Project Title: Continuous Monitoring of Water Temperature and Quantity in Headwaters and Tributaries of the Strawberry, Middle Ouachita, Upper Ouachita, Little Missouri, and Caddo Rivers

Project Summary: Several rivers in the Ouachita River basin (Ouachita, Little Missouri and Caddo) and one river in the White River basin (Strawberry River) were identified as high priority watersheds for monitoring both water temperature and water quantity, crucial variables known to influence ecology of aquatic species and ecosystem processes. These systems contain a significant number of aquatic Species of Greatest Conservation Need (SGCN) (12 – 25 per system) that could be negatively influenced by increasing water temperature and altered hydrology. Arkansas lacks comprehensive data on water temperature and quantity throughout the state, particularly in ungaged headwaters and tributaries. There is a need to establish a baseline for future monitoring, to correlate with existing and future biological and hydrological data, and to examine impacts of disturbances and watershed perturbations, including climate change, on SGCN taxa. We propose to continuously monitor water temperature (50 sites) and quantity (30 sites) for two years within priority watersheds. We will closely adhere to approved USEPA and USGS protocols to maximize utility of data collected, including the possibility of contributing Arkansas data to regional and national monitoring programs using similar techniques in wadeable streams. This project directly addresses the habitat priority of the 2018 State Wildlife Grant RFP (Table 1) to monitor temperature and flow in priority watersheds.

Project Leaders:

Dr. Ginny Adams
Professor, Biology, UCA
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Dr. Reid Adams
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Dr. Lucas Driver
Ecologist, U.S. Geological Survey
ldriver@usgs.gov

Jeff Quinn
Streams Biologist, AGFC
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Tate Wentz
Ecologist Coordinator
Research and Field Programs
Office of Water Quality, ADEQ
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Budget Summary:
Total Project Cost: $ 173,065
Total Requested from SWG: $ (Year 1 - $65,803; Year 2 - $46,825)
Matching Funds from UCA: $50,610
Matching Funds from AGFC: $5,920
Matching Funds from ADEQ: $3,906.84

Project Statement

Need –Arkansas generally lacks comprehensive, standardized data on both water temperature and water quantity in ungaged headwaters (1^{st} – 3^{rd} order) and tributaries throughout the state. Even at the national level, there is a lack of data to address changes in climate for inland streams and rivers (Braun et al. 2015, Paukert et al. 2017). Headwaters and smaller tributaries are particularly vulnerable to increased water temperature and altered hydrology due to climate change and watershed alterations (e.g., water withdrawal and changes in land use) (Daraio and Bales 2014). Monitoring of stream temperature and hydrology-related parameters is crucial, as they directly impact ecology of aquatic species (e.g., through changes to behavior, movement, reproduction, and growth) and ecosystem processes (Allan and Castillo 2007). Further, temperature and hydrology are best measured using deployed sensors for continuous, year-round data collection to maximize sensitivity and utility of the data to address concerns with SGCN taxa (USEPA 2014).

Objectives – Our objective is to continuously monitor temperature and hydrology-related parameters (stage/depth) for two years at multiple headwater and tributary reaches in each study system (N = ~50 sites total for temperature and N = ~30 sites total for stage. Discharge will be measured periodically during discrete site visits. These data can be used to 1) establish a current baseline for future monitoring, 2) correlate with existing and future biological and environmental data (physical and chemical), and 3) examine the impacts of disturbances and watershed perturbations, including climate change, on SGCN and other taxa.

Location – Site selection will be determined based on availability of established biological data (AGFC, USGS, ADEQ, and UCA), coverage within the watershed (tributaries and main stem), and access. For example, UCA has fish assemblage data at 73 sites over a 40-year time period across the study systems. ADEQ has 45 sites sampled once or twice from 1983-2002 and has collected fish assemblage, macroinvertebrate, periphyton, and water quality data from 21 sites within the study area within the last two years.

The Ouachita Mountain, South Central Plain and Ozark Highland ecoregions are included in this proposal. Within the Ouachita River basin, there are over 25 aquatic SGCN species. Some of the highest priority species include mussels (14 species) and fishes (8 species) like Arkansas Fatmucket (*Lampsilis powellii*), colorless shiner (*Notropis perpallidus*), Caddo madtom (*Noturus taylori*), paleback darter (*Etheostoma pallididorsum*), and Ouachita darter (*Percina brucethompsoni*). The Strawberry River contains 12 aquatic SGCN species (including 5 mussels and 6 fishes) including the endemic Strawberry River darter (*Etheostoma fragi*).

Approach – Water temperature and water depth will be monitored at approximately 50 sites across the five priority watersheds (Little Missouri, Caddo, Upper Ouachita, Middle Ouachita, and Strawberry), with water temperature sensors deployed at ten sites and water depth sensors concurrently deployed at six (out of ten) sites within each watershed. Sites will primarily be located within the headwaters of the main stem of each system and their major tributaries and specific locations will be selected based on combination of accessibility, professional knowledge

of the stream reach/system (e.g., distribution of specific SGCN species, or potential sensitivity to perturbation), and to maximize spatial coverage within the watershed.

Water temperature and depth (i.e. stage) will be measured and monitored continuously using deployed temperature sensors and pressure transducers generally following best practices for monitoring outlined by USEPA (2014) to maximize accuracy, compatibility, and data utility. Temperature will be monitored at ~ 30-minute intervals with Onset Hobo© Water Temp Pro v2 loggers ($\pm$ 0.2 ^{o}C). A National Institute of Standards and Technology (NIST) digital certified thermometer will be used verify accuracy of each temperature sensor prior to deployment using 3-point temperature readings under laboratory conditions with a tolerance of $\pm$ 0.2 ^{o}C. Once deployed, sensor readings will be periodically compared to a NIST thermometer in the field to verify accuracy and document sensor drift. Stage will be monitored at ~ 30-minute intervals with Onset Hobo© Water Level loggers ($\pm$ 1-2 cm), and accuracy checks and reference depths will be made with a meter stick. Data corrections for local barometric (atmospheric) pressure will be made using a land-based water level logger. Sensors will be deployed inside protective heat shield containers constructed of polyvinyl chloride (PVC) and anchored to the stream bottom.

Data will be off-loaded using a base station interfaced with a laptop. Initially, data will be off-loaded about every 2 months, but will transition to approximately quarterly intervals once successful implementation is established. Loggers will remain deployed for a minimum of two years. Additionally, during each site visit to off-load data, wadeable stream discharge will be measured with a Son-Tek Flowtracker 2 velocimeter (USGS approved method) and related to water level loggers at multiple wadeable stages to establish local stage-discharge relationships.

Descriptive summary statistics for water temperature and water depth will be generated for each site and watershed to establish baseline datasets. Time series analyses (Crawley 2007) will be used to examine relationships between water temperature, air temperature, and water depth, identify seasonal/annual trends, and compare frequency, duration, and magnitude of high/low flow events over the period of study.

Relationships between continuous water temperature and air temperature can be used as a general indicator of stream thermal sensitivity to potential climate and land-use change (Hilderbrand et al. 2014). Additionally, continuous water depth can be compared to discrete stream discharge measures across multiple stages to establish local stage-discharge relationships.

We will also explore the applicability and techniques to integrate remotely sensed water level data and discrete streamflow/discharge measurements with available hydrological data (historical measurements and flow/stage rating curves) and geomorphic data (regional stream geomorphic benchmark/flow curves; Pugh et al. 2008). Incorporation of these data sets represents an exciting potential 'next step' that could allow estimation of daily discharge at ungaged sites/streams within priority watersheds.

Expected Results and Benefits – This project will establish baseline temperature and hydrology data for headwaters and tributaries in four rivers determined to be priority watersheds for data gaps (Arkansas Wildlife Action Plan). At a larger scale, these data will provide insight into the

current trends in temperature and water levels at a regional scale. Temperature and hydrology data collected will be presented through state meetings to other stakeholders that could potentially use the data (e.g., Arkansas AFS, AWAP). Additionally, stakeholders will be invited to a workshop held at UCA to discuss protocols, how data can be accessed and related to other existing biological and environmental data, and how to move forward with future sampling. From a SGCN perspective, stakeholder interest should be high given that over 25 species of conservation concern are found across the study systems.

Year 1

Item	SWG UCA	SWG USGS	Match AGFC	Match ADEQ	Match UCA	Total SWG	Total Match
PI salary (+ fringe)*	3,600	3,590.40	2,960	1,953.42	14,359		19,272
Grad Student (salary + tuition + fringe)*	11,004						
Student worker*	2,083						
Travel	6,000	225			2,000		2,000
Biology Truck Use[1]					1,925		
Supplies[2]	32,500						
Equipment[3]					11,473		
F&A	4,074	2,731.73					
F&A unrecovered							
Total	**$59,261**	**$6,547.13**	2,960	1,953.42	29,757	**65,803**	**34,670**

Year 2

Item	SWG UCA	SWG USGS	Match AGFC	Match ADEQ	Match UCA	Total SWG	Total Match
PI salary (+ fringe)*	6,000	3,590.40	2,960	1,953.42	17,478		22,391
Grad Student (salary + tuition + fringe)*	18,767						
Student worker*	2,083						
Travel	5,000	225			2,000		2,000
Biology Truck Use[1]					1,375		
Supplies[2]	2,500						
F&A	6,928	2,731.73					
F&A unrecovered							
Total	**40,278**	**$6,547.13**	2,960	1,953.42	$20,853	**46,825**	**25,766**

[1]UCA Biology maintains two departmental vehicles. Rate was calculated as $55/day with 35 days in the field the first year and 25 days the second year of the project.
[2]Supplies include the cost of loggers (water level and temperature) for five watersheds, replacement loggers, a certified thermistor, field laptop, and supplies for installation.
[3]Equipment to be purchased by CNSM for this project includes a SonTek FlowTracker2 at a cost of $11,473.

Ginny Adams, MS University of Arkansas, PhD Southern Illinois University, more than 20 years as a researcher in a variety of ecosystems. Ginny has published over 20 papers, including 13 while at the University of Central Arkansas and contributed to over 50 professional presentations. Her research has focused on the conservation of sensitive and endangered species in relation to anthropogenic disturbance. She has served on both the Fish Taxa Team for SWG and the Fish GAP analysis and ANHC fish ranking teams. Her responsibilities on this project will include mentoring of undergraduate and graduate students in logger placement, data retrieval and downloads, and report preparation.

Reid Adams, MS University of Mississippi, PhD Southern Illinois University, greater than 20 years as a researcher of river ecosystems that includes publication of 21 peer- reviewed papers, numerous presentations given at professional meetings (> 100), and mentoring of many undergraduate and graduate student projects (> 40). He has extensive experience collecting fishes and environmental data in Arkansas, including the proposed study systems. He has successfully completed the objectives and reporting requirements for three previously funded State Wildlife Grant proposals and will work on all phases of this project, including data analysis and report writing.

Lucas Driver , MS University of Central Arkansas, PhD University of North Texas, is an Ecologist with the U.S. Geological Survey Lower Mississippi-Gulf Water Science Center. He has greater than 10 years of experience conducting research in aquatic ecology and working in freshwater streams, particularly headwater and intermittent systems, including several of the study streams in this proposal. Lucas has worked for USGS for 3 years conducting research on variety of biological, water quality, and hydrological topics. He has experience with data processing and statistical analysis of large data sets, including continuous water quality and discharge records, and ecological flow modeling. Lucas has published 5 peer-reviewed journal articles as the first author.

Jeff Quinn is a Stream Fisheries Biologist with the Arkansas Game and Fish Commission. He received his M.S. degree from the University of Arkansas, and has been employed with AGFC since 1998. Jeff has published 13 peer-reviewed papers in scientific journals and books, and is a Certified Fisheries Professional through the American Fisheries Society.

Tate Wentz is the Aquatic Ecologist Coordinator for Arkansas Department of Environmental Quality. He has a B.S. in Fisheries and Wildlife Biology from Arkansas Tech University and M.S. in Biology from Arkansas State University. Tate has worked at ADEQ for nine years as an aquatic ecologist and researched a variety of topics from efficacy of habitat restoration to the long-term effects of nutrients and major ions in wadeable streams.

Literature Cited –

Allan, J.D. and M.M. Castillo. 2007. *Stream Ecology: structure and function of running waters*. 2nd Ed. Springer Science and Business Media.

Braun, D.C., J.D. Reynolds, and D.A. Patterson. 2015. Using watershed characteristics to inform cost-effective stream temperature monitoring. *Aquatic Ecology* 49: 373-388.

Crawley, M.J. 2007. Chapter 22: Time Series Analysis *in* The R Book. John Wiley & Sons Ltd., The Atrium, Southern Gate, Chichester, West Sussex, England.

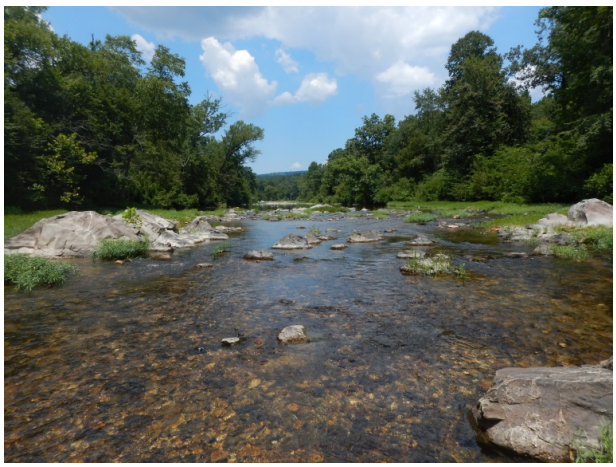
Daraio, J. A. and J.D. Bales. 2014. Effects of land use and climate change on stream temperature I: daily flow and stream temperature projections. *Journal of the American Water Resources Association* 50: 1155-1176.

Hilderbrand, R.H., M.T. Kashiwagi, and A.P. Prochaska. 2014. Regional and local scale modeling of stream temperatures and spatio-temporal variation in thermal sensitivities. Environmental Management 54:14-22.

Paukert, C.P., A.J. Lynch, T.D. Beard, Y. Chen, S.J. Cooke, M.S. Cooperman, and I.G. Cowx et al. 2017. Designing a global assessment of climate change on inland fishes and fisheries: knowns and needs. *Reviews in Fish Biology and Fisheries* 27: 393-409.

Pugh, A.L., T.J. Garday, and R. Redman. 2008. Geomorphic Characterization of the Middle Fork Saline River: Garland, Perry, and Saline Counties, Arkansas. U.S. Geological Survey Scientific Investigations Report 2007-5152, 65 p.

United States Environmental Protection Agency. 2014. Best practices for continuous monitoring of temperature and flow in wadeable streams. EPA/600/R-13/17OF. 129 Pgs.



Caroline Cone
Chief of Staff and Deputy Director

Chris Colclasure
Assistant Deputy Director

Arkansas Game and Fish Commission

Pat Fitts
Director

2/12/2018

Dr. Ginny Adams
University of Central Arkansas

Dear Dr. Adams,

The purpose of this letter is to confirm and commit $2,960 of non-federal match (salary and fringe) per year for two years (total of $5,920) towards our cooperative State Wildlife Grant proposal that monitors temperature and stage in the headwaters of the Little Missouri, Caddo, and Ouachita rivers. I will be helping students install temperature loggers in the streams as the state match towards the project. The work and time commitment has been approved by Assistant Chief Bill Posey.

Thanks,

Jeff Quinn
Stream Biologist

ADEQ
ARKANSAS
Department of Environmental Quality

Mrs. Ginny Adams
University of Central Arkansas
Via email

February 16, 2018

Re: ADEQ Office of Water Quality Planning Branch Technical and Analytical Services

Dear Mrs. Adams:

The Arkansas Department of Environmental Quality ("ADEQ") agrees with The University of Central Arkansas ("UCA") to establish the respective responsibilities between UCA and ADEQ associated with the multiagency 2018 Arkansas State Wildlife Grant, *Assessment of Temporal Variation in Temperature and Water Quantity in the Strawberry, Middle Ouachita, Little Missouri, and Caddo Rivers*.

Based on discussions, ADEQ and UCA commit to the following:

A. UCA agrees to:

   a. Address baseline data set for four rivers determined to be priority watersheds for data gaps (Arkansas Wildlife Action Plan), trends in temperature and water levels at a regional scale, and how aquatic organisms are responding.

B. ADEQ agrees to:

   a. To provide eighty (80) technical and or analytical hours for a two-year period. Services include, but are not limited to geospatial analysis, site selection and prioritization, and historical data analysis. ADEQ's total calculated in-kind match with fringe and indirect cost is $ 3,906.84 for a two-year period.

The project, if funded, is slated to begin October 1, 2019, and the parties anticipate the project lasting for a period of two years.

Sincerely,

Tate Wentz
Ecologist Coordinator
Field and Research Programs
Office of Water Quality
Arkansas Department of Environmental Quality

United States Department of the Interior

U.S. GEOLOGICAL SURVEY
Lower Mississippi-Gulf Water Science Center
Little Rock Office
401 Hardin Rd.
Little Rock, Arkansas 72211

Letter of Commitment:

U.S. Geological Survey and associated personnel agree to- and are committed to carry out the work outlined in this proposal if funding is awarded.

Lucas Driver, PhD
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