# 2016 Annual Report
# Arkansas Cooperative Fish

# & Wildlife Research Unit

**ARKANSAS COOPERATIVE**
**FISH AND WILDLIFE**
**RESEARCH UNIT**

**2016 ANNUAL REPORT**

**Arkansas Cooperative Fish and Wildlife Research Unit**
**University of Arkansas**
**Department of Biological Sciences**
**Science and Engineering Building, Room 601**
**Fayetteville, AR 72701**

Arkansas Cooperative
Fish & Wildlife Research Unit

**The unit is a cooperative program of the:**

**U.S. Geological Survey**
**Arkansas Game and Fish Commission**
**University of Arkansas**
**Wildlife Management Institute**

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## INTRODUCTION

Arkansas Cooperative Fish and Wildlife Research Unit first opened its doors in August of 1988 as one of the four units initiated that year, and one of the 40 coop units across the country associated with land grant universities, state fish and wildlife agencies, and the U.S. Geological Survey. The purpose of these units is to train graduate students in scientific methods of fish and wildlife management.

Over the past 28 years, the Arkansas Cooperative Research Unit has become an active part of state and federal research efforts in Arkansas and across the Nation. By the end of our twenty-eighth year, Arkansas Cooperative Research Unit will have initiated many research projects with Arkansas Game and Fish Commission, U.S. Fish and Wildlife Services, U.S. Geological Survey – Biological Resources Division, National Park Services, and other federal, state and private organizations as sponsors. These projects have funded the research of 65 MS and 13 PhD students, most of which are now working as professional biologists. Presently those students are employed by federal, state, and private agencies, colleges and universities, or are continuing their graduate degrees at other schools. Arkansas Cooperative Research Unit leaders and students have published 166 scientific and technical publications listing the unit and our cooperators in byline and acknowledgements, and another five publications have been accepted or submitted for publication. Unit leaders and Assistant leaders have taught many classes in fisheries and wildlife. Finally, including base funds and contracts, Arkansas Cooperative Research Unit has brought more than $19,466,895 directly into the community.

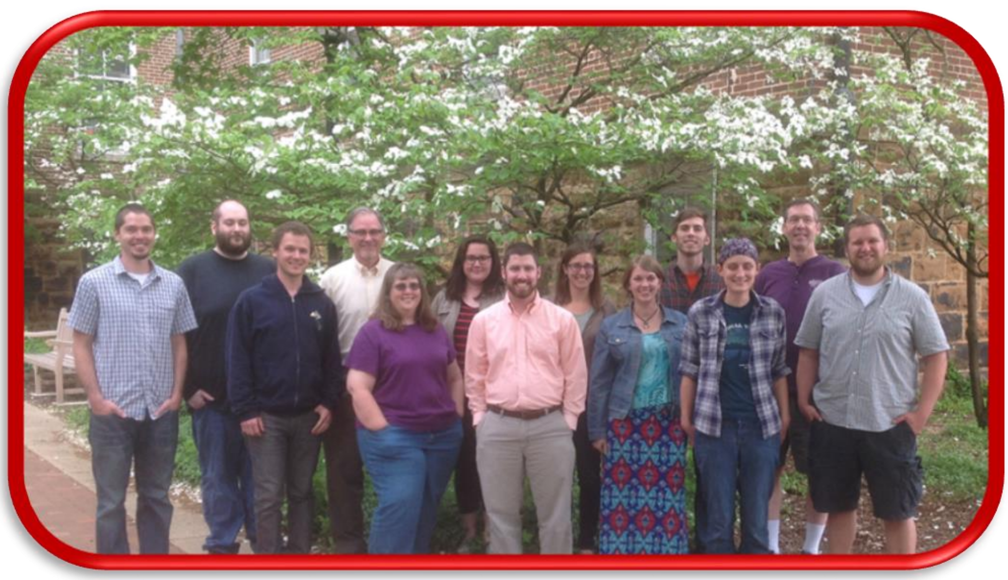
During the past quarter of a century, Arkansas Cooperative Research Unit has gone through a number of changes. We have changed our federal cooperator from U.S. Fish and Wildlife Services to National Biological Survey to National Biological Service, and we now reside within the U.S. Geological Survey. Our university department changed from Zoology to Biological Sciences and then incorporating the departments of Botany and Microbiology. We have seen eleven departmental chairs (Amlaner, Geren, Kaplan, Talburt, Rhoads, Roufa, Davis, Smith, Spiegel, Beaupre, and Henry), two unit leaders (Johnson and Krementz), six assistant unit leaders (Annette, Martin, Griffith, Kwak, Thompson, and Magoulick), four administrative assistants (Kimbrough, Koldjeski, Parker and Moler), three post-doctoral assistants (LeMar, Lehnen, and Longing), and nine research specialist/technicians (Neal, Aberson, Vaughn, Thogmartin, Lichtenberg, Piercey, Bahm, Nault, and Kitterman).

**MISSION STATEMENT**

The mission of the Arkansas Cooperative Fish and Wildlife Research Unit is to conduct programs of research, graduate education, and technical assistance that address the needs of the State of Arkansas, the region, and the nation. Research programs will pursue both basic and applied scientific questions that are relevant to the management of fish, wildlife, and their habitats. Research topics will be pursued according to cooperator priorities, availability of collaborative expertise from cooperators, and funding opportunities.

The educational mission of the Arkansas Cooperative Fish and Wildlife Research Unit shall focus on graduate and post-graduate students. Activities will include teaching of formal graduate-level classes, chairing and serving on advisory committees, mentoring the professional development of students, and participation by unit scientists in academic programs of the University of Arkansas. Students should be educated, to prepare them for advancement in broad areas of natural resource management to serve as future leaders of resource management in the State of Arkansas, region, and country. Educational programs of the Arkansas Cooperative Fish and Wildlife Research Unit will be consistent with the professional standards and hiring practices of the cooperators, similar agencies elsewhere, and relevant professional societies involved with natural resource management.

Technical assistance will be provided to unit cooperators in the areas of scientific expertise of the unit. This can include assistance with interpretation of data, preparation and review of experimental designs, identification of specific research voids or needs, and rendering professional judgment. Such activities will generally serve to link the scientists' previously established expertise to specific needs of the cooperators or other related agencies.



*Front row, left to right: Christopher Middaugh, Joseph Moore, Diane Moler, Phillip Stephenson, Nicole Graham, Auriel Fournier, and Jacob McClain. Second row, left to right: Robert Fournier, David Krementz, Allyson Yarra, Lindsey Bruckerhoff, Nathan Flannery, and Daniel Magoulick. Not pictured: John Herbert, Cari Sebright, Philip Mariage, and Dustin Lynch. Photo by Becky Harris 2016 (BISC Department)*

**PERSONNELL AND COOPERATORS**

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**CURRENT GRADUATE STUDENTS**

Lindsey Bruckerhoff, (M.S., Fisheries – Magoulick)
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Robert Fournier (Ph.D., Fisheries – Magoulick)
Brittany Furtado, (Ph.D., Fisheries – Magoulick)
Nicole Graham (M.S., Fisheries – Magoulick)
John Herbert (M.S., Wildlife – Krementz)
Dustin Lynch (Ph.D., Fisheries – Magoulick)
Jacob McClain (M.S., Wildlife – Krementz)
Christopher Middaugh (Ph.D., Fisheries – Magoulick)
Joseph Moore (M.S., Wildlife – Krementz)
Cari Sebright (M.S., Wildlife – Krementz)
Phillip Stephenson (M.S., Wildlife – Krementz)
Allyson Yarra (M.S., Fisheries – Magoulick)

**RECENTLY GRADUATED**

Lindsey Bruckerhoff, M.S. – Fisheries
John Herbert, M.S. – Wildlife
Joseph Moore, M.S. – Wildlife
Dustin Lynch, Ph.D. – Fisheries
Cari Sebright, M.S. – Wildlife

**HOURLY TECHNICIANS AND VOLUNTEERS**

Dr. Brad Austin – Fisheries projects
Ms. Rachel Arthur – Fisheries projects
Mr. Brian Becker – General Help
Mr. Brandon Burdette - SARE
Ms. Brynna Bush-Pruett – General Help
Ms. Lindsey Bruckerhoff – Fisheries projects
Ms. Allyn Dodd – Fisheries projects
Mr. Nathan Flannery – Fisheries
Mr. Robert Fournier – Fisheries projects
Ms. Brittany Furtado – Fisheries projects
Ms. Azlee Goode – SARE
Ms. Nicole Graham – Fisheries projects
Mr. John Herbert – Mallards
Ms. Brin Kessinger – REU
Mr. Scott Koenigbauer – REU
Dr. Doug Leasure – Fisheries project
Mr. Dustin Lynch – Fisheries project
Ms. Katherine Magoulick – Fisheries projects
Mr. Elliet Maples – Fisheries projects
Mr. Philip Mariage – General Help and Bob White
Ms. Elizabeth Moore – Woodcock
Mr. Joseph Moore – Woodcock
Mr. Anthony Mucciarone – Fisheries projects
Mr. Erik Ostrum – SARE
Ms. Hailee Pavisich – Rails
Ms. Cari Sebright – Woodcock
Ms. Baily Stein – REU
Mr. Phillip Stephenson – Pollinator Diversity
Ms. Allyson Yarra – Fisheries Project

## RESEARCH AND FACULTY COLLABORATORS

Dr. David Andersen – U.S. Geological Survey, Minnesota Cooperative Fish and Wildlife Research Unit
Mr. Benny Bowers – Arkansas Game and Fish Commission
Dr. Bret Collier – Louisiana State University
Mr. Dan Collins – U.S. Fish and Wildlife Services
Dr. Tom Cooper – U.S. Fish and Wildlife Service
Dr. Jack Cothern – University of Arkansas
Mr. Richard Crossett – U.S. Fish and Wildlife Service
Mr. Robert J. DiStefano – Missouri Department of Conservation
Dr. Marlis Douglas – University of Arkansas
Dr. Michael Douglas – University of Arkansas
Dr. Ashley Dowling – University of Arkansas
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Mr. Josh Duzan – Biohydrologist, The Nature Conservancy
Mr. Kevin Eads – National Park Service

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Mr. Kyle Hedges – Missouri Department of Conservation
Mr. Mark Hutchings – Arkansas Game and Fish Commission
Mr. Clifton Jackson – Arkansas Game and Fish Commission
Mr. JA "Buck" Jackson – Arkansas Game and Fish Commission
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Dr. Sarah Lehnen – U.S. Fish and Wildlife Service
Mr. Frank Loncarich – Missouri Department of Conservation
Mr. Kevin Lynch – Arkansas Game and Fish Commission
Dr. Doreen Mengel – Missouri Department of Conservation
Mr. Nolan Moore – National Park Service
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Mr. Luke Naylor – Arkansas Game and Fish Commission
Mr. Shaun Oldenburger – Texas Parks and Wildlife
Dr. Jim Petersen – Hydrologist Study Unit Chief, Ozark Plateaus Study Unit USGS Arkansas Water Science Center
Mr. Jeffrey W. Quinn – Arkansas Game and Fish Commission
Dr. Andy Radaeke – Missouri Department of Conservation
Mr. Al Stewart – Michigan Department of Natural Resources
Mr. Brian Wagner – Arkansas Game and Fish Commission
Mr. Andy Weik – Ruffed Grouse Society
Mr. Jacob Westoff – PhD. Student, University of Missouri
Ms. Rhea Whalen – U.S. Forest Service
Dr. J.D. Willson – University of Arkansas

# CURRENT FISHERIES PROJECTS

*Scott Koenigbauer holding Smallmouth Bass in a local stream of NW Arkansas, photo by Chris Middaugh (AR Coop Unit 2016)*

*Ringed crayfish, photo by Allyson Yarra (AR Coop)*

# Predicting the Spread and Understanding the Ecological Impacts of Invasive Crayfish

| | |
|---|---|
| *Funding Source:* | University of Arkansas<br>Arkansas Cooperative Fish and Wildlife Research Unit |
| *Project Duration:* | March 2015 to May 2017 |
| *Principal Investigator:* | DANIEL D. MAGOULICK |
| *Graduate Student:* | NICOLE E. GRAHAM (M.S. Student) |

## Research Objectives:

1. Examine the effects of native and invasive species, source population, and stream drying on crayfish population dynamics and ecosystem structure and function.
2. Investigate the effects of native and invasive species and source population on crayfish chelae to carapace ratio.
3. Predict the potential distribution of *Orconectes neglectus* (ringed crayfish) using *Orconectes rusticus* (rusty crayfish) and *Orconectes virilis* (northern crayfish) as 'avatar' species.

## Management Implications:

1. Examining the relative effects of native and invasive species and source population will address questions concerning ecological redundancy and may provide important insight to managers regarding relative ecosystem effects.
2. This study will aid in identifying environmentally sensitive areas that may be susceptible to future invasions by *Orconectes neglectus.*

**Project Summary:**

Crayfish are considered keystone species that impact multiple aquatic tropic levels (Momot 1995), substantially influence aquatic production through the processing of course particulate organic matter (Whitledge and Rabeni 1997), and serve as prey for more than 200 species (DiStefano 2005). Out of 571 crayfish species and subspecies worldwide, 77 percent are native to North America (Taylor 2002). Around half of North American crayfish are considered in need of protection, and the spread of invasive crayfish is of notable concern (Taylor et al. 1996). Displacement of native crayfish by invaders is often attributed to predation, competition, transmission of diseases and interference with reproduction (Lodge et al. 2000). However, the role of abiotic disturbance in mediating the distributions and ecological impacts of invasive crayfish has received recent attention (Larson et al. 2009).

Abiotic disturbances can facilitate the establishment and spread of invasive species, as well as alter their ecological impacts (Hobbs and Huenneke 1992, D'Antonio 2000, Facon et al. 2006). Stream drying is a frequent disturbance in the Ozark Highlands of Missouri and Arkansas, an area with an array of diverse and endemic crayfish (Tissevil et al. 2013). One such endemic crayfish, *Orconectes eupunctus,* is being extirpated from areas within its range following the invasion of *Orconectes neglectus* (Pflieger 1996, Flinders and Magoulick 2005, Magoulick and DiStefano 2007). Recent research has demonstrated that stream drying may play a role in the effective establishment of *O. neglectus* and the subsequent displacement of *O. eupunctus* (Larson et al. 2009).

Additionally, Magoulick (2014) provides experimental evidence that suggests *O. eupunctus* and *O. neglectus* may be largely ecologically redundant. In a trait analysis of crayfish native to Missouri and Kentucky, Larson and Olden (2010) found traits of extralimital invasive crayfish from adjacent watersheds differ from traits of extraregional invasive crayfish from distant states or watersheds. Thus, extralimital invasions may vary from extraregional invasions with regard to displacement of native species and ecological redundancy (Magoulick 2014). Previous research has examined the comparative ecological impacts of native versus invasive crayfish (Usio et al. 2006, McCarthy et al. 2006, Magoulick 2014). However, few studies have investigated the relative ecological impacts due to extralimital invasions versus extraregional invasions.

We conducted a fully factorial mesocosm experiment examining the effects of native and invasive species, source population, and stream drying on crayfish population dynamics and ecosystem structure and function. Crayfish treatments included: *O. eupunctus* (native), *O. neglectus* (invasive) from an extralimital population in Arkansas, and *O. neglectus* (invasive) from an extraregional population in Kansas. Additional treatments included simulated stream drying and control. Response variables indicative of stream structure and function included: leaf decomposition, periphyton ash free dry mass, chlorophyll a, autotrophic index, *Chironimidae* abundance, macroinvertebrate richness, daytime oxygen exchange, and sediment levels. Additional response variables included crayfish growth and survival.

The ratio of crayfish chelae width to carapace length is considered a predictor of pinching strength in crayfish, and thus is a measure of competitive superiority (Claussen et al. 2008). We investigated the effects of native and invasive species and source population on crayfish chelae to carapace ratio. Chelae to carapace ratio was measured for all crayfish treatments included in the aforementioned mesocosm experiment to determine if this important predictor of competitive dominance differed among the treatments.

Mesocosm data was analyzed using two-way Analyses of Variance (ANOVAs) and binomial regressions to evaluate the effects of crayfish identity and drying on individual response variables. Crayfish chelae to carapace ratio was analyzed using ANOVAs to assess differences across crayfish treatments. Analyses were conducted in R (R Foundation, Vienna, Austria) using an alpha value of 0.05. Results indicate that crayfish growth was greatest in *O. neglectus* (AR) treatments. Chlorophyll a was greatest in *O. neglectus* (KS) treatments, although not significantly. Additionally, leaf decomposition was least in *O. eupunctus* treatments. Drying treatments reduced chlorophyll a, sedimentation, and *Chironomidae* abundance, and increased autotrophic index and oxygen exchange. Macroinvertebrate richness was greater in control than drying treatments except for in *O. neglectus* (AR) treatments. In addition, *O. eupunctus* had the greatest chelae to carapace ratio. These results indicate that *O. eupunctus* and *O. neglectus* are not ecologically redundant. In addition, this study provides evidence that invasive species source population may differentially affect population dynamics and ecosystem structure and function.

Currently, little is known about what regions are potentially susceptible to future invasions by *O. neglectus*. Recent research demonstrates the applications of using information from data rich 'avatar' invaders to model the potential distribution for incipient invaders in the absence of data concerning their non-native distributions. This can be accomplished by examining niche shifts of 'avatar' invaders from their native to total ranges, and extrapolating invasion potential to data-poor invaders assuming they will undergo niche shifts of a similar extent (Larson and Olden 2012). We will use the avatar concept of Larson and Olden (2012) to project a potential future distribution of *O. neglectus* based on landscape related niche shifts of the well-studied congeners *O. rusticus* and *O. virilis.* This will aid in identifying environmentally sensitive areas that may be susceptible to future invasions by *O. neglectus*.

*Orconectes eupunctus, photo by Allyson Yarra (AR Coop Unit)*

# Influence of Stream Permanence, Predation and Invasive Species on Crayfish in the Ozark Highlands with an Emphasis on Species of Greatest Conservation need (*Orconectes marchandi*, *Orconectes eupunctus* and *Cambarus hubbsi*)

| | |
|---|---|
| *Funding source:* | Arkansas Game and Fish Commission<br>National Science Foundation<br>University of Arkansas<br>Arkansas Cooperative Fish and Wildlife Research Unit |
| *Project Duration*: | May 2015 to May 2017 |
| *Principal Investigator*: | DANIEL D. MAGOULICK |
| *Graduate Student*: | ALLYSON N. YARRA (M.S. Student) |

## Research Objectives:

1. Determine the influence of stream permanence on crayfish occupancy and abundance in the White River drainage.
2. Assess the importance of stream permanence and season on crayfish predation.
3. Examine the population status of *O. marchandi, O. eupunctus,* and *C. hubbsi* in the Spring River drainage and assess the potential for invasion impacts by *O. neglectus*.

## Management Implications:

1. This study will contribute to the establishment of flow-crayfish ecology relationships which may provide insight into the importance of sustainable water use in the Ozark Highlands.

2. Assessing the population status of three imperiled crayfish species in the face of an invasive species will help to guide monitoring programs.

## Project Summary:

Stream drying is an important mechanism that influences predator-prey relationships and crayfish behavior. During drought, biotic interactions (e.g., competition, predation) may intensify (Hodges and Magoulick 2011). Especially when coupled with seasonal drought, invasive species are a major threat to ecosystem integrity (Secretariat of the Convention of Biological Diversity 2010). The establishment of many invasive crayfish is often related to change that creates environments that are more favorable to introduced species and unfavorable to native species which may include habitat loss due to seasonal stream drying (Larson et al. 2009).

In the Ozark Highlands of Arkansas and Missouri, *Orconectes neglectus* has invaded portions of the Spring River drainage in southern Missouri and northern Arkansas (Flinders and Magoulick 2005). Since the Spring River drainage houses three species of crayfish that are Species of Greatest Conservation Need (*O. eupunctus*, *O. marchandi*, and *C. hubbsi*), this region is in need of monitoring. Currently, *O. eupunctus*, which was once abundant in the Spring River drainage has been displaced by *O. neglectus*. *O. neglectus* is now the dominant crayfish species in portions of the West Fork Spring River and the upper South Fork Spring River where *O. eupunctus* was formerly abundant. *O. eupunctus* still persists in the Spring River drainage, but its abundance has declined in the upstream areas that *O. neglectus* inhabits (Flinders and Magoulick 2005). Since *O. neglectus* may continue to spread throughout the drainage, understanding the population dynamics of *O. eupunctus*, *O. marchandi*, and *C. hubbsi* is important for their conservation.

It is vital to understand the combined effects of stream drying, predation, and the impacts of invasive species on native crayfish. While the seasonal drying of intermittent streams in this region is a natural process, the pressures of human water use coupled with global climate change may induce additional stress on the region's sensitive aquatic biota in the future. Information gained from the establishment of flow-crayfish ecology relationships may provide insight into the importance of sustainable water use in the Ozark Highlands. Specifically in the Spring River drainage, where an invasive species is spreading and where two of our most geographically-restricted stream crayfish occur (*O. eupunctus* and *O. marchandi*), we intend to understand the status and threats present so that we may inform future conservation decisions. Findings from this research will inform conservation and management of crayfish of greatest conservation need in the Ozark Highlands.

We conducted a mensurative field study to determine crayfish abundances, species composition, and habitat quality in 20 Ozark streams (10 intermittent, 10 permanent) in summer 2014 and 2015. In these same streams, we conducted snorkel surveys in pools adjacent to crayfish sampling locations and collected scat from riparian mammals along each stream during each season to understand how crayfish are utilized as a prey item in different seasons and levels of stream permanence.

Stream permanence influenced the occupancy of all crayfish species found whereas crayfish abundance was determined by both stream permanence and local habitat. Some species, including those of conservation concern, appear dependent on intermittent streams and managers should consider intermittent streams as an important component of freshwater biodiversity. The relative frequency of crayfish prey in the diets of riparian mammals was greater in permanent streams than in intermittent streams. The volume percentage of crayfish prey consumed by mammals was significantly greater in spring ($p=0.02$) and summer ($p<0.01$) compared to fall. Crayfish density did not influence the presence of predatory fish. The distribution, abundance, and predation risk of imperiled crayfish is important to consider in the context of increased hydrologic variability due to global climate change.

We are currently examining the population status of *O. eupunctus*, *O. marchandi*, and *C. hubbsi* in the Spring River drainage.  We are determining the population dynamics of these species and are developing simulation models in the program RAMAS Metapop to determine potential effects of *O. neglectus* invasion and drought.

*Little Missouri River, Arkansas, photo by Christopher Middaugh (AR Coop Unit)*

## Effects of Climate Change on Smallmouth Bass at their Southern Range Extent

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|---|---|
| *Funding Sources:* | University of Arkansas |
| *Project Duration:* | January 2014 to January 2017 |
| *Principal Investigator:* | DANIEL D. MAGOULICK |
| *Graduate Student:* | CHRISTOPHER R. MIDDAUGH (Ph.D. Student) |

### Research Objectives:

1. Use a bioenergetics model to predict future growth rate potential of smallmouth bass *Micropterus dolomieu* in streams in Arkansas, Oklahoma, and Missouri
2. Evaluate changes in body condition of smallmouth bass over the course of the summer between groundwater and runoff streams
3. Determine relative influence of angler harvest and climate change on smallmouth bass abundance in the Buffalo River, AR under various future climate scenarios

### Management Implications:

1. Growth of smallmouth bass could decline during summer months, but increase during other times of year in runoff streams. Groundwater streams could provide a refuge from negative seasonal growth as growth rate potential in these streams declined much less severely during summer months.
2. Field collections indicate that body condition of smallmouth bass changed over the course of summer months consistently between groundwater and runoff streams. In both stream types, smallmouth bass have declined in relative weight through summer months in two of the last three summers.

3. Simulation models indicate that climate change effects are likely to be much more important in determining smallmouth bass population characteristics than are harvest levels.
4. Results from this work could better prepare managers for future challenges that may face lotic smallmouth bass due to climate change.

**Project Summary:**

Climate change is likely to affect streams across the southern United States in a number of ways including increasing water temperatures and causing longer and more severe seasonal drought conditions. Both water temperature and seasonal droughts can structure stream fish populations, but little is known about how fishes will respond to changing conditions in warmwater streams. Further, it is unknown how different stream types (e.g., runoff and groundwater) may moderate the effects of climate change, leading to differential responses to climate change by species within. We are investigating the effects of changing climate conditions on smallmouth bass *Micropterus dolomeiu* in streams across the Ozark Highlands of Arkansas, Oklahoma, and Missouri. This region is at the southern range extent of smallmouth bass and it is unknown how this species may respond to climate change in this region.

Our first project investigates the differences in growth potential between runoff and groundwater streams. We used bioenergetics models to predict future and present growth potential of smallmouth bass across streams from both runoff and groundwater flow regimes. Using current and predicted future water temperatures for fifteen streams, we modeled monthly growth rate potential of smallmouth bass. These models predict a decline in growth rate potential during summer months, as compared to spring and fall, under present conditions for all modeled runoff streams, but not for most groundwater streams. Under future climate conditions, these models predict a strong decline in growth rate potential during summer months, and even an incapacity for growth during summer months for many runoff streams, and a much smaller decline in growth rate potential during summer months for groundwater streams. However, growth during early spring, fall, and winter is predicted to increase compared to present climate conditions. This work indicates that groundwater streams may provide a thermal refuge for smallmouth bass during summer months as compared to runoff streams.

Our second project examines changes in smallmouth bass body condition throughout summer months in both runoff and groundwater streams. In Arkansas and southern Missouri, summer water temperatures currently reach the upper thermal limit for smallmouth bass growth in some streams. Typically, groundwater streams do not become as warm during summer months as runoff streams, potentially allowing for better growth of smallmouth bass during summer months. We sampled smallmouth bass from eight streams monthly for three years (2014-2016) during summer months (June-September). For each fish captured, we measured length and weight (to calculate relative weight) and we collected diet contents. We found that smallmouth bass in groundwater streams and runoff streams both experienced declines in relative weight over the summer months in two years and there was no change in relative weight in either stream type in the third year. No diet shifts were observed in any year. We were surprised that groundwater streams declined in relative weight in a similar way to runoff streams.

The final portion of our research investigates the population level effects of climate change on a stream population of smallmouth bass. We created a simulation model parameterized using data collected by the Arkansas Game and Fish Commission in the Buffalo River, Arkansas. This data indicates that smallmouth bass recruitment is significantly related to springtime discharge and temperature. Predictive relationships between discharge, temperature, adult abundance and recruitment were then used in a population model where annual recruitment is affected by environmental conditions. These conditions are varied for a number of potential future scenarios (e.g., drought, flood, harvest).

Preliminary results indicate that climate scenarios (e.g., high drought) have a greater impact on the smallmouth bass population than differing harvest scenarios. Our models predict that reducing harvest could mitigate some of the expected impacts of climate change on the population, but not all.

*Longear sunfish (Lepomis magalotis), photo by Dustin Lynch (AR Coop Unit)*

# Biological Responses of Ozark Stream Communities to Compounding Stressors: The Convergence of Drought, Land Use, and Novel Predation

| | |
|---|---|
| *Funding Source:* | University of Arkansas<br>Arkansas Cooperative Fish and Wildlife Research Unit<br>University of Oklahoma<br>Sigma Xi Research Grant |
| *Project Duration:* | July 2014 toAugust 2017 |
| *Principal Investigator:* | DANIEL D. MAGOULICK |
| *Graduate Student:* | ROBERT J. FOURNIER (Ph.D. Student) |

## Research Objectives:

1. To determine the effects of drought and nutrient pollution on the growth and survival of stream community.
2. To examine the effects of a novel predator (largemouth bass) and native predator (smallmouth bass) on the growth and survival of stream ecosystem structure and function in normal and drought conditions.
3. To examine the ecological dynamics of apex predation and nutrient enrichment in streams.
4. To construct and parameterize a model that explores community dynamics under varying predation pressures and drought conditions.

## Management Implications:

1. Little is known regarding the combined ecological effects of common anthropogenic and natural stressors on aquatic communities. Information gained from this research will help managers to

establish regulations or mitigate factors negatively affecting fish populations in severely impacted streams.

2. Information gained through this study will help assess the potential invasion impacts of an apex predator on Ozark stream communities.

**Project Summary:**

Anthropogenic degradation of freshwater ecosystems represents a severe threat to global aquatic biodiversity (Benke 1990). Three of the most detrimental ecological disturbances to stream systems—hydrological alteration, nutrient pollution, and invasive species—have profound and diverse impacts on aquatic communities and are often some of the most pervasive threats to biodiversity in developed countries. Increasing demand for freshwater resources and the increased frequency of extreme climatic events might exacerbate the biological effects of drought conditions in streams (Beniston et al. 2007). Anthropogenic introduction of bioavailable nutrients to freshwater systems is increasing globally (Vitousek et al. 1997) with dramatic, bottom-up effects on ecosystem structure and functionality (Woodward et al. 2012). Introduced predators might destabilize food webs with extreme hunting pressure and naïve prey might not possess adequate defenses to increased predatory threats. While the individual effects of drought, nutrient pollution, and invasive predation have been studied across multiple systems, little work has been done regarding their combined effects on freshwater communities. This research will continue to explore the dynamics of severely impacted ecosystems by exposing cross sections of Ozark stream communities to combinations of common ecological disturbances.

Throughout the project, we will explore the compounded effects of drought, nutrient enrichment, and introduced predators across a series of experiments. The first was carried out in summer 2016 and explored the dynamics of drought and novel predation treatments on two species of Ozark stream fish and one crayfish in indoor mesocosms. However, preliminary results were inconclusive. It is likely that high mortality rates—including those resulting from predation—across all treatments during the experiment obscured important ecological dynamics. The second experiment (to be carried out spring 2017) will compare growth and survivorship of communities exposed to combinations of drought, and nutrient pollution. The third experiment (summer 2017 in the series will cross nutrient pollution and predation treatments.  We will also construct mathematical models that explore the metapopulation dynamics of three demographically distinct species in normal and drought conditions.

We anticipate that the results of this study will provide managers with tools to make more informed decisions regarding both the levels of the individual disturbance factors we explore as well as helping to create disturbance management plans which take into account the compounded effects of multiple stressors within one system.

# COMPLETED FISHERIES PROJECTS

*Nicky Graham, Robert Fournier, Brittany Furtado backpack electrofishing in a local stream of NW Arkansas, photo by Scott Koenigbauer (AR Coop Unit 2016)*

*Spring spawning aggregation photo by Lindsey Bruckerhoff (AR Coop Unit*)

## Trait Composition of Fish Assemblages across Hydrologic Regimes

| | |
|---|---|
| *Funding Source:* | University of Arkansas<br>Arkansas Cooperative Fish and Wildlife Research Unit |
| *Project Duration:* | August 2013 to May 2016 |
| *Principal Investigator:* | DANIEL D. MAGOULICK |
| *Graduate Student:* | LINDSEY A. BRUCKERHOFF (M.S Student) |

### Research Objectives:

1. Characterize the fish assemblages of different hydrologic regimes in Arkansas based on the relationship between hydrologic metrics and fish traits.
2. Determine how relationships between fish traits and hydrologic metrics differ between flow regimes.
3. Assess the role of spatial autocorrelation in structuring the trait composition of fish assemblages across hydrologic regimes.

### Management Implications:

1. This study contributes to the knowledge of flow-ecology relationships to aid in determining environmental flow standards.
2. This study highlights the importance of accounting for spatial autocorrelation when developing flow-ecology relationships.

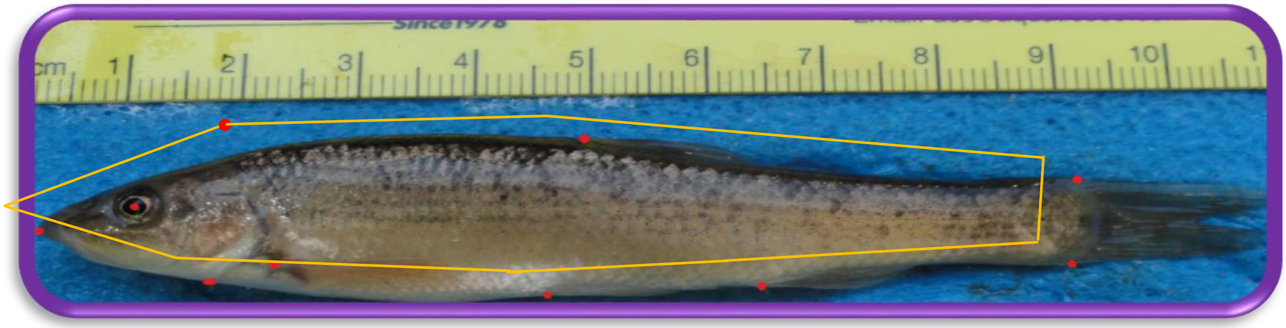
3. Identification of traits useful for monitoring changes in fish assemblages will help predict consequences of alterations to natural flow patterns due to climate change, as well as anthropogenic influence.

**Project Summary:**

In lotic systems, environmental pressures are largely determined by the hydrologic regime (Naiman et al. 2008). Ecologically important components of the hydrologic regime include the magnitude of discharge and frequency, duration, timing, and rate of change of flow events (Poff and Ward 1989, Richter and Baumgartner 1997, Poff et al. 1997). These components influence habitat volume, current velocity, channel geomorphology, substratum stability, suspended sediments, temperature, chemistry, and channel connectivity (Poff and Ward 1989, Jowett and Duncan 1990), which are all important habitat characteristics influencing which species are present (Poff 1997). Because hydrology controls so many attributes of the physical environment in streams, organisms adapt and evolve in response to maintained variation of hydrologic regimes (Lytle and Poff 2004).

Traits can be used to describe patterns of community assemblages along hydrological gradients (Poff and Allan 1995, Mims and Olden 2012). Trait based approaches assume that species traits converge when environmental pressures are similar (Southwood 1988). Based on this theory, categorizing species by different traits allows for the study of community assemblages across biogeographic boundaries (Schluter 1986). We assessed how the relationship between trait compositions of fish assemblages and hydrologic metrics differ across flow regimes. We used hydrological and fish survey data from Arkansas streams within the Ozark Highland, Arkansas Valley, Boston Mountains, and Mississippi Alluvial Plains ecoregions. Fish community survey data from the ARGAP program and flow data developed by Leasure et al. (2014) were analyzed using a combination of RLQ and four-corner analysis to determine the relationship between flow metrics, suites of flow metrics, single traits, and suites of traits (trait syndromes). In general, fish traits were structured differently across flow regimes and different hydrologic metrics describe trait structure across regimes. Duration of low flows was related to spawning characteristics in runoff streams, while variability of daily flows and constancy were important in intermittent streams. Across all flow regimes combined, variability of daily flows described the most variability in spawning characteristics.

Establishing ecological-flow relationships is a crucial component of managing lotic systems within an environmental flow framework. Species traits may be useful for developing ecological-flow relationships because they can be used to make comparisons across biogeographical boundaries. Fish traits, such as life history strategies and spawning characteristics, have been linked to hydrologic metrics and classified flow regimes at relatively large spatial scales, but not smaller, management level scales, and the role of spatial autocorrelation in driving trait distributions in stream networks has not been assessed. We used mixed moving average spatial stream network (SSN) models to (1) determine the relationship between fish traits and hydrologic metrics within classified flow regimes at a management (state) level spatial scale, (2) determine how traits are spatially auto-correlated within a stream network, and (3) compare the degree of spatial autocorrelation between flow regimes. We observed weak relationships between fish traits and hydrologic metrics, and these relationships were different between flow regimes. Spatial factors described more variability in the distribution of fish traits than hydrologic metrics within and between flow regimes and different types of spatial auto-correlation structured trait patterns across flow regimes. This study highlights the importance of considering spatial patterns when developing ecological-flow relationships.




*Central Stoneroller, photo by Lindsey Bruckerhoff (AR Coop Unit)*

## Phenotypic Divergence of *Campostoma anomalum* across Hydrologic Regimes

| | |
|---|---|
| *Funding Source:* | University of Arkansas<br>Arkansas Cooperative Fish and Wildlife Research Unit |
| *Project Duration:* | August 2013 to May 2016 |
| *Principal Investigator:* | DANIEL D. MAGOULICK |
| *Graduate Student:* | LINDSEY A. BRUCKERHOFF (M.S Student) |

### Research Objectives:

1. Test for morphological variation between fish inhabiting different hydrologic regimes.
2. Determine the relative roles of genetic divergence and phenotypic plasticity driving morphological variation.

### Management Implications:

1. Understanding how organisms have adapted to different flow regimes may provide insight into the evolutionary consequences of disrupting natural hydrologic patterns, which are increasingly threatened by climate change and anthropogenic alterations.

### Project Summary:

In lotic systems, environmental pressures are largely determined by the hydrologic regime (Naiman et al. 2008). Ecologically important components of the hydrologic regime include the magnitude of discharge and frequency, duration, timing, and rate of change of flow events (Poff and Ward 1989, Richter and Baumgartner 1997, Poff et al. 1997). These components influence habitat volume, current velocity, channel geomorphology, substratum stability, suspended sediments, temperature, chemistry, and channel connectivity (Poff and Ward 1989, Jowett and Duncan 1990), which are all important habitat characteristics influencing which species are present (Poff 1997). Because hydrology controls so many attributes of the physical environment in streams, organisms adapt and evolve in response to maintained variation of hydrologic regimes (Lytle and Poff 2004).

Some species are able to survive across a diverse range of hydrologic conditions and large geographic regions. Species distributed across heterogeneous environmental conditions (space and/or time) may exhibit intraspecific variation in physiology, morphology, and behavior. Intraspecific variation is commonly documented in fish (reviewed in Robinson and Wilson 1994) and may be the result of a combination of abiotic and biotic selective pressures. Because flow regimes influence abiotic (Poff & Ward 1989, Jowett & Duncan 1990) selection pressures and potentially influence biotic interactions (by influencing community composition), fish species may exhibit intraspecific variation across hydrologic gradients. Adaptations in response to hydrologic variation may be apparent by examining morphological variation of fish between different hydrologic regimes. Observed morphological variation may be the result of phenotypic plasticity or genetic divergence. This study aims to determine what morphological features of fish vary across hydrologic gradients. Further, this study will address whether phenotypic plasticity or genetic divergence is predominantly driving morphological variation.

Variation in morphology between fish occupying different hydrologic regimes was investigated using geometric morphometrics. Over 600 fish were collected and photographed from 20 sites within two different flow regimes (groundwater streams and intermittent). We digitized 10 landmarks on each specimen representing major features of fish morphology. Preliminary analysis indicates that deeper bodied fish are characteristic of intermittent streams, while more streamlined fish are characteristic of groundwater streams. Centroid size (mean geometric size) also differs between the two regimes. The observed difference in shape are likely due to the interaction between centroid size and shape, indicating that populations may differ in their allometric growth patterns across flow regimes.

We also conducted a 20 week long, fully factorial mesocosm experiment to determine if phenotypic plasticity or genetic divergence is driving morphological variation. We reared young of the year from two natural populations, one from a stable high flowing groundwater stream (population 1) and the other from an intermittent stream that experiences seasonally extreme low flows (population 2). The four treatment groups included: population 1 young reared in low flow conditions, population 1 young reared in high flow conditions, population 2 young reared in low flow conditions, and population 2 young reared in high flow conditions. At the end of the experiment, fish were photographed and geometric morphometric analysis was implemented using the same methods used in the comparative field study. Morphological variation due to genetic predisposition was indicated by differences in shape variables between populations. Phenotypic plasticity was indicated by differences in shape variables between treatments in each of the populations. We observed larger differences between source populations than flow treatments, indicating that divergence between populations may influence body shape more than plasticity.

# CURRENT WILDLIFE PROJECTS

*Liz Moore holding banded American Woodcock,*
*photo by Joe Moore (AR Coop Unit 2016)*

*Jacob McClain releasing a collared raccoon on Stony Point Prairie Conservation Area, photo by Kyle Hedges (Missouri Department of Conservation 2016)*

## Abundance, Foraging Behavior, and Spatial Ecology of Potential Northern Bobwhite (Colinus virginianus) Nest and Brood Predators under two Management Models

*Funding Source:* Missouri Department of Conservation
Arkansas Cooperative Fish and Wildlife Research Unit
University of Arkansas
*Project Duration:* May 2015 to May 2017
*Principal Investigators:* DAVID G. KREMENTZ
*Graduate Student:* JACOB C. MCCLAIN (M.S. Student)

**Research Objectives:**

1. Estimate abundance of raccoon (Procyon lotor) and Virginia opossum (Didelphis virginiana) for Conservation Areas managed either intensively or extensively.
2. Estimate home ranges of mesopredators living on Conservation Areas managed either intensively or extensively.
3. Estimate the likelihood of a mesopredator encountering northern bobwhite nests or broods for both intensively and extensively managed Conservation Areas.

**Management Implications:**

1. Understanding how management of Conservation Area landscapes affects the abundance, spatial ecology, and foraging behavior of mesopredators will allow managers to better manage sites to achieve northern bobwhite population goals.

## Project Summary:

Northern bobwhite (Colinus virginianus) populations have declined steadily during recent decades in Missouri and across their range. Concerned public and private stakeholders including the Missouri Department of Conservation (MDC) have begun efforts to benefit populations of this ecologically and economically important game species on public Conservation Areas (CAs). Currently CAs are managed using either an intensive or extensive approach. The Intensive Management Model (IMM) creates small, rectangular, interspersed patchy habitat mosaics of grass, cropland, woodlands, and bare ground. The Extensive Management Model (EMM) uses prescribed fire and grazing to produce patchy habitat mosaics. Preliminary results of a nest success study by MDC indicate that nest success is higher on EMM sites than IMM sites. IMM potentially creates an environment that allows for more efficient prey searching by mammalian mesopredators that may result in high predation of nests and broods in CAs and other lands similarly managed.

In 2016 we conducted our research on four state-owned Conservation Areas in southwest Missouri: Robert E. Talbot (IMM), Shawnee Trail (IMM), Stony Point Prairie (EMM), and Wah-Kon-Tah Prairie (EMM) from March 15-September 30. We trapped raccoons and opossums using live and hand-hold traps in March, June, and July. We marked opossums and raccoons with a unique identifiable collar. We marked 15, 7, 19, and 9 raccoons and 23, 9, 20, and 11 opossums on Talbot, Shawnee, Stony Point, and Wah-Kon-Tah respectively. Likewise, we outfitted a subset of raccoons (10) with GPS collars to determine home range size and document movements on Talbot (5), Stony Point (4), and Wah-Kon-Tah (1). We used game cameras to capture images of marked and unmarked individuals. We set up 28, 20, 33, and 24 cameras in a variety of habitats on Talbot, Shawnee, Stony Point and Wah-Kon-Tah respectively. Not all cameras were active throughout the sampling period for each study site. Resighting surveys were conducted for a total of 801, 567, 929, and 730 camera trap days ($\sum$days $camera_i$ was active) for Talbot, Shawnee, Stony Point, and Wah-Kon-Tah respectively.

Our game cameras detected 3,315 potential nest and brood predators of the northern bobwhite. Camera traps on Talbot (IMM) recorded multiple images of raccoons (881), opossums (692), coyotes (50), armadillos (109), bobcats (30), feral cats (5), and domestic dogs (3). On Shawnee (IMM) cameras recorded multiple images of raccoons (65), opossums (66), coyotes (28), armadillo (18), bobcat (1), and striped skunk (1). Camera traps on Stony Point (EMM) recorded multiple images of raccoons (444), opossums (262), coyotes (21), armadillos (52), bobcats (23), otters (4) and domestic dogs (2). Camera traps on Wah-Kon-Tah (EMM) recorded multiple images of raccoons (118), opossums (327), coyotes (38), armadillos (47), bobcats (2), red foxes (4), feral cats (8), and domestic dogs (13).
Taking into account resighting effort, we estimated relative abundance for raccoons and opossums by dividing the total number of photos of each species by the total camera trap days. Data for Talbot (IMM) showed that 1.1 raccoons and 0.86 opossums per camera trap day were recorded. Shawnee (IMM) had 0.12 raccoons and 0.11 opossums per camera trap day. Stony Point (EMM) had 0.48 raccoons and 0.28 opossums, while Wah-Kon-Tah had 0.16 raccoons and 0.45 opossums per camera trap day. Based simply on our camera indices, density of raccoons and opossums were highest on the intensively managed Talbot and lowest on the intensively managed Shawnee. Based on the camera indices, densities of raccoons and opossums on the extensively managed areas (Stony Point and Wah-Kon-Tah) were relatively low when compared to those of the intensively managed Talbot.

Because of some concerns over the relative abundance index, we are currently estimating density of raccoons and opossums using a spatial mark-resight model augmented with telemetry data. We programed the GPS collars (LOTEK) to record a location every 30 minutes from 8:00 pm to 7:00 am when raccoons are known to be actively foraging. Location data was stored onboard the collars which we periodically (1-2 times/week) remotely downloaded using radio-telemetry technology. The amount of data gathered by each collar varied greatly from 203-2487 points as the GPS antenna on some collars was either lost or damaged, therefore preventing the unit from taking location fixes.

The GPS data revealed that the collared raccoons spent a mean of 55% of their time foraging on Talbot (IMM) while raccoons trapped on Stony Point (EMM) only spent 28% of their time foraging on the conservation area (where the vast majority of northern bobwhite nests occurred). Additionally, based on the location data for each collared individual we created a dynamic Brownian Bridge to estimate the Utilization Density (UD) and home range for each raccoon. Mean 95% home ranges were 3.21 and 2.84 $km^2$ for Talbot (IMM) and Stony Point (EMM), respectively. Currently we are using the UD grid to estimate the probability that each raccoon would encounter individual northern bobwhite nests.


*Marked opossum (M) on Wah-Kon-Tah Prairie resighted by a game camera.*

*Phillip Stephenson sweeps floating primrose (Ludwigia peploides) to catch bees, Monroe County, Arkansas, photo by David Krementz (AR Coop Unit 2016)*

## Pollinator Communities on Actively and Passively Managed Emergent Wetlands in the Lower Mississippi Alluvial Valley of Arkansas

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|---|---|
| *Funding Source:* | U.S. Fish and Wildlife Service<br>United States Department of Agriculture<br>Arkansas Cooperative Fish and Wildlife Research Unit<br>University of Arkansas |
| *Project Duration:* | August 2014 to December 2016 |
| *Principal Investigator:* | DAVID G. KREMENTZ<br>ASHLEY P.G. DOWLING |
| *Graduate Student:* | PHILLIP STEPHENSON (M.S. Student) |

### Research Objective:

1. Compare pollinator community metrics between actively and passively managed emergent wetlands throughout the flowering season, and
2. Document whether pollinators visiting flowers in wetlands are also visiting flowers in adjacent croplands.

## Management Implications:

1. These data should assist wetland biologists in making better management decisions on public and private emergent wetlands for the health of pollinator communities.

## Project Summary:

Insect pollinators supply an ecological service to both crops and wild flowering plants by pollinating those plants which in turn increases the size and quality of harvest of agriculture crops. Despite the honeybee's effectiveness as a pollinator for many crops, the risks associated with reliance on a single managed pollinator species have become evident over the past decades as North American honeybee populations have declined by 25% due to the parasitic mite *Varroa destructor*, Colony Collapse Disorder, farming intensification, habitat fragmentation, habitat loss, and agrochemicals. Though cotton, rice, and soybeans are considered autogamous crops (self-pollinating), cross-breeding (via pollinators) helps increase yield, produce more viable seed, and enhance genetic diversity of the crop. Emergent wetlands occur adjacent to croplands across the southeastern United States and create valuable floral resources for pollinators throughout the growing season. Some of these emergent wetlands on public lands are actively managed for annual plants that produce abundant seed resources for migratory waterfowl while some emergent wetlands are more passively (less frequently or less intensely) managed resulting in more perennial plants. Pollinator communities that use emergent wetlands have been poorly documented and their benefits to crops on surrounding lands are unknown.

We surveyed actively and passively managed palustrine emergent wetlands across the lower Mississippi Alluvial Valley of Arkansas from 19 May – 18 September 2015 and from 22 May – 9 September 2016. In 2015, we selected 9 wetland sites and added 8 wetland sites in 2016 to make a total of 17 wetland sites with 4 sites directly adjacent to soybean production fields. Sites surveyed included three Wildlife Management Areas (WMA) managed by the Arkansas Game and Fish Commission (AGFC), three National Wildlife Refuges (NWR) managed by the U.S. Fish and Wildlife Service (USFWS), one Natural Area (NA) managed by the Arkansas Natural Heritage Commission (ANHC), and six private lands. At these study sites, we estimated species richness and abundance of native bees (Hymenoptera: Apoidea) using pan traps, blue-vane traps, and sweep nets. We placed pan trap stations throughout actively and passively managed emergent wetlands along a permanent transect with a random starting location, a set interval of ~20m between stations, while following an opportunistic path avoiding open water. Pan trap stations in soybean fields were arranged in a rectangular block, perpendicular to the adjacent wetland. The pan trap stations extended 100 meters into soybean fields starting 50 meters beyond the buffer between the wetland/soybean interface.

We collected 19,615 individual bees that included five families, 31 genera, and 87 species. Of these species, five (*Anthophorula asteris*, *Ceratina cockerelli*, *Diadasia enavata*, *Diaunomia triangulifera*, *Svastra cressonii*) were new Arkansas state records. In 2015, we collected 49 species in actively managed emergent wetlands, but the GOF test indicated the data did not fit the heterogeneity model ($\chi^2 = 9.864$, P = 0.02) so the species richness estimate generated was not reliable. For the passively managed emergent wetland sites, we collected 51 species with the GOF test indicating the data fit the heterogeneity model ($\chi^2 = 1.082$, P = 0.78) so we estimated species richness to be 69.45 (95% CI = 54.53 – 86.09). The 95% confidence intervals for species richness by management type overlapped indicating that both actively and passively managed emergent wetlands supported a similar suite of species. The probability of detecting a species in actively managed emergent wetlands was 0.67 (95% CI = 0.534-0.902) versus detecting a species in passively managed emergent wetlands was 0.74 (95% CI = 0.591-0.913). Detection probabilities less than ~80% indicate that raw species counts do not represent the true number of species that occur at those sites. Hence, we will rely on estimated species richness values to describe bee communities on both the active and passively managed sites. The probability of a species being present in actively managed emergent wetlands also occurring in passively managed emergent wetlands ($\varphi$ = 0.78, 95% CI = 0.60-0.975) and vice versa ($\varphi$ = 0.82, 95% CI = 0.601-1.00) was high. Of the 49 species collected in actively managed emergent wetlands, 12 (24%) were unique to actively managed sites, whereas 15 (29%) of 51 species found in passively managed emergent wetlands were unique to those sites.

In 2016, we collected 61 species in actively managed emergent wetlands with the GOF test indicating the data fit the heterogeneity model ($\chi^2$ = 5.57, P = 0.13). We estimated species richness to be 70.7 (95% CI = 61.49-84.33). For the passively managed emergent wetland sites, we collected 65 species with the GOF test indicating the data fit the heterogeneity model ($\chi^2$ = 6.02, P = 0.11) so we estimated species richness to be 83.5 (95% CI = 68.00 – 101.66). The 95% confidence intervals for species richness overlapped, indicating that both actively and passively managed emergent wetlands supported a similar suite of species. We found that the probability of detecting a species in actively managed emergent wetlands to be 0.86 (95% CI = 0.722-0.986) versus detecting a species in passively managed emergent wetlands to be 0.78 (95% CI = 0.637-0.946). We also found that the probability of a species being present in actively managed emergent wetlands also occurring in passively managed emergent wetlands ($\varphi$ = 0.98, 95% CI = 0.812-1.00) and vice versa ($\varphi$ = 0.88, 95% CI = 0.74-1.00) was high. Of the 61 species collected in actively managed emergent wetlands, 9 (15%) were unique; whereas 12 (18%) of 65 species found in passively managed emergent wetlands were unique.

In 2016, we collected 38 species in our sampled soybean fields with the GOF test indicating the data fit the heterogeneity model ($\chi^2$ = 3.6, P = 0.06).We estimated species richness to be 41.44 (95% CI = 38.00-45.99). For the adjacent passively managed emergent wetland sites, we collected 36 species with the GOF test indicating the data fit the heterogeneity model ($\chi^2$ = 0.077, P = 0.782) so we estimated species richness to be 39.05 (95% CI = 34.00 – 45.09). The 95% confidence intervals for species richness overlapped, indicating that both soybean fields and passively managed emergent wetlands support a similar suite of species. We found that the probability of detecting a species in soybean fields to be 0.92 (95% CI = 0.825-1.00) versus detecting a species in adjacent passively managed emergent wetlands to be 0.87 (95% CI = 0.753-1.00). We also found that the probability of a species being present in soybean fields also occurring in passively managed emergent wetlands ($\varphi$ = 0.74, 95% CI = 0.566-0.90) and vice versa ($\varphi$ = 0.81, 95% CI = 0.629-1.00) was high. Of the 38 species collected in soybean fields, 12 (32%) were unique; whereas 7 (21%) of 34 species found in the adjacent passively managed emergent wetlands were unique. Flight distance was recorded up to 150 meters into the soybean fields from the edge of the wetland.

Our preliminary results further justify the need for wetland reserve program easements by providing resources for bees and other insects that in turn provide crucial ecological services.

*Juvenile Brown Treesnake (Boiga irregularis) on Guam,*
*photo by Brenna Levine (Biological Sciences)*

## Using Genetics to Identify Traits Promoting Brown Treesnake (*Boiga irregularis*) Reproduction and Capturability

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|---|---|
| *Funding Source:* | Office of Insular Affairs, US Department of Interior |
| *Project Duration:* | July 2015 to July 2016 |
| *Principle Investigators:* | MARLIS R. DOUGLAS and MICHAEL E. DOUGLAS |
| *Graduate Student:* | BRENNA A. LEVINE (Ph.D. Student) |

### Research Objective:

1. Identify successful breeders by quantifying parentage, kinship, and relatedness to evaluate correlates of reproductive success.
2. Evaluate whether current control methods are effective at targeting individuals with high reproductive success.
3. Test for an association between relatedness and capturability to infer heritability of this trait.

### Management Implications:

1. The identification of traits related to high reproductive output will allow control of this invasive species to be optimized to target the individuals with highest fecundity, thus reducing the reproduction capacity of the population and reducing its potential for persistence.

2. If current control methods are not effective at capturing highly reproductive individuals in the long-term, changes to control will be necessary.
3. Finally, the potential for adaptation to large scale control efforts would suggest a need for new control methods to prevent the population from becoming refractory to trapping.

**Project Summary:**

Invasive species are a leading cause of species extinction. The highly invasive Brown Treesnake (BTS: *Boiga irregularis*) has caused the extinction or extirpation of 10 of the 13 species of birds native to the US territory of Guam since its introduction circa 1949. Furthermore, BTS is detrimental to Guam's economy, causing extensive damage to electrical infrastructure and decimating the local poultry industry (Rodda & Savidge, 2007). Improvement of Brown Treesnake control is consequently of profound importance.

Control efforts of the BTS population can be made more effective if reproduction of this invasive species is understood in more detail, as production of offspring is directly related to a population's ability to persist (Rodda *et al*., 2002). However, the secretive behavior of BTS limits studies of its reproduction in the wild (Rodda & Savidge, 2007). The difficulty in studying BTS reproduction is a major problem because successful control hinges on our ability to remove individuals from the population at a faster rate than they reproduce. This can be accomplished by identifying traits in BTS that are related to high reproductive output and optimizing control methods to target individuals with such traits (Buhl *et al*., 2005). Furthermore, monitoring of BTS reproduction post-control can provide an important check-up on the long-term success of control methods, and in particular, to address concerns that the BTS population may evolve over time to become even less 'trappable' in response to current control methods (Tyrell *et al*., 2009).

Fortunately, advances in genomic sequencing make it possible to quantify individual reproductive output from DNA samples, even in species with secretive behaviors like BTS. DNA can be sequenced from BTS tissue samples, yielding a unique genomic profile specific for each individual. These profiles can then be compared among individuals to facilitate the construction of a population-wide 'family tree' from which reproductive output of each individual can be quantified. Trait data can be considered in the context of this multi-generational family tree to identify phenotypic characteristics related to high reproductive output and to evaluate the likelihood that these traits will evolve in response to control efforts.

The central goal of this research is to describe patterns of parentage and kinship to determine individual reproductive output in BTS so as to improve and optimize control methods on Guam. We address 3 main questions germane to the improvement of BTS control:

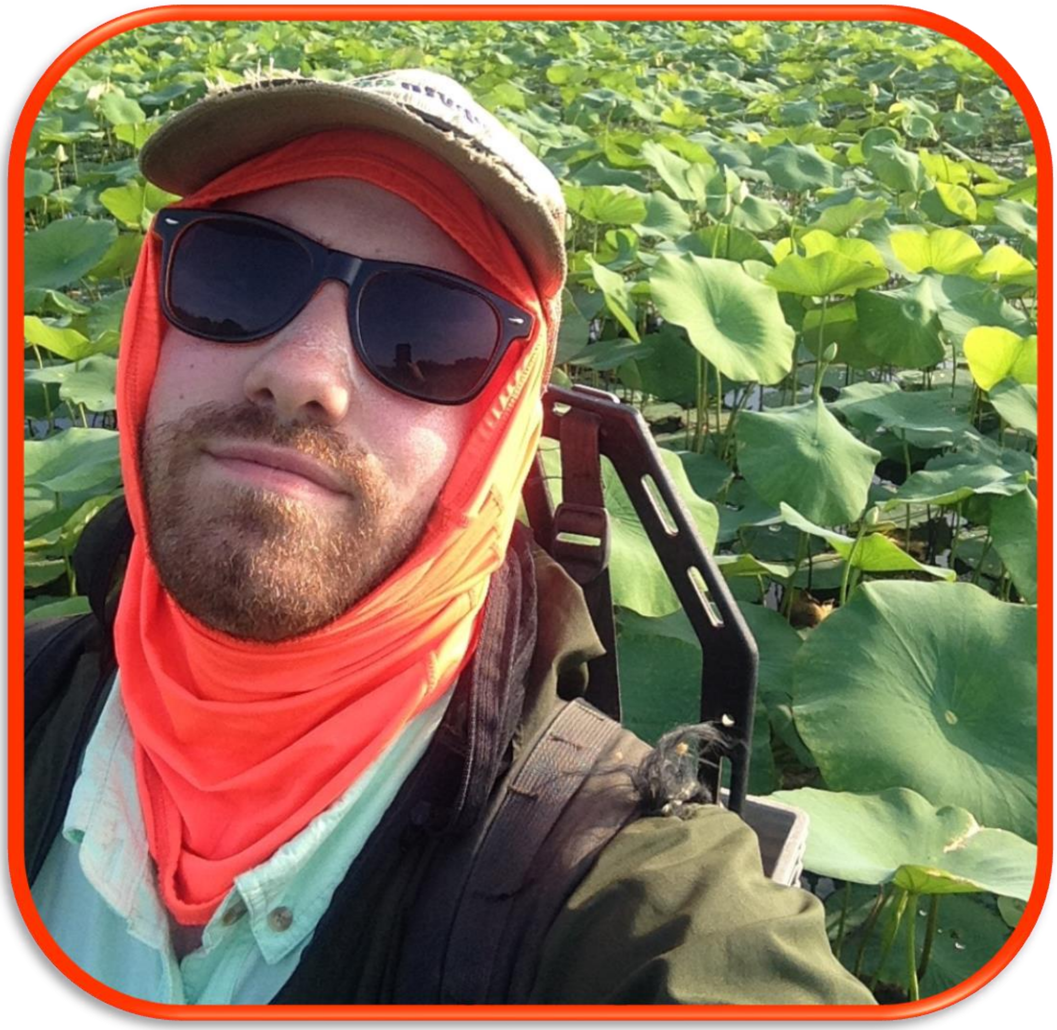
(1) Are certain traits related to high reproductive output, thus allowing control to be focused towards highly reproductive individuals?
(2) Are current control methods effective at targeting highly reproductive individuals?
(3) What is the likelihood that current control methods will cause unintended evolution of BTS, such that the population becomes increasingly uncontrollable over time?

*BTS tissue sample collection for DNA sequencing (photo by Brenna Levine, May 2016)*

To answer these questions, a multi-generational family tree is being constructed through analyses of 475 DNA samples collected from a 5 hectare population on Guam during the last 12 years. Following DNA extraction, the genomic DNA of each individual is 'cut' into small fragments with the use of enzymes. A subset of these fragments common to all individuals is then sequenced on an Illumina Next-Generation Sequencing (NGS) platform to generate a detailed genomic profile for each individual (Peterson *et al*., 2013). Using a combination of bioinformatics programs (Jones & Wang, 2010) and custom computer code, familial relationships among the BTS are then inferred via comparisons of the genomic profiles. The number of offspring produced by each individual over time can then be quantified from the multi-generational family tree. Long-term ecological data for each individual are overlaid onto the family tree to (1) facilitate identification of traits associated with high reproductive output, (2) evaluate whether current control methods target the most reproductive individuals, and (3) determine whether traits related to high reproductive output and 'controllability' are heritable and likely to evolve in response to control methods.

DNA has been extracted from 286 individuals (= 60% of samples) in the population, and genomic sequence data has been generated for 150 individuals (= 32% of samples), including 97 BTS collected during a site visit in May, 2016. NGS has yielded an average of 1,086,929 raw sequencing reads (fragments of the entire genome) per individual. DNA sequence preparation methods and filtering of raw data have been optimized to identify those DNA loci (fragments) most useful for reliable parentage and kinship assignment. Combined, these loci contain 8,864 mutations (or SNPs single nucleotide polymorphisms. These mutations are used to reconstruct the 'family tree' by comparing if individuals share the same mutations (= are likely related) or not (=unrelated). Mean expected heterozygosity of these markers, a measure of genetic diversity, was fairly high due to our optimized sequence filtering parameters ($H_e$ = 0.34). DNA extraction and sequencing of remaining samples are in progress, and will be completed by June, 2017.

# COMPLETED WILDLIFE PROJECTS



*Phillip Stephenson among the American lotus (Nelumbo lutea), Monroe County, Arkansas, photo by Phillip Stephenson (AR Coop Unit 2016)*

*Sora at Nodaway Valley Conservation Area,*
*photo by Auriel Fournier (AR Coop Unit)*

## Effects of Wetland Management Strategies on Habitat Use of Autumn Migrating Rails on Intensively-Managed Wetland Complexes in Missouri

| | |
|---|---|
| *Funding Source:* | U.S. Fish and Wildlife Service<br>Missouri Department of Conservation<br>Arkansas Cooperative Fish and Wildlife Research Unit |
| *Project Duration:* | July 2012 to June 2017 |
| *Principal Investigator:* | DAVID G. KREMENTZ |
| *Graduate Student:* | AURIEL M.V. FOURNIER (Ph.D. Student) |

### Research Objectives:

1. Evaluate the tradeoffs in response of rails and waterfowl in early versus late flooding of wetlands in the autumn.
2. Estimate Sora, Virginia, Yellow and King Rail abundance in relation to water level management and wetland habitat management regimes during autumn migration.

### Management Implications:

1. Understanding how management of impoundments for waterfowl impacts rails will result in better wetland management decisions for rails and waterfowl during autumn migration.

**Project Summary:**

The Migratory Shore and Upland Game Bird Support Task Force for rails and snipe identified four priority information needs of which one, estimate vital rates to support population modeling, requires information on where Sora concentrate during autumn migration to improve capture efficiency. While autumn may provide an opportune time to capture Sora for a telemetry study to estimate vital rates, it first will be useful to determine characteristics of habitat most likely to support rails during autumn migration.

We surveyed impoundments in four different regions of Missouri, each containing at least one Missouri Department of Conservation (MDC) Conservation Areas (CA) and one U.S. Fish and Wildlife Service (USFWS) National Wildlife Refuge (NWR). We used a distance-sampling based approach to survey managed wetland impoundments at night using ATVs and spotlights between 15 August and 31 October 2012-2016. From this data set, we estimate detection probabilities, occupancy rates and abundances. We related these estimates to habitat and management covariates at local and landscape levels.

Based on our 2012 and 2013 field seasons we initiated a three-year management experiment in 2014 at the 10 sites. At each site, two impoundments were selected and were randomly assigned to one of two flooding treatments. Our original intention was to assign treatments beforehand in a crossover design. Because of factors outside our and the managers control, we have instead established quantitative rules for each treatment to assign impoundments to the treatment after the fact. The first treatment - early flooding - began flooding on 1 August and brought the impoundment to greater than 7cm average depth by 15 September. The second treatment – late flooding – began flooding after 10 September and brought the impoundment greater than 7cm average depth by 10 October. We surveyed for rails in the same manner each year and each property manager conducted weekly ground counts for waterfowl throughout waterfowl season. We obtained hunter effort and harvest data from MDC. These data allowed us to compare the response of both rails and waterfowl to the two treatments and assess if early flooding provides better habitat for rails, and if it did, what impacts that has on subsequent waterfowl use and harvest.

We compared the two treatments using two different mixed models, one with Sora as the response, one with waterfowl as the response. Preliminary results indicated a positive response to early flooding by soras, though the amount of difference between treatments difference among years.
We found a positive response, though the amount of difference differed among years, to the early treatment. Waterfowl counts were similar between treatments across years.

*Mist nets used to capture American woodcock*

## American Woodcock Migration Ecology

| | |
|---|---|
| *Funding Source:* | Arkansas Cooperative Fish and Wildlife Research Unit,<br>Minnesota Cooperative Fish and Wildlife Research Unit,<br>U.S. Fish and Wildlife Service,<br>Ruffed Grouse Society and American Woodcock Society,<br>Texas Parks & Wildlife Department,<br>Glassen Foundation,<br>Michigan Department of Natural Resources,<br>Louisiana Department of Wildlife & Fisheries,<br>University of Arkansas,<br>Woodcock Limited |
| *Project Duration:* | August 2014 to December 2016 |
| *Principal Investigator:* | DAVID G. KREMENTZ |
| *Graduate Student:* | JOSEPH D. MOORE |

### Research Objectives:

1. Document timing of migration, rate and distance traveled, stopover length, and routes taken for both spring and fall migration of American woodcock.

### Management Implications:

1. This project will generate data on both American woodcock migratory stopover habitat characteristics and migration routes used. Combining the information from both spatial scales will allow us to identify priority areas to focus habitat management and acquisition efforts for American woodcock along these routes.

2. An increased understanding of the timing of migration initiation and migratory routes can be used to fine-tune hunting-season dates.

## Project Summary:

As with many migratory birds, migratory connectivity and migration phenology of American woodcock (Scolopax minor; hereafter, woodcock) are largely unknown. Understanding migratory connectivity and migration phenology is important in identifying factors that influence survival and fitness over the full annual cycle, but until recently, methods (i.e., data derived from banding and VHF telemetry) for elucidating migratory connectivity and migration phenology of woodcock have provided relatively coarse-resolution delineation of migration patterns. Based largely on analysis of band returns, woodcock are managed on the basis of an Eastern and a Central Management Region with management region boundaries analogous to those of the Atlantic and Mississippi Flyways.

To better understand woodcock migration and evaluate the validity of current management regions, we deployed miniature satellite transmitters on 75 woodcock, primarily in the Central Management Region, and from 2014-2016 documented migration paths of 61 individual woodcock and 88 autumn or spring woodcock migrations. Three types of transmitters were used in this project; a 9.5 g PTT, a 5 g PTT, and a 4.9 g GPS PTT. The 9 g and 5 g PTTs are solar-powered and transmit messages every two and a half days. A passing satellite receives these messages and relays them to a receiving station. The woodcock's location is estimated by measuring the amount of Doppler shift between subsequent messages. The Doppler shift occurs when the source of an energy wave (e.g., sound) is moving relative to where the wave is detected. The locations collected by these transmitters are received live. The other type of tag used is a combination GPS receiver and satellite transmitter. This tag triangulates its position every three days using messages transmitted by GPS satellites. This tag is battery powered and only has enough charge to collect thirty locations along one migration path. Once the season is complete, the tag then transmits all the GPS locations to a satellite in one burst. We deployed forty-four 9.5 g PTTs over the course of the study. We deployed ten 5 g PTTs during January 2015. These tags performed poorly and were not used in future seasons. We deployed twenty-one 4.9 g GPS PTTs in October 2015 and January 2016. We attached PTTs using a modified thigh harness. Woodcock were trapped using night-lighting with hand nets and mist-netting techniques.

Average migration duration was longer during spring (53 days) than during autumn (31 days) because woodcock made a higher number of close-together migratory stopovers, not because woodcock stayed at individual stopovers longer during spring migration. Transmitter-equipped woodcock captured in the Central Management Region used 2 primary migrations routes: a Western Route and a Central Route. The Western Route ran north-south, connecting the breeding and wintering grounds of the Central Management Region. The hourglass-shaped Central Route connected an area on the wintering grounds reaching from Texas to Florida, to sites throughout northeastern North America. Woodcock following the Central Route moved between the Appalachian Mountains and the Mississippi Alluvial Valley in western Tennessee during both autumn and spring migration. A higher than anticipated (based on previous banding data analyses) percentage (36%, n = 12) of marked woodcock captured in Texas and Louisiana and monitored during spring migration migrated to breeding-period sites in the Eastern Management Region, raising questions about the biological basis of managing woodcock in separate management regions.

# PRODUCTIVITY

*Crop duster applying insecticides near emergent marsh in the lower Mississippi Alluvial Valley, photo by Phillip Stephenson (AR Coop Unit 2016.)*

**HONORS AND AWARDS:**

**Bruckerhoff, L.A.** – Donoghue Graduate Student Scholarship, Kansas State University, 2016.

**Fournier, A.M.V.** – University of Arkansas Graduate School, Distinguished Doctoral Fellowship, 2012-2016.

**Fournier, A.M.V.** – University of Arkansas Graduate School, Travel Grant, North American Ornithological Conference, 2016.

**Fournier, A.M.V.** – Distinguished Student Service Award, The Wildlife Society University of Arkansas Student Chapter, 2016.

**Fournier, R.J.** – University of Arkansas Graduate School, Doctoral Academy Fellowship, 2013-2017.

**Furtado, B.V.** – University of Arkansas Graduate School, Doctoral Academy Fellowship, 2015-2019.

**Levine, B.A.** – University of Arkansas Sigma Xi Society, 2016.

**Levine, B.A.** – University of Arkansas P.E.O. Scholar Award, 2016.

**Krementz, D.G.** – Best Paper Wildlife Technical Session Southeastern Association of Fish and Wildlife Agencies Conference, 2015.

**Magoulick, D.D.** – Promotion from GS-13 to GS-14 Research Fish Biologist, 2016.

**Magoulick, D.D.** – U.S. Geological Survey STAR Award, 2016.

**Middaugh, C.R**. – University of Arkansas Graduate School, Doctoral Academy Fellowship, 2013-2017.

**Middaugh, C.R.** – University of Arkansas Graduate School, Travel Grant, National American Fisheries Society Conference, 2016.

**Middaugh, C.R.** – Bella Vista Fly Tyers Grant, 2016.

**Pittman, T.H.** – Best Paper Wildlife Technical Session Southeastern Association of Fish and Wildlife Agencies Conference, 2015.

**Yarra, A.N.** – General Endowment Award – Society for Freshwater Science, 2016.

**Yarra, A.N.** – Outstanding Member – University of Arkansas Fayetteville Student Subunit Arkansas Chapter – American Fisheries Society, 2016.

**Yarra, A.N.** – Scholarship for Fisheries and Aquatic Biology – Bella Vista Fly Tyers Club, 2016.

**Yarra, A.N.** – Johnson Endowed Scholarship for Outstanding First Year Graduate Student, University of Arkansas, Biological Sciences, 2016.

**COURSES TAUGHT:**

**Bruckerhoff, L.A.** – Human Physiology Laboratory – Fall 2015, Spring 2016.

**Fournier, A.M.V.** – Biometry Laboratory – Spring 2016.

**Fournier, R.J.** – Honors Principles of Biology Laboratory – Fall 2015, Spring 2016, Fall 2016.

**Graham, N.E.** – Principles of Biology Laboratory – Fall 2015, Spring 2016, Fall 2016.

**Levine, B.A.** – Conservation Genetics – Guest Lecture – Spring 2016.

**Levine, B.A.** – Human Physiology Laboratory – Fall 2015, Spring 2016, Fall 2016.

**Krementz, D.G.** – Wildlife Management Techniques – Spring 2016.

**Krementz, D.G.** – Fish and Wildlife Seminar – Spring 2016.

**Magoulick, D.D.** – Biometry: Experimental Design & Data Analysis for Biologists, Spring 2016.

**Middaugh, C.R.** – Human Physiology Laboratory – Fall 2015, Spring 2016, Fall 2016.

**Middaugh, C.R.** – Water Quality – Guest Lecturer – Fall 2016.

**Stephenson, P.L.** – Wildlife Techniques Laboratory – Spring 2016.

**Stephenson, P.L.** – Insects, Science, and Society Laboratory – Fall 2016.

**PUBLICATIONS AND PROFESSIONAL PAPERS PRESENTED:**

**Scientific Publications:**

**Fournier, A.M.V.,** K.J. Welsh, M. Polito, S. Emslie, and R. Brasso. 2016. Historic mercury exposure in the Clapper Rail (*Rallus crepitans*) in costal salt marshes of North Carolina. Bulletin of Environmental Contamination and Toxicology 97:469-473. doi 10.1007/s00128-016-1870-z.

**Fournier, A.M.V.,** A. Sullivan, J. Bump, M. Perkins, M.C. Shieldcastle, S. King. 2016. Combining citizen science species distribution models and stable isotope reveals migratory connectivity in the secretive Virginia Rail. Journal of Applied Ecology. doi 10.1111/1365-2664.12723.

**Krementz, D.G.,** K.L. Willard, **J.M. Carroll,** and K.M. Dugger. 2016. King rail (*Rallus elegans*) nesting and brood-rearing ecology in a managed wetland in Oklahoma, USA. Waterbirds 39:241-249.

**Leasure, D.R., D.D. Magoulick,** and **S.D. Longing.** 2016. Natural flow regime of the Ozark-Ouachita Interior Highlands region. River Research and Applications 32:18-35.

**Levine, B.A.**, C.F. Smith, M.R. Douglas, M.A. Davis, G.W. Schuett, S.J. Beaupre, M.E. Douglas. 2016. Population genetics of the copperhead at its most northeastern distributions. Copeia, 104:DOI10.1643/CG-13-150.

**Ludlam, J.P.,** B.T. Banks, and **D.D. Magoulick.** 2015. Density-dependent effects of omnivorous stream crayfish on benthic trophic dynamics. Freshwater Crayfish 21:165-170.

**Lynch, D.T.,** and **D.D. Magoulick.** 2016. Effects of pulse and press drying disturbance on benthic stream communities. Freshwater Science. 35:998-1009.

**Magoulick, D.D.** and **G.L. Piercey.** 2016. Trophic overlap between native and invasive stream crayfish. Hydrobiologia 766:237-246.

**Middaugh, C.R.,** B Kessinger, and **D.D. Magoulick.** 2016. Climate-induced seasonal changes in smallmouth bass growth rate potential at the southern range extent. Ecology of Freshwater Fish. doi 10.1111/eff.12320.

**Middaugh, C.R.,** T.A. Alfermann, P.A. Strickland, and P. Nguyen. 2016. A regional evaluation of Suwannee Bass and Largemouth Bass exploitation in north Florida rivers. North American Journal of Fisheries Management. 36:958-963.

**Pittman, H.T.,** and **D.G. Krementz.** 2016. Impacts of short-rotation early-growing season prescribed fire on a ground nesting bird in the Central Hardwoods Region of North America. PLOS One 11:e0147317. doi:10.1371/journal.pone.0147317.

**Pittman, H.T.,** and **D.G. Krementz.** 2016. Efficacy of landscape scale oak woodland and savanna restoration in the Ozark Highlands of Arkansas, USA. Journal of Southeastern Association of Fish and Wildlife Agencies 3:233-242.

**Reddin, C.J.,** and **D.G. Krementz.** 2016. Small mammal communities in eastern redcedar forest. American Midland Naturalist 175:113-119.

**Technical Publications:**

**Bruckerhoff, L.A.** 2016. The role of hydrologic regimes in driving morphologic divergence and the trait compositions of fish assemblages. M.S. Thesis. University of Arkansas, Fayetteville, Arkansas.

**Fournier, A.M.V.** 2016. Effects of wetland management strategies on habitat use of fall migrating rails on intensively-managed wetland complexes in Missouri. Final Report U.S. Fish and Wildlife Services, Division of migratory Birds Webless Program.

**Leasure, D.R.,** and **L.A. Bruckerhoff.** 2016. Quantifiation of hydrologic alteration and relationships to biota in Arkansas streams: Development of tools and approaches for un-gaged streams. Final

report prepared for the State Wildlife Grant program of the Arkansas Game and Fish Commission, Little Rock, Arkansas.

**Lynch, D.T.** 2016. Ecological-flow response relationships and environmental flows assessment for the Ozark Highlands. Ph.D. Dissertation. University of Arkansas, Fayetteville, Arkansas.

**<u>Papers Presented</u>:**

**Bruckerhoff, L.A., D.R. Leasure**, and **D.D. Magoulick.** 2016. Spatial auto-correlations of fish traits across hydrologic regimes and implications for developing ecological-flow relationships. Joint Meeting of Ichthyologists and Herpetologists. New Orleans, Louisiana.

**Bruckerhoff, L.A., D.R. Leasure**, and **D.D. Magoulick.** 2016. Spatial auto-correlations of fish traits across hydrologic regimes and implications for developing ecological-flow relationships. American Fisheries Society Annual Meeting. Kansas City, Missouri.

**Bruckerhoff, L.A., D.R. Leasure,** and **D.D. Magoulick.** 2016. Hydrologic regimes as potential drivers of morphologic divergence in fish. Symposium on Ecological Flow Science and Policy: Protecting Stream Systems Today; Preparing for Tomorrow. American Fisheries Society. Kansas City, Missouri.

Dodd, A.K., **D.R. Leasure, D.D. Magoulick,** and M.A. Evans-White. 2016. Characterizing tow natural flow regimes of the Ozark Highlands and Boston Mountains, Arkansas, USA. Society for Freshwater Science. Sacramento, California.

**Fouriner, A.M.V.,** K. Drake, and **D.G. Krementz.** 2016. Migratory Connectivity of Sora, Virginia Rail and Yellow Rail. North America Ornithological Conference. Washington, District of Columbia.

**Fournier, A.M.V.** 2016. Building collaborations and community in science through Twitter. North American Ornithological Conference, Twitter for Scientists Workshop. Washington, District of Columbia.

**Fournier, A.M.V.,** D.C. Mengel, and **D.G. Krementz.** 2016. Habitat use by autumn migrating Sora in the Mississippi Flyway. Society of Wetland Scientist. Corpus Christi, Texas.

**Graham, N.E.,** and **D.D. Magoulick.** 2106. Does the Native Geographic Origin of an invader affect stream structure and function? Southern Division of the American Fisheries Society Crayfish Symposium. Wheeling, West Virginia.

**Graham, N.E.,** and **D.D. Magoulick.** 2016. Does the Native Geographic Origin of an invader affect stream structure and function? Arkansas Academy of Science Annual Meeting. Fayetteville, Arkansas.

**Herbert, J.A.,** A. Chakraborty, L. Naylor, and **D.G. Krementz.** 2016. Abundance and distribution of non-breeding mallards in the lower Mississippi Alluvial Valley. North American Ornithological Congress. Washington, District of Columbia.

**Koenigbauer, S., C.R. Middaugh,** and **D.D. Magoulick.** 2016. Predation of crayfish before and during drought. Arkansas Water Resources Conference. Fayetteville, Arkansas.

**Krementz, D.G.** 2015. Marsh bird habitat use in the lower Mississippi Alluvial Valley. National Sedimentation Laboratory. Oxford, Mississippi.

**Krementz, D.G.** 2016. Migration ecology of American woodcock. Arkansas Technical University. Russellville, Arkansas.

**Lynch, D.T., D.R. Leasure,** and **D.D. Magoulick.** 2016. The influences of drought on flow-ecology relationships in Ozark Highland streams. Symposium on Ecological Flow Science and Policy: Protecting Stream Systems Today; Preparing for Tomorrow. American Fisheries Society. Kansas City, Missouri.

**Lynch, D.T., D.R. Leasure,** and **D.D. Magoulick.** 2016. The influence of drought on flow-ecology relationships in Ozark Highland streams. Plenary-Themed Special Session on Climate and drought effects on mountain stream ecosystems. Society for Freshwater Science Meeting. Sacramento, California.

**Magoulick, D.D.,** and **D.R. Leasure.** 2016. Temporal variation in flow alteration of intermittent and perennial streams in the Interior Highlands. Plenary-Themed Special Session on Eco-hydrology of intermittent rivers and ephemeral streams in the face of a changing climate. Society of Freshwater Sciences Meeting. Sacramento, California.

**Magoulick, D.D.,** and **D.R. Leasure.** 2016. Flow alteration of intermittent and perennial streams in the Interior Highlands. Arkansas Wildlife Action Plan Meeting. Mount Magazine, Arkansas.

**Middaugh, C.R.,** and **D.D. Magoulick.** 2016. Lotic smallmouth bass body condition changes induced by seasonal drying across two flow regimes in the Ozarks of Arkansas and Missouri. Missouri/Arkansas Whiter River Cooperators Meeting. Branson, Missouri.

**Middaugh, C.R.,** and **D.D. Magoulick.** 2016. Forecasting effects of angler harvest and climate change on smallmouth bass abundance at the southern edge of their range. National American Fisheries Society Conference. Kansas City, Missouri.

**Middaugh, C.R.,** and **D.D. Magoulick.** 2016. Lotic smallmouth bass body condition changes induced by seasonal drying across two flow regimes in the Ozarks of Arkansas. Bella Vista Fly Tyers Club. Bella Vista, Arkansas.

**Middaugh, C.R.,** and **D.D. Magoulick.** 2016. Lotic smallmouth bass body condition changes induced by seasonal drying across two flow regimes in the Ozarks of Arkansas. Arkansas Academy of Science. Fayetteville, Arkansas.

**Moore, J.D.,** D.E. Andersen, T.R. Cooper, and **D.G. Krementz.** 2016. American woodcock migration ecology. Mississippi Flyway Game Bird Technical Section Meeting – Webless Committee. Louisville, Kentucky.

**Moore, J.D.,** D.E. Andersen, T.R. Cooper, and **D.G. Krementz.** 2016. Migratory connectivity and migration phenology of American woodcock. 2016 State of Stopover Symposium. Milwaukee, Wisconsin.

**Stephenson, P.L.** 2016. Impacts of management emergent wetlands on bee communities in the Arkansas Delta. Mississippi State University, Department of Wildlife, Fisheries and Aquaculture. Starkville, Mississippi.

**Stephenson, P.L.** 2016. Impacts of management emergent wetlands on bee communities in the Arkansas Delta. University of Arkansas, Arkansas Entomological Society Meeting. Fayetteville, Arkansas.

**Stephenson, P.L.** 2016. Bee communities on actively and passively emergent wetlands in the Lower Mississippi Alluvial Valley of Arkansas. Arkansas Cooperative Fish and Wildlife Research Unit Annual Meeting. University of Arkansas, Department of Biology. Fayetteville, Arkansas.

**Stephenson, P.L.** 2016. UFO's: What's in our Wetlands? Arkansas Chapter of the Wildlife Society Annual Meeting. Little Rock, Arkansas.

**Yarra, A.N., D.D. Magoulick,** B.K. Wagner, R.J. DiStefano and J.W. Fetzner. 2016. Invasive species effects, populations status and population genetics of crayfish of greatest conservation need (*Orconectes marchandi, Orconectes eupunctus,* and *Cambarus hubbsi*) in the Ozark Highlands of Arkansas and Missouri. Arkansas Wildlife Action Plan Symposium. Paris, Arkansas.

**Yarra, A.N.,** and **D.D. Magoulick.** 2016. Influence of flow regime, geomorphology, and habitat on crayfish assemblages of the Ozark Highlands. Society for Freshwater Science Conference. Sacramento, California.

**Yarra, A.N.,** and **D.D. Magoulick.** 2016. Influence of flow regime, geomorphology, and habitat on crayfish assemblages of the Ozark Highlands. Southern Division of the American Fisheries Society Conference. Wheeling, West Virginia.

**Yarra, A.N., L.A. Bruckerhoff,** and **D.D. Magoulick.** 2016. Influence of flow regime, geomorphology and habitat on crayfish assemblages of the Ozark Highlands. Society for Freshwater Science. Sacramento, California.

**Posters Presented:**

**Koenigauer, S., C.R. Middaugh,** and **D.D. Magoulick.** 2016. Predation of lotic crayfish before and during drought. Arkansas Water Resources Conference. Fayetteville, Arkansas.

Levine, B.A., M.R. Douglas, J.A. Savidge, B.A. Lardner, R.N. Reed, M.E. Douglas. SNP discovery for parentage of kinship analysis in the Brown Treesnak (*Boiga irregularis*) on Guam. Joint Meeting of Ichthyologists and Herpetologists. New Orleans, Louisiana.

**COMMITTEES/TASK FORCES/RECOVERY TEAMS:**

**Fournier, A.M.V.** – Vice Chair – Open Science Section Ecological Society of America. 2016.

**Fournier, A.M.V.** – Secretary/Treasurer – Wetlands Working Group – The Wildlife Society National. 2015-2016.

**Fournier, A.M.V.** – Associate Editor – Ibis. 2016.

**Fournier, A.M.V.** – Research Committee – Black Swamp Bird Observatory. 2016.

**Fournier, A.M.V.** – Workshop Lesson Maintainer – Data Carpentry. 2016.

**Fournier, A.M.V.** – Member – American Ornithological Society. 2016.

**Fournier, A.M.V.** – Member – Society of Wetland Scientists. 2016.

**Fournier, A.M.V.** – Member – Wilson Ornithological Society. 2016.

**Fournier, A.M.V.** – Member – Ecological Society of America. 2016.

**Fournier, A.M.V.** – Member – University of Arkansas Student Chapter – The Wildlife Society. 2016.

**Fournier, A.M.V.** – Member – Associations of Field Ornithologists. 2016.

**Fournier, A.M.V.** – Member – Waterbirds Society. 2016.

**Fournier, A.M.V.** – Member – Biology Graduate Student Association – University of Arkansas. 2016.

**Fournier, A.M.V.** – Peer Reviewer – Avian Conservation and Ecology, Ecology and Evolution, Methods in Ecology and Evolution, Wilson Journal of Ornithology – 2016.

**Graham, N.E.** – Vice President – University of Arkansas Student Chapter – American Fisheries Society. 2016.

**Graham, N.E.** – Member – Biology Graduate Student Association – University of Arkansas. 2016.

**Krementz, D.G.** – Member – Curriculum Committee – University of Arkansas. 2012-present.

**Krementz, D.G.** – Graduate Student Advisory Committee – Kelly Halloran, M.S. Department of Biological Sciences, University of Arkansas. 2015-present.

**Krementz, D.G.** – Graduate Student Advisory Committee – Heather Wallace, Ph.D. Department of Biological Sciences, University of Arkansas. 2015-present.

**Krementz, D.G.** – Graduate Student Advisory Committee – Brenna Levine, Ph.D. Department of Biological Sciences, University of Arkansas. 2015-present.

**Krementz, D.G.** – Member – The Wildlife Society. 1998-present.

**Krementz, D.G.** – Member – National Resources Conservation Service Marshbird Working Group. 2011-present.

**Krementz, D.G.** – Member – National Resources Conservation Service Wildlife Working Group. 2011-present.

**Krementz, D.G.** – Member – West Gulf Coastal Plain JV landbird technical group. 2009-present.

**Krementz, D.G.** – Chair – Webless Committee, Mississippi Flyway Technical Section. 2006-present.

**Krementz, D.G.** – Member – Arkansas Game and Fish Commission – Arkansas Wildlife Action Plan. 2015- present.

**Krementz, D.G.** – Member – Midwest Marshbird Monitoring Group. 2012- present.

**Krementz, D.G.** – Faculty Advisor – University of Arkansas Student Chapter of The Wildlife Society. 2011- present.

**Krementz, D.G.** – Associate Editor, Southeastern Naturalist Journal. 2016.

Levine, B.A. – Member – Scientific Advisory Board – The Copperhead Institute. 2014 – present.

Levine, B.A. – Member – Sigma Xi Society. 2016.

Levine, B.A. – Member – American Society of Ichthyologists and Herpetologist. 2010 – present.

Levine, B.A. – Member – Biology Graduate Student Association, University of Arkansas. 2010 – present.

**Magoulick, D.D.** – External Reviewer for promotion and Tenure Applications, University of Illinois. 2016.

**Magoulick, D.D.** – Member – North American Benthological Society. 1986–present.

**Magoulick, D.D.** – Member – American Fisheries Society. 1990–present.

**Magoulick, D.D.** – Member – Ecological Society of America. 1990-present.

**Magoulick, D.D.** – Member – Sigma Xi Scientific Research Society. 1984-present.

**Magoulick, D.D.** – Member – Project Kaleidoscope Faculty for the 21$^{st}$ Century. 1999-present.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Chelsea Kross, Ph.D. Department of Biological Sciences, University of Arkansas. 2015 – present.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Allyn Dodd, Ph.D. Department of Biological Sciences, University of Arkansas. 2015 – present.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Kayla Sayre, M.S. Department of Biological Sciences, University of Arkansas. 2015 – present.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Brooke Howard-Parker, M.S. Department of Biological Sciences, University of Arkansas. 2015 – present.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Kyler Hecke, M.S. Department of Biological Sciences, University of Arkansas. 2014-present.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Jacqueline Guzy, Ph.D. Department of Biological Sciences, University of Arkansas. 2014-present.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Melissa Welch, M.S. Department of Biological Sciences, University of Arkansas. 2013-present.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Shrijeeta Ganguly, Ph.D. Department of Biological Sciences, University of Arkansas. 2013-2016.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Whitney Nelson, Ph.D. Department of Biological Sciences, University of Arkansas. 2013-present.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Philip Vogrinc, M.S. Department of Biological Sciences, University of Arkansas. 2013-2016.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Auriel Fournier, Ph.D. Department of Biological Sciences, University of Arkansas. 2012-2017.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Hal Halvorson, Ph.D. Department of Biological Sciences, University of Arkansas. 2012-2016.

**Magoulick, D.D.** – Graduate Student Advisory Committee – Kapil Khadka, Ph.D. Department of Biological Sciences, University of Arkansas. 2012-present.

**Magoulick, D.D.** – Faculty Search Committee – Invertebrate Ecologist, Department of Biological Sciences, University of Arkansas. 2015 - present.

**Magoulick, D.D.** – Yellowcheek Darter Recovery Plan Team – U.S. Fish and Wildlife Services. 2013-present.

**Magoulick, D.D.** – Adaptation Science Management Team for Gulf Coastal Plain Ozarks Landscape Conservation Cooperative – U.S. Fish and Wildlife Services. 2012-present.

**Magoulick, D.D.** – Inter-agency Climate Change Working Group. 2010-present.
**Magoulick, D. D.** – Nature Conservancy Science Advisory Board. 2010-present.
**Magoulick, D.D.** – Fish Taxa Team – Arkansas Wildlife Action Plan. 2010-present.
**Magoulick, D.D.** – Crayfish Taxa Team – Arkansas Wildlife Action Plan. 2010-presnt.
**Magoulick, D.D.** – International Union for Conservation of Nature (IUCN) Australia Freshwater Fish Conservation Work Group. 2009-present.
**Magoulick, D.D.** – U.S. Fish and Wildlife Service Aquatic Nuisance Species Task Force. 2007-present.
**Magoulick, D.D.** – Arkansas Invasive Species Task Force. 2007-present.
**Magoulick, D.D.** – Arkansas Zebra Mussel Task Force. 1997-present.

**Middaugh, C.R.** – Treasurer – University of Arkansas Subunit of the American Fisheries Society. 2015-2016.
**Stephenson, P.L.** – Chair-elect – Student Development Working Group – The Wildlife Society. 2016.
**Stephenson, P.L.** – President – University of Arkansas Student Chapter – The Wildlife Society. 2015-2016.
**Yarra, N.A.** – Secretary –University of Arkansas Student Chapter – American Fisheries Society. 2016.
**Yarra, N.A.** – Member – Student Resources Committee – Society of Freshwater Science. 2016.

**TECHNICAL ASSISTANCE:**

**Training Offered:**

**Fournier, A.M.V.** – Advanced R Programming and Graphing Workshop – North American Ornithological Conference – Washington, District of Columbia – 2016.
**Fournier, A.M.V.** – Software Carpentry Workshop – University of Connecticut – Mansfield, Connecticut – 2016.
**Fournier, A.M.V.** – Software Carpentry Workshop – Federal Reserve Board – Washington, District of Columbia – 2016.
**Fournier, A.M.V.** – Software Carpentry Workshop – U.S. Department of Agriculture – Washington, District of Columbia – 2016.

**Training Received:**

**Fournier, A.M.V.** – Wilderness First Aid – NOLS Wilderness Medicine Institute – University of Arkansas – 2016.
**Fournier, A.M.V.** – Adult First Aid/CPR/AED American Red Cross – University of Arkansas – 2016.
**Fournier, A.M.V.** – Spatial Capture Recapture Workshop – University of Georgia - 2016.
**Fournier, A.M.V.** – Game Theoretical Modeling of Evolution in Structured Populations Tutorial NIMBios – University of Tennessee – 2016.
**Fournier, A.M.V.** – NSC Defensive Driving II – U.S. Department of Interior – 2016.
**Fournier, R.J.** – Wilderness First Aid – NOLS Wilderness Medicine Institute – University of Arkansas – 2016.
**Graham, N.E.** – Wilderness First Aid – NOLS Wilderness Medicine Institute – University of Arkansas – 2016.
**Krementz, D.G.** – Uniformed Services Employment and Reemployment Rights – U.S. Department of Interior – 2016.

**Krementz, D.G.** – Veteran Employment Training for Federal Hiring Managers Course – U.S. Department of Interior – 2016.

**Krementz, D.G.** – Federal Information Systems Security Awareness + Privacy and Records Management – U.S. Department of Interiors – 2016.

**Krementz, D.G.** – NSC Defensive Driving II – U.S. Department of Interior – 2016.

**Krementz, D.G.** – Annual Ethics Training – U.S. Department of Interior – 2016.

**Moler, D.J.** – NSC Defensive Driving Course 9th Edition – U.S. Department of Interior – 2016.

**Moler, D.J.** – Hiring Foreign National – University of Arkansas, Human Resources – 2016.

**Moler, D.J.** – Fair Labor Standards Act for Arts & Sciences – University of Arkansas, Human Resources – 2016.

**Moler, D.J.** – I-9 Completion – University of Arkansas, Human Resources – 2016.

**Moler, D.J.** – Basis Travel Enhancement Training – University of Arkansas, Travel Office – 2016.

**Moler, D.J.** – Discriminatory Harassment – University of Arkansas, Human Resources – 2015.

**Ostrum, E.M.** – Adult First Aid/CPR/AED – American Red Cross – 2016.

**Ostrum, E.M.** – NSC Defensive Driving Course 9th Edition – U.S. Department of Interior – 2016.

**Ostrum, E.M.** – Hazardous Waste I – University of Arkansas – 2016.

**Stephenson, P.L.** – Wilderness First Aid – NOLS Wilderness Medicine Institute – University of Arkansas – 2016.

**Stephenson, P.L.** – Chronic Wasting Disease Sampling Workshop – Arkansas Game and Fish Commission – 2016.

**Stephenson, P.L.** – Nuisance Bat Workshop – Arkansas Game and Fish Commission – 2016.

**Yarra, A.N.** – Wilderness First Aid – NOLS Wilderness Medicine Institute – University of Arkansas – 2016.

**<u>Outreach</u>:**

**Fournier, A.M.V.** – Outdoor Education Volunteer – Hobbs State Park.

**Fournier, A.M.V.** – Keynote, Ohio Ornithological Society Annual Conference

**Fournier, A.M.V.** – Talk, Arkansas Audubon Society Annual Conference

**Fournier, A.M.V.** – Seminar, University of Toledo, Department of Environmental Sciences.

**Fournier, A.M.V.** – Science Fair Judge, 3 local and 1 regional science fair.

Levine, B.A. – Herpetology and Ecology Guest Speaker – Fayetteville High School, Fayetteville, Arkansas.

Levine, B.A. – Science Fair Judge – Northwest Arkansas Regional Science Fair, Fayetteville, Arkansas.

**Magoulick, D.D.** – Regional Sciences Fair Judge. 2008-present.

**Middaugh, C.R.** – Science Fair Judge – St. Joseph Catholic School.

**Moore, J.D.** – American woodcock migration ecology website overseer – located on Ruffed Grouse Society website.

**Moore, J.D.** – America woodcock migration ecology research featured in various newspapers, magazines and websites regionally, nationally, and internationally.

**Stephenson, P.L.** – Birds and Breakfast – Hobbs State Park.

**Stephenson, P.L.** – Insect Festival – University of Arkansas, Department of Entomology.

**Yarra, A.N.** – Northwest Arkansas Regional Science Fair Judge.

**Yarra, A.N.** – Presentation, Bella Vista Fly Tyers Club.