Project title: Developing baseline distribution and population status information for aquatic invertebrates in the waterfalls of Arkansas

Project summary: This project addresses a key data gap in the aquatic habitat and small stream funding priority of the SWG 2016 RFP, and the associated action to 'Obtain baseline information on distribution and population status for multiple species of aquatic invertebrates.' Specifically, we propose to develop rigorous baseline surveys of distributions and population status assessments for aquatic invertebrate in waterfall habitats, which are a unique and completely unstudied habitat in Arkansas and N. America. Knowledge of such aquatic invertebrate diversity, distributions, and abundance, along with their habitat associations, is critical for developing sound biodiversity and conservation management practices, especially in the face of emerging threats to flow regimes.

Project Leader: Adam M. Siepielski, Assistant Professor, Department of Biological Sciences, 601 Science and Engineering, University of Arkansas, Fayetteville AR 72701. Phone: 479-575-6357. Email: amsiepie@uark.edu.

Project Co-leader: Michelle Evans-White, Associate Professor, Department of Biological Sciences, 601 Science and Engineering, University of Arkansas, Fayetteville AR 72701. Phone: 479-575-4706. Email: mevanswh@uark.edu.

Project budget:

SWG amount requested:	$56,842
Match (35%) amount provided:	$19,894.70
Total amount of project:	$76,736.70

PROJECT STATEMENT

Need: This project addresses a key data gap in the aquatic habitat and small stream funding priority listed in Table 1 of the SWG 2016 RFP, and the associated action to 'Obtain baseline information on distribution and population status for multiple species of aquatic invertebrates.'

Knowledge of aquatic invertebrate diversity, distributions and abundance is critical for developing sound biodiversity and conservation management practices. Necessary for meeting these goals is establishing baseline data of species in unique habitats that have otherwise been overlooked in previous efforts. The proposed project fills this gap by proposing to develop baseline surveys of aquatic invertebrates in waterfall habitats.

Waterfalls are distinct habitats characterized by torrential flow and steep rock faces (Fig. 1) (Clayton 1995). These features present unique challenges to the organisms that inhabit them as they must contend with the forces of moving water exasperated by the effects of gravity. Additionally, the rock faces making up waterfalls are devoid of vertebrate predators. Such a distinct habitat may result in unique species assemblages. Indeed, invertebrates are known to form unique assemblages in waterfalls, and members of some groups, such as some Elmidae (riffle beetles) and Plecoptera (stoneflies), are only found in this distinct habitat type (e.g., Rackemann et al. 2013).

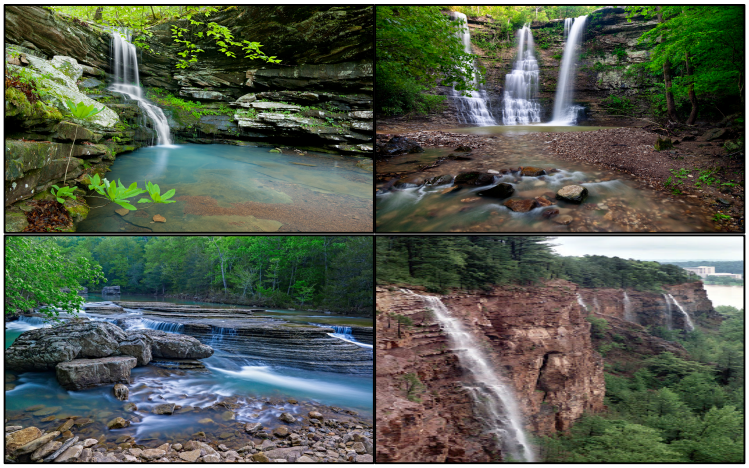


Figure 1. Some of the diversity of waterfall habitats in Arkansas. Photo credits clockwise from top left: Magnolia Falls, Upper Buffalo (William Dark), Twin Falls, Smith Creek (Paul Caldwell), Emerald Park Falls (Johnnie Chamberlin), Six Finger Falls, Falling Water Creek (Paul Caldwell),

Presently, no surveys of diversity, abundance and population status exist for invertebrates found in waterfall habitats in AR (or in N. America). Thus, the conservation significance of what may be a unique habitat type is completely understudied. If waterfalls support unique assemblages, they may constitute an important contribution to regional freshwater invertebrate diversity (e.g., Offmen and Ikpi 2012, Rackemann et al. 2013). Given the threats to flow regimes climate models predict in the next several decades (Dai 2013, Trenberth et al. 2014), it is imperative to develop baseline data for such habitats to develop effective strategies for mitigation of climate impacts on freshwater resources (Leger et al. 2013, Woodward et al. 2012).

Purpose and objectives: The purpose of the proposed work is to determine whether waterfalls in AR contain unique assemblage of invertebrates. Our proposed work has two objectives:

1. Conduct baseline surveys of invertebrate diversity in Arkansas waterfalls
2. Develop an understanding of habitat associations through ecological modelling

Location: Our study will be conducted throughout four Arkansas ecoregions: Boston, Ozark, and Ouachita Mountains and the Arkansas Valley (Fig. 2). Study sites will be chosen across these regions and stratified among different waterfall types (e.g., Fig. 1) to maximize our ability to identify environmental characteristics that may be associated with the occurrence and abundance of different invertebrate species.

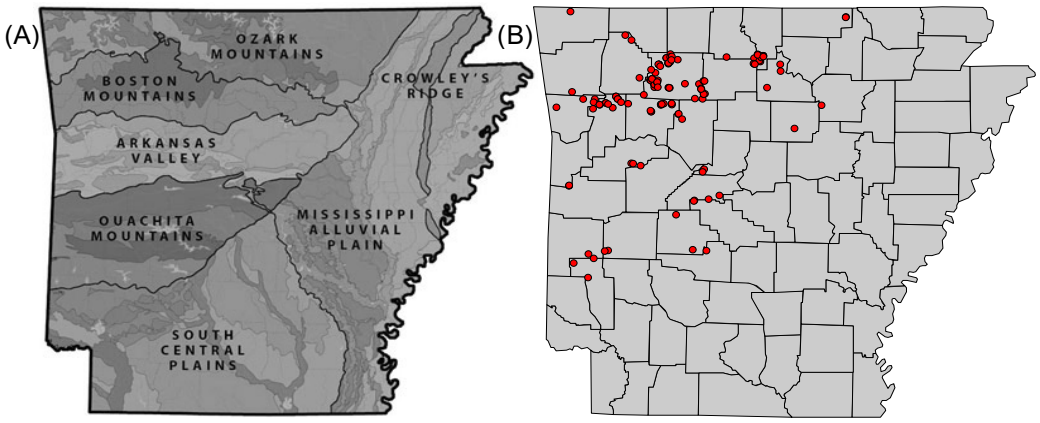


Figure 2. A) Arkansas level III ecoregions (downloaded from www.uaex.edu/enivornment-nature/water/quality) and B) locations (red circles) of 140 known waterfalls in the state or Arkansas.

Approach:

Objective 1. During each of two years we will conduct surveys of aquatic invertebrates at 15 waterfalls per year in the study region. Because invertebrate phenologies often vary throughout the year, sampling will occur during the winter, spring, summer and fall. During summer, waterfalls typically do not flow, but this period of time would provide an opportunity for further surveys to allow us to characterize the substrate behind each waterfall.

We will use standard aquatic invertebrate sampling methods modified for waterfall habitats (e.g., Rackemann et al. 2013) following the U.S. E.P.A. rapid bioassessment protocol (Barbour et al. 1999). Additionally, we will take samples from vegetation growing on waterfall rock faces to quantify invertebrate diversity and abundance in this sub-habitat type. At each waterfall we will sample the waterfall face, and the stream above and below each waterfall. This sampling regime will allow us to determine if the assemblage of species found in waterfalls are unique, or if they are simply a subset of those taxa found in the source stream.

From this occurrence and abundance data we will use multivariate statistical analyses to determine if waterfalls contain unique assemblages of invertebrates. This can be determined by using indicator species analysis (Cáceres et al. 2010), standard community turnover analyses (Anderson et al. 2011), as well as traditional species diversity metrics (Legendre and Legendre 1998).

Objective 2. The second objective will use ecological modeling to relate occurrence and abundance data with environmental features. This approach will allow us to construct a predictive model of species occurrence and abundances throughout our study region. With this model we can classify which areas to best prioritize for maintaining any possible unique assemblages. Such a forecasting approach would allow use to determine specific locations where these assemblages may become most threatened in the near future and what locations might continue to represent suitable habitat.

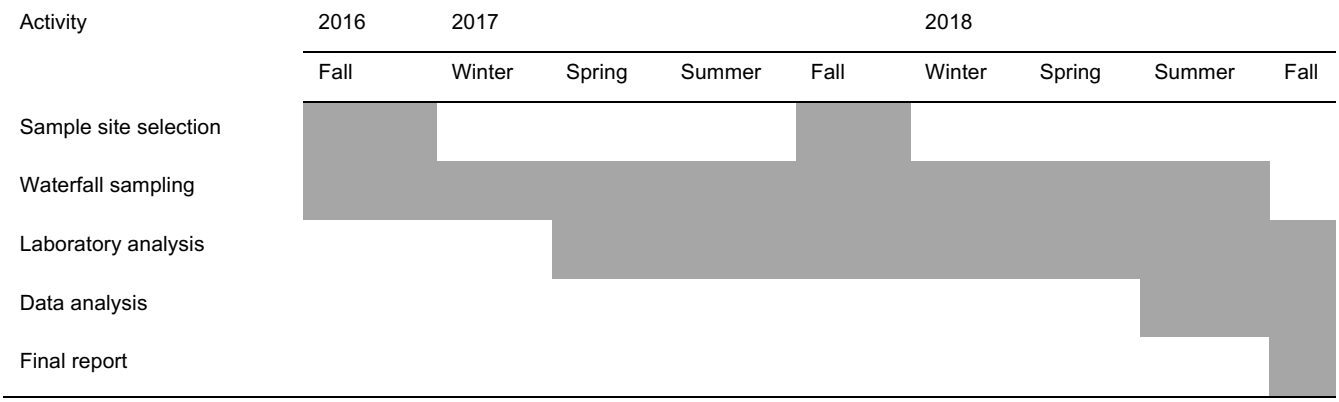
At each waterfall, and the associated stream above and below the waterfall, we will identify macrohabitat types, waterfall structure (i.e., slope, substrate type, etc.), and measure water quality (i.e., temperature, conductance, dissolved oxygen, pH, turbidity, nutrients, productivity) and flow dynamics (i.e., flow rate).

We will then construct statistical models to determine if spatial variation in invertebrate assemblages identified in objective 1, both between streams and waterfall habitats, and across different waterfall sites, can be explained by measured environmental features. We will use canonical correspondence analysis and structural equation modelling, along with associated

multivariate community ordination techniques, including NMDS (Legendre and Legendre 1998), to statistically derive important environmental gradients from these data.

Anticipated timeline of activities

Timeline of activities



Expected Results and Benefits: This project will provide a rigorous distribution and population status assessment of aquatic invertebrates found in a unique habitat in Arkansas. Knowledge of aquatic invertebrate diversity, distributions and abundance is critical for developing sound biodiversity and conservation management practices and remains a targeted effort of Arkansas's CWCS. Necessary for meeting these goals is establishing baseline data of species in unique habitats that have otherwise been overlooked in previous efforts. This work will help to determine if waterfall habitats and the species assemblages associated with them should be further prioritized for SGCN listing. Furthermore, this effort will provide the requisite baseline data for using these species as potential ecological indicators and model taxa for addressing broader freshwater issues in the state of Arkansas.

Project Budget:

Budget Category	**FY 1**	**FY2**	**Total**
M.S. Student Salary (9 month)	$12996	$13386	$26382
GRA Tuition	5040	5292	10332
Undergraduate technician	4500	4500	7308
Supplies	500	500	1000
Travel	2000	2000	4000
Fringe (UA institutional rate)	869	894	1764
Subtotal	27992	28850	56842
35% Match (UARK salary & in kind services, waived indirect costs)	9797.20	10097.50	19894.70
Total	37789.20	38947.50	76736.70

Qualifications:

Adam Siepielski has degrees in Wildlife and Fisheries Sciences (B.S.), Ecology (M.S.) and Zoology (Ph.D.) from the Pennsylvania State University, New Mexico State University, and the University of Wyoming, respectively. He received postdoctoral training in aquatic invertebrate ecology from Dartmouth College. He is a population and community ecologist whose work focuses on understanding spatial variation in the determinants of aquatic insect community structure at local and regional scales. He has more than 15 years of experience in ecological studies and has published more than 30 peer reviewed scientific publications.

Michelle Evans-White has degrees in Fisheries Biology (B.S.) and Biology (M.S.) from Kansas State University and the University of Notre Dame (Ph.D.). She is a broadly trained stream ecologist focusing on population, community, and ecosystem responses to anthropogenic change. She has over 20 years of experience collecting and identifying benthic macroinvertebrates and analyzing water chemistry samples.

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