STATE WILDLIFE GRANT PROGRAM
State of Illinois
Final Report
September 1, 2016 to September 1, 2019

Project Number: T-114-R-1

Project Title: Monitoring Ecological Responses to Partial Hydrologic Reconnection of the Cache River

Principle Investigator: Matt Whiles
Department of Zoology
Southern Illinois University
Carbondale, IL 62901-6501

352 294-3161 mwhiles@ufl.edu

Legal Name of Entity doing the project: Southern Illinois University

Summary:

We examined a suite of physical and biological variables at 4 sites in the Upper Cache River (UCR) and 4 sites in the Lower Cache River (LCR). Results build on earlier studies suggesting that the LCR continues to suffer from low flows because of its hydrologic disconnection form the UCR and associated headwaters. Low flows in the LCR result in frequent oxygen stress, particularly during summer when water temperatures are warm, flows are lowest, and in some periods duckweed covers the channel. Chronic low flows in the LCR have also resulted in accumulation of organic sediments in the channel, and these sediments contribute to higher respiration rates that exacerbate oxygen stress in the system.

The degraded physical conditions in the LCR affect inhabitant communities. Invertebrate communities in the LCR reflect degraded conditions and are generally dominated by small bodied, tolerant taxa such as midges (Chironomidae). More sensitive taxa, such as the EPT groups (Ephemeroptera, Plecoptera, Trichoptera) are more abundant in the UCR compared to the LCR. Differences in the invertebrate communities in the two river reaches translate in to differences in aquatic insect emergence production and food for riparian predators. Emergence production is higher in the UCR, includes higher production of larger bodied taxa such as mayflies and caddisflies, that are likely more important food sources for riparian predators such

as birds, bats, and amphibians. Fish communities in the UCR and LCR are in need of further study, but preliminary observations indicate the fish communities mirror the invertebrates, with higher diversity and higher numbers of sensitive species in the UCR compared to the LCR.

Results add to mounting evidence that restoration of at least some flow in the LCR will improve system health and biotic integrity, and restore/enhance some of the ecosystem services historically provided by the river.

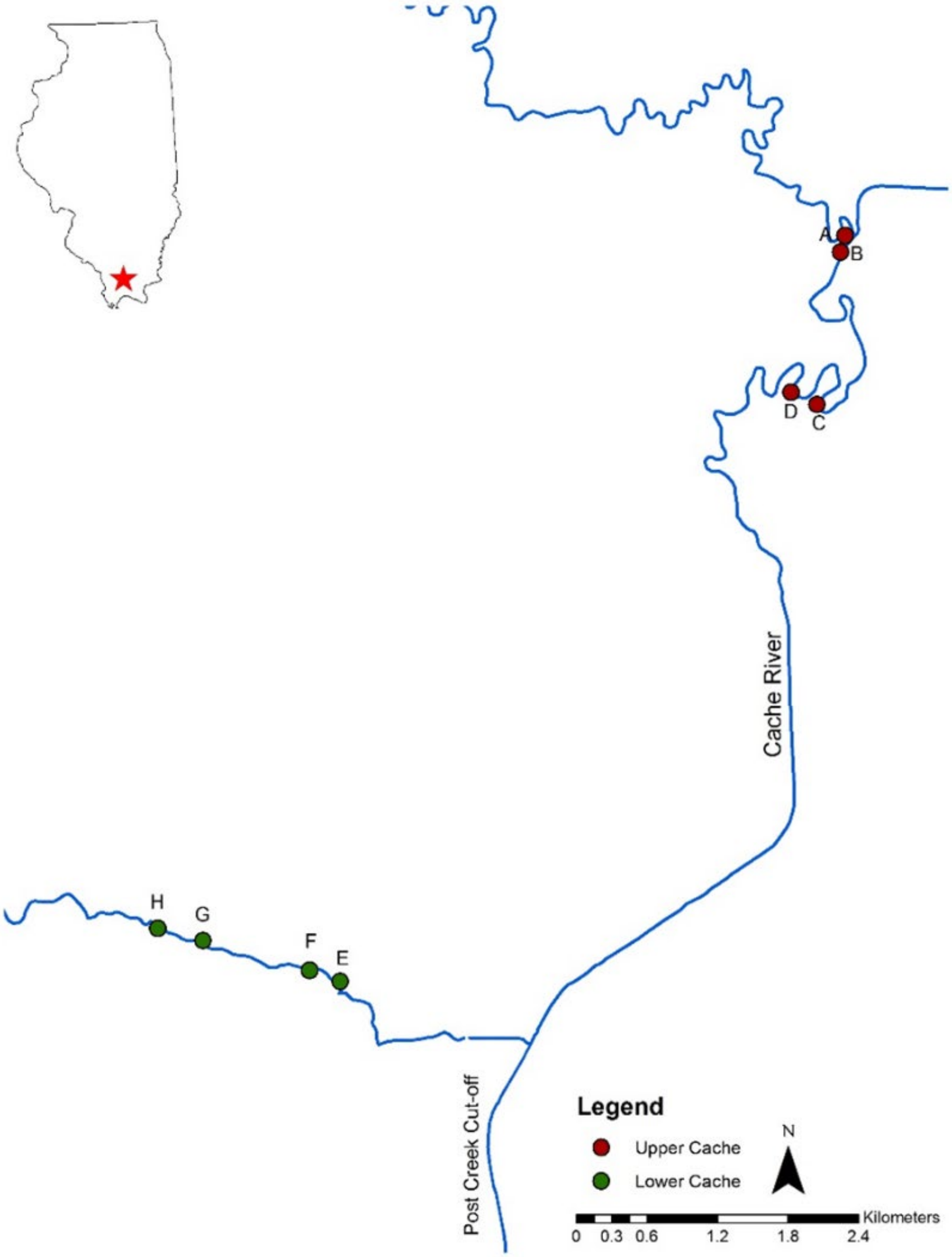
Objectives/completed work:

1) Quantify changes in the physical template of the LCR, including flow velocity, dissolved oxygen, temperature, and light penetration from pre- to post-reconnection conditions.

We monitored a suite of physical (flow, dissolved oxygen, temperature, light penetration) parameters at 4 sites located above the reconnection site (UCR) and 4 sites below the reconnection (LCR; Fig. 1). Data logging dissolved oxygen meters and light meters were deployed at the sites quarterly when river conditions allowed for 4 day periods. Flow velocities were measured routinely while sondes were deployed and biological samples were collected (see below).

As predicted, oxygen levels (Fig. 2) and water velocities were consistently lower in the LCR compared to the UCR. Water temperature and light penetration in the UCR and LCR were similar during the study.

Figure 1. Study sites located on the UCR and LCR



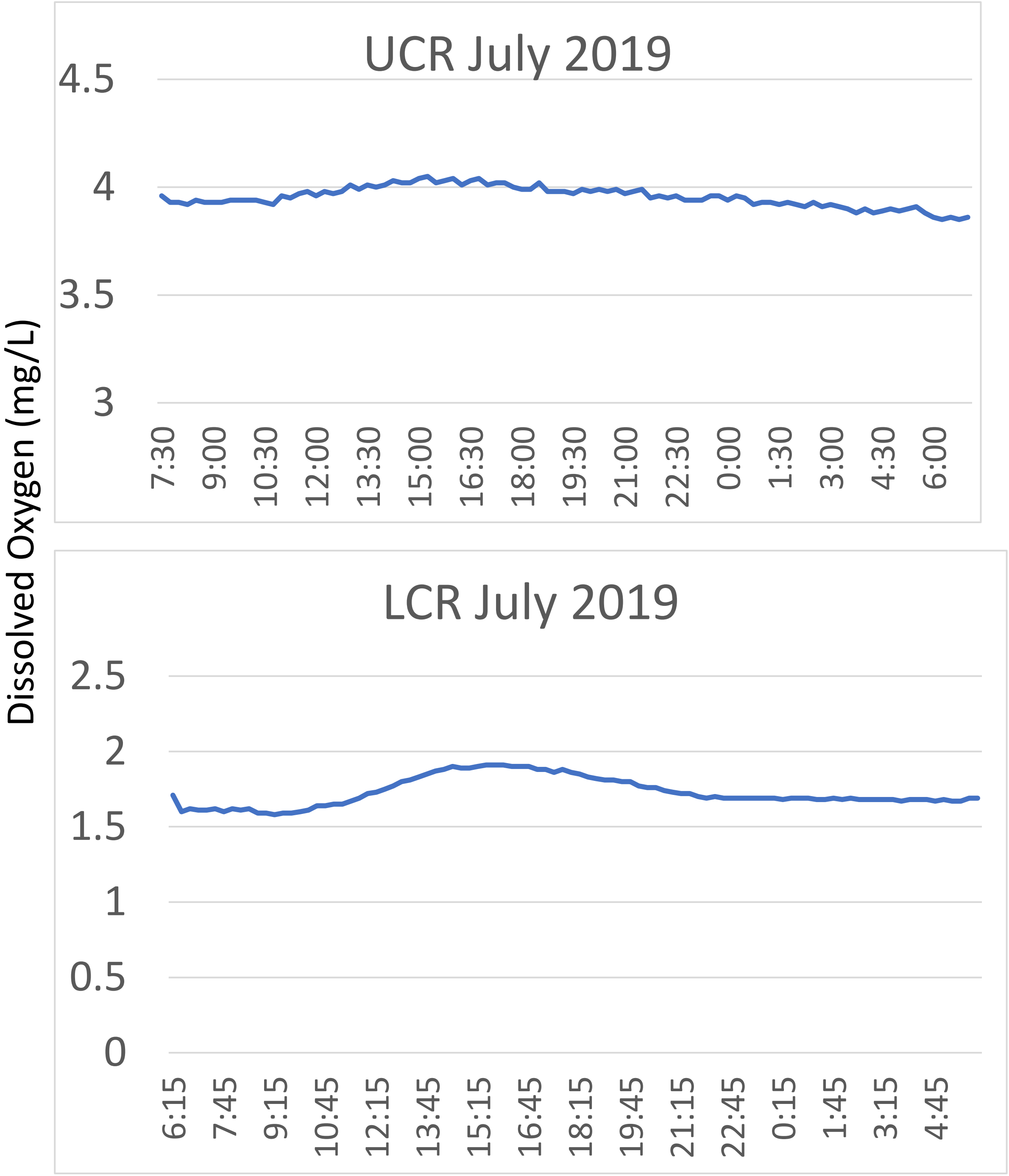


Figure 2. Typical summer diel dissolved oxygen curves (July 2019) from the UCR and LCR. Note the two sites are plotted on different scales.

2) Assess organic matter pools and associated energy flow dynamics, including organic sediments, sediment respiration, primary production, system metabolism, and duckweed cover, before and after the partial reconnection.

We monitored a suite of biological (organic sediments, sediment respiration, primary production, system metabolism, duckweed cover) parameters at 4 sites located above the reconnection site (UCR) and 4 sites below the reconnection (LCR). Benthic organic matter resources and duckweed cover were measured monthly beginning in June 2017. Sediment organic content and respiration were measured during low flows in summer.

As predicted, organic sediments and sediment oxygen demand were higher in the LCR compared to the UCR, where flow helps flush organic sediments out of the system. In contrast to some of our prior studies on the Cache, there was no appreciable duckweed cover in the main channel of the LCR on most sample dates. No duckweed cover was observed on the UCR during this study.

Dissolved oxygen curves (Fig. 1) indicate that both the UCR and LCR have net heterotrophic metabolism, with the LCR more strongly heterotrophic and often experiencing anoxia due to high respiration rates in the system. Accumulated organic sediments contribute to this respiration, and respiration rates of organic sediments in the LCR (0.06 Mg O_2 g Ash Free Dry Mass M^{-2} Min^{-1}) are significantly higher than in the UCR (0.03 Mg O_2 g Ash Free Dry Mass M^{-2} Min^{-1}). Dredging and/or restoration of flow in the LCR would help remove accumulated organic sediments that are contributing to oxygen stress in the system during low flow periods.

3) Quantify changes in in-stream invertebrate communities (abundance, biomass, community structure), adult insect emergence (biomass and community structure), and fish communities (abundance, biomass, and community structure) from pre- to post-reconnection conditions.

We sample benthic invertebrates from snags, the dominant stable substrate in the river, at all 8 study sites at least seasonally. Total invertebrate abundance ranged from ~13,700 individuals m^2 channel in the UCR to ~67,300 individuals m^{-2} channel in the LCR over the study. Abundance was higher in the LCR than in the UCR ($P = 0.038$), with about 2-3x more macroinvertebrates

m^{-2} channel in the LCR, but there were no differences among study years (*P* = 0.18). Total biomass ranged from ~490 mg AFDM m^{-2} channel in the UCR in 2013 to ~1460 mg AFDM m^{-2} channel in the LCR in 2010. Biomass did not differ between the UCR and LCR (*P* = 0.34) or among years (*P* = 0.16). However, mean macroinvertebrate body mass was much higher in the UCR; mean size ranged from 0.019 mg in the LCR to 0.092 mg in the UCR, and this difference was significant (*P* = 0.031).

Species richness of benthic invertebrates was higher in the UCR than the LCR (*P* = 0.024). Results for Shannon Diversity Index were similar to those for species richness; diversity was higher in the UCR than the LCR (*P* = 0.016). The mean annual HBI score for the LCR ranged from 7.7 to 8.1 (poor water quality and very significant organic pollution), while in the UCR it ranged from 6.7 to 7.2 (fairly poor water quality and significant organic pollution) (Hilsenhoff, 1987), and was overall higher in the UCR ($P < 0.0001$).

We sampled emerging aquatic insects at the 4 study sites in the UCR and LCR at least seasonally over the study period. Overall emergence abundance, production, richness, and diversity of emerging aquatic insects were all significantly higher in the UCR than in the LCR ($p < 0.0001$) (Table 1), and the two river segments supported distinct aquatic insect based on both abundance (*p* = 0.004) and production (p = 0.007). Patterns indicated the UCR provides better habitat that enhances emerging insect communities. Chironomids accounted for the majority of emergence abundance and production in both river segments, which is consistent with studies in other regions where midges often dominate emergence. However, the UCR supported greater abundance and production of Ephemeroptera, Plecoptera, and Trichoptera (EPT) taxa. Thus, both the UCR and LCR support tolerant taxa, but the UCR has more intolerant EPT taxa.

Table 1. Mean (± SE) insect emergence diversity (Shannon Index, H'), abundance, production, and EPT abundance and production at UCR and LCR sites. * Indicates significant difference ($p < 0.05$) between UCR and LCR sites.

Site	H'*	Mean Abundance*	Mean Production*	Mean EPT Abundance*	Mean EPT Production*
UCR A	0.25 (0.10)	247.81 (117.54)	136.35 (61.63)	6.73 (2.41)	20.13 (11.31)
UCR B	0.40 (0.12)	189.44 (61.73)	121.32 (38.13)	8.56 (3.13)	14.83 (6.72)
UCR C	0.22 (0.10)	233.42 (92.69)	128.36 (43.57)	2.50 (1.03)	8.70 (5.41)
UCR D	0.18 (0.08)	202.33 (87.97)	110.28 (41.08)	2.42 (1.29)	2.10 (1.07)
Mean UCR	0.26 (0.05)	210.93 (41.43)	122 (28.48)	4.75 (1.03)	10.81 (3.33)
LCR E	0.20 (0.08)	38.5 (10.95)	28.69 (8.60)	2.25 (1.40)	2.51 (1.44)
LCR F	0.16 (0.09)	54 (20.28)	39.08 (14.36)	0.083 (0.08)	0.10 (0.10)
LCR G	0.12 (0.05)	25 (14.33)	23.02 (13.30)	1.17 (1.17)	3.90 (3.90)
LCR H	0.14 (0.06)	19.92 (5.90)	14.25 (3.49)	0.33 (0.22)	0.17 (0.12)
Mean LCR	0.15 (0.03)	37.25 (6.78)	27.53 (5.23)	0.92 (0.43)	1.62 (0.95)

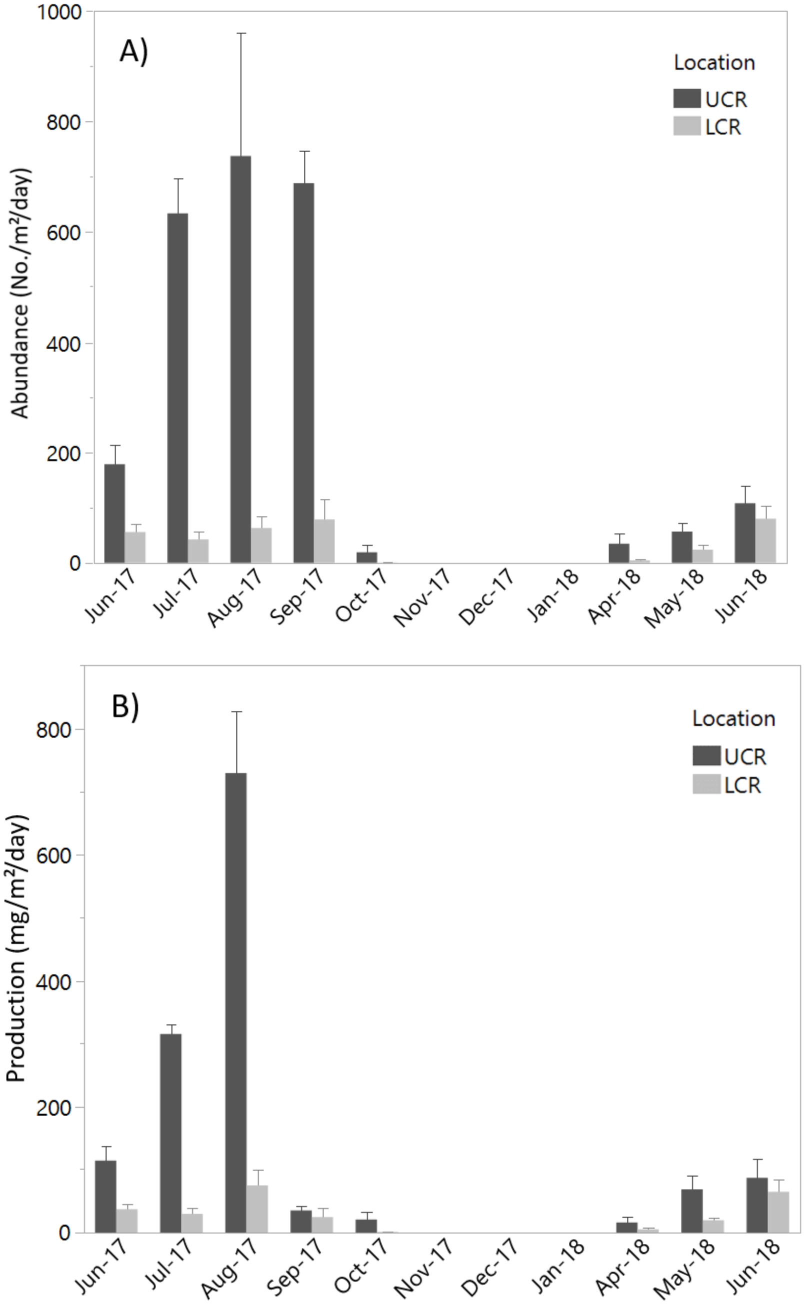


Figure 3. Total insect emergence abundance (treatment, $F_{[1,78]} = 72.09$, $p < 0.001$; date, $F_{[12,78]} = 16.57$, $p < 0.001$; treatment x date, $F_{[12,78]} = 12.73$; $p < 0.001$) (A) and production (treatment, $F_{[1,78]} = 84.09$, $p < 0.001$; date, $F_{[12,78]} = 35.49$, $p < 0.001$; treatment x date, $F_{[12,78]} = 25.16$, $p < 0.001$) (B) at UCR and LCR sites during year 1 of the study. Error bars indicate 1 standard error.

Due to frequent high flows and the loss of key personnel from SIU during this project, and more recently the inability to secure permits for sampling, adequate fish sampling was not completed. However, preliminary fish sampling indicated that fish communities in the UCR are considerably more diverse than the LCR, particularly around weirs in the UCR where benthic species such as Banded Sculpin (*Cottus carolinae*) and Dusky Darter (*Percina sciara*) are common.