SECTION 4 – BIOLOGICAL ASSESSMENT

4.1 Introduction

The Nature Conservancy – Arkansas Field Office (TNC-ARFO) personnel performed a biological assessment of the Cache River and its major tributaries in conjunction with geomorphic characterization, channel stability assessment, flow regime characterization, and sediment/nutrient loading assessments. The goal of this integrated effort was to develop a comprehensive water quality, biological, and physical parameter model of the Cache River and its tributaries. The results will be used by The Nature Conservancy and other conservation
partners to determine threat abatement and to implement a watershed restoration strategy for the Cache River basin.

The biological objective of this project was to describe fishes and macroinvertebrates of the Cache River watershed in 2004 and 2005 that (1) can be used for comparative purposes and (2) will serve as a biologic baseline to quantify future results from BMP implementation.

TNC-ARFO staff surveyed 25 sites from the headwaters to the mouth of the river to collect a database on the status of the biota at sites representing different watershed sizes. Vannote et al. (1980) showed that there are natural differences in the biological community along a longitudinal gradient from headwaters to mouth due to differences in physical and chemical conditions of rivers. It is unknown which differences naturally occur among streams in the Cache River basin. Comparison of different watershed sizes could not be used to assess environmental quality, because natural differences become masked with those that are anthropogenic in character. To avoid these confounding effects, one must employ one or more of the following comparisons: (1) comparison of present biological conditions of the entire Cache River watershed, from headwaters to mouth, to historic or future conditions of that same area, (2) comparison of a site within the Cache River watershed to a proximal stream site in the Mississippi River Alluvial Plain (MSRAP) having roughly the same watershed size, (3) comparison of present conditions of a specific site within the Cache River watershed to past or future conditions for that particular site (Brown et al. 2003).

Little is known about biotic assemblages of eastern Arkansas prior to the conversion of most of the area to agricultural purposes. Specific comparisons were made in this project of species richness and composition of fishes of the Cache River to available historical records of species richness (Killgore and Hoover 1992), (Robinson and Buchanan, 1984). It is anticipated that additional biological assessments of the Cache River and/or its tributaries will be done using the same methods in the future. Data collected for this project will serve as a measurement tool for future assessments that address fluctuations in the biological community as a result of water quality, hydrologic, or any of a number of habitat alterations. In addition, this baseline data will be useful in determining the level of success of any restoration efforts that may take place in the watershed in the near future.

4.2 Study Sites

Thirty-three sites were selected on 22 major Cache River or Bayou DeView tributaries each in association with a corresponding hydrologic gauging station either on site or directly downstream of the tributary’s confluence with the main channel. Sites were designated as either Cache River (CR) or Bayou DeView (DV) and were each designated with a number (0-22) in correlation with one of 33 temporary or permanent (USGS) gaging stations located throughout the watershed. Sites CR002, CR005, CR006, CR009, CR013, DV000, DV001, and DV002 were excluded from biological sampling as they were beyond the scope and capacity of this study, resulting in a total of 25 sampling sites. Precise locations are shown in Appendix C.
4.3 Fishes

The native fish fauna of Arkansas is composed of a diverse group of 197 species classified in 56 genera and 25 families (Robinson and Buchanan, 1988). Characteristics of fish assemblages have been and remain important in evaluating the condition of water resources. Each taxa has its own specific habitat requirements and responds to natural and anthropogenic disturbance in different ways. Certain species, including *Lepomis cyanellus* (green sunfish) are tolerant of disturbance and may increase in relative abundance in a degraded system. In contrast, most Percidae (darters) are highly sensitive to such conditions and may disappear altogether under adverse conditions. Therefore fish are a good indicator of environmental quality. By assessing the current ecological condition of the Cache River and its tributaries, one can establish a tangible and widely understood biological baseline for assessing future alterations of the system.

4.2.1 Methods
The 25 study sites were sampled for fishes quarterly during the period of one hydrologic year, May 2004 to June 2005. A rapid habitat assessment form (Appendix D4) was completed on-site for each sampling event in accordance with standard operating procedures outlined by the North Carolina Department of Environmental Resources (NCDER 2001). Sampling was performed in accordance with the “Rapid Bioassessment Protocol” described by Barbour et al. (1999) using a Smith Root battery-powered electrofishing unit. Because of the lack of riffle, run, and pool sequences at many of the sites, a standard reach length of 100 meters was used. For each standard reach a representative mixture of habitats was designated and sampled. Fish were held in oxygenated buckets and were identified streamside. Any fish that could not be identified in the field were preserved in 10% buffered formalin and returned to the laboratory where they were transferred to 70% ethanol and identified. All fishes collected were identified to species (Robinson and Buchanan, 1988). Voucher specimens or photographs will be housed at the Arkansas Field Office of The Nature Conservancy. The data from the four sampling periods at each site were pooled and the following calculations were performed: species richness (S), Shannon-Weiner index of Diversity (H'), evenness (E), and proportion of individuals as *Lepomis cyanellus* (green sunfish).

4.2.2 Results
A total of 3452 fishes representing 54 species were sampled at the 25 study sites (Appendix C2). Because differentiation of the species *Lepomis megalotis* (longear sunfish) from *Lepomis marginatus* (dollar sunfish) is difficult even in a laboratory setting, both were reported as *Lepomis sp.* Certain sites were more intensively sampled than others, because many of the streams included in the study were dry during much of the summer and fall seasons resulting in fewer than four sampling events at such locations. A complete list of sampling dates for each site is included in Appendix C2. Species richness and relative abundance of fishes differed greatly among the sites as did evenness and *L. cyanellus* percentages (Figures 4-1 through 4-4). Such differences are expected as each site has a particular watershed size and is influenced by a different set of anthropogenic disturbances (Brown et. al, 2003). Data are not intended for arbitrary comparison among sites, but rather to other sites within the MSRAP ecoregion of comparable watershed size or to data collected at the same site in the future. Metrics from each sampling event as well as the relative proportion of major fish taxa is included in Appendix C3.
Figure 4-1. Data from the four sampling periods at each site were pooled. These data are intended for comparison to data from other MSRAP stream sites of comparable watershed size or to data collected at the same site in the future. They are not intended for comparison among sites (i.e. to each other).

Figure 4-2. Data from the four sampling periods at each site were pooled. These data are intended for comparison to data from other MSRAP stream sites of comparable watershed size or to data collected at the same site in the future. They are not intended for comparison among sites (i.e. to each other).
Figure 4-3. Data from the four sampling periods at each site were pooled. These data are intended for comparison to data from other MSRAP stream sites of comparable watershed size or to data collected at the same site in the future. They are not intended for comparison among sites (i.e. to each other).

Figure 4-4. Data from the four sampling periods at each site were pooled. These data are intended for comparison to data from other MSRAP stream sites of comparable watershed size or to data collected at the same site in the future. They are not intended for comparison among sites (i.e. to each other).
4.2.3 Discussion

The “Index of Biotic Integrity” (IBI) was developed by Karr et al. (1986) and provides a theoretical framework for evaluating the environmental quality of small Midwestern warm water streams using 12 biological metrics based on fish assemblages. Although the IBI has been modified for use in many regions and ecosystems, an IBI has not yet been developed for streams within the MSRAP ecoregion. Therefore, our analysis focused on general and widely accepted ecological metrics including Species Richness (S), Shannon-Weiner index of diversity (H’), community evenness (E), and proportion of individuals as *Lepomis cyanellus* (green sunfish.)

The data from all four sampling events were pooled in the calculation of these metrics.

The total number of fish species, or Species Richness, is known to decrease with increased environmental degradation as does H’ and E, whereas the percentage of individuals as *Lepomis cyanellus*, conversely, tends to increase. The environmental quality of the study sites cannot be calculated from this data because each of these metrics is affected by variables including anthropogenic disturbance, watershed size, stream type, and proximity to Crowley’s Ridge. However, general trends can be observed on the scale of the entire watershed (Fig. 4-1 – 4-4).

All study sites were on low-gradient streams within the Mississippi River Alluvial Plain. The study area was historically characterized by meandering stream channels, sloughs, and oxbow lakes, all connected to an extensive system of bottomland hardwood wetlands. Many of these natural streams, however have long been converted to ditches (or ‘channelized’) for flood control and to increase the amount of arable land. The channelization process has effectively left the northern half of the Cache River watershed as no more than straight, shallow ditches with few or no deep pools. These streams have little instream habitat and are so deeply incised that they no longer access their floodplain during high water events. They are often characterized by eroding banks, unstable bed structures and greatly elevated suspended sediment concentrations. In addition, the removal of riparian corridors causes a rise in water temperatures, which often leads to the death of isolated fish populations, literally baking them in the sun during the dry summer months.

The project sites are grouped into one of three broad categories based on anthropogenic alterations to the system: unchannelized, recently channelized and/or maintained (<15 years before present), and channelized historically (>15 years before present). Five of our sites (CR003, CR007, CR008, DV003, and DV004) are on streams or stream sections that remained unchannelized. The streams at sites CR004, CR011, CR012, CR015, CR016, CR019, CR020, CR021, CR022, and DV008 have all been recently channelized or maintained. The remaining sites (CR010, CR014, CR017, CR018, DV005, DV006, DV007, DV009, DV010, DV011) are located in stream sections that have been channelized in the past, but have had at least 15 years without direct riparian or instream alterations.

Those sites that lie in unchannelized stream reaches (Fig. 4-5) have fish populations with characteristics of healthy MSRAP ecosystems. These are streams that continue to flood on an annual to semi-annual basis and all have at least small riparian buffer zones intact (>5m). The fishes collected from these sites represent a diverse guild with many lowland specialists including *Lepomis punctatus* (spotted sunfish), *Lepomis microlophus* (dollar sunfish), *Lepomis symmetricus* (bantam sunfish), *Elassoma zonatum* (banded pygmy sunfish), *Fundulus chrysotus*...
(golden topminnow) *Etheostoma fusiforme* (swamp darter) and *Etheostoma proliare* (cypress darter). Note: CR007 and CR008 were problematic sites to electrofishing due to deep water, poor conductivity, and limited visibility. It is therefore probable that our data for those two sites represents an incomplete sampling of their respective fish populations.

Recently channelized streams (Fig 4-7), in contrast, were characterized by an absence of the above species. Alternatively, there was an abundance of generalists including *Lepomis cyanellus* (green sunfish) and *Lepomis macrochirus* (bluegill) and other species able to tolerate extremes of temperature, turbidity, and dissolved oxygen. Gamefish including *Micropterus salmoides* (largemouth bass), *Pomoxis annularis* (white crappie), and *Pomoxis nigromaculatus* (black crappie) were less abundant in recently channelized reaches than elsewhere. This data supports other studies that have found the effects of stream channelization on fishes: reduced abundance, shifts in relative species abundance, reduced species diversity, and elimination or reduction in abundance of rare or threatened species (Robinson and Buchanan, 1984).

Sites on streams that have been historically channelized (Fig. 4-6) were less predictive of their respective populations than those of the previous two categories. Some sites, including DV005, DV006, and DV007 remain hydrologically connected to their floodplain and have recovered remarkably well from the channelization process. Others, including sites CR017, CR018, and DV011 support diverse assemblages of fishes, but lack the lowland species characteristic of this ecoregion. Still others (CR014, CR015, DV009, and DV010) have characteristics of sites that have been recently channelized.

Figure 4-5. Bayou DeView at monitoring site DV004 illustrating an unchannelized stream reach.
Figure 4-6.  Big Creek at monitoring site CR018 illustrating a **historically channelized** stream reach.

Figure 4-7.  Cache River Ditch Number 1 at monitoring site CR022 illustrating a **recently channelized** stream reach.
4.4 Macroinvertebrates

Benthic macroinvertebrates are defined as organisms that live on the sediment or on the bottom substrates of streams or rivers and cannot pass through a number 30 U.S. series screen (0.595 mm) (Barbour et al, 1999). They are an extremely important element of stream communities, recycling organic matter and converting it to a form that can be used by other aquatic organisms. As with fish, certain benthic macroinvertebrates have very specific tolerances and thus are excellent indicators of environmental quality. For example, members of the orders Ephemeroptera, Plecoptera, and Tricoptera (EPT) are considered intolerant of organic enrichment. Although the presence of tolerant organisms alone cannot prove that an environment has been degraded, the absence of intolerant organisms can be used as an indicator of such degradation. By assessing the current macroinvertebrate communities of the Cache River watershed, one can establish a biological baseline for assessing any future changes that may occur within the ecosystem.

4.3.1 Methods
The 25 study sites were sampled for macroinvertebrates quarterly during the period of one hydrologic year, May 2004 to June 2005. A rapid habitat assessment form (Appendix D1) was completed on-site for each sampling event in accordance with the standard operating procedures for benthic macroinvertebrates outlined by NCDER (2001). Sampling was performed in accordance with the "Rapid Bioassessment Protocol" described by Barbour et al. (1999) using the multihabitat approach. Because of the lack of riffle, run, and pool sequences at many of the sites, a standard reach length of 100 meters provided a representative mixture of habitats and was designated and sampled for each site. All samples were preserved in 70% ethanol and sent to a third party laboratory for identification. All organisms were identified to family using appropriate scientific keys. Voucher specimens are housed at the TNC-ARFO. At each site the data from the four sampling periods were pooled and the following calculations were performed: taxa richness, Shannon-Weiner index of diversity (H’), evenness (E), percentage of organisms belonging to the orders Ephemeroptera, Plecoptera, and Tricoptera (EPT), and percentage or organisms belonging to the order Chironomidae.

4.3.2 Results
A total of 2761 benthic macroinvertebrates were identified from the 25 study sites, representing 46 families and 14 orders (Appendix C3). Certain sites were more intensively sampled than others. Many of the streams included in the study were dry during much of the summer and fall seasons, resulting in fewer than four sampling events at such locations. A complete list of sampling dates for each site is included in Appendix C2. Benthic macroinvertebrate taxa richness and relative abundance varied greatly among the sampling sites, as did H’, E, percent EPT, and percent Chironomidae (Figures 4-8 through 4-12). Such differences are expected because each site has a particular watershed size and is influenced by a different set of anthropogenic disturbances (Brown et. al, 2003). Data are not intended for arbitrary comparison among sites, but rather to other sites within the MSRAP ecoregion of comparable watershed size or to data collected at the same site in the future.
Figure 4-8. Data from the four sampling periods at each site were pooled. These data are intended for comparison to data from other MSRAP stream sites of comparable watershed size or to data collected at the same site in the future. They are not intended for comparison among sites (i.e. to each other).

Figure 4-9. Data from the four sampling periods at each site were pooled. These data are intended for comparison to data from other MSRAP stream sites of comparable watershed size or to data collected at the same site in the future. They are not intended for comparison among sites (i.e. to each other).
Figure 4-10. Data from the four sampling periods at each site were pooled. These data are intended for comparison to data from other MSRAP stream sites of comparable watershed size or to data collected at the same site in the future. They are not intended for comparison among sites (i.e. to each other).

Figure 4-11. Percent EPT is defined as the percentage of collected individuals belonging to one of the following insect Orders: Ephemeroptera, Plecoptera, Tricoptera. Data from the four sampling periods at each site were pooled. These data are intended for comparison to data from other MSRAP stream sites of comparable watershed size or to data collected at the same site in the future. They are not intended for comparison among sites (i.e. to each other).
4.3.3 Discussion
As with fishes, much work has been done in the development of “Indices of Biological Integrity” for benthic macroinvertebrates for different regions around the globe (Kerans and Karr, 1994). However, an IBI has not yet been developed for the MSRAP ecoregion. The analysis focused on general and widely accepted ecological metrics including taxa richness, Shannon-Weiner index of diversity ($H'$), community evenness ($E$), proportion of individuals belonging to the orders Ephemeroptera, Plecoptera, and Tricoptera (percent EPT), and proportion of individuals belonging to the family Chironomidae. The data from all four sampling events were pooled in the calculation of these metrics.

The total number of benthic macroinvertebrate taxa, or taxa richness, is known to decrease with increased environmental degradation as does $H'$, $E$, and percent EPT whereas the percentage of individuals as Chironomidae, conversely, tends to increase. The environmental quality of the study sites can not be calculated from this data because each of these metrics is affected by variables including anthropogenic disturbance, watershed size, stream type, and proximity to Crowley’s Ridge. However, general trends can be observed on the scale of the entire watershed (Fig. 4-8 - 4-12).

Similar trends were present in the benthic macroinvertebrate data as were noted with the fish study. Macroinvertebrate populations indicative of healthy ecosystems were present in conjunction with unchannelized stream reaches and with historically channelized reach with an
active floodplain. Those sites on incised streams, which are confined within their banks, even during high flow, generally had benthic macroinvertebrate communities indicative of impaired watersheds such low taxa richness, $H'$, and percent EPT, but relatively high percent Chironomidae).

4.5 References


