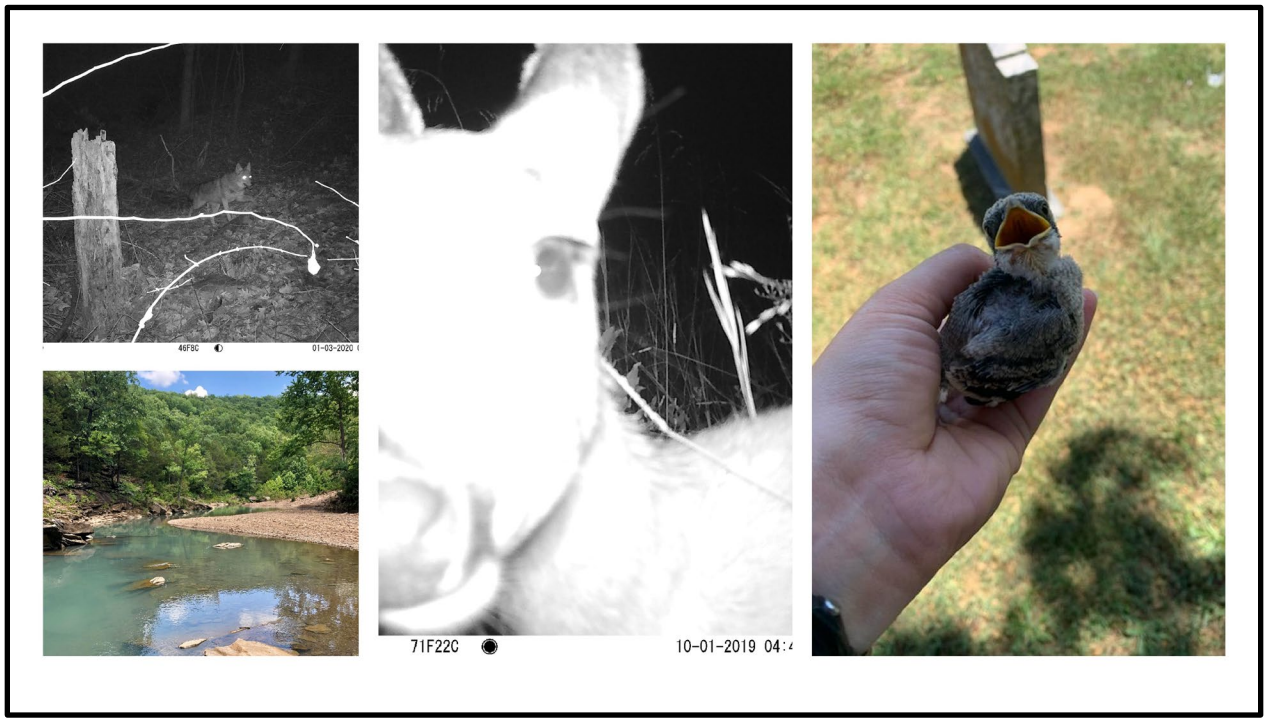
Arkansas Fish and Wildlife Cooperative Research Unit 2022 Annual Report



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INTRODUCTION

The Cooperative Research Units program was established in 1935 to enhance graduate education in fisheries and wildlife sciences and to facilitate research and technical assistance between natural resource agencies and universities on topics of mutual concern. Today, there are 41 Cooperative Research Units in 39 states, with a National Program Office located at the U.S. Geological Survey in Reston, Virginia. The Arkansas Cooperative Fish and Wildlife Research Unit first opened its doors in August of 1988. Over the past 33 years, the Arkansas Cooperative Research Unit has proudly trained and graduated over 72 MS and 16 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 over 200 peer-reviewed publications.

During the past thirty-four years, the Arkansas Cooperative Research Unit has gone through a number of changes. Our most recent change has been the addition of assistant unit leader, Dr. Caleb Roberts in January 2021. The arrival of Caleb brings the Unit to a 3 Principal Investigator unit for the first time in over 20 years. To learn more about the current members of the Arkansas Cooperative Research Unit, funding, research projects, and the activities and productivity of the current faculty and staff visit the official website at:

https://www1.usgs.gov/coopunits/unit/Arkansas

DIRECTION STATEMENT

The Arkansas Cooperative Fish and Wildlife Research Unit performs research designed to address the needs of Cooperators, bridging the gap between applied and basic wildlife and fisheries science. Collectively, the unit scientists study fish and wildlife occupancy and distribution, factors affecting population and community dynamics of fish and wildlife with a focus on the role of natural and human disturbances, the impacts of introduced species, landscape ecology, and fire ecology. The unit works with many taxa, including birds, reptiles, freshwater fish and crayfish, mammals, and insects. Other research topics are addressed as needed, in keeping with the Cooperative Research Program's mission to prioritize the needs of our Cooperators by remaining flexible and open to new areas of inquiry.

Unit scientists will advance the training and education of graduate and undergraduate students at the University of Arkansas by teaching up to one graduate-level course per year in Biological Sciences, recruiting, training, and mentoring exceptional undergraduate and graduate students as well as postdoctoral researchers, and serving on graduate committees of non-Unit students.

The Arkansas Unit will endeavor to find opportunities for interaction and engagement between unit students and Cooperators as well as collaboration potential with fellow faculty at the University of Arkansas. Technical support and training will be provided to Cooperators and other agencies as the need exists.

NEWS AND UPDATES

- John Veon has successfully completed his master's degree and has started a PhD program at University of California at Davis.
- Andrhea Massey has successfully completed her master's degree and is working for the Dept of Defense and Colorado State University at Fort Polk, Louisiana.
- All of the cooperators are in the process of updating our cooperative agreement which will for the first time in the unit's history make the U.S. Fish and Wildlife Service an official signatory.
- Former Magoulick lab member, Lindsey Bruckerhoff, has joined the Oklahoma Cooperative Unit
- PhD student, Sarah Sorensen has passed her qualifying exams and is now a PhD candidate.
- Ellery Ruther has received a Directorate Fellowship through the US Fish and Wildlife Service and is working with USFWS for the summer.
    - Additionally, Ellery was one of 3 finalists interviewing with AGFC for the Bobwhite Coordinator position, showing that the pipeline between the Unit and AGFC is strong.
- Brett and Luke Naylor working together to offer the Delta Waterfowl Hunter course this upcoming fall semester.

RESEARCH PROJECTS

Completed

- Effects of Freshwater Turtle Harvest on Populations of Turtles in the Mississippi Alluvial Valley (completed December 2021)
- Armadillo burrow commensals in 4 ecoregions of Arkansas (completed spring 2022)
- Nocturnal basking behavior of turtles (completed summer 2021)
- Overwintering mallard body mass trends from 1979 – 2021 within the Lower Mississippi Alluvial Valley (completed December 2021)
- Winter stonefly distribution, habitat requirements, life history, and population status in Arkansas (completed June 2022)
- Effects of Flow Regime and Natural Hydrologic Disturbance on Fish Assemblage Structure (completed May 2022)
- Impacts of disturbance and network topology on food web stability and complexity (completed May 2022)
- Hydrologic alteration and geomorphic instability in the Illinois River Watershed and potential impacts on mussel SGCN and associated fish communities (completed May 2022)
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Ongoing

- Spotted Turtle Movement and Population Dynamics on a Military Installation
- Effects of neonicotinoid pesticides on Loggerhead Shrike
- Mammal Community Response to Human Land Use
- Suburban Wildlife of Northwest Arkansas
- Exploring Eastern Spotted Skunk (*Spilogale putorius*) distribution and habitat associations in southwestern Arkansas.
- Breeding and Migration Ecology and Distribution and Abundance of Arkansas King Rails
- Impacts of Egyptian Goose and other invasive aquatic avifauna in Arkansas
- Snapshot USA: A nationwide camera trapping study
- Horizon Scan: Predicting the next Invasive Species
- Integrating spatial data for predicting the influence of altered hydrologic and thermal conditions on fish assemblage traits and taxa across stream flow regimes
- Effects of Drought on Rainbow Darter (*Etheostoma caeruleum*) Growth, Survival and Refuge Use as a Preliminary Study for the Endangered Yellowcheek Darter (*Nothonotus moorei*)
- Non-Invasive Distance Sampling via Snorkel and Video Surveys of Darters in the Little Red River, Arkansas
- Endangered yellowcheek darter (*Etheostoma moorei)* movement and refuge use
- Influences of Disturbance on an Ozark-endemic Petitioned Crayfish
- A rapid mapping tool for quantifying grassland management outcomes
- Exploring assumptions of community occupancy models in stream systems

Upcoming and Potential Projects

- Distribution, Habitat Associations, and Seasonal Activity Patterns of Striped Skunk (*Mephitis mephitis*) in each of the Ecoregions of Arkansas (In cooperation with Blake Sasse, AGFC)
- Northern Bobwhite occupancy surveys on Camp Robinson (funding applied for with Nick Goforth of Arkansas National Guard).
- Near real-time acoustic monitoring of birds (awaiting funding from Dept of Defense)
- Impacts of Feral Hogs on Songbirds (FWS SSP – Summer 2023)
- Risk assessment for Giant Salvinia (*Salvinia molesta*) in Arkansas waters (AGFC funding: August 2022 - July 2023)
- Applying data integration, niche modeling, and novel spatial early warning metrics to predict cogongrass (*Imperata cylindrica*) invasion (funding application via USDA NIFA AFRI)
- Landscape and local-scale habitat influences on distribution and abundance of the crayfish *Faxonius euphunctus*, *Faxonius wagneri*, and *Faxonius roberti* in the Spring River, Strawberry River and Eleven Point River drainages (Arkansas Game and Fish Commission)
- Habitat associations and population genetic structure of the endemic Beaded Darter *Etheostoma clinton* in the upper Ouachita River system (Arkansas Game and Fish Commission SWG)

HIGHLIGHTED RESEARCH PROJECTS

Bobcat caught on trail camera at Bear Hollow/Ozark Natural Science Center

Mesocarnivore Density Along an Urban to Rural gradient in Northwest Arkansas

Funding Sources:	United States Geological Survey (grant name here) Arkansas Cooperative Fish and Wildlife Research Unit University of Arkansas, VCRI
Project Duration:	August 2021 – August 2023
Principal Investigators:	Brett DeGregorio
Graduate Student:	Leah McTigue (M.S. Student)

Research Objectives:

1. Examine the impacts of urbanization on mesocarnivore density through the use of game cameras and the Random Encounter Model.
2. Investigate how anthropogenic factors impact mesocarnivore density along an urban to rural gradient.

Management Implications:

1. Through this study we hope to assess trends in wildlife communities along an urban to rural gradient and provide valuable information for management agencies to aide and improve current conservation efforts and management practices.

Project Summary:

As urbanization and human development expand rapidly on a global scale, monitoring how wildlife communities are affected is critical. Some species of wildlife, such as raccoons (Procyon lotor), red fox (Vulpes vulpes) and Virginia opossums (Didelphis virginiana) can thrive in urban areas, whereas

other species such as bobcats (Lynx rufus), prefer more natural, undisturbed sites and are often absent from highly urban areas.

Northwest Arkansas is rapidly expanding in population and human development, with the current population of 546,725 expected to double by 2045 (NWARPC 2021). To assess the impact of urbanization on mesocarnivores within Northwest Arkansas, we conducted a trail camera study across 12 study sites, ranging from city parks within city limits to more natural nature preserves in the Ozark Mountains. Our study took place in the greater Fayetteville metropolitan area, Northwest Arkansas. All study sites were within the Ozark Mountain Ecoregion and contained recreational hiking trails for accessing camera locations. We chose sites that were dominated by mature oak-hickory forest and located between 220-554 meters in elevation to account for variation in wildlife communities. Our study included ANHC Natural Areas, National Forests, City of Fayetteville parks, and private reserves.

To calculate density, we chose 5 focal species (Coyote, Bobcat, Opossum, Raccoon, and Red Fox) and applied the Random Encounter Model to the trail camera detection data. The Random Encounter Model was developed by Marcus Rowcliffe in 2008 as a way to use trail camera data to calculate the density of unmarked animals. We then compared density calculations against 5 variables used to measure levels of anthropogenic factors and environmental features: Housing Unit Density, anthropogenic noise, distance to water, area of forest cover, and open developed areas (parks, golf courses, etc). Through this analysis we hope to assess trends in wildlife communities along an urban to rural gradient and determine what environmental and anthropogenic features have the highest impact on wildlife communities.

Emily Johansson is studying the mammal community that occurs in the yards of Northwest Arkansas and evaluating which yard features attract particular wildlife and which features deter wildlife

Occupancy and Diversity of Mammals in Residential Yards: Effects of Yard Features and Landscape Cover

Funding Source:	Arkansas Game and Fish Commission (Base Funds) University of Arkansas, Biological Sciences University of Arkansas, Office of Undergraduate Research
Project Duration:	Summer 2021 – December 2023
Principal Investigator:	Brett DeGregorio
Graduate Student:	Emily Johansson (M.S. Student)

Research Objectives:

1. To determine the influence of yard features and landscape cover on mammal community composition and diversity
2. Quantify occupancy and activity patterns of predators across a suburban gradient

Management Implications:

1. Many mesopredators can exploit human-subsidized resources and attain abnormally high densities with repercussions for trophic interactions and disease dynamics, understanding how different species respond to yard-level features can help managers understand how to predict and mitigate the resources available to focal mesopredators.

Project Summary:

As the human population increases globally, human development continues to expand. Currently, one of the major land cover types in the United States is suburban development comprised of residential housing and lawns with over 50% of the United States population living in suburban areas. Suburban landscapes are dominated by moderate density human housing interspersed with lawns and other greenspace. Wildlife living in areas being converted to human development must move from these areas or adapt. While suburban development is designed for human habitation and comfort, it provides unique opportunities for co-existence with wildlife that differ from urban or rural developments and can support biodiverse wildlife communities.

The suburban environment consists of numerous independent greenspaces (lawns) managed differently by homeowners. These lawns vary in size, configuration, structure, use, and management. For adaptable wildlife able to coexist with humans in suburban areas, resources such as food, water, and shelter may be abundant albeit patchily distributed. This patchy distribution of resources can lead to patterns of wildlife presence and use varying from yard to yard. Particular species of wildlife may be attracted to yards to exploit food (compost, bird feeders, vegetable gardens etc) while others use yards for water sources or shelter sites.

Despite the abundant resources available to wildlife in the suburban environment there are numerous dangers and deterrents present. The suburbs can be dangerous and disruptive to wildlife due to vehicle traffic, predatory pets, conflicts with humans, light pollution, and noise etc. While certain yards may be attract wildlife there are also other features that deter wildlife from yards such as those with free-roaming pets, motion-activated lights, or impenetrable fences. While some of these yard-level deterrents may cause wildlife to avoid particular yards they may result in more nuanced changes in wildlife behavior such as shifts in activity patterns. Many mammalian species are capable of being active during the day or the night and shift their activity to take advantage of resources, temperatures, and to avoid predation or competitors. The activity patterns of animals in the suburban environment likely provides insight into how they are interacting with the various resources and threats in this novel environment.

Northwest Arkansas is the fastest developing area of the state and among the most rapid in the entire country. The predominant type of development occurring is conversion of forested areas to suburban development to accommodate the rapidly increasing human population. The rapid growth and development of this region is almost certainly leading to changes in the wildlife community and provides opportunity to evaluate how different yard features offer different attractants and repellents to wildlife. Because the suburban matrix provides a complex risk-reward environment for wildlife, the presence and behavior of wildlife are almost certainly influenced by the resources available within individual yards. From the perspective of an animal, not every yard is created equal. Understanding what resources are positively associated with the presence of particular wildlife (or are negatively associated), provides to homeowners the agency to manipulate their yards to attract or deter particular wildlife. The value of a yard for particular wildlife is likely a function of the food, water, and shelter resources it provides as well as the presence of factors that are associated with danger or are deterrents (e.g., pet dogs, fences, human activity).

A tagged pair of King Rails caught in April 2022. (Photo Jess Schmit)

Breeding and Migration Ecology and Distribution and Abundance of Arkansas King Rails

Funding Source:	State Wildlife Grant, Arkansas Game and Fish Commission University of Arkansas, Biological Sciences Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	January 2022 – June 2024
Principal Investigator:	Caleb Roberts
Graduate Student:	Jessica Schmit (M.S. Student)

Research Objectives:

3. Capture and GPS mark migrating and breeding rails using the habitat at Choctaw West WMA, and capture juvenile birds in summer to evaluate breeding site fidelity
4. Connectivity of the site with the rest of the annual cycle for the three cohorts of birds
5. Investigate nest site selection and habitat preferences at Choctaw West WMA
6. Compare King Rail habitat and abundance to other sites across the Arkansas Delta
7. Analyze existing marsh bird survey data from across the state to quantify King Rail distribution and abundance and compare regional habitat and landscape attributes to Choctaw West WMA attributes

Management Implications:

2. This study will provide AGFC with critical knowledge of King Rail population dynamics in Arkansas, and determine how Choctaw West WMA may function as a source for other sites both in Arkansas and the Mississippi Flyway.

3. We will also investigate breeding habitat needs at local, landscape, and regional scales and research wetland restoration outcomes to guide future management.

Project Summary:

King rails (*Rallus elegans*) are a secretive marsh bird species of special conservation concern in Arkansas and other states where they occur. Their population has declined over the last few decades due to habitat loss and wetland degradation. We need to take a multifaceted approach to understanding King Rail habitat needs and use in Arkansas for their continued conservation.

Freddie Black Choctaw West WMA was previously determined to have multiple pairs of breeding King Rails (Budd and Krementz, 2017). It is the only known public site to have recorded multiple breeding pairs. It is most notable that Choctaw West is a recent restoration project and King Rails began breeding there almost immediately. This WMA offers an incredible opportunity to learn more about their breeding habits, behavior and site selection in response to dramatic wetland restoration.

This project seeks to accomplish several key goals: determine migratory connectivity and site fidelity to Choctaw West, compare King Rail abundance and distribution to other sites in the Arkansas Delta, analyze and compare existing marsh bird survey data from across the state to quantify King Rail distribution and abundance, and distinguish regional habitat and landscape characteristics. Additionally, there will also be a focus on the breeding rails and their nesting behavior and habitat selection for nesting and raising broods.

The Egyptian Goose (Alopochen aegyptiaca) is an exotic invasive waterfowl with established breeding populations in Arkansas. Photo by Tobi NDH (CC BY-NC-SA 2.0).

Impacts of Egyptian Goose and other invasive aquatic avifauna in Arkansas

Funding Source:	University of Arkansas, Biological Sciences, Arkansas Game and Fish Commission
Project Duration:	Fall 2021 – May 2023
Principal Investigator:	Caleb Roberts
Graduate Student:	Percy Marshall (MS Student)

Research Objectives:

1. Synthesize existing scientific literature on the impacts of Egyptian Geese and other invasive aquatic avifauna on native ecosystems and agroecosystems.
2. Determine current distribution of Egyptian Goose in Arkansas via field surveys.

Management Implications:

1. The literature review will (i) provide AGFC with information on the potential impacts of Egyptian Geese and other invasive aquatic avifauna on Arkansas ecosystems and agroecosystems, and it will (ii) arm AGFC with information to educate the public on invasive aquatic avifauna impacts and increase public support for invasive aquatic avifauna management.
2. This project will provide AGFC with updated information on the distribution of Egyptian Geese and a comparison with past distribution information. This will help determine if Egyptian Geese are expanding their range in Arkansas.

Project Summary

In an increasingly interconnected world, the ecological and financial cost of nuisance and invasive species is expected to continue to climb through the movement of exotic biota. In order

to respond to the presence of introduced species, it is critical to understand what impacts they are likely to pose to a given area. Waterfowl are one such category of invasive species of concern due to their popularity of accidental introduction, ease of movement, and propensity to affect both terrestrial and aquatic ecosystems. Studies have been undertaken to understand the effects different invasive waterfowl species have had across North America, but the scope of current knowledge is uncertain due to lack of synthesis. Here I am undertaking a systematic literature review to understand the ecological impacts of invasive waterfowl in North America, with an eye for assessing the scope, distribution, and scale of studies on invasive waterfowl. I expect to find considerable overlap between human greenspace design and waterfowl habitat preference, aggression between invaders and domesticated and native animal populations, as well as nuisance activity in both agricultural settings and human recreational spaces. Using the information of the historical impacts of invasive waterfowl, we will provide information for better assessment of local risk and potential management strategies for newer invasive populations.

Mammoth Spring Crayfish, photo by Leah Bayer (AR Coop Unit)

Effects of seasonal drought and stream permanence on colonization-extinction dynamics of an Ozark-endemic petitioned crayfish

Funding Source:	University of Arkansas, Distinguished Doctoral Fellowship University of Arkansas, Biological Sciences Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	January 2022 – December 2023
Principal Investigator:	Daniel D. Magoulick
Graduate Student:	Leah M. Bayer (Ph.D. Candidate)

Research Objectives:

1. Determine the effects of seasonal drought and stream permanence on colonization and extinction dynamics of *Faxonius marchandi*, the Mammoth Spring Crayfish.

Management Implications:

1. This project directly relates to whether federal listing may be warranted for *Faxonius marchandi*. If ESA listing is warranted, understanding the effects of invasion and drought will be essential in identifying and implementing recovery efforts.
2. Understanding the influence of drying conditions will allow us to better predict how *F. marchandi* will respond to the increased drying predicted to occur with future climate change.

Project Summary:

Climate models predict increased temperatures and frequency of extreme precipitation events in the coming years for many regions of the United States, including the Southeast. Stream drying is a frequent abiotic disturbance in the Ozark Highlands of north-central Arkansas and south-central Missouri. More specifically, the Ozark Highlands are prone to natural seasonal drought events, causing streams to become very low or dry for several months each year. Stream drying is known to impact freshwater populations such as crayfish. In addition to decreased water availability, droughts can

amplify biotic (ex. invasion) and abiotic stressors. Additionally, droughts can reduce survival rates and mean body size of crayfish. Crayfish may be more resilient to the impacts of seasonal drought by acting as metapopulations.

The Mammoth Spring Crayfish, *Faxonius marchandi*, is one narrow-ranged endemic that is considered imperiled and a "species of greatest conservation need" in Arkansas (S2, SGCN), critically imperiled in Missouri (S1/S2), and imperiled globally (G2). The species is currently under consideration by the U.S. Fish and Wildlife Service for protection under the U.S. Endangered Species Act. Populations of *F. marchandi* are limited to the eastern portion of the Spring River drainage of Arkansas and Missouri, and their densities are higher in intermittent streams versus permanent streams. Population genetics indicate two main clades of *F. marchandi* in the upper versus lower reaches of the Spring River drainage, splitting these two groups into Evolutionary Significant Units (ESUs).

To better understand how drying conditions influence the colonization and extinction of *F. marchandi*, we are collecting presence-absence and abiotic stream data across four seasons for intermittent and permanent streams. These data will allow us to construct a multi-season dynamic occupancy model and obtain colonization and extinction rates for the two ESUs of *F. marchandi* during peak dry season and peak flow season in two different flow regimes. To date, we have completed one summer season (May – June 2022) of field work using quantitative kick-net surveys. We surveyed *F. marchandi* at 25 sites (13 intermittent, 12 groundwater) across the Spring River Drainage. In total, we captured 305 (Clade 1 =182, Clade 2 = 123) *F. marchandi* individuals in the surface and hyporheic zones. Currently, we are preparing for our second field season in September-October 2022.

(Top) Mesocosms at the University of Arkansas's Biological Greenhouse, photo: Kearstin Findley (AR Coop Unit)

Effects of Drought on Rainbow Darter (*Etheostoma caeruleum*) Growth, Survival and Refuge Use as a Preliminary Study for the Endangered Yellowcheek Darter (*Nothonotus moorei*)

Funding Source:	United States Geological Survey University of Arkansas, VCRI
Project Duration:	August 2020 – May 2023
Principal Investigator:	Daniel D. Magoulick
Graduate Student:	Kearstin Findlay (Ph.D. Student)

Research Objectives:

1. Determine effects of drought on growth and survival of Rainbow Darter.
2. Examine refuge selection and use strategies of Rainbow Darter during drought.
3. Examine the use of PIT tags and VIE tags in Rainbow Darters and evaluate mortality rates.
4. Provide preliminary information for Yellowcheek Darters and evaluate methods and materials prior to the use of an endangered species.

Management Implications:

1. This project uses a surrogate species (*E. caeruleum*) to provide preliminary information on how darter growth, survival, and refuge seeking behavior may respond to drought.
2. This project addresses specific aspects of research suggested in the recovery plan of Yellowcheek Darters, such as examining habitat use during drought and examining how future climate trends may impact species of concern.
3. This project evaluates the use of PIT and VIE tagging protocols in small, benthic, stream fishes.

Project Summary:

Drought conditions are expected to increase in intensity and frequency worldwide as a result of anthropogenic climate change. Seasonal drying is typical in northern Arkansas and can result in the loss of shallow water habitats, which can greatly impact aquatic species causing them to respond in a variety

of ways. Refuge seeking behavior by moving into pools, migrating long distances to permanently wet habitats, or burrowing into the hyporheic zone are three options for fishes to persist during drought conditions. However, for many species, it is still unknown how they respond behaviorally and physiologically to drought conditions. This study used stream mesocosms to simulate press drought to evaluate how Rainbow Darter (*Etheostoma caeruleum*) growth, survival, and refuge seeking behavior respond to drying conditions as a preliminary study for the critically endangered, Arkansas endemic Yellowcheek Darter (*Nothonotus moorei*). Passive integrated transponder tags (PIT) and visible implant elastomer tags were utilized to differentiate between individuals to observe growth changes, survival, and refuge seeking behavior.

Rainbow Darters were observed utilizing pool and slope habitats as refuge during stream drying but were not shown to exclusively use riffle habitats when present. Passive integrated transponder (PIT) tags had a higher detection probability (92%) than visible implant elastomer (VIE) tags (17%). However, during the tagging process through the first five days of the fish being added to the mesocosms PIT tags had a higher mortality rate (20%) than VIE tags (5%). However, when using ANOVA to look at only fish added to the mesocosms (i.e. excluding initial tagging mortality) there were no significant effects of treatment type (p-value = 0.19) or tag type (p-value = 0.34) on fish survival. There was also no significant interaction between treatment and tag type effect on survival (p-value = 0.56). Treatment type did not have a significant effect on growth for either mass (p-value = 0.92) or length (p-value = 0.73) of fish. A two-way ANOVA for behavior data did not show a significant effect of treatment type on the average number of fish observed (p-value = 0.98), nor was there a significant interaction between treatment type and habitat type (p-value = 0.51). However, there was a significant effect of habitat type on the average number of fish observed (p-value = 0.03) and a Tukey test revealed that pools had significantly more observations of fish than riffle habitats (p-value = 0.02).

This study provides valuable information as to how Rainbow Darters behaviorally and physiologically respond to drought as well as evaluates two tagging procedures in small stream fish. Our study suggests that PIT tags may result in a higher detection probability compared to VIE tags, however, caution should be used when implementing PIT tag procedures as mortality can be considerably higher than VIE tags. It should be noted that this was the researchers first time utilizing tagging procedures, which may account for some degree of mortality. Observations collected in this study also provide support that Rainbow Darters are not riffle obligate species and do utilize deeper habitats when drought conditions occur. Overall, our study aims to aid in the conservation of native fishes experiencing pressure from drought worldwide.

Recent And Accepted Publications

Roberts CP, Allen CR. 2021. Futures of the Sandhills. Book chapter in Sandhills Atlas.

Fournier, R.J. and D.D. Magoulick. 2022. Drought and nutrient pollution produce multiple interactive effects in stream ecosystems. PLoS ONE 17(7):e026922. doi.org/10.1371/journal.pone.0269222

Kays et al. (B.A. DeGregorio). 2022. Snapshot USA 2020: A second coordinated national camera trap survey of the United States during the COVID-19 pandemic. 2022. Ecology https://doi.org/10.1002/ecy.3775

Magoulick, D.D., K.C. Wynne and J. Clark. 2022. Morphological traits related to potential invasiveness of two subspecies of the crayfish *Faxonius neglectus*. River Research and Applications 38: 1-9.

Roberts CP, Uden DR, Allen CR, Angeler DG, Powell LA, Allred BW, Jones MO, Maestas JD, Twidwell D. 2022. Tracking spatial regimes in animal communities: implications for resilience-based management. Ecological Indicators. doi.org/10.1016/j.ecolind.2022.108567

DeGregorio, B.A., Veon, J.T. and Massey, A., 2022. Wildlife associates of nine-banded armadillo (*Dasypus novemcinctus*) burrows in Arkansas. Ecology and Evolution, 12: 1-10.

Roberts, C. P., Scholtz, R., Fogarty, D. T., Twidwell, D., & Walker Jr, T. L. (2022). Large-scale fire management restores grassland bird richness for a private lands ecoregion. *Ecological Solutions and Evidence*, *3*(1), e12119.

Tetzlaff, S.J., Sperry, J.H. and DeGregorio, B.A., 2022. You can go your own way: No evidence for social behavior based on kinship or familiarity in captive juvenile box turtles. Applied Animal Behaviour Science, 248, p.105586.

Angeler DG, Roberts CP, Twidwell D, Allen CR. 2022. The role of rare avian species for spatial resilience of shifting biomes in the Great Plains of North America. Frontiers in Ecology and Evolution, 10.

Donovan VM, Roberts CP, Fogarty DT, Wedin DA, Twidwell D. 2022. Targeted grazing and mechanical thinning enhance forest stand resilience under a narrow range of wildfire scenarios. Ecosphere, 13.

Twidwell D, Uden DR, Roberts CP, Allred BW, Jones MO, Naugle DE, Allen CR. 2022. Mapping Panarchy to Improve Visualization of Complex Environmental Change. In Gunderson LH, Allen CR, Garmestani A, editor(s), Applied Panarchy: Applications and Diffusion Across Disciplines, pages 136. Island Press.

Allen CR, Angeler DG, Garmestani A, Roberts CP, Sundstrom SM, Twidwell D, Uden DR. 2022. Applications of Spatial Regimes. In Gunderson LH, Allen CR, Garmestani A, editor(s), Applied Panarchy: Applications and Diffusion Across Disciplines, pages 94. Island Press.

DeGregorio, Wolff, and Rice. 2021. Evaluating hydrophones for detecting underwater-calling frogs: implications for monitoring imperiled species. Herpetological Conservation and Biology 16(3):513–524.

Lassiter, E.V., M Asher, G. Christie, C. Gale, A. Massey, C. Massery, C.R. Middaugh, J. Veon, and B.A. DeGregorio. 2021. Northern Bobwhite Occupancy Patterns on Multiple Spatial Scales Across Arkansas. Journal of Fish and Wildlife Management 12: 502-512

Bayer, L.M., R.J. Fournier and D.D. Magoulick. 2021. Modelling effects of crayfish invasion and drought on population dynamics of generalized crayfish life history strategies. Aquatic Conservation: Marine and Freshwater Ecosystems 31:457–468. DOI:10.1002/aqc.3516

DeGregorio, B.A., C. Gale, E. Lassiter, A. Massey, C. Roberts, and J. Veon. 2021. Nine-banded Armadillo (*Dasyrus novemcinctus*) Activity Patterns are Influenced by Human Activity. Ecology and Evolution: 15874-15881.

Fournier, R.J., N.R. Bond and D.D. Magoulick. 2021. Modeling effects of disturbance across life history strategies of stream fishes. Oecologia 196:413-425

Magoulick, D.D., S.W. Hodges, M.P. Dekar, M.K. Scott, M.R. Rabalais and C.M. Bare. 2021. Hydrologic variation influences stream fish assemblage dynamics through flow regime and drought. Scientific Reports 11:10704. doi.org/10.1038/s41598-021-89632

Cove, M. V., et al. (B.A. DeGregorio). 2021. Snapshot USA: the first coordinated national camera trap survey of the United States – data from 2019. Ecology. *Online early*. doi.org/10.1002/ecy.3353

Courses Taught

DeGregorio, B.A. - Wildlife Management and Conservation in Arkansas. Spring 2022.
Magoulick, D. - Biometry. Spring 2022.
Lassiter, E.V. – Principles of Biology Prep Team. Fall 2021
Lassiter, E.V. – Biometry. Spring 2022
Veon, J. – Human Physiology Laboratory, Fall 2021
Shaw, M. – Principles of Biology. Fall 2021
Johansson, E.P – Physiology. Spring 2022
Marshall, P. – Physiology. Fall 2021, Spring 2022