ARKANSAS COOPERATIVE
FISH AND WILDLIFE
RESEARCH UNIT

2014 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

The unit is a cooperative program of the:

US 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 US Geological Survey, Biological Resources Division. The purpose of these units is to train graduate students in scientific methods of fish and wildlife management.

Over the past 26 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-sixth year, Arkansas Cooperative Research Unit will have initiated many research projects with Arkansas Game and Fish Commission, US Fish and Wildlife Services, US Geological Survey, National Park Services, and other federal, state and private organizations as sponsors. These projects have funded the research of 57 MS and 10 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 156 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 I fisheries and wildlife. Finally, including base funds and contracts, Arkansas Cooperative Research Unit has brought more than $17,992,898 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 US Fish and Wildlife Services to National Biological Survey to National Biological Service, and we now reside within the US Geological Survey. Our university department changed from Zoology to Biological Sciences and then incorporating the departments of Botany and Microbiology. We have seen ten departmental chairs (Amlaner, Geren, Kaplan, Talburt, Rhoads, Roufa, Davis, Smith, Spiegel, and Beaupre), 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 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, ad 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: Dustin Lynch, Christopher Middaugh, Lindsey Bruckerhoff, Nicole Graham, Cari Sebright. Second row, left to right: Daniel Magoulick, Robert Fournier, Phillip Stephenson, Joseph Moore, Auriel Fournier. Third row, left to right: David Krementz, and Diane Moler. Not pictured: John Herbert, Doug Leasure, and Jeremiah Flannery. Photo by Angela Hamilton 2015 (AR Coop Unit)

PERSONNELL AND COOPERATORS

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CURRENT GRADUATE STUDENTS

Lindsey Bruckerhoff, (MS, Fisheries – Magoulick)
Auriel Fournier (PhD, Wildlife – Krementz)
Robert Fournier (PhD, Fisheries – Magoulick)
Nicole Graham (MS, Fisheries – Magoulick)
John Herbert (MS, Wildlife – Krementz)
Doug Leasure (PhD, Fisheries – Magoulick)
Dustin Lynch (PhD, Fisheries – Magoulick)
Christopher Middaugh (PhD, Fisheries – Magoulick)
Joseph Moore (MS, Wildlife – Krementz)
H. Tyler Pittman (PhD, Wildlife – Krementz)
Cari Sebright (MS, Wildlife – Krementz)
Phillip Stephenson (MS, Wildlife – Krementz)

RECENTLY GRADUATED

Beckwith, Brooke, B.S. – Fisheries
Pittman, H. Tyler, Ph.D. – Wildlife
Reddin, Christopher, M.S. – Wildlife
Ronke, M. Eliese, M.S. – Wildlife
Smith, Kaitlyn, B.S. – Fisheries

HOURLY TECHNICIANS AND VOLUNTEERS

Mr. J. Alex Baeher – E-flow
Mr. Thomas C. Boersig III – E-flow
Mr. Matthew E. Boone – Rails
Ms. Lindsey A. Bruckerhoff – E-flow
Mr. Daniel K. Datlof – Rails
Mr. Alan J. Edmondson – General Help
Mr. Jonathan H. Fournier – General Help
Mr. John A. Herbert – Mallards
Ms. Alexandra P. Hooks – E-flow
Ms. Larin L. McMartin – E-flow
Ms. Brette K. Mendes –E-flow
Mr. H. Tyler Pittman – Turkey
Mr. Christopher J. Reddin – Small Mammals
Ms. Julie Rhee – E-flow
Ms. Kayla R. Sayre – E-flow
Mr. Nicholas C. Seeger – Rails
Ms. Kaitlyn S. Werner – E-flow

RESEARCH AND FACULTY COLLABORATORS

Dr. Tom Cooper – US Fish and Wildlife Service
Mr. Robert J. DiStefano – Missouri Department of Conservation
Mr. Jacob Westoff – PhD. Student, University of Missouri
Mr. Jeffrey W. Quinn – Arkansas Game and Fish Commission
Dr. Sarah Lehnen – Consultant
Dr. John Jackson – Department of Biological Sciences, Arkansas Tech University
Mr. Ethan Inlander – Biohydrologist, The Nature Conservancy
Dr. Jim Petersen – Hydrologist Study Unit Chief, Ozark Plateaus Study Unit USGS Arkansas Water Science Center
Mr. Richard Crossett – US Fish and Wildlife Service
Ms. Rhea Whalen – US Forest Service
Mr. Kevin Lynch – Arkansas Game and Fish Commission
Mr. Benny Bowers – Arkansas Game and Fish Commission
Mr. Luke Naylor – Arkansas Game and Fish Commission
Mr. Houston Havens – Mississippi Department of Wildlife, Fisheries and Parks
Dr. Andy Radaeke – Missouri Department of Conservation
Dr. Doreen Mengel – Missouri Department of Conservation
Mr. Nolan Moore – National Park Service
Mr. Kevin Eads – National Park Service
Dr. Marlis Douglas – University of Arkansas
Dr. Michael Douglas – University of Arkansas
Dr. Jack Cothern – University of Arkansas

COMPLETED WILDLIFE PROJECTS

Radio marked woodcock, photo by Cari Sebright (AR Coop Unit)

Wildlife

C. Reddin processing a fulvous harvest mouse, Pea Ridge National Military Park, Arkansas (AR Coop Unit)

Small Mammal Baseline Inventory Survey of Pea Ridge National Military Park, Benton County, Arkansas

Funding Sources:	U.S. National Park Service University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	August 2012 to August 2013
Principal Investigator:	DAVID G. KREMENTZ
Graduate Student:	CHRISTOPHER REDDIN (M.S. Student)

Research Objectives:

1. To produce a baseline estimate of small mammal abundance, diversity, and species richness for the six main habitat types that occur at Pea Ridge National Military Park, Benton County, Arkansas.
2. To assess Texas mouse (Peromyscus attwateri) habitat use.

Management Implications:

1. To determine what species of small mammal may be lost from Pea Ridge National Military Park due to anticipated habitat management actions, especially removal of eastern red cedar (Juniperus virginiana var. virginiana).

Project Summary:

The goal of resource management at Pea Ridge National Military Park (PERI), Benton County, Arkansas is to interpret the civil war battle that occurred there on 7-8 March 1862. One management objective of the National Park Service is for the landscape to reflect the natural range of conditions present at the time of the battle. As the landscape has gone through a number of changes since that battle (James 2008), vegetation management practices including burning and mechanical thinning will be needed to return the landscape to its former state. Altering the vegetation landscape may cause changes in the species composition of small mammals that currently occur there. Further, one of the species out at PERI, the Texas mouse, is known to inhabit red cedar stands along cliffs and bluffs. Since red cedar tends to be found in the marginal soils around cliffs and bluffs, we also wanted to see if the Texas mouse is responding to the vegetation, the substrate, or both.

At PERI are found six habitat types including: 1) cool season grassland dominated by tall fescue (Festuca arundinacea) and redtop (Agrositis gigantea), 2) warm season grassland dominated by indiangrass (Sorghastrum nutans) and big bluestem (Andropogon gerardii), 3) oldfield sites, 4) post oak-blackjack oak (Quercus stellata, Q. merilandica) forest, 5) oak-hickory (Q. spp., Carya spp.) forest, and 6) red cedar forest. In August 2012 we positioned two small mammal trapping lines in each of the five main habitat types for a total of ten lines. At each site we set out 21 Sherman traps (8 x 9 x 23 cm) and four Tomahawk traps (#202) in a line as well as a Moultrie motion-activated game camera near a likely spot to observe larger animal movements. Where available, the Tomahawk traps were placed on the bole of a tree at ~3 m to catch squirrels. Trapping occurred for five consecutive nights at each location. Captured animals were given an individually numbered #1005-1 monel ear tag to identify recaptures and we recorded species, weight, and sex. Trapping began in September 2012 and continued through August 2013. We divided the 12-month time frame into four seasons: autumn (Sep-Nov), winter (Dec-Feb), spring (Mar-May), and summer (Jun-Aug). From the winter session onward we added 1 additional trap line in each forested habitat. We ran each trapping line for one 5-day session each season, for a total of 125 trap-nights per season and 500 for the year. This allowed us to determine changes in small mammal community structure among seasons. We also trapped at 7 additional trap lines divided between locations along rock-strewn, dolomite bluffs in red cedar and post oak forest to gauge Texas mouse use of rocky substrate.

To quantify the habitat relationships of the animals we caught, each season we measured vegetation at the start of each trapping line, at 9 randomly selected points within the habitat patch each line was in, and within the three woodland habitat types, and at trap locations where an animal was caught. At each point we recorded canopy cover, tree basal area, average ground cover, and average vertical obstruction.

We captured 289 animals a total of 544 times belonging to 9 species: 270 captures of 129 individual Peromyscus spp. (due to difficulty in distinguishing deer mice [P. maniculatus] from white-footed mice[P. leucopus] we lumped them together), 119 captures of 44 individual Texas mice, 76 captures of 57 individual fulvous harvest mice (Reithrodontomys fulvescens), 23 captures of 23 individual least shrews (Cryptotis parva), 33 captures of 20 individual hispid cotton rats (Sigmodon hispidus), 14 captures of 8 individual golden harvest mice (Ochrotomys nuttalli), 5 captures of 4 individual prairie harvest mice (R. montanus), 1 capture of 1 individual southern flying squirrel, and 2 captures of 1 individual unknown Reithrodontomys. We captured 156 animals in post oak-blackjack oak woodlands, 131 in red cedar woodlands, 125 in oldfields, 75 in warm season grassland, 44 in oak-

hickory, and 13 in cool season grasslands. We captured 73 animals in the autumn session, 99 in winter, 199 in spring, and 173 in summer.

Oldfields were the most species rich habitat with 7 species caught there while oak-hickory forest was the least species rich habitat with only Peromyscus spp. and Elliot's short-tailed shrew being caught there. We caught the fulvous harvest mouse, hispid cotton rat, and least shrew only in grassland habitats while the southern flying squirrel and Elliot's short-tailed shrew we only captured in forests. We trapped the Texas mouse, golden harvest mouse, and Peromyscus spp. in both grasslands and forested habitats, though in larger numbers in forests. We only caught the southern flying squirrel and plains harvest mouse in one habitat each, red cedar forest and cool season grassland, respectively. Peromyscus spp. is the only animal we found in every habitat.

Using multiple permutational ANOVA tests on every pairwise comparison of habitats by season and species abundance, we found that all three forested habitats had similar small mammal communities, while the small mammal communities in oldfield and warm season grasslands were unique. Cool season grassland had a similar small mammal community compared to oak-hickory forest. The similarity between small mammal communities in forested habitats results from the dominance of Peromyscus spp. in those communities (34%, 90%, and 92% of the total abundance in red cedar, post oak, and oak-hickory forest, respectively).

Away from rocky substrate, we estimated Texas mouse abundance to be six times higher in red cedar than post oak, though one trap line skewed the data as it contributed 82% of all Texas mice caught in red cedar. When we trapped along rocky bluffs, we estimated 11 Texas mice among 4 post oak trap lines but did not catch a single Texas mouse across 3 red cedar trap lines. Since our results are conflicting, we will conduct three more lines of trapping in rocky, red cedar habitat at Devil's Eyebrow State Recreation Area in March to collect additional data.

Except for a single southern flying squirrel, which are difficult to catch and common in many types of forests, we did not find any threatened, endangered, or even unique small mammals in our red cedar forest transects. As such, we do not foresee that red cedar removal will result in the extirpation of any small mammal species from PERI. Further, all three grassland habitats, which red cedar invades and converts into woodland, have higher diversity estimates than red cedar. From a small mammal community perspective, removal of red cedar would likely be benefit the small mammal biodiversity at PERI. Cool-season grassland does have a state listed species of special concern, the plains harvest mouse. Further research is needed to understand this species' ecology and response to different habitat management practices, especially prescribed fire, as we found it in small numbers.

Temperate-nesting Canada geese being rounded up for banding in Hot Springs, Arkansas, July 2013

Survival, Abundance, and Distribution of Temperate-nesting Canada Geese (Branta Canadensis) in Arkansas

Funding Source:	University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	August 2012 – May 2014
Principle Investigator:	DAVID G. KREMENTZ
Graduate Student:	M. ELIESE RONKE (M.S. Student)

Research Objectives:

1. To estimate annual survival and hunter recovery rates in Arkansas from 2005-2011 and to determine whether annual survival rates have decreased with liberalized hunting regulations.
2. To determine the abundance of temperate-nesting Canada geese in Arkansas from 2002-2011 and to project future abundance.
3. To estimate the annual geographic range of temperate-nesting Canada geese in Arkansas from 2004-2012 and predict future range.

Management Implications:

1. The temperate-nesting population of Canada geese in Arkansas has grown since the reintroduction of Canada geese in Arkansas. To better manage this population, the Arkansas Game and Fish Commission must have an understanding of the past, present, and predicted

future patterns of survival, recovery, abundance, and distribution of temperate-nesting geese within the state.

Project Summary:

Management of Canada geese (Branta canadensis) has evolved over the past decades, especially with the reintroduction of the giant Canada goose (B. c. maxima) throughout the central and eastern United States. Canada goose hunting in Arkansas is meant to provide opportunities for as many interested hunters as possible. The Arkansas Game and Fish Commission (AGFC) has liberalized Canada goose hunting regulations over the past decade and instituted an early season in September 2007 to harvest temperate-nesting geese before migratory populations arrive. Identifying the effects of time and varying hunting regulations on the temperate-nesting population in Arkansas will help determine best potential strategies for meeting of the Canada goose management goals.

The AGFC bands temperate-nesting Canada geese in Arkansas annually during flight-feather molt, typically the last week of June and first week of July at locations in the Arkansas River Valley and Southwestern and Northwestern Arkansas. From 1999-2012 approximately 13,000 geese received federal aluminum leg bands. Hunters reported recoveries of banded geese to the U.S. Geological Survey Bird Banding Laboratory (BBL) in Laurel, Maryland.

We retrieved banding and recovery data for the years 2001 to 2011 from BBL in October 2012 for analysis. In addition to BBL data, we retrieved data on live recaptures of banded geese for the years 2006 to 2011 from the AGFC in August 2012. We also retrieved completed birder checklists in Arkansas during the breeding season for the years 2004-2012 from eBird, a website Audubon and Cornell Lab of Ornithology organize, for species distribution modeling.

Survival

We estimated annual survival rates for 2006-2011 using the Burnham joint live-dead capture-mark-recapture model in Program MARK. We incorporated the effects of potential hunting pressure in survival models by assigning two categories, pre-liberalization (2005-2006) and post-liberalization (2007-2011) based on the introduction of the September hunting season in 2007. We incorporated the effects of age in survival models using the standard 2-age approach and the 3-age approach Heller (2010) described, which accounts for molt migrant geese post-sampling.

We used quasi-likelihood Akaike's Information Criterion (QAIC) to select among candidate models. We ranked models using the resulting ΔQAIC values, and we selected the model with the lowest QAIC as the model most plausible given the data. We considered all models within ΔQAIC ≤ 2.00 acceptable models for the data to account for model-selection uncertainty. We determined model averages for annual survival rates of adult and young geese. We then calculated the annual hunter recovery rate using the model averages of annual survival.

Two models, incorporating the 2-age approach and the 3-age approach, were equally plausible while neither harvest regulations nor year were important in explaining variation in survival rates. In the top models, young survival rate confidence intervals were higher than adult survival rate confidence intervals. Model averaged annual adult survival rates were 0.761 (SE=0.0103) while young survival rates were 0.847 (SE=0.0143). Model averaged hunter recovery rates (f) were 0.078 (SE=0.0067) for adults and 0.050 (SE=0.0066) for young.

Abundance

We used the Lincoln Index to determine temperate-nesting Canada goose abundance in Arkansas. We fit a best fit power curve using the exponential population growth formula to the Lincoln abundance estimates from 2002-2011 to predict the growth of goose populations in Arkansas. Initial

abundance estimates using a harvest rate derived from the Arkansas direct recovery rate of banded geese produced a statewide abundance estimate for 2011 of over 500,000 individuals, nearly one third of the 1.6 million temperate-nesting Canada geese estimated for the Mississippi Flyway. One possible explanation of the high initial estimate relates to the harvest rate of Arkansas Canada geese. The harvest rates derived from the Arkansas direct recovery rate ($\bar{x}$=0.054, SE=0.007) is well below the Mississippi Flyway average harvest rate ($\bar{x}$=0.17, SE=0.008) for giant Canada geese. Therefore we created an adjusted Lincoln estimate using a regional estimate of harvest rate based on the average direct recovery rates of Arkansas, Kentucky, Missouri Oklahoma, and Tennessee, states with similar temperate-nesting Canada goose populations.

The unadjusted Lincoln Index for temperate-nesting Canada Geese in Arkansas in 2011 was 189,861 (SE=30,007). The trendline index for 2011 was 333,678 (SE=198,299) and using this trendline index, we project over 460,000 geese by 2020. The Lincoln Index adjusted with the regional average harvest rate for temperate-nesting Canada Geese in Arkansas in 2011 was 138,268 (SE=19,433). The trendline index for 2011 was 200,783 (SE=91,063) and using this trendline index, we project over 260,000 geese by 2020.

Distribution

We created maps of the distribution of temperate-nesting Canada geese in Arkansas for 2004 to 2012 using coordinates of Canada goose hunter recoveries from BBL and sightings during the breeding season from eBird, a website Audubon and Cornell Lab of Ornithology organize. We produced shapefiles of the encounter points in ArcGIS for each year. We then created kernel density estimations and volume estimates with contour lines in R using the home range estimation package, adehabitatHR. We used the series of resulting images to display the change in temperate-nesting Canada goose distribution over time. Volume contour maps show an increase in Canada goose encounters in northwestern Arkansas and along the Arkansas River Valley. Pockets of geese also occurred in southwestern and northeastern Arkansas. The highest concentrations of temperate-nesting Canada geese occurred in the center and northwestern corner of the state.

We created a wind rose diagram of temperate-nesting Canada goose dispersal in Arkansas from 2001-2011 using the coordinates of the banding location and final recovery or live recapture location of 1,417 geese encountered greater than 15km from their original banding location. The wind rose diagram of dispersal in Arkansas shows movement in the east and west directions. Forty-two percent of geese dispersed along the east-west axis, 25% east and 17% west. The average dispersal distance was 50km (SE=1.13km). The first quartile, median, and third quartile distances were 24km, 31km, and 63km, respectively. The maximum dispersal distance was 344km, the path stretching from the Fort Smith area in western Arkansas to the Dumas area in the southeastern corner of Arkansas along the Mississippi River.

We will also examine 137 geese banded in Arkansas and recovered outside of Arkansas to determine if the distance traveled is a function of sex or age.

Wildlife

Tyler Pittman tracking turkeys, photo by Charity Woolsey (AR Coop Unit)

The Effects of Prescribed Fire on Female Eastern Wild Turkey on the White Rock Ecosystem Restoration Project

Funding Sources:	Arkansas Game and Fish Commission U.S. Forest Service National Wild Turkey Federation (State and National Chapters) University of Arkansas
Project Duration:	January 2011 to January 2014
Principal Investigator:	DAVID G. KREMENTZ
Graduate Research Assistant:	H. TYLER PITTMAN (Ph.D. Student)

Research Objectives:

1. Examine habitat selection of female wild turkeys at multiple spatial scales and seasons with respect to burn regimes. We will pay particular attention to nest site selection.
2. Document pre-nesting movements of hens and relate those movements to nest and hen breeding success.
3. Estimate period and annual hen survival, and productivity.

4. Compare our habitat use, movements and vital rate estimates against those same comparable values for radio-marked wild turkey hens monitored at the same site in 1992 and 1993 before large scale growing season prescribed burns were used.
5. Develop management recommendations to enhance nesting habitat availability, hen survival and recruitment in the Central Hardwoods Region.

Management Implications:

1. Reexamination of the prescribed fire management regimes in the central hardwood region in relation to providing habitat suited to supporting an eastern wild turkey population
2. Examination of possible forest management alternatives to better suit the eastern wild turkey population and the goals of the U.S. Forest service in the region

Program Summary:

The eastern wild turkey (Meleagris gallopavo silvestris) was almost extirpated from Arkansas, but with help of restocking and significant changes to the management regulations, the subspecies has rebounded to >100,000 birds statewide (Widner 2007). This statewide success has however not been sustained in all areas of the state, especially White Rock Wildlife Management Area (WMA) on the Ozark-St. Francis National Forest. In this region of the western Ozark Mountains, steady decreases in harvest numbers have been observed over recent years causing concern for the wild turkey population. One possible cause of this decline in population numbers could be the extensive and intensive prescribed fire regime that the U.S. Forest Service employs.

During late winter (Mid-January to 1 April 2011-2013) we trapped eastern wild turkey females in the White Rock WMA using rocket nets at trap sites baited with cracked corn. After capture, females were each fitted with a 90-100g Platform Transmitter Terminals (PTTs) satellite transmitter using a modified backpack harness. The PTTs were capable of transmitting Global Positioning System (GPS) coordinates along with other sensor data via the Argos-Trios Satellite system every 48-120 hrs. Despite extensive trapping effort, only 5 females were captured and marked in 2011. After approximately 6 months all PTTs deployed in 2011 had malfunctioned and ceased transmitting GPS coordinates. In 2012 we captured and marked 34 females, of which 31 survived to the breeding season. In 2013 we captured 33 adult females and 18 juvenile females of which we deployed 33 PTTs, 20 on adult females and 13 on juvenile females. We monitored every female deployed with a PTT until either mortality or transmitter failure. Currently 5 PTTs from 2012 and 15 PTTs from 2013 are still functioning.

We identified 39 initial nest attempts and 7 renest attempts during the 2012 field season. During the 2013 field season we identified 33 initial nest attempts and 12 renest attempts. To examine nest-site selection we collected habitat covariates at pre-nesting locations, 40m and 300m from nest-sites, and nest-sites. At these locations we collected vegetation covariates such as visual concealment, stem counts, and canopy cover. We also collected topographic covariates and covariates derived from USDA Forest Service geographic information system (GIS) data such as mechanical treatments, distance to roads, and time since prescribed fire. We then used mixed effects logistic regression to determine what habitat covariates best explained the discrimination between nest-sites and non-nest-sites. We developed a candidate model set (n=16) that consisted of micro-habitat models, covariates collected at <10m scale, macro-habitat models, covariates collected at >10m scale, and hybrid-habitat models that included covariates collected at both scales. We used Akaike Information Criterion (AIC_c) to select among models. Our results suggest that nest site selection is a multi-scale process. We found that nest sites had higher values of visual concealment (0-1m), were more steep, and had higher amounts of woody ground cover (woody vines & oak regeneration <2 years in age) than non-nest-sites. We also

found that nest-sites had fewer stems of small shrubs (ground level diameter <5cm) and fewer stems of medium trees (15-30cm dbh). We also observed a significant interaction term between the percent visual concealment (0-1m) and time since fire suggesting visual concealment increases with increasing time since fire. We also examined nest patch selection and found that females selected patches smaller than 40m in size which potentially could be a result of small disturbance, such as tree fall gaps and/or the patch dynamics of large disturbance such as prescribed fire.

We monitored and determined the ultimate fate, hatched or destroyed, of 49 initial nest attempts and 16 renest attempts over 2012 and 2013. We used this information and habitat covariates collected at each of these nest sites to estimate nest survival, nest success rates, and hen success rates. The daily nest survival rate (DSR) is the probability a nest will survive to the next day and the nest success rate (NSR) is the probability that a nest will be successfully incubated to hatch. Hen success is the proportion of available females that successfully incubate and hatch at least one nest that year. DSR and NSR were best explained by differences in age over four weekly periods of incubation. No top models included habitat covariates as predictors of DSR and NSR. The NSR from the top model was 0.286 (SE=0.062) for adults and 0.007 (SE=0.019) for juveniles over the entire study. Hen success was 26% for adults in 2012 and 23% in 2013 compared to 20% hen success found previously on White Rock WMA (Badyeav 1994).

We estimated period and annual survival rates for females using GPS location data and sensor data transmitted from the PTTs. We used the known fate and nest survival models in program MARK to estimate survival rates. We estimated annual survival rates on a monthly basis over 2012 and 2013. The top explanatory model indicated that survival varied on a seasonal basis. The model suggested that survival was lower during the breeding season (Mar-Jun) and during the fall season (Oct-Nov). The annual survival rate was 0.65 (95%CI=(0.616,0.684)) for 2012. We plan to complete this analysis when birds captured in 2013 have been on the landscape for a full year. Breeding season survival rates were 0.802 (95%CI=(0.692, 0.879)) in 2012 and 0.769 (95%CI=(0.652, 0.855)) in 2013.

We are currently estimating female home ranges using dynamic Brownian bridge movement models (dBBMM). We will use the dBBMMs to examine prenesting habitat selection and brood habitat selection for those individual that successfully hatched a nest. We are analyzing vegetation data collected under a repeated measures sampling design to assess the response of vegetation to the current prescribed fire regime. We will examine vegetation patch dynamics in response to prescribed fire using remotely sensed data. These two analyses in combination with our nest-sites selection results should provide more insightful into the role prescribed fire plays in the availability of nest habitat. In 2013 we initiated a trail camera survey to estimate pre-harvest abundance on White Rock WMA. We are currently collecting a second year of survey data and plan to evaluate and hopefully develop a survey method for statewide implementation.

Literature Cited:

Chandler, R. B., Royle, J. A. Spatially explicit models for inference about density in unmarked or partially marked populations. The Annals of Applied Statistics. Vol. 7, No. 2, pp.936-954, 2013.

Damm, P. E. Using Automated Cameras to Estimate Wildlife Populations. Auburn University, December 13, 2010.

Royle, J. A. N-Mixture models for estimating population size from spatially replicated counts. Biometrics Vol. 60, pp. 108-118, 2004.

Young King Rail

King Rail Breeding and Brood Ecology

Funding Source:	U.S. Fish and Wildlife Service University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	May 2011 to June 2015
Principal Investigator:	DAVID G. KREMENTZ
Graduate Student:	AURIEL M.V. FOURNIER (Ph.D. Student)

Research Objectives (after expansion of scope):

1. Identify habitat characteristics of locations used by sora, Virginia rails, and king rails in the autumn on four wetland complexes in Missouri
2. Evaluate sora, Virginia rail, and king rail occupancy and abundance relative to water level management and wetland habitat management regimes during autumn migration

Project Summary:

King Rails north of the Gulf Coast in the central and Mississippi flyways are endangered, threatened or a species of concern. Breeding and brood rearing habitat use of King Rails were identified as Priority Information needs for Rails and Snipe at the U.S. Fish and Wildlife Service King Rail Conservation Plan Workshop. This project was originally funded to look at the breeding and brood ecology of King Rails in southeast Oklahoma but because of the drought that greatly reduced King Rail numbers at the study site we changed the scope of the project.

We expanded the scope of this project so we could perform a series of randomized management experiments to better understand the habitat use and timing of King Rails during fall migration by looking at managed wetland impoundments on public lands.

By expanding the scope of this project we will be able to better inform the management of water level change and disturbance manipulation of public wetland impoundments which are predominantly being managed for waterfowl habitat during migration. The change of scope of this project will allow us to take an additional year to conduct experimental manipulations of wetland impoundments across Missouri to better understand the role of management in the occupancy and habitat use of these impoundments by King Rails and other secretive marsh birds.

We will work closely with managers from the Missouri Department of Conservation and the U.S. Fish and Wildlife Service to identify a series of wetland impoundments in each of our four study regions and randomly select units each year to be managed under different levels of water level management and disturbance.

During the 2012 season we detected 6 King Rails across our 12 study sites. The change of scope in this project funded the 2013 season of this project, and the results of that can be found in the summary for Effects of Wetland Management Strategies on Habitat Use of Autumn Migrating Rails in Missouri, in this report. Project will be completed June 2015.

CURRENT WILDLIFE PROJECTS

Sora underwater, photo by Auriel Fournier (AR Coop Unit)

Sora at Fountain Grove 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 University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	July 2012 to September 2015
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 to early versus late flooding of wetlands in the autumn.
2. Estimate Sora, Virginia, Yellow and King Rail occupancy rates and 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 are surveying 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 are employing a distance-sampling based approach to survey managed wetland impoundments at night using ATVs and spotlights between 15 August and 31 October 2012-2015. From this data set, we will estimate detection probabilities, occupancy rates and abundances. We will relate these estimates to habitat and management covariates at local and landscape levels

Based on our 2012 and 2013 field seasons we initiated a two year management experiment in 2014 at the 10 sites in – minus Mingo NWR. At each site, two impoundments were selected and were randomly assigned to one of two flooding treatments. The first treatment - early flooding - began flooding on 1 August and brought the impoundment to 'full pool' by 15 September. The second treatment – late flooding – began flooding on 31 September and brought the impoundment to full pool by 31 October. In 2015 the treatments will be switched (i.e., early in 2014 will be late in 2015). We will survey for rails in the same manner as in 2012 and 2013 and each property manager will conduct weekly ground counts for waterfowl throughout waterfowl season, and also keep track of hunter effort and harvest. These data will allow 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 does, what impacts that has on subsequent waterfowl use and harvest.

We detected fewer rails in 2014 than the previous two years, but also had reduced effort (2 observers vs 4, on a per effort basis the numbers of Sora were similar). Each year we have seen a declining number of Yellow, Virginia and King Rails Sora were found on every CA/NWR surveyed. Sora migration began in late August and did not form a single peak as it had in the previous two years. We detected fewer Sora in the southeast region during all rounds as compared to the numbers of Sora detected at the northern regions in both 2012 and 2013. The migratory timing of rails in 2012 and 2013 are not significantly different (Kolmogorov-Smirnov test $p=0.09$). 2014 is different than both 2012 and 2013 (Kolmogorov-Smirnov test $p \leq 0.001$ for both). We did not have enough detections of the other rails to compare them statistically. Our visual comparison of the three years of Virginia Rail distributions suggests the peak of migration was slightly later in each successive year. Qualitatively we believe Yellow Rail migration through Missouri was later in 2013 than in 2012. We only observed one Yellow Rail in 2014 and so cannot comment on timing. No Black Rails or King Rails were detected during the 2014 survey period. We intend to survey 10 August - 31 October, 2015 using the same methods. In 2015 the flooding treatments will be flipped, with early becoming late, and vice versa.

We estimated abundance of Sora using the gdistsamp() function. We found a significant difference in abundance between the two treatments when broken down by region, except in the north east region where flooding confounded the treatments ($p=0.04$).

In 2014, we did not find a significant difference in waterfowl use between the two treatments except in two cases where the early treatment had higher use then the later treatment ($p=0.09$). We will also be comparing waterfowl harvest between the treatments once that data is compiled.

We have discontinued the helicopter portion of this project because we could not obtain FAA approval. We are pursuing funding for a 2016 field season to extend the experiment for a third year and allow us to hold the treatment constant to look for year effects.

American Woodcock, Wedington Wildlife Management Area, photo by Tyler Pittman (AR Coop Unit)

Spring Migration Ecology of American Woodcock (Scolopax minor) in the Central Management Region of the United States

Funding Source:	University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	August 2013 to May 2015
Principal Investigator:	DAVID G. KREMENTZ
Graduate Student:	CARI SEBRIGHT (M.S. Student)

Research Objective:

1. Document habitat use of American woodcock during spring migration in Arkansas, Missouri, Iowa and Illinois.

Management Implications:

1. Knowledge of habitats used during spring migration will allow managers to better manage for American woodcock across the Central Management Region.

Project Summary:

The American woodcock (*Scolopax minor*) is an elusive and sought after game bird. However American woodcock (hereafter called woodcock) populations have been in steady decline since 1968 in the Central and Eastern Management Regions in the United States (Cooper and Rau 2013). In 2006 a Migratory Shore and Upland Game Bird Support Task Force was established to develop research priorities to better manage woodcock habitat (Case et al. 2010). One of the priority information needs listed by the Task Force is to document habitat use during migration (Case et al. 2010). Most studies to date have focused on both the northern breeding grounds and the southern wintering grounds while little to no research has been conducted on the migration routes.

We will solicit both citizen scientists and volunteers from federal and state agencies to conduct surveys on woodcock in Arkansas, Missouri, Iowa and Illinois which are located between the breeding and wintering grounds of the Central Region. We will conduct surveys from 15 January to 20 April during the spring migration in 2014 and 2015. We will conduct surveys in a wide variety of habitat types to collect abundance data and location information. From these locations we will be able to exactly describe nocturnal habitats used, but we are also interested in diurnal habitats used. We will investigate potential diurnal habitats used by these birds using a GIS analysis. First, we will need to estimate the average distance a woodcock flies from a nocturnal roosting field to the surrounding diurnal habitat. We hope to accomplish this by capturing a sample of woodcock in Arkansas and fitting them with VHF transmitters. We will determine locations for each marked bird at least twice a day during the diurnal period to determine distances traveled from nocturnal to diurnal habitat. Once we have an estimate of these distances, we will use these estimates to describe the habitat surrounding the singing grounds using large scale vegetation GIS layers like LANDFIRE data.

Preliminary Results:

During the 2014 field season, 227 volunteers conducted 1,038 surveys during the crepuscular period from 15 January to 20 April. No woodcock were detected on 607 surveys, 360 surveys had some (1-5) woodcock detected, and 71 had many (>6) woodcock detected. In spring 2014, we caught seven woodcock in northwest Arkansas and attached transmitters to five. We located all marked woodcock at least once before they migrated. Marked woodcock remained in the area a median of 4 days, with a range of 9 days before migrating. We recorded 24 diurnal locations for marked woodcock. The average distance moved between nocturnal and diurnal habitat was 345 m (SE 23.5 m). No marked woodcock moved >600 m between nocturnal and diurnal habitat.

Future Direction:

Our goal for the spring of 2015 is to increase survey coverage across the study area, focusing on regions and habitats not surveyed well in 2014. We want to collect more data on distances traveled between nocturnal and diurnal habitats by redeploying transmitters that fall off of birds before they continue migration. Finally, we will target those habitat types where many woodcock were detected on nocturnal surveys in 2014 but for which we have no telemetry data.

Wildlife

Mallard flushing from a flooded field, photo from internet

The Role of Surface Water and Food Availability on the Abundance and Distribution of Wintering Waterfowl in the Arkansas Mississippi Alluvial Valley

Funding Source:	University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	August 2013-May 2015
Principle Investigator:	DAVID G. KREMENTZ
Graduate Student:	JOHN HERBERT (M.S. Student)

Research Objectives:

1. Relate waterfowl distributions and abundances to environmental and habitat covariates.
2. Analyze the temporal and spatial changes in waterfowl abundance during a single season and amongst years.

Management Implications:

1. This study will provide land managers with information to improve waterfowl conservation strategies during the winter months in Arkansas. Since we will be using agriculture and flood data, this information can better inform farmers in the Mississippi Alluvial Valley (MAV) on how they can contribute to waterfowl conservation. Further cooperative measures with farmers and land managers in the MAV can contribute to higher waterfowl yields during the winter.

Project Summary:

Arkansas winters large numbers of dabbling ducks, diving ducks and geese (Reinecke et al. 1989). In particular, Arkansas is the primary wintering area for mallards (*Anas platyrhynchos*) in North America (Bellrose 1976, Reinecke et al. 1989). Arkansas consistently has the highest mallard harvest per year of any state, and the Arkansas Delta contains the majority of those harvested mallards (Green and Krementz 2008). For this reason, studying the factors that influence winter distribution and abundance of mallards will help biologists better manage this species and likely other dabbling ducks. This research will address the effect that surface water and other environmental covariates has on the spatial movements and abundance of mallards over time.

The Arkansas Game and Fish Commission (AGFC) conducts aerial waterfowl surveys four times each winter. In 2009, the AFGC began to conduct surveys using a stratified random design by separating the MAV into five strata. The AGFC further advanced the survey design by developing a new stratified random sampling design based on U.S. Geological Survey watersheds, which separated the MAV into eleven separate strata. This new sampling design increased the precision and accuracy of the survey results. We are using data obtained by the AGFC aerial winter waterfowl surveys from November 2009 through January 2015.

To examine habitat selection we collected habitat types from the USDA geographic information system (GIS) data Cropland Data Layer. We have also calculated a weather severity index (Schummer et al. 2010) to determine how weather affects the movement of wintering waterfowl. To achieve surface water availability, we are using Landsat imagery (provided by USGS) corresponding with survey dates. These images are geoprocessed using the Normalized Difference Water Index (NDWI), which will extract the surface water available for waterfowl.

Prelimary analysis suggests that rice fields, soybean fields and hardwood bottom land forests support the highest numbers of mallards during the winter. It also suggests that the Cache River watershed has the highest abundance of mallards in the winter. We will develop a set of candidate models with additional covariates of surface water, managed lands, food available on agriculture fields and weather and determine the environmental covariates most important for wintering waterfowl. We will then determine how population size affects the movement of waterfowl across the MAV. These findings will be able to provide land managers with information to improve waterfowl conservation strategies during the winter months in Arkansas.

NEW WILDLIFE PROJECTS

Snow Geese Flying over flooded field in the Arkansas Mississippi Alluvial Valley, photo by John Herbert (AR Coop Unit)

Wildlife

P. Stephenson processing a sweep net sample, Crockett County, Tennessee

Pollinator Communities on Native and Managed Emergent Wetlands in the Lower Mississippi Alluvial Valley of Arkansas

Funding Source:	University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	August 2014 to December 2016
Principal Investigator:	DAVID G. KREMENTZ
Graduate Student:	PHILLIP STEPHENSON (M.S. Student)

Research Objective:

1. Document pollinators in native and managed emergent wetlands throughout the flowering season,
2. Compare pollinator communities between native emergent wetlands, managed emergent wetlands, and adjacent croplands, and
3. Document whether pollinators visiting flowers in wetlands also visit flowers in adjacent croplands.

Management Implications:

1. These data should be useful for the long-term management of emergent wetlands on public and private land for the health of pollinator communities.

Project Summary:

In 2014 President Obama issued a memorandum to promote the health of honey bees and other pollinators. With this memorandum, the President established a pollinator health task force to create an action plan that will focus Federal efforts on understanding, preventing, and recovering from pollinator losses. 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 ~20 years 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 (Steffan-Dewenter et al. 2002; Tylianakis et al. 2005; Biesmeijer et al. 2006; National Research Council 2006; vanEngelsdorp et al. 2009). With agrochemicals being discussed as a major factor in pollinator declines, Chief James Kurth of the National Wildlife Refuge System issued a memorandum stating that by January 2016, the National Wildlife Refuge System will no longer use neonicotinoid pesticides in agricultural practices in the Refuge System. Though cotton, rice, and soybeans are considered autogamy (self-pollinating), cross-breeding (via pollinators) helps increase yield, produce more viable seed, and enhance genetic diversity of the crop (Kremen et al. 2002; Pu et al. 2014). Emergent wetlands occur adjacent to croplands throughout the Southeastern United States and create valuable floral resources for pollinators throughout the growing season. Emergent wetlands are a class within the Palustrine system of Cowardin et al. (1979). This emergent wetland class consists of two subclasses, persistent and non-persistent vegetation. An emergent wetland is characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens (Cowardin et al. 1979). Moist-soil wetlands are intensively managed for annual plants that produce abundant seed resources for migratory waterfowl, moist substrate for shorebirds, and breeding grounds for amphibians. Programs like the Agricultural Conservation Easement Program (formerly the wetland reserve program) seek to reestablish native plant communities, improve water quality, and provide habitat, but their role in creating floral resources for pollinators has been overlooked. Pollinator communities that use wetlands have been poorly documented and their benefits to surrounding lands are not understood. Our project seeks to document and compare pollinator communities in native and managed emergent wetlands and secondly their role in pollinating crops in sites adjacent to managed wetlands.

We will survey pollinators during the growing seasons of 2015 and 2016 using pan traps and sweep nets at 7 native wetlands, 7 moist-soil wetlands and 3 croplands in the central portion of the Arkansas Delta (centered on the Cache River National Wildlife Refuge). Pan traps will be placed along one randomly located transect in each wetland once every 2 weeks per site during the growing season (12-16 weeks) for 12 hour intervals to collect pollinators that emerge at different times during the growing season and also that forage at different times of the day. One field site will be visited per day on a 14-day rotation. Pan trap transects will be conducted in the adjacent croplands on the same schedule as the adjacent wetland during peak flowering of cotton and soybeans. We will conduct five randomly located sweep net transects (25 sweeps per transect) in each habitat type. We will attempt to identify all pollinators to family and/or species. Those insects that I cannot identify will be sent for identification to experts at the University of Arkansas entomology museum, to S. Droege (U.S. Geological Survey), or V. Tepedino (USDA Bee Biology and Systematics Laboratory). We will estimate species richness using SPECRICH2 (White et al. 1978) and species capture probabilities using COMDYN (Nichols et al. 1998). These estimators are efficient at dealing with uncertainty in capture probabilities among sampling methods and habitat types.

We predict that pollinator diversity will be greatest in native emergent wetlands. We also predict that relative floral resources diversity and levels will drive pollinator diversity. These findings should describe the composition and phenology of pollinator communities of palustrine emergent persistent wetlands as well as pollinator communities of the nearby moist-soil wetlands located within the Mississippi Alluvial Valley. These findings should provide evidence that properties enrolled in the

Agricultural Conservation Easement Program can also generate quality foraging and nesting sites for a variety of pollinators.

Wildlife

American Woodcock with a 5 g Satellite Transmitter, photo by Joseph Moore (AR Coop Unit

American Woodcock Migration Ecology

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

Research Objectives:

1. Document timing of migration initiation, rate of migration, stopover length, routes taken, and final destination for both spring and fall migration of American woodcock.
2. Describe land use characteristics at American woodcock stopover sites

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:

American woodcock (*Scolopax minor*) are a species of conservation concern across eastern North America. Results from the Singing-ground Survey, an index used to monitor woodcock populations, show long-term declines across the species' range (Cooper and Rau 2014). Understanding American woodcock migration as it relates to population ecology is a high-priority information need–in part, because the migratory period is believed to be a period of high mortality (D.J. Case and Associates 2010). The current understanding of woodcock migration ecology has been limited by available technology such as VHF telemetry, band-recovery, and wing collection survey data (Myatt and Krementz 2007*a, 2007b*). Recent developments in the miniaturization of satellite transmitters (PTTs) now allow satellite telemetry of American woodcock. We are deploying PTTs on woodcock in their breeding and wintering grounds of the Central Management Region, an area with boundaries similar to that of the Mississippi Flyway (Coon et al 1977, Cooper and Rau 2014). This will allow us to document timing of migration initiation, rate of migration, stopover length, routes taken, and final destination for both spring and fall migration, and to describe land use characteristics at migratory stopover sites.

In fall 2013, we initiated a pilot project evaluating the use of satellite transmitters (PTTs) to investigate woodcock migration ecology. We refurbished seven 9.5 g PTTs available to us and, with an exception from the U.S. Geological Survey Bird Banding Laboratory regarding transmitter mass restrictions, deployed these PTTs on adult female woodcock with mass >200 g. We attached PTTs using a modified thigh harness (Rappole and Tipton 1991). Woodcock were trapped using night-lighting with hand nets and mist-netting techniques (McAuley et al. 1993). We deployed PTTs on females captured at Tamarac National Wildlife Refuge in northwest Minnesota September 2013 (n = 1), Sherburne Wildlife Management Area in Louisiana January 2014 (n = 4), and Ozark National Forest in northwest Arkansas March 2014 (n =1). With the exception of one marked female in Louisiana, which we believe was killed by an owl upon release, all females (n = 5) successfully migrated; the Minnesota female migrated both during the fall and spring. All females (n = 3) marked in Louisiana migrated to the Eastern Management Region whereas the Arkansas and Minnesota females migrated within the Central Management Region (Fig. 1). We deployed three additional 9.5 g PTTs on American woodcock at Sherburne National Wildlife Refuge, Minnesota during fall 2014. We also received data during fall migration from three of the PTTs previously deployed. As of January 9, 2015, the latest recorded locations of these birds are in Texas, Louisiana, Mississippi, Missouri, Tennessee, and Virginia. Our initial results suggest: (1) that larger females can successfully migrate with a 9.5 g PTT, (2) that the harness attachment method does not inhibit 'normal' migration, and (3) that the 9.5 g solar-powered units are receiving sufficient light energy to recharge the battery.

In January 2015 we were able to acquire ten 5 g PTTs. The 5 g PTTs, recently developed by Microwave Telemetry, are in theory preferable to the 9.5 g units. Their reduced size allows us to deploy units on any woodcock greater than 150 g (instead of only females >200 g), however there is uncertainty whether the smaller unit will receive enough light energy to charge the battery. In January and February of 2015 we deployed three 9.5 g and four 5 g PTTs in Texas, and five 9.5 g and six 5 g PTTs in Louisiana.

In total, we deployed 27 PTTs throughout the Central Management Region. We plan to deploy an additional 25 PTTs on woodcock in their breeding and wintering grounds in the coming year. We have created a publicly accessible website showing up-to-date locations of tagged birds (www.ruffedgrousesociety.org/woodcockmigration). Data from this project will provide an insight into

woodcock migration ecology that could form a basis for directing woodcock management along migration routes.

Literature Cited:

Coon, R. A., T. J. Dwyer, and J. W. Artmann. 1977. Identification of potential harvest units in the United States for the American woodcock. Proceedings of the Woodcock Symposium 6:147–153.

Cooper, T.R., and R.D. Rau. 2014. American woodcock population status, 2014. U.S. Fish and Wildlife Service, Laurel, Maryland. 16 pp.

D.J. Case and Associates (editor). 2010. Priority information needs for American woodcock: a funding strategy. Developed for the Association of Fish and Wildlife Agencies by the Migratory Shore and Upland Game Bird Support Task Force. 16pp.

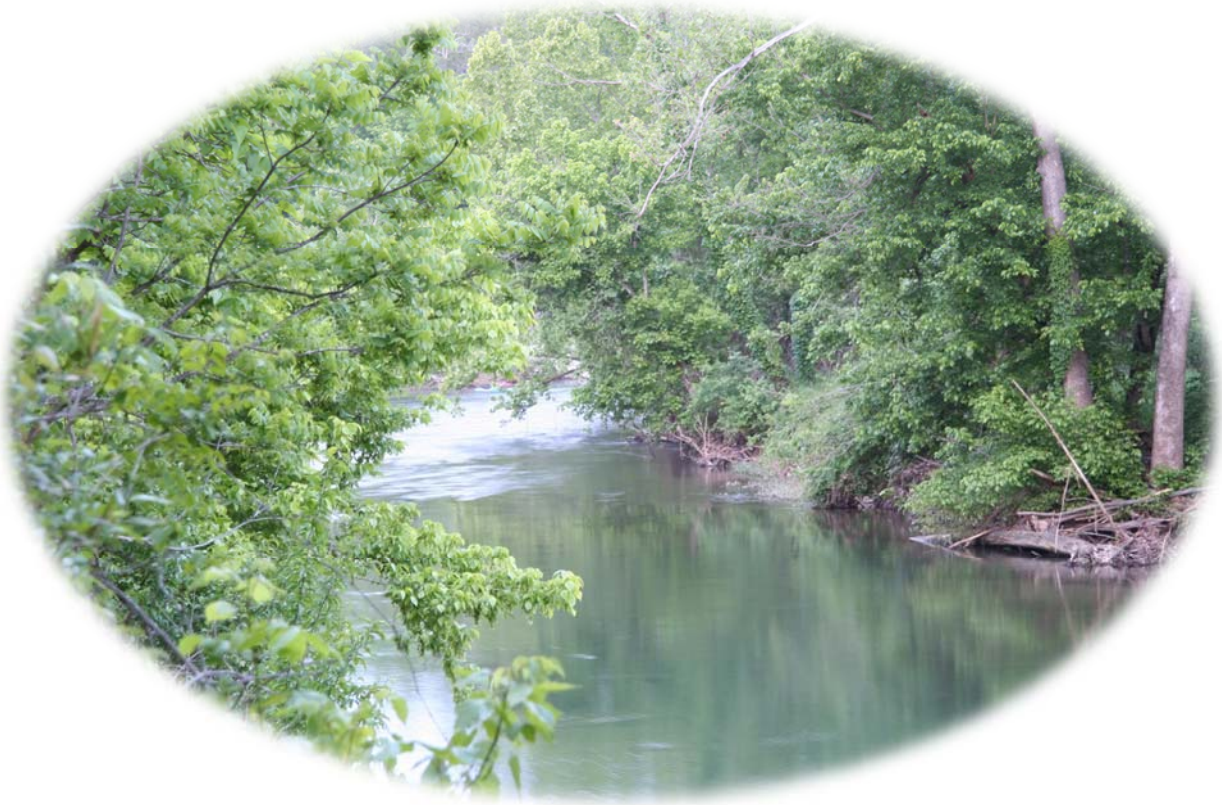
McAuley, D.G., J.R. Longcore, and G.F. Sepik. 1993. Techniques for research into woodcock: experiences and recommendations. Pages 5-11 *in* J.R. Longcore and G.F. Sepik, editors. Eighth woodcock symposium. U.S. Fish and Wildlife Service Wildlife Resource Biological Report 16, Washington, D.C., USA.

Myatt, N.A. and D.G. Krementz. 2007. American woodcock fall migration using Central Region band-recovery and wing-collection survey data. Journal of Wildlife Management 71: 336–344.

Myatt, N.A. and D.G. Krementz. 2007. Fall migration and habitat use of American woodcock in the central United States. Journal of Wildlife Management 71:1197-1205.

Rappole, J.H. and A.R. Tipton. 1991. New harness design for attachment of radio transmitters to small passerines. Journal of Field Ornithology 62:335–337.

COMPLETED FISHERIES PROJECTS



Crooked Creek, photo by Christopher Middaugh (AR Coop Unit)

Orangethroat and fantial darters, photo by Dustin Lynch (AR Coop Unit)

Effects of Drought on Behavior, Growth, and Survival of Etheostoma spectabile and Etheostoma flabellare in Stream Mesocosms

Funding Source:	University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	May 2013 to May 2014
Principal Investigator:	DANIEL D. MAGOULICK
Graduate Student:	DUSTIN LYNCH (Ph.D. Student)
Undergraduate Student:	KAITLYN SMITH WERNER (Student)

Objectives:

1. Determine effect of drought on growth, survival and refuge use behavior of orangethroat and fantail darter

Management Implications:

1. This study will provide greater insight into the populations of two Arkansas darter species.
2. With this information, an understanding of anthropogenic effects on the species could be described and monitored closely in conservation efforts as well as water withdrawal.
3. The study will give conservation ecologists and those attempting to preserve darter habitats more knowledge as to what factors improve or degrade these species chance of survival and recolonization.

Project Summary:

Both the orangethroat (E. spectabile) and fantail darter (E. flabellare) are small, benthic species that cohabitate similar aquatic environments in the northwest Arkansas portion of the Illinois River tributaries (Robinson and Buchanan, 1988). The orangethroat darter prefers small headwater creeks where it is found in shallow riffles of slow to moderate current, and it has also been reported to occupy marginal regions of pools (Pflieger, 1975). Multiple authors have reported the orangethroat's lack of presence in large, deep streams having deep riffles (Robinson and Buchanan, 1988). The polytypic fantail darter is also found in small stream riffles, but seem to prefer a swift current (Robinson and Buchanan, 1988). The orangethroat darter and the fantail darter have overlapping spawning seasons and similar feeding preferences.

It is suspected that in headwater streams where periodic drying is common, habitat selection influences the distribution and densities of darter species. As a riffle dries, the occupants of the riffle have limited options. The inhabitants must move into neighboring pools, move into the hyporheic zone, migrate large distances to a persistent riffle or perish. It is not well established how specific darter species like the orangethroat and fantail survive during these drying events. Given observed presence of orangethroat darters in marginal regions of pools, we suspect that these species will move from the riffle to a nearby pool, and occupy the marginal or hyporheic zone until the riffle is restored. Fantail darters have been observed in pools, but usually in juvenile stages. It is unclear how these darters will seek refugia in the absence of a swift riffle, but we hypothesize that the adult fantail darters used for this experiment will occupy the marginal hyporheic zone alongside the orangethroat darters.

In this experiment we used indoor mesocosms to examine the survivorship, growth, and behavioral patterns of the fantail and orangethroat darters in a drought situation. We hypothesized that both species would show reduced growth and survival under drought conditions.

This experiment answered many valuable questions about Arkansas darter species that have been little discussed. Drought had an effect on both Orangethroat Darters and Fantail Darters, but differently. While the Fantail Darters seemed to seek refuge from the drought conditions in pools and hyporheic zone within the substrate, the Orangethroat Darters clearly sought refuge in the sloped portion between the riffle and pool sections of the mesocosm. This is interesting because the sloped region has rarely been considered as a microhabitat previous to this experiment, and further experimentation could reveal this region of streams to be a microhabitat for other stream fishes as well.

Although growth and survival were not significantly affected by the treatment in this experiment, this experimental design carried out on a larger time scale in combination with more intense drying could provide different results. More experimentation is necessary to determine at what length of time drought and drying conditions affect darters survival and inhibit growth. The experiment was also a key step toward investigating the effects of drought and drying on the federally endangered Yellowcheek Darter. With this experimental design and the alterations discussed previously, many unanswered questions seem to be reasonably obtainable. In the near future, it will be possible to examine the relationships of drought and drying on Yellowcheek Darters in order to make conservation efforts of habitat more effective. This could be an important step in the conservation of Yellowcheek Darters. In the future, this experiment could prove to be a model for examining the refugia strategies and survivorship of the federally endangered yellowcheek darter in response to an induced drying event. This study could also prove to be useful in understanding how anthropogenic drying events, caused by dams or through agricultural water withdrawal, can inhibit the growth and survivorship of two common Ozark darter species.

Orangethroat Darter, Etheostoma spectabile squamosum (left), photo by Dustin Lynch (AR Coop Unit)
Cardinal Shiner, Luxilus cardinalis (right), photo by Dustin Lynch (AR Coop Unit)

Population Genetics of Orangethroat Darter and Cardinal Shiner: Effect of Flow Regime

Funding Source:	University of Arkansas Arkansas Department of Higher Education Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	May 2013 to May 2014
Principal Investigator:	DANIEL D. MAGOULICK
Faculty Investigator:	MARLIS R. DOUGLAS
Graduate Student:	MAX BANGS
Graduate Student:	DUSTIN LYNCH
Graduate Student:	DOUGLAS R. LEASURE
Undergraduate Student:	BROOKE BECKWITH

Research Objectives:

1. Examine gene flow and genetic structure of *Etheostoma spectabile squamosum* and *Luxilis cardinalis* in both perennial groundwater streams and intermittent streams.

Management Implications:

1. Little is known about the influence of flow regime on gene flow and genetic structure of stream fishes. This study will provide vital information about how different flow regimes affect gene flow and dispersal.
2. This data could be useful for the long-term management of streams and species that inhabit them, including endangered species.

Project Summary:

Understanding the population dynamics of freshwater fish species inhabiting streams is of growing importance due to the environmental pressures that affect these systems (Huey *et al*. 2011).

Drainage topography (landscape) and flow regime, particularly drought or partial drying, affect connectivity and are important natural factors that influence population dynamics (Hodges & Magoulick 2011; Huey *et al*. 2008, 2011). Currently, knowledge about the dispersal of freshwater fish is limited due to difficulties with directly measuring demographic parameters (Lamphere & Blum 2012). However, combining demographic and genetic approaches could provide information crucial to understanding the population dynamics of fish (Lamphere & Blum 2012). In this study, I will be focusing on the genetic structure of two small fishes, Orangethroat Darter (*Etheostoma spectabile*) and Cardinal Shiner (*Luxilus cardinalis*) inhabiting streams with perennial groundwater flow. These data could be used to infer relationships between flow regime and population connectivity, and, in turn, could be applied to identify environmental flows required to maintain native fish assemblages in the region, including imperiled species.

Etheostoma spectabile is a benthic species known to live a relatively sedentary lifestyle. It inhabits primarily small headwater creeks and spring-runs where it occupies shallow riffles (Robinson & Buchanan 1988). This species exhibits high phenotypic variation across Arkansas and has been divided into five subspecies (Robinson & Buchanan 1988). The one I will focus on is the Arkansas Scaly Orangethroat Darter, *E. s. squamosum* (Figure 1). This subspecies has a larger body size than other subspecies found in Arkansas (Robinson & Buchanan 1988).

Luxilus cardinalis is found in northwest Arkansas in clear, north bank tributaries of the Arkansas River (Figure 2). It is a schooling species that lives in small, clear, gravel-bottomed streams or small rivers and is found in deep riffles or pools with moderate current (Robinson & Buchanan 1988) and its dispersal potential is likely much greater than that of the *E. spectabile.*

Our main goal was to compare the population structure of *E. s. squamosum* with that of *L. cardinalis* in two river drainages. These particular species were chosen because we expected their different dispersal capabilities and life history traits to influence distribution of and connectivity among populations. We assessed population structure by analyzing sequence diversity in two mitochondrial DNA genes. We predicted that *L. cardinalis* will have much greater gene flow and consequently a less pronounced population structure than *E. s. squamosum* due to the differences in habitat use, swimming ability, and dispersal potential.

Distribution of Genetic Diversity. Based on the life history traits of the species, we expected *E. s. squamosum* to exhibit greater genetic divergence than *L. cardinalis*. Indeed, AMOVA revealed high variation between the two drainages in *E. s. squamosum* and low variation in *L. cardinalis*. These results were congruent with expectations and reflect low rates of gene flow between Elk and Illinois River drainages in *E. s. squamosum* and high rates of gene flow in *L. cardinalis*.

Genetic Structure in Etheostoma spectabile. The haplotype network for *E. s. squamosum* revealed two distinct clusters separated by ten mutations, indicating co-occurrence of two distinct lineages in the Illinois River, likely representing distinct subspecies. To take this into account, we re-calculated pairwise F_{ST} values by splitting each population in the Illinois Rivers into two groups based on lineage. After this correction, pairwise F_{ST} values were significant for comparisons involving the two different lineages. However, pairwise F_{ST} values within the same lineage were not significant for comparisons between the two drainages. This is likely due to the low significance threshold after Bonferroni correction. Furthermore, splitting of populations by lineage reduced sample sizes for the three populations in the Illinois River drainage, further limiting the power of analyses to detect population structure. However, no haplotypes were shared between the two drainages and most haplotypes were unique to each population, with a total of six haplotypes shared among sites within drainages. This strongly suggested low levels of gene flow among populations and drainages in *E. spectabile*, and this is congruent with what is known about the life history of this species.

Genetic Structure in Luxilus cardinalis. The haplotype distribution for *L. cardinalis* showed several shared haplotypes among sites and drainages, suggesting that there was gene flow between the

two drainages. The haplotype network reflected few nucleotide differences among haplotypes, indicating little genetic structure in this species.

In contrast, population pairwise F_{ST} values of *L. cardinalis* were surprisingly high within the Elk River drainage. Closer examination of haplotype distribution revealed that the INDI population (Indian Creek) in the Elk River drainage was fixed for a single haplotype (all individuals share the same haplotype) that was not found in the other two populations in this drainage (BUFF and LISU), but was detected at low frequency in two out of three sites in the Illinois River (PEAV and SAGR). Similarly, a low number of haplotypes was found for *L. cardinals* in the Elk River as compared to the Illinois River, with 6 versus 14 haplotypes, respectively. These results indicated that the Elk River drainage was likely more impacted by agro-urban land-use than the Illinois River drainage. However, F_{ST} values are highly affected by sample size and eight individuals may not have been sufficient to encapsulate the genetic diversity within these populations. A larger sample size would provide better estimates of population pairwise F_{ST} values that in turn would allow for better inference of gene flow in *L. cardinalis.*

Future Research. Genetic diversity of a species can be affected by many factors. However, there is not much understanding of the potential relationship between gene flow and flow regime. Future research could use these preliminary data to further examine relationships between flow regimes and gene flow or dispersal. A better understanding of how flow regimes influence dispersal in native fish species could be useful for the long-term management of streams and species that inhabit them, including endangered species (Huey *et al.* 2008).

Another possibility for furthering this study would be collection of more individuals (larger sample sizes) for microsatellite DNA analysis in comparison with the mitochondrial DNA data. The microsatellite loci would provide more detailed information about the population structure of *E. spectabile* and *L. cardinalis* and hence yield insights into recent dispersal and gene flow in these two species.

Furthermore, co-occurrence of two distinct lineages in *E. spectabile* was unexpected and complicated analyses. Broader geographic sampling would be needed to assay distribution of these two lineages within and among drainages would help to clarify spatial extent of the zone of overlap. Again, microsatellite analyses could be insightful to test for admixture (hybridization and/or introgression) between the two lineages. Analyses of other subspecies in the *E. spectabile* complex would be necessary to determine if the second lineage is an already recognized subspecies, or if it may represent yet undetected biodiversity on a microscale.

Fisheries

Yocum Creek, Carroll County, Oklahoma, photo by Dustin Lynch (AR Coop Unit)

Classification of Arkansas flow regimes, regional ecological-flow response relationships and environmental flows assessment of the Ozark region

Funding Source:	Arkansas Game and Fish Commission University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	September 2010 to July 2014
Principal Investigator:	DANIEL D. MAGOULICK
Graduate Research Assistant:	DOUGLAS R. LEASURE
Graduate Research Assistant:	DUSTIN LYNCH

Objectives:

1. Classify stream types within Arkansas based on hydrology and geomorphology
2. Develop regional-level hydrology-biology response relationships for a portion of the Ozarks

Management Implications:

1. Products of this study, including a statewide river classification system and regional ecological-flow relationships, will form the scientific framework for environmental flow standards and aid studies involving the impacts of global climate change on Arkansas's unique streams and rivers.

Project Summary:

Providing adequate water quantity and quality in streams and rivers is a pressing issue worldwide. It is crucial to determine appropriate environmental flows in streams. This proposal develops the first phase in a multi-year study, involving many partners and a series of steps towards the goal of producing the scientific basis for environmental flow standards within Arkansas. Products of this study, including a statewide river classification system and regional ecological-flow relationships will form the scientific framework for setting environmental flow standards and understanding impacts of global climate change. These ecological-flow response relationships will help determine instream flow needs in the Ozarks and will provide the basis for conservation of at least 9 fish species, 11 crayfish species, and 11 insect species of greatest conservation need, including yellowcheek darter, Arkansas darter, Ozark shiner, longnose darter, silver redhorse, stargazing darter, Ozark chub, and current darter. This work will positively impact many species and ecosystems statewide, those of greatest conservation need and otherwise.

Hydrologic classification has been widely adopted in eco-hydrology, often with the goal of characterizing flow-ecology relationships and crafting appropriate water management for individual types of rivers or streams. We have now completed a regional river classification and quantitative descriptions of each natural flow regime for the Ozark-Ouachita Interior Highlands region of Arkansas, Missouri, and Oklahoma. Sixty-four reference streams in relatively undisturbed condition were identified based on the hydrologic disturbance index and by screening GIS databases for potential sources of hydrologic alteration such as dams, water discharge sites, urbanization, and agriculture. Based on daily flow records from 64 reference streams, seven natural flow regimes were identified using mixture model cluster analysis: Groundwater Stable, Groundwater, Groundwater Flashy, Perennial Runoff, Runoff Flashy, Intermittent Runoff, and Intermittent Flashy. Sets of flow metrics were selected that best quantified nine ecologically important components of each natural flow regime. An uncertainty analysis was performed to avoid selecting metrics strongly affected by measurement uncertainty that can result from short periods of record. Measurement uncertainties (bias, precision, and accuracy) were quantified for 170 commonly used flow metrics produced by the USGS Hydrologic Index Tool. The ranges of variability expected for select flow metrics under natural conditions were quantified for each flow regime to provide a reference for future assessments of hydrologic alteration. A random forest model was used to predict the natural flow regimes of all stream segments in the study area based on climate and catchment characteristics and a map was produced. The geographic distribution of flow regimes suggested distinct eco-hydrological regions that may be useful for conservation planning. This classification system provides a hydrologic foundation for future examination of flow-ecology relationships in the region, including our own study of ecological communities in Groundwater streams of the Springfield Plateau.

In 2014, we finished processing all benthic macroinvertebrate samples collected in 2012 and 2013. We then conducted analyses on fish, crayfish, and RTH (richest targeted habitat) and QMH (qualitative multi-habitat) macroinvertebrate data collected in both the 2012 and 2013 field seasons to complete Objective 2 of this study.

We examined flow-ecology relationships in the Ozark Highlands over two years with contrasting environmental conditions, a drought year (2012) and a flood year (2013) in flashy groundwater streams on the Springfield Plateau. We examined metrics of community structure in fish, crayfish, and macroinvertebrates using an IT multiple regression approach with *a priori* selected predictor variables incorporating hydrology, habitat, geomorphology, and water quality. Additionally, we used a canonical ordination approach relating these same biological response variables to metrics of flow alteration using a small apriori selected set of flow alteration variables and via an exploratory forward selection procedure examining all flow alteration variables.

We found that hydrology was an important variable influencing fish, crayfish and macroinvertebrate community structure, but often less important than other types of environmental

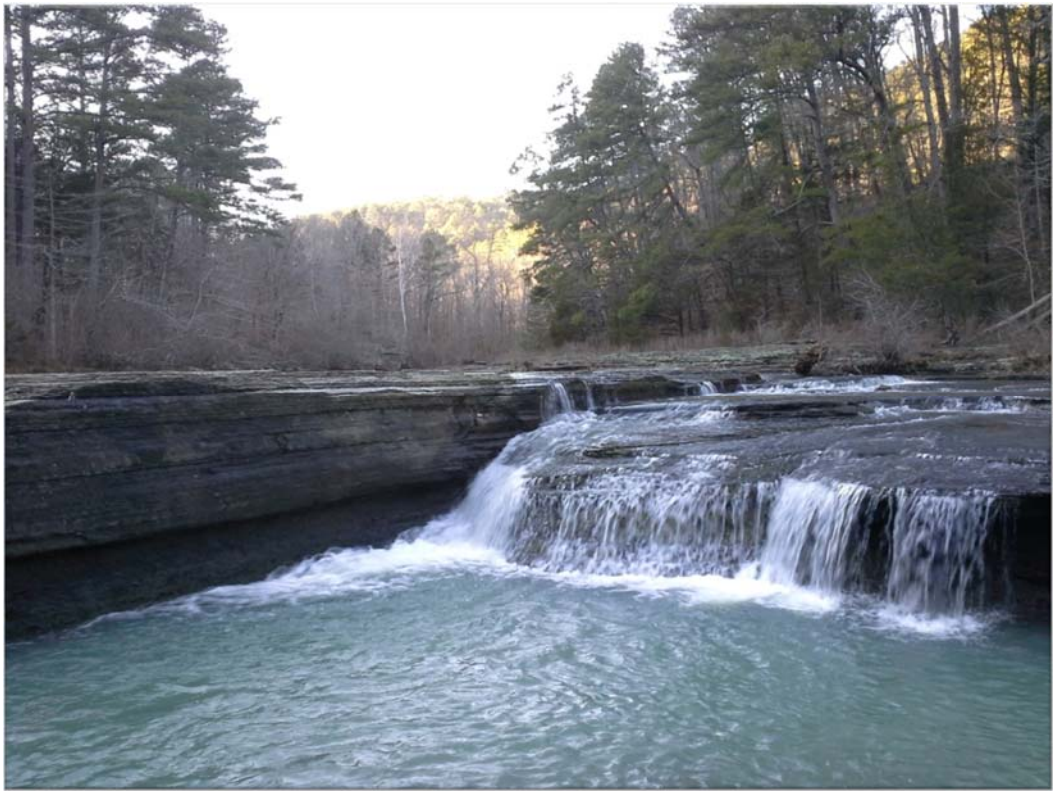
variables, especially in a drought year. We found substantial between-year variation in flow-ecology relationships. We found less significant relationships overall during the flood year than the drought year. When a small set of *a priori* flow alteration metrics were examined, we did not see strong flow alteration-ecology relationships.

Exploratory canonical ordination showed strong flow alteration-ecology relationships varying among taxonomic and sample type groups and most flow alteration metrics examined showed significant reductions relative to expected. Crayfish communities were most influenced by changes in frequency and duration of high flows, whereas macroinvertebrates were sensitive to timing of low flows, and fish responded to alteration in a combination of duration, frequency, and magnitude of flow variables. Flow alteration, along with habitat, geomorphology and water quality, appear to have important influences on fish, crayfish and macroinvertebrate community structure. While variables and relationships highlighted by this study could be used by managers to conserve stream communities in the Ozark Highlands, variation among groups in flow alteration-ecology relationships, as well as temporal variation in flow-ecology relationships, suggests difficulty in choosing a small number of variables to target entire stream communities.

CURRENT FISHERIES PROJECTS

Rock Bass, photo by Dustin Lynch (AR Coop Unit)

Fisheries



Haw Creek, Arkansas

Quantification of Hydrologic Alteration and Relationships to Biota in Arkansas Streams: Development of Tools and Approaches for Un-Gaged Streams

Funding Source:	Arkansas Game and Fish Commission Arkansas Cooperative Fish and Wildlife Research Unit University of Arkansas
Project Duration:	March 2014 to June 2016
Principal Investigator:	DANIEL D. MAGOULICK
Postdoctoral Fellowship:	DOUGLAS R. LEASURE

Research Objectives:

1. Develop the capability to assess flow alteration at un-gaged streams in Arkansas.
2. Quantify hydrologic alteration in streams with existing biological community data and establish key relationships between flow alteration and the integrity of stream communities.
3. Assess potential biological impact of hydrological alteration for streams of conservation interest, such as the Little Red River.

Management Implications:

1. Results from this work will contribute to a scientific foundation for environmental flow standards in Arkansas.

2. Developing methods to assess hydrologic alteration for *un-gaged* streams will allow existing biological data to be used to examine issues of flow alteration in Arkansas, saving resources otherwise needed to collect biological data at gage sites.
3. This work will positively impact many species and ecosystems statewide, those of greatest conservation need and otherwise.
4. Information from this study will also be useful for dealing with water use issues, such as those from natural gas development.

Project Summary:

Providing adequate water quantity and quality in streams and rivers is a pressing issue in Arkansas and worldwide. For this reason, it is crucial to determine appropriate flows in streams to protect fish and wildlife needs (environmental flows). A crucial component of determining environmental flows is determining hydrologic alteration. Additionally, the ability to determine hydrologic alteration for sites where discharge data does not exist (i.e. un-gaged sites) is crucial to examining environmental flows for most streams in Arkansas and the U.S. A method has been proposed by Carlisle *et al.* (2010) to assess hydrologic alteration at gaged sites by comparing observed flow characteristics of a gaged stream to expected natural flow characteristics predicted based on catchment and climate characteristics. Currently, only a small portion of existing biological data are from stream sites where USGS stream gages are in operation, making it difficult to relate stream flow and flow alteration to biological communities.

We will develop an approach to assess flow alteration at un-gaged sites in portions of Arkansas, Oklahoma, and Missouri that include the Ozark Highlands, Boston Mountains, Arkansas Valley, Ouachita Mountains, and Arkansas' South Central Plains. We will first use the Carlisle *et al.* (2010) method to quantify flow alteration at gage sites within our study area. We will then use relationships between flow alteration and catchment characteristics at these sites as the basis for predicting flow alteration at un-gaged sites. Catchment characteristics will include things like agricultural intensity, dam storage, and degree of urbanization. This approach will allow us to, 1) relate flow alteration to land use/land cover, 2) map natural flow characteristics and flow alteration throughout our study area, and 3) relate flow alteration to existing biological data for multiple stream types and sizes.

We have now completed the first step using the Carslisle *et al.* (2010) method to assess flow alteration histories of 211 stream sites with USGS gages. To do this, we first identified 64 streams that were in least-disturbed reference condition. Climate and catchment characteristics of these sites were related to stream hydrology using random forest models (Breiman 2001). A model was built for each of 187 flow metrics that we used to describe stream hydrology. Prediction errors were assessed using several approaches and found to be acceptable for most flow metrics. These models were used to estimate natural hydrology at all sites with stream gages. Gage data were used to calculate 187 flow metrics representing actual flow conditions for every 15 year period within each gage's record.

Flow alteration was measured as $\frac{(O-E)}{error}$, where *O* was the observed value of a flow metric calculated from gage data, *E* was the expected natural value for that flow metric based on a random forest model, and *error* was the standard deviation of predictions from the random forest model. *Error* includes natural variation of flow metrics as well as model error. The *O*/*E* ratio of Carlisle *et al.* (2010) was not used because of issues when flow metrics were zero. Flow alteration was calculated for every 15 year period in a gage's record to create a disturbance history for each flow metric. We are now in the process of validating our modeled flow alteration histories by comparing them to known disturbances at some sites.

Next, we will use current flow alteration estimates along with catchment characteristics of all 211 gage sites as training data to build a new random forest model to predict flow alteration at un-gaged sites. Flow alteration will be assessed at all sites with existing biological data that would be suitable to associate specific degrees and types of flow alteration with biological community responses. We have obtained and formatted the Arkansas Stream GAP data and are now working to quantify climate and catchment characteristics at these sites in preparation for assessing flow alteration. Existing biological data from the ecologically-sensitive Little Red River drainage will also be used as a case study.

Our tool will be available for future assessments of flow alteration throughout the state, except the Mississippi Alluvial Plain. This project adds an important component to our current research in which we have completed 1) a regional hydrologic classification of rivers, and 2) aquatic community sampling in the field to develop ecological-flow relationships within groundwater flashy streams of the Ozark Highlands ecoregion. Our research program contributes to a scientific framework for setting environmental flow standards in Arkansas and will positively impact many species and ecosystems statewide, those of greatest conservation need and otherwise.

References:

Breiman L. 2001. Random forests. *Machine Learning* 26:217-222

Carlisle DM, Falcone J, Wolock DM, Meador RM, Norris RH. 2010. Predicting the natural flow regime: Models for assessing hydrological alteration in streams. *River Research and Applications* 26:118-136.

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

Trait Composition of Fish Assemblages along Hydrologic Gradients

Funding Source:	University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	August 2013 –May 2015
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. Compare trait based and taxonomic based approaches for describing changes in fish assemblages in response to hydrologic variation
3. Test for morphological variation between fish inhabiting different hydrologic regimes
4. Determine the relative roles of genetic divergence and phenotypic plasticity driving morphological variation

Management Implications:

1. This study contributes to the knowledge of flow-ecology relationships to aid in determining environmental flow standards.
2. 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.
3. Understanding the roles of phenotypic plasticity and genetic divergence may provide insight into the evolutionary consequences of flow alteration.

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). This study aims to determine the relationship between trait compositions of fish assemblages and hydrological variability.

In addition to trait variation between fish assemblages, hydrologic factors may also influence intraspecific and interspecific phenotypic variation. 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.

I am currently examining the trait composition of fish assemblages by using hydrological and fish survey data from Arkansas streams within the Ozark Highland, Arkansas Valley, Boston Mountains, and Mississippi Alluvial Plains ecoregions. Hydrologic variability is described by nine flow metrics measuring the magnitude of flow events at average, low, and high flow conditions, the frequency and duration of low and high flow conditions, and the timing and rate of change of flow events. Fish community survey data from the ARGAP and NAWQA programs and flow data from USGS gauging stations are being analyzed using a combination of RLQ and four-corner analysis to determine the relationship between the nine flow metrics, overall hydrologic variability, single traits, and suites of traits (trait syndromes). This analysis will determine how fish trait compositions change across hydrologic gradients, as well as how individual components of the hydrologic regime affect fish assemblages.

Variation in morphology between fish occupying different hydrologic regimes will be investigated using geometric morphometrics. Over 600 fish were collected and photographed from 20 sites within two different flow regimes (groundwater streams and intermittent). I 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.

I conducted a 20 week long, fully factorial mesocosm experiment to determine if phenotypic plasticity or genetic divergence is driving morphological variation by. I 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 is currently being completed using the same methods used in the comparative field study. Morphological variation due to genetic predisposition will be indicated by differences in shape variables between populations. Phenotypic plasticity will be indicated by differences in shape variables between treatments in each of the populations.

Artificial stream units at Oklahoma University Biological Research Station, 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 University of Oklahoma Sigma Xi Research Grant Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	July 2014 to July 2016
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 2014 and explored the dynamics of drought and nutrient pollution treatments on two species of Ozark stream fish in large, outdoor mesocosms. However, preliminary results were inconclusive. It is likely that high mortality rates across all treatments during the experiment obscured important ecological dynamics. The second experiment—to be carried out summer 2015—will compare growth and survivorship of communities exposed to combinations of drought, and apex predation treatments with either a native smallmouth bass or a novel largemouth bass. The third experiment in the series will cross nutrient pollution and predation treatments. Next, we will perform a manipulative field experiment in the Boston Mountains ecoregion of northwestern Arkansas by manipulating community and predator abundances while adding nutrient diffusing substrata to explore community dynamics against unmanipulated habitats within the system. Finally, we will construct a mathematical model which explores predatory impacts of native and novel predation on metacommunity dynamics 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 effect the compounded effects of multiple stressors within one system.

Fisheries

Crooked Creek, Arkansas, photo by Christopher Middaugh (AR Coop Unit)

Hindcasting and Forecasting Effects of Angler Harvest, Land Use and Climate Change on Smallmouth Bass Growth and Survival at the Southern Edge of Their Range

Potential Funding Source:	University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	January 2014 to January 2017
Principal Investigator:	DANIEL D. MAGOULICK
Graduate Student:	CHRISTOPHER R. MIDDAUGH (Ph.D. Student)

Research Objectives:

1. Determine relative influence of angler harvest, and climate change on smallmouth bass Micropterus dolomieu abundance in the Buffalo River and Crooked Creek, AR at present, and future time periods
2. Incorporate bioenergetics modeling to examine effects of angler harvest and climate change on smallmouth bass growth in Crooked Creek, AR
3. Compare these models with other rivers along a latitudinal gradient

Management Implications:

1. The relative effects of harvest and climate change on smallmouth bass abundance and growth will be compared and managers could use this information in future regulation changes
2. Regulation strategies to maximize growth and/or abundance could be examined
3. Results could better prepare managers for future challenges that may be presented by climate change

Project Summary:

Many rivers ecosystems have been extensively altered by anthropogenic influences such as channelization, riparian vegetation removal, and urbanization. Many of these land use factors are interrelated and can affect river ecosystems in complex ways including altering flow regimes and increasing water temperatures. Further, climate change could exacerbate the effects of altered land use on discharge and water temperature by increasing precipitation stocasticity and increasing air temperatures. River discharge and temperature are particularly influential factors on fish populations such as smallmouth bass Micropterus dolomieu, especially at larval and juvenile stages. Better understanding of how abiotic factors structure smallmouth bass populations is critical for better management of this species, especially as climate change alters lotic habitats.

We will create an age-structured model to explore the influences of climate change and angler harvest on smallmouth bass abundance and growth using two time periods: present and future (similar to Peterson and Kwak 1999). Smallmouth bass data have been provided from long-term AGFC Buffalo River and Crooked Creek sampling. This data set indicates that age-0 smallmouth bass catch-per-unit-effort is significantly related to May temperature and April discharge in the Buffalo River, AR. We will use USGS river gauges and NOAA climate data to model present river discharge and temperature. We will use existing climate models to extrapolate precipitation and temperature to future conditions.

A preliminary bioenergetics model has also been created and parameterized from literature values. This model indicates that in the Buffalo River, AR, smallmouth bass may have an increased capacity for growth during winter months and a decreased capacity for growth during summer months after climate change. This model will be integrated with the population model to examine both growth and abundance changes in response to climate change and model more complex climate scenarios. The model will also be used to simulate different regulation scenarios under present and future conditions. These simulations will provide managers with recommendations on how to best manage smallmouth bass in regards to abundance and size structure especially in regards to future climate change. Eventually, these models will be compared with similar models created for other rivers along a latitudinal gradient to examine differences in smallmouth bass response to climate change.

References:

Peterson, J. T., and T. J. Kwak. 1999. Modeling the effects of land use and climate change on riverine smallmouth bass. Ecological Applications 9:1391-1404.

NEW FISHERIES PROJECTS

Northern Hogsucker, photo by Dustin Lynch (AR Coop Unit)

Ringed crayfish, photo by Dustin Lynch (AR Coop Unit)

Ecosystem Effects and Distribution Modeling of Invasive Crayfish

Proposed Funding Source:	Arkansas Game and Fish Commission University of Arkansas Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	March 2015 –May 2016
Principal Investigator:	DANIEL D. MAGOULICK
Graduate Student:	NICOLE E. GRAHAM (M.S. Student)

Research Objectives:

1. Examine the factors influencing the abundance and distribution of Orconectes neglectus within its native and invaded ranges.
2. Predict the potential distribution of Orconectes neglectus using Orconectes rusticus as an 'avatar' species.
3. Examine the effects of stream drying and comparative effects of Orconectes eupunctus (native), Orconectes neglectus (extralimital invader), and Orconectes rusticus (extraregional invader) on stream structure and function.

Management Implications:

1. This study will aid in identifying environmentally sensitive areas that may be susceptible to future invasions by Orconectes neglectus.
2. Examining relative effects of extralimital and extraregional invaders may provide insight into potential ecosystem impacts based on the spatial extent of the invasion.

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, primarily due to the spread of invasive crayfish (Taylor et al. 1996). Displacement of native crayfish by invaders is of notable concern, and 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 sequential displacement of O. eupunctus (Larson et al. 2009).

Currently, little is known about the factors influencing the abundance and distribution of O. neglectus within its native and invaded ranges. Understanding these factors is necessary in order to predict potential regions susceptible to invasion. 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 propose to examine the species-environment relationship of O. neglectus in order to investigate factors of importance in determining this species' abundance and distribution. This will be accomplished by using GIS to link abundance data from previous surveys to abiotic landscape data and using a random forest model to select environmental variables influencing abundance of O. neglectus within its native and invasive ranges. This information will be used to produce a current distribution map of O. neglectus. In addition, we will use the avatar concept of Larson and Olden (2012) to project a potential future distribution of O. neglectus based on hydrologic niche shifts of the well-studied congener O. rusticus. This will aid in identifying environmentally sensitive areas that may be susceptible to future invasions by O. neglectus.

Furthermore, previous research has examined the comparative ecological impacts of native versus invasive crayfish species, however, few studies have investigated the relative impacts due to invaders from adjacent watersheds (extralimital invaders) versus invaders from distant regions (extraregional invaders). We propose to conduct a fully factorial mesocosm experiment that will examine the effects of stream drying and effects of native, extralimital, and extraregional crayfish on stream structure and function. Treatments will include: simulated stream drying without crayfish presence, simulated stream drying with O. eupunctus (native) presence, simulated stream drying with O. neglectus (extralimital invader) presence, simulated stream drying with O. rusticus (extraregional invader) presence, control without crayfish presence, control with O. eupunctus presence, control with O. neglectus presence, and control with O. rusticus presence. We will examine the responses of primary production and community respiration, leaf breakdown, periphyton ash free dry mass, chironomid abundance, and sediment levels as indicators of stream structure and function. This study will provide insight into potential ecosystem impacts based on the origin of an invader.

Sulphur Springs Diving Beetle, photo by Scott Longing (AR Coop Unit)

Multi-scale assessment of habitat and distribution of the endemic Sulphur Springs diving beetle: A novel application of a new spatial statistics model for stream networks

Funding Source:	University of Arkansas Honors College Arkansas Cooperative Fish and Wildlife Research Unit
Project Duration:	May 2014 to May 2015
Principal Investigator:	DANIEL D. MAGOULICK
Graduate Student:	DOUGLAS R LEASURE (Ph.D. Student)
Undergraduate Student:	JEREMIAH NATHAN FLANNERY (B.A. Student)

Research Objectives:

1. Identify factors that contribute to or prevent the existence of viable habitats for the Sulphur Springs Diving Beetle.
2. Identify habitats in a new, expanded range that likely contain this beetle.
3. Examine the effect of human development on presence of Sulphur Springs Diving Beetle in headwater streams.

Management Implications:

1. This study will shed light on the behavior and environmental preferences of a species that is classified as critically imperiled but has little research conducted on it.
2. Understanding the proximity at which human development affects the Sulphur Springs Diving Beetle may be useful to establishing guidelines for ecologically sound land development.

Project Summary:

Understanding the human and environmental factors that play into whether a location is suitable for an organism is an important factor in prediction of potential new locations (Newton-Cross, White, & Harris 2007). Heterosternuta sulphuria (pictured on the previous page), (syn. Hydroporus sulphurius, Heterosternuta sulphurius; Wolfe 2000; Nilsson 2007), is a species of diving beetle commonly found in small headwater streams (figure 1) and is classified as endemic to Arkansas with a priority score of 80/100, a state conservation rank of S1, and a global conservation rank of G1 (Longing & Haggard 2009).

This study proposes to reexamine data collected by Scott Longing related to H. sulphuria distribution in depth by focusing on the environmental factors which impact H. sulphuria. This is important to do because little is known of its full distribution or habitat requirements. We hypothesized that H. sulpuria is more widespread than its current classification suggests, and that a riparian buffer of forest can offset the negative impact of urbanization on H. sulphuria presence.

Attributes of watersheds and riparian zones associated with H. sulphuria collection sites (e.g. forest cover in the watershed) were quantified using software recently developed at the University of Arkansas. Variables of interest for this project include: forest canopy cover, urban area, concentration of roads, impervious surfaces, groundwater flow, and hayfields.

Logistic regression models will be compared using a handful of variables that are perceived to be ecologically significant at different radii/buffer sizes around sample locations in order to choose the scale at which each variable has the strongest relationship with H. sulphuria presence. Throughout the analysis, the relative weight of competing hypotheses will be assessed by comparing model fit using Akaike Information Criterion, which favors parsimonious models. Area Under Curve will be used as a general measure of model fit appropriate for logistic regression because it is “threshold-independent” (Venables & Ripley 1994; Hanley & McNeil 1982).

We wish to test five variable combinations as competing hypotheses. These five variable combinations each try to explain variation in Sulphur Springs Diving Beetle presence as a combination of urbanization and development happening within a certain distance of the sample site. This will hopefully explain factors that are most important in whether a habitat is suitable for H. Sulphuria. We will also perform random forest analysis with an expanded set of variables to make a more precise model. Regressions are optimized to fit the data through a series of binary decisions, while making predictions with subsets of the data (Breiman 2001). It will aggregate them to create a model which is less likely to over-fit our own data. The location probabilities from the models we make will be used to support or negate claims that H. sulphuria is likely more widespread than accounted for and has many potentially suitable habitats in the region. This will aid further research and help inform as to whether H. sulphuria should have a less severe conservation status.

Literature Cited:

Breiman, Leo. "Random Forests." Machine Learning 45.1 (2001): 5-32.
Hanley, James A., and Barbara J. Mcneil. "The Meaning and Use of the Area Under a Receiver Operating Characteristic (ROC) Curve." Radiology 142.1 (1982): 29-36.

Nilsson, A. N. 2007. Some necessary corrections of the spelling of species-group names within the family Dytiscidae. Zootaxa 1615:49-54.
Longing, Scott D., and Brian E. Haggard. “Sulphur Springs Diving Beetle (Heterosternuta sulphuria) Status Report.” Final, Arkansas Game and Fish Commission, 2009: State Wildlife Grant T26-R-2

Longing, Scott D., P. A. Bacon, and G. L. Harp. "Distribution, Conservation and Current Status of Three Endemic Heterosternuta (Coleoptera: Dytiscidae: Hydroporinae) in Arkansas." Journal of the Arkansas Academy of Science 67 (2013): 177-79.

Wolfe, G. W. 2000. Key to species of Heterosternuta of Canada and the United States. Pages 230-232 in Predaceous diving beetles (Coleoptera: Dytiscidae) of the Nearctic region, with emphasis on the fauna of Canada and Alaska. D. J. Larson, Y. Alarie, and R. E. Roughley, eds. National Research Council of Canada Research Press, Ottawa, Ontario, Canada.

PRODUCTIVITY

Putting up mist nets to capture American Woodcock, photo by Auriel Fournier (AR Coop Unit)

HONORS AND AWARDS:

Fournier, A.M.V. – University of Arkansas Graduate School, Distinguished Doctoral Fellowship, 2012-2016
Fournier, A.M.V. – Arkansas Audubon Society Annual Trust Award Recipient, 2014
Fournier, R.J. – University of Arkansas Graduate School, Doctoral Academy Fellowship, 2013-2017.
Fournier, R.J. – Loren Hill Graduate Research Fellowship, University of Oklahoma, Biological Station, 2014.
Fournier, R.J. – Sigma Xi Grant in Aid of Research, University of Arkansas-Fayetteville. 2014.
Herbert, J.A. – Arkansas Audubon Society Annual Trust Award Recipient, 2014
Leasure, D.R. – Outstanding Paper of the Year Recipient, Coleopterist Society, 2014
Leasure, D.R. – Delbert Swartz Endowed Graduate Fellowship for Outstanding Graduate Student, 2014
Lynch, D.T. – University of Arkansas Graduate School, Distinguished Doctoral Fellowship, 2011-2015
Middaugh, C.R. – University of Arkansas Biology Department, GT Johnson Endowed Scholarship for Outstanding First Year Graduate Student, 2014
Middaugh, C.R. – University of Arkansas Graduate School, Doctoral Academy Fellowship, 2014-2018
Pittman, H.T. – Scott D. Shull Wildlife Memorial Assistantship, University of Arkansas, 2014
Sebright, C.E. – Harold and Margaret Hedges Memorial Scholar ship in Ornithology, 2014
Sebright, C.E. – Arkansas Audubon Society Annual Trust Award Recipient, 2014
Yarra, A. – Best Student Paper Award, Arkansas Water Resources Center Conference, 2014

COURSES TAUGHT:

Krementz, D.G. – Wildlife Management and Techniques – 2014.
Krementz, D.G. – Seminar in Biology – Proposal/Grant Writing – 2014.
Magoulick, D.D. – Biometry: Experimental Design and Analysis – 2014.

PUBLICATIONS AND PROFESSIONAL PAPERS PRESENTED:

Scientific Publications:

Carroll, J.M. and **D.G. Krementz**. 2014. Density and Abundance of Wintering Wilson's Snipe in the Mississippi Flyway. Wildlife Biology 20:108-114.
Krementz, D.G., R. Crossett, and S.E. Lehnen. 2014. Nocturnal Field Use by Fall Migrating American Woodcock in the Delta of Arkansas. Journal of Wildlife Management 78:264-272.
Magoulick, D.D. 2014. Impacts of Drought and Crayfish Invasion on Stream Ecosystem Structure and Function. River Research and Applications 30:1309-1317.
Middaugh, C.R., M.S. Sepúlveda, and T.O. Höök. 2014. Growth and Behavior Effects of the Lampricide TFM on Non-target Fish Species. Journal of Great Lakes Research 40:1010-1015.
Nolen, M.S., **D.D. Magoulick**, R.J. DiStefano, E.M. Imhoff, and B.K. Wagner. 2014. Predicting Probability of Occurrence and Factors Affecting Distribution and Abundance of Three Ozark Endemic Crayfish Species at Multiple Spatial Scales. Freshwater Biology 59:2374-2389.

Technical Publications:

Leasure, D.R., D.T. Lynch, and J.R. Schluterman. 2014. Classification of Arkansas Flow Regimes, Region Flow-Ecology Relationships and Environmental Flows Assessment for the Ozark Region. Final Report prepared for the State Wildlife Grant program of the Arkansas Game and Fish Commission, Little Rock, Arkansas.

Pittman, H.T. 2014. Effects of Large Scale Growing Season Prescribed Burns on Movement, Habitat Use, Productivity, and Survival of Female Wild Turkey on the White Rock Ecosystem Restoration Project of the Ozark-St. Francis National Forest. University of Arkansas, Fayetteville, Arkansas.

Reddin, C.J. 2014. Small Mammal Community Associations and Habitat Use at Pea Ridge National Park, Bento County, Arkansas. University of Arkansas, Fayetteville, Arkansas.

Ronke, M.E. 2014. Survival, Abundance, and Geographic Distribution of Temperate-Nesting Canada Geese in Arkansas. University of Arkansas, Fayetteville, Arkansas.

Papers Presented:

Fournier, A.M.V. and **D.G. Krementz**. 2014. The Response of Fall Migrating Sora to Wetland Management. Arkansas Chapter of the Wildlife Society Spring Meeting. Conway, Arkansas.

Fournier, A.M.V. and **D.G. Krementz**. 2014. The Use of U.A.V.s to Assess Wetland Vegetation Interspersion. Arkansas State Chapter of the Wildlife Society Spring Meeting. Conway, Arkansas.

Herbert, J.A., L.N. Naylor, and **D.G. Krementz**. 2014. Potential Use of Current Waterfowl Surveys in the Lower Mississippi Alluvial Valley. Mississippi Flyway Council. Johnston, Iowa.

Leasure, D.R. 2014. Habitat of Endangered American Burying Beetle in Western Arkansas: Addressing Issues of Spatial Scale and Detection for Satellite Based Monitoring. Invited Speaker. Department of Biology, University of Nebraska-Kearney. Kearney, Nebraska.

Leasure, D.R., **D.D. Magoulick,** and S.D. Longing. 2013. Natural Flow Regimes of the Ozark and Ouachita Mountain Region. American Fisheries Society. Little Rock, Arkansas.

Leasure, D.R. 2013. The Modern Era of "Big Data" in GIS: Multi-scale Modeling of Species Distributions, Hydrology, and Gene Flow. American Fisheries Society. Little Rock, Arkansas.

Leasure, D.R. 2013. Geodata Crawler: A Centralized National Geodatabase and Automated Multi-scale Data Crawler to Overcome GIS Bottlenecks in Data Analysis Workflows. Ecological Society of America. Minneapolis, Minnesota.

Leasure, D.R. and **D.D. Magoulick**. 2014. A Foundation for Arkansas E-flows: Hydrologic Classification and Flow Alteration modeling. Special Session on *Environmental Flows: What, Why, and How?* Arkansas Water Resources Conference. Fayetteville, Arkansas.

Leasure, D.R. and **D.D. Magoulick**. 2014. Assessment of Hydrologic Alteration at Un-gaged Streams. Arkansas Cooperative Fish and Wildlife Research Unit Annual Meeting. Mayflower, Arkansas.

Leasure, D.R., D.D. Magoulick, and S.D. Longing. 2014. Natural Flow Regimes of the Ozark-Ouachita Interior Highlands Region. Arkansas Cooperative Fish and Wildlife Research Unit Annual Meeting. Mayflower, Arkansas.

Lynch, D.T. and **D.D. Magoulick**. 2014. Environmental Flows in the Ozark Highlands: Contrasting Hydrology-Biology Linkages between a Drought Year and a Flood Year. Arkansas Wildlife Action Plan Conference. Mount Magazine, Arkansas.

Lynch, D.T. and **D.D. Magoulick**. 2014. Environmental Flows in the Ozark Highlands: Contrasting Hydrology-Biology Linkages between a Drought Year and a Flood Year. Arkansas Wildlife Action Plan Symposium. Mount Magazine, Arkansas.

Lynch, D.T. 2014. Ecological Flow-Response Relationships in the Ozark Highlands. Arkansas Water Resources Center Annual Research and Watershed Conference. Fayetteville, Arkansas.

Lynch, D.T. and **D.D. Magoulick**. 2014. Flow-ecology Relationships in the Ozark Highlands. Special Session on *Environmental Flows: What, Why and How?* Arkansas Water Resources Conference. Fayetteville, Arkansas.

Lynch, D.T. and **D.D. Magoulick**. 2014. Ecological-flow Response Relationships in the Ozark Highlands. Integrative Session on *The Science and Management of Environmental Flows: Recent Developments and Remaining Challenges,* Joint Aquatic Sciences Meeting. Portland Oregon.

Lynch, D.T. and **D.D. Magoulick**. 2014. Flow-ecology Relationships in the Ozark Highlands. American Fisheries Society. Quebec City, Quebec, Canada.

Magoulick, D.D. and **D.T. Lynch**. 2014. Effects of Seasonal Drying on Fish and Crayfish Assemblages in Simulated Intermittent Streams. Integrative Session on *Advancing the science and management of temporary aquatic habitats.* Joint Aquatic Sciences Meeting. Portland, Oregon.

Magoulick, D.D. 2014. Classification of Natural Flow Regimes and Flow-ecology Relationships in the Ozark-Ouachita Interior Highlands Region. Joseph W. Jones Ecological Research Center. Newton, Georgia.

Magoulick, D.D. 2014. Environmental Flows: What, Why and How? Special Session on *Environmental Flows: What, Why, and How?* Arkansas Water Resources Conference. Fayetteville, Arkansas.

Pittman, H.T. 2014. Ecological Impacts of Early Growing Season Prescribed Fire on Eastern Wild Turkey in the Ozark Highlands of Arkansas. Arkansas Technical University, Fish and Wildlife Seminar Series. Russellville, Arkansas.

Pittman, H.T. 2014. The Effects of Early Growing Season Prescribed Fire on the Nesting Ecology of the Easter Wild Turkey in the White Rock Wildlife Management Area, Arkansas. Arkansas Game and Fish Commission Turkey Team Meeting. Conway, Arkansas.

Pittman, H.T. 2014. Landscape Scale Early Growing Season Prescribed Fire and Its Effect on Eastern Wild Turkey Nest Site Selection in the Ozark Highlands, Arkansas, USA. The 38th Annual NWTF Convention and Sport Show, Technical Meeting. Nashville, Tennessee.

Pittman, H.T., B. Bowers, K. Lynch, and R. Whalen. 2014. Annual and Seasonal Survival of Eastern Wild Turkey in the Ozark Highlands, Arkansas, USA. 74th Midwest Fish and Wildlife Conference. Kansas City, Missouri.

Posters Presented:

Baecher, J., D.R. Leasure, D.T. Lynch, and **D.D. Magoulick**. 2014. Influence of Land Use and Hydrologic Disturbance on Crayfish Assemblages. Plenary-Themed Special Integrated Session on *Large-scale Limnology – Integrating Across Landscapes to Understand Regional Controls on Bio-diversity and Nutrient Cycles.* Joint Aquatic Sciences Meeting, Portland, Oregon.

Fournier, A.M.V., D.G. Krementz, D.C. Mengel, and A.H. Raedeke. 2014. Effects of Wetland Management Strategies on Habitat Use of Fall Migrating Rails in Intensively-Managed Wetland Complexes in Missouri. The Wildlife Society National Conference. Pittsburgh, Pennsylvania.

Pittman, H.T., B. Bowers, K. Lynch, and R. Whalen. 2014. Landscape Scale Early Growing Season Prescribed Fire and Its Effect on Easter Wild Turkey Nest Site Selection in the Ozark Highlands, Arkansas, USA. 74th Midwestern Fish and Wildlife Conference. Kansas City, Missouri.

Reddin, C.J. and **D.G. Krementz**. 2014. Texas Mice Habitat Use in the Ozark Mountains. 74th Midwest Fish & Wildlife Conference. Kansas City, Missouri.

Yarra, A., L.A. Bruckerhoff, and **D.D. Magoulick**. 2014. Influence of Geomorphology and Land Use on Fish Community Structure in Ozark Highland Streams. Arkansas Water Resources Center Conference. Fayetteville, Arkansas.

Douglas, T., C.R. Middaugh, and **D.D. Magoulick**. 2014. Influence of Geomorphology and Land Use on Fish Community Structure in Ozark Highland Streams. Arkansas Water Resources Center Conference. Fayetteville, Arkansas.

Committees/Task Forces/Recovery Teams:

Bruckerhoff, L.A. – President – University of Arkansas American Fisheries Society – 2014.

Bruckerhoff, L.A. – Member – Biological Graduate Student Association, University of Arkansas. 2014.

Fournier, A.M.V. – Member – Yellow Rail Working Group. 2013 – Present.

Fournier, A.M.V. – Treasure – Student Development Working Group – The Wildlife Society National. 2014

Fournier, A.M.V. – Treasure – Biology Graduate Student Association, University of Arkansas. 2014.

Fournier, A.M.V. – Science Fair Judge Regional/Local Science Fairs NW Arkansas. 2014.

Fournier, R.J. – Science Fair Judge – Haas Hall Academy, Fayetteville, Arkansas. 2014.

Herbert, J.A. – Member – Biology Graduate Student Association, University of Arkansas. 2014

Krementz, D.G. – Chairman – Web-less Committee, Mississippi Flyway Game Bird Technical Section – International. February 2006 – Present.

Krementz, D.G. – Member – Lower Mississippi Alluvial Valley Joint Venture Migratory Bird Science Team – Regional. 2014**.**

Krementz, D.G. – Member – West Gulf Coastal Plain/Ouachita Land-bird Technical Working Group – Regional. August 2009 – Present.

Krementz, D.G. – Member – Nation Resources Conservation Service Arkansas Wildlife Sub-committee – State. 2011 – Present.

Krementz, D.G. – Member – Arkansas Wildlife Action Plan – State. 2014.

Krementz, D.G. – Chairman – Donald R. Rusch Memorial Game Bird Research Scholarship Committee – International. 2012 – 2014.

Krementz, D.G. – Member – Web-less Game Bird Proposal Selection Committee – International. 2011 – Present.

Krementz, D.G. – Faculty Advisor – University of Arkansas Student Chapter of the Wildlife Society. 2005 – Present.

Krementz, D.G. – Member University of Arkansas Biological Sciences Facility Committee. 2008 – Present.

Krementz, D.G. – Member University of Arkansas Biological Sciences Graduate Studies Committee. 2012 – Present.

Magoulick, D.D. – Undergraduate Honors Student Supervised, Allyson Yarra, B.S. 2014.

Magoulick, D.D. – Undergraduate Honors Student Supervised, Tevin Douglas, B.S. 2014.

Magoulick, D.D. – Undergraduate Honors Student Supervised, J. Nathan Flannery, B.S. 2014.

Magoulick, D.D. – Undergraduate Honors Student Supervised, Brooke Beckwith, B.S. 2012-2014.

Magoulick, D.D. – Undergraduate Honors Student Supervised, Kaitlyn Smith, B.S. 2012-2014.

Magoulick, D.D. – Graduate Student Advisory Committee, Kyler Hecke, M.S., Department of Fisheries and Aquaculture, University of Arkansas-Pine Bluff. 2014.

Magoulick, D.D. – Graduate Student Advisory Committee, Mallory Jeffers, M.S., Department of Biological Sciences, University of Arkansas-Fayetteville. 2014.

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

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

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

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

Magoulick, D.D. – Graduate Student Advisory Committee, Phillip Vogrinc, M.S., Department of Biological Sciences, University of Arkansas-Fayetteville. 2013 – Present.

Magoulick, D.D. – Graduate Student Advisory Committee, Ayla Smartt, M.S., Department of Biological Sciences, University of Arkansas-Fayetteville. 2013 – 2014.

Magoulick, D.D. – Graduate Student Advisory Committee, M. Eliese Ronke, M.S., Department of Biological Sciences-Fish and Wildlife Research Unit, University of Arkansas-Fayetteville. 2013 – 2014.

Magoulick, D.D. – Graduate Student Advisory Committee, Auriel Fournier, Ph.D., Department of Biological Sciences-Fish and Wildlife Research Unit, University of Arkansas-Fayetteville. 2012 – Present.

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

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

Magoulick, D.D. – Graduate Student Advisory Committee, Cameron Chesbro, M.S., Department of Biological Sciences, University of Arkansas-Fayetteville. 2012 – 2014.

Magoulick, D.D. – Graduate Student Advisory Committee, H. Tyler Pittman, Ph.D., Department of Biological Sciences-Fish and Wildlife Research Unit, University of Arkansas-Fayetteville. 2011 – 2014.

Magoulick, D.D. – Graduate Student Advisory Committee, Brad Austin, Ph.D., Department of Biological Sciences, University of Arkansas-Fayetteville. 2010 – 2014.

Magoulick, D.D. – Aquatic Ecologist Search Committee, Department of Biological Sciences, University of Arkansas-Fayetteville. 2014.

Magoulick, D.D. – Organizer of Special Session on "Environmental Flows: What, why and how?" at 2014 Arkansas Water Resources Conference. 2014.

Magoulick, D.D. – Adaptation Science Management Team for Gulf Coast Plain Ozarks Landscape Conservation Cooperative. 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 – Present.

Magoulick, D.D. – Upper White River Basin Foundation Technical Advisory Group. 2008 – Present.

Magoulick, D.D. – U.S. Fish and Wildlife Service Aquatic Nuisance Species Task Force. 2007 – Present.

Middaugh, C.R. – Science Fair Judge – Haas Hall Academy – 2014.

Middaugh, C.R. – Vice President, University of Arkansas American Fisheries Society – 2014.

Moore, J.D. – Member – Biology Graduate Student Association, University of Arkansas. 2014.

Stephenson, P.S. – Member – Donald Rusch Memorial Game Bird Research Scholarship Committee of the Wildlife Society. 2014.

Stephenson, P.S. – President, University of Arkansas Student Chapter of the Wildlife Society. 2014.

TECHNICAL ASSISTANCE:

Training Offered:

Leasure, D.R. – Undergraduate Honors Student GIS Use & Advising – University of Arkansas – 2014
Leasure, D.R. – Graduate Student GIS Use & Advising – Texas Tech University-Lubbock – 2013

Training Received:

Bruckerhoff, L.A. – Adult First Aid/CPR/AED American Red Cross – University of Arkansas – 2014
Bruckerhoff, L.A. – Principles and Techniques of Electro Fishing – U.S. Department of Interior – 2014
Fournier, R.J. – Adult First Aid/CPR/AED American Red Cross – 2014
Krementz, D.G. – Federal Informational Systems Security Awareness and Privacy and Records Management (FISSA) – U.S. Department of Interior – 2014
Krementz, D.G. – Uniformed Services Employment and Re-employment Rights Act (USERRA) – U.S. Department of Interior – 2014
Krementz, D.G. – USGS Sustainability and Environmental Management System Awareness – U.S. Department of Interior – 2014
Krementz, D.G. – Veteran Employment Training for Hiring Mangers – U.S. Department of Interior – 2014
Krementz, D.G. – Adult First Aid/CPR/AED American Red Cross – University of Arkansas – 2014
Lynch, D.T. – Adult First Aid/CPR/AED American Red Cross – University of Arkansas – 2014
Magoulick, D.D. – Adult First Aid/CPR/AED American Red Cross – University of Arkansas – 2014
Middaugh, C.R. – Electrofishing Safety – U.S. Department of Interior – 2014
Middaugh, C.R. – Adult First Aid/CPR/AED American Red Cross – University of Arkansas -2014
Middaugh, C.R. – DOI Health Program Overview – U.S. Department of Interior – 2014
Middaugh, C.R. – Industrial Hygiene Training – U.S. Department of Interior – 2014
Middaugh, C.R. – NSC Defensive Driving II – U.S. Department of Interior -2014
Moore, J.D. – Safety: Authorities, Roles and Responsibilities – U.S. Department of Interior – 2014
Moore, J.D. – Safety: DOI Safety and Occupational Health Overview – U.S. Department of Interior – 2014
Moore, J.D. – Safety: Field Employee Orientation – U.S. Department of Interior – 2014
Moore, J.D. – Safety: USGS Safety and Occupational Health Program Overview – U.S. Department of Interior – 2014
Moore, J.D. – Safety: USGS Safety Program Requirements – U.S. Department of Interior – 2014
Sebright, C.E. – NSC Defensive Driving Course 4 – U.S. Forest Service – 2014

Outreach:

Fournier, A.M.V. – Invited Seminar, Arkansas Tech University Fish and Wildlife Seminar
Fournier, A.M.V. – Volunteer, The Wildlife Society National Conference, Pittsburgh, Pennsylvania
Fournier, A.M.V. – Presentation, Boys and Girls Club of Bentonville, Arkansas
Fournier, A.M.V. – Presentation, Springdale Alternative High School
Fournier, A.M.V. – Bird Banding Demonstrations, Hobbs State Park
Fournier, A.M.V. – Presentation, Local Library Science Programs
Sebright, C.E. – The Woodcock Word, Project newsletter sent out to 240 volunteers and coordinators