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**Illinois DNR**

**2009 SWG Grant Application System**

**Project Title:**

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|---|---|
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| Project Information | |
|---|---|
| **Project Title:** | **DEMONSTRATING THE BENEFITS OF STREAM RECONNECTION TO AQUATIC COMMUNITIES IN THE CACHE RIVER BASIN** |

Project Description

The Cache River watershed, located in the Cache River Conservation Opportunity Area, has been the site of numerous restoration efforts focused on reversing habitat loss and degraded water quality associated with human alterations of the watershed. Returning river and floodplain hydrology to a more natural state by reconnecting the upper Cache River to the lower Cache River has been proposed, with the goal of benefiting in-stream communities. However, this is a controversial topic, as there are concerns about how re-connection will affect flooding and questions regarding the degree of biological benefits that will actually be realized (e.g., cost/benefit issues). To address this, we will perform an experimental manipulation that will allow us to assess and demonstrate the effects of increasing stream flow on oxygen dynamics and macroinvertebrate communities in the lower Cache River. We will do so by pumping water into the lower Cache River to simulate reconnection. Documenting in-stream responses will allow for informed decision making regarding costs and benefits of future restoration efforts.

Type of Project

X Implementation ○ Planning

( Match Rates Implementation: 50% Federal : 50% Non-Federal | 75% Federal : 25% Non-Federal )

Dollars Requested

| Dollars Requested | Total Federal | Total Non-Federal | Total Cost of Project |
|---|---|---|---|
| 1st Year Funding | $157,859 | $144,747 | $302,606 |
| 2nd Year Funding | $154,070 | $134,507 | $288,577 |
| 3rd Year Funding | $57,121 | $98,186 | $155,307 |
| Totals: | $369,050 | $377,440 | $746,490 |

**Need:** (3000 characters)

Stream restoration projects have increased ten-fold since 1990, with nearly 10 billion dollars spent in the US to date (Bernhardt et al. 2005). Unfortunately, designs of many restoration projects often do not take into consideration basic ecological concepts (Palmer 2009). Others, although designed more prudently, have not been monitored for "ecological success" (Bernhardt et al. 2005, Palmer and Bernhardt 2006). Given the increasing demand for restoration projects, and the need for quantitative measures of their effects on communities and ecosystem functioning, studies of restoration projects are critical for justifying and guiding future efforts.

The Cache River watershed lies at the confluence of four major physiographic provinces and harbors high aquatic species diversity (McNab and Avers 1994). The Cache watershed is also recognized as one of the few regions in the US containing wetlands of international significance, which include critical breeding and overwintering grounds for migratory birds. The Cache supports 44% of the native fish species and 60% of native mussels species in Illinois, as well as 34 crustacean and >340 macroinvertebrate species (IDNR 1997). However, the Cache has experienced impaired water quality that threatens this biodiversity, and much of this is related to human modifications to the landscape and channel (IEPA 2008).

Several restoration projects have been carried out in the Cache River basin. These include construction of weirs to stabilize the channel. These weirs also act as "hotspots" of aquatic insect production (Walther and Whiles 2008), and potentially provide important food and habitat for fish. Reconnecting the upper and lower Cache River channels, which were separated to facilitate drainage of agricultural lands, has been proposed as a restoration project to address water quality issues and ecological integrity in the lower Cache. Reconnection would increase flow in the Lower Cache River and influence oxygen dynamics (e.g., Garvey et al. 2007), presumably resulting in positive responses by aquatic communities, but the pros and cons and costs/benefits of reconnection are difficult to assess without quantitative information on potential ecological responses.

**Objectives:** (3000 characters)

1- Validate hydrologic models that predict the stream response (mean cross-sectional velocity) to the addition of water (increased flow) to the lower Cache River
2- Quantify oxygen dynamics in the lower Cache River before and after the addition of water.
3- Determine how increasing flow in the lower Cache channel will affect the production, abundance, and diversity of macroinvertebrate communities.

To assess and demonstrate potential benefits of increasing flow to water quality and stream communities in the lower Cache, we will simulate reconnection to the upper Cache by pumping water into the lower Cache. We will focus on responses of dissolved oxygen and macroinvertebrates. We predict that increased flows will enhance dissolved oxygen levels based on Garvey et al. (2007). We also predict that macroinvertebrate community structure will change, with increases in diversity, abundance, biomass, and production of important groups such as filter-feeding caddisflies, which represent major food resources for many stream fishes. This study is novel, as simulation of stream reconnection has not been attempted, and it will provide quantitative information on the ecological effects of reconnection prior to the implementation of a restoration project. Thus, the products of this effort will allow for informed decision-making regarding the potential reconnection of the Cache River and other, similar restoration efforts.

Two years of data collection and analyses will be required to meet these objectives. Sampling monthly for 1 year before pumping and 1 year during the flow addition will allow us to accurately assess any changes in oxygen dynamics and calculate annual production of macroinvertebrates, while accounting for seasonal variability. Estimating macroinvertebrate production, although time-intensive, will allow for an accurate, quantitative measure of potential changes in food availability to higher trophic levels (and target species for management and conservation) such as fishes.

**Approach:** (3000 characters)

We will simulate reconnection of the upper and lower Cache River channels by pumping water from the upper Cache into the lower Cache over the Karnak Levee. The stream surface gradient of the lower Cache may be altered by raising or lowering weirs to facilitate increasing stream velocity. All weirs that are altered in the process will be designed to fail in flood events so that drainage of private lands is not compromised. Further, water will be pumped only during baseflow conditions in summer, when dissolved oxygen levels are at their lowest. We have met with local drainage district personnel and they are supportive of our efforts; they will be involved in all planning and implementation phases of this project.

As part of this effort, we will modify and validate the accuracy of hydrologic models of reconnection previously published by the Illinois State Water Survey (DeMissie et al. 2008). The physical parameters in the ISWS model will be field verified, and altered if necessary, by surveying stream reaches and flow patterns included in the model during pumping.

We will quantify and compare oxygen dynamics (and associated metabolism and primary production) and macroinvertebrate communities before pumping (summer, low water periods of 2010) and during pumping (pumping during summer, low water periods during 2011) at 4 sites in the lower Cache River and 4 reference sites in the upper Cache. Data-logging dissolved oxygen meters will be placed at sites in the upper and lower Cache to measure dissolved oxygen and temperature every 10 minutes for at least 24 continuous hours once a month. Dataloggers will be mounted on fence posts within a meter of the bottom of the stream. Oxygen concentrations will be used to estimate whole-stream metabolism using a one-station method (Owens 1974). Primary production will be assessed by measuring benthic chlorophyll-*a* concentrations. Results will allow us to quantitatively assess changes in dissolved oxygen and stream metabolism to increased flows.

The effects of increased flows on stream communities will be assessed by monthly sampling of macroinvertebrates associated with snag habitats (submerged wood) and drifting in the

channel at each of 4 sites in the lower and upper (reference) Cache before (2010) and during (2011) pumping. Three snags at each site will be sampled by placing a 250 um mesh bag over a piece of submerged wood and removing it with a saw. Surface area of each snag sample will be determined by measuring length and circumference. Macroinvertebrates will be identified to the lowest feasible taxonomic level (usually genus), measured, and biomass will be calculated using length-mass regressions (Benke et al. 1999). Snag surface area will be used to normalize biomass data to $mg/m^2$ and secondary production will be estimated using standard approaches (Benke and Huryn 2006). Stream reaches will be surveyed at least once each year to determine total amount of wood in the stream, which will be used to estimate a habitat-weighted estimate of secondary production (Wallace and Benke 1984).

Invertebrate biomass in drift will be measured by placing three drift nets (250 µm mesh) in the stream at each site for 15 minutes each month and samples will be processed as described above. Mean velocity during sampling will be determined for each drift net to normalize biomass of invertebrates per liter of water.

**Relationship to the Plan** (3000 characters)

This project will contribute to attaining many of the goals of the state wildlife plan including (i) *increasing the knowledge of distribution and abundance of wildlife*, (ii) *describing stream habitat and conditions*, (iii) *describing problems in the stream*, and (iv) *describing effects of a proposed conservation project* (IDNR 2005). The Cache River watershed is home to 17 state listed species, including “species in greatest need of conservation”. The stream reaches included in this study have populations of the state endangered Cypress minnow, *Hybognathus hayi,* and the rare dragonfly, *Arigomphus maxwelli* (IDNR 1997). We will monitor macroinvertebrate communities in the river for two years, while documenting oxygen dynamics in the stream. Ultimately we will provide quantitative information on how the proposed reconnection of the Cache River would influence water quality and stream communities.

This project also addresses many of the stream-specific goals of the plan, including actions 7a and 7b, *increasing our understanding of baseline conditions and the effects of altered hydrology and water quality* (IDNR 2005). By simulating stream reconnection, we will increase our understanding of how a future restoration effort, whose goal is to restore the natural hydrology in the lower Cache River, would influence in-stream habitat quality and stream ecosystem processes (secondary production of macroinvertebrates and stream metabolism). Because our study design would allow us to measure a gradient of influence from increased flow (the morphology of the channel is not uniform, so increasing discharge will have different effects on water velocity in each reach) we expect that responses of stream ecosystem processes will be correlated to the reach-specific change in flow. We would directly address the effects of low water velocity and dissolved oxygen on the stream, two parameters which placed the Cache River on the impaired waters (303(d)) list (IEPA 2008).

**Anticipated Outcomes and Benefits:** (3000 characters)

The ultimate purpose of this project is to provide information that will allow for informed cost-benefit analyses of reconnecting the Cache River. Given the paucity of information on the effects of restoration efforts on ecosystem processes in general, this study will also represent a strong contribution to the science of stream restoration that will undoubtedly resonate well beyond southern Illinois. The “simulated reconnection” of Cache River will guide the logistics

and planning of the proposed future reconnection project. We will demonstrate how increasing water velocity will affect oxygen and macroinvertebrate communities, two foundations of aquatic ecosystem health.

This project will also strengthen one of the historically more active and successful groups associated with an Illinois Conservation Opportunity Area (COA). The Cache watershed group has been a model for other COAs to follow, and this project will further growing collaborations among researchers at SIU, agency personnel (IDNR and USFWS), private organizations (TNC), a private company (Little River Research and Design) and private landowners, who all have a vested interest in generating information that will guide this and other proposed restoration efforts.

This effort will provide opportunities to train graduate and undergraduate students, as well as a post-doctoral fellow, in restoration ecology and conservation and will immerse them in important local decision making processes in southern Illinois. The project objectives will be accomplished in 2 years by two graduate students and a post-doctoral fellow at Southern Illinois University Carbondale. We will also provide important opportunities for undergraduate students at SIUC by hiring undergraduate students to assist with field and laboratory components of this study.

The end products of this project will be two Master's theses, one in Civil and Environmental Engineering, one in Zoology; at least four peer-reviewed scientific papers; and at least four presentations at scientific meetings by the graduate students and post-doc. We will also compile the information gathered, including papers published in scientific journals and detailed data, to be distributed to interested parties and presented at meetings of regional stakeholders.

| **Signature of Applicant:** | |
|---|---|
| Date: | |
| **Signature of department or unit head** (if required): | |
| Date: | |

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