

# **MISSOURI COOPERATIVE FISH & WILDLIFE RESEARCH UNIT REPORT**

**January 2015 to November 2016**



## **Cooperating Agencies:**

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

## TABLE OF CONTENTS

The Tradition of the Missouri Unit.....	4
Accomplishments of the Missouri Unit .....	5
Niki Fuemmeler .....	7
Unit and Cooperator Personnel Roster .....	8
Teaching and Engaging Students by Missouri Unit Staff and Affiliates.....	9
Current Graduate Students.....	12
Current Post Doctoral Research Associates and Research Staff .....	15
Past Graduate Students and Research Staff and Their Current Employment.....	16
Past Post Doctoral Research Associates and Research Staff .....	17
Research Projects .....	18
Dr. Craig Paukert .....	19
Dr. Amanda Rosenberger.....	35
Dr. Elisabeth Webb.....	43
PROJECTS THROUGH THE UNIT .....	58
Peer Reviewed and Technical Publications .....	60
Publications by Unit Scientists and Students.....	61
Presentations by Unit Scientists and Students .....	65
Theses and Dissertations.....	72
Committees and Other Professional Service.....	73
Awards and Recognition.....	77
Science in the News and Outreach.....	81

# MISSOURI COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

302 Anheuser-Busch Natural Resources Building  
University of Missouri, Columbia, MO 65211-7240  
Phone: (573) 882-3634      FAX (573) 884-5070  
[CoopUnit@missouri.edu](mailto:CoopUnit@missouri.edu)

The Unit Annual Report has been produced for over 30 years. If you desire any additional information, please contact Niki Fuemmeler at our address.



Above: Portrait of Aldo Leopold to Rudolph Bennett (acting leader of the Missouri Unit, 1947-1948): "With high hopes for the Missouri Unit."

Front cover: Getting ready to track Smallmouth bass on the Jack's Fork River.

## 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 have changed since the Missouri Unit was 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 our present status is a testament to the cooperators who pushed 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 (even a survey on wolf and coyote damage in Missouri). The 2016 report contains Unit research projects related to climate change, endangered and invasive species, pesticides, amphibian sampling protocols, and mussel and crayfish conservation, in addition to more traditional management such as evaluation of light goose harvest and methods to determine waterfowl abundance. Some funding sources for our research are different now than in years past. In addition to our strong support and numerous projects from the Missouri Department of Conservation, we have projects supported by the Missouri Department of Natural Resources, 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 our cooperators. Although the projects may be different than projects from 75 years ago, the theme of conducting applied research to meet the needs of our cooperators remains the same.

These are also changing times within the University of Missouri. The Department of Fisheries and Wildlife Sciences has been dissolved with other Departments to become the School of Natural Resources. What does this mean to the Missouri Unit? Unit scientists currently supervise about 55% of all graduate students in the Fisheries and Wildlife Sciences Emphasis Area and Unit scientists are the only faculty with graduate students in fisheries or aquatic organismal ecology. 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.

## ACCOMPLISHMENTS OF THE MISSOURI UNIT

We are very proud of our students and staff accomplishments that our highlighted in the report. During the 2-year reporting period, the Missouri Unit:

- Advised 21 current graduate students and 5 research staff
- Graduated 6 students and 5 research staff have moved on to other jobs
- Coordinated 28 active research projects and completed 11
- Received research grants totaling over \$7.4 million
- Produced a total of 38 peer reviewed publications
- Taught 40 graduate students and 6 undergraduates students
- Helped 32 undergraduates gain experience through research technician positions
- Gave 114 presentations including 35 invited or seminars to university departments or agencies
- Received a total of 61 awards, including 11 international awards (all by students) and 18 national awards (8 by students)
- Provided at least 21 public outreach events or news releases about our science



M.S. student Julia Guyton and a couple of friends.

## THE MISSOURI COOPERATIVE FISH AND WILDLIFE RESEARCH UNIT

The Cooperative Research Unit 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 *"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 as 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 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 waterbird ecology, big river ecology and management, and stream aquatic resources have long been emphasized. An attempt is made to complement and strengthen existing research disciplines 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 state and regional fish and wildlife resources.

## NIKI FUEMMELER



Our longest tenured Missouri Unit staff is retiring at the end of December, 2016. Niki Fuemmeler has been our administrative officer since 2006 and an incredible asset to the Missouri Unit. In the last 6 years, we have had complete turnover in the USGS Scientists in the Missouri Unit and therefore Niki has been instrumental in training Craig, Lisa, and Amanda to meet all the rules and policies both within USGS and the University of Missouri. She has kept us in line and let us know when we did something wrong (which was often!).

We all appreciate the help that Niki has provided us and she will be missed. Anyone that knows Niki and the Missouri Unit will know that Niki was in charge. Her shoes will be hard to fill.

# Unit and Cooperator Personnel Roster

## Permanent Unit Personnel

Craig Paukert, Unit Leader  
(573) 882-3524  
[PaukertC@missouri.edu](mailto:PaukertC@missouri.edu)

Lisa Webb, Assistant Leader-Wildlife  
(573) 882-2591  
[WebbLi@missouri.edu](mailto:WebbLi@missouri.edu)

Amanda Rosenberger, Assistant Leader-Fisheries  
(573) 882-9653  
[RosenbergerA@missouri.edu](mailto:RosenbergerA@missouri.edu)

Niki Fuemmeler, Administrative Officer  
(573) 882-3634  
[FuemmelerN@missouri.edu](mailto:FuemmelerN@missouri.edu)

## University of Missouri Collaborators

### School of Natural Resources Faculty

Matt Gompper  
Keith Goyne  
Charles H. Nilon  
Doug Noltie  
Frank R. Thompson III  
Mitchell Weegman  
Joanna Whittier  
Sonja Wilhelm-Stanis

### Faculty From Other MU Programs

Chris Wilke, Statistics  
Kevin Bradley, Plant Science  
Lori Eggert, Biological Sciences  
Deborah Finke, Plant Science  
Rico Holdo, formerly Biological Sciences  
Mike Urban, Geography  
Fred vom Saal, Biological Sciences

## Unit Coordinating Committee

Thomas Payne, Vice Chancellor and Dean  
College of Agriculture, Food and  
Natural Resources  
2-69 Agriculture Building  
University of Missouri  
Columbia, MO 65211  
(573) 882-3846  
[PayneT@missouri.edu](mailto:PayneT@missouri.edu)

John R. Jones, Interim Director  
School of Natural Resources  
103 Anheuser-Busch Natural Resources Building  
University of Missouri  
Columbia, MO 65211-7220  
(573) 882-3543  
[JonesJ@missouri.edu](mailto:JonesJ@missouri.edu)

Tom Draper, Deputy Director  
Missouri Department of Conservation  
P O Box 180  
Jefferson City, MO 65102-0180  
(573) 751-4115 Ext 3217  
[Tom.draper@mdc.mo.gov](mailto:Tom.draper@mdc.mo.gov)

John Thompson, Deputy Chief  
Cooperative Fish and Wildlife Research Units  
U.S. Geological Survey  
12201 Sunrise Valley Drive – MS 303  
Reston, VA 20192  
(703) 648-4262  
[jthompson@usgs.gov](mailto:jthompson@usgs.gov)

Patrick Ruble, Midwest Representative  
Wildlife Management Institute  
12748 West Bank Drive  
Millersport, OH 43046  
[PatRubleWMI@columbus.rr.com](mailto:PatRubleWMI@columbus.rr.com)

Jim Hodgson, Wildlife and Sportfish Restoration  
US Fish and Wildlife Service, Region 3  
One Federal Drive  
Fort Snelling, MN 55111  
(612) 713-5131  
[Jim\\_Hodgson@fws.gov](mailto:Jim_Hodgson@fws.gov)

## TEACHING AND ENGAGING STUDENTS 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 January 2015 to Fall 2016.

Course	Credits	Instructor	Semester	Undergrad. Enroll.	Grad. Enroll.
FW 8460: Wetland Ecology	3	L. Webb	Fall 2016	0	10
FW 8520: Stream Ecology	3	A. Rosenberger	Spr 2016	2	10
FW 8001: Future of Fisheries	1	C. Paukert	Spr 2016	0	9
FW 8001: Hierarchical Bayesian Modeling	1	T. Wagner (Penn St.); Paukert organized	Sum 2015	0	11
FW 4950: Undergraduate research	1-2	Paukert/Webb/Rosenberger	Multiple	4	0
<b>Total</b>				<b>6</b>	<b>40</b>



The Wetland Ecology class discussing wetland soils on a field trip to visit Nebraska wetlands.

Unit Scientists and students guest lecture in many undergraduate and graduate courses. Below is a list of courses where we have given at least one guest lecture in 2015 and 2016.

<b>Course Name and Number</b>	<b>Type of students</b>
FW 8460: Wetland Ecology	Graduate
FW 8001: Grant Writing	Graduate
FW 4600/7600: Ecosystem Management (2)	Undergraduate/graduate
FW 4650: Wildlife Management Planning	Undergraduate
FW 3600: Conservation Biology (2)	Undergraduate
FW 3900: Ecology of Fishes	Undergraduate
NATR 1070: Ecology of Renewable Resources Management (3)	Undergraduate
NATR 2160: Issues in Natural Resources and the Environment (2)	Undergraduate

In addition, research projects under the direction of Unit Scientists provide a valuable opportunity for undergraduate exposure to the fisheries and wildlife field to gain valuable field and laboratory skills. In 2015-2016, the Unit has supported over 32 MU undergraduate technicians on multiple projects.

Unit Scientists also facilitate student learning and professional development opportunities through means other than formal teaching. For example, Unit Scientists organized two meetings (one undergraduate and one graduate) with the Director of the Missouri Department of Conservation.



Missouri Department of Conservation Director Bob Ziehmer listening to MU undergraduates.

Other student engagement activities included:

- Delivering student workshops on resume and CV writing, plus interview skills and on the job conduct
- Delivering a half day workshop on occupancy modeling for graduate students/faculty
- Developing workshops on how to get into graduate school
- Supporting undergraduate participation in professional society meetings
- Participate in student mentoring events at professional meetings
- Supporting MU Fisheries and Aquatic Sciences Society's aquarium housed in the Anheuser Bush Natural Resources Building



Native mussels on the move!

## CURRENT GRADUATE STUDENTS

### 2015 TO PRESENT

*\*Student received degree during the reporting period.*

Name	Research Project	Previous Education	Advisor
Elisa Baebler, M.S.	Habitat selection and movement of riverine fishes under regulated flows on the Lower Osage River	B.S. Colorado St. Univ.	Dr. Paukert
Wade Boys, M.S.	Effects of neonicotinoids on aquatic invertebrates in Missouri wetlands	B.S. Ohio Northern University	Dr. Webb
T. Joseph Chilton, M.S.	Habitat associations of two species of endemic crayfish in the Meramec River Drainage	B.S. Missouri State University	Dr. Rosenberger
*Leslie Crawford, M.S.	Development of standardized visual sampling methods for assessing community metrics of unionid mussel species and tribal groups in Missouri	B.S. Univ. of Missouri	Dr. Rosenberger
Jackie Dearborn, M.S.	Habitat use for roosting and foraging by maternity colonies of Indiana bats ( <i>Myotis sodalists</i> )	B.S. Muhlenberg College	Drs. Webb & Amelon
Corey Dunn, Ph.D.	Development of sampling protocols for mid-sized rivers	B.S. Virginia Tech	Dr. Paukert
*Jake Faulkner, M.S.	Seasonal habitat selection of Niangua darters	B.S. Univ. of Missouri	Dr. Paukert
Drew Fowler, Ph.D.	Body condition of harvested snow geese during the Light Goose Conservation Order	B.S. Texas A&M Univ. M.S. Louisiana State Univ.	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 & Webb
Brian Hidden, M.S.	Linking waterfowl distribution and abundance to spatial and temporal distribution and abundance of wetland habitat	B.S. Oklahoma State Univ.	Dr. Webb

*Evan Hill, M.S.	Linking wetland management decisions to distribution, habitat use and nesting efforts of secretive marsh birds in Missouri	B.S. Gustavus Adolphus College	Dr. Webb
Kayla Key, Ph.D.	Identification of risks and threats to mussel assemblages in the Meramec drainage through spatially-explicit niche modeling	B.S. Univ. of Tennessee at Martin M.S. Univ. of Texas-Tyler	Dr. Rosenberger
*Ethan Kleekamp, M.S.	Identifying reference reaches for MO streams	B.S. Truman State Univ.	Dr. Paukert
Kyle Kuechle, M.S.	Neonicotinoid concentrations in Missouri wetlands and potential effects on the avian community	B.S. Bemidji State University	Dr. Webb
Joe LaRose, M.S.	Invertebrate communities in restored and remnant Missouri prairies	B.S. University of Alabama	Drs. Webb & Finke
Michael Moore, Ph.D.	Dispersal and habitat selection of Lake Sturgeon in Missouri River tributaries	B.S. Univ. of Missouri M.S. Virginia Tech	Dr. Paukert
*Meagan Montgomery, M.S.	Fish use of passage facility and seasonal wetland pools at Eagle Bluffs Conservation Area (EBCA)	B.S. Univ. of Missouri	Dr. Galat
Rory Mott, M.S.	Thermal Preferences and water quality tolerances of the endangered Topeka shiner	B.S. Eastern Illinois Univ.	Dr. Rosenberger
Zach Morris, M.S.	Electrofishing immobilization thresholds for catfish and bass	B.S. Missouri St. Univ.	Dr. Paukert
*Sean O'Daniels, M.S.	Light reflectance patterns of decayed wood with implications for the visual ecology of woodpeckers	B.S. Graceland College	Drs. Webb & Kesler
Rachel Owen, Ph.D.	Effects of predicted climate change on wetland ecosystem function	B.S. Iowa State University M.S. South Dakota State University	Drs. Webb & Goyne
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., Univ. of Nebraska M.S., S. Dakota St. Univ.	Dr. Paukert

Travis Schepker, M.S.	Food resource availability for spring migratory waterfowl at mid- latitudinal wetlands	B.S. Univ. of Missouri	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. Univ. of Missouri	Dr. Rosenberger
*Jacob Schwoerer, M.S.	Assessment of climate change vulnerability to aquatic biota in National Parks	B.S. Univ. of Wisconsin- Stevens Point	Dr. Paukert
Nick Sievert, Ph.D.	Influence of flows and climate change on stream fishes	B.S. Univ. of Wisconsin- Madison M.S. Univ of Missouri	Dr. Paukert
Dane Smith, M.S.	Summer habitat selection by Indiana and northern long-eared bats on National Wildlife Refuges	B.S. Middle Tennessee State University	Drs. Webb & Amelon



MS student Elisa Baebler and John Brant collecting fish for transmitter implantation.

## CURRENT POST DOCTORAL RESEARCH ASSOCIATES AND RESEARCH STAFF

### 2015-PRESENT

*\*Staff obtained other employment during the reporting period.*

Name	Research Project	Previous Education	Advisor
Brandon Brooke	Development of sampling protocols for mid-sized rivers	B.S. Univ. of Missouri	Dr. Paukert
*Dr. Kristen Bouska	Importance of floodplains under climate change; modeling native mussels in the Meramec River drainage	B.S. Univ. of Wisconsin – La Crosse M.S. Kansas State Univ. PhD. Southern Illinois Univ.	Drs. Paukert and Rosenberger
Dr. Derek Corcoran Barrios	Bat occupancy patterns in the Plumas national Forest as a function of wildfire and restoration activities	B.S. Concepcion University M.S. Pontifical Catholic University of Chile Ph.D. Pontifical Catholic University of Chile	Dr. Webb
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 Univ. M.S. Indiana Univ. PhD. Univ. of Maryland	Drs. Paukert and Rosenberger
*Ryan Lueckenhoff	Effects of DO on aquatic biota	B.S. Univ. of Missouri M.S. Univ. of Nebraska	Dr. Paukert
Dr. Anson Main	Effects of neonicotinoids on non-target native pollinator communities in Missouri field margins	B.A. University of Alberta M.L.A. University of Toronto Ph.D. University of Saskatchewan	Drs. Webb and Goyne
*RuthAnn Martin	Thermal Preferences and Water Quality Tolerances of the endangered Topeka shiner	B.S. Univ. of Missouri	Dr. Rosenberger
Emily Tracy-Smith	Evaluation of ecological flows for Missouri	B.S. Univ. of Florida M.S. Univ. of Missouri	Dr. Paukert
*Dr. Jacob Westhoff	Life history of the freckled crayfish	B.S. Univ. of Missouri M.S. Tennessee Tech. Univ. PhD. Univ. of Missouri	Dr. Rosenberger
*Dr. James Whitney	Effects of climate change on fishes	B.S. Emporia St. Univ. M.S. Kansas St. Univ. Ph.D. Kansas St. Univ.	Dr. Paukert

**PAST GRADUATE STUDENTS AND RESEARCH STAFF AND THEIR CURRENT  
EMPLOYMENT**

**2010-PRESENT**

**GRADUATE STUDENTS**

Name	MU Education	Current Employment	Advisor
Justin Buckler	M.S. 2011	Environmental Scientist, Missouri Department of Natural Resources	Dr. Galat
Leslie (Crawford) Lueckenhoff	M.S. 2015	Assessment and Restoration Specialist, Missouri Department of Natural Resources	Dr. Rosenberger
Andy Dinges	M.S. 2013	Assistant Migratory Game Bird Biologist, North Dakota Game and Fish Department	Dr. Webb
Jake Faulkner	M.S. 2015	Unit Chief, Missouri Department of Natural Resources	Dr. Paukert
Jeff Fore	Ph.D. 2012	Ecologist, The Nature Conservancy	Drs. Galat & Sowa
Daniel Garrett	Ph.D. 2010	Lead Biologist, Washington Department of Fish and Wildlife	Dr. Rabeni
Jason Harris	M.S. 2013	Fish Biologist, Minnesota Department of Natural Resources	Dr. Paukert
Evan Hill	M.S. 2015	Wildlife Programs Coordinator, Missouri Department of Conservation	Dr. Webb
Ethan Kleekamp	M.S. 2015	Contractor, US Fish and Wildlife Service	Dr. Paukert
Josh Lallaham	Ph.D. 2012	Assistant Professor, St. Mary's University	Dr. Galat
Sean O'Daniels	M.S. 2016	Biologist, Tetra Tech Environmental Consulting	Dr. Webb
Doreen Mengel	M.S. 2010	Research Scientist, Missouri Department of Conservation	Dr. Galat
Jacob Schwoerer	M.S. 2015	Environmental Scientist, City of Jefferson City	Dr. Paukert
Nick Sievert	M.S. 2014	PhD student, University of Missouri	Dr. Paukert

Jonathan Spurgeon	M.S. 2012	PhD student, University of Nebraska	Dr. Paukert
Jessi Tapp	M.S. 2013	Wildlife Biologist, Missouri Department of Conservation	Dr. Webb
Jacob Westhoff	Ph.D. 2011	Research Scientist, Missouri Department of Conservation	Dr. Rabeni

### **PAST POST DOCTORAL RESEARCH ASSOCIATES AND RESEARCH STAFF**

<b>Name</b>	<b>MU Affiliation</b>	<b>Current Employment</b>	<b>Advisor</b>
Dr. William Beatty	Post-Doctoral Researcher, 2013-2014	Research Ecologist, US Geological Survey	Drs. Webb & Kesler
Dr. Kristen Bouska	Post-Doctoral Researcher, 2014-2015	Research Ecologist, US Geological Survey	Drs. Paukert & Rosenberger
Danielle Fox	Sr. Research Specialist, 2015- 2016	Biologist, Missouri Department of Conservation	Dr. Rosenberger
Dr. Katy Klymus	Post-Doctoral Researcher, 2012-2014	Research Ecologist, US Geological Survey	Dr. Paukert
Ryan Lueckenhoff	Sr. Research Specialist, 2013- 2015	Private Lands Biologist, Missouri Department of Conservation	Dr. Paukert
Ruth Ann Martin	Sr. Research Specialist, 2014- 2015	Nurse, University of Missouri Hospital	Dr. Rosenberger
Dr. Allison Pease	Post-Doctoral Researcher, 2010-2012	Assistant Professor, Texas Tech University	Dr. Paukert
Dr. Michelle Staudinger	Post-Doctoral Researcher, 2011-2013	Science Coordinator, US Geological Survey, Northeast Climate Science Center	Dr. Paukert
Dr. Jacob Westhoff	Post-Doctoral Researcher, 2011-2014	Research Scientist, Missouri Department of Conservation	Drs. Paukert & Rosenberger
Dr. James Whitney	Post-Doctoral Researcher, 2014-2016	Assistant Professor, Pittsburg State University	Dr. Paukert

## RESEARCH PROJECTS



Kyle Kuechle installing tree swallow nest boxes as part of his graduate research

## Dr. Craig Paukert

### CONSERVATION PLANNING FOR FISHES IN THE UPPER COLORADO RIVER BASIN

#### Investigators

Nick Sievert, PhD student, MU  
James Whitney, Post doc, MU  
Dr. Joanna Whittier, MU  
Dr. Craig Paukert, MU

#### Project Supervisors

Dr. Joanna Whittier, MU  
Dr. Craig Paukert, MU

#### Funding

U.S. Geological Survey, National Gap  
Analysis Program  
U.S. Geological Survey, Cooperative  
Research Units  
RWO 109  
Western Native Trout Initiative

#### 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 a conservation  
assessment to inform conservation and  
adaptive management decisions.

#### Location

Upper Colorado River Basin

#### Completion

December 2015

#### Status

Complete

#### Progress and Results

Fishes of the Upper Colorado River Basin have one of the highest levels of endemism in the United States. We applied a complementarity-based approach to develop priority ranks (0 – 1; low to high) for catchments in the Upper Colorado River Basin. We used methods and a framework that we had previously developed for the Lower Colorado River Basin so both basins could be integrated into a cohesive unit. Our approach incorporated an anthropogenic threat index, fish species distribution models, and other metrics (i.e., habitat fragmentation, non-native species richness) potentially impacting conservation value of the riverscape. We developed the anthropogenic threat index based on the presence/absence of stressors known to influence the persistence of fish species. For the species distribution models, we incorporated metrics describing the topography, hydrology, land use, climate, and biogeography of the basin to model predicted probability of occurrence for native and non-native species. Contiguous regions with high conservation value (> 0.8) are located in the headwaters of the upper Green, Yampa, and San Juan rivers, Green-Colorado and San Juan-Colorado rivers confluences, and designated wilderness areas of the Rocky Mountains. The intent was to provide an ecologically-based conservation assessment using the distribution of native fish species and the threats to persistence that could be used by land managers in the decision-making process to strategically place conservation efforts.

#### Selected Products

Whittier, J., and N. Sievert. 2015. Conservation assessment for native fish in the Upper Colorado River Basin. Final Report to the Western Native Trout Initiative, Report UM-URCB-2014.

# THE ROLE OF TRIBUTARIES ON ECOSYSTEM RECOVERY OF THE MISSOURI RIVER

## Investigators

Emily Pherigo, M.S. student, MU  
Dr. Craig Paukert, MU  
Wyatt Doyle, U.S. Fish and Wildlife Service

## Project Supervisors

Dr. Craig Paukert, MU

## 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.

## Location

Osage River

## Completion

June 2015



## Status

Complete

## Progress and Results

We investigated the seasonal patterns of fish abundance, species richness, and big river fish presence above and below a low-dam (L&D1) on the Osage River. Boat electrofishing, benthic trawls, and beach seines collected 15,619 fish representing 71 species in the lower 30 rkm of the Osage River, September 2012 through July 2013. Of the 71 species collected, 13 species were unique to upstream of the structure, and ten species were unique to below the structure. Half of the species unique to the fish community below L&D1 were big river species - Skipjack Herring *Alosa chrysochloris*, Speckled Chub *Macrhybopsis aestivalis*, Stonecat *Noturus flavus*, White Bass *Morone chrysops*, and Yellow Bass *Morone mississippiensis*. Overall, species richness did not differ above and below L&D1; however, there were differences in the proportion of big river species depending on what sampling technique was used. Regardless of season or gear, reaches downstream of L&D1 were more similar to each other than to sites upstream of the structure and sites within four miles of the confluence with the Missouri River were also similar to each other. This study provides evidence that L&D1 is a semi-permeable barrier to big river fish in the Osage River and to the seasonal use of Missouri River tributaries by big river fishes.

## Selected products:

Pherigo, E. 2015. Seasonal Fish Community Above and Below a Low-Head Dam on a Lower Missouri River Tributary. Final Report to USGS, SSP program.

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

## Investigators

Katy Klymus, Post doc, MU  
Dr. Craig Paukert, MU  
Duane Chapman, USGS  
Cathy Richter, USGS

## Project Supervisors

Dr. Craig Paukert, MU

## Funding

US Geological Survey  
Environmental Protection Agency  
RWO 118, 119

## Cooperators

US Geological Survey

## 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

## Completion

May 2015

## Status

Complete

## 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 hold 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. 2015. Quantification of eDNA shedding rates from invasive bighead carp *Hypophthalmichthys nobilis* and silver carp *Hypophthalmichthys molitrix*. *Biological Conservation* 183:77-84.

Klymus, K. E., C. A., Richter, D. C. Chapman, and C. P. Paukert. 2015. A reply to Iversen et al.'s comment Monitoring of animal abundance by environmental DNA — An increasingly obscure perspective. *Biological Conservation* 192:481-482.

## ASSESSMENT OF AVAILABLE ECOLOGICAL FLOW DATA

### Investigators

Emily Tracy-Smith, Sr. Research Associate, MU  
Dr. Craig Paukert, MU  
Jason Persinger, MDC  
Del Lobb, MDC  
Paul Blanchard, MDC

### Project Supervisors

Dr. Craig Paukert, MU

### Funding

MDC 360

### Objectives

Develop a comprehensive geodatabase to determine the state of knowledge on where biologic, hydrologic, stream temperature, land-use, flow alterations, Integrated Aquatic Database (IAD), 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

### Completion

June 2015

### Status

Completed

### Progress and Results

The science related to stream flow management is rapidly evolving. The Missouri Department of Conservation (MDC) has made it a priority to be at the forefront of ecological flow science and to understand how flow alterations affect riverine systems and their biota. To make stream flow management decisions that are based on the best available science for protecting aquatic resources, we need to understand and organize the current data that are available on alterations to our stream systems and link that information with the available flow and biological data for our streams. This will allow us a cost-effective and efficient way to identify sites in Missouri where alteration has occurred, and where we have additional data already collected to answer some of the flow ecology relationship questions. To achieve this, we developed a comprehensive geodatabase to determine where biologic, hydrologic, stream temperature, land-use, and flow alteration data exist. We created multiple appendices identifying sites with various levels of data, including sites that are altered and unaltered, to begin characterizing the degree of hydrologic alteration in Missouri. We identified potential analysis sites to develop provisional flow ecology relationships, where sites from multiple datasets are paired temporally and spatially using a geographic information system (GIS). By organizing the available data, we have identified data gaps that may guide future data collection and monitoring efforts. The information gained in this project will be used to help improve MDC's ecological flow work by guiding future research needs and allowing MDC to make more accurate and defensible flow recommendations.

### Products

Tracy-Smith, E., C. Paukert, P. Blanchard, M. Combes, D. Lobb, J. Persinger. 2015. *Assessment of Available Missouri Ecological Flow Data*, Missouri Natural Resources Conference, Osage Beach, Missouri.

Tracy-Smith, E. and C. Paukert. 2016. Final Report *Assessment of Available Ecological Flow Data*. Missouri Department of Conservation, 21 p.

## DEVELOPMENT OF REFERENCE REACHES FOR MISSOURI STREAMS

### Investigators

Ethan Kleekamp, M.S. student  
Dr. Craig Paukert, MU  
Dr. Joanna Whittier, MU  
Dr. Amanda Rosenberger, MU  
Randy Sarver, DNR  
Dave Michaelson, DNR

### Project Supervisors

Dr. Craig Paukert, MU  
Dr. Joanna Whittier, MU

### Funding

Missouri Department of Natural Resources

### Cooperators

Matt Combes, 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

### Completion

September 2016

### Status

Complete

### Progress and Results

North American freshwater resources have grown increasingly imperiled as a result of human-induced landscape alterations. The need exists for a flexible, quantitative approach to characterizing stream impairment and identifying candidate least-disturbed stream reaches to serve as benchmarks for high quality physical habitat and biological integrity. After accounting for natural sources of biological variation, we used boosted regression trees to model the influence of channel morphology, substrate, cover, and water quality, and watershed-level flow modification and fragmentation, urbanization, agriculture, and point-source pollution on stream fish and aquatic macroinvertebrate community characteristics of wadeable streams of Missouri. Biotic metrics related to stream health (e.g., Ephemeroptera, Plecoptera, Trichoptera richness, native lithophilic fish species richness) increased with bankfull width/depth ratios and dissolved oxygen, and decreased with increasing total chlorophyll. Watershed-level environmental predictors accounted for between 4% and 51% of the variation in biotic metrics. We predicted biotic metric values to over 28,000 wadeable stream reaches across the state and rescaled and summed individual metric scores to generate an overall estimate of biological integrity at each site. We identified streams scoring in the top 95<sup>th</sup> percentile of each stream size class and aquatic subregion to serve as regional candidate least-disturbed reference reaches predicted to exhibit relatively high quality habitat and biotic conditions. Our method represents a novel approach to characterizing and forecasting stream impairment, and represents a critical step in refining existing biological indices, developing a companion physical habitat index, and ultimately conserving the diversity and integrity of Missouri's flowing waters.

### Selected products

Kleekamp, E. 2016. Streams in a changing landscape: identifying candidate reference reaches to assess the physical and biotic integrity of Missouri's wadeable streams. M.S. Thesis, University of Missouri.

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

## Investigators

Nick Sievert, M.S. student  
Dr. Craig Paukert, MU  
Dr. Joanna Whittier, MU

## Project Supervisors

Dr. Craig Paukert, MU

## Funding

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

## Cooperators

Dr. Dana Infante, Michigan 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.

Develop stream classes based on climate sensitive fish species and identify stream reaches which are expected to experience a change in class based on future climatic conditions.

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.

## Completion

June 2016

## Status

Completed

## 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 to 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 in response to 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 the current conditions of stream habitats based on specific disturbances that limit stream fishes and future conditions that could result in community shifts due to changes in 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 met 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 predicted changes to stream habitats in response to predicted changes in climate. Tailored current and future condition assessments for target species are available for all stream reaches in the U.S. portion of the NE CSC via a web-based viewer.

## Selected Products

Sievert, N.A., *et al.* 2016. Assessing climate impacts based on observed fish responses to stream temperature and flow metrics. 146<sup>th</sup> Annual Meeting of the American Fisheries Society

Sievert, N.A., *et al.* 2016. An Assessment of Potential Changes in Habitat Classes Due to Climate Change in the Northeast Climate Science Center Region. 76<sup>th</sup> Midwest Fish and Wildlife Conference

# ASSESSING THE IMPACT OF CLIMATE CHANGE ON INLAND FISHERIES

## Investigators

Dr. James Whitney, Post doc, MU  
Dr. Craig Paukert, MU

## Project Supervisors

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

## Funding

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

## Cooperators

Dr. Doug Beard, USGS  
Bonnie Myers, USGS  
Doug Austen, American Fisheries  
Society

## 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

North America

## Expected Completion

December 2016

## Status

In progress

## Progress and Results

Understanding how climate change will impact, and is currently impacting inland fishes is a critical need. We convened an expert workshop in June 2015 to examine the effects of global climate change on inland fish and fisheries in the U. S. and Canada. This workshop culminated in a special issue of Fisheries with four peer reviewed manuscripts related to 1) individual-level responses, 2) population- and assemblage-level changes, 3) human dimensions, and 4) management and adaptation to climate change. Climate-related deviations from optimal temperatures and salinity may result in chronic stress that challenges the neuroendocrine and osmoregulatory systems of fishes, alters cardiorespiratory performance and aerobic scope, and affects immune responses. However, only 31 peer-reviewed publications between 1985 and 2015 document observed impacts of climate change on North American inland fishes. Three pathways may affect inland fisheries through climate change: by directly affecting fish populations and habitats, affecting environmental conditions that affect the fishers, and through mitigation and adaptation strategies by agencies. Managers can use traditional approaches (e.g., harvest regulations) to tackle climate change issues. Managing for a resilient ecological system may require strategies to increase age structure of populations, or provide a diversity of species for fishers.

## Selected Products

Paukert, C. P., and 8 coauthors. 2016. Adapting inland fisheries management to a changing climate. Fisheries 41(7):374-384.

Lynch, A. J., and 10 coauthors. 2016. Climate change effects on North American inland fish populations and assemblages. Fisheries 41(7):346-361.

Hunt, L. and 8 coauthors. 2016. Identifying alternate pathways for climate change to impact inland recreational fishers. Fisheries 41(7):362-373.

Whitney, J. E., and 8 coauthors. 2016. Physiological basis of climate change impacts on North American inland fishes. Fisheries 41(7): 332-345.

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

## Investigators

Jacob Schwoerer, M.S. student, MU  
Dr. Craig Paukert, MU  
Dr. Joanna Whittier, MU  
Hope Dodd, NPS

## Project Supervisors

Dr. Craig Paukert, MU

## Funding

USGS, NRPP Program  
NPS I and M Program  
RWO 123

## Objectives

How much do fish and aquatic invertebrate communities vary across time and space naturally so that we may recognize when changes occur?

What is the vulnerability of fish and aquatic invertebrate communities in Midwest NPS units?

What streams will likely experience the largest change in the future given future projections of climate and land use?

## 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. We leveraged efforts by the NPS, USGS, and universities to 1) develop baseline aquatic community variability across space and time, 2) identify aquatic communities vulnerable to climate and land use change, and 3) determine 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 was assessed using several metrics (IBI and HBI) calculated for each site and each year; variability will be determined using the coefficient of variation (cv) of these metrics among sites and years. An index of aquatic biota vulnerability to climate and land use change was developed based on fish and invertebrate taxa trait data. The final index developed may now be used to assess vulnerability of aquatic communities to environmental stressors. Geo-referenced datasets of predicted air temperature and precipitation to 2080 allowed us to identify parks that will experience the greatest aquatic community threat. The fish community at each of the NPS units was less temporally variable than spatially variable, but there was no consistent relationship found with aquatic invertebrates across park units. Invertebrates at each NPS unit were most vulnerable to an altered flow regime while the fish were most vulnerable to in-stream physical habitat alteration. Our results provide a framework for understanding community variability and for determining aquatic biota vulnerability throughout Midwestern streams, which provided 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. Project is nearing completion.

## Products

Schwoerer, J. M. 2016. Assessing the Vulnerability of Stream Communities and the Consistency and Use of Biotic Indices in Least-Disturbed Streams. MS Thesis. University of Missouri, Columbia.

# FISH COMMUNITY RESPONSE TO STREAM FLOW ALTERATIONS IN WADEABLE MISSOURI STREAMS

## Investigators

Emily Tracy-Smith, Sr. Research Associate, MU  
Dr. Craig Paukert, MU  
Jason Persinger, MDC  
Del Lobb, MDC  
Paul Blanchard, MDC

## Project Supervisors

Dr. Craig Paukert, MU

## Funding

MDC 379

## Objectives

This five-year study is aimed at understanding how flow alterations affect riverine systems and their biota. The goal of this project is to improve the Missouri Department of Conservation's ecological flow protection and management efforts through better understanding of fish community responses to stream flow alterations.

Use existing data (e.g. RAM data, gage stations, known stream flow alterations) and previously published research to develop specific flow-ecology hypotheses and quantify preliminary relationships of ecological response by stream size, type, season, and taxa.

Based on existing or developed protocols conduct fish sampling and habitat evaluation where data are insufficient for testing flow-ecology hypotheses.

## Location

Missouri

## Expected Completion

June 2020

## Status

In progress

## Progress and Results

A diversity of ecological flow issues will continue to arise due to climate change and increased demand for water, making stream flow management a complex and long-term issue. To bolster the ecological basis for stream flow management, we established a spatial framework using existing data for Missouri streams. Initial datasets included 1,855 fish community sites, 431 stream gages, and the locations of 5,517 dams, 4,456 springs, and 4,591 losing stream segments. To better understand how flow alterations affect riverine systems and their biota we developed metrics that define basic attributes of impoundments and metrics for the hydrologic effect of withdrawals, using their natural surrogate, losing streams. We also incorporated locations of springs that mask the effects of losing streams on hydrology. Working downstream from each headwater segment, we used RivEX software to accumulate values of these metrics for every stream segment within the Missouri stream network. The resulting datasets will be used to evaluate differences in fish communities as a function of flow alterations (impoundments and withdrawals) and to develop and test hypotheses about potential responses to flow conditions. We established a group of experts to serve as an advisory role in the development of flow-ecology hypotheses. This process produced draft lists of flow sensitive fish habitat groups and potential life history traits related specifically to Missouri streams. The flow-ecology relationships developed for this project, will focus on fish, because fish serve as surrogates for stream health and biotic integrity and are sensitive to the effects of streamflow alterations. Results will assist in the determination of the flows needed in water management decisions and development of flow recommendations.

## Products

Tracy-Smith, E., C. Paukert, P. Blanchard, M. Combes, D. Lobb, J. Persinger. 2016. *Assessment of Flow Alterations for Missouri Streams*, Missouri Natural Resources Conference, Osage Beach, Missouri.

Tracy-Smith, E. C. Paukert, P. Blanchard, M. Combes, D. Lobb, J. Persinger. 2016. *Using Existing Data to Examine Fish Community Changes Due to Stream Flow Alterations*, Ecological Flow Science and Policy Symposium, American Fisheries Society Meeting, Kansas City, Missouri.

## LAKE STURGEON HABITAT USE AND MOVEMENT IN MISSOURI RIVER TRIBUTARIES

### Investigators

Michael Moore, Ph.D. student  
Dr. Craig Paukert, MU  
Travis Moore, MDC  
Del Lobb, MDC  
Dave Herzog, MDC  
Quinton Phelps, MDC  
Sara Tripp, MDC  
Ivan Vining, MDC

### Project Supervisors

Dr. Craig Paukert, MU

### Funding

MDC 391

### Objectives

Determine distribution, movement, and site fidelity of adult Lake Sturgeon in the Osage and Gasconade Rivers using acoustic telemetry with manual tracking and remote receivers.

Determine microhabitat selection of adult Lake Sturgeon in the Osage and Gasconade Rivers.

Determine dispersal of stocked juvenile Lake Sturgeon in the Osage and Gasconade Rivers.

### Location

Missouri

### Expected Completion

August 2021

### Status

In progress

### Progress and Results

Populations of Lake Sturgeon in Missouri plummeted in the early 1900's due to overharvest and construction of dams that blocked access to crucial spawning habitats. In response, Missouri listed the Lake Sturgeon as endangered in 1974. At the time three recovery goals for Lake Sturgeon were outlined: 1. Establish a self-sustaining population of lake sturgeon in the Mississippi and Missouri rivers. 2. Ensure public understanding of, appreciation for, and cooperation with the Lake Sturgeon recovery effort. 3. Establish a Lake Sturgeon population that can support a unique sport fishing opportunity. Restoration projects to date including the stocking of over 330,000 fingerlings may begin to pay dividends in the state. Occasional reports of anglers catching large Lake Sturgeon as well as the documentation of Lake Sturgeon spawning below Dam 26 on the Mississippi River may suggest that reproductively mature stocks of Lake Sturgeon are growing.

However, other aspects of the recovery goals remain unmet. Biologists suspect that Lake Sturgeon in the Missouri River drainage use important habitats in the large tributaries such as the Osage and Gasconade rivers. Our research will provide estimates of home range size and macro- and micro- scale habitat use of Lake Sturgeon. We will provide the Missouri Department of Conservation insight on the degree of population mixing among tributaries to use in defining management units, guidelines for restoring habitat in these rivers, as well as information on the availability of appropriate spawning habitat. We are beginning to develop public outreach and education tools to disseminate information on Lake Sturgeon in Missouri including a blog and presence on social media platforms.

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

## Investigators

Elisa Baebler, M.S. student, MU  
Dr. Craig Paukert, MU  
Del Lobb, MDC

## Project Supervisors

Dr. Craig Paukert, MU

## Funding

MDC 358

## 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 is measured continuously during summer and fall using data sondes at twelve monitoring sites across 75 river km. Data collection and QA/QC is ongoing. 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.

## HABITAT SELECTION AND MOVEMENT OF RIVERINE FISHES UNDER REGULATED FLOWS ON THE LOWER OSAGE RIVER

### Investigators

Elisa Baebler, M.S. student, MU  
Dr. Craig Paukert, MU  
Del Lobb, MDC

### Project Supervisors

Dr. Craig Paukert, MU

### Funding

MDC 358

### Objectives

Determine how movement of two common fish in the lower Osage River, Spotted Bass and Shorthead Redhorse, is related to stream flow and timing.

Determine how selection of habitat (e.g., temperature, dissolved oxygen, depth, velocity, and cover) by Spotted Bass and Shorthead Redhorse is influenced by stream flow and time of year.

Document temperature and dissolved oxygen dynamics in backchannels and the main channel under a range of streamflow connectivity to determine when suitable habitat is most limited.

### Location

Osage River, Missouri

### Expected Completion

December 2017

### Status

In progress

### Progress and Results

Flow regime plays a fundamental role in the biology of aquatic species whose life events are often triggered by changes in streamflow, temperature, and day length. Yet, the consequences of altered streamflow and the associated habitat limitations on fish behavior are poorly understood. Streamflow on the lower Osage River in Missouri is regulated by Bagnell Dam, a hydroelectric facility located 132 km upstream of the confluence with the Missouri River. The discharge released from the dam fluctuates daily and water depth can rise and fall 5 m, resulting in dynamic habitat conditions. This study used radio telemetry to track the daily movement and habitat selection of Spotted Bass and Shorthead Redhorse during high flow, low flow, and changing flow conditions. Twenty-three fish of each species were implanted with radio transmitters in March 2016, approximately 19 river km downstream of the dam. Fish tracking is ongoing and will continue through spring 2017. This study will provide a better understanding of the influence of depth, velocity, temperature, dissolved oxygen, and cover on habitat used by riverine fish in regulated rivers. We will integrate bathymetric and velocity maps created by MDC with habitat selection results in order to create models depicting probable locations of Spotted Bass and Shorthead Redhorse within the study reach. The results can be used to determine the impacts of regulated flow and season on fish movement, habitat use, and hydrologic connectivity of backchannels in the Lower Osage River and can inform managers about fish response to environmental change.



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

## Investigators

Dr. Kristen Bouska, Post doc, UMESC  
Dr. Garth Lindner, Post doc, MU  
Dr. Craig Paukert, MU  
Dr. Robert B Jacobson, CERC

## Project Supervisors

Dr. Craig Paukert, MU  
Dr. Robert B. Jacobson, CERC

## Funding

U.S. Geological Survey, Northeast  
Climate Change and Wildlife Science  
Center – USGS RWO 129

## 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 2017

## 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. Through a series of surveys and workshops with floodplain conservation land managers along the upper and middle Mississippi River and the lower Missouri River we evaluated management priority, management intensity, and available scientific information for management objectives and conservation targets. Metrics of inundation, including depth and extent of inundation, frequency of inundation, and duration of inundation, were considered the most useful metrics for management of floodplain conservation lands. Therefore, we developed floodplain inundation metrics for the historic period of record and under a future climate change scenario for the lower 500-miles of the Missouri River. Using modeled historic water surface elevations from 1930-2012, we developed daily 30-m grids of floodplain depth and synthesized these into composite grids that represent the expected areas inundated under discrete flood return intervals and also the average days inundated per year, during the growing season, and during the bird migratory season. These same composite grids were also generated under a climate change scenario of projected runoff changes for the Missouri River.

## Selected Products

Bouska, K.B., G.A. Lindner, C.P. Paukert, and R.B. Jacobson, 2016, Stakeholder-led science: engaging resource managers to identify science needs for long-term management of floodplain conservation lands, *Ecology and Society* 21(3):12.

Lindner, G.A., K.B. Bouska, E.A. Bulliner, C.P. Paukert, R.B. Jacobson, Sep. 2016, Science to inform management of floodplain conservation lands under non-stationary conditions, Presentation to Large River Monitoring Forum.

# DETERMINING ELECTROFISHING RESPONSE THRESHOLDS OF SMALLMOUTH BASS, FLATHEAD CATFISH, AND BLUE CATFISH

## Investigators

Zach Morris, M.S. Student, MU  
Dr. Craig Paukert, MU  
Zach Ford, MDC  
Andy Turner, MDC

## Project Supervisors

Dr. Craig Paukert, MU

## Funding

MDC 380

## Objectives

Determine the effective conductivity of Smallmouth Bass, Flathead Catfish, and Blue Catfish.

Determine taxis and immobilization power thresholds for fish of varying sizes of each species over a range of temperatures using a variety of waveforms.

Generate power goals and sampling recommendations for the most efficient waveform to induce taxis and immobilization each species.

## Location

Missouri

## Expected Completion

May 2018

## Status

In progress

## Progress and Results

As part of an ongoing effort with in MDC to standardize electrofishing methods for targeting sportfish, this project was developed to determine the capture-prone response thresholds of Smallmouth Bass, Blue Catfish, and Flathead Catfish under different electrofishing waveforms. The goal is to determine the most efficient waveform for collection of each species, and measure how this may differ by fish size and water temperature. In addition, the effective conductivity of each fish species is to be determined, which is an integral part of electrofishing standardization. In the spring of 2016, effective conductivity experiments for Smallmouth Bass were conducted in the lab at MU. Results suggest that the effective conductivity of the Smallmouth Bass may be around  $120\mu\text{S}/\text{cm}$ , close to the standard value of 115 that is typically assumed for electrofishing standardization. As of the fall of 2016, data have been compiled from 90 Smallmouth Bass trials and over 200 trials with Blue Catfish. All of these trials were conducted at high water temperatures, near the upper end of the range that MDC samples are conducted. Initial trends show that size plays a role in a fish's susceptibility to electricity, with larger fish being more easily immobilized. In addition, immobilization thresholds of blue catfish vary across waveforms, with higher frequency waveforms having lower thresholds. For Blue Catfish, a forced surfacing response was observed with low frequency waveforms. This may be more important to collecting fish than immobilization, as attempts to capture fish under high frequency electrofishing were unsuccessful.



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

## Investigators

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

## Project Supervisors

Dr. Craig Paukert, MU

## Funding

MDC 359

## 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 and Results

Substantial monitoring and research has been 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-wadeable rivers). 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.

Field sampling lasted from summer 2014–spring 2016. In total, 35 surveys were completed within nine rivers in three separate seasons. Simulations demonstrate protocols can detect 75% and 90% of fish richness using 30% and 59% of original survey effort. Species richness varied across sites, but did not vary seasonally. Richness was 200–300% higher than fish richness reported by historical surveys. Moreover, sampling documented dozens of new distributional records highlighting seasonally dynamic linkages between big rivers, mid-sized rivers, and wadeable tributaries.

## Selected Products

Dunn, C., and C. Paukert. 2016. Emerging distribution patterns and preliminary results from the Missouri mid-sized rivers fish sampling protocol: A scalable multi-method tool for studying Missouri's large-river fish assemblages. Missouri Natural Resources Conference.

Dunn, C., and C. Paukert. 2015. Development of a spatially balanced fish sampling protocol for mid-sized rivers of Missouri. Annual Meeting of the American Fisheries Society.

# HABITAT USE AND DISTRIBUTION OF LITHOPHILIC SPAWNING AND RIFFLE FISHES IN THE EAST FORK OF THE BLACK RIVER

## Investigators

M.S. student TBD  
Dr. Craig Paukert, MU

## Project Supervisors

Dr. Craig Paukert, MU

## Funding

MDC 389

## Objectives

Determine spawning habitat selectivity of East Fork Black River lithophilic spawning fishes.

Examine summer habitat use and longitudinal differences in abundance of lithophilic spawning and riffle fishes downstream from the lower reservoir dam.

Make recommendations for particle sizes and locations for gravel addition.

## Location

East Fork of the Black River, Missouri

## Expected Completion

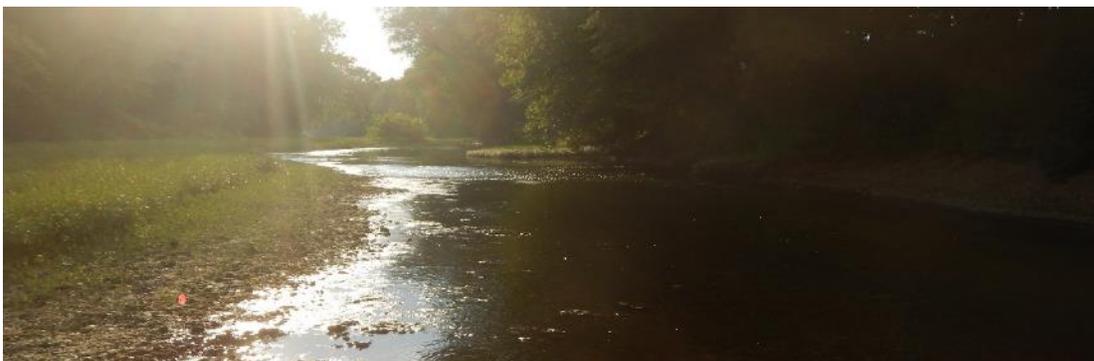
June 2020

## Status

In progress

## Progress and Results

In July 2014, the Federal Energy Regulatory Commission (FERC) issued a new license for Ameren Missouri (Ameren) to continue operation and maintenance of its Taum Sauk Pumped Storage Project. However, there is concern that the dam and sediment trap has limited gravel deposition in the river below the dam and may be affecting the native fishes. Current information is not sufficient to determine the potential for populations of macroinvertebrates and fish species that require gravel areas to benefit from enhancement of habitat through long-term gravel addition. This study will complement those efforts by providing MDC staff with information to evaluate the potential for long-term gravel addition in the East Fork Black River to enhance habitat for lithophilic spawning fishes (which require gravel for spawning) and riffle fishes, and develop recommendations for particle sizes and locations to use for any such augmentation. This study will evaluate the potential for long-term gravel addition in the East Fork Black River to enhance habitat for lithophilic spawning and riffle fish species. These efforts will complement substrate and macroinvertebrate studies and develop recommendations for particle sizes and locations to use for any gravel additions. Study results will allow MDC staff to use sound science for promoting practices that ensure sufficient habitat to protect and manage the aquatic resources of the East Fork Black River. In addition, the fish spawning and habitat use information collected will be applicable to managing other Ozark rivers.



## Dr. Amanda Rosenberger

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

#### Investigators

Leslie [Crawford] Lueckenhoff, M.S.  
Student, MU

Matthew Schrum, M.S. Student, MU

Andrew Glen, Undergraduate, MU

Dr. Amanda Rosenberger, MU

Stephen McMurray, MDC

#### Project Supervisor

Dr. Amanda Rosenberger, MU

#### Funding

MDC 356

Love Foundation

#### Cooperators

Missouri Department of Conservation

#### Objectives

Determine the three most common visual methods for sampling mussels in the Meramec River in Missouri.

Conduct paired sampling in sites, 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

#### Completion

December 2016

#### Status

In Progress

#### Progress and Results

Missouri contains some of the most diverse mussel beds in the Midwest, but lacks a comprehensive monitoring framework for sampling unionid mussel assemblages. Development of a standardized and validated sampling methods framework is essential for collecting precise and accurate data to facilitate informed management decisions. Sampling freshwater mussels in wadeable rivers often involves visual-based survey methods subject to multiple levels of bias. Five methods were implemented at 14 sites throughout the Meramec River Basin. Results suggested that an extensive, qualitative survey method (timed visual search) detected a greater proportion of mussel species with consistently higher detection rates than more intensive, quantitative methods. Measures of mussel assemblage structure varied by method due to greater effectiveness of extensive survey methods in detecting locally rare species. However, dominant species within mussel assemblages were detected similarly across all survey methods. Under the range of conditions examined in this study, habitat variables did not substantially affect how well methods detected species present in sites; however analysis identified water depth and site size as potential sources of bias. Sampling efficiencies of visual-based quadrats will be used to determine if visual techniques provide reasonable approximation of overall mussel abundances and to investigate factors that influence their effectiveness. Length frequencies will also be compared among methods in addition to abundance estimates or CPUE to determine the potential of between-method comparisons.

#### Selected Products

Lueckenhoff, L. 2015. Development of standardized visual sampling methods for assessing community metrics of unionid mussel species and tribal groups in Missouri. M.S. Thesis, University of Missouri, Columbia.

Schrum, M. 2016. Anticipated Graduation: December 2016. Public Defense Seminar. Development and validation of standardized sampling protocols for assessing freshwater mussel species' populations in Missouri. M.S. Thesis, University of Missouri. September, 2016.

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

**Investigators**

Dr. Kristen Bouska, Post doc, MU  
Dr. Garth Lindner Post doc, MU  
Kayla Key, PhD Student, MU  
Dr. Amanda Rosenberger, MU  
Stephen McMurray, MDC

**Project Supervisor**

Dr. Amanda Rosenberger, MU

**Funding**

MDC 367

**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 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, Missouri

**Expected Completion**

June 2017



**Status**

In Progress

**Progress and Results**

The Meramec River basin, located in the northeastern Ozark region of Missouri, has one the most diverse mussel faunas in the Midwest. Basin-wide mussel surveys documented declines in species richness and diversity in this system over the past thirty years. However, the mechanisms leading to this decline are poorly understood. A better understanding of the habitat requirements of mussels will provide insight into the causes of mussel decline, which will improve conservation management actions. In this project, we use remotely sensed datasets to identify the basic physical habitat requirements related to channel hydraulics, hydrology, and geomorphology that are needed to support diverse aggregations of mussels. The maximum entropy modeling method (Maxent) was applied to generate a fundamental niche model based on the hydrogeomorphic input variables and known locations of diverse mussel assemblages. This method uses incomplete information (i.e., presence only data) to find the probability of distribution of maximum entropy (i.e., closest to uniform) given the constraints of known locations and environmental variables. The model identifies locations throughout the Meramec Basin that provide the fundamental characteristics allowing establishment of diverse mussel aggregations. Over the next year, the model predictions will be 1) validated in the field, 2) used to identify additional biotic and abiotic limiting factors for mussels, and 3) guide site-selection for a detailed reach-scale study of habitat requirements. The results of this project improve our basic understanding of the habitat needs of freshwater mussels and the mechanisms leading to their decline, and providing key information to guide state-wide mussel conservation efforts.

**Selected Products**

Lindner, G., A.E. Rosenberger, K. Key, and K. Bouska. 2016. Towards a strategic and spatially-explicit conservation assessment and monitoring program for mussels in Missouri. Invited Seminar, University of Texas at Tyler. April, 2016.

# A SPATIAL ASSESSMENT OF THE STATUS AND RISKS TO MUSSEL CONCENTRATIONS IN THE MERAMEC DRAINAGE IN MISSOURI

## Investigators

Kayla Key, Ph.D. Student, MU  
Dr. Amanda Rosenberger, MU  
Steve McMurray, MDC, MDC  
Dr. Kristen Bouska, Post doc, MU  
Dr. Garth Lindner Post doc, MU

## Project Supervisor

Dr. Amanda Rosenberger, MU

## Funding

MDC 376

## Cooperators

Missouri Department of Conservation

## Objectives

Investigate the presence and absence of species-rich mussel beds in areas that meet fundamental requirements.

Spatially describe threats to species-rich mussel assemblages on the landscape and identify areas at risk.

Develop a strategic and spatially-explicit monitoring framework for freshwater mussels in the Meramec River Basin that identifies 1) areas at risk of decline and extinction 2) threats to mussel assemblages, and 3) areas most likely to be successful in management opportunities.

## Location:

Meramec River Drainage, Missouri

## Completion

June 2019

## Status

In Progress

## Progress and Results

To conserve a taxonomic group, the fundamental requirements that allow it to thrive and factors best suited to predict their current distributions must be identified. Freshwater mussels are one of the most imperiled taxa in the United States. Modeling mussel distributions in the United States has been difficult due to the unique life history and habitat requirements of mussels. Further, limitations on mussel monitoring and modeling have served as obstacles in mussel conservation. Increased focus on mussel ecology and biology has led to the identification of geomorphological and hydrological characteristics of streams as successful predictors in mussel distributions. Given limited resources, a strategic approach to describing mussel requirements and threats will improve effectiveness and lower cost of mussel conservation and monitoring programs. This project will determine the distribution and diversity of mussels within these areas and assess risks to mussel diversity. This work will provide a foundation for developing monitoring protocols to determine status of mussel communities to inform and prioritize restoration actions.

## Products

Key, K., G. Linder, and A.E. Rosenberger. 2016. A tool for identifying potential threats to species on a landscape level: An example geared towards endangered freshwater mussels in Missouri. Organization of Fish and Wildlife Information Managers Annual Meeting. Ponca State Park, NE. October, 2016.

Key, K., G. Lindner, K. Bouska, and A. Rosenberger. 2016. Using maxent to generate a fundamental niche model for diverse mussel assemblages within the northeastern Ozark region of Missouri. Poster Presentation, Missouri Natural Resource Conference, Osage Beach, MO. February, 2016.

--. American Fisheries Society Annual Meeting, Kansas City, MO. August, 2016.



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

### Investigators

Dr. Jacob Westhoff, Post doc, MU  
Dr. Amanda Rosenberger, MU  
Robert DiStefano, MDC

### Project Supervisor

Dr. Amanda Rosenberger, MU

### Funding

MDC 365

### 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, Missouri

### Completion

June 2016

### Status

Complete

### Progress and Results

The vulnerable Freckled Crayfish, *Cambarus maculatus* Hobbs and Pflieger, 1988 is endemic to only one drainage in eastern Missouri, USA, which is impacted by heavy metals mining and adjacent to a rapidly-expanding urban area. We studied populations of *C. maculatus* in two small streams for 25 months to describe annual reproductive cycles, and gather information about fecundity, sex ratio, size at maturity, size-class structure, and growth. We also obtained information about the species' density at supplemental sampling streams. We captured a monthly average of more than 50 *C. maculatus* from each of the two study populations. The species exhibited traits consistent with a *K*-strategist life history; long-lived, slow-growing, with fewer but larger eggs than sympatric crayfish species. Breeding season occurred in mid- to late autumn, potentially extending into early winter. Egg brooding occurred primarily in May. Young of year were first observed in June. We estimated that these populations contained 4 to 6 size-classes, observed smaller individuals grew faster than larger individuals, and most became sexually mature in their second year of life. Densities of *C. maculatus* were low relative to several sympatric *Orconectes* spp. Life history information presented herein will be important for anticipated future conservation efforts.

### Products

DiStefano, R.J., J.T. Westhoff, C.W. Ames, and A.E. Rosenberger. 2016. Life history of the vulnerable endemic crayfish *Cambarus (Erebicambarus) maculatus* (Decapoda: Cambaridae) in Missouri, USA. *Journal of Crustacean Biology*.

Westhoff, J. T., R. DiStefano, C. Ames, and A.E. Rosenberger. 2015. Life history of the Freckled Crayfish *Cambarus maculatus* in two Missouri Streams. Oral Presentation for the Southern Division of the American Fisheries Society, Savannah, Georgia. January 2015.

--. Poster Presentation for the Missouri Natural Resources Conference. February, 2015.

# A GLOBAL REVIEW OF FRESHWATER CRAYFISH TEMPERATURE TOLERANCE, PREFERENCE AND OPTIMAL GROWTH

## Investigators

Dr. Jacob Westhoff, Post doc, MU  
Dr. Amanda Rosenberger, MU  
Robert DiStefano, MDC

## Project Supervisor

Dr. Amanda Rosenberger, MU

## Funding

MDC 365

## Cooperators

Missouri Department of Conservation

## Objectives

Review the literature on thermal ecology for freshwater crayfish worldwide, with emphasis on studies that estimated temperature tolerance, temperature preference, or optimal growth.

Explore relationships between temperature metrics and species distributions.

## Location

University of Missouri

## Completion

June 2016

## Status

Complete



## Progress and Results

Conservation efforts must account for ongoing ecosystem alteration due to a changing climate, introduced species, and shifting land use. This type of management can be facilitated by an understanding of the thermal ecology of aquatic organisms. However, information on thermal ecology for entire taxonomic groups is rarely summarized, and reviews of the science can facilitate its advancement. Crayfish are one of the most globally threatened taxa, and ongoing declines could have serious consequences on aquatic ecosystem function due to their significant biomass and ecosystem roles. Our goal was to review the literature on thermal ecology for freshwater crayfish worldwide, with emphasis on studies that estimated temperature tolerance, temperature preference, or optimal growth. We also explored relationships between temperature metrics and species distributions. We located 56 studies containing information for at least one of those three metrics, which covered approximately 6% of extant crayfish species worldwide. Information on one or more metrics existed for all three genera of Astacidae, four of the 12 genera of Cambaridae, and three of the 15 genera of Parastacidae. Investigations employed numerous methodological approaches for estimating these parameters, which restricts comparisons among and within species. The only statistically significant relationship we observed between a temperature metric and species range was a negative linear relationship between absolute latitude and optimal growth temperature. We recommend expansion of studies examining the thermal ecology of freshwater crayfish and identify and discuss methodological approaches that can improve standardization and comparability among studies.

## Products

Westhoff, J. and A.E. Rosenberger. 2016. A global review of freshwater crayfish temperature tolerance, preference, and optimal growth. *Reviews in Fish Biology and Fisheries* 26:329-349.

Westhoff, J.T. and A.E. Rosenberger. 2016. We have a lot to learn about crayfish and temperature. *Crayfish News* 38:4.

Westhoff, J., C. Rice, and A. Rosenberger. 2016. Research can inform management of aquatic ectotherms facing a thermally dynamic future: a crayfish example. Missouri Natural Resources Conference, Osage Beach, Missouri, February 2016.

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

## Investigators

Rory Mott, M.S. Student, MU  
Dr. Amanda Rosenberger, MU  
Dr. Douglas Novinger, MDC

## Project Supervisor

Dr. Amanda Rosenberger, MU

## Funding

MDC 374

## 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

Regulatory agencies have improved implementation of water quality standards and stream health nationwide. However, standards are typically set as threshold values based on lethal tests, which are not suited to measure sub-lethal stressors that may adversely affect organisms. Prairie stream fish are adapted to a variable thermal environment; therefore, their tolerance levels are not indicative of their thermal preferences or their capacity for acclimation. Given that both ambient temperature and acclimation temperature affect swimming ability, we expanded on these findings by using swimming speed to measure potential growth for fish acclimated over a range of temperatures. Running thermal profiles at different starting acclimation temperatures, using swimming speed as an indicator of physiological performance, we constructed a maximum swimming speed-temperature relationship that shows both tolerances and preferences of our model species, the Red Shiner (*Cyprinella lutrensis*) while accounting for acclimation potential. We found that swimming performance optimum was between 13.3°C and 27.6°C depending on the acclimation conditions. We are presently analyzing similar data for the Federally Endangered Topeka Shiner (*Notropis topeka*) and using expected maximum swimming speed to determine the effects of ammonia, ammonia byproducts, and salt on the performance of Topeka shiners. In addition, we are analyzing their response to a gradual reduction in oxygen in laboratory conditions to determine tolerance to hypoxia.

## Products

Mott, R. and A.E. Rosenberger. 2016. Developing Non-lethal Methodology for Testing Thermal Optima and Tolerance in Small Prairie Stream Minnows. Poster Presentation for the American Fisheries Society Annual Meeting, Kansas City, Missouri, August 2016.

Mott, R. and A. Rosenberger. 2016. Water quality requirements and preferences of the Topeka Shiner (*Notropis topeka*). Poster Presentation, Missouri Natural Resources Conference, Osage Beach, Missouri, February 2016.

# A WATER QUALITY PROFILE OF THE LITTLE BLACK RIVER SYSTEM TO DETERMINE POTENTIAL CAUSES FOR MUSSEL DECLINE AND TO IDENTIFY POTENTIAL SITES FOR MITIGATION AND REINTRODUCTION

## Investigators

Matt Schrum, Research Associate, MU  
Dr. Amanda Rosenberger, MU  
Steve McMurray, MDC

## Project Supervisor

Dr. Amanda Rosenberger, MU

## Funding

MDC 385

## Cooperators

Missouri Department of Conservation

## Objectives

Thermally characterize the Little Black River.

Characterize water quality longitudinally along the river.

Conduct invertebrate sampling strategically along the river length.

Research records on the Little Black River to determine likely sources of spills and any fish kills.

Sample areas with mussels present and determine if recruitment is taking place.

## Location:

Little Black River, MO

## Completion

December 2017

## Status

In Progress

## Progress and Results

Status surveys in known freshwater mussel beds in the Little Black River in the Current River drainage showed a precipitous decline in mussel richness and density in the late 1980s and early 1990's. Causes for this decline remain unknown. Two primary clues – presence of a small bed just downstream of a spring influx and heavy erosion of shells - suggest the cause may be related to water quality; if the issue is ongoing, restoration would require addressing the sources of poor water quality prior to any reintroduction or re-establishment efforts. Our overarching goal is to eliminate sources of ongoing water quality issues to determine if sites in the Little Black River are presently suitable for reintroduction efforts and, potentially, narrow down the causes of the precipitous decline there. We will also investigate the ongoing presence of toxins and poor water quality through macroinvertebrate sampling. The combined results should provide a comprehensive picture that details the current status of the habitat quality of the Little Black River. In addition, the results may reveal how altered water or sediment quality are directly or indirectly affecting the faunal communities in the river.

## Products

Schrum, M. and A. Rosenberger. 2016. Identification of the cause of mussel population collapse and current habitat suitability assessment in the Little Black River system, Carter, Ripley, and Butler Counties, Missouri, First Progress Report, Missouri Department of Conservation, September 2016.



**DISTRIBUTION AND HABITAT ASSOCIATIONS OF ENDEMIC CRAYFISHES IN THE MERAMEC RIVER BASIN: THE “VULNERABLE” FRECKLED CRAYFISH AND BELTED CRAYFISH**

**Investigators**

T. Joe Chilton, M.S. student, MU  
Dr. Amanda Rosenberger, MU  
Robert DiStefano, MDC

**Project Supervisor**

Dr. Amanda Rosenberger, MU

**Funding**

MDC 390

**Cooperators**

Missouri Department of Conservation

**Objectives**

Comprehensively estimate the distribution (occupancy rate and probability of detection) of SOCC (the Freckled Crayfish and Belted Crayfish).

Determine habitat use patterns of both species and propose natural or anthropogenic factors that could be contributing to their absence in areas of the drainage.

**Location:**

Meramec River Drainage, Missouri

**Completion**

June 2018

**Status**

In Progress

**Progress and Results**

The Freckled Crayfish and Belted Crayfish are endemic to only the Meramec River Drainage (MRD) of Missouri and have among the smallest ranges of all crayfish species. Much of the Freckled Crayfish’s known range falls within one of MDC’s Priority Landscapes, the Middle Meramec River Conservation Opportunity Area. Both are listed (MDC) as “Vulnerable” (S3) due to their narrow range near the rapidly-developing St. Louis metropolitan area and, for the Freckled Crayfish, its low abundance at most known locations. The Freckled Crayfish was recommended for upgrading to “imperiled” status in one conservation analysis, and the Belted Crayfish’s comparatively smaller range is additional cause for concern. Recent study indicates these crayfishes are threatened by 1) mining activities that are affecting crayfish populations in the Big River sub-basin, and 2) invasive crayfish found in MRD headwaters. Scientific information is scant for both species, including information on distributions, population genetics, habitat requirements, and life histories. We will determine the distribution and habitat use of both species simultaneously (because they have overlapping known ranges) to remedy the lack of information available on which to base management and policy decisions. This will help determine if conservation measures enacted have potential to benefit both species, or if different management approaches will be required.



## Dr. Elisabeth Webb

### USING AGENT-BASED WATERFOWL MOVEMENT MODELS TO IDENTIFY CONSERVATION SOLUTIONS TO LARGE SCALE ENVIRONMENTAL VARIATION AND LAND USE CHANGE

#### Investigators

Dr. William Beatty, Post doc, MU  
Dr. Elisabeth Webb, MU  
Dr. Dylan Kesler, IBP

#### Project Supervisors

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

#### Funding

Upper Mississippi River and Great Lakes Joint Venture  
US Geological Survey, Northeast Climate Science Center

#### Cooperators

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

#### Objectives

Evaluate energetic carrying capacity models in the context of waterfowl habitat and space use for mallards and American black ducks.

Develop and evaluate an Individual Based Model to quantify the effects of land cover and land use change at spring migration stopover areas on dabbling duck movements and migration chronology.

#### Location

North America

#### Completion

August 2015

#### Status

Complete

#### Progress and Results

We analyzed combined quantitative movement metrics derived from data collected with GPS satellite telemetry units attached to 33 mallards and 55 American black ducks with existing information about habitats, landscapes, energetics, in migratory waterfowl populations. The energetic carrying capacity models (ECCs) predicted mallard space use most effectively during spring and fall migration, but there was limited relationship with mallard movements in the winter, and between ECC predictions and American black ducks. We also developed an individual-based model to evaluate the effects of future land use and land cover changes on spring migrating dabbling ducks in North America. We assessed the effects of climate change on dabbling duck stopover duration, movement distances, and mortality. Although all three scenarios presented migrating ducks with increased amounts of wetland habitat, scenarios also contained substantially less cropland, which decreased overall carrying capacity of the study area and led to longer migration stopover times. Thus, conservation planners will have to address population-level energetic implications of shifting agricultural food resources and increased uncertainty in yearly precipitation patterns within the next 50 years.

#### Products

Beatty, W.S., D.C. Kesler, E.B. Webb, L.W. Naylor, A.H. Raedeke D.D. Humburg, J.M. Coluccy and G.J. Soulliere. *In press*. How will predicted land use change affect waterfowl spring stopover ecology? Inferences from an agent-based model. *Journal of Applied Ecology*.

Beatty, W.S., E.B. Webb, D.C. Kesler, L.W. Naylor, A.H. Raedeke D.D. Humburg, J.M. Coluccy and G.J. Soulliere. 2015. An empirical test of a continental management strategy: do landscape energetic models predict waterfowl space use during the non-breeding period? *Journal of Wildlife Management* 79:1141-1151.

# PERCEPTION OF ULTRAVIOLET WAVELENGTHS IN A NORTH AMERICAN WOODPECKER

## Investigators

Sean O'Daniels, M.S. student, MU  
Dr. Dylan Kesler, IBP  
Dr. Elisabeth Webb, MU

## Project Supervisor

Dr. Dylan Kesler, IBP  
Dr. Lisa Webb, MU

## Funding

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

## Cooperators

Dr. Scott Werner, USDA/APHIS  
Dr. Jeanne Mihail, MU

## 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

## Completion

May 2016

## Status

Complete

## Progress and Results

We tested the functional significance of UV cues for wild caught Pileated Woodpecker (*Dryocopus pileatus*) by placing frozen mealworms behind UV-reflective covers, UV-absorptive covers, or decayed red pine substrates within the same 1.2 m poles in independent experiments. Behavioral responses were greater towards both UV-reflective and UV-absorptive substrates in three experiments. Study subjects therefore reliably differentiated and attended to two distinct UV conditions of a foraging substrate. Behavioral responses were greater towards decayed pine substrates (UV-reflective) than sound pine substrates suggesting that decayed pine can be a useful foraging cue. We also tested whether decay fungi known to be associated with woodpecker cavity sites could alter substrate reflectance in a species-specific manner that is visually discriminable by woodpeckers. Our analyses indicated 6 of 10 decayed substrate/control comparisons were above the threshold of discrimination (i.e. indicating differences in reflectance discriminable by woodpeckers). We conclude that woodpeckers should be capable of visually detecting decayed wood in areas on trees where bark is absent, and they should also be able to visually detect species-specific differences in wood substrates decayed by fungi used in this study.

## Products

O'Daniels, S.T. 2016. Light reflectance patterns of decayed wood with implications for the visual ecology of woodpeckers. M.S. Thesis, University of Missouri.

O'Daniels, S.D., D.C. Kesler, J.D. Mihail, E.B. Webb and S.J. Werner. *In review*. Functional visual sensitivity to ultraviolet wavelengths in the Pileated Woodpecker (*Dryocopus pileatus*) and its influence on foraging substrate selection. *Physiology & Behavior*.

O'Daniels, S.D., D.C. Kesler, J.D. Mihail, E.B. Webb and S.J. Werner. *In review*. Light reflectance of decayed wood varies by decay fungi: implications for woodpecker visual cues. *Ibis*.

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

## Investigators

Evan Hill, MS student, MU  
Dr. Elisabeth Webb, MU  
Doreen Mengel, MDC

## Project Supervisor

Dr. Elisabeth Webb, MU

## Funding

MDC 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

## Completion

November 2016

## Status

Complete

## Progress and Results

We used dynamic occupancy modeling to evaluate factors that influence secretive marshbird occupancy and colonization/departure probabilities. The top colonization/departure model for sora included vegetation density and percent of a site containing emergent vegetation, with both variables having a positive relationship with colonization probability and a negative relationship with departure probability. The top sora occupancy model indicated a positive relationship between occupancy probability and duration of drawdown. The top occupancy model for least bittern included the percent site inundated and overall area inundated. The top colonization/departure model for American bittern included vegetation interspersions. American bittern occupancy models indicated a positive relationship between occupancy probability and duration of drawdown. The top colonization/departure model for Virginia rail included range of water depth and range of vegetation height, both of which had a negative relationship with colonization and departure probability. Percent of a wetland containing emergent vegetation and the average water depth were positively associated with probability of selection at the wetland scale. At the point scale, relative probability of use was positively related with water depth and percent of a site in emergent vegetation, and negatively associated with vegetation density. Nest survival was positively related with average water depth at nest points. Both migrants and breeders were more likely to use wetlands with emergent vegetation interspersed with patches of open water. Drawdown schedules will increase occupancy if they are timed to conform to the life history stage of the target species, providing water for migrants in April-May, and for breeders in June and July.

## Products

Hill, E.B. 2015. Linking wetland management decisions to secretive marsh bird habitat use during spring migrations and summer breeding on public wetlands in Missouri. M.S. Thesis, University of Missouri.

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

## Investigators

Brian Hidden, M.S. student, MU  
Dr. Elisabeth Webb, MU  
Dr. Andy Raedeke, MDC

## Project Supervisor

Dr. Elisabeth Webb, MU

## Funding

MDC 363

## Cooperators

Missouri Department of  
Conservation

## Objectives

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

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

Evaluate the influence of wetland availability and food abundance on dabbling duck abundance and distribution in north central Missouri during fall and winter.

## Location

North Central Missouri

## Expected Completion

December 2016

## Status

In progress

## Progress and Results

Little is known about habitat availability, waterfowl abundance, and food abundance on private wetlands in Missouri. This project aims to model probability of wetland inundation (habitat availability), quantify waterfowl use of private wetlands, and assess the influence of wetland availability and food abundance on dabbling duck distribution in north Missouri.

Probability of autumn wetland inundation was modeled using observed precipitation values, presence of hydric soil, wetland area, and watershed land use. We collected Landsat 5 TM satellite images for years 2004-2006 and 2008-2010 to determine wetland inundation and develop wetland inundation models. We flew 3 aerial surveys in 2014 and 6 aerial surveys in 2015-2016 via fixed wing aircraft beginning the first week of November and ending in January. To reduce variation and increase precision of estimates, the survey area was stratified utilizing knowledge of waterfowl distribution in the region. Transects were randomly selected using wetland area to weight selection probability. We collected seed biomass estimates from 12 public wetlands and 12 private wetlands within 30 km of the public wetlands. Seed head clippings and soil core samples collected from each site were used to quantify waterfowl food abundance in the region. We used probability of wetland inundation and food abundance estimates to assess how waterfowl use the landscape in autumn.

The results from this project will be instrumental in informing natural resource wetland management activities on private lands in the region. Specifically, it will assist wetland managers in tracking the response of management activities on waterfowl food resources and waterfowl distribution. It will inform wetland management decisions regarding the role each public wetland plays in its surrounding landscape in providing habitat for autumn migrating waterfowl. It will assist MDC in quantifying available energetic supply for migrating and wintering waterfowl given yearly environmental conditions. Finally, results will 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 RESOURCE BASED MODEL TO ESTIMATE FOOD AVAILABILITY FOR MIGRATORY WATERFOWL

## Investigators

Travis J. Schepker, M.S. student, MU  
Dr. Elisabeth Webb, MU  
Ted LaGrange, Nebraska Game and  
Parks Commission

## Project Supervisor

Dr. Elisabeth Webb, MU

## Funding

Great Plains Landscape Conservation  
Cooperative, U.S. Fish and Wildlife  
Service

## 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 2017

## Status

In progress

## Progress and Results

Despite a 90% decrease in wetland habitats and ongoing degradation from urban and agricultural land use, Nebraska's Rainwater Basin (RWB) serves as a critical staging area for migratory waterfowl using the Central Flyway. Given the RWB's annual role in sustaining relatively large waterfowl densities with limited wetland habitat, it is necessary that conservation managers obtain accurate estimates of wetland derived food resource availability to calculate energetic carrying capacity.

We assessed spring food availability for dabbling ducks at public, cropped, and Wetlands Reserve Program (WRP) wetlands in the RWB during 2014 and 2015. Overall, seed density was greatest in cropped wetlands ( $\bar{x}$  = 608kg/ha), followed by public ( $\bar{x}$  = 590kg/ha), and finally WRP wetlands ( $\bar{x}$  = 561kg/ha). Energetic quality (true metabolizable energy) for available forage was also greatest at cropped wetlands ( $\bar{x}$  = 2.3kcal/g), followed by WRP ( $\bar{x}$  = 1.8kcal/g), and finally public wetlands ( $\bar{x}$  = 1.7kcal/g). Forage density in the RWB appears comparable to other landscape scale studies at similar latitudes, however energetic quality of forage produced was significantly less than the estimate currently used by managers in the RWB (2.5kcal/g). Given the relatively favorable seed production observed in this study, conservation and inundation of WRP and cropped wetlands may be a viable option to increase energetic carrying capacity for dabbling ducks in other regions.

We also developed a suite of species distribution models to evaluate the relationship between local food availability and wetland landscape structure in determining waterfowl habitat use during migration. In 2014 and 2015 we observed a strong relationship between food availability and waterfowl density ( $p < 0.05$ ) in all of our top models suggesting that forage may be a limited resource for waterfowl during spring. The relationship between waterfowl density and wetland area in the surrounding landscape had a negative relationship ( $p < 0.05$ ) suggesting that wetland habitat might also be limited.

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

**Investigators**

Drew Fowler, Ph.D. student, MU  
Dr. Elisabeth Webb, MU  
Dr. Mark Vrtiska, Nebraska Game and  
Parks Commission

**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. jump shot) during the light goose conservation order.

Examine differences in species, age, sex, breeding origin and wintering location of lesser snow and Ross's geese harvested over decoys and jump shot during the light goose conservation order.

Assess implications of differential harvest rates on population dynamics of light geese and potential impacts to management actions.

**Location**

Arkansas, Missouri, Nebraska, South Dakota

**Expected Completion**

May 2018

**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 jeopardized 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.

Lesser snow and Ross's geese were collected during spring migration (February-May) of 2015 and 2016 in Arkansas, Missouri, Nebraska and South Dakota. Birds were collected and categorized by the different methods of take: over decoys, sneaking/stalking, and pass shooting. Currently, specimen dissections are ongoing but are projected to conclude in the fall of 2016. During dissections, specimens are sexed, aged, weighed, measured for body size and assessed for total body protein and lipid content. Additionally, flight feathers and muscle tissues are analyzed to assess previous year molting origin and prior winter habitat location, respectively. Preparation of materials for isotopic analyses is ongoing but projected to conclude in the summer of 2017. Statistical comparisons for evaluating body condition between 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, method of collection, and molting and wintering origins 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

Julia Guyton, M.S. student, MU  
Dr. Craig Paukert, MU  
Dr. Lisa Webb, MU  
Frank Nelson, MDC  
Doreen Mengel, MDC  
Dr. Andy Raedeke, MDC

## Project Supervisors

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

## Funding

MDC 370

## 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

Providing habitat for migratory waterfowl has historically been the focus of management strategies for Missouri's public wetlands. However, wetlands are also used by other less visible taxa, such as fish and amphibians, which reside largely below the water's surface. Being able to identify and monitor the full suite of taxa using wetland areas would be insightful to comprehensively manage these unique habitats. Our goal was to develop a standardized rapid assessment protocol to efficiently determine fish and amphibian species presence and richness in Missouri wetlands. We evaluated the efficiency and effectiveness of four sampling methods including two passive methods (mini-fyke nets and minnow traps) and two active methods (dipnets and seines). 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.

To date, all field sampling has been completed and preliminary data analysis is being conducted. We sampled 30 wetlands in three Missouri ecoregions during spring and summer 2015 and 2016 and collected over 200,000 individual fish and amphibians comprised of 55 fish and 15 amphibian species, including 5 Missouri Species of Conservation Concern (SOCC). Our results suggest that mini-fyke nets caught the greatest number of individual fish and amphibians, and were the most efficient method for detecting fish species. Mini-fykes were the most efficient method for detecting amphibian species in some seasons, but efficiency was likely altered due to changing habitat conditions, like increased vegetation. Mini-fyke nets caught all 5 of the SOCC and unique species not caught by any other method.

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

### Investigators

Jackie Dearborn, MS student, MU  
Dr. Elisabeth Webb, MU  
Dr. Sybill Amelon, USFS  
Shauna Marquardt, USFWS  
Karen Mangan, USFWS  
Lindsay Landowski, USFWS

### 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

May 2017

### Status

In Progress

### Progress and Results

The goal of this project was 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. 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.

In the summer of 2015 we caught and tracked 11 female Indiana bats at Cypress Creek and Mingo NWRs to 16 distinct roost locations. In the summer of 2016 we caught and tracked 8 female and 2 male Indiana bats at both refuges to 15 distinct roost locations. Both years at Cypress Creek NWR the bats selected artificial roosts almost exclusively. Single season occupancy modeling from 2015 acoustic data indicates that *Myotis* species select areas with higher stand density, meaning they forage in wooded wetlands more than in herbaceous wetlands or croplands.

Currently, data from 2016 is being entered and analyzed. Discrete choice analysis will be used to evaluate habitat selection data collected in 2016 and those results will be compared to the results from the 2015 data. In addition, multi-species and multi-season occupancy models will be run in order to determine potential differences in habitat use among different *Myotis* species. Given sufficient data, fixed kernel analysis will be run from 2015 and 2016 in order to gain an understanding of home-range size for maternity colonies of Indiana bats on the refuges. Results from this study 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.

# EFFECTS OF PREDICTED CLIMATE CHANGE ON PLAYA WETLAND ECOSYSTEM FUNCTION AND ECOLOGICAL SERVICES

## Investigators

Rachel Owen, Ph.D. student, MU  
Dr. Elisabeth Webb, MU  
Dr. Keith Goyne, MU

## Project Supervisors

Dr. Elisabeth Webb, MU  
Dr. Keith Goyne, MU

## Funding

Missouri EPSCoR, National Science Foundation

## Cooperators

Dr. Bo Svoma, MU  
Dr. Dave Haukos, USGS/Kansas State

## Objectives

Quantify the effects of simulated climate change conditions on soil biogeochemistry, plant production, microbial processes, and greenhouse gas emissions.

Elucidate differences in these responses between soils collected from Northern playas and Southern playas.

Simulate the impact of increased nitrogen inputs (from surface runoff) on nitrogen biogeochemistry in Northern and Southern playa soils.

Create a soil assessment framework to assess the overall playa soil health in regards to wildlife habitat, nutrient filtration, and groundwater recharge.

## Location

Rainwater Basin, Nebraska  
Southern High Plains, Texas

## Completion

May 2019

## Status

In Progress

## Progress and Results

We are conducting a six-month greenhouse experiment on playa soils from Nebraska and Texas to quantify treatment effects (based on predicted climate changes) on seed bank plant production, soil chemical properties, ion speciation, and ecological tipping point. Soil mesocosm containers are being subjected to four hydroperiod treatments, representing historic and future climate conditions. Local data were used to create the historic climatic simulation and CMIP5 – BCCA downscaled atmosphere ocean general circulation models (AOGCMs) for the RCP 4.5 emission scenarios (years 2071-2099) were used to develop future climatic simulations. Plant and seed biomass will be measured by dry weight at the end of the experiment. Plant species composition and plant physiological response are measured biweekly using the Simpson's Diversity Index and chlorophyll content of the dominant species, respectively. Daily soil moisture readings are being used to track treatment conditions and deionized water is added as needed to maintain appropriate conditions. Soil temperature and redox potential are measured continuously using a data logger and sensors. Soil solution samples are collected following heavy rainfall events using suction lysimeters and bulk soil samples are collected biweekly. Preliminary results show that redox potential responds to precipitation events, but soil only becomes anoxic after major rainfall events (> 50 mm). After three months of simulated precipitation, plant diversity is primarily dependent on wetland site, rather than precipitation treatment. Final results of this experiment will identify vegetative and soil properties most sensitive to hydroperiod alteration and identify the greatest potential risks to playa ecosystem functions in a changing climate.

# BAT OCCUPANCY PATTERNS IN THE PLUMAS NATIONAL FOREST AS A FUNCTION OF WILDFIRE AND FOREST RESTORATION

## Investigators

Dr. Derek Corcoran, Post doc, MU  
Dr. Elisabeth Webb, MU  
Dr. Dylan Kesler, IBP  
Dr. Matthew Johnson, USFS

## Project Supervisors

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

## Funding

U.S. Forest Service

## Cooperators

Institute for Bird Populations  
Plumas Audubon Society

## Objectives

Evaluate the effects of fire severity, distance to fire, fire heterogeneity, habitat availability and forest characteristics on the occupancy, distribution, and diversity of sensitive bat species to guide restoration of the Moonlight Fire and inform post-fire management of forests for sensitive bats across the Sierra Nevada, as well as developing a protocol for acoustic monitoring of bats for the Plumas National Forest.

## Location

Plumas National Forest, CA

## Completion

April 2017

## Status

In progress

## Progress and Results

Our objectives are to determine what factors associated with wildfires affect bat occupancy in Plumas National Forest, California, with emphasis in three species of concern for the Forest Service. We used k-means to classify the forest environment into five habitat types based on altitude, distance to water, distance to road, and vegetation type, and randomly sampled 13 sites in each habitat type in areas impacted by wildfire and in areas not impacted by wildfire. Of those 130 points, 125 were surveyed within the Plumas National Forest using the Pettersson's D500x acoustic bat detector during the summers of 2015 and 2016.

We have used Occupancy models to evaluate the effect of fire using Fire Intensity and distance to fire patches. Occupancy models were structured and ranked using an information theoretic approach. Our results indicate that 15 of the 17 species had higher probability of occupancy in areas that experienced wildfire during the past 20 years, including three bat species of conservation concern (Forest Service Sensitive Species). Results indicate a positive relationship between fire intensity and bat species occupancy, in particular distance from and to wildfires were selected for 12 of the 15 species.

## Products

Corcoran, D., L. Webb, and D. Kesler (2016). DiversityOccupancy: Building Diversity Models from Multiple Species Occupancy Models. R package version 1.0.6.

# QUANTIFYING NEONICOTINOID CONCENTRATIONS IN MISSOURI WETLANDS, THEIR DRIVING FACTORS AND POTENTIAL EFFECTS TO THE ASSOCIATED AVIAN COMMUNITY

## Investigators

Kyle Kuechle, M.S. student, MU  
Dr. Elisabeth Webb, MU  
Doreen Mengel, MDC

## Project Supervisors

Dr. Elisabeth Webb, MU

## Funding

MDC 381

## Cooperators

MDC

## Objectives

Quantify neonicotinoid concentrations in Missouri public wetlands and evaluate landscape characteristics correlated with those concentrations.

Develop a predictive model for temporal and spatial variation of neonicotinoid concentrations in Missouri wetlands.

Compare tree swallow (*Tachycineta bicolor*) reproductive and brood rearing efforts at wetlands with varying neonicotinoid concentrations.

## Location

Missouri

## Completion

December 2017

## Status

In progress

## Progress and Results

Neonicotinoids are the most widely used and fastest growing class of insecticides commercially available for agricultural use in North America. Objectives for this project seek to quantify neonicotinoid concentrations in Missouri public wetlands along with correlated landscape factors, and develop a model of spatial and temporal variation for neonicotinoid concentrations. Despite increased sampling efforts, little is known about neonicotinoid concentrations in intensively managed moist-soil wetlands common to Missouri and which factors influence their persistence and toxicity. To that end, we sampled water and sediment from 40 public wetlands under different common management regimes across Missouri during three sampling periods in 2016 (pre-plant, post-plant, and after autumn inundation) and will sample prior to planting spring 2017 to estimate persistence. All samples are analyzed for the six most common agricultural neonicotinoid active ingredients (imidacloprid, clothianidin, thiamethoxam, thiacloprid, acetamiprid, dinotefuran). Clothianidin was the most commonly detected neonicotinoid in water samples collected pre-planting (26 of 39 wetlands) with a maximum detected concentration of 0.041 µg/L. We evaluated the relationship between watershed land-use as well as wetland management variables (e.g. crop planting) and concentration variability among wetlands, found neonicotinoid concentrations increased with the proportion of associated agricultural land use. Tree swallow nest boxes (100) were placed at 10 experimentally treated wetlands spring of 2016. Nesting and brood rearing efforts will be compared between wetlands with varying neonicotinoid concentrations during the nesting season of 2017, hypothesizing neonicotinoids may cause invertebrate prey to become a limiting factor during critical life stages of tree swallows. Results of this study will be useful in determining neonicotinoid risk to aquatic invertebrates and wetland-dependent organisms reliant on these critical food resources for which Missouri wetlands are typically managed.

# EFFECTS OF DIRECT APPLICATION OF NEONICOTINOIDS ON AQUATIC MACROINVERTEBRATE COMMUNITIES IN MISSOURI PUBLIC WETLANDS

## Investigators

Wade Boys, M.S. student, MU  
Dr. Elisabeth Webb, MU  
Doreen Mengel, MDC

## Project Supervisor

Dr. Elisabeth Webb, MU

## Funding

MDC 381

## Cooperators

MDC

## Objectives

Assess the impacts of direct application of neonicotinoids on MDC intensively managed wetlands on aquatic macroinvertebrate biomass, taxa richness, and secondary production.

Evaluate the effects of neonicotinoid concentrations on the survival of aquatic macroinvertebrate species with different life histories.

Quantify whether concentrations of thiamethoxam alters trophic interactions between a vertebrate (American Bullfrog [*Rana catesbeiana*]) and invertebrate (Anisoptera) predator and their shared prey (*Gammarus fossarum*).

## Location

Missouri

## Expected Completion

May 2018

## Status

In progress

## Progress and Results

We selected 22 study wetlands at nine different MDC Conservation Areas; each area having one or two paired wetland study units. We assigned one wetland within each pair to be planted with neonicotinoid treated corn seed and one to be planted with untreated seed. In spring 2016, we collected baseline water, sediment, and aquatic invertebrate samples. Water and sediment samples were sent to the University of Nebraska to be analyzed for neonicotinoid concentrations. Aquatic invertebrate samples were processed in the lab. All study units were planted with appropriate corn seed (treated vs. untreated) in Spring 2016.

We are presently preparing for our second round of field sampling in late October through mid-November. Two additional sampling periods will occur in January 2017 and March 2017. We are also continuing to process invertebrate samples in the lab and analyzing neonicotinoid concentration data from spring 2016 sampling.



# EFFECTS OF NEONICOTINOID SEED-TREATMENT USE ON NON-TARGET NATIVE POLLINATOR COMMUNITIES IN MISSOURI FIELD MARGINS

## Investigators

Dr. Anson Main, Post doc, MU  
Dr. Elisabeth Webb, MU  
Dr. Keith Goyne, MU  
Doreen Mengel, MDC

## Project Supervisors

Dr. Elisabeth Webb, MU  
Dr. Keith Goyne, MU

## Funding

MDC 383

## Cooperators

MDC

## Objectives

Survey levels of neonicotinoids in soils and vegetation of agricultural field margins located on MDC conservation areas.

Determine the rate of degradation and/or accumulation in Missouri soils over time.

Validate potential routes of exposure for non-target terrestrial insects.

Evaluate the effects of annual neonicotinoid seed-treatment use on a range of native pollinator species.

## Location

MDC Conservation Areas:  
Atlanta CA, MO  
Fountain Grove CA, MO  
Indian Hills CA, MO  
Thomas Hill Reservoir CA, MO  
Whetstone Creek CA, MO

## Completion

June 2018

## Status

In progress

## Progress and Results

Most current neonicotinoid scholarship has focused on the effects of neonicotinoids toward social honeybee populations. By comparison, the majority of native pollinator species (e.g., solitary bees) found on agricultural sites either nest in the ground and/or pollinate plants near to production crops. It is unknown how many of these species are affected by intensive insecticide use.

To that end, we selected five conservation areas with six fields per site ( $n = 30$ ) which will be sampled at four discrete intervals (pre-seeding, post-seeding, mid-growing, near harvest). In year one, we will focus on collecting baseline data; in year two, fields will be assigned one of three treatments: previously treated to treated seed, previously treated to untreated seed, untreated to untreated seed. To validate routes of exposure, we will collect soils, vegetation, and representative insects at agricultural fields that will be analyzed for neonicotinoid residues. Our goal is to understand how native pollinator communities are affected by seed-treatment use and how they respond to neonicotinoid concentration changes over time.

Since April of 2016, we have continuously sampled six agricultural fields (4 previously treated, 2 untreated) per conservation area for field and field margin soils, margin vegetation, and pollinators. All fields were either seeded using neonicotinoid-treated seeds (e.g., corn) or were left as untreated fields. Margin vegetation was characterized (e.g., species composition, percent cover) using quadrats, harvested, weighed, and a subsample collected for residue analysis. Blue vane traps were deployed in the field and margins for 24 hours in tandem with three timed sweep netting sessions per margin to collect representative pollinators. Other variables such as margin width, field size, and life history traits are further recorded. To date, three sampling periods have been completed with 2465 pollinators collected and identified to species. An additional 90 soil samples and ~250 plant samples have been collected and will be analyzed for neonicotinoid residues. Future statistical analyses will include occupancy modeling to identify characteristics most associated with high insect abundance and diversity of native pollinator communities in agroecosystems.

# EVALUATING DIFFERENCES IN INVERTEBRATE COMMUNITIES BETWEEN REMNANT AND RESTORED PRAIRIES IN MISSOURI

## Investigators

Joe LaRose, M.S. student, MU  
Dr. Elisabeth Webb, MU  
Dr. Deborah Finke, MU  
Max Alleger, MDC

## Project Supervisors

Dr. Elisabeth Webb, MU  
Dr. Deborah Finke, MU

## Funding

MDC 383  
Prairie Fork Charitable Endowment  
-Trust

## Cooperators

MDC

## Objectives

Identify what species of cicadas, bees, and grasshoppers inhabit three of the prairies in the Upper Osage Grasslands.

Compare invertebrate communities of reconstructions to the communities in nearby remnants, identifying which species may not be colonizing reconstructions.

Evaluate the effects of size, distance, and age of reconstruction on invertebrate species richness and community composition.

## Location

Wah'Kon-Tah Prairie  
Schell-Osage Conservation Area  
Linscomb Wildlife Area  
Tucker Prairie Natural Area  
Prairie Fork Conservation Area

## Expected Completion

December 2017

## Status

In progress

## Progress and Results

The tallgrass prairie is one of the most endangered ecosystems in North America. MDC managers have established thousands of acres of prairie reconstruction plantings in Missouri to augment the remaining fragments of native grassland.

Our goal is to evaluate how the invertebrate communities have responded to reconstruction efforts by comparing reconstructions with nearby remnants. We conducted sampling at three sites in the Upper Osage Grasslands, Wah'Kon-Tah prairie, Linscomb Wildlife Area, and Schell- Osage Conservation Area, and two sites in central Missouri, Tucker Prairie and Prairie Fork, in 2016. Our study focuses on three taxonomic groups that fulfill a variety of ecosystem roles: grasshoppers, native bees, and grassland cicadas. Bees were collected using bee bowls, and grasshoppers using sweepnets, three times between June and September. Bees and grasshoppers will be identified to species, allowing for species richness and community composition estimates from each prairie. We will examine the effects of age, size, and distance to nearest remnant on community composition as well as identify the specific species that do and do not occupy the reconstructions. In cases where dispersal constraints limit colonization, target species may be identified for release into reconstructions.

# SUMMER HABITAT SELECTION BY INDIANA BATS (*MYOTIS SODALIS*) AND NORTHER LONG-EARED BATS (*MYOTIS SEPTENTRIONALIS*) ON NATIONAL WILDLIFE REFUGES IN NORTHERN MISSOURI

## Investigators

Dane Smith, M.S. student, MU  
Dr. Elisabeth Webb, MU  
Dr. Sybill Amelon, USFS  
Shauna Marquardt, USFWS

## Project Supervisors

Dr. Elisabeth Webb, MU  
Dr. Sybill Amelon, USFS

## Funding

U.S. Geological Survey, SSP Program  
RWO 130

## Cooperators

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

## Objectives

Determine roost locations and habitat characteristics of *M. sodalis* and *M. septentrionalis* maternity colonies on NWR lands in northern Missouri.

Compare selected habitat to overall stand characteristics in order to develop a predictive model for roost selection by species of interest.

Evaluate habitat selection of *M. sodalis* and *M. septentrionalis* in presence and absence of other species on an east-west gradient in order to assess potential for multi-species management.

## Locations

Squaw Creek, Swan Lake, and Big Muddy National Wildlife Refuges

## Completion

May 2019

## Status

In progress

## Study Design

Forest bat communities will be surveyed using acoustic sampling and mist netting to determine occupancy on selected NWR lands, with emphasis placed on federally listed species. Acoustic data will also guide site selection for mist netting in an effort to trap, radio tag, and track listed species to summer maternity colonies. Five bats of each listed species will be tagged and tracked each season at each refuge for a total of 60 bats. Once diurnal roost trees have been identified, emergence counts will be conducted nightly to determine colony size. A number of habitat characteristics (canopy cover, mean stem density, available bark, and number of snags) will be used to quantify habitat characteristics of known roost sites and randomly chosen unused sites. These data will be used to better understand factors that influence roost selection and to develop a predictive model for site selection by listed species. Variation in roost selection in the presence/absence of other species will be used to assess the potential for multi-species management. Data will be analyzed using discrete choice modeling and information theoretic approaches to evaluate habitat requirements at the local, regional, and landscape scale. Results of this study will inform NWR land managers of the effectiveness of specific forest management techniques to the conservation of bat habitat and reveal the relative importance of habitat resources on NWRs.

## PROJECTS THROUGH THE UNIT

### DR. SONJA WILHELM STANIS EVALUATION OF NON-TOXIC AMMUNITION OUTREACH EFFORTS ON MIDWEST REGION NATIONAL WILDLIFE REFUGES

**Investigators**

John Schulz, Ph.D. student, MU  
Dr. Sonja Wilhelm Stanis, MU

**Project Supervisor**

Dr. Sonja Wilhelm Stanis, MU

**Funding**

U.S. Fish and Wildlife Service  
RWO 131

**Cooperators**

U.S. Fish and Wildlife Service, Region  
3 Migratory Birds

**Objectives**

Will there be a positive, measurable change in hunter attitudes, opinions, and behaviors toward the voluntary use of non-toxic hunting ammunition resulting from the outreach efforts?

Will there be a positive, measurable change in the number of hunters who report using non-Pb ammunition for deer hunting on refuges and whose intentions are to use non-Pb ammunition for deer hunting in the future?

**Location**

National Wildlife Refuges in Region 3  
of the USFWS

**Completion**

June 2019

**Status**

In progress

**Progress and Results**

In 2014, the U.S. Fish and Wildlife Service's (USFWS) Midwest Region chartered a working group to reduce the risk of lead exposure to bald eagles caused by spent lead (Pb) ammunition from deer hunting on National Wildlife Refuges (NWR). Based on the working group's recommendations and guidance from leadership, the region is implementing strategic communication and outreach strategies to encourage hunters to voluntarily use non-Pb ammunition for firearms deer hunting on NWR lands.

This proposed project focuses on the evaluation the outreach strategies and objectives to determine if they are successful in changing hunters' attitudes, opinions, and behaviors to switch to non-Pb ammunition. Information about hunters' attitudes and beliefs, as well as other factors contributing to their ability or decision to use non-Pb ammunition will also be explored. A better understanding of the influences on behavior and the impact of outreach strategies (e.g., message and communication tool development) will guide subsequent outreach efforts in the Midwest region and possibly across the country.

## DR. DON TILLITT

### THE EFFECTS OF REDENTICIDES ON THE HEALTH OF HAWAIIAN TRIGGERFISH

**Investigators**

Rachelle Riegerix, PhD student, MU  
Dr. Donald Tillitt

**Project Supervisor**

Dr. Donald Tillitt

**Funding**

U.S. Geological Survey  
RWO 128

**Cooperators**

U.S. Fish and Wildlife Service

**Objectives**

Determine acute toxicity testing conditions for fish exposures to anticoagulant rodenticides.

**Location**

Hawaii

**Completion**

December 2017

**Status**

In progress

**Progress and Results**

Bird colonies at certain US Fish and Wildlife Service (USFWS) Pacific Island National Wildlife Refuges (PINWR) have suffered severe losses due to rat infestations. USFWS uses anticoagulant rodenticides (ARs) for rat eradication and control programs to protect native species. Evaluations of AR-related risk to non-target species have been conducted by USFWS in PINWR; however, risks of ARs to coral reef fish have not been included in those assessments. Toxicity testing was conducted using an Up and Down Procedure for red-toothed triggerfish, largemouth bass, and fathead minnow to determine median lethal dose (LD50). LD50s of AR chemicals were compared to target species and other non-target species in a species sensitivity distribution which showed triggerfish to be less sensitive. Sublethal effects were evaluated by clotting times of red-toothed triggerfish and freshwater fish. Bioconcentration and excretion of ARs by fish will be used for risk assessment to humans. This pharmacokinetics study will be in collaboration with Kathy Kuivila (USGS- Oregon Water Science Center) and postdoc. A field study is also currently being designed to evaluate environmental exposure, and risk assessment of AR exposure to coral reef fish in Hawaii.

**Products**

Riegerix, R. and D.E. Tillitt. 2016. *Toxicity of three anticoagulant rodenticides in non-target fish species*. North America SETAC and World Congress, Orlando, FL, 6-11 November.

**PEER REVIEWED AND TECHNICAL PUBLICATIONS**



Former M.S. student Leslie Lueckenhoff and current M.S. student Matt Schrum evaluating sampling protocols for native mussels in an Ozark river.

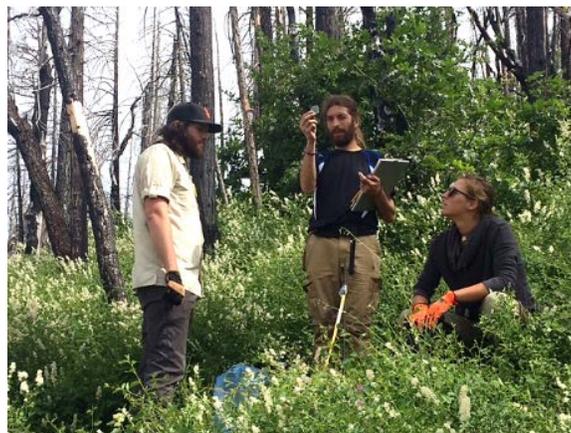
## PUBLICATIONS BY UNIT SCIENTISTS AND STUDENTS

### Peer Reviewed Journal Articles

1. Anderson, K. R., D. C. Chapman, T. T. Wynne, K. Masagounder, and C. P. Paukert. 2015. Suitability of Lake Erie for bighead carps based on bioenergetics models and remote sensing. *Journal of Great Lakes Research* 41:358-366.
2. Beatty, W. S., E. B. Webb, D. C. Kesler, L. W. Naylor, A. H. Raedeke, D. D. Humburg, J.M Coluccy, and G.J. Soulliere. 2015. An empirical test of a continental management strategy: do landscape energetic models predict waterfowl space use during the non-breeding period? *Journal of Wildlife Management* 79:1141-1151.
3. Beatty, W.S., D.C. Kesler, E.B. Webb, L.W. Naylor, A.H. Raedeke D.D. Humburg, J.M. Coluccy and G.J. Soulliere. In press. How will predicted land use change affect waterfowl spring stopover ecology? Inferences from an agent-based model. *Journal of Applied Ecology*.
4. Bouska, K. L., G. A. Lindner, C. P. Paukert, and R. B. Jacobson. 2016. Stakeholder-led science: engaging resource managers to identify science needs for long-term management of floodplain conservation lands. *Ecology and Society* 21:12.
5. Bouska, K.L., G.W. Whitledge, C. Lant. 2015. Development and evaluation of fourteen species distribution models for native Midwestern fish species. *Hydrobiologia* 747:159-176.
6. Breeggemann, J. J., M. A. Kaemingk, T. J. DeBates, C. P. Paukert, J. R. Krause, A. P. Letvin, T. M. Stevens, D. W. Willis, and S. R. Chipps. 2016. Potential direct and indirect effects of climate change on a shallow natural lake fish assemblage. *Ecology of Freshwater Fish* 25:487-499.
7. Dinges, A.J., E.B. Webb and M.P. Vrtiska. 2015. Effects of the Light Goose Conservation Order on non-target waterfowl distribution during spring migration. *Wildlife Biology* 21:88-97.
8. Dinges, A.J., E.B. Webb and M.P. Vrtiska. In press. Effects of the Light Goose Conservation Order on waterfowl behavior and energy expenditure during spring migration. *Wildlife Society Bulletin*.
9. DiStefano, R.J., J.T. Westhoff, C.W. Ames, and A.E. Rosenberger. 2016. Life history of the vulnerable endemic crayfish *Cambarus (Erebicambarus) maculatus* (Decapoda: Cambaridae) in Missouri, USA. *Journal of Crustacean Biology* 36:615-627.
10. Dunn, C. G. 2016. Documentation of *Cryptobranchus alleganiensis alleganiensis* (Eastern Hellbender) Predation on Nest-Associate Stream fishes. *Northeastern Naturalist* 23:8-11.
11. Dunn, C. G., and P. L. Angermeier. 2016. Development of Habitat Suitability Indices for the Candy Darter, with Cross-scale Validation across representative Populations. *Transactions of the American Fisheries Society* 145: 1266-1281.
12. Fischer, J., C. Paukert, and M. Daniels. 2015. Influence of riparian and watershed alterations on sandbars in a Great Plains river. *River Research and Applications* 31:1140-1150.
13. Foley, K., A.E. Rosenberger, and F. Mueter. 2015. Effectiveness of low-effort, single-pass backpack electrofisher use for estimation of juvenile coho salmon abundance in Alaskan headwater streams. *Fisheries Science* 81: 601-610.
14. Haynes, T., J. Schmutz, J.F. Bromaghin, S.J. Iverson, V.M. Padula, and A.E. Rosenberger. 2015. Diet of yellow-billed loons in Arctic lakes during the nesting season inferred from fatty acid analysis. *Polar Biology* 38:1239-1247.

15. Hunt, L. E. P. Fenichel, D. C. Fulton, R. Mendelsohn, J. W. Smith, T. D. Tunney, A. J. Lynch, C. P. Paukert, and J. Whitney. 2016. Identifying alternate pathways for climate change to impact inland recreational fishers. *Fisheries* 41:362-373.
16. Jacobson, R.B., G. Lindner, and C.J. Bitner. 2015. The role of floodplain restoration in mitigating flood risk, Lower Missouri River, USA. Pages 203-243 in P. F. Hudson and H. Middlekoop, editors. *Geomorphology and Management of Lowland Floodplains: North American and European Fluvial Systems in an Era of Global Environmental Change*: Springer.
17. Kaemingk, M. A., J. C. Jolley, C. P. Paukert, D. W. Willis, K. Henderson, R. S. Holland, G. A. Wanner, and M. L. Lindvall. In press. Common carp disrupt ecosystem structure and function through middle-out effects. *Marine and Freshwater Research*.
18. Kesler, D.C., E.B. Webb and J.R. Walters. In press. *Conservation Tools and Strategies in Ornithology: Foundation, Critique and Application*, M. Morrison, A. Rodewald, G. Voelker, J. Prather, and M. Colón, editors. Johns Hopkins University Press.
19. Klymus, K. E., C. A., Richter, D. C. Chapman, and C. P. Paukert. 2015. Quantification of eDNA shedding rates from invasive bighead carp *Hypophthalmichthys nobilis* and silver carp *Hypophthalmichthys molitrix*. *Biological Conservation* 183:77-84.
20. Klymus, K. E., C. A., Richter, D. C. Chapman, and C. P. Paukert. 2015. A reply to Iversen et al.'s comment "Monitoring of animal abundance by environmental DNA — An increasingly obscure perspective." *Biological Conservation* 192:481-482.
21. Laske, S, T. Haynes, A. Rosenberger, J. Koch, M. Wipfli, M. Whitman, C. Zimmerman. 2016. Surface water connectivity structures Arctic lake fish assemblages: Influence of local and regional drivers. *Freshwater Biology* 61:1090-1104.
22. Laske, S.M., A.E. Rosenberger, W.J. Kane, M.S. Wipfli, and C.E. Zimmerman. In Press. Top-down control of invertebrates by Ninespine Stickleback in Arctic ponds. *Freshwater Biology*.
23. Lynch, A. J., B. J. E. Myers, C. Chu, L. A. Eby, J. A. Falke, R. P. Kovach, T. J. Krabbenhoft, T. J. Kwak, J. Lyons, C. P. Paukert, and J. E. Whitney. 2016. Climate change effects on North American inland fish populations and assemblages. *Fisheries* 41:346-361.
24. Midway, S. R., T. Wagner, J. D. Zydlewski, B. J. Irwin, and C. P. Paukert. 2016. Transboundary fisheries science: Meeting the challenges of inland fisheries management in the 21st century. *Fisheries* 41: 538-546.
25. Neuswanger, J, M. Wipfli, A. Rosenberger, and N. Hughes. 2016. Measuring fish and their habitats: Versatile 2-D and 3-D video techniques with user-friendly software. *Canadian Journal of Fisheries and Aquatic Sciences* 73:1-13.
26. Neuswanger, J., M.S. Wipfli, M. Evenson, N. Hughes, and A.E. Rosenberger. 2015. High summer stream discharge strongly correlates with low productivity of stream-type Chinook salmon in two Alaskan rivers in the Yukon drainage. *Canadian Journal of Fisheries and Aquatic Sciences* 72: 1125-1137.
27. Paukert, C. P., B. Glazer, G. J. A Hansen, B. Irwin, P. C. Jacobson, J. L. Kershner, B. Shuter, J. Whitney, and A. Lynch. 2016. Adapting inland fisheries management to a changing climate. *Fisheries* 41:374-384.
28. Roberts, A., J. Hundley, A. Rosenberger, K. Bouska, D. Mosby, B. Simmons, and G. Lindner. 2016. Quantitative survey of freshwater mussels (Unionidae) and assessment of sediment contamination in the Big River, Missouri. Fish and Wildlife Service Report (Available Online, <https://www.fws.gov/Midwest/es/ec/nrda/SEMONRDA/index.html>).

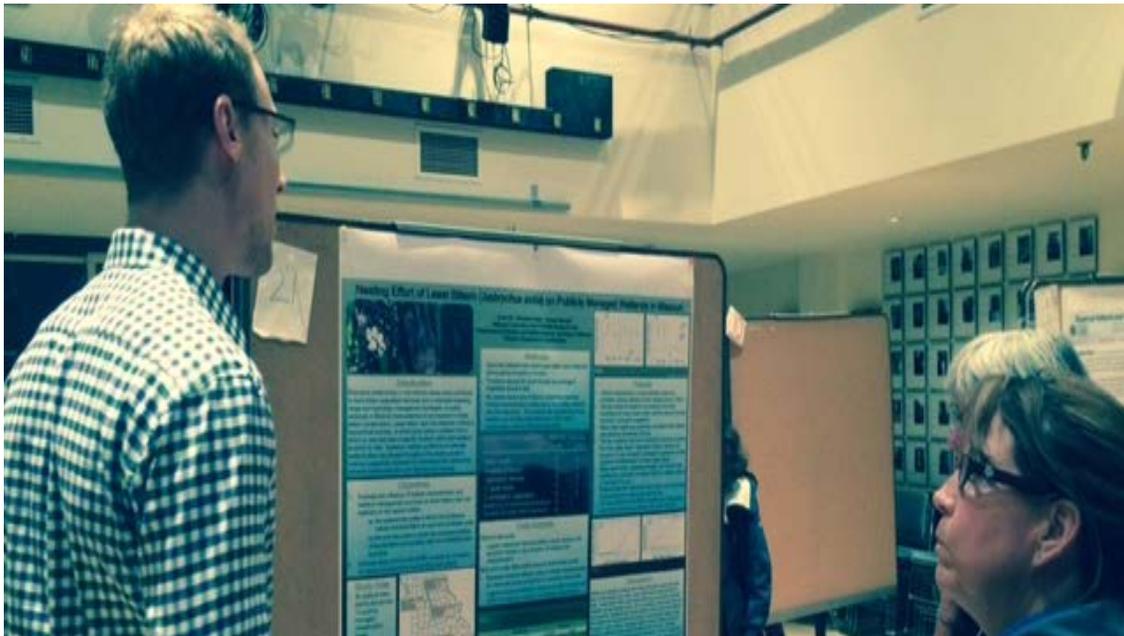
29. Rosenberger, A.E., J.B. Dunham, J. Neuswanger, and S. Railsback. 2015. Legacy effects of wildfire on stream thermal regimes and rainbow trout ecology: an integrated analysis of observation and individual-based models. *Freshwater Science* 34:1571-1584.
30. Sievert, N., Craig Paukert, Y. Tsang, and D. Infante. 2016. Development and assessment of indices to determine stream fish vulnerability to climate change and habitat alteration. *Ecological Indicators* 67: 403-416.
31. Spurgeon, J. J., C. P. Paukert, B. D. Healy, C. A. Kelley, and D. P. Whiting. 2015. Can translocated native fishes retain their trophic niche when confronted with a resident invasive? *Ecology of Freshwater Fish* 24:456-466.
32. Spurgeon, J. J., C. P. Paukert, B.D. Healy, M. Trammell, D. Speas, and E. Omana-Smith. 2015. Translocation of Humpback Chub into tributary streams of the Colorado River: implications for conservation of large river fishes. *Transactions of the American Fisheries Society* 144:502-514.
33. Stafford, J. D., A. K. Janke, E. B. Webb, and S. R. Chipps. 2016. Invertebrates in Managed Waterfowl Marshes. Pages 565-600 in D. Batzer and D. Boix, editors. *Invertebrates in Freshwater Wetlands: An international perspective on their ecology*. Springer.
34. Tapp, J.L. and E.B. Webb. 2015. Aquatic invertebrate response to habitat management at Wetland Reserve Program easements in the lower Mississippi Alluvial Valley. *Wetlands* 35:183-192.
35. Westhoff, J. and A.E. Rosenberger. 2016. A global review of freshwater crayfish thermal ecology. *Reviews in Fish Biology and Fisheries* 26:329-349.
36. Westhoff, J.T. and A.E. Rosenberger. 2016. We have a lot to learn about crayfish and temperature. *Crayfish News* 38:4.
37. Westhoff, J.T., C. Paukert, S. Ettinger-Dietzel, H. Dodd, and M. Siepker. 2016. Behavioural thermoregulation and bioenergetics of riverine smallmouth bass associated with ambient cool-period thermal refuge. *Ecology of Freshwater Fish* 25:72-85.
38. Whitney, J. E., R. Al-Chokhachy, D. B. Bunnell, C. A. Caldwell, S. J. Cooke, E. J. Eliason, M. Rogers, A. Lynch, and C. Paukert. 2016. Physiological basis of climate change impacts on North American inland fishes. *Fisheries* 41: 332-345.



Derek Corcorran Barrios collecting field measurements in the Plumas National Forest.

# ORAL AND POSTER PRESENTATIONS

2015-PRESENT



Ethan Kleekamp, M.S. student, giving a presentation to Missouri Water protection Forum I Jefferson City, Missouri (top), and Evan Hill explaining his research at the Waterbirds Society meeting in Bar Harbor, Maine (bottom).

## PRESENTATIONS BY UNIT SCIENTISTS AND STUDENTS

### 2015-PRESENT

#### Departmental Seminars

1. Bouska, K., G. Lindner, C. Paukert, R. Jacobson. 2016. Science to inform management of floodplain conservation lands under non-stationary conditions. US Geological Survey Columbia Environmental Science Center, Columbia, MO.
2. Dunn, C. G., and C. P. Paukert. 2016. Development of sampling methodology for documenting fish richness patterns within mid-sized rivers of Missouri. US Geological Survey Columbia Environmental Science Center, Columbia, MO.
3. Lindner, G., A.E. Rosenberger, K. Key, and K. Bouska. 2016. Towards a strategic and spatially-explicit conservation assessment and monitoring program for mussels in Missouri, University of Texas at Tyler, Tyler TX.
4. Paukert, C. 2016. Climate Change Effects on Fish: What We Know and What We Can Do About It. Departmental Seminar, Natural Resources Ecology and Management, Iowa State University, Ames, IA.
5. Paukert, C. 2015. The Missouri Cooperative Fish and Wildlife Research Unit: Overview and Expertise. US Geological Survey Columbia Environmental Science Center, Columbia, MO.
6. Paukert, C. 2016. Southwestern vs Midwestern Rivers: Confessions of a Former Colorado River Fish Ecologist. Departmental Seminar, Watershed Sciences, Utah State University, Logan, UT.
7. Paukert, C. 2016. What Do WE Really Know About Climate Change and Fish? US Geological Survey Columbia Environmental Science Center, Columbia, MO.
8. Rosenberger, A.E., Lueckenhoff, L. M. Schrum, K. Bouska, and G. Lindner. 2016. Our vision for a statewide mussel conservation assessment in Missouri. U.S. Geological Survey Center for Environmental Research, Columbia, MO.
9. Lindner, G., A.E. Rosenberger, K. Key, and K. Bouska. 2016. Towards a strategic and spatially-explicit conservation assessment and monitoring program for mussels in Missouri. University of Texas at Tyler, Tyler, TX.
10. Sievert, N.A., C.P. Paukert, D. Infante, Y.P. Tsang, W.M. Daniel, J. Whittier, K. Herreman, and J. Stewart. 2016. Development of an index to assess the risk of change in stream fish habitat due to climate change. US Geological Survey Columbia Environmental Science Center, Columbia, MO.
11. Webb, E. 2015. Neonicotinoid insecticides in Missouri ecosystems. US Geological Survey Columbia Environmental Science Center, Columbia, MO.

#### Invited Presentations

1. Beatty, W., E. Webb, D. Kesler, A. Raedeke, L. Naylor, D. Humburg, G. Soulliere, and J. Coluccy. 2016. Effects of landscape energetics on mallard and American black duck movement. 7<sup>th</sup> North American Duck Symposium, Annapolis, MD.
2. Daniel, W., N. Sievert, D. Infante, C. Paukert, J. Stewart, J. Whittier, T. Wagner, K. Herreman, and Y. Tsang. 2016. FISHTAIL: a decision support mapper for conservation of stream fish habitats of the NE CSC region. USGS Northeast Climate Science Center Webinar Series.
3. Daniel, W., N. Sievert, D. Infante, C. Paukert, J. Stewart, J. Whittier, T. Wagner, K. Herreman, and Y. Tsang. 2016. FISHTAIL: A decision support mapper for conserving stream fish habitats of the NE CSC region. Midwest Fish and Wildlife Conference, Grand Rapids, MI.
4. Infante, D., N. Sievert, W. Daniel, C. Paukert, J. Whittier, Y. Tsang, and J. Stewart. 2016. FISHTAIL: Conserving stream habitats and fishes from current and future threats throughout large regions. World Fisheries Congress, Busan, South Korea.

5. Key, K., G. Linder, and A.E. Rosenberger. 2016. A tool for identifying potential threats to species on a landscape level: An example geared towards endangered freshwater mussels in Missouri. Organization of Fish and Wildlife Information Managers Annual Meeting. Ponca State Park, NE.
6. Laske, S.M. A.E. Rosenberger, M.S Wipfli, C.E. Zimmerman. 2016. Hydrology and fish composition drives lentic food web structure in Arctic Alaska. Society for Freshwater Science, Sacramento, CA.
7. Lindner, G. and A.J. Miller, 2015, Restoration design of headwater channels and implications for floodwave propagation in urban streams, Hinkson Creek Collaborative Adaptive Management Science Team meeting, Columbia, MO.
8. Lindner, G., C. Paukert, A. Rosenberger, R. Jacobson, K. Bouska, and E. Bulliner. 2016. An examination of costs and benefits for capturing meaningful hydro-geomorphic criteria for aquatic biota in rivers. American Fisheries Society Annual Meeting, Kansas City, MO.
9. Lindner, G., K. Bouska, C. Paukert, R.B. Jacobson, 2015, Science to inform management of floodplain conservation lands under non-stationary conditions, Missouri River Agency Coordination Team quarterly meeting. Mound City, MO.
10. Lindner, G., K. Bouska, E.A. Bulliner, C. Paukert, R.B. Jacobson, 2016, Science to inform management of floodplain conservation lands under non-stationary conditions: Inundation Mapping, Large River Monitoring Forum webinar series, September, 2016.
11. Lindner, G., K. Key, K. Bouska, and A.E. Rosenberger. 2016. Derivation of hydrogeomorphic variables for fundamental niche modeling of unionid mussel concentrations in Missouri Ozark Rivers. American Fisheries Society Annual Meeting, Kansas City, MO.
12. Myers, B. J. E., A. J. Lynch, T. J. Krabbenhoft, R. P. Kovach, T. J. Kwak, J. A. Falke, C. Chu, D. B. Bunnell, C. P. Paukert. 2016. Global synthesis of climate change effects on inland fish. American Fisheries Society Annual Meeting. Kansas City, MO.
13. Paukert, C. 2015. Climate Change: What Does this Mean for Fisheries Management? Missouri Natural Resources Conference, Osage Beach, MO.
14. Paukert, C. and N. Sievert. 2016. Indices for biological assessments: past, present, and future. Global Inland Fisheries Conference, Rome, Italy.
15. Paukert, C. P., and 8 coauthors. 2016. Adapting fisheries management to a changing climate: lessons from North America. 7th World Fisheries Congress, Busan, South Korea.
16. Paukert, C., L. Hunt, A. Lynch, and J. Whitney. 2016. Agency Adaptation Strategies and Inland Recreational Fishers Response to Climate Change. American Fisheries Society Annual Meeting, Kansas City, MO.
17. Peterson, J.T., C.P Paukert, A.E. Rosenberger, S.K. Brewer. 2015. Standardized sampling: a call for gear calibration. 145th Annual Meeting of the American Fisheries Society, Portland OR.
18. Rosenberger, A.E., K. Bouska, S. McMurray, G. Lindner, K. Key, M. Schrum, and L. Lueckenhoff. 2016. Towards a strategic and spatially-explicit mussel conservation assessment and monitoring program in Missouri - our vision. Invited Presentation for the American Fisheries Society Annual Meeting, Kansas City, MO.
19. Schwoerer, J., C. Paukert, and H. Dodd. 2015. Consistency among biotic indices to represent environmental conditions: implications for restoration monitoring. Midwest Fish and Wildlife Conference, Indianapolis, IN.
20. Sievert, N., Y. Tsang, W. Daniel, C. Paukert, D. Infante, J. Whittier, K. Herreman, and J. Stewart. 2016. Assessing climate impacts based on observed fish responses to stream temperature and flow metrics. American Fisheries Society Annual Meeting, Kansas City, MO.
21. Tracy-Smith, E., P. Blanchard, M. Combes, D. Lobb, C. Paukert, and J. Persinger. 2016. Using Existing Data to Examine Fish Community Changes Due to Stream Flow Alterations. American Fisheries Society Annual Meeting, Kansas City, MO.
22. Ward, J., and C. Paukert. 2016. Analysis of Factors Influencing Rock Bass Population Dynamics in an Ozark Border Stream. American Fisheries Society Annual Meeting, Kansas City, MO.

23. Webb, E., W. Beatty, D. Kesler, A. Raedeke, L. Naylor and D. Humburg. Evaluation of GPS transmitters in tracking mallards during the non-breeding season. 7<sup>th</sup> North American Duck Symposium, Annapolis, MD.
24. Whittier, J., J. Whitney, C. Paukert, J. Olden, and A. Strecker. 2016. Projected range shifts of fishes in response to climate change in an arid-land river system. 7<sup>th</sup> World Fisheries Congress, Busan, South Korea.

### **Presentations at Professional Societies, Workshops, and Conferences**

1. Amelon, S., D. Barrios, J. Dearborn, S. Marquardt and E. Webb. 2016. Habitat Characteristics Influencing Summer Occupancy of *Myotis* Species in Bottomland Hardwood Ecosystems. San Antonio, TX. North American Society for Bat Research, San Antonio, TX.
2. Beatty, W., E. Webb, D. Kesler, A. Raedeke, L. Naylor, D. Humburg, G. Soulliere, and J. Coluccy. How will predicted land use change affect mallard spring migration stopover ecology? Inferences from an agent-based model. 7<sup>th</sup> North American Duck Symposium, Annapolis, MD.
3. Bouska, K., G. Lindner, R. Jacobson, and C. Paukert. 2015. Identifying floodplain conservation land management priorities and science needs for the Lower Missouri River. Missouri River Natural Resources Conference, Nebraska City, NE.
4. Corcoran, D., D. Kesler, E. Webb and M. Johnson. 2016. Burn, Baby, Burn: Effects of Wildfire on Bat Species Occupancy Probability in the Sierra Nevada Mountains. North American Society for Bat Research, San Antonio, TX.
5. Dearborn, J., E. Webb, S. Amelon and S. Marquardt. 2016. Indiana bat (*Myotis sodalis*) maternity colony roost site habitat selection in bottomland hardwood forests. Midwest Fish and Wildlife Conference, Grand Rapids, MI.
6. Dunn, C. and C. Paukert. 2015. Development of the Missouri Midsized Rivers Fish Sampling Protocol with preliminary results from the lower Gasconade River. Missouri Natural Resources Conference, Osage Beach, MO.
7. Dunn, C., and C. Paukert. 2015. Development of a spatially-balanced sampling protocol for mid-sized rivers in Missouri. American Fisheries Society Annual Meeting, Portland, OR.
8. Dunn, C., and C. Paukert. 2016. Emerging distributional patterns and preliminary results from the Missouri Mid-Sized Rivers Fish Sampling Protocol: A scalable multi-method tool for studying Missouri's large-river fish assemblages. Missouri Natural Resources Conference, Osage Beach, MO.
9. Fowler, D, M. P. Vrtiska and E. B. Webb. 2015. Which geese are being harvested? Body condition of lesser snow (*Chen caerulescens caerulescens*) and Ross's Geese (*C. rossii*) harvested by different methods during the Light Goose Conservation Order. North American Arctic Goose Conference, Winnipeg, MB, Canada.
10. Fowler, D. N., E. B. Webb, K. A. Hobson, and M. P. Vrtiska. 2016. Using Isotopic Signatures of Arctic and Sub-arctic Nesting Colonies to Determine Breeding Origin of Harvested Lesser Snow Geese. 7<sup>th</sup> North American Duck Symposium, Annapolis, MD.
11. Fowler, D. N., M. P. Vrtiska, and E. B. Webb. 2016. Does body condition of lesser snow and Ross's Geese harvested during the Light Goose Conservation Order differ from the general population? Oral presentation. 2016 Annual Conference of The Wildlife Society, Raleigh, NC.
12. Glen, A. R., L. K. Lueckenhoff, M. C. Schrum, and A. E. Rosenberger. 2015. The effect of sculpturing on the comparability of external shell aging for freshwater mussels. Freshwater Mollusk Conservation Symposium (FMCS), St. Charles, MO.
13. Glen, A. R., L. K. Lueckenhoff, M. C. Schrum, and A. E. Rosenberger. 2015. Comparability of external shell aging techniques for sculptured vs. non-sculptured freshwater mussels. Missouri Natural Resources Conference (MNRC), Osage Beach, MO.

14. Guyton, J. E. Webb, C. Paukert, and F. Nelson. 2016. Don't put a fish out of water: developing sampling protocols to integrate fish into wetland management decisions. American Fisheries Society Annual Meeting, Kansas City, MO.
15. Guyton, J. E. Webb, C. Paukert, and F. Nelson. 2016. Don't put a fish out of water: developing sampling protocols to integrate fish into wetland management decisions. American Fisheries Society Annual Meeting, Kansas City, MO.
16. Guyton, J. E. Webb, C. Paukert, and F. Nelson. 2015. Developing a rapid assessment protocol to monitor fish in Missouri wetlands. Midwest Fish and Wildlife Conference, Grand Rapids, MI.
17. Guyton, J. E. Webb, C. Paukert, and F. Nelson. 2016. Nothing but net: Developing a rapid assessment protocol to monitor fish in Missouri wetlands. Missouri Natural Resources Conference. Osage Beach, MO.
18. Healy, B., C. P. Paukert, and W. E. Pine, III. 2015. Integrating Cooperative Ecosystem Study Units into Fisheries Management Planning at Grand Canyon National Park. Biennial Conference of Science and Management of the Colorado Plateau. Flagstaff, AZ.
19. Hidden, B., E. Webb, A. Raedeke, and S. Gao. 2016. An Aerial Strip-transect Survey to Assess Autumn Waterfowl Distribution and Abundance in Missouri. The Wildlife Society, Annual meeting Raleigh, NC.
20. Hidden, B., E. Webb. and A. Raedeke. 2015. Modeling inundation probability for Missouri wetlands within the Grand and Missouri River Ecoregion. Midwest Fish and Wildlife Conference, Indianapolis, IN.
21. Hidden, B., E. Webb. and A. Raedeke. 2015. Modeling probability of wetland inundation for the Grand and Missouri River Ecoregion in autumn. Society of Wetland Scientists, Annual Meeting, Providence, RI.
22. Hidden, B., E. Webb. and A. Raedeke. 2015. Modeling probability of wetland inundation for Missouri wetlands in autumn. Missouri Natural Resource Conference, Osage Beach MO.
23. Hidden, B., E. Webb., A. Raedeke, and S. Gao. How Many Birds Are We Missing? Assessing Waterfowl Distribution and Abundance in Missouri Using an Aerial Strip-transect Survey. North American Duck Symposium, Annual meeting 2016, Annapolis MD.
24. Hidden, B., E. Webb., and A. Raedeke. 2015. Modeling Inundation Probability of Missouri Wetlands During Fall Waterfowl Migration. The Wildlife Society, Annual meeting, Winnipeg, Manitoba, Canada.
25. Hidden, B., E. Webb., and A. Raedeke. 2016. Modeling Inundation of Missouri's National Wetland Inventory Wetlands in Autumn. North American Duck Symposium, Annual meeting, Annapolis MD.
26. Hidden, B., P. Marley, E. Webb., A. Raedeke, S. Gao. 2015. Modeling inundation probability for Missouri wetlands within the Grand and Missouri River Ecoregion. Missouri GIS Conference, Springfield, MO.
27. Hill, E., E. Webb. and D. Mengel. 2015. Connecting wetland management strategies to the habitat relationships of secretive marsh birds on public wetlands in Missouri. Midwest Fish and Wildlife Conference, Indianapolis, IN.
28. Hill, E., E. Webb. and D. Mengel. 2015. How wetland management strategies affect the habitat associations of secretive marsh birds on public wetlands in Missouri. Missouri Natural Resources Conference, Osage Beach, MO.
29. Hill, E.B., E.B. Webb and D. Mengel. 2015. Use of a dynamic occupancy model to evaluate secretive marsh bird response to wetland management practices during spring migration. Annual Waterbirds Society Meeting, Bar Harbor, ME.
30. Hoem Neher, T., A.E. Rosenberger, C. Zimmerman, C. Walker, and S. Baird. 2015. Deciphering estuary use by juvenile coho salmon: building a strong portfolio. Annual Meeting of the American Fisheries Society, Portland, OR.
31. Key, K., G. Lindner, K. Bouska, and A. Rosenberger. 2016. Using maxent to generate a fundamental niche model for diverse mussel assemblages within the northeastern Ozark region of Missouri. Missouri Natural Resource Conference, Osage Beach, MO.

32. Kleekamp, E., and C. Paukert. 2015. A bottom-up approach to characterizing least disturbed stream habitat. American Fisheries Society Annual Meeting, Portland, OR.
33. Kleekamp, E., and C. Paukert. 2015. Assessing Environmental Drivers of Fish Community Structure. Midwest Fish and Wildlife Conference, Indianapolis, IN.
34. Kleekamp, E., and C. Paukert. 2016. Evaluating a physical habitat-based classification of Missouri's stream fish communities. Missouri Natural Resources Conference, Osage Beach, MO.
35. Laske, S, A Rosenberger, W Kane, M Wipfli, C Zimmerman. 2015. Top-down effects of Ninespine Stickleback on invertebrate communities of small Arctic ponds: an experimental approach. Alaska American Fisheries Society Annual Meeting, Homer, AK.
36. Lindner, G. and A.J. Miller, 2015, How does stream restoration affect floodwave propagation in urban channels? Geological Society of America 2015 Annual Meeting, Baltimore, MD.
37. Lindner, G. K. Bouska, C. Paukert, R. Jacobson. 2016. Floodplain inundation mapping to support multi-objective restoration and management of conservation lands on the lower Missouri River. Midwest Fish and Wildlife Conference, Grand Rapids, MI.
38. Lindner, G., K. Bouska, K. Key, and A. Rosenberger. 2016. Maxent modeling for Missouri Ozark unionids with macroscale hydro-geomorphic variables. Midwest Fish and Wildlife Conference, Grand Rapids, MI.
39. Lindner, G., K. Bouska, R. Jacobson, and C. Paukert. 2016. Stakeholder-led Science: Engaging floodplain conservation land managers to identify and meet science needs. International Society for River Science Biennial Meeting, LaCrosse, WI.
40. Lueckenhoff, L. K. and A. E. Rosenberger. 2015. Intensive vs. extensive sampling methods: effectiveness of visual methods for assessing freshwater mussel communities. Freshwater Mollusk Conservation Symposium (FMCS), St. Charles, MO.
41. Mabery, M., C. Dunn, and C. Paukert. 2016. Population Dynamics of Gravel Chub in Two Missouri Rivers. Missouri Natural Resources Conference, Osage Beach, MO.
42. Mott, R. and A. Rosenberger. 2016. Water quality requirements and preferences of the Topeka Shiner. Missouri Natural Resources Conference, Osage Beach, MO.
43. Mott, R. and A.E. Rosenberger. 2016. Developing Non-lethal Methodology for Testing Thermal Optima and Tolerance in Small Prairie Stream Minnows. American Fisheries Society Annual Meeting, Kansas City, MO.
44. O'Daniels, S., D. Kesler, E. Webb, and S. Werner. 2015. Behavioral Evidence for Functionally Significant Sensitivity to Ultraviolet Wavelengths in a Woodpecker, *Dryocopus pileatus*. Midwest Fish and Wildlife Conference. Indianapolis, IN.
45. O'Daniels, S., D. Kesler, E. Webb, S. Werner, and J. Mihail. 2015. Functionally Significant Sensitivity to Ultraviolet Wavelengths in the Pileated Woodpecker: Implications for Woodpecker Interactions with Wood Decay Fungi and Anthropogenic Structures. American Ornithologists' Union and Cooper's Ornithological Society Joint Meeting. Norman, OK.
46. O'Daniels, S., D. Kesler, E.B. Webb, S. Werner, and J. Mihail. 2016. On the visual ecology of woodpeckers. North American Ornithological Conference, Washington, D.C.
47. O'Daniels, S., D. Kesler, E. Webb, S. Werner, and J. Mihail. 2016. Ultraviolet condition of wood may influence foraging substrate selection by Pileated Woodpeckers. 53<sup>rd</sup> Annual Animal Behavior Society Conference. Columbia, MO.
48. O'Daniels, S.T., D.C. Kesler, E.B. Webb, S.J. Werner, J.D. Mihail. 2016. Could spectral characteristics of decayed wood signal woodpeckers? 27th Vertebrate Pest Conference, Newport Beach, CA.
49. Paukert, C., J. Westhoff, and A. Pease. Effects of Climate Change on Smallmouth Bass in Midwestern US Streams. American Fisheries Society Annual Meeting, Portland, OR.
50. Schepker, T.S., T. LaGrange, D. Tillitt, E. Webb. 2016. Neonicotinoids; An Emerging Threat to Wetland-Dependent Wildlife? The Wildlife Society, Raleigh, NC.

51. Schepker, T.S., T. LaGrange, E. Webb. Mid-Latitudinal Wetlands during Migration. 2015 Rainwater Basin Joint Venture Information Seminar, Grand Island, NE.
52. Schepker, T.S., T. LaGrange, E. Webb. 2016. Evaluating Spring Food Resource Phenology For Dabbling Ducks In the Nebraska Rainwater Basin, USA. North American Duck Symposium 7. Annapolis, MD.
53. Schepker, T.S., T. LaGrange, E. Webb. 2016. Evaluating the Relationship between Food Availability and Landscape Structure in Determining Waterfowl Habitat use during Spring Migration. The Wildlife Society, Raleigh, NC.
54. Schepker, T.S., T. LaGrange, E. Webb. How do food availability and landscape structure influence dabbling duck distribution during spring migration? 2016 Rainwater Basin Joint Venture Information Seminar, Grand Island, NE
55. Schepker, T.S., T. LaGrange, E. Webb. 2016. Evaluating the relationship between local food availability and wetland landscape structure in determining dabbling duck habitat use during migration. North American Duck Symposium 7, Annapolis, MD.
56. Schepker, T.S., T. LaGrange, J. Tapp, E. Webb. 2016. Are local site conditions or landscape structure more important in predicting waterbird distribution? Testing competing hypotheses across the non-breeding season. North American Ornithological Conference, Washington, D.C.
57. Schrum, M. and A. Rosenberger. 2016. Development of sampling protocols for freshwater mussel density estimates in the Meramec River Basin, Missouri. Missouri Natural Resources Conference, Osage Beach, MO.
58. Schrum, M. and A.E. Rosenberger. 2016. Development of sampling protocols for freshwater mussel density estimates in the Meramec River Basin, Missouri. Midwest Fish and Wildlife Conference, Grand Rapids, MI.
59. Schrum, M.C. and A.E. Rosenberger. 2014. Sampling efficiency of visual 0.25 m<sup>2</sup> quadrat method for freshwater mussel density estimates in the Meramec Basin, Missouri. Midwest Fisheries and Wildlife Conference, Indianapolis, IN.
60. Schrum, M.C. and A.E. Rosenberger. 2015. Comparison of visual and quantitative methods for freshwater mussel density estimates in the Meramec River Basin, Missouri. Freshwater Mollusk Conservation Society Conference, Saint Louis, MO.
61. Schrum, M.C. and A.E. Rosenberger. 2015. Sampling efficiency of visual 0.25 m<sup>2</sup> quadrat method for freshwater mussel density estimates in the Meramec basin, Missouri. Missouri Natural Resources Conference, Osage Beach, MO.
62. Schrum, M.C., A.E. Rosenberger, and S. McMurray. 2015. Effectiveness of visual quadrats for freshwater mussel density estimates. American Fisheries Society, Portland, OR.
63. Schwoerer, J. H. Dodd, and C. Paukert. 2015. Using habitat, climate, and competitive interactions to predict co-occurring smallmouth bass and largemouth bass in the Ozark National Scenic Riverways. Missouri Natural Resources Conference, Osage Beach, MO.
64. Schwoerer, J., C. Paukert, and H. Dodd. 2015. Consistency among biotic indices to represent environmental conditions: implications for biotic assessments. American Fisheries Society Annual Meeting, Portland, OR
65. Schwoerer, J., C. Paukert, and H. Dodd. 2015. Vulnerability of stream communities within the National Park Services' Heartland Inventory and Monitoring Network. Midwest Fish and Wildlife Conference, Grand Rapids, MI.
66. Schwoerer, J., C. Paukert, and H. Dodd. 2016. Stream community vulnerability to climate and land use change within the National Park Services' Heartland Inventory and Monitoring Network. Missouri Natural Resources Conference, Osage Beach, MO.
67. Schwoerer, J., H. Dodd, and C. Paukert. 2016. Relationships among biotic indices and their responses to ecological gradients in least-disturbed Ozark streams. American Fisheries Society Annual Meeting, Kansas City, MO.

68. Schwoerer, J., H. Dodd, and C. Paukert. 2016. Using habitat, climate, and biotic interactions to predict co-occurring smallmouth bass and largemouth bass in the Ozark National Scenic Riverways. American Fisheries Society Annual Meeting, Kansas City, MO.
69. Sievert, N., C. Paukert, and J. Whittier. 2015. Conserving Missouri's Stream Fish Through Protected and Priority Areas: An Evaluation of Species Representation and Conservation Opportunities. Missouri Natural Resources Conference, Osage Beach, MO.
70. Sievert, N., C. Paukert, and J. Whittier. 2015. Incorporating Existing Conservation Networks into Freshwater Conservation Planning. American Fisheries Society Annual Meeting, Portland, OR
71. Sievert, N., C. Paukert, and J. Whittier. 2015. Prioritizing Stream Conservation in Missouri's Conservation Networks: Applications and Lessons for Landscape Scale Freshwater Conservation Planning. Midwest Fish and Wildlife Conference, Indianapolis, IN.
72. Sievert, N., W. Daniel, Y. Tang, C. Paukert, D. Infante, J. Whittier, K. Herreman, J. Stewart, T. Wagner. 2016. An Assessment of Potential Changes in Habitat Classes Due to Climate Change in the Northeast Climate Science Center Region. Midwest Fish and Wildlife Conference, Grand Rapids, MI
73. Tracy Smith, E., P. Blanchard, M. Combes, D. Lobb, C. Paukert, and J. Persinger. 2015. Evaluating Fish Community Changes to Stream Flow Alterations. American Fisheries Society Annual Meeting, Portland, OR.
74. Tracy-Smith, E., P. Blanchard, M. Combes, D. Lobb, C. Paukert, and J. Persinger. 2016. Assessment of Flow Alterations for Missouri Streams. Missouri Natural Resources Conference, Osage Beach, MO.
75. Tracy-Smith, E., P. Blanchard, M. Combes, D. Lobb, C. Paukert, and J. Persinger. 2015. Assessment of Available Missouri Ecological Flow Data. Missouri Natural Resources Conference, Osage Beach, MO.
76. Westhoff, J. T., R. DiStefano, C. Ames, and A.E. Rosenberger. 2015. Life history of the Freckled Crayfish *Cambarus maculatus* in two Missouri Streams. Southern Division of the American Fisheries Society, Savannah, GA.
77. Westhoff, J., C. Rice, and A. Rosenberger. 2016. Research can inform management of aquatic ectotherms facing a thermally dynamic future: a crayfish example. Missouri Natural Resources Conference, Osage Beach, MO.
78. Westhoff, J., R. DiStefano, C. Ames, and A. Rosenberger. 2015. Life history of the Freckled Crayfish in two Missouri streams. Missouri Natural Resources Conference, Osage Beach, MO.
79. Whittier, J., J. Westhoff, and C. Paukert. 2016. A comparison of accuracy and precision among temperature loggers at typical stream temperatures. Missouri Natural Resources Conference, Osage Beach, MO.



## THESES AND DISSERTATIONS

### 2015-PRESENT

Faulkner, J. 2015. Multi-scale Resource Selection of Niangua Darters in the Osage River Basin, Missouri. M.S. Thesis, University of Missouri, Columbia. C. P. Paukert, advisor.

Hill, E. 2015. Linking Wetland Management Decisions to Secretive Marsh Bird Habitat Use During Spring Migration and Summer Breeding on Public Wetlands in Missouri. M.S. Thesis, University of Missouri, Columbia. E. B. Webb, advisor.

Kleekamp, E. 2016. Streams in a Changing Landscape: Identifying Candidate Reference Reaches to Assess the Physical and Biotic Integrity of Missouri's Wadeable Streams. M.S. Thesis, University of Missouri, Columbia. C. P. Paukert, advisor.

Lueckenhoff, L. 2015. Development of Standardized Visual Sampling Methods for Assessing Community Metrics of Unionoid Mussel Species and Tribal Groups in Missouri. M.S. Thesis, University of Missouri, Columbia. A. R. Rosenberger, advisor.

O'Daniels, S.T. 2016. Light Reflectance Patterns of Decayed Wood with Implications for the Visual Ecology of Woodpeckers. M.S. Thesis, University of Missouri, Columbia. E. B. Webb, advisor.

Schwoerer, J. 2016. Assessing the Vulnerability of Stream Communities and the Consistency and Use of Biotic Indices in Least-Disturbed Streams. M.S. Thesis, University of Missouri, Columbia. C. P. Paukert, advisor.



Sampling mussel habitat in an Ozark river.

## COMMITTEES AND OTHER PROFESSIONAL SERVICE

### 2015 TO PRESENT

#### **Craig Paukert**

- Invited panel member, Multi-institutional Land-grant Partnership Initiative, to develop pathways for underrepresented student to obtain graduate degrees and agency employment, University of Puerto Rico, 2016
- IUCN Red List Status Report Update Lead for Paddlefish, 2016-present
- Past President, Education Section of the AFS, 2015-present
- American Fisheries Society Governing Board, 2013-2015
- Congressional Briefing, climate change impacts to inland fisheries, 2016
- Invited Member, Science Committee, National Fish Habitat Initiative, 2005-present
- Co-Chair, Symposium Committee, AFS Annual Meeting, 2015-2016
- Nominating Committee, American Fisheries Society, 2015 - present
- Panel member, USGS role for landscape science to Assoc. Dir Kinsinger, 2015-2016
- Committee member, NSF NEON sampling protocol development for lakes and streams, 2013-2015
- Invited member, Biodiversity workgroup, Global Inland Fisheries Conference, Rome, 2016
- Guest Editor, Reviews in Fish Biology and Fisheries, 2016-present
- Guest Editor, Fisheries, American Fisheries Society, 2015-2016
- Outside member tenure/promotion review, Texas Tech University, 2015
- Michigan St Univ and USGS Science To Action Fellowship, 2014-present
- USFWS, Missouri River Effects Analysis Expert Panel, 2014-2015
- USFWS, Midwest Region, Committee on Fish Passage for WI River, 2014-2015

#### **Amanda Rosenberger**

- Freshwater Mussel Conservation Society, Development Team Core Leader, Professional Development Ad-hoc Committee, 2016 - present
- American Fisheries Society, Co-Chair, Education Section Best Student Presentation Award Committee, 2016 - present
- American Fisheries Society, Past-President, Missouri Chapter, 2016
- American Fisheries Society, President, Missouri Chapter, 2015-16
- American Fisheries Society, President-Elect, Missouri Chapter, 2014-2015
- Symposium co-organizer, Midwest Fish and Wildlife Conference, 2015
- Univ. of Central Missouri, Advisory Board, Department of Biology and Agriculture 2016
- Strategic Planning Committee, Univ. of Missouri School of Natural Resources, 2015 - present
- OSHER Continuing Education Program for Senior citizens, University of Missouri Extension, Volunteer Instructor, 2014 - present
- Speaker, Missouri Master Naturalists 2015-2016

**Lisa Webb**

- Associate Editor, *Wildlife Society Bulletin*, 2011 - present
- Vice Chair/Chair/Past Chair, TWS Wetlands Working Group. 2013 - present
- Diversity Committee, MU School of Natural Resources
- Search Committee for Water Quality Faculty Position, University of Missouri School of Natural Resources
- Science Program Committee member, 7<sup>th</sup> North American Duck Symposium Conference 2014-2016
- Speaker, Missouri Master Naturalists Lake of the Ozarks Chapter 2015

**Elisa Baebler, M.S. Student Advised by Paukert**

- Posters Sub-Committee. 146th Annual Meeting of the American Fisheries Society, 2016
- Treasurer, Wildlife and Fisheries Science Graduate Student Organization, 2016-2017
- Wildlife and Fisheries Youth Outreach Booth, South Farm Showcase, Columbia, 2016

**Kristen Bouska, Post-Doctoral Researcher Supervised by Paukert and Rosenberger**

- Symposium organizer, American Fisheries Society Annual Meeting, 2015
- Missouri Chapter of the American Fisheries Society newsletter Co-Editor, 2014-2015

**Corey Dunn, Ph.D. Student Advised by Paukert**

- Co-advisor for undergraduate-lead research project, 2015-2016
- Candy Darter Conservation Committee, 2016
- Leader of biannual stream biomonitoring for the Fisheries and Aquatic Sciences Society at the University of Missouri, 2015 – 2016
- President of Wildlife and Fisheries Sciences Graduate Student Organization, 2015

**Drew Fowler, Ph.D. Student Advised by Webb**

- Co-advisor for undergraduate-led research project, 2015 – 2016
- Graduate advisor to MU Chapter of Ducks Unlimited

**Julia Guyton, M.S. Student Advised by Webb and Paukert**

- President, Mizzou Student Association for Fire Ecology/Tiger Fire Crew, 2016-2017
- Vice President, MU Wildlife and Fisheries Graduate Student Organization, 2015-2016
- Logistics Coordinator, MU Student Association for Fire Ecology/Tiger Fire Crew, 2014-16

**Brian Hidden, M.S. Student Advised by Webb**

- Graduate Professional Council representative for School of Natural Resources 2015-2016

**Kayla Key, Ph.D. Student Advised by Rosenberger**

- Planning Committee, Organization of Fish and Wildlife Information Managers Annual Meeting, 2016
- President, MU Wildlife and Fisheries Sciences Graduate Student organization, 2016
- Member and seminar lunch coordinator for Fish and Wildlife Department GSA, 2015

**Ethan Kleekamp, M.S. Student Advised by Paukert**

- President, Columbia MO Quail Forever Chapter
- MU Fisheries and Wildlife Sciences Graduate Student Organization Representative, 2015-2016

**Michael Moore, Ph.D. Student Advised by Paukert**

- Member, North American Sturgeon and Paddlefish Society Student Subunit, 2016 - present
- IUCN Red List Assessment Working Group for Sturgeon and Paddlefish, 2016 - present

**Rachel Owen, Ph.D. Student Advised by Webb**

- Appointed Chair, ASA-CSSA-SSSA Graduate Student Committee, 2016
- Appointed Member, SSSA Graduate Student Committee, 2015-2017
- Appointed Member, SSSA Undergraduate Research Symposium Committee, 2016-2018
- Vice President, MU Graduate Student Association, 2016-2017
- SNR Representative, MU Graduate Professional Council, 2016-2017
- Associate Member, Sigma Xi 2015 - present

**Zach Morris, M.S. Student Advised by Paukert**

- Board of Directors, Conservation Federation of Missouri, 2016-present

**Matthew Schrum, M.S. Student Advised by Rosenberger**

- Treasurer, MU Wildlife and Fisheries Sciences Graduate Student Organization, 2015

**Travis Schepker, M.S. Student Advised by Webb**

- Search Committee for Water Quality Faculty Position, University of Missouri School of Natural Resources, 2016

**Jacob Schwoerer, M.S. Student Advised by Paukert**

- Beginner/Intermediate GIS for Fisheries Scientists, Continuing Education Instructor, American Fisheries Society, 2015, 2016
- MU Fisheries and Wildlife Sciences Graduate Student Organization Representative, 2015-2016

**Nick Sievert, M.S. Student Advised by Paukert**

- Secretary/Treasurer, Fisheries Information and Technology Section of the American Fisheries Society, 2015 - present
- Newsletter Editor, Fisheries Information and Technology Section of the American Fisheries Society, 2012 - 2016
- North Central Division Representative, Student Subsection of the Education Section of the American Fisheries Society, 2015 - 2016
- President, Fisheries and Wildlife Sciences Graduate Student Organization, University of Missouri, 2015 - 2016

- Chair and Fisheries and Wildlife Representative, School of Natural Resources Graduate Student Organization, University of Missouri, 2015 - 2016
- Manuscript review for Journal of Applied Ecology, Reviews in Fish Biology and Fisheries, and USGS peer review, 2016
- Program Committee and Posters Sub-Committee. 146<sup>th</sup> Annual Meeting of the American Fisheries Society, 2016
- Symposium Organizer, “Climate Change Effects on Fish Habitat”, 145<sup>th</sup> Annual Meeting of the American Fisheries Society, 2015
- Beginner/Intermediate GIS for Fisheries Scientists, Continuing Education Instructor, American Fisheries Society, 2015, 2016
- Wildlife and Fisheries Youth Outreach Booth, South Farm Showcase, Columbia, 2016
- Guest Lecturer in Ecosystem Management, Ecology and Renewable Resource Management, and Fish Ecology, University of Missouri, 2015-2016

**Emily Tracy-Smith, Sr. Research Specialist Advised by Paukert**

- Symposium Coordinator, American Fisheries Society Annual Meeting, 2016
- Newsletter Editor, Missouri Chapter of the American Fisheries Society, 2015 - present
- Member of the Conference Planning Committee, Organization of Fish and Wildlife Information Managers, 2016

**Jacob Westhoff, Post Doctoral Researcher Co-Advised by Paukert and Rosenberger**

- Editorial Board, Freshwater Crayfish, 2015



Participants at a workshop held on 22 May 2016 in Busan, South Korea to identify how to conduct an assessment on the effects of climate change on global inland fisheries. Participants represented government agencies and NGS from the US, Canada, The UK, FAO, Vietnam, Laos, Tanzania, and China.

## AWARDS AND RECOGNITION

2015 TO PRESENT



Diana Hallett (left) and the MU College of Agriculture, Food, and Natural Resources Dean Tom Payne (right) with 2016 D.L. Hallett Fellowship winner, Julia Guyton.

**Craig Paukert**

- US Geological Survey STAR Award, Superior Performance Achievement, 2015, 2016
- US Geological Survey STAR Award for Helping with Landscape Science Initiative, 2016
- Missouri Chapter of the American Fisheries Society Fisheries Excellence Award, 2016
- Invited presentation, U.S. Geological Survey Columbia Environmental Research Center, 2015
- Invited presentation, Utah State University, 2016
- Invited presentation, Iowa State University, 2016

**Amanda Rosenberger**

- Promotion to Cooperative Associate Professor, University of Missouri, 2015
- Promotion through Research Grade Evaluation process within USGS, 2015
- Missouri Chapter of the American Fisheries Society Certificate of Appreciation, 2015
- Invited presentation, U.S. Geological Survey Columbia Environmental Research Center, 2016
- Invited presentation, University of Texas at Tyler, 2015

**Lisa Webb**

- USGS STAR Award, Superior Performance Achievement, 2015, 2016
- Promotion through Research Grade Evaluation process within USGS, 2015
- Invited presentation, Mississippi Flyway Technical Committee Meeting 2016
- Invited presentation, U.S. Geological Survey Columbia Environmental Research Center, 2016

**Corey Dunn, Ph.D. Student Advised by Paukert**

- Missouri Chapter of the American Fisheries Society Student Achievement Award, 2016.
- Best Student Aquatics Paper, Missouri Natural Resources Conference, 2015

**Drew Fowler, PhD Student Advised by Webb**

- Graduate Research Fellowship, Institute for Wetland and Waterfowl Research, DU Canada 2016
- North American Artic Goose Travel Grant, 2015

**Julia Guyton, M.S. Student Advised by Webb and Paukert**

- TWS Wetlands Working Group Student Travel Award, TWS Annual Meeting, 2016
- American Fisheries Society Best Student Poster Award Finalist, American Fisheries Society Annual Meeting, 2016
- D.L. Hallett Fellowship, Department of Fisheries and Wildlife, MU, 2016
- University of Missouri Graduate Fellowship, MO Chapter of The Wildlife Society, 2016
- James D. Chambers Memorial Scholarship, MO Chapter of The Wildlife Society, 2016
- Janice Lee Fenske Memorial Award Finalist, 2016
- Phi Kappa Phi Graduate Honor Society, 2015-present
- Conservation Leaders for Tomorrow Scholarship, Max McGraw Wildlife Foundation and the Wildlife Management Institute, 2015

**Brian Hidden, M.S. Student Advised by Webb**

- 3<sup>rd</sup> Place Poster Presentation, 7<sup>th</sup> North American Duck Symposium, 2016
- North American Duck Symposium Travel Award, 2016
- D.L. Hallett Fellowship, Department of Fisheries and Wildlife, MU 2015

**Evan Hill, M.S. Student Advised by Webb**

- Missouri Chapter of The Wildlife Society Fellowship, 2015

**Jordan Holtswarth, Undergraduate Research Advised by Webb**

- Undergraduate Research Scholarship, College of Agriculture, Food and Natural Resources, 2016

**Kayla Key, Ph.D. Student Advised by Rosenberger**

- Research Scholarship Award, Organization of Fish and Wildlife Information Managers, 2016
- Best Student Aquatic Poster Presentation, Missouri Natural Resources Conference, 2016
- Invited Presentation, Organization of Fish and Wildlife Information Managers, 2016

**Kyle Kuechle, M.S. Student Advised by Webb**

- Edward D. and Sally M. Futch Graduate Fellowship, Institute for Wetland and Waterfowl Research, DU Canada, 2016

**Garth Lindner, Post-Doctoral Researcher Advised by Paukert and Rosenberger**

- Invited Presentation, University of Texas at Tyler, 2016

**Leslie Luekenhoff, M.S. Student Advised by Rosenberger**

- Freshwater Mollusk Conservation Society Travel Award, 2015
- University of Missouri Agricultural Association Award, 2015

**Anson Main, Post-Doctoral Researcher Advised Webb**

- Session Chair, Society of Environmental Toxicology and Chemistry World Congress, 2016
- Invited Presentation, North Dakota State University Biology/Water Resources Research Institute Seminar Series, 2016
- AGRO New Investigator Award Finalist, American Chemical Society National Meeting, 2016

**Mary Mabery, Undergraduate Student Advised by Paukert**

- Conservation Federation of Missouri Stegner Scholarship, 2015

**Michael Moore, Ph.D. Student Advised by Paukert**

- Outstanding Teaching Assistant, Virginia Tech Department of Fish and Wildlife Conservation, 2016
- Best Student Paper Presentation, Virginia Chapter of the American Fisheries Society Annual Meeting, 2016
- Selected as one of four participants in the Emerging Leaders Mentorship Award Program for the American Fisheries Society at the National Conference, 2016

**Rory Mott, MS Student Advised by Rosenberger**

- Finalist, Best Student Poster Award Symposium, American Fisheries Society Annual Meeting, 2016

**Sean O'Daniels, M.S. Student Advised by Webb**

- Transworld Airline Scholarship, University of Missouri, 2015

**Rachel Owen, Ph.D. Student Advised by Webb**

- C.E. Marshall Scholarship from Department of Soil, Environmental, and Atmospheric Sciences, 2016
- Future Leaders in Science Award from American Society of Agronomy, 2016

**Matthew Schrum, M.S. Student Advised by Rosenberger**

- Best Student Aquatics Poster Presentation, Missouri Natural Resources Conference, 2015
- Carl Morrow Graduate Scholarship: Fisheries, 2015

**Travis Schepker, M.S. Student Advised by Webb**

- Best Poster Presentation, 7<sup>th</sup> North American Duck Symposium, 2016
- Janice Lee Fenske Memorial Award finalist, 2016
- Conservation Federation of Missouri Carl Morrow Fellowship, 2015
- Audubon Society of Missouri Graduate Research Scholarship, 2015

**Jacob Schwoerer, M.S. Student Advised by Paukert**

- Best Student Aquatics Paper, Missouri Natural Resources Conference, 2016
- Finalist, Best Student Poster Award Finalist, American Fisheries Society Annual Meeting, 2016

**Nick Sievert, Ph.D. Student Advised by Paukert**

- Charles P. Bell Conservation Scholarship, Conservation Federation of Missouri Charitable Trust, 2016
- Carl Morrow Graduate Scholarship for Fisheries, Conservation Federation of Missouri Charitable Trust, 2016
- Outstanding Thesis Award Finalist, University of Missouri, Department of Fisheries and Wildlife Sciences, 2016

**Emily Tracy-Smith, Sr. Research Specialist Advised by Paukert**

- MU Staff Development Award to attend the Organization of Fish and Wildlife Information Managers Annual Conference, 2015.

**Brendan Woodall, Undergraduate Research Advised by Webb**

- Undergraduate Research Scholarship, College of Agriculture, Food and Natural Resources 2015
- Conservation Federation of Missouri Forestry Scholarship, 2015



Brian Hidden (left), and Travis Schepker (right) with Lisa Webb with their First (Travis) and Third (Brian) Place Student Poster Awards and the North American Duck Symposium in April 2016.

## SCIENCE IN THE NEWS AND OUTREACH

### BELOW IS A SUMMARY OF OUTREACH EVENTS AND COOPERATIVE RESEARCH UNIT SCIENCE THAT MADE THE NEWS

2015 TO PRESENT



Craig Paukert (right) and former post-doctoral researcher James Whitney (second from right) at a June 13, 2016 Congressional staffer briefing on climate change effects on inland fish. Others pictured are Len Hunt (left), Ontario Ministry of Natural Resources and Forestry and Abigail Lynch (second from left), USGS National Climate Change and Wildlife Science Center.

### **Craig Paukert**

- Briefed Capitol Hill Congressional staffers on the effects of climate change on inland fish, 2016
- Briefed Department of Interior Deputy Assistant Secretary for Water and Science on the effects of climate change on inland fish, 2016
- Wyoming NPR Radio discussed our research on how climate change affects inland fish, 2016
- Thunder Bay Ontario Radio discussed our research on how climate change affects fish, 2016
- Field and Stream webpage highlighted our research on how climate change affects fish, 2016
- Interview from Public News Service on how climate change may affect Missouri fish and wildlife, 2016
- Wrote an article on what the Missouri Cooperative Research Units is and how they contribute to Missouri's conservation legacy in the July 2016 issue of Conservation Federation Magazine
- The MU College of Agriculture, Food and Natural Resources highlighted work on climate change and inland fish, 2016
- Was 'Collaborator of the Month' for the MU College and Agriculture, Food, and Natural Resources related to work climate change and inland fish, 2016
- Was on USGS main page on project related to climate change and inland fish, 2016

### **Amanda Rosenberger**

- Presented a summary of Missouri fish diversity, anatomy, and ecology for the Missouri Master Naturalist Group, 2016
- Interviewed for the Great Outdoors Radio Show, Subject: Crayfish and Mussels, 2016
- Presented a summary of crayfish diversity, biology, ecology, and conservation issues for the Missouri Master Naturalist Group, 2015
- Organized a discussion series on the book "For the Love of Rivers" for the OSHER lifelong learning institute, 2016
- Organized a Seminar Series on Evolutionary Biology for the Osher Lifelong Learning Institute, 2015

### **Lisa Webb**

- The MU College of Agriculture, Food and Natural Resources highlighted research on mallard habitat selection during migration, 2015
- Presented an overview of wetland ecosystem functions in Missouri for the Missouri Master Naturalists, 2015
- Presentation to the MU chapter of The Wildlife Society on waterfowl reliance on Missouri wetlands, 2015
- Organized MO Cooperative Fish and Wildlife Students to highlight their research on the national Cooperative Research Units webpage and Twitter account

### **Drew Fowler, Ph.D. Student Advised by Webb**

- Interviewed by Harvest Public Media and NPR's Here and Now for research on lesser snow goose body condition

### **Michael Moore, Ph.D. Student Advised by Paukert**

- Interviewed on National Public Radio Morning Edition about microfishing, the art of catching very small fish, 2016