2018 State Wildlife Grant Proposal

Title: Determining factors influencing hydrologic alteration and geomorphic instability in the Illinois River Watershed and potential impacts on mussel SGCN and associated fish communities

Project Summary: The Illinois River Watershed (IRW) has undergone significant alteration due to recent land use and land cover (LULC) changes associated with rapid urbanization in Northwest Arkansas. We propose to (1) quantify and assess the influence of impervious surface area and other natural and anthropogenic land use factors on hydrologic alteration and geomorphic instability of gaged and ungaged streams in the IRW; and (2) evaluate the influence of hydrologic alteration and LULC change on the spatial distribution of mussel SGCN (see below) and associated fish communities in the IRW using state aquatic GAP species location data and museum collection records.

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Project Partner: William Posey, Fisheries Assistant Chief Special Programs, Arkansas Game and Fish Commission, #2 Natural Resources Drive, Little Rock, AR 72205; 501-223-6369; William.Posey@agfc.ar.gov

Total SWG Funding Requested: $56,492

Amount and Source of Matching Funds or In-kind Services: $27,191 unrecovered indirect cost, University of Arkansas

Total Project Budget: $83,683

Funding Priorities Addressed by Proposal

- Determine hydrologic alteration of gaged and ungaged streams in the Illinois River Watershed due to impervious surfaces and other land use factors.
- Provide information for developing and implementing a watershed protection plan with appropriate conservation actions to protect aquatic species, maintain channel condition, and ensure good water quality.
- The project will benefit the conservation of mussel SGCN including: *Lampsilis rafinesqueanna* (Neosho Mucket)*, Quadrula cylindrical* (Rabbitsfoot)*, Alsasmidonta marginata* (Elktoe)*, Fusconaia sp. cf. flava* ("Elongate" Pigtoe)*, Venustaconcha ellipsiformis* (Ellipse)*, Pleurobema sintoxia* (Round Pigtoe)*, Villosa iris* (Rainbow)*, Villosa lienosa* (Little Spectaclecase), *and Toxolasma parvum* (Lilliput).

Project Location

The Illinois River Watershed (IRW) covers an area of 1654 mi^2 split between Arkansas (739 mi^2) and Oklahoma (914 mi^2) (Figure 1). Arkansas contains approximately 85% (65 mi^2) of the combined (e.g. low, medium, high intensity) developed land area within the IRW, but only a quarter of the forested land area (Figure 2). The combined population of Washington and Benton Counties in the Arkansas portion of the IRW has increased by 56% from 2000 (est. pop. 311,121) to 2016 (est. pop. 486,340) and is expected to continue growing at an equivalent rate over the next decade.

Need

Understanding the effects of impervious surfaces and other land use factors on hydrologic alteration is an important component in developing a comprehensive watershed protection plan for communities and resource agencies to restore and maintain natural channel conditions, protect aquatic fauna, and ensure good water quality of streams within the IRW. Expansion of impervious surface area associated with urbanization and construction of roads, parking lots, and rooftops can drastically alter the infiltration capacity of soils, increasing the amount and rate of storm water runoff into stream channels (Brabec et al. 2002). Hydrologic alteration, which includes changes in the magnitude, frequency, timing, and duration of peak flows, is a predominant stressor for aquatic fauna and can greatly intensify the potential for streambank erosion and geomorphic instability (Bunn and Arthington 2002). The use of LULC metrics to model and predict the extent of hydrologic alteration of streams in the IRW is particularly important given the significant increase in impervious surface area and other changes associated with recent urban development within the watershed.

Rainfall variability and frequency of extreme precipitation events are predicted to increase for the Ozark-Ouachita Interior Highlands over the next decade, resulting in even greater extremes of both wet and dry conditions (Diffenbaugh et al. 2005). Increased mobilization and runoff of sediment and contaminants into streams can severely impact the health of aquatic biological communities, particularly benthic species like mussels that are highly susceptible to water quality declines. Freshwater mussels are among the most endangered faunal groups in North America and are vital indicator species of stream health and water quality (Bogan 2008). Since most freshwater mussel species in Arkansas and Oklahoma are obligate ectoparasites that require a fish host for reproduction, protecting mussel-fish assemblages from the effects of hydrologic alteration and water pollution is essential to conservation and management strategies.

Objectives

1. **Quantify and assess hydrologic alteration and geomorphic instability of gaged and ungaged streams in the IRW related to impervious surface area and other natural and anthropogenic land use factors.**
2. **Assess the influence of hydrologic alteration and other LULC factors on the distribution of mussel SGCN and associated fish species in the IRW.**

Objective 1 Approach: Flow metrics for gaged stream reaches and catchment-level landscape metrics at a spatial resolution of 30 m^2 will be identified and collected for the IRW from sources including the Stream Catchment (StreamCat) (Hill et al. 2016), USGS National Water Inventory System (NHIS), National Hydrography Dataset Plus Version 2 (NHDPlusV2), Geospatial Attributes of Gages for Evaluating Streamflow (GAGES II), and the National Land Cover Database (NLCD). Leasure et al. 2016 previously classified natural flow regimes for gaged and ungaged streams within the IRW (Figure 1) and we will incorporate these data in our analyses. We will focus our analyses on specific LULC changes occurring at discrete 5-year intervals from 2001-2016, encompassing a period of rapid urbanization within the IRW.

We will assess geomorphic instability of streams in the IRW using a modified rapid geomorphic assessment (RGA), the Ozark Stream Erosion Potential Index (OSEPI), developed by Heeren et al. (2012). The index consists of nine diagnostic criteria, including critical bank erosion and representative channel cross section, as well as reach-length measurements of streambank cohesion, curvature, and protection from established riparian woody-vegetation cover. Each observation is scored and the values are summed to provide and index of relative channel stability. Assessments will be carried out for stream reaches at all 25 USGS gages within the IRW (14 in AR and 11 in OK) in early summer of 2019 following peak annual flows and the index values will be incorporated in the analysis.

We will quantify the influence of impervious surfaces and other natural and anthropogenic land use variables on hydrologic alteration and geomorphic instability of gaged streams in the IRW using random forest (RF) classification. The RF models developed for gaged streams will then be used to predict hydrologic alteration for ungaged stream reaches in the IRW. Using LULC data from the 2001-2016 NLCD (2016 NLCD available December, 2018), we will identify specific changes occurring over 5-year intervals contributing to hydrologic alteration of streams in the watershed. Additionally, we will map spatiotemporal patterns of hydrologic alteration and geomorphic instability in the IRW using Empirical Bayesian Kriging (EBK), which employs an iterative, maximum likelihood approach to generate predictions even when data are moderately non-stationary (Krivoruchko 2012).

Objective 2 Approach: We will further evaluate the influence of hydrologic alteration and LULC change on mussel SGCN in the Illinois River watershed following an approach similar to that used in Objective 1. Presence-absence data for mussels will be collected from the Arkansas aquatic GAP, Oklahoma Natural Heritage Inventory databases, and museum collection records, in addition to other sources. Separate RF models will be fit for each mussel SGCN to assess which LULC and hydrologic variables are most influential in determining mussel species distributions within the watershed. In addition, we will identify the most influential fish species associated with mussel SGCN, which will help to further refine and target aquatic community conservation and management needs for the watershed.

Expected Project Outcomes and Benefits

The results of this study will significantly improve our understanding of the distribution of mussel SGCN and associated fish communities in relation to hydrologic alteration and LULC change within the Illinois River Watershed. Results from the proposed research will also provide an important scientific basis for

developing a watershed protection plan for communities and resource agencies to restore and maintain natural channel conditions, protect aquatic fauna, and ensure good water quality of streams within the IRW. We will produce maps showing how natural and anthropogenic features vary spatially at stream reach, flow-regime, catchment and watershed scales to provide insight into how different landscape factors may influence hydrologic alteration and geomorphic instability, and identify locations where further assessment is needed. All maps produced through this project also will be made available at www.ArkansasWildlife.com.

Budget

Budget Category	SWG Funds	Matching Funds	Total
Salary/Benefits	$51,492	$27,191	$78,683
Operating Expenses			
Travel	$3,000		$3,000
Journal Publication Fees	$2,000		$2,000
Total	**$56,492**	**$27,191**	**$83,683**

Literature Cited

Bogan, A. E. 2008. Global diversity of freshwater mussels (Mollusca, Bivalvia) in freshwater. Hydrobiologia **595**:139-147.

Brabec, E., S. Schulte, and P. L. Richards. 2002. Impervious surfaces and water quality: a review of current literature and its implications for watershed planning. Journal of planning literature **16**:499-514.

Bunn, S. E., and A. H. Arthington. 2002. Basic principles and ecological consequences of altered flow regimes for aquatic biodiversity. Environmental Management **30**:492-507.

Diffenbaugh, N. S., J. S. Pal, R. J. Trapp, and F. Giorgi. 2005. Fine-scale processes regulate the response of extreme events to global climate change. Proceedings of the National Academy of Sciences of the United States of America **102**:15774-15778.

Heeren, D. M., A. R. Mittelstet, G. A. Fox, D. E. Storm, A. T. Al-Madhhachi, T. L. Midgley, A. F. Stringer, K. B. Stunkel, and R. D. Tejral. 2012. Using rapid geomorphic assessments to assess streambank stability in Oklahoma Ozark streams. Transactions of the ASABE **55**:957-968.

Hill, R. A., M. H. Weber, S. G. Leibowitz, A. R. Olsen, and D. J. Thornbrugh. 2016. The Stream-Catchment (StreamCat) Dataset: A Database of Watershed Metrics for the Conterminous United States. JAWRA Journal of the American Water Resources Association **52**:120-128.

Krivoruchko, K. 2012. Empirical bayesian kriging. ESRI: Redlands, CA, USA. Available online at: http://www.esri. com/news/arcuser/1012/empirical-byesian-kriging. html (Last accessed 08.02. 2016).

Qualifications

Project Leaders

Dr. John T. Fox - Post Doctoral Fellow Arkansas Cooperative Fish and Wildlife Research Unit, Department of Biological Sciences, University of Arkansas 2017-present
Ph.D. in Fish and Wildlife from Virginia Tech – 2015
M.S. in Biology from the University of Central Arkansas - 2009
Author of 4 peer-reviewed scientific publications

Dr. Daniel D. Magoulick - Assistant Unit Leader/ Professor, USGS, Arkansas Cooperative Fish and Wildlife Research Unit, Department of Biological Sciences, University of Arkansas 2000-present
Ph.D. in Biological Sciences from University of Pittsburgh – 1994
Author of 38 peer-reviewed scientific publications

Project Partners

Bill Posey of Arkansas Game & Fish Commission is a leading biologist in Arkansas for protecting and conserving aquatic species. He will assist in compiling a spatial database of mussel collection records for the Illinois River Watershed in Arkansas and Oklahoma.

Previous SWG Grants

Magoulick, D.D. and J.W. Quinn. 2016-2018. Arkansas Game and Fish Commission. Flow ecology relationships and environmental flows assessment for the Ozark-Ouachita Interior Highlands and the West Gulf Coastal Plains. $96,882.

Magoulick, D.D., R.J. DiStefano, B.K. Wagner and J.W. Fetzner, Jr. 2014-2016. Arkansas Game and Fish Commission. Invasive species effects, population status and population genetics of crayfish species of greatest conservation need (*Orconectes marchandi*, *Orconectes eupunctus*, and *Cambarus hubbsi*) in the Ozark Highlands of Arkansas and Missouri. $80,208.

Magoulick, D.D. and D.R. Leasure. 2014-2016. Arkansas Game and Fish Commission. Quantification of hydrologic alteration and relationships to biota in Arkansas streams: Development of tools and approaches for un-gaged streams. $53,000.

Magoulick, D.D., S. Longing, J.W. Quinn, J. Jackson, J. Duzan and J. Petersen. 2011-2013. Arkansas Game and Fish Commission. Classification of Arkansas flow regimes, regional ecological-flow response relationships and environmental flows assessment for the Ozark region. $172,000.

Magoulick, D.D. 2005-2007. Arkansas Game and Fish Commission. Effect of the Introduced Crayfish, *Orconectes neglectus*, on Native Crayfish in the Spring River Drainage. $68,390.

Figures

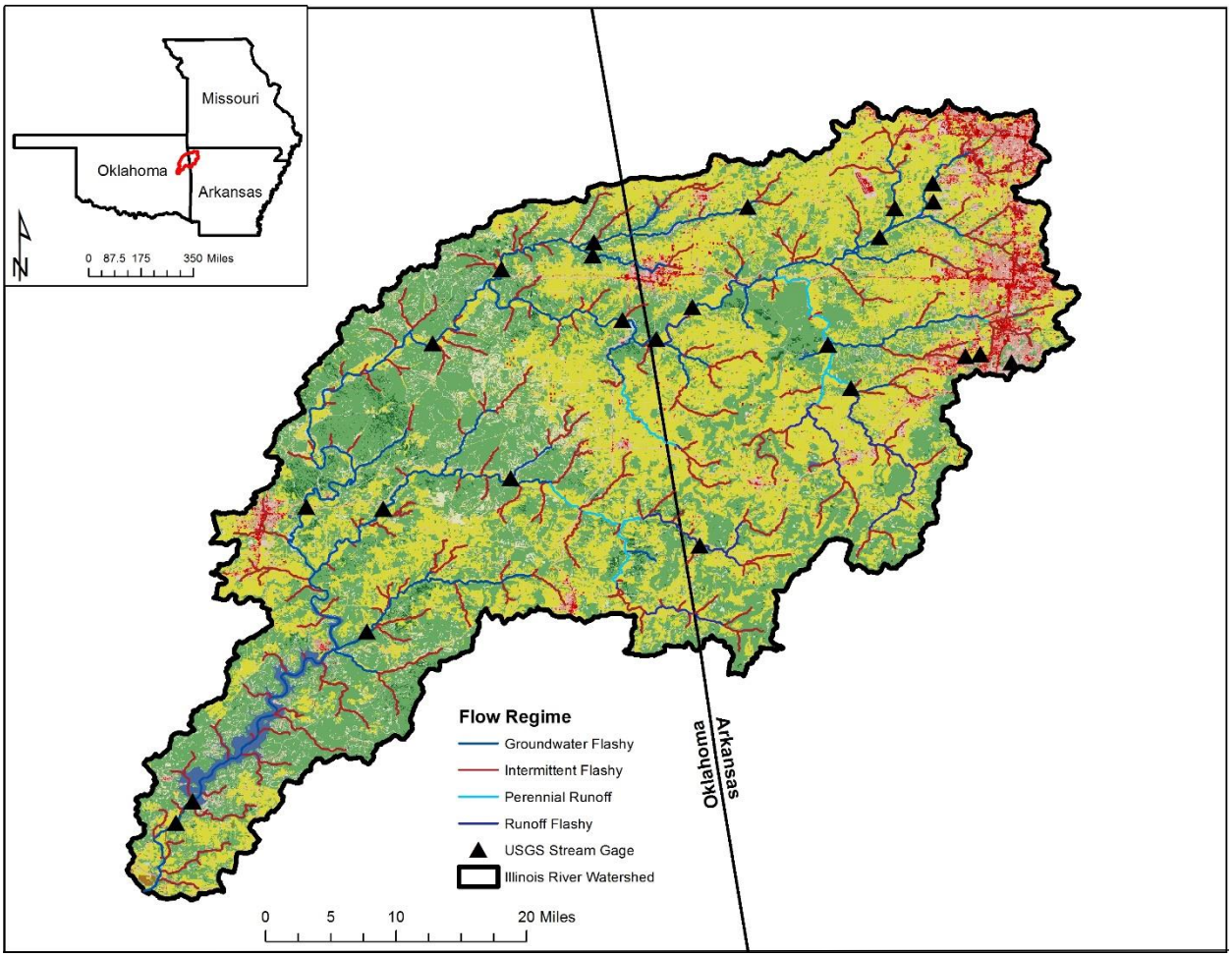

Figure 1. Map of the Illinois River watershed showing stream flow regimes, locations of USGS stream gages, and 2011 NLCD land cover.

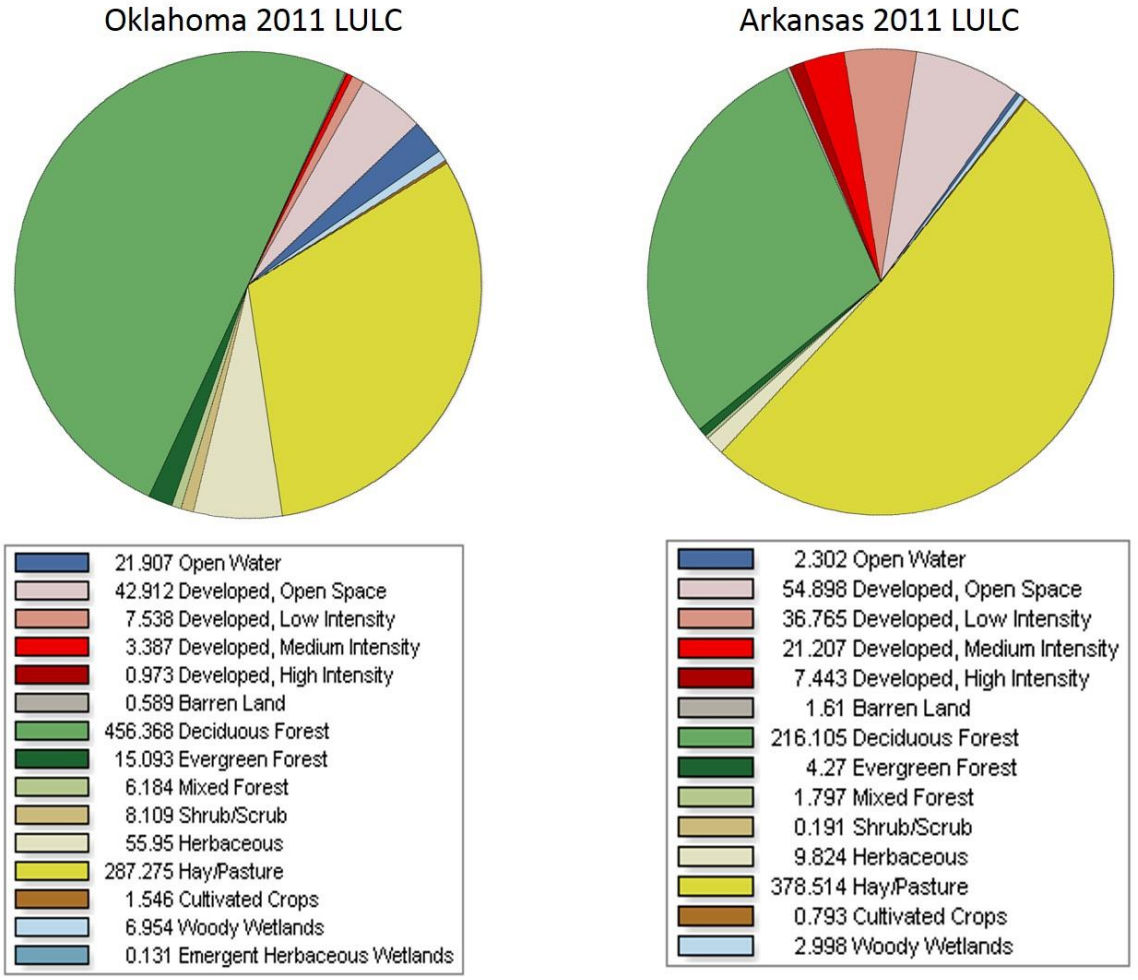

Figure 2. 2011 NLCD land use and land cover (mi^2) in the Illinois River watershed for Arkansas and Oklahoma.