Effects of Riparian Buffer Width and Farm Pond Proximity on Fish Assemblages in the Black River Watershed in Arkansas

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Introduction

The southeastern United States is home to many endemic highland fishes adapted to clear water with low nutrient and sediment loads (Scott and Helfman 2001). Anthropogenic disturbances such as altered land use and deforestation can result in increased erosion and runoff, therefore increasing nutrient and sedimentation deposition into these upland streams and causing them to be more characteristic of lower-elevation systems. This homogenization of stream habitat can contribute to biotic homogenization, altering fish assemblage as fish normally occurring in downstream habitats are able to move upstream and specialized highland species may be lost (Scott and Helfman 2001). Belsky et al. (1999) found several examples of this shift in species composition in relation to the riparian buffer. As streamside grazing by livestock increased, water temperatures and sedimentation increased as well, causing sensitive species to decrease, while more disturbance-tolerant species increased. When measuring riparian land use in relation to its influence on streams, a buffer width of 100 to 200 meters from each bank is common, yet it is important to consider the overall land use throughout the catchment and how well it is reflected by land use in the riparian (Alan 2004).

While the importance of riparian buffers has been widely studied, less has been published on the effects of farm ponds and other small impoundments on nearby streams. Perkin et al. (2014) found stream fish diversity decreased as watershed impoundments increased in the Arkansas River basin. Hedden et al. (2018) observed lower fish density and lower species richness in impounded watersheds. Reservoir construction may also lead to the homogenization of fish assemblages due to species introductions and extirpations (Falke and Gido 2005).

Persistence is a measure of species additions and subtractions to a community over time, while stability measures changes in relative abundances of species (Adams and Adams 2019). Jennifer Main (2019) found that persistence and stability of fish assemblages in the Strawberry River of Arkansas were positively associated with forest within the 200-meter upstream riparian buffer and negatively associated with pasture at this scale (Figure 1). She also found persistence negatively correlated with the number of farm ponds within a 100-meter or 50-meter upstream buffer (Figure 1). Ultimately, her data indicated that as pasture land use and number of farm ponds increase at these scales in the Strawberry River watershed, the fish communities in the Strawberry River and its tributaries are changing.

This study will expand research conducted by Main (2019) and investigate persistence and stability of fish assemblages from 70 sites in the Black River drainage of Arkansas—specifically Strawberry, Fourche, Spring, and Eleven Point rivers—in relation to land use, riparian buffer width, and farm ponds. Data will also be collected on riffle stability. Riffle stability can be indicative of overall stability of a stream reach by comparing particle sizes of mobile and recently deposited sediment. The size and transport rate of sediment entering a stable stream reach will be similar to those exiting the reach (Kappesser 2002). If sediment entering the reach exceeds that which is exiting the reach, some sediment is deposited within the reach and a textural change in the streambed is said to have occurred (Kappesser 2002). If this difference in incoming and exiting sediment continues, loss of pool habitat and an increase in run habitat may occur (Kappesser 2002). A variety of mobile as well as deposited particles are present at riffles, making riffles useful for determining if and to what degree textural change may be occurring (Kappesser 2002). The more we know about the impacts of riparian buffer width and farm ponds on fish assemblages and instream habitat, the more effectively we can manage them and protect the biodiversity of these Arkansas streams.

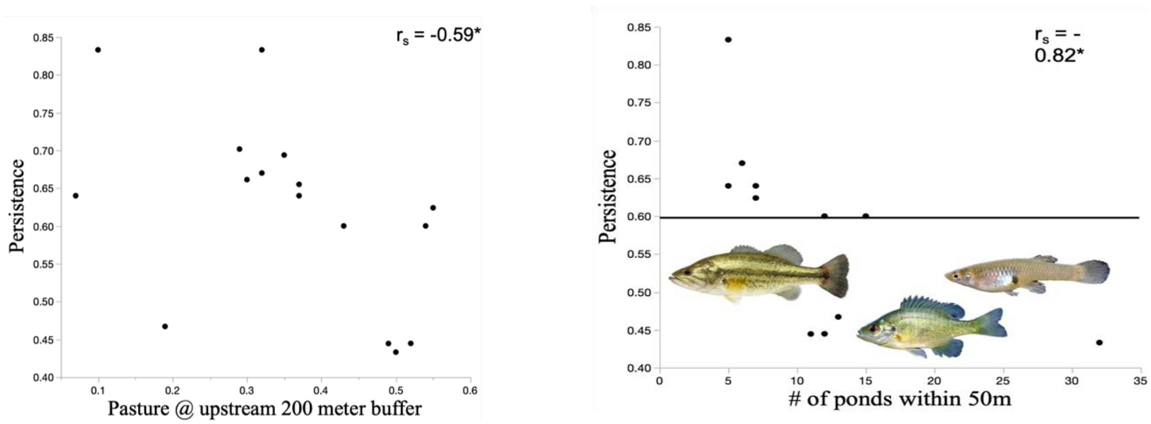

Figure 1. Main (2019) found a decline in persistence with an increase in pasture land use in the 200-m upstream riparian buffer and an increase in number of farm ponds within 50 m of the stream.

Methods

The methods of this project will closely follow those used by Main (2019). I will use the USGS website StreamStats to delineate watersheds upstream from fish sample site coordinates taken from Adams and Adams (2019). I will use ArcGIS to convert resulting files into layers that can be uploaded to Google Earth Pro and then measure distance from farm ponds within this delineated watershed to the nearest streambank, as well as distance from streambanks to the edge of the riparian buffers. Google Earth Pro will also be used to determine if farm ponds were present in 1994 and if connection between these ponds and the adjacent streams occurred over time. I will work independently to collect data from Google Earth and ArcGIS. After farm pond and buffer width data are collected, they will be entered into JMP along with the fish community data collected by previous students in the Adams' lab (Main 2019, Gavrielides defending 2020, Rezac defending 2020).

Trips to each of the field sites will be needed to collect data on riffle stability. This will require at least 6 multi-day trips with a crew of 3-4 people. Riffle stability will be quantified using a Riffle Stability Index (RSI) modified from Kappesser (2002). To calculate RSI, two riffles within each fish sampling reach will be selected. Within each riffle, 100 particles will be measured to the nearest mm on the intermediate axis following methods by Wolman (1954) to determine the particle size distribution of mobile material in the stream channel. Additionally, 10-30 of the largest particles will be measured from an adjacent depositional bar. These particles will also be measured to the nearest mm and will be chosen based on a lack of embeddedness and lack of algae or moss, showing recent movement. Riffle stability data will be used along with instream habitat data collected during fish community sampling to explore possible relationships between stream channel stability and land use.

Fish community data were collected in the 1970s and 80s by graduate students from Arkansas State University and the University of Louisiana at Monroe (formerly Northeast Louisiana University) for each system investigated by this study (Hilburn 1987, Robison & Beadles 1974, Johnson 1977, Bounds 1977, Winters 1985). These historical fish community data will be compared to contemporary collections to determine changes in assemblage structure (NMDS multivariate analysis), persistence, and stability. Persistence will be calculated as 1-Turnover of species presence-absence data, and stability will be calculated from the Bray Curtis dissimilarity matrix in PCORD. We will examine correlations between the land use data (farm ponds and riparian buffer width) along with other LULC (land use land cover) data and fish community data.

Expected Outcomes and Significance

Few data exist to provide underlying mechanisms for why fish assemblages change over time. Previous research conducted by Adams' lab students has shown a significant shift in fish community structure and an increase in biotic homogenization (communities looking more similar through time) in the Ozarks of Arkansas but few mechanistic explanatory variables, aside from pasture land use, have been explored. These data will provide critical information for land management and implementation of BMPs (best management practices).

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