas by Mallards.

Quantify the influence of spatial variance in energetic carrying capacity on movement and habitat selection of Mallards.

Identify important habitat types to migrating and wintering populations in Arkansas and Missouri.

Location
North America

Expected Completion
August 2013

Status
Complete

Progress and Results
To evaluate the impact of habitat types and protected areas on mallard space use, we tracked 33 adult female mallards (*Anas platyrhynchos*) throughout the midcontinent region using global positioning system (GPS) satellite transmitters. We used Bayesian discrete choice models to examine the influence of local habitat types and landscape composition on mallard space use during the non-breeding period. We separated the non-breeding period into three seasons, including autumn migration, winter, and spring migration. Results indicated habitat selection at the local scale (<30 km) was generally influenced by local and landscape-level variables across all seasons. Variables in top models at the local scale included proximities to cropland, emergent wetland, open water, and woody wetland. Similarly, variables associated with area of cropland, emergent wetland, open water, and woody wetland were also included at the local scale. At the relocation scale (>30 km), mallards selected resource units based on more generalized variables, including proximity to wetlands and total wetland area. These results emphasize the role of landscape composition in waterfowl habitat selection and provide further support for local wetland landscapes to be considered functional units of waterfowl conservation and management.

We also examined mallard wetland selection patterns during the non-breeding period to evaluate the utility of protected areas to waterfowl in North America. We implemented a use-availability resource selection design to examine mallard use of wetlands under varying degrees of protection. Specifically, we examined effects of proximities to National Wildlife Refuges, private land, state wildlife management areas, Wetland Reserve Program easements, and waterfowl sanctuaries on mallard wetland selection. In addition, we included landscape-level variables that measured areas of sanctuary and WRP within the surrounding landscape of each used and available wetland. We developed 8 wetland selection models according to season (autumn migration, winter, spring migration), hunting season (present, absent), and time period (diurnal, nocturnal). Parameter estimates indicated wetland selection patterns varied across seasons and time

periods, but mallards consistently selected wetlands with greater areas of sanctuary and WRP in the surrounding landscape. Consequently, WRP may provide important habitat for migratory waterfowl and supplement protected area networks in the midcontinent region. Additionally, wetland selection patterns demonstrated that anthropogenic disturbance patterns may impact local distributions of waterfowl during the non-breeding period.

Products

Beatty, W.S., D. C. Kesler, E. B. Webb, A. H. Raedeke, L. W. Naylor, and D. D. Humburg. 2014. The role of protected area wetlands in waterfowl habitat conservation: implications for protected area network design. Biological Conservation 176:144-152.

Beatty, W.S., E. B. Webb, D. C. Kesler, A. H. Raedeke, L. W. Naylor, and D. D. Humburg. 2014. Landscape effects on mallard habitat selection at multiple scales during the non-breeding season. Landscape Ecology 29:989-1000.

Beatty, W.S., D. C. Kesler, E. B. Webb, A. H. Raedeke, L. W. Naylor, and D. D. Humburg. 2013. Quantitative and qualitative approaches to identifying migration chronology in a continental migrant. PLoS ONE 8(10):e75673.

EFFECTS OF THE LIGHT GOOSE CONSERVATION ORDER ON BEHAVIOR OF WATERFOWL AND HUNTING PARTICIPANTS IN THE RAINWATER BASIN OF NEBRASKA

Investigators
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Dr. Mark Vrtiska, Nebraska Game and Parks Commission

Project Supervisor
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Funding
Nebraska Game and Parks Commission
U.S. Geological Survey
RWO 117

Cooperators
Nebraska Game and Parks Commission

Objectives
Quantify duration, distribution and frequency of participation in the Light Goose Conservation Order in the Rainwater Basin.

Evaluate habitat use and behavior of light geese and non-target species during the Light Goose Conservation Order in the Rainwater Basin.

Determine factors influencing stakeholder opinions and participation in Light Goose Conservation Order in Nebraska.

Location
Rainwater Basin, Nebraska

Completion
December 2012

Status
Complete

Progress and Results
Spring is an energetically important time period for migratory waterfowl and the Rainwater Basin (RWB) of Nebraska is an important spring staging area for waterfowl. Special regulations have been set to protect non-target species from hunting disturbance during the Light Goose Conservation Order (LGCO). Thus we evaluated how waterfowl react to hunting disturbance in relation to these special regulations and gathered hunter opinions on current and future management strategies to regulate this hunting season.

In both 2011 and 2012, dabbling duck densities were greater on wetlands closed to hunting during early season when over 90% of hunting parties were recorded on study wetlands. There were no differences in densities for both years between open and closed wetlands during late season when hunting pressure subsided. In 2011 mallards and Northern pintails spent more time foraging in wetlands closed to hunting during early season, but no differences in behavior were detected in late season. In 2012 ducks spent more time foraging in both early and late seasons on wetlands open to hunting and habitat quality could have played more of a role in observed differences this year. Migration chronology also occurred over a much shorter time frame in 2012and hunting disturbance may not been as likely to affect behavior. A mail questionnaire was sent to over 4,000 hunters after the conclusion of the 2012 LGCO. Hunters generally agreed that restrictive regulations during the LGCO in the RWB are important. Hunters were most in favor of a season that was open to hunting seven days a week with more public wetlands closed to hunting, while the second most favorable choice selected by hunters was the restrictive regulations currently in place. Given that dabbling duck densities were greater on wetlands closed to hunting, providing wetlands free from hunting disturbance during the LGCO is likely an important management strategy at migration stopover sites.

Products
Dinges, A.J., E.B. Webb, M.P. Vrtiska, C.H. Nilon, and S.A. Wilhelm Stanis. *In press*. Migratory bird hunter opinions regarding future management strategies for controlling light goose populations. Wildlife Society Bulletin.

Dinges, A.J. 2013. Participation in the Light Goose Conservation Order and effects on behavior and distribution of waterfowl in the Rainwater Basin of Nebraska. M.S. Thesis.

WATERBIRD USE AND FOOD AVAILABILITY ON WETLAND RESERVE PROGRAM SITES ENROLLED IN THE MIGRATORY BIRD HABITAT INITIATIVE

Investigators
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Dr. Elisabeth Webb, MU

Project Supervisor
Dr. Elisabeth Webb, MU

Funding
Love Foundation
Natural Resource Conservation Service

Cooperators
Missouri Department of Conservation
Natural Resources Conservation Service
Mississippi State University
U.S. Fish and Wildlife Service

Objectives
Quantify food availability for shorebirds during migration on Wetland Reserve Program lands in the Mississippi Alluvial Valley.

Quantify food availability for migrating and wintering waterfowl on Wetland Reserve Program lands in the Mississippi Alluvial Valley.

Assess local and landscape factors influencing waterbird density and species richness on Wetland Reserve Program sites.

Location
Southeast Missouri, eastern Arkansas

Completion
May 2013

Status
Complete

Progress and Results
The Natural Resource Conservation Service implemented the Migratory Bird Habitat Initiative (MBHI) in summer 2010 to with the goal of improving wetland habitats conditions on Wetland Reserve Program (WRP) easements in the Lower Mississippi Alluvial Valley. Priorities for WRP lands included addressing waterbird food habitats, providing habitat structure, and additional management activities such as planting and/or disking on moist-soil wetlands. We conducted waterbird surveys and collected seed and invertebrate samples on WRP wetlands enrolled in MBHI (n=13), WRP wetlands not enrolled in MBHI (n=12), and intensively managed publicly owned wetlands (n=7) in the LMAV of Arkansas and Missouri to quantify food availability and habitat use from autumn 2011 and winter 2012 by fall migrating shorebirds and wintering dabbling ducks. Dabbling duck densities at MBHI wetlands were 2.1 times greater than at WRP wetlands; but did not differ from densities at public wetlands. Regardless of wetland type, dabbling duck densities were approximately 2.6 times greater at private wetlands (MBHI and WRP) that were actively inundated compared to sites that were not inundated. During autumn, invertebrate production at MBHI contracts was almost 20 times greater than at WRP easements and production at easements that were mowed was approximately 10 times greater compared to easements that were not mowed. During winter, invertebrate production was greater on private lands (MBHI and WRP) than public lands. Thus, management activities at WRP easements have the potential to increase seed biomass and invertebrate production, and create habitat conditions similar to long-term publicly managed wetlands within a relatively short time frame.

Products
Tapp, J.L. 2013. Waterfowl use and food availability on Wetland Reserve Program sites in the Lower Mississippi Alluvial Valley. M.S. Thesis, University of Missouri.

LINKING WETLAND MANAGEMENT DECISIONS TO DISTRIBUTION, HABITAT USE, AND NESTING EFFORTS OF SECRETIVE MARSH BIRDS IN MISSOURI

Investigators
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Dr. Elisabeth Webb, MU
Doreen Mengel, MDC
Dr. Andy Raedeke, MDC

Project Supervisor
Dr. Elisabeth Webb, MU

Funding
Missouri Department of Conservation
CA 354

Cooperators
Missouri Department of Conservation

Objectives
Validate wetland management planning models for secretive marsh birds.

Evaluate MDC management strategies as they pertain to the distribution, habitat selection, and nesting success of SMBs across the range of predicted habitats and management strategies.

Quantify the distribution, habitat selection, and nesting success of SMBs on MDC wetland areas.

Location
Missouri

Expected Completion
August 2015

Status
In Progress

Progress and Results
We selected twelve study areas, and classified wetland units within study areas based on water level management and stratified survey point selection based on the vegetation communities. We generated detection histories for the following five focal species: sora, Virginia rail, king rail, American bittern, and least bittern. We used detection histories generated from these surveys to calculate detection and occupancy . We then determined how different habitat and management classifications influenced detection probability and site occupancy by including them as covariates in the occupancy models. In 2013, we conducted 738 surveys at 120 survey points from 8 April to 29 June. In 2014 we conducted 995 surveys at 227 points from 1 April to 6 June. In 2013, least bittern occupancy was positively correlated with passive management, water depth, and vegetation height, and negatively correlated with active management. In 2013, sora occupancy was positively correlated with passive management, vegetation height, and vegetation density. In the same year, American bittern occupancy was positively correlated with vegetation height and the proportion of a 50m radius surrounding a survey point that was inundated. Further analysis of the data is taking place for 2014, which will test for the influence of habitat characteristics on occupancy estimates for that year, as well as determining the effect of habitat characteristics at multiple spatial scales for both years. We searched for nests in study sites where we detected SMBs that were also flooded at the beginning of the nesting season. We found 40 nests in 2013, and calculated a daily survival probability of 0.64. In 2014, we found 43 nests, and calculated a daily survival probability of 0.21

LINKING WATERFOWL DISTRIBUTION AND ABUNDANCE TO SPATIAL AND TEMPORAL DISTRIBUTION AND ABUNDANCE OF WETLAND HABITAT

Investigators
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Dr. Elisabeth Webb, MU
Dr. Andy Raedeke, MDC

Project Supervisor
Dr. Elisabeth Webb, MU

Funding
Missouri Department of Conservation
U.S. Geological Survey

Cooperators
Missouri Department of Conservation

Objectives
Develop and evaluate an aerial survey to estimate waterfowl density in north central Missouri during fall and winter.

Develop and evaluate models predicting probability of wetland inundation for wetlands in north central Missouri in November.

Evaluate the relationship of dabbling duck density and distribution with probability of wetland inundation and individual wetland seed biomass in north central Missouri.

Location
North Central Missouri

Expected Completion
May 2016

Status
In progress

Progress and Results
Missouri wetlands are important for migratory waterfowl as they fulfill energetic demands and stopover sites during the fall and winter. However, little is known about waterfowl use, habitat availability, and food production on private wetlands in Missouri. This project aims to quantify waterfowl use of all wetlands in Missouri, model probability of wetland habitat availability of Missouri wetlands, and compare waterfowl food production between public and private wetlands.

Aerial surveys will be performed via fixed wing aircraft bi-weekly beginning the first week of October and ending in January. To reduce variation of detection rate and increase precision of estimates, the survey area is stratified by wetland and waterfowl densities. Sampling transects will be selected by weighted random sampling using the probability of inundation to weight the probability of selection. Probability of wetland inundation will be modeled for November using hydrologic input, hydric soil rating, and watershed characteristics. The results of the wetland inundation modeling will also be used to inform the weighting of aerial survey transect selection. Finally we will collect seed biomass estimates from both actively managed public wetlands (n=12) and private wetlands (n=12) within 30km of the public wetlands in north central Missouri. Seed head clippings and soil core samples will be collected from each site to quantify waterfowl food production.

The results from this project will be instrumental in informing natural resource biologists' management activities. Specifically, results can assist wetland managers in tracking the response of management activities on waterfowl food resources and waterfowl distribution. Results will also inform wetland management decisions regarding the role each public wetland plays in its surrounding landscape and potentially assist MDC in developing a user interface for True-met concerning energetic supply for migrating and wintering waterfowl. And finally, results can inform Joint Ventures of the potential energetic demands of migrating waterfowl that Missouri wetlands meet during the fall and winter migration.

DEVELOPMENT OF A SPATIALLY AND TEMPORALLY EXPLICIT RESOURCED BASED MODEL TO ESTIMATE FOOD AVAILABILITY FOR SPRING MIGRATORY WATERFOWL

Investigators
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Ted LaGrange, Nebraska Game and Parks Commission

Project Supervisor
Dr. Elisabeth Webb, MU

Funding
Great Plains Landscape Conservation Cooperative

Cooperators
Nebraska Rainwater Basin Joint Venture
Nebraska Game and Parks Commission
U.S. Fish and Wildlife Service

Objectives
Quantify food availability for waterfowl during migration on wetlands within the Nebraska Rainwater Basin.

Determine how waterfowl distribute themselves in relation to variations of food abundance in space and time during spring migration.

Assess the indirect effects of neonicotinoid insecticides on invertebrates at wetlands in an agricultural landscape.

Location
Nebraska Rainwater Basin

Expected Completion
May 2016

Status
In progress

Progress and Results
Mid-latitudinal wetlands play a critical role in the life histories of wetland dependent waterbirds during migration. In the spring, their primary function is to facilitate passage from southern wintering areas to more northern breeding grounds by providing areas to rest, and replenish energetic food resources required to complete migration. Recent studies have shown that female mallards arriving on breeding grounds in with high lipid and protein reserves nest sooner, have larger clutch sizes, and greater nest propensity.

The Nebraska Rainwater Basin (RWB) is strategically positioned midway between important waterfowl wintering areas (Southern High Plaines, and the Mississippi Alluvial Valley), and northern breeding grounds (Prairie Pothole Region and northwards). Unfortunately the RWB has observed a 90% loss in its historic wetlands which has likely had a negative impact on waterfowl populations on a continental scale. Current conservation management is guided by energetic carrying capacity models and the amount of forage required to support annual migrants. Unfortunately the current model used in the RWB is based solely on late summer seed collections from public wetlands, which might only be applicable to fall migration. It is likely that seed depletion by preceding fall migrants in tandem with natural decomposition results in a substantial decrease in seed availability during the spring.

Food resources are thought to be a limiting factor during spring migration, thus increasing food production in the RWB and at other mid-latitudinal wetlands could lead to an overall increase in North American waterfowl populations. Given the limited monetary resources available for wetland procurement and restoration, it is essential that carrying capacity models be as accurate as possible. Therefore the overall objective of this study is to increase the effectiveness of current strategies by developing spatially and temporally explicit resourced based models to estimate food availability for spring migrants. We will add additional resolution to the model by incorporating invertebrate production, a resource thought to be important to waterfowl diets, however absent in current models.

WHICH GEESE ARE BEING HARVESTED? BODY CONDTION OF LESSER SNOW (*CHEN CAERULESCENS CAERULESCENS*) AND ROSS'S GEESE (*C. ROSSII*) HARVESTED BY DIFFERENT METHODS DURING THE LIGHT GOOSE CONSERVATION ORDER

Investigators
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Project Supervisor
Dr. Elisabeth Webb, MU

Funding
Nebraska Game and Parks Commission

Cooperators
Nebraska Game and Parks Commission
Missouri Department of Conservation
Arkansas Game and Fish Commission
South Dakota Game, Fish and Parks

Objectives
Evaluate body condition of lesser snow and Ross's geese harvested by various methods (e.g., over decoys vs. pass shot) during the light goose conservation order.

Examine differences in species, age, sex, and breeding origin of lesser snow and Ross's geese harvested by various methods (e.g., over decoys vs. pass shot) during the light goose conservation order.

Assess implications of differential harvest rates on population dynamics of lesser snow and Ross's goose and potential impacts to management actions.

Location
Arkansas, Missouri, Nebraska, South Dakota

Expected Completion
December 2017

Status
In progress

Progress and Results
The Light Goose Conservation Order (LGCO) was implemented in 1999 as an attempt to reduce light geese populations to a sustainable level and reduce pressure to jeoparadized arctic ecosystems through liberalized hunting regulations. Despite its implementation, current efforts appear to be ineffective in reducing light goose populations. Previous research has suggested that light geese harvested during the LGCO are disproportionately in poorer body condition than the general population of light geese. Therefore current harvest strategies may actually benefit populations by lessening impacts of competition for food and other resources. Objectives for this project collectively aim to evaluate differences in body condition of geese harvested by various methods (e.g., over decoys vs. pass shot) during the light goose conservation order in order to understand potential impacts to management actions.

Sampling of lesser snow and Ross's geese will take place during late winter and spring migration (February-May) 2015 and 2016 in Arkansas, Missouri, Nebraska and South Dakota. Birds will be collected and categorized by the different methods of take: over decoys, sneaking/stalking, and pass shooting. We will determine age and sex by cloacal and internal examination and tail-feather characteristics and weigh each bird and obtain various measurements of size (e.g., length of tarsus, middle toe, culmen, and wing chord). We will categorize geese into 2 age classes to estimate potential differences in body mass and nutrient reserves among ages. A random sample of collected birds also will be selected and analyzed for carcass composition to obtain estimates of total body lipids and ash-free lean dry mass (i.e., an index of protein) of birds as a standard to compare all birds. Carcasses will be frozen until specimens can be plucked and analyzed for lipids using duplicate petroleum ether extraction with a Soxhlet apparatus and for ash-free lean dry mass following standardized procedures. Statistical comparisons for evaluation of body condition between the different methods of harvest, adjusting for body size, will be made using generalized linear mixed models, and include body size, collection date, collection location, sex, and method of collection as independent variables. Additionally, composition of harvest of age and species between flocks and harvested geese, for all categories, will be made using categorical data analysis procedures.

DEVELOPMENT OF A FISH AND AMPHIBIAN RAPID ASSESSMENT PROTOCOL FOR WETLANDS: LINKING MANAGEMENT TO WETLAND SYSTEM PROCESSES

Investigators
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Project Supervisors
Dr. Craig Paukert, MU
Dr. Lisa Webb, MU

Funding
MDC

Cooperators
Multiple wetland managers statewide

Objectives
Assess efficiency and effectiveness of a variety of sampling methods to determine probability of presence and species richness of amphibians and fish in MDC wetlands.

Quantify effects of region, season, and habitat complexity on detection probability for amphibians and fish in MDC wetlands.

Recommend standardized assessment protocol for use by MDC wetland area managers to evaluate amphibian and fish response to wetland management decisions.

Location
Missouri

Expected Completion
June 2017

Status
In progress

Progress
Manipulating water levels within wetland complexes mimics wetland ecosystem processes to ensure habitat conditions vary both in time and space to benefit a wide range of wetland-dependent species. Although providing seasonally flooded habitats to accommodate the needs of migratory water birds is a priority on Missouri's actively managed wetland areas, these floodplain conditions are also used by a wide-variety of other wetland dependent species. Wetland dependent taxa such as fish and amphibians are much more difficult to detect, resulting in management decisions made with the assumption that an action beneficial to one suite of species will also benefit a wider range of species. However, there is uncertainty associated with this assumption. Monitoring to reduce the associated uncertainty allows managers to weigh the needs of a variety of species' life history requirements and increasing awareness of the biological trade-offs inherent in their management decisions. Better informed management decisions based on monitoring could result in certain management actions that are delayed or expedited to benefit an alternate taxonomic group without sacrificing the primary management objective. Fish and amphibians are ideal target taxa to monitor in wetlands due to the perceived conflict of among taxonomic groups and certain wetland conditions. Many fish benefit from having access to the floodplain for foraging, spawning, migration corridors, and refugia. Amphibians benefit from having access to seasonal wetlands for breeding and larval development. Information regarding seasonal fish and amphibian species composition and use of floodplain habitats would help inform wetland management decisions. This would provide managers with a better understanding of how needs of lesser-known species can be incorporated into management actions without detrimental effects to more traditional management activities. Therefore, we will conduct a 2-year study to determine the best sampling methods to determine the presence of fish and amphibians in wetland in different regions of the state.

IDENTIFICATION OF SUMMER HABITAT FOR FEDERALLY ENDANGERED INDIANA BAT WITHIN THE OZARK CENTRAL RECOVERY UNIT

Investigators
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Project Supervisor
Dr. Elisabeth Webb, MU

Funding
USGS Science Support Partnership
U.S. Fish and Wildlife Service
RWO 126

Cooperators
U.S. Fish and Wildlife Service
U.S. Forest Service

Objectives
Survey forest bat communities with emphasis on distribution of Indiana bats and species of special conservation concern using mist nets and acoustic sampling.

Use radio telemetry to locate maternity colonies, monitor foraging habits and corridor use by Indiana bats and evaluate habitat selection of foraging and roosting resources by colonies.

Assess forest stand structure of roosting and foraging areas in comparison to areas without known roosting or foraging to determine Indiana bat habitat selection.

Location
Mingo NWR (Missouri)
Cypress Creek NWR (Illinois)

Expected Completion
December 2016

Status
In Progress

Progress and Results
The goal of this project is to locate maternity colonies of federally endangered Indiana bats (*Myotis sodalis*) and characterize maternity roosting and foraging on Cypress Creek and Mingo National Wildlife Refuges, in order to gain a better understanding of habitat selection in the Ozark – Central Recovery Unit. If colonies of Indiana bats are not located, then secondary focal species of concern such as Rafinesque's big-eared bat (*Corynorhinus rafinesquii*), Southeastern myotis (*M. austroriparius*), or Northern long-eared bat (*M. septentrionalis*) will be studied instead. In addition, acoustic sampling along transects will provide baseline data and long-term monitoring of the population status and distribution of Indiana bats and other species of conservation concern on federal lands.

We will attempt to capture and attach radio transmitters to twenty adult female Indiana bats/site/season, for a total of 80 bats over the entire study. All bats will be tracked until transmitters fall off or batteries fail. We will use triangulated foraging locations to determine home range, distance traveled by individuals, and movement routes in addition to roost and foraging site habitat selection. A variety of habitat characteristics (canopy cover, number of snags, mean stem density, etc.) will be quantified in occupied habitat and at random sites, to better understand the factors that influence selection of roosting and foraging sites. We will use discrete-choice analyses and information theoretic approaches to evaluate habitat selection of foraging and roosting sites at multiple spatial scales. Results will be able to be used to assess the relative importance of particular forest management strategies or habitat characteristics to Indiana bats during specific portions of the annual cycle. This is particularly important since they are a high priority species of concern, and since there is potential for them to be a surrogate species, based on the potential benefits to other species through habitat management for Indiana bats.

PROJECTS TO OTHER FACULTY THROUGH THE UNIT

DR. JOHN FAABORG

USE OF EARLY-SUCCESSIONAL HABITATS BY FOREST BREEDING BIRDS: CONVENIENCE OR NECESSITY?

Investigators
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Alicia Burke, MS student, MU

Project Supervisor
Dr. John Faaborg, MU

Funding
U.S. Fish and Wildlife Service
RWO 113

Cooperators
Missouri Dept. of Conservation

Objectives
Recent studies have suggested that many mature forest-breeding migratory birds may use early successional habitats after breeding, but it is unclear the extent that this use is necessary as part of the annual cycle of such birds.

We will use radio-tracking of Ovenbird, Worm-eating Warbler, and Red-eyed Vireo to determine the extent that young birds of these species require early-successional habitats after they become independent of their parents.

Location
Missouri Ozark Forests

Completion
June 2013

Status
Complete

Progress and Results
Studies in the Midwest and elsewhere have suggested that a variety of mature forest breeding birds spend a portion of the post-breeding season in early successional habitats such as clearcuts. Anders et al. 1998 was among the first papers to demonstrate this with the Wood Thrush, where all radio-tracked birds moved from mature forest breeding habitat to early successional habitat after independence from their parents. Others have shown similar behavior by this species elsewhere. Several studies using mist nets have captured many other forest-breeding species in clear cuts after independence, and it has often been assumed that these birds stay in the cuts for long periods of time, but netting does not provide good data in this regard.

In this study, we netted a variety of clearcuts for two summers to determine use of such cuts by forest birds, then in the last summer we captured hatching-year individuals of Ovenbird, Worm-eating Warbler, and Red-eyed Vireo in clear cuts and put radio transmitters on some of these birds. These birds were then followed for the duration of the life of their radio (ideally 20 days).

Initial observations from our radio-tracking suggests that young Ovenbird and Worm-eating Warbler move to clear cuts after becoming independent of their parents and they stay there for long periods of time (up to 20 days). Young Red-eyed Vireo were captured in the clear cuts but moved back to mature forest soon after the radios were put on them and these birds moved extensively after that.

We will do formal analysis of capture rates and locations for our radio-tracked individuals this fall to provide a quantitative analysis of bird movements.

DR. SCOTT HOLAN

DEVELOPMENT OF POPULATION AND SURVIVAL ESTIMATES FOR PALLID STURGEON IN THE LOWER MISSOURI RIVER

Investigators
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Guohui Wu, PhD student, MU

Project Supervisors
Dr. Scott Holan, MU

Funding
U.S. Geological Survey
Missouri Cooperative Fish and Wildlife Research Unit
RWO 106

Cooperators
U.S. Army Corp of Engineers
U.S. Fish and Wildlife Service
Missouri Department of Conservation
Nebraska Game and Parks Commission

Objectives
Develop pallid sturgeon population and survival estimates that will predict numbers of fish surviving from hatchery outputs and ultimate population size in future decades.

Develop a model to predict hatchery reared pallid sturgeon survival and dispersal (short- and long-term) related to stocking size, location, season, and genetic origin.

Location
Lower Missouri River

Completion
July 2014

Status
Complete

Progress and Results

Similar to other fish species, previous capture probability, survival rate, and population size estimates for the federally-listed as endangered pallid sturgeon have been obtained using capture-recapture models (e.g., Cormack-Jolly-Seber (CJS) with and without Robust Design). We present a Bayesian-based approach to estimate capture probability, survival rate, and population size of shovelnose and pallid sturgeon in the Lower Missouri River using open population capture-recapture CJS and Jolly Seber models. There are several advantages to using a Bayesian approach, including straightforward, accurate quantification of uncertainty for the estimated parameters and for deterministic functions of the estimated parameters. In our analysis, models with time-varying capture probability and gear effort covariates were preferred. Short-term, timeframe-specific sampling was a poor substitute for year-round sampling. Assuming high tag retention rates, there were estimated to be around 4000 hatchery and 1400 wild pallid sturgeon as of 2009 with population size not increasing with stocking. Concurrently, shovelnose sturgeon overall population size seemed stable throughout the study period; however, age-2, age-3, and age-4+ age group population sizes were lowest by the end of the study with overall population size estimated around 600 thousand in March through June 2010.

DR. DYLAN KESLER

MOVEMENT ECOLOGY AND HABITAT SELECTION IN MID-CONTINENT WATERFOWL

Investigators
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Dr. Elisabeth Webb, MU

Project Supervisor
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Dr. Elisabeth Webb, MU

Funding
Upper Mississippi River Great Lakes Joint Venture
Arkansas Game and Fish Commission
Ducks Unlimited
Missouri Department of Conservation
Natural Resource Conservation Service

Cooperators
Arkansas Game and Fish Commission
Ducks Unlimited
Missouri Department of Conservation
Natural Resource Conservation Service

Objectives
Test for differential selection of private wetlands compared to publicly managed areas by Mallards.

Quantify the influence of spatial variance in energetic capacity on movement and habitat selection of Mallards.

Identify important habitat types to migrating and wintering populations in Arkansas and Missouri.

Location
North America

Expected Completion
August 2015

Status
In progress

Progress and Results
Effective waterfowl management and conservation requires approaches at multiple temporal and spatial scales that extend across state and national jurisdictions. Over $4 billion have been invested in waterfowl habitat, but it remains unclear how habitat management activities influence waterfowl populations, especially during the nonbreeding period of the annual life cycle. To begin addressing these uncertainties, pilot efforts with satellite transmitter-equipped mallards (*Anas platyrhynchos*) and American black ducks (*Anas rubripes*) have been conducted to develop initial insights into large scale and cross-seasonal movements and habitat use. In this project, we bring together the two efforts to gather movement metrics derived from data collected with GPS satellite telemetry units attached to 40 mallards and 68 American black ducks. This information is combined with existing information about habitats, landscapes, energetics, weather and demography in migratory waterfowl populations. Our aim is to develop and parameterize spatially explicit agent-based models of movement and habitat selection during the nonbreeding period, and to use these models to evaluate alternative approaches to managing migratory waterfowl and their habitats under a range of potential future land-use scenarios that incorporate large-scale environmental variation. Results will inform habitat management and conservation planning across multiple scales.

Products

Kesler, D. C., A. Radedke, J. Foggia, W. Beatty, E. B. Webb, D. Humburg, L. Naylor. 2014. Effects of satellite transmitters on captive and wild mallards. Wildlife Society Bulletin 38:557-565. DOI: 10.1002/wsb.437.

DR. RAY SEMLITSCH

EFFECTS OF ENDOCRINE DISRUPTING CHEMICALS ON HEALTH OF AQUATIC ORGANISMS

Investigators
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Rachelle Riegerix, PhD student, MU

Project Supervisor
Dr. Donald Tillitt, USGS

Funding
U.S. Geological Survey
RWO 113

Cooperators
U.S. Fish and Wildlife Service

Objectives
Managers at National Wildlife Refuges at some remote islands refuges use rodenticides to control rat populations. If these chemicals enter aquatic habitats when used, they may threaten the health of fish or other aquatic organisms. This study investigates the effects of these chemicals on fish health.

Location
National Wildlife Refuges

Completion
December 2017

Status
In progress

Progress and Results
Aquatic and terrestrial natural resources are subject to multiple uses, and as a consequence, organisms are subject to multiple stressors. Informed decision making weighs the benefits and the risks associated with the stresses that come with the inevitable multi-use scenarios, including exposure to EDCs. Therefore, the goal of this Research Work Order (RWO) is to develop tool and information on the risks associated with EDC exposures to our DOI aquatic resources. Quantitative evaluation of risks and associated uncertainties are critical for sound resource management. The specific objectives of this RWO are to: 1) develop models to quantify dose-response relationships of EDCs in species of concern; and 2) evaluate how risk estimates of EDCs to wildlife populations translate from physiological indicators to population level outcomes.

DR. MICHAEL STAMBAUGH

FIRE HISTORY AND FOREST COMMUNITY DYNAMICS AT THE WICHITA MOUNTAINS

Investigators
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Dr. Richard Guyette, MU

Project Supervisor
Dr. David Galat, MU

Funding
U.S. Fish and Wildlife Service
RWO 105, 120

Cooperators
Missouri Cooperative Fish and Wildlife Research Unit

Objectives
Reconstruct historic fire events to characterize fire regime and describe demographics and growth of eastern redcedar.

Location
Wichita Mountains National Wildlife Refuge

Completion
September 2013

Status
Complete

Progress and Results

A total of three new fire history sites were established at the refuge and all data have been collected for these sites. Sites were located at Hollis Canyon, Rain Gauge Flat, and Cache Creek. A total of 189 trees were sampled at these sites and additional trees were sampled opportunistically in other locations within the Special Use Area. Currently we are summarizing the fire histories for each individual site and for the larger refuge area. All fire history records span a common period of 1746 to 2005. The earliest record extends back to 1637 and the earliest fire detected was in 1712. Transects were used to characterize the tree vegetation at the fire history sites. An absolutely dated tree-ring width chronology has been constructed from dead and living eastern redcedar trees on the refuge. The chronology extends back to the 13th century. We have begun analyses to characterize the climate-growth response of redcedar. Vegetation plot sampling to characterize eastern redcedar expansion has been completed. Two different models are being developed: 1) a predictive model of the age of redcedar based on topographic, vegetation, and environmental conditions and, 2) a set of probability models for the presence of red cedars in different age classes.

DR. FRED VOM SAAL

ENDOCRINE DISRUPTING CHEMICAL (EDC)-INDUCED EPIGENETIC CHANGES ON GENES REGULATING REPRODUCTION IN FISH

Investigators
Dr. Fred vom Saal, MU

Project Supervisor
Dr. Craig Paukert, USGS

Funding
US Geological Survey
Columbia Environmental Research Center

Cooperators
US Geological Survey
University of Missouri

Objectives
Determine if atrazine exposure causes modifications of chromatin state by regulating histone protein recruitment in medaka.

Quantify alteration of DNA methylation on the promoters of select steroid pathway genes, specifically estrogen receptor, androgen receptor, membrane progestin receptor, aromatase, vitellogenin, DMRT1 that are involved in reproduction and sexual behaviors in medaka.

Promoter and other genomic regions that are open and active before and after the atrazine treatment will be obtained.

Location
Nationwide

Expected Completion
December, 2014

Status
In progress

Progress and Results
Atrazine is one of the most commonly used herbicides in the world. In the United States, it is being used as a selective triazine for annual broadleaf control and annual usage has been estimated to be between 66 and 82 million pounds. Atrazine has been routinely detected in surface and ground waters, particularly in mid-western states, at concentrations from 1 to 25 μg/L. However, atrazine related effects through endocrine mechanisms on vertebrate reproduction and development have not received the same level of ecological risk evaluation.

Reproductive dysfunction in mammals has been attributed to atrazine-induced effects on neurotransmitter and neuropeptide functions resulting in suppression of luteinizing hormone and prolactin surges with subsequent disruption of hypothalamic control of pituitary function. The observed effects in mammals have occurred at elevated oral doses and it is not known if atrazine works through these same mechanisms of action in other vertebrates that are exposed through different routes of uptake. However, it is known that many of these same neuroendocrine pathways exist in fishes. Our studies in fathead minnow and medaka suggest that Atrazine at the dose lower than environmental level causes follicular atresia and variability in the relative proportions of oocyte stages, with a significant reduction in total spawning events. Mechanistically, it has been shown in other fish models that atrazine blocks the action of the progestin 17, 20β,21-trihydroxy-4-pregnen-3-one to up-regulate sperm motility and blocks final oocyte maturation through modulation of membrane progestin receptor. In zebrafish and mammalian cell culture system the action of atrazine has been found to be mediated through genomic interaction of an orphan nuclear receptor (Sf1) on aromatase promoter. Aromatase is the enzyme required for conversion of Testosterone into estradiol-17beta in fish.

FISH AND WILDLIFE FACULTY PROJECTS

2012 TO PRESENT

DR. JOHN JONES

THE LAKES OF MISSOURI VOLUNTEER PROGRAM

Investigators
Anthony Thorpe, MU
Daniel Obrecht, MU

Project Supervisor
Dr. John R. Jones, MU

Funding
Missouri Department of Natural Resources

Cooperators
Ozarks Water Watch

Objectives
To determine current water quality of Missouri lakes.

To monitor Missouri lakes for changes over time.

To educate the public about nonpoint source pollution, water quality issues and lake ecology.

Location
Statewide

Expected Completion
Ongoing

Status
In progress

Progress and Results
The Lakes of Missouri Volunteer Program (LMVP) has recruited citizens to collect water quality samples in Missouri‘s lakes for the past 22 years. The goals of the LMVP are to determine current water quality in Missouri‘s lakes, to monitor for changes in water quality over time and to educate the public about lake ecology and water quality issues. In 2013 the LMVP engaged volunteers to collect over 850 water samples at 125 lake sites across the state. The data are used by the Missouri Department of Natural Resources, the Missouri Department of Conservation, the U.S. Army Corps of Engineers, the U.S. Environmental Protection Agency, watershed groups, lake managers and citizens to address various water quality data needs. The LMVP website (lmvp.org) hosts the program‘s newsletters and data reports and receives thousands of visitors each month.

Products
The Water Line (LMVP Newsletter): http://lmvp.org/publications.htm
Website: http://lmvp.org/publications.htm
Annual Data Reports: http://lmvp.org/Data/2009/index

STATEWIDE LAKE ASSESSMENT PROJECT

Investigators
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Daniel Obrecht, MU

Project Supervisor
Dr. John R. Jones, MU

Funding
Missouri Department of Natural Resources

Objectives
To generate Missouri lake and reservoir water quality data. The data are used to document existing conditions, evaluate trends, model lake processes and assist with management decisions.

Location
Statewide

Expected Completion
Ongoing

Status
In progress

Status
In progress

Progress and Results
The Statewide Lake Assessment Project is aimed at determining water quality in Missouri‘s lakes. Each summer approximately 75 lakes throughout the state are sampled on four occasions. Of these lakes, 40 are monitored each summer to allow for tracking of long-term regional trends. The other monitored lakes are selected from a list of approximately 200 Missouri water bodies on a rotating basis. In 2013 sampling was expanded to 90 lakes to assess conditions following a drought period. Data collected through the project are shared with the Missouri Department of Natural Resources to help the state meet Clean Water Act requirements, to the Missouri Department of Conservation to aid in fisheries management, to municipalities managing drinking water reservoirs and to citizens interested in water quality in their favorite lake.

Products
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Michaletz, P. H., D. V. Obrecht, J. R. Jones. 2012. Influence of environmental variables and species interactions on sport fish communities in small Missouri impoundments. North Amer. J. of Fisheries Manage. 32:6, 1146-1159.

Pittman, B., J. R. Jones, J. Millspaugh, R. J. Kremer and J. A. Downing. 2013. Sediment organic carbon distribution in 4 small northern Missouri impoundments: implications for sampling and carbon sequestration. Inland Waters 3:39-46.

Jones J, Brett MT. 2014. Lake nutrients, eutrophication, and climate change. In: Freedman B, editor. Global environmental change. Dordrecht (Netherlands): Springer. p. 273–279.

DR. DYLAN KESLER

DEVELOPING RESCUE SCENARIOS FOR THE MICRONESIAN KINGFISHER

Investigators
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Dr. Dylan Kesler, MU

Project Supervisor
Dr. Dylan Kesler, MU

Funding
U.S. Fish and Wildlife Service, Missouri Cooperative Fish and Wildlife Research Unit
RWO 112

Cooperators
U.S. Fish and Wildlife Service
Association of Zoos and Aquariums
College of Micronesia.

Model and identify suitable candidate islands to establish the Guam Micronesian Kingfisher in Pacific Oceania.

Ground truth candidate islands to determine suitability.

Model captive and release population dynamics to identify suitable release individuals and predict post release dynamics.

Location
Pacific Oceania, Guam, Federated States of Micronesia, French Polynesia, Marshall Islands, Commonwealth of the Mariana Islands, Republic of Palau

Status
Complete

Progress and Results
The Guam Kingfisher (*Todiramphus cinnamominus*) has been extirpated from its native range by the introduced brown tree snake (*Bioga irregulars*). Kingfisher populations declined over several decades, and threats to the birds were finally recognized in 1984 when they were listed as endangered. Attempts to breed the birds in captivity initially met with limited success, but the population has rebounded substantially in recent years to the point where re-introductions and translocations are being considered. However, little is known about where the birds might be reintroduced, or how translocations and reintroductions might affect the extant population of birds. Further, little is known about which reintroduction approaches might be most effective for establishing a viable rescue population of the kingfishers. This project was initiated to develop conservation approaches for recovering the critically endangered Micronesian Kingfishers through the establishment of a rescue population. First we developed conceptual and quantitative models to identify potential release locations. Models were then ground-truthed, and modified to incorporate contemporary data collected in the field. The final phase of research included developing quantitative population models to test alternate reintroduction scenarios. Results from the work indicated that the islands of Kosrae, Yap, and islets within the greater Chuuk group of the Federated States of Micronesia are most suited to introduced populations of the birds.

Products since 2012
Laws, R. J., and D. C. Kesler. 2012. A Bayesian network approach for selecting translocation sites for endangered island birds. Biological Conservation 155:178-185.

Laws, R. J., and D. C. Kesler. 2012. Site selection for the establishment of a wild population of the Guam Micronesian kingfisher. Technical report submitted to U.S. Fish and Wildlife Service.

Laws, R. J., and D. C. Kesler. 2014. Micronesian Kingfisher population persistence under multiple translocation scenarios. Technical report submitted to U.S. Fish and Wildlife Service.

CONSERVATION OF INSULAR SEABIRDS IN PACIFIC OCEANIA

Investigators
Lisa Sztukowki, M.S. student, MU
Dr. Dylan Kesler, MU

Project Supervisor
Dr. Dylan Kesler, MU

Funding
Chugach Support Services, Inc.
U.S. Air Force, 15th Airlift Wing
U.S. Department of Defense Legacy Resource Management Project

Cooperators
Chugach Support Services, Inc.
U.S. Air Force, 15th Airlift Wing

Objectives
Assess the likelihood of rodenticide bait consumption by nesting Sooty Terns on Wake Island.

Assess the relative influence on hatch-year survival of body condition, rat predation, interspecific aggression, climate conditions, parental attendance, and vegetation.

Identify the developmental stage at which Sooty Tern chicks suffer the highest rate of mortality.

Location
Wake Island, HI

Completion
May 2013

Status
Complete

Progress and Results
Invasive introduced mammals can cause catastrophic effects on delicate island ecosystems. Introduced new world rats (*Rattus* spp.) have been identified as one of the greatest threats to insular systems of Pacific Oceania and managers have responded with large-scale eradication projects. The US Air Force has scheduled and conducted a rat eradication on Wake Island to protect and restore the island's ecosystems and to improve military effectiveness. We initiated work to reduce impacts on non-target species. We assessed the likelihood of rodenticide bait consumption by nesting seabirds and identifying the factors influencing hatch-year survival. We used color band mark and resight techniques, radiotelemetry, and automated photography to monitor survival and behavior in breeding seabirds on Wake Island during 2008, 2009 and 2010. Data were analyzed and results indicated that although some birds do ingest poison bait, the frequency of such ingestions were exceedingly low.

Products since 2012
Sztukowski, L. A., and D. C. Kesler. 2013. Environmental fluorescence and conservation bait consumption by Sooty Terns (*Sterna fuscata*): implications for eradication programs. Bird Conservation International 23:36-44.

SPACE USE AND TERRITORIALITY IN CRITICALLY ENDANGERED TUAMOTU KINGFISHER

Investigators
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Dr. Dylan Kesler, MU

Project Supervisor
Dr. Dylan Kesler, MU

Funding
Disney Worldwide Conservation Fund
Pacific Islands Conservation Research Association
Société d'Ornithologie de Polynésie Manu
University of Missouri Conservation Biology Program

Cooperators
Société d'Ornithologie de Polynésie Manu
Disney's Animal Kingdom

Objectives
Identify key habitats needed for Tuamotu Kingfisher conservation.

Identify resource requirements needed at translocation destination.

Location
Niau Atoll, Tuamotu Archipelago, French Polynesia

Completion
October 2012

Status
Complete

Progress and Results
Our investigation is aimed at identifying the ecological requirements of the critically endangered Tuamotu Kingfisher (*Todiramphus gambieri*) and providing management recommendations that help prevent the bird's extinction. The species is confined to the lowland forests on Niau Atoll in French Polynesia, with a total population of fewer than 250 individuals. A multi-scale resource selection study was based on island-wide surveys and radiotelemetry relocation data from 2006-2010. The birds avoided atoll feo forest vegetation and appeared to rely on agricultural coconut plantations. The plantations were managed with prescribed burning, coconut harvest, and understory clearing. Coconut plantations provided foraging habitat with open understory and visible ground where the kingfishers hunted lizards and other prey items. Such habitat conditions might resemble those of the original lowland forest, which no longer occur on most Tuamotu islands. A subsequent test was made of factors that have the potential to influence space use, and results showed that variation in territory characteristics correlated with the spatial configuration of foraging patches. The Tuamotu Kingfishers appeared to have a maximum territory length limited by their ability to effectively defend territory boundaries, guard nests, and provision nestlings. Thus, regions where habitats occur in very linear or distant patches may be unsuitable for translocations and conservation colonizations. Translocation was identified as a potential conservation strategy for Tuamotu Kingfishers, and additional criteria were provided for island selection to establishing a rescue population.

Products since 2012
Kesler, D. C. 2012. Foraging habitat distributions affect territory size and shape in the Tuamotu Kingfisher. International Journal of Zoology Article ID 632969, 7 pages:1-7.

Kesler, D. C., A. S. Cox, G. Albar, A. Gouni, J. Mejeur, and C. Plasse. 2012. Translocation of Tuamotu kingfishers, post-release exploratory behavior and harvest effects on the donor population. Pacific Science 66:467-480.

NEST-SITE SELECTION IN NORTH SLOPE SHOREBIRDS: RELATIVE IMPACTS OF SNOW, HABITAT, AND BEHAVIORAL FACTORS

Investigators
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Dr. Richard Lanctot, U.S. Fish and Wildlife Service

Project Supervisor
Dr. Dylan Kesler, MU

Funding
U.S. Fish and Wildlife Service

Objectives
Identify ecological, social, and physical features that influence nest-site selection in Arctic-breeding shorebirds.

Location
Barrow, Alaska

Status
In progress

Expected Completion
May 2015

Status
In progress

Progress and Results
The Arctic is experiencing a rate of climate change nearly twice the global average. Rising temperatures could inflict considerable change on Arctic ecology and landscape composition, and potentially affect the reproductive success of millions of shorebirds that migrate to the region each summer to breed. We are evaluating how current physical, ecological, and social features influence where shorebirds choose to nest. The locations of 1,928 shorebird nests including Dunlin (*Calidris alpina*), Red Phalarope (*Phalaropus fulicarius*), Pectoral Sandpiper (*Calidris melanotos*), Semipalmated Sandpiper (*Calidris pusilla*), Long-billed Dowitcher (*Limnodromus scolopaceus*), and American Golden Plover (*Pluvialis dominica*) were documented over nine field seasons at fixed study plots in Barrow, Alaska. Models comprised of combinations of variables associated with habitat, conspecific and heterospecific population characteristics, and snow cover were composed to represent hypotheses for shorebird nest-site selection. Additionally, we are examining marked populations of Dunlin and Semipalmated Sandpiper to infer how mate fidelity and sex influence nest-site habitat selection and breeding territory fidelity in individuals. Results indicated that shorebirds express specific nest site selection preferences, even though tundra landscapes appear relatively uniform.

Products
Cunningham, J. A. 2014. Nest site selection in arctic-breeding shorebirds: effects of habitat, social factors, and experience. University of Missouri-Columbia, MS Thesis. D. C. Kesler, advisor.

POTENTIAL FOR SPECIES TRANSLOCATION IN RESPONSE TO CLIMATE CHANGE AND HABITAT RESTORATION: BROWN-HEADED NUTHATCH IN THE MISSOURI OZARKS

Investigators
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Dr. Dylan Kesler, MU
Dr. Frank Thompson III, USFS

Project Supervisor
Dr. Dylan Kesler, MU
Dr. Frank Thompson III, USFS

Funding
U.S Forest Service

Cooperators
USDA Forest Service, Northern Research Station

Objectives
Study Brown-headed Nuthatches in northern portions of the range to develop a resource utilization function.

User results to identify potential translocation sites in the Missouri Ozarks.

Identify landscape factors associated with the dispersal of birds into unoccupied habitat.

Locations
Missouri Ozarks
Arkansas Ouachitas and Ozarks

Expected Completion
May 2015

Status
In progress

Progress and Results
Climate change is predicted to result in the northward advance of pine woodlands from the American southeast. Southern pine systems are home to a fire-adapted endemic avifauna that include the Red-cockaded Woodpecker (*Picoides borealis*), Bachman's Sparrow (*Aimophila aestivalis*), and the Brown-headed Nuthatch (*Sitta pusilla*). The Brown-headed Nuthatch is a cooperatively breeding resident bird that has been little studied in the shortleaf pine habitats in the northern portions of its range, including the Ouachita and Ozark mountains of Arkansas. Extensive pine woodland restoration efforts in the Missouri Ozarks have created potentially suitable habitat for the nuthatch. This project aims to develop tools that facilitate the northward movement of the birds through conservation colonizations. We investigated the Brown-headed Nuthatch in Arkansas with a combination of surveys and mark and resight techniques. Data were used to develop a resource-selection function and a multiscale model that will subsequently be used to evaluate potential reintroduction sites in Missouri. Results indicated that the birds actively select for habitat features within home ranges, including trees used for nesting. Further, survey results indicated that dispersal by the nuthatches northward may be affected by landscapes and bird dispersal behavior.

Products
Stanton, R. A., D. C. Kesler, F. R. Thompson III. *In press*. Resource configuration and abundance affect space use of a cooperatively breeding resident bird. Auk.

Stanton, R. A. 2013. Habitat selection of brown-headed nuthatches at multiple spatial scales. University of Missouri-Columbia, MS Thesis. D. C. Kesler, supervisor.

EFFECTS OF THREE DECADES OF LANDSCAPE CHANGE ON INSULAR AVIFAUNA

Investigators
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Dr. Dylan Kesler, MU

Project Supervisor
Dr. Dylan Kesler, MU

Funding
U.S. Fish and Wildlife Service
Pacific Island Conservation Research Association (PICRA)

Cooperators
Conservation Society of Pohnpei
College of Micronesia

Objectives
Assess current avian populations on islands of Kosrae and Pohnpei. Compare results to previous studies to identify population trends.

Identify avian responses to anthropogenic changes in the landscape in the last 30 years.

Utilize results to model future responses to future anthropogenic changes and climate change.

Locations
Pohnpei, Federated States of Micronesia

Anticipated Completion
May 2016

Status
In progress

Progress and Results
This project is intended to model avifaunal ecological responses to long-term and large-scale landscape change on Pohnpei Island, Federated States of Micronesia. Spatially explicit data from bird surveys in 1983, 1994, and 2012 were used in combination with three decades of vegetation mapping to derive density and occupancy models for the island's host of endemic and threatened birds. Those models were then used to construct a predictive GIS model that was utilized to evaluate potential impacts of future island-scale climate-related habitat changes on Pohnpei's avifauna. Simulations will be run to evaluate a range of potential future effects of climate and anthropogenic habitat changes to island avifauna. Avian surveys have been completed on the islands of Pohnpei and Kosrae, Federated States of Micronesia using occupancy modeling techniques, time to detection techniques, and distance techniques. Model simulations are expected to be completed in the year to come.

Products
Oleiro, P. C. 2014. Avian population responses to anthropogenic landscape changes in Pohnpei, Federated States of Micronesia. University of Missouri-Columbia, MS Thesis. D. C. Kesler, advisor.

Oleiro, P., and D. C. Kesler. 2013. Effects of landscape change and factors likely to influence future avifauna population change on Pohnpei Island. Final project report submitted to Pacific Islands Climate Change Cooperative and the Curators of the University of Missouri, Columbia. (technical report prepared in cooperation with Conservation Society of Pohnpei and College of Micronesia).

Pott, M., D. C. Kesler, and P. Oleiro. 2012. Ant Atoll, Federated States of Micronesia, Scoping trip 2012. Technical evaluation of Ant Atoll invasive species distributions for low island conservation guidance in Micronesia. (technical report prepared in cooperation with Island Conservation, and Conservation Society of Pohnpei).

SURVIVAL AND MOVEMENT OF MISSOURI'S GREATER PRAIRIE-CHICKEN

Investigators
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Dr. Dylan Kesler, MU
Dr. Tom Thompson, MDC
Max Allegar, MDC
Kevin Sullivan, MDC
Brent Jamison, USFWS

Project Supervisor
Dr. Dylan Kesler, MU

Funding
Missouri Department of Conservation
Audubon Society of Missouri
Webster Groves Nature Study Society
Prairie Biotic Research Inc.

Cooperators
Missouri Department of Conservation

Objectives
Examine and compare survival and movements of translocated and resident adult and juvenile Greater Prairie-Chickens.

Identify landscape habitat compositions and configurations that benefit populations of Greater Prairie-Chickens.

Location
Wah'Kon-Tah Prairie, Missouri
Taberville Prairie, Missouri

Anticipated Completion
October 2015

Status
In Progress

Progress and Results
The Missouri Department of Conservation has engaged in a range of recovery efforts to address the declining population of Greater Prairie-Chickens. Despite substantial work, foundational information is needed about Greater Prairie-Chicken adult and juvenile vital rates. The relationship between Greater Prairie-Chicken demography and habitat composition and configuration is also a subject requiring further study. To address these information gaps we designed a radiotelemetry study of resident birds and birds captured in Kansas and released in Missouri. Extensive radio-tracking of both resident and translocated prairie chickens was completed through the 2010 and 2011 spring and summer seasons. Over 4,000 locations were obtained, presenting us with a unique and exciting opportunity to model movement and survival for these birds. We answered management questions about Greater Prairie-Chicken conservation, translocation and reintroduction.

Products
Winder, V. L., K. M. Carrlson, A. J. Gregory, C. A. Hagen, D. A. Haukos, D. C. Kesler, L. B. McNew, J. C. Pitman, L. A. Powell, J. Smith, T. Thompson, D. H. Wolfe, B. K. Sandercock. *In prep.* Lek sites drive female resource use in ten populations of prairie-chickens. *In prep.*

Carrlson, K. M., D. C. Kesler, T. R. Thompson. 2014. Resident and translocated greater prairie-chicken survival and habitat use. Journal for Nature Conservation 5:405-412.

Kemink, K. M., and D. C. Kesler. 2013. Using movement ecology to inform translocation efforts: a case study with an endangered lekking bird species. Animal Conservation 16:499-457.

Kemink, K. M. 2012. Survival, habitat use, and movement of resident and translocated Greater Prairie Chickens. M.S. Thesis, University of Missouri-Columbia. D. C. Kesler, advisor.

IMPORTANCE OF MOUNTAIN PINE BEETLE INFESTATIONS AND FIRE AS BLACK-BACKED WOODPECKER HABITAT IN THE BLACK HILLS, SOUTH DAKOTA

Investigators
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Dr. Joshua Millspaugh, MU
Dr. Dylan Kesler, MU
Dr. Mark Rumble, U.S. FS
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Project Supervisor
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Dr. Dylan Kesler, MU

Funding
U.S. Forest Service
South Dakota Department of Game, Fish and Parks

Cooperators
U.S. Forest Service
South Dakota Department of Game, Fish and Parks
Wind Cave National Park

Objectives
How is black-backed woodpecker space-use affected by resource distribution within a home range?

What is the relative value of habitat created by wildfire, mountain pine beetle infestation, and prescribed fire to black-backed woodpeckers?

What factors affect long-distance movement of black-backed woodpeckers?

Location
Black Hills, South Dakota

Expected Completion
May 2015

Status
In progress

Progress and Results
Wildfire and beetle infestations are naturally occurring events in most western forests, but these disturbances are often considered undesirable. However, recent and ongoing research suggests that disturbed forests provide important habitat for rare species, and prescribed burning is being tested as a management tool. The black-backed woodpecker (*Picoides arcticus*) is a disturbance-associated species of conservation concern that has recently been petitioned for listing as Threatened or Endangered under the Endangered Species Act. Effective conservation and management at multiple scales requires detailed knowledge of how the distribution of resources within a home range affects woodpecker space-use, how demographic rates differ between habitat created by wildfire, prescribed fire, and beetle infestations, and how woodpeckers move between habitats at landscape scales. We collected home range, demographic, and movement data from 234 individually marked birds year-round from April 2008 through August 2012. Our project thus represents one of the largest black-backed woodpecker datasets in existence. We will evaluate resource selection by correlating space-use within each home range with associated vegetation characteristics. We will evaluate the relative quality of habitat created by wildfire, prescribed fire, and mountain pine beetle infestations by estimating habitat-specific survival and reproductive success. Finally, we will evaluate the factors affecting large-scale movements by correlating known dispersals with factors thought to influence movements, such as breeding failure or the time since a disturbance. Our results will provide resource managers in South Dakota and beyond with information necessary for effective conservation of black-backed woodpeckers.

Products
Rota, C. T., M. A. Rumble, J. J. Millspaugh, C. P. Lehman, and D. C. Kesler. 2014. Space-use and habitat associations of black-backed woodpeckers (*Picoides arcticus*) occupying recently disturbed forests in the Black Hills, South Dakota. Forest Ecology and Management 313:161-168.

Rota, C. T., J. J. Millspaugh, M. A. Rumble, C. P. Lehman, and D. C. Kesler. 2014. The role of wildfire, prescribed fire,

and mountain pine beetle infestations on the population dynamics of a disturbance dependent species. PLoS ONE: 10.1371/journal.pone.0094700

Rota, C. T., J. J. Millspaugh, D. C. Kesler, C. P. Lehman, M. A. Rumble, C. M. Bodinof. 2013. A re-evaluation of the modified case-control model for use in resource selection studies. Journal of Animal Ecology 82:1165-1173.Lehman, C. P., D. C. Kesler, C. T. Rota, M. A. Rumble, E. M. Seckinger, T. M. Juntti, and J. J. Millspaugh. 2011. Hand-held netguns: a technique for capturing Black-backed Woodpeckers. Journal of Field Ornithology 82:430-435

Rota, C. T. 2013. Not all forests are disturbed equally : population dynamics and resource selection of black-backed woodpeckers in the Black Hills, South Dakota. Ph.D. Dissertation, University of Missouri-Columbia. J. J. Millspaugh, advisor.

RANGE-WIDE ANALYSIS OF RED-COCKADED WOODPECKER HABITAT AND MOVEMENT

Investigators
Dr. Ann McKellar, MU
Dr. Dylan C. Kesler, MU
Dr. Robert J. Mitchell, Jones Ecological Research Center
Dr. Jeffrey R. Walters, Virginia Tech

Project Supervisor
Dr. Dylan Kesler, MU

Funding
United States Army Engineer Research and Development Center (ERDC), Construction Engineering Research Laboratory, Champaign, IL 61822

Cooperators
Sandhills Ecological Institute
Virginia Tech
North Carolina State University
Fort Bragg
Marine Corps Base Camp Lejeune
Eglin Air Force Base

Objectives
Evaluate association between habitat conditions, group size and reproduction across the range of the endangered Red-cockaded Woodpecker.

Identify association between habitat characteristics and movement in groups of cooperatively breeding Red-cockaded Woodpeckers.

Location
Southeastern United States

Expected Completion
May 2015

Status
In Progress

Progress and Results
The objective of this project is to support conservation and recovery of a federally listed endangered avian species, the red-cockaded woodpecker. We aimed to identify the range of habitat conditions that constitutes high-quality foraging habitat for red-cockaded woodpeckers, which will support recommendations for new red-cockaded woodpecker foraging habitat guidelines. This project has two components: (1) studies of the relationship between foraging habitat and red-cockaded woodpecker fitness across the species range, and (2) studies of foraging habitat selection by individual red-cockaded woodpecker groups on Eglin Air Force Base. This project is being conducted under a cooperative agreement between the Engineer Research and Development Center - Construction Engineering Research Laboratory (ERDC-CERL) and The Curators of the University of Missouri. Results indicate that red-cockaded woodpecker is using a diverse array of restored landscapes, and that remaining conservation challenges for the species are often site-specific.

Products since 2012
McKellar, A. E., R. Langrock, D. C. Kesler, J. R. Walters. 2014. Using hidden Markov models to examine behaviour and movement states in a cooperatively breeding bird. Behavioral Ecology: *in press.*

McKellar, A. E., D. C. Kesler, R. J. Mitchell, D. K. Delaney, and J. R. Walters. 2014. Geographic variation in fitness and foraging habitat quality in an endangered bird. Biological Conservation 175:52-64.

McKellar, A. E., D. C. Kesler, R. J. Mitchell, D. K. Delaney, and J. R. Walters. 2013. Range-side meta-analysis of red-cockaded woodpecker foraging habitat suitability. Final report submitted to United States Army Engineer Research and Development Center (ERDC) Construction Engineering Research Laboratory, Champaign, IL.

Kesler, D. C., and J. R. Walters. 2012. Social composition of destination territories and matrix habitat affect red-cockaded woodpecker dispersal. Journal of Wildlife Management 76:1028-1035.

ECOLOGY AND CONSERVATION OF RECENTLY CONTACTED AND UNCONTACTED POPULATIONS IN THE AMAZON BASIN

Investigators
Dr. Robert S. Walker, MU
Dr. Markus J. Hamilton, Santa Fe Institute
Dr. Dylan C. Kesler, MU

Project Supervisor
Dr. Robert S. Walker, MU
Dr. Dylan C. Kesler, MU

Funding
University of Missouri

Objectives
Use demographic modeling to evaluate potential impacts of first contact on previously uncontacted peoples in the Brazilian Amazon.

Use remote sensing and species niche modeling to identify the locations of previously uncontacted peoples in the Brazilian Amazon, and to evaluate the efficacy of lands protected for cultural reserves.

Location
Brazil

Anticipated Completion
September 2016

Status
In progress

Progress and Results
Lowland South America has long been a battle-ground between European colonization and the indigenous populations of people living in the area. Initial waves of European colonization brought disease epidemics, slavery, and violence that had catastrophic impacts on indigenous cultures. We focused research on the demography of 238 surviving populations in Brazil, and used longitudinal censuses from all known indigenous Brazilian societies to quantify three demographic metrics: 1) effects of European contact on indigenous populations; 2) empirical estimates of minimum viable population sizes; and 3) estimates of post-contact population growth rates. We used this information to conduct population viability analyses. Our results showed that all surviving populations suffered extensive mortality during, and shortly after, contact. However, most surviving populations exhibit positive growth rates within the first decade post-contact. Our findings paint a positive demographic outlook for these indigenous populations, though long-term survival remains subject to powerful externalities, including politics, economics, and the pervasive illegal exploitation of indigenous lands. In a second project phase, we are using remote sensing and species niche modeling to identify areas where previously uncontacted groups of humans may be living in the Amazon Basin.

Products
Hamilton, M. J., Walker, R. S., and Kesler, D. C**.** 2014. Crash and rebound of indigenous populations in lowland South America. Scientific Reports 4, 4541. doi:10.1038/srep04541.

PERCEPTION OF ULTRAVIOLET WAVELENGTHS IN A NORTH AMERICAN WOODPECKER

Investigators
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Dr. Dylan Kesler, MU
Dr. Elizabeth Webb, MU
Dr. Scott Werner, USDA/APHIS
Dr. Jeanne Mihail, MU

Project Supervisor
Dr. Dylan Kesler, MU
Dr. Lisa Webb, MU

Funding
Arkion Life Sciences, LLC
Avian Power Line Interaction Committee
Critter Control, Inc.

Objectives
Evaluate whether woodpeckers are sensitive to UV light, and whether that sensitivity is associated with foraging.

Identify whether UV sensitivity in woodpeckers can be used to develop dissuasive techniques for preventing woodpecker damage to anthropogenic structures.

Location
National Wildlife Research Center, Ft. Collins, CO

Expected Completion
May 2016

Status
In progress

Progress and Results
Woodpeckers are an ecologically and economically important group that is globally distributed across forest and woodland systems. Past research has revealed that several species of woodpeckers exhibit a preference for placing cavities in trees that are infected by certain species of fungal heart rots, but the method for this selection remains unknown. Woodpeckers also preferentially forage in rot-softened wood substrates, which typically have a higher arthropod biomass than uninfected wood. The pattern of light wavelengths reflected by wood can be altered by some species of wood decay fungi, such that a particular defect can be identified simply by analyzing the reflectance pattern of the wood. In 2013 and 2014, we grew pure cultures of 2 species of wood decay fungi known to be selected by woodpeckers for cavity placements. We analyzed the light reflectance patterns of infected wood samples and found that the reflectance patterns were different from controls across the range of the avian visual spectrum, including in the ultraviolet. The perception of ultraviolet (UV) wavelengths by birds was discovered over 40 years ago, and has been described in dozens of species across a diversity of avian taxa. The functional significance of UV has been demonstrated using behavioral assays in both foraging and mate choice decisions. To date, no woodpecker species has been evaluated with regards to UV sensitivity. We have developed a novel foraging-based behavioral assay to test for UV sensitivity using the pileated woodpecker (*D. pileatus*) as a model organism. This information is relevant for all aspects of woodpecker management, including use of UV cues to alter woodpecker behaviors (eg. reduce window strikes or damage to anthropogenic structures).

CAPTIVE MANAGEMENT, STRESS, AND REPRODUCTION IN THE GUAM MICRONESIAN KINGFISHER

Investigators
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Dr. Dylan Kesler, MU
Dr. Trista Strauch, MU
Dr. Duane Keisler, MU

Project Supervisor
Dr. Dylan Kesler, MU

Funding
Pacific Islands Conservation Research Association
Association of Zoos and Aquariums

Objectives
Identify environmental factors and husbandry procedures that influence stress and breeding success in captive Guam Micronesian kingfishers.

Locations
Various breeding institutions across the continental US and on Guam
Pohnpei, Federated States of Micronesia
Saipan, Commonwealth of the Northern Mariana Islands

Expected Completion
May 2015

Status
In progress

Status
In progress

Progress and Results
The Guam Micronesian kingfisher (*Todiramphus cinnamominus*) is among the most endangered species in the world, as the birds exist only as a captive population of approximately 150 individuals in 23 captive breeding institutions. We have focused on stress management and husbandry techniques to identify how institutions can facilitate captive breeding success, to a point where population expansion and conservation release can be supported. We developed a technique to extract corticosterone from feathers, and we validated a radioimmunoassay for measuring corticosterone, which has substantially improved the efficacy measurement over previous approaches. Information about captive facility conditions was collected remotely from all 23 institutions holding the birds, with loggers that record sound pressure level, temperature, and relative humidity, and through online surveys. Environmental data were also collected from wild habitats on Pohnpei, Federated States of Micronesia, and Saipan, Commonwealth of the Northern Mariana Islands, within known territories of wild congeneric kingfishers. To date, we have obtained feather samples from 118 individual captive birds, representing 22 of the institutions housing Guam Micronesian kingfishers. Further, we collected feathers from 15 wild adult Pohnpei Micronesian kingfishers (*T. reichenbachii*) captured in Pohnpei and 28 wild adult Collared kingfishers (*T. chloris*) captured on Saipan, which will serve as models for stress levels in wild Pacific kingfishers. Using this information, we expect to identify and recommend the optimal conditions for minimizing stress in the captive population. Application of our results will likely improve breeding, accelerate population growth, bolster genetic viability in the population, and lead to the standardization of husbandry techniques throughout the breeding program.

Products
Alba, A. C., D. C. Kesler, T. A. Strauch, and D. H. Keisler. 2013. Captive management, stress, and reproduction in the Guam Micronesian kingfisher: *Project design*. Association of Zoos and Aquariums Mid-Year Meeting. Charleston, SC (national invited oral presentation).

Alba, A. C., D. C. Kesler, T. A. Strauch, and D. H. Keisler. 2013. Captive management, stress, and reproduction in the

Guam Micronesian kingfisher: *Progress and preliminary results*. Honolulu field office of the U.S. Fish and Wildlife Service (invited oral presentation).

Alba, A. C., D. C. Kesler, T. A. Strauch, and D. H. Keisler. 2014. Captive management, stress, and reproduction in the Guam Micronesian kingfisher: *Methods for avian stress management*. Association of Zoos and Aquariums Mid-Year Meeting. Memphis, TN (national invited oral presentation).

Alba, A. C., D. C. Kesler, T. A. Strauch, and D. H. Keisler. 2014. Captive management, stress, and reproduction in the Guam Micronesian kingfisher. Association of Zoos and Aquariums and International Marine Mammal Trainers' Association Annual Conference. Orlando, FL (national poster presentation).

DR. CHARLES NILON

URBAN BIODIVERSITY AND ECOSYSTEM SERVICES

Investigators
Dr. S. Cilliers, North-West University, South Africa
Ms. L. Frazee, Rutgers University
Dr. C. Dobbs, City of Melbourne, Australia
Dr. M. Goddard, University of Leeds, UK
Dr. D. Roberts, eThekwini Municipality, South Africa
Dr. M. Winter, The Synthesis Centre for Biodiversity Sciences (sDIV), Germany
Dr. K. Yocom, University of Washington

Project Supervisor / Investigators
Dr. Myla Aronson, Rutgers University
Dr. Charles Nilon, MU

Funding
National Socio-Environmental Synthesis Center (SESYNC)

Objectives
Our project addresses three questions:
1. How do cities approach biodiversity and ecosystem service monitoring, restoration, and policy?
2. How do these approaches change across cities with different systems of governance, planning, and socio-economics, and development histories?
3. Do environmental policies in cities designed for conservation or restoration of ecosystem services also conserve biodiversity?

Location
Annapolis, MD / Leipzig, Germany

Completion
December 2015

Status
Ongoing

Progress and Results

Understanding the social and ecological factors that drive biodiversity and ecosystem services (ESS) in cities is critical for conservation and the human experience. Cities are ideal laboratories for studying the drivers of biodiversity and ESS, as well as documenting methods for monitoring, management, and restoration of biodiversity and ESS. Understanding these factors allows us to better design and plan cities for sustainable conservation and ecosystem function. Here we propose to bring together ecologists, sociologists, and design and policy professionals to examine the ecological and social linkages among biodiversity, ESS, and environmental policy and how these can best be monitored, managed, and restored within and across cities globally.

Our working group is reviewing planning documents from 50 cities in North America, Europe and the global south. We will compile additional data sets for the cities containing social and demographic data from national censuses; environmental policies developed by cities that address biodiversity and ESS; and restoration projects that focus on biodiversity and ESS. We will survey and interview planners from the cities to identify city-specific factors influencing biodiversity and ecosystem service policies and practice. Our syntheses of these data sets will target researchers and practitioners and document approaches used in urban areas to address biodiversity conservation and management of ecosystem services.

URBIONET: A GLOBAL NETWORK FOR URBAN BIODIVERSITY RESEARCH AND PRACTICE

Investigators
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Project Supervisor / Investigators
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Dr. Myla Aronson, Rutgers University
Dr. Chris Lepczyk, Auburn University
Dr. Tommy Parker , Univ. of Memphis
Dr. Paige Warren, University of Massachusetts-Amherst

Funding
National Science Foundation

Objectives
Expand an existing global database on bird and plant diversity in the world's cities particularly in South America, Central America and the Caribbean, Africa, and Southeast Asia.

Identify patterns and processes shaping urban biodiversity across the world's cities and to quantify the importance of physical, climatic, and social factors in driving patterns of urban biodiversity.

Develop recommendations for monitoring biodiversity in urban areas.

Location
Columbia, MO / New Brunswick, NJ

Anticipated Completion
March 2019

Status
Ongoing

Progress and Results
Over half of the world's human population lives in cities, making the human experience of nature increasingly defined within urban areas. In order to understand how cities can support both humans and biodiversity, greater collaboration is needed among scientists, urban planners, and design professionals. This project will create a research coordination network to bring together these disciplines to study the factors affecting biodiversity in cities (UrBioNet). The network will facilitate engagement of scientists globally and develop databases and materials focusing on the plants and animals of cities that are relevant to local residents, urban planners, and managers. This project will expand existing global databases of plants and birds in cities and develop new databases of bats, fish, and insect pollinators of cities and their surrounding regions. The network will focus on the compilation and monitoring of urban biota in areas of high regional biodiversity, such as tropical cities and cities within biodiversity hotspots. Three scientific working groups will use information collected in this network to answer questions regarding the ecological relationships of different species to urbanization, with consideration of cultural and social aspects, and develop recommendations for monitoring urban ecosystems. Key activities in support of the network include: network-wide meetings; workshops; and the development of an online graduate course on urban biodiversity. UrBioNet will further serve the scientific community by supporting the development of global, regional, and local databases to test hypotheses on the patterns of species based on the physical, climatic, and social features of cities.

LAND OWNERS AND LAND MANAGERS RESPOND TO CLIMATE CHANGE

Investigators
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Mr. Eric Fishel, M.S. student, MU

Project Supervisors
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Dr. Robert Pierce, MU
Dr. Nadia Navarrete-Tindall, Lincoln University

Funding
National Science Foundation

Cooperators
Missouri EPSCOR Community Engagement Team

Objectives
Assess context for management of residential lots by studying change in residential land cover in Boone, Cole, and Scott Counties – 1930 – present.

Assess residential land management practices and land owner / manager perception of their land management practices in Boone, Cole, and Scott Counties.

Assess owner/manager perceptions of drought and climate change scenarios and preference for potential management scenarios.

Location
Boone, Cole and Scott Counties, Missouri

Completion
August 2019

Status
In Progress

Progress and Results
Private land owners make management decisions at a variety of scales, from individual homeowners or residents making decisions about an urban lot to land owner decisions about the management of agriculture lands of several thousand hectares. Managing for resiliency to climate change requires an understanding of land managers' preferences and desired outcomes and how these influence management goals and practices. As part of the first phase of this project we are collecting data on vegetation structure, land management practices and land owner perceptions of management on urban, ex-urban, small town and rural land parcels in three Missouri counties.

BALTIMORE ECOSYSTEM STUDY BIRD MONITORING PROJECT

Investigators
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Project Supervisors
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Dr. Paige Warren, University of Massachusetts-Amherst

Funding
Cary Institute for Ecosystem Studies and National Science Foundation

Objectives
The BES Bird Monitoring Project is a breeding bird survey designed to find out what birds are found in the breeding season in Baltimore and where. Our monitoring efforts will show associations among block group socioeconomic variables, land cover, land use, and habitat features with breeding bird abundance, to provide information for land managers on possible consequences of land use changes on bird communities.
A distinguishing feature of the bird monitoring at BES LTER, relative to other urban bird work, is the capacity for long-term monitoring of features at multiple scales through links to other parts of the project. Different processes influence habitat for birds at different scales, e.g. ongoing household level human decision-making at lot scale vs. block or neighborhood scale abandonment/re-development. Our project seeks to understand how these processes impact bird occurrence, abundance, and composition differ at the lot, block and neighborhood scale.

Location
Baltimore, MD

Expected Completion
September 2016

Status
In progress

Progress and Results
We continue annual monitoring of the breeding bird communities at 132 bird census points in Baltimore. Co-location of bird monitoring with USDA Forest Service I-Treee plots facilitates use of other BES data on local environmental features and household- and neighborhood-scale management by humans collected from the same sites. Previous BES research has identified at least 4 distinct urban bird communities in Baltimore, including two communities associated with distinct residential landscape types: mature trees and open-but-shrubby neighborhoods. The presence of each community type is significantly correlated with local factors such as urban tree canopy cover, management of decaying wood (e.g. dead tree branches), and horticultural decisions (e.g. amount of shrub versus lawn cover). In BES III, we will expand on this work to address whether neutral processes (extinction and colonization) are also contributing to the distribution of bird species among sites of the same community type. Through spatial analysis of long-term monitoring data, we will test whether community similarity declines with distance (regional factors dominate) versus whether community similarity increases with environmental similarity (local factors dominate).

In 2013 we started a study of vacant lots as bird habitats. We are studying bird species composition and abundance, nesting success of selected species. Our work considers the origin of the lots, vegetation structure within the lots, and the lots in a landscape context as predictors of bird use.

PLAYGROUNDS WITHOUT BORDERS: EVALUATING PLAYGROUND ENVIRONMENTAL INTERVENTIONS AMONG LOW-INCOME ELEMENTARY SCHOOLCHILDREN

Investigators
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Dr. Charles Nilon, MU
Dr. LaShaune Johnson, MU
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Dr. Joe LeMaster, University of Kansas

Project Supervisor
Dr. Stephen Sayers, MU

Funding
Robert Wood Johnson Foundation
Active Living Research

Cooperators
Columbia Public Schools

Objectives
Determine the effect of a playground environmental intervention on: a)School recess and lunch-time MVPA% (percent of available time spent engaged in MVPA). b)Total daily MVPA.
c) Open space MVPA (minutes of MVPA that take place in outdoor open spaces). d) Aggregate proportion of schoolchildren who are active on school playgrounds.

Assess why children use their school and neighborhood environments.

Elicit parents' and children's perceptions regarding a) intervention planning and construction processes and b) how their school and neighborhood context impacts children's response to the intervention.

Location
Columbia, MO

Completion
January 2013

Status
Complete

Progress and Results
Playground environmental interventions provide a prime opportunity to promote children's activity as they can reach large populations of children from all racial, ethnic and socioeconomic groups, and provide a safe environment for active play. These interventions may increase the proportion of available playtime at school in which children participate in moderate to vigorous physical activity (MVPA). Some issues remain unclear: how such interventions can be successfully tailored to benefit low-income and ethnic minority U.S. children (since most were conducted in Europe and not among minority students); whether increases in PA at school are matched by increases outside school, both temporally and spatially; whether benefits last beyond the immediate post-intervention period; and to what extent children's social and physical neighborhood environment influences their response to the intervention. We investigated these issues by evaluating a school-based, quasi-experiment environmental intervention that sought to increase PA by modifying school playground environments in Columbia, MO. Our overall goal was to assess when, where and to what extent school playground environmental interventions increase children's PA, and to use these results to inform local advocacy efforts to prevent obesity in low-income and minority children. We evaluated 4 schools, 2 of which will receive the environmental intervention early (Fall 2011) and 2 late (Spring 2012). We will measure PA at baseline (Spring 2011), and every 6 months thereafter during the study.

In school interventions were shaped by the culture of the school and outcomes of interventions were influenced by teachers and staff. School interventions did shape PA outside the school, however this influence is filtered by the range of outdoor environments that children experience before and after school and on weekends.

NATURE WORKS TALLGRASS PRAIRIE RESTORATION

Investigators
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Project Supervisor
Mr. Peter Van Linn III, Forest Park Forever
Dr. Charles Nilon, MU

Funding
Forest Park Forever

Objectives
Summarize and evaluate management and restoration activities in Forest Park.

Identify indicators for evaluating success of tallgrass prairie restoration.

Location
St. Louis, MO

Completion
December 2016

Status
In Progress

Progress and Results
We are collaborating with Forest Park Forever on an evaluation of a tallgrass prairie restoration project in the park. The first phase of the project is a review and summary of existing information on past management activities in the park. We are also reviewing publishing literature on restoration practices in large urban parks with an initial goal of identifying approaches for evaluating the tallgrass prairie restoration.

DR. JOSHUA MILLSPAUGH

DEVELOPMENT OF A LONG-TERM MONITORING PLAN FOR NATIONAL PARKS IN THE NORTHERN GREAT PLAINS

Investigators
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Kara Paintner, NPS

Project Supervisor
Joshua Millspaugh, MU

Funding
National Park Service Northern Great Plains Network (NGPN)

Cooperators
National Park Service NGPN

Objectives
Complete a "Vital Signs" Monitoring Plan outlining monitoring priorities, objectives, sampling designs, protocol-development timelines, and general data-management, reporting, and administrative procedure for the NGPN.

Guide the NGPN and NPS Partners in addressing quantitative issues related to development of sampling designs for monitoring vegetation, water quality, and other attributes.

Develop and publish an edited book with contributions from statistical experts on quantitative design and analysis in long-term monitoring efforts.

Implement additional ecological and adaptive-management investigations for NGPN parks.

Location
Rapid City, South Dakota

Completion
August 2012

Status
Complete

Progress and Results

As one of 32 networks in the National Park Service (NPS) Inventory and Monitoring (IandM) Program, the Northern Great Plains Network (NGPN) is developing and implementing a long-term monitoring program for 13 NPS units in North and South Dakota, eastern Wyoming, and northern and western Nebraska. In this project, we worked with the NGPN IandM staff and park managers to identify, prioritize, and develop monitoring objectives for tracking the condition of selected natural-resource attributes and stressors. Through close collaboration with the NGPN, we successfully completed the NGPN Vital Signs Monitoring Plan, allowing the Network to begin operational monitoring. In addition to general scientific guidance, we provided quantitative guidance to the NGPN related to development of specific monitoring protocols, particularly related to the Network's top priorities of monitoring vegetation and water quality in its parks. To obtain and disseminate recommendations from top monitoring experts worldwide on quantitative issues in monitoring, we completed an edited volume, "Design and Analysis of Long-term Ecological Monitoring Studies."

Products

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Gitzen, R. A., M. Wilson, J. Brumm, M. Bynum, J. Wrede, J. J. Millspaugh, and K. J. Paintner. 2010. Northern Great Plains Network Vital Signs Monitoring Plan. Natural Resource Report NPS/NGPN/NRR—2010/186. National Park Service, Fort Collins, CO.

EVALUATION OF SILVICULTURAL MANAGEMENT IN MISSOURI OAK-HICKORY FORESTS: A META-ANALYSIS OF MOFEP DATA

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Christopher Rota, MU
Joshua Millspaugh, MU

Project Supervisor
Joshua Millspaugh, MU

Funding
Missouri Department of Conservation

Cooperators
Missouri Department of Conservation

Objectives
Complete a meta-analysis of MOFEP bird and herptile data collected before the 2011 timber cuts.

Provide guidance on future data collection, analysis, and sampling strategies.

Location
Southern Missouri

Completion
July 2014

Status
Complete

Progress and Results

The Missouri Ozark Forest Ecosystem Project (MOFEP) was designed to evaluate the impacts of even-aged, uneven-aged, and no-harvest management on forest systems owned by the Missouri Department of Conservation (MDC). MOFEP is unique because it is an experimental assessment (i.e., control, pre- and post-treatment periods) which considers long-term management processes. We completed a meta-analysis using data collected before the 2011 MOFEP timber harvest using temporal models. Our meta-analysis considers the reptile, amphibian, and forest interior bird responses to MOFEP during the first 15 years after post-treatment. Our meta-analysis demonstrates a diversity of responses among ecological groups, although we noted high similarity in responses within ecological groups, with the exception of mature forest interior birds. We noted wide variation in the response of individual mature forest bird species to both uneven-aged and even-aged forest management. In contrast, all early successional bird species showed a positive response in territory counts in both uneven-aged and even-aged sites although counts of most early successional species were greatest shortly after treatment and declined to zero by the end of our evaluation period. The early successional bird group was the only group for which the 95% credible interval of the treatment response (uneven and even-aged management) did not overlap 0. Nearly all frog and toad species exhibited fewer captures in both even and uneven-aged management; the only exception was the green frog which showed a slightly positive response to uneven-aged management. Similarly, all salamander species showed a negative response in the number of captures to both uneven and even-aged management. In contrast to frogs, toads, and salamanders, all lizards showed an increase in the number of captures in even and uneven-aged management sites. The number of snake captures generally increased in uneven-aged sites, but decreased for nearly all species in even-aged treated sites. Our analyses indicate that 15 years after the initiation of forest management treatments on MOFEP, the magnitude of change for the ecological groups we studied in response to treatments was small except for early successional birds.

PHYSIOLOGICAL AND BEHAVIORAL RESPONSE OF AFRICAN ELEPHANTS TO REINTRODUCTION

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Project Supervisor
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Funding
National Research Foundation (South Africa)
University of KwaZulu-Natal (Amarula Elephant Research Programme)

Cooperators
University of KwaZulu-Natal
University of Missouri
iSimangaliso Wetland Park
Pilanesburg National Park Phinda Game Reserve
Mabula Game Reserve
Hluhluwe-Umfulozi Game Reserve

Objectives
Investigate causes of high stress hormone concentrations in elephants.

Investigate behavioral responses to chronic stress.

Investigate how elephant physiological state influences movement patterns.

Location
South Africa

Completion
August 2012

Status
Complete

Progress and Results

Reintroduction of elephants is a valuable conservation tool given the ecological and economic importance of maintaining elephant populations. However, translocated elephants can exhibit destructive behavior such as the top-down altering of vegetative structure and ecosystem processes, as well as killing of rhinos and increased aggression toward or killing of humans. Managers need to know what drives elephant behavior in order to limit potential detrimental effects. We investigated the physiological and behavioral response of elephants to reintroduction in 5 different parks and reserves in South Africa. First, knowledge of the potential cues of stress in elephants could provide a better understanding of factors that put elephants on edge and how to potentially limit dangerous and destructive behaviors. Therefore, we assessed potential environmental (e.g., rainfall and temperature) and biological (e.g., size and density of elephants) factors which explain park to park differences in observed stress hormone levels. We found that the amount of time that had elapsed since release was the single most important factor, and that elephants can take up to 10 years to physiologically adjust to their new home. Second, we assessed the influence of physiological state on movement of elephants and found that when elephants are in an elevated physiological state they are less likely to leave refugia and cover. Collectively this study has provided important information to managers so that they can identify how long elephants require to physiologically adjust following reintroduction, and be able to better predict when and where areas of potential human-elephant conflict are likely to be greatest.

Products

Jachowski, D.S., R. Slotow and J.J. Millspaugh. 2012. Physiological stress and refuge behavior by African elephants. PLoS ONE 7:e31818.

Jachowski, D. S., R. Slotow, and J. J. Millspaugh. 2014. Good virtual fences make good neighbors: opportunities for conservation. Animal Conservation 17:187-196.

Jachowski, D. S., R. Montgomery, R. Slotow, and J. J. Millspaugh. 2013. Unraveling complex associations between physiological state and movement in African elephants. Functional Ecology 27:1166-1175.

Jachowski, D. S., R. Slotow, and J. J. Millspaugh. 2013. Delayed physiological adaptation by African elephants following reintroduction. Animal Conservation 16:575-583.

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IMPORTANCE OF MOUNTAIN PINE BEETLE INFESTATIONS AND FIRE AS BLACK-BACKED WOODPECKER HABITAT IN THE BLACK HILLS, SOUTH DAKOTA

Investigators
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Chad Lehman, SD Dept. of Game, Fish, and Parks

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Funding
U.S. Forest Service
SD Dept. of Game, Fish and Parks

Cooperators
U.S. Forest Service
SD Dept. of Game, Fish and Parks
Wind Cave National Park

Objectives
How is black-backed woodpecker space-use affected by resource distribution within a home range?

What is the relative value of habitat created by wildfire, mountain pine beetle infestation, and prescribed fire to black-backed woodpeckers?

What factors affect long-distance movement of black-backed woodpeckers?

Location
Black Hills, South Dakota

Expected Completion
May 2013

Status
Complete

Progress and Results
Wildfire and beetle infestations are naturally occurring events in most western forests, but these disturbances are often considered undesirable. However, recent and ongoing research suggests that disturbed forests provide important habitat for rare species, and prescribed burning is being tested as a management tool. The Black-backed woodpecker (*Picoides arcticus*) is a disturbance-associated species of conservation concern that has recently been petitioned for listing as Threatened or Endangered under the Endangered Species Act. Effective conservation and management at multiple scales requires detailed knowledge of how the distribution of resources within a home range affects woodpecker space-use, how demographic rates differ between habitat created by wildfire, prescribed fire, and beetle infestations, and how woodpeckers move between habitats at landscape scales. We collected home range, demographic, and movement data from 234 individually marked birds year-round from April 2008 through August 2012. Our project thus represents one of the largest black-backed woodpecker datasets in existence. We found positive population growth rates only in forests recently burned by summer wildfire and declining population growth rates in mountain pine beetle infestations and forests treated with fall prescribed fire. Home ranges were smallest in 1-2 year post-summer wildfire habitat and increased with time since fire. Within their home range, woodpeckers were most likely to use dead trees > 27 cm DBH that were burned at moderate or high severity. Publications evaluating apparent foraging success and movement rates across habitats are currently in review or preparation.

Products
Rota, C. T., J. J. Millspaugh, M. A. Rumble, C. P. Lehman, and D. C. Kesler. 2014. The role of wildfire, prescribed fire, and mountain pine beetle infestations on the population dynamics of black-backed woodpeckers in the Black Hills, South Dakota. PLoS ONE 9:e94700.

Rota, C. T., M. A. Rumble, J. J. Millspaugh, C. P. Lehman, and D. C. Kesler. 2014. Space use and habitat associations of Black-backed Woodpeckers (*Picoides arcticus*)

occupying recently disturbed forests in the Black Hills, South Dakota. Forest Ecology and Management 313:161-168.

Lehman, C. P., D. C. Kesler, C. T. Rota, M. A. Rumble, E. M. Seckinger, T. M. Juntti, and J. J. Millspaugh. 2011. Netguns: a technique for capturing black-backed woodpeckers. Journal of Field Ornithology 82:430-435.

ECOLOGY AND MANAGEMENT OF REINTRODUCED ELK IN MISSOURI

Investigators
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Project Supervisor
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Funding
Missouri Department of Conservation
Rocky Mountain Elk Foundation

Objectives
Evaluate resource selection and space use of reintroduced elk in Missouri.

Evaluate demographics of reintroduced elk in Missouri.

Develop an aerial sightability model to monitor abundance of the reintroduced elk herd in Missouri.

Evaluate the population dynamics of the Missouri elk population.

Assess how stress and disturbance may affect elk in Missouri.

Location
Southern Missouri

Expected Completion
July 2016

Status
In Progress

Progress and Results
The Missouri Conservation Commission approved a plan to restore a wild elk (*Cervus elaphus*) population to Missouri in October 2010. A total of 108 elk were translocated from Kentucky to Missouri from 2011-2013. The Missouri Department of Conservation (MDC) and the University of Missouri compiled a research and management plan for elk restoration which outlined 5 research objectives. The overall goal of this research project is to build the foundation necessary for effective management of the elk population. Every adult elk released in Missouri was fitted with a GPS-PTT radio-collar that enables us to monitor movements and habitat use of the animal. We attempted to capture all juvenile elk shortly after birth and fit each with VHF collars to monitor survival. We have received over 137,476 locations from the GPS collars to date. Fidelity to the release site is high, 88% of locations have been within the Peck Ranch Conservation Area, and 97% of locations have been within the Elk Restoration Zone identified by MDC. Adult and yearling survival increased with time since release. During 2011, annual survival for the 2011 release cohort was 88%. This increased to 97% (95% CI = 80, 100) in 2012, compared to adult and yearling survival for the 2012 release cohort during 2012 of 58% (95% CI = 40, 73). During 2013, adult and yearling survival was 94 (95% CI = 85, 99), 90 (95% CI = 81, 99), and 82% (95% CI = 67, 91) for the 2011-, 2012-, and 2013-release cohorts, respectively. Calf production is comparable to other recently reintroduced populations, and has ranged from 62% to 67% during 2011-2013. Annual survival of elk calves born in Missouri was 63 (95% CI = 28, 88), 40 (95% CI = 27, 63), and 31% (95% CI = 14, 57%) during 2011, 2012 and 2013, respectively. Based on current vital rates, the population is static to decreasing with a growth rate (λ) of 0.97. We expect vital rates to increase as the population becomes established. We have conducted 7 sightability census flights during 2011-2013. Seventy-four percent of the 35 groups of elk present during the surveys were sighted by observers. Census flights during winter leaf-off conditions appear a viable method to estimate population abundance. We will continue to monitor resource use, population dynamics, and behavior of this population to help guide management as the elk population continues to grow and adapt to the Missouri landscape.

BROAD-SCALE RESOURCE SELECTION AND FOOD HABITS OF A RECENTLY REINTRODUCED ELK POPULATION IN MISSOURI

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Project Supervisor
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Lonnie Hansen, MDC

Funding
Missouri Department of Conservation
Rocky Mountain Elk Foundation

Cooperators
Missouri Department of Conservation

Objectives
Evaluate seasonal broad-scale resource selection for the reintroduced elk population in the Missouri Ozarks.

Examine diet composition and forage availability for the Missouri elk population to determine seasonal diet selection.

Location
Southern Missouri

Expected Completion
May 2015

Status
In progress

Progress and Results
Since being extirpated from the eastern United States, elk (*Cervus elaphus*) have been reintroduced to 11 eastern states including the recent reintroduction to Missouri in 2011. Although some aspects of the ecology of eastern populations of elk have been studied, habitat needs are not well understood. The goals of our research are to determine the broad-scale resource selection and food habits of the reintroduced elk population in Missouri. This study is a part of a comprehensive research project on the Missouri elk population examining many facets of their ecology. GPS-PTT radio-collars were placed on all 106 adult elk prior to being released to assist in accomplishing the various research objectives of the project. Since summer 2011, we have received 137,476 locations from the GPS collars to date.

To examine food habits, we use elk locations to locate and collect fecal samples from randomly selected individuals. We send the samples to the Washington State Habitat and Nutrition Lab for microhistological analysis to determine diet composition. During the summers of 2013 and 2014, we also collected forage availability data by estimating the percent cover of plant species along 207 transects stratified by vegetation type. We are comparing diet composition and forage availability using a ranking procedure to determine diet selection of 12 forage classes. Our preliminary analysis ranked cereal grains, cool-season grasses, and legumes as highly selected by elk across all seasons. It was evident that elk in Missouri are acquiring a substantial portion of their diet from food plots with at least 1/4 of their diet coming from cultivated species across all seasons. However, oak (*Quercus spp.*) browse and hard mast did make up substantial portions of the diet especially during fall and winter.

To assess broad-scale resource selection, we are using a discrete-choice model to evaluate the potential effects of cover, forage availability, and human disturbance on the distribution of elk on the landscape. The results of this study will help MDC in making sound decisions concerning elk habitat management.

INITIAL MOVEMENTS OF REINTRODUCED ELK IN MISSOURI

Investigators
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Funding
Missouri Department of Conservation
Rocky Mountain Elk Foundation

Objectives
Assess initial movements of elk that were reintroduced to Missouri.

Assess elk movement response to deer hunters.

Location
Southern Missouri

Expected Completion
July 2016

Status
In Progress

Progress and Results

Initial movements of reintroduced wildlife populations can determine short-term restoration success. Managers need ways to encourage animals to exhibit high release site fidelity so that they can mitigate suboptimal breeding, reduce mortality rates, and minimize human-wildlife conflicts that are sometimes associated with low site fidelity. We studied initial movement ecology of adult and yearling elk (*Cervus elaphus*) reintroduced to the Missouri Ozarks in 2011 (n=32), 2012 (n=21), and 2013 (n=31) for the initial 6 months post-release. All released elk were fitted with GPS collars which obtained locations at 2-5 hour intervals. Elk acclimated to their environment in discrete phases, including 1) immediate departure from the release site and elevated movement rates, followed by 2) establishing a home range and gradually expanding their range using previously used area. Compared to other restorations in eastern North America, site fidelity was high. High site fidelity overall and small home ranges in elk recently restored to Missouri may be attributed to soft release, suitable habitat, and minimal human disturbance.

Although wildlife reintroductions are often intended to provide the public with recreational opportunities, human disturbance at the release site may compromise the reintroduction effort. Animals that are disturbed may demonstrate reduced reproduction and survival. We studied the response of reintroduced elk to managed deer hunts in 2011, 2012, and 2013. All elk were fitted with GPS collars that obtained fixes every 2-5 hours. We asked deer hunters to carry GPS units during the hunts in order to assess spatiotemporal elk-hunter interactions. Collectively, their behaviors indicate that elk identified a fraction of their range to use as refugia and made more directed movements to leave the immediate vicinity of deer hunters. This study provides evidence that elk are adaptable to human-wildlife disturbance even shortly (4 months) after reintroduction, and that animal reintroductions do not preclude recreational use of public lands where both are management priorities.

PROCESSES DETERMINING THE ABUNDANCE OF TERRESTRIAL WILDLIFE COMMUNITIES ACROSS LARGE SCALES

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Funding
National Science Foundation

Cooperators
University of Missouri
North Carolina Museum of Natural Sciences
Smithsonian Institute

Objectives
Standardize camera trapping protocol for determining animal abundance

Establish a multi-scale approach for modeling animal abundance/distribution.

Design an infrastructure for citizen science modeling.

Location
Throughout East Coast of U.S.

Expected Completion
July 2015

Status
In Progress

Progress and Results

In the dynamic 21st century providing mechanistic explanations of the local abundance and distribution of animals is of paramount importance. If the environmental conditions affecting these distributions can be determined, predictive models across vast spatial and temporal scales can be developed to assist species conservation and management initiatives. In this project we are developing a citizen science sampling and modeling program to identify the factors influencing animal abundance and distribution throughout the East Coast of the United States. Our program is based on motion-sensitive camera traps, deployed across the study area by volunteers, to document species presence. The data resulting from these traps are currently being used to estimate relative species abundance and distribution. We are currently conducting three different analyses: (1) occupancy models to determine relative abundance of species while accounting for imperfect detection, (2) general linear models that predict species counts, or activity, and (3) multi-species interaction models in a Bayesian framework. In all three cases, we are assessing wildlife responses to covariates including human recreational uses such as hunting and hiking, human development, and habitat characteristics. We hope that the monitoring program developed for this assessment will provide a template for implementation of similar programs over much larger areas. Thus, the factors influencing species abundance and distribution could be assessed at continental or even global scales.

EFFECTS OF COMMERCIAL HARVEST ON TURTLES IN THE MISSOURI RIVER

Investigators
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Jeff Briggler, MDC

Project Supervisor
Joshua Millspaugh, MU
Jeff Briggler, MDC

Funding
Missouri Department of Conservation

Cooperators
Missouri Department of Conservation
Southern Illinois University
University of Southern Mississippi

Objectives
To determine what level of commercial turtle harvest is sustainable

To determine the impact of commercial harvesting on the size structure, sex ratio, and fecundity of harvested turtle populations.

To develop a stage-based population model from existing data and information obtained from this study that can assess alternative harvest strategies.

To collect tissue from each species from each of the commercial waters' rivers and from other non-commercial waters across the state for analyses of microchemistry (isotopes) indicators in order to determine if source of origin for each species can be distinguished.

Location
Missouri - Statewide

Expected Completion
July 2015

Status
In progress

Progress and Results

Commercial turtle harvest is cited as being a major influence of turtle population declines. In Missouri, little is known about the demographics of harvested turtle populations. In order to assess the impacts of harvest on these populations, we completed a mark-recapture study of these species in 2011 and 2012 on the Missouri River and two of its tributaries where harvesting is not legal, the Osage and Gasconade rivers. In both years, snapping turtle abundance was lower in the Missouri River than the Osage and Gasconade tributaries. These abundance estimates and harvest rates were used to model population growth of these three species. In order to assess the potential impacts of harvest on harvested turtle populations, we developed stage-based matrix models to assess turtle population response to our estimated harvest rates. For populations at mean demographic rates, harvest rates of both adults and juvenile snapping turtles need to be $\leq 2.3\%$ to maintain population sustainability ($\lambda = 1$), and for softshells, no level of harvest was sustainable. Elasticity analyses showed that adults were the most important segment of the population demographically, which indicates that even low levels of harvest may have detrimental local-scale effects on the long-term sustainability of turtle populations. We assessed our ability to determine river of capture for individual turtles using microchemistry analysis of turtle nail samples collected from snapping turtles, smooth softshells, and spiny softshells in 2010 through 2012. We used stable isotope analysis (SIA) to determine the composition of stable hydrogen and oxygen isotopes, and inductively coupled plasma mass spectrometry (ICP-MS) to determine the strontium and calcium ratios and concentrations found within turtle nail samples. Our methods offer an approach for others interested in confirming the legality of commercial turtle harvest activity, but we caution against application of our model without proper validation.

Products

Zimmer, S. A., J. T. Briggler, and J. J. Millspaugh. 2014. Modeling the effects of commercial harvest on population growth of river turtles. Chelonian Conservation and Biology: *In press*.

EFFECTS OF ENERGY DEVELOPMENT ON MULE DEER IN WESTERN NORTH DAKOTA

Investigators
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Project Supervisor
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Bruce Stillings, North Dakota Game and Fish Department

Funding
North Dakota Game and Fish Department
North Dakota Industrial Commission
Bureau of Land Management

Cooperators
North Dakota Game and Fish Department

Objectives
Determine how energy development in western North Dakota impacts mule deer demographics and space use.

Location
Western North Dakota

Expected Completion
May 2017

Status
In progress

Progress and Results

Our field work began in winter 2013 when we captured and radio-collared 90 female mule deer. A second capture took place in December 2013 when we captured and collared 46 additional deer. Currently we have 112 radio-collared deer: 65 mule deer does, 17 mule deer yearlings (collared as fawns), and 30 mule deer fawns. To date, we have collected roughly 150,000 GPS fixes from radio-collars on 106 mule deer does and 60 female mule deer fawns. Additional captures are planned for December 2014.

Capture crews collected blood samples from all adult deer captured for pregnancy testing. BioTracking, LLC analyzed blood samples from our February capture and 59/60 adult does tested positive for Protein B (a protein only found in pregnant deer), and one tested with low levels of Protein B (symptomatic of an aborted fetus or poor blood sample).

In 2013, during the first few months after our initial capture we recorded 6 fawn and 5 doe deaths. All fawn mortalities and 4 of the 5 adult mortalities were north of the McKenzie county line. The one exception, which was due to mountain lion predation, was a doe just south of the McKenzie county line. The contrast in survival between northern and southern deer was likely due to more prolonged, deeper snow cover in the northern badlands.

Necropsies indicated poor body condition (very low body fat levels and in femur bone marrow) for most of our deer. Nearly 20% of adult does and 30% of the fawns shifted to new home ranges between mid-March and early June. The longest movements were around 20 miles for both adults and fawns (nearly yearlings at the time of movements). However, the majority of deer have remained within a single home range since capture.

GREATER SAGE-GROUSE ECOLOGY IN RESPONSE TO WIND ENERGY DEVELOPMENT IN CARBON COUNTY, WYOMING

Investigators
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Project Supervisor
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Mark Rumble, USFS

Funding
Power Company of Wyoming
National Wind Coordinating Collaborative
U.S. Forest Service, Rocky Mountain Research Station
Wyoming Game and Fish Department
National Fish and Wildlife Foundation
Bureau of Land Management
National Renewable Energy Lab
Western Association of Fish and Wildlife Agencies

Cooperators
U.S. Forest Service, Rocky Mountain Research Station
University of Missouri
Power Company of Wyoming
Wyoming Game and Fish Department
Bureau of Land Management
SWCA Environmental Consultants
Overland Trail Cattle Company

Objectives
Collect baseline energy development data regarding greater sage-grouse, including: adult and juvenile survival; daily and seasonal movements; multi-scale resource selection; lek dynamics; and brood ecology.

Location
Carbon County, Wyoming

Expected Completion
May 2015

Status
In progress

Progress and Results

Greater sage-grouse (*Centrocercus urophasianus*) are highly dependent on sagebrush-dominated ecosystems and threats to the sagebrush ecosystems have been described extensively. However, the extent of wind energy development on sage-grouse populations and habitats are unknown. The Power Company of Wyoming LLC (PCW) proposes to build a 1,000 turbine, 2,000 – 3,000 megawatt wind farm on the Overland Trail Cattle Company LLC ranch south of Rawlins, Wyoming, making it an ideal site to evaluate the potential impacts of wind energy development on sage-grouse.

Since 2011, we have maintained 50 female and 20-40 male sage-grouse tagged with global positioning systems platform transmitter terminals (GPS PTTs), 50 males tagged with very high frequency (VHF) transmitters, and 50 juveniles (25 male, 25 female) tagged with VHF transmitters. We collected up to 12 locations/day from each sage-grouse tagged with GPS PTTs and at least 1 location/month for sage-grouse tagged with VHF transmitters.

We are currently evaluating survival, movements, and resource selection of sage-grouse, using location data gathered from tagged sage-grouse. Two Master's students recently completed other portions of the project. Aleshia Fremgen focused on lek dynamics, including male lek attendance, sightability on leks, and movements between leks. Leslie Schreiber evaluated brood ecology, including nest selection, chick survival, and brood-rearing site selection. Details of their results can be found in this report.

Results from our study and post-construction studies collecting similar data will be compared to determine how wind energy development affects sage-grouse and how to mitigate impacts.

MALE GREATER SAGE-GROUSE LEK ATTENDANCE, INTERLEK MOVEMENTS, AND SIGHTABILITY IN CARBON COUNTY, WYOMING

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Christopher Rota, MU
Christopher Hansen, MU

Project Supervisor
Joshua Millspaugh, MU

Funding
Power Company of Wyoming
National Wind Coordinating Collaborative
U.S. Forest Service, Rocky Mountain Research Station
Wyoming Game and Fish Department
National Fish and Wildlife Foundation
Bureau of Land Management
National Renewable Energy Lab

Cooperators
U.S. Forest Service, Rocky Mountain Research Station
University of Missouri
Power Company of Wyoming
Wyoming Game and Fish Department
Bureau of Land Management
SWCA Environmental Consultants
Overland Trail Cattle Company

Objectives
Determine attendance rates per lek and per individual male.

Estimate frequencies of male sage-grouse interlek movements.

Evaluate male sage-grouse sightability and population size from lek counts.

Location
Carbon County, Wyoming

Expected Completion
May 2015

Status
In progress

Progress and Results

The impacts of wind energy developments on Greater Sage-grouse (*Centrocercus urophasianus*) are unknown, but studies with other grouse species or in oil and gas developments indicate that there may be avoidance responses to turbines, or lower populations at leks. This study is part of a larger, long-term Before-After-Control-Impact study assessing impacts of wind energy development on sage-grouse. This project is in the pre-construction phase of a 1,000 turbine wind energy development, and focuses on male breeding ground (lek) ecology.

Global Positioning System Passive Terminal Transmitters (GPS-PTT) and VHF transmitters were deployed on male sage-grouse to determine how frequently individual males attend leks, lek attendance rates per lek, and the variables that may increase or decrease attendance. Date and time of day strongly influenced attendance rates, and males were less likely to attend with precipitation. Using the marked birds, we also assessed the frequency and direction of movements between leks during spring. Factors driving movements were different annually but males were more likely to move if they had less mass, more likely to move towards leks surrounded by a higher proportion of sage cover. Additionally males were less likely to move during precipitation but more likely to move following precipitation. Males displayed high fidelity for their leks, with movement probabilities ranging from 0.04% to 2.18% daily. We have currently collected about 155,000 locations from 145 GPS-PTT tagged males since spring 2011.

In addition we evaluated sightability of male sage-grouse to determine a detection probability for males during lek counts. During the 2012- 2014 breeding seasons, we collected 266 sightability observations, and the average detection of male sage grouse during lek counts was 87.0%. We found vegetation and cover characteristics, such as sage height and snow cover, most strongly influenced detection, and models predicted detection well. We then used the detection probability with lek count data to more accurately estimate population size.

GREATER SAGE-GROUSE CHICK SURVIVAL AND NEST PRODUCTIVITY PRIOR TO WIND ENERGY DEVELOPMENT IN WYOMING

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Christopher Hansen, MU
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Project Supervisor
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Funding
Power Company of Wyoming
National Wind Coordinating Collaborative
U.S. Forest Service, Rocky Mountain Research Station
Wyoming Game and Fish Department
Western Association of Fish and Wildlife Agencies

Cooperators
U.S. Forest Service, Rocky Mountain Research Station
University of Missouri
Power Company of Wyoming
Wyoming Game and Fish Department
Bureau of Land Management
SWCA Environmental Consultants
Overland Trail Cattle Company

Objectives
Collect and evaluate baseline, pre-wind energy development data regarding sage-grouse chick survival, nest site selection, and brood ecology.

Location
Carbon County, Wyoming

Expected Completion
May 2015

Status
In progress

Progress and Results

Small changes in nest productivity and chick survival in Greater sage-grouse (*Centrocercus urophasianus*) populations can have large effects on the population growth rate and abundance. Knowledge of sage-grouse population demographic rates is important because the species is considered "warranted but precluded" under the Endangered Species Act (1973). As part of a study quantifying sage-grouse demographics prior to construction of a wind energy facility, we estimated net nest productivity of radio-equipped female sage-grouse (n = 44 in 2011; 52 in 2012; 46 in 2013) and estimated the survival rate of chicks associated with each radio-equipped female on the Overland Trail Ranch in south-central Wyoming, USA. Our post-hatch estimates of nest productivity [2.79 ± 0.68 (SE) chicks/female in 2011; 2.00 ± 2.87 (SE) chicks/female in 2012; and 1.54 ± 0.47 (SE) chicks/female in 2013] were low when compared to estimates from other studies. We estimated chick survival by conducting repeated nocturnal spotlight surveys in which we counted the chicks associated with each radio-equipped female (n = 14 in 2011; 14 in 2012; 9 in 2013). We used a modified logistic-exposure method to estimate daily chick survival rates and survival over a 70-day time period while examining relationships between chick survival and weather and temporal variables. Chick survival rates to 70 days-post-hatch [2011: 0.120 ± 0.082 (SE), 2012: 0.031 ± 0.034 (SE), 2013: 0.157 ± 0.049 (SE)] were very low. However, these rates should be placed in the broader context of sage-grouse chick survival which exhibits high annual variation due to a variety of extrinsic factors. The low rates of nest productivity and chick survival suggest that this area may be of marginal quality for sage-grouse. Research is needed to elucidate the mechanisms behind the persistence of birds on the area and the low demographic rates we observed.

MANAGING WILDLIFE IN THE FACE OF CHANGING CLIMATE

Investigators
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Hong He, MU
Wayne Thogmartin, USGS

Project Supervisor
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Frank Thompson III, USFS

Funding
U.S. Forest Service

Cooperators
U.S. Geological Survey
U.S. Forest Service

Objectives
What are the impacts of current land cover and climate on the abundance of focal bird species in the Midwestern United States?

What is the response of focal bird species abundance to landscape change under alternative climate and forest management scenarios focused on resilience, adaptation, and carbon sequestration to mitigate climate change effects in the Missouri Ozark Highlands?

What are the economic tradeoffs of managing forests for resilience, adaptation, carbon sequestration, and avian species through timber revenues and carbon credits in the Missouri Ozark Highlands?

Location
Midwestern United States
Missouri

Expected Completion
May 2015

Status
In progress

Progress and Results
Climate change is becoming a major concern for avian species and has the potential to compound current human-induced pressures (e.g. habitat loss and degradation) to wildlife both directly (e.g. phenology, temperature regulation and mortality) and indirectly (e.g. fire frequency and vegetation changes). Climate projections for the Midwestern United States call for southerly climates to shift north. These shifts have the potential to alter ecosystem structure and function, affecting vegetation and avian species across North America. Currently, birds are experiencing phenological shifts on both breeding and wintering grounds potentially creating a divergence between available habitat and suitable climatic conditions for breeding birds. Using a Bayesian hierarchical framework, we determined the impacts of current land cover and climate on the abundance of focal bird species in the Midwestern United States.

Our results highlight positive and negative consequences to a suite of avian species over a vegetation gradient to differences in climate and land cover. Habitat variables drove patterns of abundance in migratory and resident species, although climate was also influential in predicting abundance for some species occupying more open habitat. Northern bobwhite had abundance positively affect by winter temperature and was the only species that exhibited any significant effect of climate. Models for birds primarily occupying early successional habitats performed better with a combination of habitat and climate variables whereas models of species found in contiguous forest performed best with canopy cover alone.

Future work will link these species models with downscaled General Circulation Models (GCMs) and landscapes simulated in LANDIS to predict the response of forest products and wildlife species to forest management focused on mitigating and adapting to the projected changes in climate for the Missouri Ozark Highlands.

ADVANCEMENT OF ECOREGIONAL, LANDSCAPE-BASED POPULATION MODELS FOR USE IN CONSERVATION PLANNING IN RESPONSE TO CLIMATE CHANGE

Investigators
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Project Supervisor
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Funding
Gulf Coastal Plains and Ozarks LCC
U.S. Forest Service

Cooperators
U.S. Forest Service
Gulf Coastal Plains and Ozarks LCC
Central Hardwoods Joint Venture
University of Missouri

Objectives
Model responses of regional wildlife populations to landscape change.

Validate model components that relate wildlife population processes to habitat and landscape patterns.

Incorporate structured decision making and optimization to guide regional conservation planning.

Location
Central Hardwoods Bird Conservation Region

Expected Completion
August 2016

Status
In progress

Progress and Results

Sustaining wildlife populations in the face of global change and habitat fragmentation and loss requires conservation planning and actions at large scales. Landscape-based population models offer a valuable advance in conservation planning because they allow an understanding of the effects of local actions on regional growth, which is necessary for translating regional goals into local actions. Having demonstrated their power to inform conservation planning by evaluating responses of forest songbirds to simulated conservation scenarios, we must now adapt these models to incorporate dynamic landscapes so that the impacts of land-use and climate change can be evaluated. We will apply the models to landscapes output from coupled climate, ecosystem, and forest dynamics models to evaluate wildlife responses to such changes. Simultaneously, we will continue validating model components that relate wildlife population processes to habitat and landscape patterns. Finally, we will incorporate structured decision making and optimization to guide regional conservation planning.

Products

Bonnot, T. W., F. R. Thompson, III, J. J. Millspaugh, and D. T. Jones-Farrand. 2013. Landscape-based population viability models demonstrate importance of strategic conservation planning for birds. Biological Conservation 165:104-114.

POPULATION ESTIMATE FOR BLACK-BACKED WOODPECKERS (PICOIDES ARCTICUS) IN THE BLACK HILLS, SOUTH DAKOTA

Investigators
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Frank Thompson, III, USFS
Mark Rumble, USFS

Project Supervisor
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Frank Thompson, III, USFS

Funding
Black Hills National Forest
South Dakota Department of Game, Fish and Parks
South Dakota Department of Agriculture, Division of Resource Conservation and Forestry
Wyoming Department of Game, Fish and Parks

Cooperators
Black Hills National Forest
South Dakota Department of Game, Fish and Parks
Wyoming Department of Game, Fish and Parks

Objectives
Determine relationships between environmental and habitat factors with detection probability and density of black-backed woodpeckers.

Incorporate objective 1 into models that show black-backed woodpecker density in the Black Hills and provide a population estimate for the Black Hills and Bearlodge Mountains.

Location
Black Hills, South Dakota

Expected Completion
June 2017

Status
In progress

Progress and Results
Black-backed woodpeckers (*Picoides arcticus*) are rare residents of northern conifer forests, including the Black Hills. They often are associated with forest perturbations that result in recently killed trees (snags) from fire, insects or disease. Although these disturbances are naturally occurring throughout most western forests they are often suppressed. Black-backed woodpeckers are “species of greatest conservation need” in South Dakota and Wyoming. The population in the Black Hills is physically and genetically isolated from other populations and was recently petitioned for protection under the Endangered Species Act as a Distinct Population Segment. Population status and trend are unknown and species-specific surveys are needed. The study will take place in the Black Hills and Bearlodge Mountains. Point counts oriented along transects will be conducted in March-May 2015 and 2016 to estimate the population size. Two strata, one representing forest conditions likely to support black-backed woodpeckers and the second representing forests unlikely to support them, will be determined using remote sensing products. Line transects will be distributed throughout these two areas using a stratified random design. We will use models that simultaneously model detection probability and estimate abundance based on repeated surveys and distances to detections. We will use the best model of bird abundance to create a density map that will estimate the total population size across Black Hills National Forest. This study will provide an updated population estimate that will assist wildlife management entities with a benchmark for future goal setting and for continued evaluation of impacts of the various disturbance regimes in the Black Hills.

SURVIVAL, RECRUITMENT, AND MOVEMENT PATTERNS OF WHITE-TAILED DEER IN MISSOURI

Investigators
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Project Supervisor
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Emily Flinn, Missouri Department of Conservation
Jason Sumners, Missouri Department of Conservation

Funding
Missouri Department of Conservation

Cooperators
University of Missouri
Missouri Department of Conservation

Objectives
Estimate regional annual sex- and age-specific survival and recruitment rates for white-tailed deer in two contrasting regions of Missouri.

Evaluate movement and space use patterns of white-tailed deer in relation to landscape and habitat features in two contrasting regions of Missouri.

Refine population models used to management white-tailed deer in Missouri.

Location
South-central and North-west Missouri

Expected Completion
May 2021

Status
In Progress

Progress and Results

Over the last several decades, landscape level changes in habitat condition, deer densities, harvest vulnerability, hunter selectivity, and predator populations have resulted in unknown changes in white-tailed deer survival and recruitment rates, thus affecting MDC's ability to effectively model deer populations. Regulation recommendations based on models that may not accurately reflect current deer population dynamics because of the incorporation of data of unknown accuracy could lead to poorly informed harvest regulation recommendations and management decisions. Erroneous harvest regulations and management recommendations have the potential to negatively influence several stakeholder groups, including production landowners, motorists, hunters, and erode public trust in MDC's ability to manage deer and other resources. Survival and recruitment rates produced from this study will enhance MDC's ability to accurately simulate deer populations, thus ensuring science-based information guides MDC's regulatory decisions. Additionally, with the emergence of chronic wasting disease (CWD) in captive and free-ranging deer in Missouri it is critically important that current and future disease management strategies are derived from science-based information. Movement patterns (i.e., Dispersal distance and home range size) affect the spread and spatial distribution of diseases, including CWD and bovine tuberculosis. Therefore, of equal importance is the ability to incorporate regional information on deer movement patterns (i.e., dispersal, home range) into disease management strategies, including appropriate spatial scales in which management actions should be applied. Consequently, increasing MDC's and Missouri citizens' confidence that disease management actions are being implemented on an appropriate scale to be effective and yield desired results.

MODELING CHRONIC WASTING DISEASE DYNAMICS AND POTENTIAL IMPACTS ON WHITE-TAILED DEER POPULATIONS IN MISSOURI

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Funding
Missouri Department of Conservation

Cooperators
University of Missouri
Missouri Department of Conservation

Objectives
Estimate regional annual sex- and age-specific survival and recruitment rates for white-tailed deer in two contrasting regions of Missouri.

Evaluate movement and space use patterns of white-tailed deer in relation to landscape and habitat features in two contrasting regions of Missouri.

Refine population models used to management white-tailed deer in Missouri.

Location
Missouri

Expected Completion
May 2016

Status
In Progress

Progress and Results

Current work is focused on formulating an agent-based model (ABM) of chronic wasting disease (CWD) in white-tailed deer. The causative agent of CWD is poorly characterized, and we have a limited understanding of the transmission dynamics of CWD. Using an ABM-based approach, we hope to better understand the complexity of the spread of CWD in Missouri and its impact on white-tailed deer populations.

The model code has been written in NetLogo, using the geographic data for the CWD containment zone in north-central Missouri (provided by MDC). We have used forest cover data (percent forest cover) for six counties in the containment zone to set up the model landscape, and initial deer distribution. Deer population dynamics are parameterized using published references and expert opinions, and processes like reproduction, dispersal and hunting mortality have been included in the model. The model has a time step of one month, and a model run comprises of simulations for a period of 100 years. The age-structure and sex ratio of the deer population is maintained throughout the model run.

We are presently undertaking verification and validation of this ABM. We are also in the process of incorporating CWD transmission in the current deer population model. The next step would be to use the model to play out various scenarios under different assumptions, thereby contrasting the consequences of alternative CWD management strategies.

REGIONAL TURKEY POPULATION MONITORING FOR A COORDINATED HARVEST MANAGEMENT STRATEGY

Investigators
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Mike Clawson, University of Washington

Project Supervisor
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Jason Isabelle, Missouri Department of Conservation

Funding
Missouri Department of Conservation

Cooperators
University of Missouri
Missouri Department of Conservation
University of Washington

Objectives
Develop a regional wild turkey statistical population reconstruction model to estimate survival, harvest rates, abundance, and population growth rates.

Develop user-friendly software for future analysis of age-at-harvest software.

Estimate sex and age specific seasonal and annual natural survival rates for turkeys in Northeast Missouri.

Location
Northeast Missouri

Expected Completion
June 2020

Status
In Progress

Progress and Results
The reintroduction of eastern wild turkeys in Missouri has led to hunted populations that are the envy of the rest of the country. Recently, however, expanded hunting opportunities and corresponding declines in spring harvest have led to an emerging uncertainty about current harvest management strategies. The development of new analytical techniques and a retrospective analysis of annual harvest probabilities, natural survival, and abundance at state-wide levels would assist managers in understanding the relative role of harvest in affecting wild turkey populations, and provide the foundational basis for an adaptive harvest management process. We are developing new analytical procedures, based on modern statistical population reconstruction techniques, to assessment wild turkey demographics. These modern methods allow for inclusion of readily available age-at-harvest and hunter effort information. The approach can also identify important data gaps that could be filled by additional field studies, thereby putting future research efforts into a more meaningful context. Specifically, we are developing regional wild turkey SPR models, which will allow estimation of natural survival and harvest rates, while simultaneously estimate abundance and population growth rate. These models would be developed and applied using field data collected over the next several years in Missouri, including banding and radiotelemetry data. Thus, this project provides the analytical component necessary for future management and monitoring of wild turkeys.

DR. FRANK THOMPSON

APPLICATION OF BAYESIAN HIERARCHICAL MODELS TO LINKING ANIMAL DEMOGRPAHICS TO CLIMATE AND LANDSCAPE FACTORS

Investigators

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Dr. Frank Thompson III, USFS, MU
Becky Peak, MN DNR

Project Supervisor
Dr. Frank Thompson III, USFS, MU

Funding
U.S. Forest Service, Northern Research Station
U.S. Geological Survey Northeast Climate Science Center

Cooperators
University of Massachusetts Amherst
U.S. Forest Service
U.S. Army, Fort Hood

Objectives
To provide more rigorous analytical methods for estimating key demographic parameters and for relating these to climate and landscape factors.

Location
Midwestern United States

Expected Completion
2015

Status
In progress

Progress and Results
We are working with several long-term data sets to investigate how productivity, survival, and abundance are related to climate and landscape factors. Understanding of key demographic relationships is necessary for parameterizing more applied models investigating climate and landscape change scenarios, which may be used to guide conservation design. Our initial efforts are focused on survival, productivity and population change of the endangered golden cheeked warbler in Texas. We are using hierarchical models that account for bird movement when estimating survival as well as a combined demographic modeling framework that simultaneously considers survival and productivity to estimate population change. We will also be investigating direct effects of climate on nesting success and productivity.

DIURNAL AND NOCTURNAL BREEDING BIRD RESPONSE TO PINE SAVANNA AND WOODLAND RESTORATION THROUGHOUT THE OUACHITA-OZARK INTERIOR HIGHLANDS

Investigators
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Dr. Frank Thompson III, USFS, MU

Project Supervisor
Dr. Frank Thompson III, USFS, MU

Funding
U.S. Forest Service, Northern Research Station, Mark Twain National Forest, Ouachita National Forest

Objectives
Determine relationships between breeding-season density of focal birds and vegetation structure, pine abundance, and fire frequency across a gradient of pine savanna, woodland and forest.

Determine relationships between breeding-season abundance of Eastern Whip-poor-will and Chuck-will's-widow and habitat composition and fire frequency across a landscape gradient of pine savanna, woodland, forest, and open land.

Determine relationships between nesting success of focal songbird species and vegetation structure, pine abundance, and fire frequency across a gradient of pine savanna, woodland and forest.

Location
Ouachita-Ozark Interior Highlands of Missouri, Arkansas, and Oklahoma

Expected Completion
May 2016

Status
In progress

Progress and Results
Restoration of pine savanna and woodland communities in the Ouachita-Ozark region of Missouri, Arkansas, and Oklahoma is of great interest in order to maintain floristic and biological diversity. Considerable effort and funding is now aimed at reestablishing, and ultimately maintaining, large tracts of this once dominant ecosystem. It is important to understand the relationships between the breeding bird community, vegetative structure, and fire regime in these communities in order for land managers to effectively restore and maintain them. Our objective is to study various aspects of the breeding bird community across the gradient from open pine savanna to closed canopy forest. We will focus on a preselected suite of species (both passerine and non-passerine) to determine abundance and reproductive success throughout the habitat gradient. By collecting information on breeding bird densities and nesting success, we will be able to examine how fire frequency, vegetative structure and landscape composition across the habitat gradient affect the species of the Ouachita-Ozark region, some of which are of regional concern. These results will aid land managers in effectively planning, creating, and maintaining threatened ecosystems.

MULTI-SCALE FACTORS AFFECTING ABUNDANCE OF BATS AND INSECT PREY IN SAVANNAS, WOODLANDS, AND FORESTS IN THE OZARK HIGHLANDS, USA

Investigators
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Sybill Amelon, USFS

Project Supervisor
Dr. Frank Thompson III, USFS, MU

Funding
U.S. Forest Service, Northern Research Station

Objectives
Evaluate the utility of n-mixture models for repeated count data and general multinomial-Poisson models using removal sampling on bat capture data.

Determine the importance of relationships between prescribed fire, vegetation structure, and habitat type with insect abundance across a gradient of savanna, woodland, and forests in the Ozark Highlands.

Determine support for relationships between landscape composition and pattern, habitat structure, prescribed burning, and insect abundance with bat abundance in Ozark landscapes composed of a mix of savanna, woodland, and forest.

Location
Ozark Highlands of Missouri

Expected Completion
May 2017

Status
In progress

Progress and Results
We are investigating broader ecological issues (e.g. multi-scale habitat selection, proximate and ultimate factor effects on abundance, and estimate true abundance) while addressing two contemporary conservation issues: the restoration of savanna and woodlands and bat conservation. Savanna woodland restoration is taking place across the Midwest. Our main objective is to study changes to bat and insect prey abundance at multiple scales across a gradient ranging from savannas and woodlands managed by fire, to unmanaged closed canopy forests. We are determining bat abundance of four common bat species and sampling insect prey using four different trap types at each mist-net site. Additionally, we are testing the utility of two different abundance models on bat capture data since recapture rates are low so traditional methods to estimate abundance are not useable for capture date. Once we fit the better model, we will evaluate how habitat characteristics at the local, patch, and landscape scale and ultimate (insect prey) factors predict bat species abundance. Our results will provide land managers and other shareholders with broad scale information on the effects of restoration management on insect abundance. We will also provide insight on how an ultimate factor, insect prey abundance, may affect habitat selection for wildlife species based on changes in food availability caused by restoration management. More generally, understanding how bats respond to multi-scale proximate and ultimate factors is essential because bats are of high conservation concern. Besides increasing our knowledge of habitat selection for wildlife, this project will improve our (scientists, management agencies, and other shareholders) ability to plan conservation management strategies at scales most influential to bat populations. Our study will provide abundance estimates that can be extrapolated over spatial and temporal scales and used to create population estimates for species to assess status, population trends, and viability. This is especially necessary in light of recent population declines of bat species related to landscape conversion, wind energy developments, and WNS.

DR. JOANNA WHITTIER

DEVELOPING STREAM TEMPERATURE AND FLOW MODELS: IDENTIFICATION OF GAPS IN THE DISTRIBUTION AND AVAILABILITY OF STREAM TEMPERATURE AND FLOW DATA

Investigators
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Dr. Kevin Wehrly, Michigan DNR

Project Supervisor at MU
Dr. Joanna Whittier, MU

Funding
Northeast Climate Science Center
Great Rivers Cooperative Ecosystem Studies Unit

Objectives
Gather local, State, and Federal stream temperature data within upper Midwest and Northeast by leveraging existing relationships with state agencies, consortia members, the LCC's, USFWS, USGS, USFS, and EPA.

Evaluate the ability of multiple models to replicate stream temperature at a fine-grained spatial scale and the ability of the models to scale to larger contexts.

Location
Upper Midwest and Northeast U.S.

Completion
September 2013

Status
Completed

Progress and Results
Stream temperature has a direct and indirect effect on many biological, physical, and chemical processes in the freshwater environment. For example, metabolic rates of most stream organisms are controlled directly by temperature. Feeding and breeding behaviors are altered when temperature changes, resulting in divergent preferences for habitat for cool-water and warm-water species. Conservation and management decisions regarding aquatic systems face new challenges as future temperatures are projected to rise markedly and flow timing is projected to shift for many watersheds under climate change impacts.

The goal of this project was to identify locations for existing available stream temperature data throughout the NECSC region. Staff at the USGS Wisconsin Water Science Center built a web-based decision support mapper to display the stream temperature inventory network and associated metadata through a publically available online site (Fig.1). We coordinated our effort with efforts conducted by the US Forest Service in the Pacific Northwest to provide users with similar products. The sites are color-coded to indicate the general organization collecting the datasets.

We hope that information gathered will be used to direct future stream temperature sampling efforts to increase the coverage across states and in regions with little to no monitoring efforts in place.

Investigators
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Dr. Steve Hostetler, Oregon State University
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Project Supervisor
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Funding
Missouri Department of Conservation
CA 349

Objectives
Characterize current and future water temperature patterns for Missouri streams.

Examine the relationship between water temperature and flow rates for Missouri streams.

Location
Missouri state-wide

Expected Completion
June 2015

Status
In progress

Progress and Results
Water temperature is one of the most important drivers of ecosystem function in aquatic systems and an important indicator for impacts of natural and anthropogenic influences. Not only can water temperature affect the presence or absence of aquatic organisms, it can also influence food consumption, growth and metabolism, aquatic invertebrate composition, and food webs. Therefore, stream thermal regimes often dictate management decisions such as selection of species to stock at a given location, harvest regulations as affected by growth, and mitigation of anthropogenic disturbances affecting native species distributions. In this study, we are focusing on the influences of stream type, flow rate, and climate on stream temperature throughout Missouri. Recent research identified three primary stream types in Missouri (intermittent, perennial/runoff dominated, and perennial/groundwater dominated) and four secondary stream types (perennial runoff - flashy, perennial runoff - moderate baseflow, perennial groundwater - stable, and perennial groundwater - super stable) that are typically in geographically-distinct subregions. We distributed water temperature loggers (Fig. 1) across the perennial stream types near 65 USGS gage stations that collect continuous flow rate measurements and avoid direct impacts from anthropogenic modifications.

This project will provide land managers with relationships between flow metrics and water temperature to aid in the evaluation of projects impacting water flow within the stream subtypes established for Missouri and project how stream temperature patterns may shift under future climatic conditions.

POTENTIAL CONSERVATION PRIORITY AREAS FOR STREAMS IN THE UPPER COLORADO RIVER BASIN

Investigators
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Nick Sievert, M.S. student, MU

Project Supervisor at MU
Dr. Joanna Whittier, MU

Funding
Western Association of Fish and Wildlife Agencies
Western Native Trout Initiative

Cooperators
Desert Fishes Habitat Partnership

Objectives
Quantify and geo-reference a threat index for the Upper Colorado River Basin using techniques based on our published research.

Provide conservation priority rankings for native fishes.

Location
Upper Colorado River Basin

Completion
November 2014

Status
In progress

Progress and Results
Building on research that we conducted in the Lower and Upper Colorado River basins, we are developing potential priority areas for conservation of native fishes the Upper Colorado River Basin. An anthropogenic threats classification has been created using existing data such as road density, dam locations, mining operations, 303d listed streams, and other factors deemed to threaten aquatic resources.

Conservation priority values will be calculated based on the contribution of a stream reach to the representation of native species across the basin, while considering the impacts of anthropogenic threats and non-native species (e.g., Strecker *et al.* 2011). This will be done using Zonation conservation planning software which works by iteratively removing the lowest value stream reach to maximize the representation of species within the remaining reaches in the basin. This process results in the assignment of conservation priority values from 0-1 (low to high) where reaches with values near one generally have the most valuable stream fish communities (uncommon species occurrences, high diversity) with low anthropogenic threats and absence of non-natives, and values near zero have less valuable stream fish communities (common species, low diversity) with high anthropogenic threats and presence of non-natives. This methodology allows us to incorporate a broad array of information (threats, land use, species occurrence, and additional habitat factors) in the decision-making process for selecting conservation areas; which should produce a better product than limiting the process to a subset of these variables. Conservation priority areas identified through this process will maximize the representation of all native stream fish in the smallest number of stream reaches, which also have low anthropogenic and non-native species impacts. These priority areas will be presented to resource professionals to identify stream reaches with the highest returns for aquatic biodiversity conservation with investment in protection or management.

PEER REVIEWED AND TECHNICAL PUBLICATIONS

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* Denotes Graduate Student or Post doc
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Technical and Popular Publications

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ORAL AND POSTER PRESENTATIONS

Evan Hill, M.S. student, giving a presentation to Missouri Department of Conservation managers.

PRESENTATIONS BY UNIT SCIENTISTS AND STUDENTS

* Denotes Graduate Student or Post doc

** Denotes Undergraduate Student

*Beatty, W.S., D.C. Kesler, E.B. Webb, A.H. Raedeke, L.W. Naylor, and D.D. Humburg. 2013. Quantitative and qualitative approaches to identifying migration chronology in a continental migrant. Joint Meeting of the Cooper Ornithological Society and American Ornithologists' Union, Chicago, IL.

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*Crawford, L. K. and A. E. Rosenberger. 2014. Development of validated standard methods for assessing unionoid mussel communities. Missouri Natural Resources Conference, Osage Beach, MO.

*Crawford, L. K. and A. E. Rosenberger. 2014. Effectiveness of visual sampling methods for assessing unionoid mussel communities. 74th Annual Midwest Fish and Wildlife Conference, Kansas City, MO.

*Dinges, A., E.B. Webb, and M.P. Vrtiska. 2012. Behavior and distribution of dabbling ducks during the Light Goose Conservation Order in the Rainwater Basin of Nebraska. Midwest Fish and Wildlife Conference, Wichita, KS.

*Dinges, A., E.B. Webb, and M.P. Vrtiska. 2012. Effects of the Light Goose Conservation Order on waterfowl behavior and distribution in the Rainwater Basin of Nebraska. The Wildlife Society Meeting, Portland, OR.

*Dinges, A., E.B. Webb, and M.P. Vrtiska. 2013. Hunting disturbance and its effects on dabbling ducks during the Light Goose Conservation Order in the Rainwater Basin of Nebraska. North American Duck Symposium, Memphis, TN.

*Dinges, A., E.B. Webb, and M.P. Vrtiska. 2013. Migratory bird hunter opinions on future control options for Light Goose populations. North American Duck Symposium, Memphis, TN.

**Dolan, M. *E. Pherigo, and C. Paukert. 2013. Age and growth of spotted bass in the Osage and Gasconade rivers. Missouri Natural Resources Conference, Osage Beach, MO.

**Dolan, M., J. Whittier, *J. Westhoff, and *T. Schepker. 2014. A comparison of precision among temperature loggers at typical stream temperatures. American Fisheries Society Meeting, Quebec City, Quebec, Canada.

*Foley, K. and A.E. Rosenberger. 2012. Habitat variables and their effect upon single-pass backpack electrofisher sampling efficiency within an Alaskan headwater system. Mat-su Science and Conservation Symposium. Palmer, AK.

*Foley, K. and A.E. Rosenberger. 2013. Habitat variables and their effect upon single-pass backpack electrofisher sampling efficiency within an Alaskan headwater system. Mat-su Science and Conservation Symposium. Palmer, AK.

*Foley, K. and A.E. Rosenberger. 2012. Habitat use patterns and longitudinal distribution of juvenile coho salmon in small order tributaries of the Little Susitna River. Alaska Cooperative Fish and Wildlife Research Unit Annual Review, Fairbanks, AK.

*Fowler, D. N. 2014. Snow Geese (*Chen caerulescens caerulescens*) – Too much of a good thing? Annual meeting of the Missouri Audubon Society, Osage Beach, MO.

Galat. D. L. 2014. Overview of collaborative Adaptive Management (CAM). Collaborative Adaptive Management (CAM*Net*) Rendezvous, Weaverville CA.

Galat. D. L. and J. Higgins. 2012. Integrated River Basin Management: a viable option for Mississippi River Basin sustainability? Workshop: Mississippi River ecological restoration from on the ground to integrated river basin management. EcoSummit 2012 - Ecological Sustainability: restoring the Planet's Ecosystem Services, Columbus, OH.

Gray, M.J., H.M. Hagy, and E.B. Webb. 2013. Obtaining reliable estimates of food availability in moist-soil wetlands for dabbling ducks. North American Duck Symposium, Memphis, TN.

*Gutsch, M. and A.E. Rosenberger. 2012. Overwintering habitat use of juvenile coho salmon in the Anchor River, Alaska. Defense seminar to the Fisheries Division, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, AK.

*Harris, J., and C. Paukert. 2013. Aquatic applications of ArcGIS: tracking and analyzing telemetry data. Midwest Fish and Wildlife Conference, Wichita, KS.

*Harris, J., C. Paukert, S. Bush, M. Allen, and M. Siepker. 2012. Movement and habitat selection of largemouth bass: implications for reservoir habitat improvements. American Fisheries Society Annual Meeting, St. Paul, MN.

*Harris, J., C. Paukert, S. Bush, M. Allen, and M. Siepker. 2012. Movement and habitat selection of largemouth bass: implications for reservoir habitat improvements. Missouri/Arkansas White River Partnership Meetings, Branson, MO.

*Harris, J., C. Paukert, S. Bush, M. Allen, and M. Siepker. 2013. Using largemouth bass to evaluate a large reservoir habitat project. Missouri Natural Resources Conference, Osage Beach, MO.

*Harris, J., C. Paukert, S. Bush, M. Allen, and M. Siepker. 2013. How largemouth bass respond to a large reservoir habitat enhancement project. American Fisheries Society Annual Meeting, Little Rock, AR.

*Harris, J., C. Paukert, S. Bush, M. Allen, and M. Siepker. 2013. Using largemouth bass to evaluate a large reservoir habitat project. Midwest Fish and Wildlife Conference, Wichita, KS.

**Haverly, Z., *J.L. Tapp and E.B. Webb. 2014. Effects of inundation patterns on macroinvertebrate biomass, richness and production in seasonal wetlands. Midwest Fish and Wildlife Conference, Kansas City, MO.

*Haynes, T.B. Biotic and abiotic factors contributing to the distribution of fish and breeding loons on the North Slope. Defense presentation to the School of Fisheries and Ocean Sciences, Fairbanks, AK.

*Haynes, T., A.E. Rosenberger, M. Lindberg, and J.A. Schmutz. 2013. Occupancy patterns of fishes in Arctic lakes provide clues to dispersal mechanisms in a harsh environment. Alaska Chapter of the American Fisheries Society Annual Meeting, Fairbanks AK (award received).

*Haynes, T., A. E. Rosenberger, M. S. Lindberg, M. Whitman, and J. A. Schmutz. 2012. Using multiple survey methods to examine detection probabilities of Arctic fish in lakes on the North Slope, AK. Seminar, 39th annual AFS – Alaska Chapter Conference. Kodiak, AK (award received).

*Haynes, T. B., J. A Schmutz, M. S. Lindberg, K. G. Wright, B. D. Uher-Koch, A. E. Rosenberger. 2014. Occupancy of yellow-billed and Pacific loons: evidence for interspecific competition and habitat mediated co-occurrence. Oral presentation at the Pacific Seabird Group Annual Meeting. Juneau, AK.

Healy, B., E. Omana Smith, M. Trammel, C. Nelson, C. Paukert, *J. Spurgeon, M. Crawford, D. Speas. 2014. NPS Fisheries Program Updates: Humpback chub translocations to Grand Canyon tributaries. Glen Canyon Dam Adaptive Management Program, Technical Working Group Meeting, Phoenix, AZ

*Hill, E.B., E.B. Webb, and D. Mengel. 2014. Linking wetland management decisions to distribution and habitat use of secretive marsh birds in Missouri public wetlands. Annual meeting of the Missouri Audubon Society, Osage Beach, MO.

*Hill, E.B., E.B. Webb, and D. Mengel. 2014. Linking wetland management decisions to distribution and habitat use of secretive marsh birds in Missouri public wetlands. Midwest Bird Conservation and Monitoring Workshop, Port Washington, WI.

*Hill, E.B., E.B. Webb and D. Mengel. 2014. Linking wetland management decisions to distribution and habitat use of secretive marsh birds in Missouri public wetlands. Midwest Fish and Wildlife Conference, Kansas City, MO.

*Hoem-Neher, T. and A.E. Rosenberger. 2012. Ecology of juvenile coho salmon in Alaska estuaries and influences of estuary habitats on the expression of life history characteristics of coho salmon. Seminar, Alaska Chapter of the AFS, Kodiak, AK.

*Hoem-Neher, T. and A.E. Rosenberger. 2012. Ecology of juvenile coho salmon in Alaska estuaries and influences of estuary habitats on the expression of life history characteristics of coho salmon. Seminar, Defense seminar to the Fisheries Division, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, Fairbanks, AK.

*Hoem-Neher, T. and A.E. Rosenberger. 2012. Ecology of juvenile coho salmon in Alaska estuaries and influences of estuary habitats on the expression of life history characteristics of coho salmon. Kachemak Bay Research Reserve Community Council Meeting, Homer, AK.

*Hoem-Neher, T. and A.E. Rosenberger. 2012. Ecology of juvenile coho salmon in Alaska estuaries and influences of estuary habitats on the expression of life history characteristics of coho salmon. Kachemak Bay Research reserve Summer Seminar Series, Homer, AK.

*Hoem-Neher, T. and A.E. Rosenberger. 2012. Using otoliths to decipher estuary use by young salmon. Seminar, Kachemak Bay Science Conference, Homer, AK (award received).

*Hoem-Neher, T. and A.E. Rosenberger. 2012. Using otoliths to decipher estuary use by young salmon. Kachemak Bay Science Conference, Homer, AK. July, 2012.

*Kaemingk, M., J. Jolley, C. Paukert, D. Willis, R. Holland, G. Wanner, and M. Lindvall. 2012. The role of common carp in shallow lake ecosystems. American Fisheries Society Annual Meeting, St. Paul, MN.

Kaminski, R.M. *J.L. Tapp, E.B. Webb and 12 additional co-authors. 2012. Science and conservation combating the Gulf Oil Spill: The Migratory Bird Habitat Initiative. The Wildlife Society Meeting, Portland, OR.

*Kleekamp, E., and C. Paukert. 2014. Streams in a Changing Landscape: Predicting In-Stream Habitat Reference Conditions Using Landscape Characteristics. American Fisheries Society Meeting, Quebec City.

*Klymus, K., D. Chapman, C. Richter, and C. Paukert. 2013. DNA shedding rates of Asian carps, for use in understanding field collections of eDNA. International Conference on Aquatic Invasive Species, Niagara Falls, Ontario.

*Klymus, K., D. Chapman, C. Richter, and C. Paukert. 2013. DNA shedding rates of Asian carps, for use in understanding field collections of eDNA. American Fisheries Society Annual Meeting, Little Rock, AR.

*Laske, S. M., J. C. Koch, C. E. Zimmerman, M. S. Wipfli, and A. E. Rosenberger. 2013. Fish distribution in a warming Arctic: what current patterns may tell us about the future. Alaska Chapter of the AFS Annual Meeting, Fairbanks, AK.

*Laske, S., A.E. Rosenberger, J.C. Koch, C.E. Zimmerman, and M.S. Wipfli. 2014. Feeding frenzy: Exploring the role of ninespine stickleback in Arctic freshwater food webs. Annual Meeting of the Society for Freshwater Science, Portland, OR.

*Laske, S., A.E. Rosenberger, J.C. Koch, C.E. Zimmerman, and M.S. Wipfli. 2013. Fish distribution in a warming Arctic: what current patterns may tell us about the future. Alaska Chapter of the AFS Annual Meeting, Fairbanks, AK.

*Laske, S., A.E. Rosenberger, M.S. Wipfli, and C.E. Zimmerman. 2012. Fishes and Freshwater Food Webs. CAE Workshop, Anchorage, AK.

*Neuswanger, J., M. Wipfli, A.E. Rosenberger, and N. Hughes. 2013. Territoriality and Shadow Competition within Schools of Juvenile Chinook Salmon. Alaska Chapter of the AFS Annual Meeting, Fairbanks, AK.

*Neuswanger, J., M. Wipfli, A.E. Rosenberger, and N. Hughes. 2012. Territoriality and Shadow Competition within Schools of Juvenile Chinook Salmon. AFS Annual Meeting, Minneapolis, MN (award received).

*Neuswanger, J., M. Wipfli, M. Evenson, A.E. Rosenberger, and N. Hughes. 2012. Flow-induced variability in the stock-recruitment relationships of two Interior Alaskan rivers, and related ecological mechanisms. Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative's Chinook Salmon Synthesis Workshop, Anchorage, AK.

*Neuswanger, J., N. Hughes, M.S. Wipfli, and A.E. Rosenberger. 2012. The importance of drifting debris for drift-feeding juvenile Chinook salmon. Seminar, Midnight Sun Science Symposium, Fairbanks, AK (award received).

Mengel, D., F. Nelson, A. Raedeke, and E. Webb. 2013. First steps in wetland management ARM: developing a decision-support tool. North American Duck Symposium, Memphis, TN.

Paukert, C. 2014. Chubs on the move: translocation of the endangered humpback chub in Grand Canyon. Southern Illinois University, Department of Zoology, Carbondale, IL (invited seminar).

Paukert, C. 2013. Native fish conservation in the Desert Southwest: lessons from Grand Canyon. Michigan State University, Department of Fisheries and Wildlife, East Lansing, MI (invited seminar).

Paukert, C. 2014. More than chubs and suckers: conservation of fishes in large Midwestern rivers. University of Arizona, Tucson, AZ (invited seminar).

Paukert, C. More than the Mississippi and Missouri: Conservation and Management of Other Large River Fishes in the Midwest. Missouri S & T, Department of Biology, Rolla, MO (invited seminar).

Paukert, C. 2012. Graduate school: what you need to know. University of Missouri Fisheries and Aquatic Sciences Society, Columbia, MO.

Paukert, C., *M. Dornecker, *J. Faulkner, *J. Harris, **M. Moore, *E. Pherigo, *L. Pierce, *N. Sievert, *J. Spurgeon, and *M. Staudinger. 2013. How are state freshwater fisheries agencies adapting to climate change? National Adaptation Forum, Denver, CO.

Paukert, C., and *A. Pease. 2012. Potential effects of climate change on growth, prey consumption, and population dynamics of stream-dwelling smallmouth bass in the central U.S. American Fisheries Society Annual Meeting, St. Paul, MN.

Paukert, C., and *J. Faulkner. 2012. Seasonal changes in instream habitat selection of Niangua darters. American Fisheries Society Annual Meeting, St. Paul, MN.

*Pherigo, E., and C. Paukert. 2013. Fish community of the Osage and Gasconade rivers. Missouri Natural Resources Conference, Osage Beach, MO.

*Pherigo, E., and C. Paukert. 2013. Summer fish community in two Missouri River tributaries. Midwest Fish and Wildlife Conference, Wichita, KS.

*Pherigo, E., and C. Paukert. 2013. Fish community in a regulated and free-flowing Missouri River tributary, 2012-2013. American Fisheries Society Annual Meeting, Little Rock, AR.

*Pherigo, E., and C. Paukert. 2014. Fish communities above and below a low head dam on the Osage River. Missouri Natural Resources Conference, Osage Beach, MO.

*Pherigo, E., and C. Paukert. 2014. Effects of a low head dam on the fish community in the Osage River, a regulated tributary of the Lower Missouri River. Missouri River Natural Resources Conference, Nebraska City, NE.

*Pherigo, E., and C. Paukert. 2014. Fish community above and below a low head dam on the Osage River. Midwest Fish and Wildlife Conference, Kansas City, MO.

*Pherigo, E., and C. Paukert. 2013. The effects of river regulation and a low-head dam on the fish communities in two Missouri River tributaries. Missouri River Natural Resources Conference and Biological Opinion Forum, Jefferson City, MO.

*Pherigo, E., C. Paukert, and D. Papoulias. 2014. Effects of river regulation on reproductive condition of spotted bass (*Micropterus punctulatus*) and golden redhorse (*Moxostoma erythrurum*) in two Lower Missouri tributaries. Midwest Fish and Wildlife Conference, Kansas City, MO.

*Pherigo, E., C. Paukert, and D. Papoulias. 2014. Reproductive condition of spotted bass (*Micropterus punctulatus*) and golden redhorse (*Moxostoma erythrurum*) in the Osage and Gasconade Rivers. Missouri Natural Resources Conference, Osage Beach, MO.

*Pherigo, E., C. Paukert, and D. Papoulias. 2014. Effects of river regulation on reproductive condition of spotted bass (*Micropterus punctulatus*) and golden redhorse (*Moxostoma erythrurum*) in two Lower Missouri tributaries. Missouri River Natural Resources Conference, Nebraska City, NE.

*Pierce, L. L., C. Paukert, and J. Whittier. 2012. A family-level evaluation of the drivers of fish invasions. Mid-west Fisheries and Wildlife Conference, Wichita, KS.

*Pierce, L., C. Paukert, and J. Whittier. 2012. A taxonomic evaluation of the drivers of species invasions in the Upper Colorado River Basin. American Fisheries Society Annual Meeting, St. Paul, MN.

*Pierce, L., C. Paukert, and J. Whittier. 2013. A family-level evaluation of drivers of fish invasions. Midwest Fish and Wildlife Conference, Wichita, KS.

*Pierce, L., C. Paukert, and J. Whittier. 2013. A family-level evaluation of drivers of fish invasions. American Fisheries Society Annual Meeting, Little Rock, AR.

*Pierce, L., C. Paukert, and J. Whittier. 2014. Landscape-scale assessment of tributaries on small-bodied fish assemblage structure of large rivers. Midwest Fish and Wildlife Conference, Kansas City, MO.

Quist, M., M. Mather, D. Parrish, S. Chipps, T. Kwak, and C. Paukert. 2013. The voices of reality: why effective fisheries education is challenging; practical ways to move forward. American Fisheries Society Annual Meeting, Little Rock, AR.

Richter, C., *K. Klymus, D. Chapman, and C. Paukert. 2014. Quantification of eDNA Shedding Rates from Invasive Bighead Carp *Hypophthalmichthys nobilis* and Silver Carp *Hypophthalmichthys molitrix*. American Fisheries Society Meeting, Quebec City, Canada.

**Ridgway, J., *E. Pherigo, and C. Paukert. 2014. An assessment of larval fish drift in the Lower Osage and Gasconade rivers. Missouri Natural Resources Conference, Osage Beach, MO.

**Ridgway, J., *E. Pherigo, and C. Paukert. 2014. Larval fish assemblages of a free flowing and a regulated tributary of the Lower Missouri River. Midwest Fish and Wildlife Conference, Kansas City, MO.

**Ridgway, J., *E. Pherigo, and C. Paukert. 2014. Larval fish assemblages of a free flowing and a regulated tributary of the Lower Missouri River. Missouri River Natural Resources Conference, Nebraska City, NE.

Rosenberger, A.E., J. Dunham, *J. Neuswanger, B. Rieman, H. Neville, S. Railsback, and J. Buffington. 2014. Resilience of rainbow trout in Idaho streams to wildfire-related disturbance. Symposium Seminar, American Fisheries Society Annual Meeting, Quebec City, Canada (invited symposium seminar).

Rosenberger, A.E., J. Dunham, H. Neville, *J. Neuswanger, S. Railsback, and B. Rieman. 2012. Resilience of rainbow trout in Idaho streams to wildfire-related disturbance. Invited Symposium Seminar, AFS Annual Meeting, Minneapolis, MN.

Rosenberger, A.E., *T. Hoem-Neher, *M. Gutsch, *L. Wirth, *T. Haynes, *S. Laske, *K. Foley, C. Zimmerman, A. Prakash, and J. Margraf. 2013. Landscape Ecology of Fishes in Alaska. Missouri Department of Conservation, Columbia, MO (invited seminar).

Rosenberger, A.E., *T. Hoem-Neher, *M. Gutsch, *L. Wirth, *T. Haynes, *S. Laske, *K. Foley, C. Zimmerman, A. Prakash, and J. Margraf. 2014. Landscape Ecology of Fishes in Alaska. University of Florida, Department of Fisheries and Aquatic Sciences. Gainesville, FL (invited seminar).

Rosenberger, A.E., T. Hoem-Neher, *M. Gutsch, *L. Wirth, *T. Haynes, *S. Laske, *K. Foley, C. Zimmerman, A. Prakash, and J. Margraf. 2012. Landscape Ecology of Fishes in Alaska. Virginia Polytechnic Institute and State University, Department of Fisheries and Wildlife Sciences, Blacksburg, VA (invited seminar).

Rosenberger, A.E., *T. Hoem-Neher, *M. Gutsch, *L. Wirth, *T. Haynes, *S. Laske, *K. Foley, C. Zimmerman, A. Prakash, and J. Margraf. 2012. Landscape Ecology of Fishes in Alaska. Invited Seminar, Missouri Department of Conservation, Columbia, MO.

Rosenberger, A.E. and K. Polivka. 2012. Multiple tools and conceptual approaches for evaluating fish habitat selection. Invited Symposium Presentation, AFS Annual Meeting, Minneapolis, MN.

Rosenberger, A.E., R. Thurow, J. Dunham, and J. Peterson. 2012. Utility of electrofishing and snorkeling for censusing salmonids: why validation is essential. AFS Annual Meeting, Minneapolis, MN.

*Schepker, T. J. and E.B. Webb 2014. Neonicotinoid Insecticides and Wetland Bird Ecology. Annual meeting of the Missouri Audubon Society, Osage Beach, MO.

*Schrum, M. C., L. K. *Crawford, A. E. Rosenberger, and S. E. McMurray. 2014. Development of standardized and validated methods for sampling freshwater mussels in Missouri: Evaluation of factors affecting estimation of community and population metrics using visual survey approaches. Final proposal presentation to Missouri Department of Conservation, Columbia, MO.

*Schrum, M., A. E. Rosenberger, and *L. Crawford. 2014. Development of standardized and validated methods for sampling freshwater mussels in Missouri: Evaluation of factors affecting estimation of population metrics using visual survey approaches. Anheuser Busch Natural Resources Building, University of Missouri-Columbia, MO.

*Schwoerer, J, J. Ridgway, C. Rice, S. Schlick, H. Dodd, and C. Paukert. 2014. The role of thermal regime on interspecific competition between largemouth bass and smallmouth bass in the Ozark National Scenic Riverways. American Fisheries Society Meeting, Quebec City.

*Sievert, N., and C. Paukert. 2012. Evaluation of conservation networks to protect aquatic biodiversity in Missouri. American Fisheries Society Annual Meeting, St. Paul, MN.

*Sievert, N., and C. Paukert. 2013. Assessing the vulnerability and distribution of Missouri's stream fish species. Missouri Natural Resources Conference, Osage Beach, MO.

*Sievert, N., and C. Paukert. 2013. Development and evaluation of vulnerability indices for Missouri's stream fishes. Midwest Fish and Wildlife Conference, Wichita, KS.

*Sievert, N., and C. Paukert. 2013. A vulnerability assessment for Missouri stream fish species: development and evaluation. American Fisheries Society Annual Meeting, Little Rock, AR.

*Sievert, N., C. Paukert, and J. Whittier. 2013. Missouri's conservation networks: representation of stream fish species and relative conservation value. American Fisheries Society, Little Rock, AR.

*Sievert, N. A., C. P. Paukert, and J. B. Whittier. 2014. A framework for evaluating aquatic biodiversity in existing conservation networks. 74th Midwest Fish and Wildlife Conference. Kansas City, MO.

*Sievert, N., C. Paukert, and J. Whittier. 2014. A Framework for Identifying Opportunities for Aquatic Biodiversity Conservation. American Fisheries Society Annual Meeting, Quebec City.

Smith, C., D. Marmorek, P. Dixon, D. Galat, R. Jacobson, K. Loftin, and J. Nestler. 2013. Independent Science on a Large Scale – A Panel Discussion. National Conference on Ecosystem Restoration (NCER), Schaumburg, IL.

*South-Wirth, L., A.E. Rosenberger, A. Prakash, and J. Margraf. 2013. A remote sensing, GIS-based approach to identify spawning habitat for fall chum salmon in the mainstem Tanana River. Seminar, Alaska Chapter Meeting of the AFS, Fairbanks, AK.

*Spurgeon, J., and C. Paukert. 2013. Conservation of freshwater fishes through translocation: a case study involving an endangered large-river cyprinid. Annual meeting of the Nebraska Chapter of the American Fisheries Society, Gretna, NE.

*Spurgeon, J., C. Paukert, B. Healy, and D. Whiting. 2012. Food webs and translocation: implications for native fish restoration. American Fisheries Society Annual Meeting, St. Paul, MN.

*Tapp, J.L., and E.B. Webb. 2013. Effects of management on aquatic invertebrate biomass, production and community composition at Wetland Reserve Program easements in the lower Mississippi Alluvial Valley. International Society of Wetland Scientists Meeting, Duluth, MN.

*Tapp, J.L., and E.B. Webb. 2013. Waterfowl and shorebird use of Wetland Reserve Program sites in Arkansas and Missouri. North American Duck Symposium, Memphis, TN.

*Tapp, J.L., and E.B. Webb. 2013. Dynamics of waterfowl food availability at Wetland Reserve Program Sites in Arkansas and Missouri. North American Duck Symposium, Memphis, TN.

*Tapp, J.L., and E.B. Webb. 2012. Dynamics of waterbird use and food availability at Wetland Reserve Program Sites in Arkansas and Missouri. Midwest Fish and Wildlife Conference, Wichita, KS.

*Tapp, J.L., and E.B. Webb. 2012. Waterbird use and food availability on Wetland Reserve Program Sites Enrolled in the Migratory Bird Habitat Initiative. The Wildlife Society Meeting, Portland, OR.

*Tidwell, P.R., E.B. Webb, M. Vrtiska, and A. Bishop. 2013. Effects of wetland density on lipid and triglyceride levels in spring migrating mallards and blue-winged teal. North American Duck Symposium, Memphis, TN.

*Tidwell, P.R., E.B. Webb, M. Vrtiska, and A. Bishop. 2013. Diet and food selection of female mallards and blue-winged teal during spring migration. North American Duck Symposium, Memphis, TN.

Tracy-Smith, E., C. Paukert, D. Lobb, and P. Blanchard. 2012. Ecological flow linkages: identifying relevant literature and recent advances. American Fisheries Society Annual Meeting, St. Paul, MN.

Tracy-Smith, E., C. Paukert, D. Lobb, and P. Blanchard. 2013. A review of fish responses to stream flow metrics. Midwest Fish and Wildlife Conference, Wichita, KS.

Tracy-Smith, E., C. Paukert, D. Lobb, and P. Blanchard. 2013. A review of fish responses to stream flow metrics. Missouri Natural Resources Conference, Osage Beach, MO.

Tracy-Smith, E., C. Paukert, D. Lobb, P. Blanchard, and J. Persinger. 2013. Fish responses to stream flow metrics. American Fisheries Society Annual Meeting, Little Rock, AR.

Tracy-Smith, E., C. Paukert, D. Lobb, P. Blanchard, and J. Persinger. 2014. Missouri Ecological Flows. Missouri Natural Resources Conference, Osage Beach, MO.

Webb, E.B., D.C. Kesler, *W.S. Beatty, and A.H Raedeke. 2013. Using agent-based waterfowl models to identify conservation solutions to environmental and land-use change. Mississippi Flyway Council Meeting. Bloomington, IN (invited seminar).

Westhoff, J. T., and C. P. Paukert. 2013. Movement of riverine smallmouth bass in a thermally heterogeneous system. Annual Meeting of the Southern Division of the American Fisheries Society, Nashville, TN.

*Westhoff, J., and C. Paukert. 2012. Habitat and temperature selection of smallmouth bass in the Jacks Fork River. Missouri/Arkansas White River Partnership Meetings, Branson, MO.

*Westhoff, J., and C. Paukert. 2013. Thermal and physical habitat characteristics of the Ozark National Scenic Riverways. Missouri Natural Resources Conference, Osage Beach, MO.

Whiting, D., C. Paukert, B. Healy, and *J. Spurgeon. 2012. Food web dynamics in Bright Angel Creek, Grand Canyon: Implications for native fish conservation. American Fisheries Society Annual Meeting, St. Paul, MN.

Whittier, J., C. Paukert, J. Olden, *A. Strecker, and *K. Pitts. 2012. Assessment of predicted changes in land use and climate on fish habitat conditions in the arid southwest United States. American Fisheries Society Annual Meeting, St. Paul, MN.

Whittier, J., and C. Paukert. 2012. Assessment of predicted changes in land use and climate on fish habitat conditions in the arid Southwest United States. American Fisheries Society, Minneapolis, MN.

*Wirth, L., A.E. Rosenberger, A. Prakash, J. Margraf, and H. Hamazaki. 2012. A remote sensing, GIS-based approach to identify fall chum salmon spawning habitat in the mainstem Tanana River, Alaska. AFS Annual Meeting, Minneapolis, MN.

PRESENTATIONS BY FISH AND WILDLIFE FACULTY AND STUDENTS

* Denotes Graduate Student or Post doc
** Denotes Undergraduate Student

*Alba A. C., D. C. Kesler, T. A. Strauch, and D. H. Keisler. 2013. Captive management, stress, and reproduction in the Guam Micronesian Kingfisher. Invited presentation to the Honolulu field office of the U.S. Fish and Wildlife Service, Honolulu, HI (invited).

Amelon, S. A, and F. R. Thompson III. 2011. Roosting and foraging resource selection for eastern red bat (*Lasiurus borealis*). Annual meeting of the Wildlife Society, Kona, HI.

**Anglin, D., *L. Pierce, and R. Hayward. 2012. Knowledge vs. habit: can angler's behavior be changed? Lessons learned from a class project. Midwest Student Fisheries Colloquium, Champaign-Urbana, IL.

Arntzen, J., Thompson III, F.R.; Faaborg, J. 2013. Improving survival estimates: An investigation of search bias. In: 131st stated meeting of the American Ornithologists' Union held in Conjunction with the 83rd Annual Meeting of Cooper Ornithological Society. Chicago, IL.

*Bleisch, A., *B. J. Keller, J. Millspaugh, T. Bixler, R. Dent, L. Hansen, R. Houf, S. McWilliams, and J. Sumners. 2013. Initial movements of a newly reintroduced elk herd in the Missouri Ozarks. 20th Annual Wildlife Society Conference, Milwaukee, WI.

*Bleisch, A., *B. J. Keller, J. Millspaugh, T. Bixler, R. Dent, L. Hansen, R. Houf, S. McWilliams, and J. Sumners. 2013. Initial movements of a newly reintroduced elk herd in the Missouri Ozarks. Missouri Natural Resources Conference. Tan-Tar-A Resort, Osage Beach, MO.

*Bonnot, T. W., D. T. Jones-Farrand, F. R. Thompson, and J. J. Millspaugh. 2012. Landscape-based population viability models demonstrate importance of strategic conservation planning for birds. 5th North American Ornithological Conference, Vancouver, British Columbia, Canada.

*Bonnot, T. W., F. R. Thompson, J. J. Millspaugh, and T. Jones-Farrand. 2014. Modeling impacts of climate change on regional landscapes and populations. National Workshop on Large Landscape Conservation. Washington, D.C.

*Bonnot, T. W., F. R Thompson III, J. J. Millspaugh, D. T. Jones-Farrand, and W. D. Dijak. 2012. Linking climate, landscape, and population models to predict changes in forests and bird populations in the central hardwoods. 73rd Annual Midwest Fish and Wildlife Conference, Wichita, KS.

*Bonnot, T. W., M. L. Wildhaber, J. J. Millspaugh, A. J. DeLonay, R. B. Jacobson, D. M. Papoulias, J. L. Albers. 2012. Resource selection of gravid shovelnose sturgeon in the Lower Missouri River. 73rd Annual Midwest Fish and Wildlife Conference, Wichita, KS (Invited).

Burke, A.D., Faaborg, J., and Thompson III, F.R. 2013. Use of regenerating clearcuts by mature forest breeding birds: Convenience or necessity? In: 131st Stated Meeting of the American Ornithologists' Union held in Conjunction with the 83rd Annual Meeting of Cooper Ornithological Society, Chicago, IL.

Clawson, M. V., J. R. Skalski, and J. J. Millspaugh. 2013. Guidelines for applying statistical population reconstruction to assess demographics of harvested populations. 20th Annual Wildlife Society Conference, Milwaukee, WI.

Conroy, L., M. Rumble, S. Gamo, and J. J. Millspaugh. 2014. Elk, roads, and people on the Black Hills National Forest. Pathways 2014 Conference: Integrating human dimensions into fish and wildlife management. Estes Park, CO.

Cox, A.S., W.A. Cox, F.R. Thompson III, and J. Faaborg. 2013. Factors affecting post-fledging survival in passerine birds and the value of post-fledging studies to conservation efforts. In: 131st Stated Meeting of the American Ornithologists' Union held in Conjunction with the 83rd Annual Meeting of Cooper Ornithological Society, Chicago, IL.

*Cunningham, J. A., D. C. Kesler, and R. B. Lanctot. 2013. Habitat and social factors influence nest site selection in Arctic-breeding shorebirds. American Ornithologists Union and Cooper Ornithological Society Joint Meeting, Chicago IL.

*Cunningham, J. A., D. C. Kesler, and R. B. Lanctot. 2013. Habitat and social factors influence nest site selection in Arctic-breeding shorebirds. 5th Western Hemisphere Shorebird Group meeting. Santa Marta, Colombia.

Forrester, T., M. Baker, R. Costellos, *E. Kalies, R. Kays, W. McShea, J. J. Millspaugh, and A. Parsons. 2014. Effects of coyotes on mesopredator activity patterns. 21st Annual Wildlife Society Conference, Pittsburgh, PA.

Fraser, J.S., H.S. He, F.R. Thompson III, W.D. Dijak, B.B. Hanberry, and W.J. Wang. 2014. Modeling change in maximum growing spaces under projected climate scenarios in the Central Hardwood Forest using an ecosystem process model. In: The 99th ESA Annual Meeting; 2014. Sacramento, CA.

Fraser, J.S., H.S. He, J. Yang, S.R. Shifley, and F.R. Thompson III. 2013. Designing a fire module for LANDIS PRO to simulate variable intensity fire regimes on forest landscapes. In: 98th Annual Meeting and Exposition of the Ecological Society of America. Minneapolis, MN.

Fremgen, A. L., J. J. Millspaugh, M. A. Rumble, C. P. Hansen, C. T. Rota, and S. Gamo. 2014. Use of multi-state mark-recapture models to assess male greater sage-grouse movements between leks. 21st Annual Wildlife Society Conference, Pittsburgh, PA.

Fremgen, A. L., J. J. Millspaugh, M. A. Rumble, C. P. Hansen, C. T. Rota, and S. Gamo. 2014. Use of multi-state mark-recapture models to assess male greater sage-grouse movements between leks. Central Mountains and Plains Section, Wildlife Society Conference, Sheridan, WY.

George, A.D., F.R. Thompson III, and J. Faaborg. 2013. Effects of season and air temperature on snake activity patterns: Implications for nest predation. In: 131st stated meeting of the American Ornithologists' Union held in conjunction with the 83rd Annual Meeting of Cooper Ornithological Society. Chicago, IL.

*Gitzen, R., R. Renken, D. Fantz, R. Jensen, J. Favara, and J. Millspaugh. 2013. Hierarchical modeling of *Peromyscus* responses to experimental forest harvests. 93rd Annual Meeting of the American Society of Mammalogists, Philadelphia, PA.

*Gitzen, R., R. Renken, D. Fantz, R. Jensen, J. Favara, and J. Millspaugh. 2013. Hierarchical modeling of *Peromyscus* responses to experimental forest harvests. 20th Annual Wildlife Society Conference, Milwaukee, WI.

Guyette, R. P., F. Thompson III, D. C. Dey, J. B. Whittier, and M. C. Stambaugh. 2013. Future and past fire variability in North American ecosystems calculated with the physical chemistry of climate. 9th North American Forest Ecology Workshop. Bloomington, IN.

He, H.S., W.J. Wang, J.S. Fraser, S.R. Shifley, and F.R. Thompson, III. 2013. Designing a forest landscape model that simulates density-based stand dynamics at regional scales. In: 98th Annual Meeting and Exposition of the Ecological Society of America. Minneapolis, MN.

*Jachowski, D. S., R. Slotow, and J. J. Millspaugh. 2014. Linking animal physiology and movement behavior: a case study of the African elephant. Symposium on Animal Movement and the Environment, Raleigh, NC.

Jin, W., H.S. He, F.R. Thompson, III, and S.R. Shifley. 2013. Comparing predictions of forest aboveground biomass of LINKAGES v2.2, PnET-II, and ED2 with long-term field data in temperate forests of the United States. In: 98th Annual Meeting and Exposition of the Ecological Society of America. Minneapolis, MN.

Jin, W., H.S. He, F.R. Thompson, III, and S.R. Shifley, S.R. 2014. Comparing predictions of aboveground woody biomass of PnET-II, Linkages v2.2, and ED2 with decadal field data at plot and landscape scales. In: The 99th ESA Annual Meeting, Sacramento, CA.

Joos, C., J. Faaborg, and F.R. Thompson, III. 2013. Survival and population dynamics of Bell's Vireos in Central Missouri. In: 131st Stated Meeting of the American Ornithologists' Union held in Conjunction with the 83rd Annual Meeting of Cooper Ornithological Society. Chicago, IL.

*Kalies, E.L., R. Kays, T. Forrester, A. Parsons, M. Baker, J.J. Millspaugh, W. McShea, and R. Costello. 2014. eMammal: Broad-scale long-term mammal research through citizen science. Symposium on Animal Movement and the Environment, Raleigh, NC.

Kays, R., R. Costello, W. McShea, T. Forrester, M. Baker, A. Parsons, R. A. Montgomery, *E. L. Kalies, and J. J. Millspaugh. 2014. Citizen science camera trapping as a solution for broad-scale, long-term monitoring of wildlife populations. North American Congress for Conservation Biology, Missoula, MT.

Kehmeier, J., N. Wojcik, J. Millspaugh, C. Hansen, M. Rumble, S. Gamo, and G. Miller. 2014. Overview of greater sage-grouse monitoring efforts: Chokecherry and Sierra Madre Wind Energy Project, Carbon County, Wyoming. Western Agencies 29th Sage and Columbian sharp-tailed grouse workshop. Elko, NV.

*Keller, B., *A. Bleisch, *T. Smith, J. Millspaugh, T. Bixler, R. Dent, L. Hansen, R. Houf, S. McWilliams, and J. Sumners. 2013. Vital rates and resource selection of the Missouri elk population. 18th Annual Eastern Elk Management Workshop. Cable, WI.

*Keller, B. J., *A. Bleisch, *T. Smith, J. Millspaugh, R. Dent, L. Hansen, D. Hasenbeck, R. Houf, S. McWilliams, and J. Sumners. 2014. Missouri's elk population: research and preliminary results. Missouri Natural Resources Conference. Osage Beach, MO.

*Keller, B. J., L. P. Hansen, and J. J. Millspaugh. 2013. Vital rates of newly restored elk in Missouri: how do they compare with other Eastern elk populations? 20th Annual Wildlife Society Conference, Milwaukee, WI (Invited).

*Keller, B. J., *R. A. Montgomery, L. P. Hansen, and J. J. Millspaugh. 2014. Vital rates of newly restored elk in Missouri: how do they compare with other Eastern elk populations? 74th Annual Midwest Fish and Wildlife Conference, Kansas City, MO.

Kendrick, S.W., P.A. Porneluzi, D.L. Morris, J.M. Haslerig, F.R. Thompson, III, J. Faaborg. 2013. Stand-level breeding bird density response to experimental forest management in the Missouri Ozarks. In: 131st Stated Meeting of the American Ornithologists' Union held in Conjunction with the 83rd Annual Meeting of Cooper Ornithological Society. Chicago, IL.

Kesler, D.C. 2012. A Bayesian network modeling approach for guiding conservation site selection. Complexity Modeling Group. University of Missouri, Columbia, MO (invited).

Kesler, D.C. 2012. Communications plan for the Society for Ornithology. Invited presentation to the Ornithological Council and presidents from international ornithological societies. Dallas, TX (invited).

Kesler, D.C. 2012. Conservation when seas are rising – modeling climate change effects on island birds. Saturday Morning Science Series. University of Missouri. (invited).

Kesler, D.C., and *A. S. Cox. 2014. Landscape effects on foraying and dispersal in woodpeckers. International conference on woodpeckers in a changing world. Vitoria-Gasteiz, Spain (invited).

Kesler, D. C., and *R. J. Laws. 2012. Recovery of the endangered Micronesian Kingfisher: options and directions. Invited WebEx presentation to the Honolulu field office and Portland, Oregon regional office of the U.S. Fish and Wildlife Service. WebEx to Honolulu and Portland (invited).

Kesler, D. C., E. B. Webb, *W.S. Beatty, A. H. Raedeke, L. W. Naylor, and D. D. Humburg. 2013. Using agent-based waterfowl models to identify conservation solutions to environmental variation and land-use change. Mississippi Flyway Council Meeting, Bloomington, IL(invited).

*Laws, R. J., and D. C. Kesler, 2012. Micronesian Kingfisher population status and options for assisted colonization. Invited presentation to the American Zoo and Aquarium Association Mid Year Meeting. Palm Springs, CA (invited).

*LeBrun, J. J., *J. E. Schneiderman, F. R. Thompson, III, W. E. Thogmartin, W. D. Dijak, H. S. He, and J. J. Millspaugh. 2013. How does forest management focused on mitigating climate change affect avian species? 98th Annual meeting of the Ecological Society of America, Minneapolis, MN.

*LeBrun, J. J., W. E. Thogmartin, F. R. Thompson, III, and J. J. Millspaugh. 2014. Using climate and land cover to predict avian abundance across the Midwestern United States. 74th Annual Midwest Fish and Wildlife Conference. Kansas City, MO.

*McKellar, A. E., D. C. Kesler, R. J. Mitchell, D. K. Delaney, and J. R. Walters. 2013. Range-wide variation in foraging habitat quality for the red-cockaded woodpecker. American Ornithologists Union and Cooper Ornithological Society Joint Meeting, Chicago IL.

Millspaugh, J. J. 2014. Animal movements and models for management and conservation. Symposium on Animal Movement and the Environment, Raleigh, NC (Invited).

Millspaugh, J. J., D. Musil, and M. Holloran. 2012. Sage-grouse and wind energy development: an overview of three current projects. 28th Sage and Columbian Sharp-tailed Grouse Workshop, Steamboat Springs, CO.

Millspaugh, J. J., M. A. Rumble, and *A. L. Fremgen, C. P. Hansen, R. S. Gamo, J. Kehmeier, and N. Wojcik. 2012. Ecology of male greater sage-grouse before wind energy development in south-central Wyoming. Wind Wildlife Research Meeting IX, Denver, CO.

Millspaugh, J. J., M. A. Rumble, C. P. Hansen, R. S. Gamo, J. Kehmeier, and N. Wojcik. 2012. Ecology of male Greater sage-grouse before wind energy development in south-central Wyoming. 28th Sage and Columbian Sharp-tailed Grouse Workshop in Steamboat Springs, CO.

*Moll, R. J., J. J. Millspaugh, J. Beringer, J. Sartwell, Z. He, J. A. Eggert, X. Zhao, R. J. Woods, and K. C. Vercauteren. 2014. Development and evaluation of a terrestrial animal-borne video system for large mammals. 21st Annual Wildlife Society Conference, Pittsburgh, PA.

*Oleiro, P. C. and D. C. Kesler. 2013. Avian ecological response to anthropogenic and climate changes in an oceanic landscape. American Ornithologists Union and Cooper Ornithological Society Joint Meeting, Chicago IL.

*Oleiro, P. C. and D. C. Kesler. 2013. Avian Population Responses to Climate Change and Anthropogenic Landscape Alterations in Pohnpei, Micronesia. Presentation given at the 1st PICSC/PICCC Science Review Symposium, Honolulu, HI.

*Oleiro, P. C. and D. C. Kesler. 2013. Pohnpei 2012 bird survey preliminary analysis and avian population responses to climate change and anthropogenic landscape alterations in Pohnpei, Micronesia. Presentation given at the U.S. Fish and Wildlife Service Pacific Region Office, Honolulu, HI.

*Oleiro, P. C., D. C. Kesler, and E. Joseph. 2013. Pohnpei 2012 bird survey preliminary analysis and avian population responses to climate change and anthropogenic landscape alterations. Presentation given at the Governors Palace, Kolonia, Pohnpei, Federated States of Micronesia. (invited).

Parsons, A., R. Kays, *E. Kalies, W. McShea, R. Costello, T. Forrester, M. Baker, and J. J. Millspaugh. 2014. Quantifying coyote response to long-term hunting with a large-scale, citizen-science camera trapping survey. 21st Annual Wildlife Society Conference, Pittsburgh, PA.

*Rota, C. T., *E. Kalies, W. McShea, T. Forrester, R. Kays, and J. J. Millspaugh. 2014. Modeling multi-species occupancy probabilities with zero-inflated multivariate Bernoulli models: generalizing occupancy models to > 3 species. 21st Annual Wildlife Society Conference, Pittsburgh, PA.

*Rota, C.T., D. C. Kesler, C. P. Lehman, M. A. Rumble, and J. J. Millspaugh. 2012. Black-backed woodpecker home range size and resource selection in habitat created by mountain pine beetle infestations in the Black Hills of South Dakota. Vertebrate Responses to Bark Beetles, Laramie, WY (invited).

*Rota, C.T., and J. J. Millspaugh. 2013. A Bayesian kernel density estimator for evaluating animal home range. 98th Annual meeting of the Ecological Society of America, Minneapolis, MN.

*Rota, C.T., and J. J. Millspaugh. 2014. Resource selection functions workshop. Symposium on Animal Movement and the Environment, Raleigh, NC (Invited).

*Rota, C.T., J. J. Millspaugh, D. C. Kesler, C. P. Lehman, M. A. Rumble, and C. Bodinof. 2012. A Bayesian modified case-control model for estimating absolute probability of use from use-availability data. Ecological Society of America 97th Annual Conference, Portland, OR.

*Rota, C.T., J. J. Millspaugh, M. R. Rumble, C. Lehman, and D. C. Kesler. 2013. Not all habitats are distributed equally: Black-backed woodpecker population dynamics in burned forests and mountain pine beetle infestations. 20th Annual Wildlife Society Conference, Milwaukee, WI.

*Rota, C. T., J. J. Millspaugh, M. R. Rumble, C. Lehman, and D. C. Kesler. 2013. Not all habitats are distributed equally: Black-backed woodpecker population dynamics in burned forests and mountain pine beetle infestations. AOU Annual Meeting, Chicago, IL.

*Rota, C.T., J.J. Millspaugh, M.A. Rumble, C.P. Lehman, and D.C. Kesler. 2014. Not all habitats are disturbed equally: Black-backed Woodpecker population dynamics in burned forests and mountain pine beetle infestations. Large Wildland Fires: Social, Political & Ecological Effects. University of Montana, Missoula, MT.

Rumble, M. R., *C. T. Rota, D. C. Kesler, J. J. Millspaugh, and C. P. Lehman. 2013. Ecological relations of black-backed woodpeckers to wildfire, prescribed fire, and mountain pine beetle infestations. National Forest Advisory Board Meeting. Rapid City, SD.

Schneiderman, J., H. He, F.R. Thompson, III, W. Dijak. 2012. Assessing forest landscape response to future climate projections in the Missouri Ozark Highlands. US-IALE abstract book. 27th Annual Landscape Ecology Symposium Informing Decisions in a Changing World, Newport, RI.

Schneiderman, J.E.; H.S. He, F.R. Thompson, III, W.D. Dijak, and *J.J. LeBrun. 2013. Forest management plans for mitigating projected future climate change in the Missouri Ozark Highlands. In: 98th Annual Meeting and Exposition of the Ecological Society of America, Minneapolis, MN.

*Schreiber, L. A., J. J. Millspaugh, M. A. Rumble, F. R. Thompson, III, and C. Hansen. 2014. Greater sage-grouse chick survival and productivity prior to wind energy development in Wyoming. Central Mountains and Plains Section, Wildlife Society Conference, Sheridan, WY.

Schulz, J. H., *T.W. Bonnot, J. J. Millspaugh, and T. Mong. 2012. Statewide and local recruitment of mourning doves in Missouri. 73rd Annual Midwest Fish and Wildlife Conference, Wichita, Kansas.

*Smith, T., *B. Keller, *A. Bleisch, J. Millspaugh, R. Dent, L. Hansen, D. Hasenbeck, R. Houf, S. McWilliams, and J. Sumners. 2014. Food habits of a recently reintroduced elk population in the Missouri Ozarks. 74th Annual Midwest Fish and Wildlife Conference, Kansas City, MO.

*Stanton, R., D. C. Kesler, and F. R. Thompson III. 2013. Can Missouri support a reintroduced population of brown-headed nuthatches? 2013 Missouri Natural Resources Conference, Jefferson City, MO.

*Stanton, R. A., F. R. Thompson, and D. C. Kesler. 2013. Cost-sensitive find-scale resource selection in a cooperatively-breeding resident bird. American Ornithologists Union and Cooper Ornithological Society Joint Meeting, Chicago IL.

*Stanton Jr., R.A., D.C. Kesler, and F.R. Thompson III. 2013. Cost-sensitive fine-scale resource selection in a cooperatively-breeding resident bird. In: 131st Stated Meeting of the American Ornithologists' Union held in Conjunction with the 83rd Annual Meeting of Cooper

Ornithological Society, Chicago, IL.

Thompson III, F.R.; W.A. Cox, and J. Reidy. 2013. The effects of temperature on nest predation by mammals, birds, and snakes. In: 131st Stated Meeting of the American Ornithologists' Union held in Conjunction with the 83rd Annual Meeting of Cooper Ornithological Society, Chicago, IL.

Wang, W.J., H.S. He, M.A. Spetich, S.R. Shifley, F.R. Thompson III, and J.S. Fraser. 2013. Evaluating effects of forest harvesting on mitigating oak decline on a Central Hardwood Forest landscape. In: 98th Annual Meeting and Exposition of the Ecological Society of America. Minneapolis, MN.

Wang, W.J., H.S. He, F.R. Thompson III, J.S. Fraser, B.B. Hanberry, and W.D. Dijak. 2014. Changes in tree species abundance, forest composition and structure in response to climate change and disturbance in U.S. Central Hardwood Forests Region. In: The 99th ESA Annual Meeting, Sacramento, CA.

Winder, V. L., B. K. Sandercock, C. A. Hagen, D. A. Haukos, D. C. Kesler, M. A. Patten, L. A. Powell. 2013. Lek sites drive female resource use in ten populations of prairie-chickens. Meeting of the North American Ornithological Societies. Estes Park, CO.

Wojcik, N., A. Widmer, J. Kehmeier, J. Millspaugh, C. Hansen, M. Rumble, S. Gamo, and G. Miller. 2014. Greater sage-grouse winter habitat use and site fidelity in south-central Wyoming. Western Agencies 29th Sage and Columbian sharp-tailed grouse workshop, Elko, NV.

Wojcik, N. D., J. Falkner, J. Kehmeier, J. Millspaugh, C. Hansen, M. Rumble, S. Gamo, and G. Miller. 2014. Patterns of inter-annual and intra-annual nest site selection and fidelity by greater sage-grouse in south-central Wyoming. Western Agencies 29th Sage and Columbian sharp-tailed grouse workshop, Elko, NV.

Wolf, A. J., R. G. Jensen, R. B. Renken, D. K. Fantz, and J. J. Millspaugh. 2014. Long-term effects of different forest management practices on Ozark herpetofauna. Joint Meeting of Ichthyologists and Herpetologists, Chattanooga, TN.

Wolf, A. J., R. G. Jensen, R. B. Renken, D. K. Fantz, J. J. Millspaugh, and C. W. Anderson. 2012. Long-term effects of different forest management practices on Ozark herpetofauna. 73rd Annual Midwest Fish and Wildlife Conference, Wichita, KS.

Wolf, A. J., R. G. Jensen, R. B. Renken, D. K. Fantz, J. J. Millspaugh, *R. A. Gitzen, and C. W. Anderson. 2013. Effects of clearcutting and selective timber harvest on Ozark small mammals and herpetofauna: past and future of a long-term project. 9th North American Forest Ecology Workshop, Bloomington, ID.

Wolf, A. J., R. G. Jensen, R. B. Renken, D. K. Fantz, J. J. Millspaugh, *R. A. Gitzen, and C. W. Anderson. 2013. Effects of clearcutting and selective timber harvest on Ozark small mammals and herpetofauna. Missouri Natural Resources Conference, Osage Beach, MO.

*Womack, K., F.R. Thompson III, S. Amelon. 2013. Summer home range size of the female *Myotis sodalis* in Missouri. In:16th International Bat Research Conference & 43rd North American Symposium on Bat Research, Costa Rica.

*Zimmer, S., J. Briggler, *R. Gitzen, and J. Millspaugh. 2012. The effects of commercial harvest on Missouri river turtle populations. 73rd Annual Midwest Fish and Wildlife Conference, Wichita, KS.

*Zimmer, S., J. Briggler, *R. Gitzen, and J. Millspaugh. 2012. Effects of commercial harvest on river turtles. 19th Annual Wildlife Society Conference, Portland, OR.

*Zimmer-Shaffer, S., J. T. Briggler, and J. J. Millspaugh. 2014. Implications of the effects of commercial turtle harvest on turtle populations in Missouri. 74th Annual Midwest Fish and Wildlife Conference, Kansas City, MO (invited).

THESIS AND DISSERTATIONS

STUDENTS ADVISED BY UNIT SCIENTISTS

Dinges, A. 2013. Participation in the Light Goose Conservation Order and effects on behavior and distribution of waterfowl in the Rainwater Basin of Nebraska. M.S. Thesis, University of Missouri, Columbia. E.B. Webb, advisor.

Harris, J. 2013. Habitat selection, movement, and home range of largemouth bass (*Micropterus salmoides*) following a habitat enhancement project in Table Rock Lake, Missouri. M.S. Thesis, University of Missouri, Columbia. C. P. Paukert, advisor.

Tapp, J. 2013. Waterbird use and food availability on Wetland Reserve Program easements enrolled in the Migratory Bird Habitat Initiative. M.S. Thesis, University of Missouri, Columbia. E.B. Webb, advisor.

STUDENTS ADVISED BY FISH AND WILDLIFE FACULTY COOPERATORS

Bleisch, A. D. 2014. Initial movements and disturbance response of a newly reintroduced elk herd in the Missouri Ozarks. M.S. thesis, University of Missouri, Columbia. J. J. Millspaugh, advisor.

Cunningham, J. 2014. Nest site selection and the effect of snow cover on North Slope shorebirds. M.S. Thesis, University of Missouri, Columbia. D.C. Kesler, advisor.

Hogg, J. 2013. Habitat associations of birds of prey in urban business parks. M.S. Thesis, University of Missouri, Columbia. C.H. Nilon, advisor.

Jachowski, D. S. 2012. Demographic, behavioral, and physiological responses of wildlife to reintroduction. Ph.D. dissertation, University of Missouri, Columbia. J. J. Millspaugh, advisor.

Kemink, K. M. 2012. Movement and demography in Missouri's greater prairie-chicken. M.S. Thesis, University of Missouri, Columbia. D.C. Kesler, advisor.

Oleiro, P. C. 2014. Avian population responses to anthropogenic landscape changes in Pohnpei, Federated States of Micronesia. M.S. Thesis, University of Missouri, Columbia. D.C. Kesler, advisor.

Rota, C. T. 2013. Not all forests are disturbed equally: population dynamics and resource selection of Black-backed woodpeckers in the Black Hills, South Dakota. Ph.D. dissertation, University of Missouri, Columbia. J. J. Millspaugh, advisor.

Schreiber, L. A. 2014. Greater sage-grouse nest site selection, brood-rearing site selection, and chick survival in Wyoming. M.S. thesis, University of Missouri, Columbia. J. J. Millspaugh, advisor.

Stanton, R. A. M.S. 2013. Habitat selection of Brown-headed Nuthatches at multiple spatial scales. M.S. thesis, University of Missouri, Columbia. D.C. Kesler and F.R. Thompson, advisors.

Zimmer, S. A. 2013. Implications of commercial harvest of river turtles in Missouri. M.S. thesis, University of Missouri, Columbia. J. J. Millspaugh, advisor.

COMMITTEES AND OTHER PROFESSIONAL SERVICE

2012 TO PRESENT

UNIT SCIENTISTS AND STUDENTS

David Galat –

- Platte River Recovery Implementation Program, Independent Science Advisory Committee, 2009-2014
- Missouri River Recovery Implementation Committee (MRRIC). Alternate Representative Fish & Wildlife, member Science and Adaptive Management Working Group, 2011- 2013
- The Nature Conservancy's Great Rivers Partnership, Science Advisor, 2011-2013
- Missouri River Recovery Program, Independent Science Advisory Panel, 2013-2014
- Core Advisory Group, Collaborative Adaptive Management Network (CAMNet) 2009-2014
- Associate Editor, River Research and Applications, 2003-2014
- Co-editor, Special Issue of Ecology and Society: Advancing Collaborative Adaptive Management (CAM) 2011 to 2014

Craig Paukert –

- President, Education Section of the AFS, 2013-present
- American Fisheries Society Governing Board, 2013-present
- National Climate Assessment, Technical Input Committee, Biodiversity, Ecosystems and Ecosystem Services Technical Committee, 2011-2012
- Steering Committee, 2014 Midwest Fish and Wildlife Conference, 2011-2014
- Program Chair, 2014 Midwest Fish and Wildlife Conference, 2011-2014
- Invited Member, Science Committee, National Fish Habitat Initiative, 2005-present
- Research Grade Evaluation Panel, US Geological Survey, Chicago, 2013
- Invited Member, USGS Large River Monitoring Forum, 2012-present
- Member, Fish Passage Advisor Council, International Conference on Engineering and Ecohydrology for Fish Passage, 2013-2014
- Eastern Tallgrass Prairie and Big Rivers LCC River Restoration Technical Advisory Committee, 2013-present
- Invited workgroup member (of 8), NSF NEON sampling protocol development of long term monitoring on NEON lakes and streams, 2013
- USGS representative, Workshop on obtaining jobs in state and federal government, Univ. of Missouri, School of Natural Resources, 2012
- Graduate Affairs Committee, Fisheries and Wildlife Sciences, MU, 2010-present

Amanda Rosenberger –

- President-Elect, Missouri Chapter, 2014-present
- Program Committee member, 2013 AFS Annual Meeting, Little Rock, AR, 2012-2013
- Time and Place Committee chairperson, 2011-2013

- Secretary-treasurer, Habitat Section, 2009-2013
- Space Allocation Committee, College of Natural Resources, 2012-13
- Participated in annual South Farm Showcase to promote Cooperative Research Unit Research and Activities, 2012-13
- Missouri River Relief outreach and community education, 2013-14
- Osher Continuing Education Program for Senior citizens, University of Missouri Extension, Instructor for class covering Missouri aquatic diversity.
- Affiliate Faculty, University of Alaska Fairbanks, 2011-present

Lisa Webb –

- Co-editor, Special Issue of *Wildfowl*: Ecology and Conservation of North American Waterfowl
- Associate Editor, *Wildlife Society Bulletin*, 2011 to Present.
- Vice-chair, TWS Wetlands Working Group. 2013 to Present
- Program Committee member (Wildlife Chair), 2014 Midwest Fish and Wildlife Conference, 2012 - 2014
- Poster Session Chair, Ecology and Conservation of North American Waterfowl Symposium, 2011 to 2013
- Scientific Committee Member, Ecology and Conservation of North American Waterfowl Symposium, 2011 to 2013

Leslie Crawford, M.S Student Advised by Rosenberger –

- President, FASS (Student subunit of AFS), 2014

Corey Dunn, PhD. Student Advised by Paukert –

- President, Wildlife and Fisheries Sciences Graduate Student organization, 2014-Present
- Biomonitoring Coordinator, MU Fisheries and Aquatic Sciences Society

Sean O'Daniels, M.S. Student Advised by Webb and Kesler –

- Avian Power Line Interaction Committee Competitive Research Grant - May, 2013

Landon Pierce, PhD. Student Advised by Paukert –

- Newsletter co-editor, Education Section of the American Fisheries Society, 2012-2013
- Past-President, Student Subsection of the American Fisheries Society, 2014-Present
- President, Student Subsection of the American Fisheries Society, 2013-2014
- President-elect, Student Subsection of the American Fisheries Society, 2012-2013
- Judge, Undergraduate Travel Award, Student Subsection of the American Fisheries Society, 2012-2014
- Judge, Young Professional Travel Award, Education Section of the American Fisheries Society, 2014
- Member, Young Professional Committee, Fish Management Section of the American Fisheries Society, 2014

Emily Pherigo, M.S. Student Advised by Paukert –

- President, MU Wildlife and Fisheries Graduate Student Organization, 2012-2013

- Member, Fisheries and Aquatic Sciences Society, MU student chapter of Missouri AFS, 2012-present

Travis Schepker, M.S. Student Advised by Webb –

- American Fisheries Society Student Achievement and Travel Award, 2013
- University of Missouri School of Natural Resources Hoyt Scholarship, 2013

Nick Sievert, M.S. Student Advised by Paukert –

- Newsletter Editor, Fisheries Information and Technology Section of the American Fisheries Society, 2012-present
- Vice President, MU Wildlife and Fisheries Graduate Student Organization, 2012-2013.

Emily Tracy-Smith, Sr. Research Specialist Advised by Paukert-

- MU Staff Development Award to attend the American Fisheries Society Annual Meeting, 2013

Jacob Westhoff, Postdoc Advised by Paukert and Rosenberger-

- Faculty Advisor, Fisheries and Aquatic Sciences Society at MU (AFS Student Subunit), 2013-2014
- Editorial Board, *Freshwater Crayfish*, 2010 – present

Thank you letter from an outreach event partially organized by Bob Pierce, MU Fisheries and Wildlife Extension faculty (far right), Lisa Webb (far left, back row), Amanda Rosenberger (front center) and graduate student Leslie Crawford (front row, second from right).

FISH AND WILDLIFE FACULTY AND STUDENTS

Dylan C. Kesler -

- American Ornithologists Union *Elective Member*, 2012-present
- University of Missouri Animal Care and Use Committee, 2012-2014
- Representative to the National Association of University Fisheries and Wildlife Programs Research Roadmap for Natural Resources, 2012-2013
- Society for Ornithology Executive Planning Committee, 2012-2013
- Editor for VHF radiotelemetry web page for Migratory Connectivity Project, 2011-present
- Science Advisor to the Association of Zoos and Aquariums for Micronesian Kingfisher species survival plan, 2001-present
- Micronesian Kingfisher recovery committee member, 2001-present
- Conservation Committee for the Society for Ornithology, 2011-2012
- Chair of Communications Committee for the Society for Ornithology, 2011-2012.
- Publications Committee for the Society for Ornithology, 2011-2012
- Invited advisor of bird conservation to Pohnpei State, Federated States of Micronesia, 2010-present
- Invited expert reviewer for IUCN Red List of threatened species, 2010-present
- Invited expert contributor for IUCN Red List of threatened species and Invasive Alien Vertebrates on Islands database, 2012

Joshua J. Millspaugh -

- Associate Editor, Journal of Wildlife Management, 2009-present
- Associate Editor, Wildlife Society Bulletin, 2014-present
- Director of Graduate Studies, Department of Fisheries and Wildlife Sciences
- Chair and Panel Member, Committee to review methods to identify and map sage-grouse winter concentration areas for Wyoming Chapter of The Wildlife Society and the Wyoming Governor's Sage-Grouse Implementation Team, 2013
- Elected Member, College of Agriculture, Food, and Natural Resources Promotion and Tenure Committee, 2013-present
- Appointed, University of Missouri Research Board, 2011-2013

Joanna Whittier –

- Immediate-President, Fisheries Information and Technology Section of the AFS, 2013 – Present
- President, Fisheries Information and Technology Section of the AFS, 2011 – 2013

AWARDS AND RECOGNITION

2012 TO PRESENT

UNIT SCIENTISTS AND STUDENTS

David Galat –

- Certificate of Appreciation for Outstanding Service: Committee on the Missouri River Recovery and Associated Sediment Management Issues Member (2008-2010). National Research Council of the National Academies, Water Science and Technology Board

Craig Paukert –

- USGS STAR Award, Superior Performance Achievement, 2012-2013 (2)
- Invited presentation, Southern Illinois University, 2014
- Invited presentation, Michigan State University, 2013

Amanda Rosenberger –

- Outstanding Recent Alumna from the College of Natural Resources, Virginia Tech, 2013
- Affiliate Faculty, School of Fisheries and Ocean Sciences, Univ. of Alaska Fairbanks, 2012-13
- Invited presentation, University of Florida, 2014
- Invited presentation, Virginia Polytechnic Institute and State University, 2012

Leslie Crawford, M.S. Student Advised by Rosenberger –

- Best Student Aquatic Poster Presentation, Missouri Natural Resources Conference, 2014

Jason Harris, M.S. Student Advised by Paukert –

- Best Student Aquatics Presentation, Missouri Natural Resources Conference, 2013

Landon Pierce, Ph.D. Student Advised by Paukert –

- American Fisheries Society Skinner Memorial Award, 2012
- Joan Duffy Travel Grant, 2012

Emily Pherigo, M.S. Student Advised by Paukert –

- Finalist, Best Student Poster (with undergraduate Josey Ridgeway), American Fisheries Society Annual Meeting, 2014
- Second Place, Best Poster (with undergraduate Josey Ridgeway), Missouri River Natural Resources Conference, 2014
- Conservation Federation of Missouri Morrow Scholarship, 2014
- Best Student Aquatics Presentation, Missouri Natural Resources Conference, 2014
- Robert A. Klumb Missouri River Natural Resources Conference Student Travel Award, 2014
- Janice Lee Fenske Memorial Award Winner, 2014

Nick Sievert, M.S. Student Advised by Paukert –

- Outstanding Graduate Student, Department of Fisheries and Wildlife Sciences, MU, 2013
- American Fisheries Society Skinner Memorial Award, 2014
- Janice Lee Fenske Memorial Award finalist, 2014
- Joan Duffy Travel Grant, 2014
- Best Student Poster, American Fisheries Society Annual Meeting, 2013

Jacob Westhoff, Postdoc Advised by Paukert and Rosenberger-

- Preparing Future Faculty Postdoctoral Fellowship at MU, 2014-2015

2014 Janice Lee Fenske Award finalist, Nick Sievert (left) and Janice Lee Fenske Award winner, Emily Pherigo (right) with their advisor, Craig Paukert at the Midwest Fish and Wildlife Conference, Kansas City, Missouri, January 2014.