ILLINOIS NATURAL HISTORY SURVEY
CENTER FOR AQUATIC ECOLOGY

ANNUAL PROGRESS REPORT

EVALUATION OF WATERSHED MANAGEMENT PRACTICES FOR IMPROVING STREAM QUALITY IN THE ILLINOIS WATERSHED PROGRAM

H.R. Dodd, D.H. Wahl, G. F. McIssac, J.H. Hoxmeier, and D. Roseboom

Submitted to
Division of Fisheries
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Executive Summary

The Pilot Watershed Study contains five jobs: 101.1 Effects of Best Management Practices (BMPs) on physical/chemical indicators of stream quality, 101.2 Effects of BMPs on fish community structure, fish abundance, and population size structure, 101.3 Effects of BMPs on fish growth rates, 101.4 Effects of BMPs on benthic macroinvertebrate community structure and crayfish abundance, and 101.5 Analysis and reporting.

These jobs were completed for each sampling site. Four basins were selected for this study: the Embarras, Spoon, Cache, and the Kaskaskia (Figure1). In each of the four basins in this study, we monitored four sites: two in the Pilot Watershed (treated with BMPs) and two in the Reference Watershed (control stream with minimum BMPs). In the Pilot Watershed, one site is located downstream to assess watershed-scale effects of BMP implementation at a larger drainage area and a second site is sampled upstream in the watershed. In the Reference Watershed, two sites were sampled at positions similar to those in the Pilot Watershed. The length of each site was defined as 20 times the mean bankfull width (W_{bf}) at the site (see also Lyons 1992, Simonson et al. 1994, Gough 1997). All basins were sampled in 1998 and 1999 except the Kaskaskia basin in which only downstream sites were sampled in 1999 due to problems with locating a suitable reference watershed in 1998 and low water levels at upstream sites in 1999.

In Job 101.1, physical and chemical habitat data were collected from the pilot (treated) and reference (control) streams. Habitat consisted of site-scale and transect – scale variables. Site-scale parameters are habitat characteristics which change very little over the reach of stream (e.g. temperature, discharge, etc.) and, thus, were collected at one location in the site. Transect-scale variables are those attributes expected to vary considerably within a site (e.g. substrate, channel width, etc.) and were measured along 10 transects within the site. Data analysis of pre-BMP site-scale and transect-scale habitat characteristics is ongoing and baseline data from 1998 and 1999 are presented in this report.

In Jobs 101.2 and 101.3, fish were collected in autumn of 1998 and 1999 with an AC electric seine. Structures for aging were taken from all fish caught in 1998 and from

selected species in 1999. All fish were measured (total length) and weighed except when numbers of a species were high, then, the first 100 were measured and the remaining fish were counted. Fish greater than 100 mm in total length were measured in the field, while smaller fish were preserved in ethanol, identified and measured in the laboratory. In general, fish community structure in pilot and reference streams was similar. Number of species collected in pilots were comparable to their respective reference sites with the exception of the Hurricane Upper (pilot) site and Big Lower (pilot) site which showed lower species richness. Similarity indices showed fish composition was also comparable between pilot and reference streams with most sites having relatively high similarity in fish assemblage structure. Analysis of catch per unit effort (CPUE) detected little difference between relative fish abundance between upper and lower sites of pilot and reference watersheds before implementation of BMPs. Most pilot and reference sites within each basin were similar in overall average fish lengths and weights although averages for individual species may have been slightly higher in one site or the other. To examine the quality of the aquatic resource before BMPs, Index of Biotic Integrity (IBI) scores were computed and found to be relatively high at most pilot and reference sites, indicating good stream quality. Age structure of selected species was examined and differences in mean ages analyzed. Determination of fish growth rates is ongoing and preliminary age data from selected fish species indicated no clear trend in population age structure for a particular species.

In Job 101.4, benthic macroinvertebrates samples were collected in autumn of 1998 and spring, summer, and autumn of 1999 to evaluate pre-BMP community structure and abundance in pilot and reference streams. A stratified random sampling design was used where riffle, run, and glide/pool habitats were sampled in proportion to their occurrence at the sites. A core sampler was used to collect macroinvertebrates from glide/pool areas with soft sediments while a Hess sampler was used in riffle or run habitats with hard substrates (i.e. larger gravel and cobble). In the laboratory, samples were elutriated through various sizes of sieves to separate the sediment from the organisms. Macroinvertebrates are being identified to the lowest taxonomic level. Identification of samples from 1998 and 1999 are ongoing, but preliminary baseline data from glide/pool habitats taken in 1998 and 1999 are presented in this report. Taxa richness was relatively high in glide/pool habitats with similar numbers of taxa between pilot and reference sites within a season. Catch per area (CPA) was computed to examine baseline differences in relative abundance of all taxa at a site and date. Across basins, there was no clear trend in CPA, although within basins some trends were apparent. Percentage of individuals in Ephemeroptera, Plecoptera, and Trichoptera (%EPT) families was low in most glide/pool habitats at the study sites. To assess stream quality, Hilsenhoff's Family Biotic Index (FBI) was calculated for each site, date, and habitat type (i.e. glide/pool, run, or riffle) (Hilsenhoff 1987, Hilsenhoff 1988). Although fish IBI scores indicated relatively good stream quality at most sites, FBI scores showed poor to very poor stream quality in these sites. However, riffle and run habitats in these sites have not been analyzed at the study sites and FBI scores are likely to change with further invertebrate identification in these habitats.

Job 101.1 Effects of BMPs on physical/chemical indicators of stream quality.

OBJECTIVE

To determine local and watershed-wide responses of physical/chemical factors to the implementation of watershed management practices.

INTRODUCTION

Despite the success of the Clean Water Act in reducing the impacts of point source pollution on freshwater ecosystems, many lotic systems in the United States remain in a degraded condition, largely as a result of non-point sources of pollution (USEPA 1990). Sources of non-point pollution include runoff from agricultural fields, logging activities, and urban areas. In predominately agricultural systems, the most significant types of pollution include excessive inputs of sediment, nutrients (from fertilizers, livestock, etc.), and pesticides. Nonpoint source pollution from agricultural practices is regarded as the dominant form of pollution currently impacting rivers and lakes in the country (USEPA 1995). As a result of heavy agricultural land use in Illinois, non-point source pollution is a major problem for Illinois watersheds.

In agricultural landscapes, on-field and off-field techniques, termed best management practices (BMPs), for reducing non-point source pollution are well known (see Gale et al. 1993). Also, in-stream practices for stabilizing stream banks, increasing habitat diversity, etc., for improving water quality and enhancing fish production have received considerable study, especially in coldwater streams (NRC 1992, Hunt 1993). However, the majority of these studies on BMPs were conducted at the plot or field scale, over relatively short time frames (e.g., Magette et al. 1989). Very few studies have addressed the impacts of BMPs at the watershed scale (Muscutt et al. 1993, Tim et al. 1995) or on a large temporal scale (Muscutt et al. 1993, Osborne and Kovacic 1993). The Illinois Pilot Watershed Study is designed to examine physical and chemical water quality as well as biotic indicators at the watershed level across a long temporal scale.

PROCEDURES

Physical/chemical habitat data were collected using two levels of sampling: site-scale and transect-scale. Site-scale parameters (Table 1) were collected at one location in the site (e.g., water temperature, discharge) or are based on maps of the entire site (e.g., drainage area, stream order) and are assumed to be representative of the entire site. Some variables are assumed to be constant over the duration of the study and were measured only once (Table 1).

Transect-scale variables are those which are expected to vary considerably within a site (Table 2). These variables, which pertain to stream channel morphology, bottom substrate, cover for fish, macrophyte abundance, condition of stream banks, and riparian land use/vegetation, were measured on ten, equally spaced transects perpendicular to the flow. The Stream Assessment Protocol for Ontario (Stanfield et al. 1998) was used to sample these habitat variables. Detailed methods for each parameter are given in Table 2. All transect-scale parameters were measured in autumn of 1998 and late summer 1999 after fish sampling had been conducted with the exception of the Kaskaskia basin which was only sampled in 1999 due to lack of a suitable reference watershed in 1998. We will continue to sample transect-scale characteristics once/year during the study.

Responsibility for site-scale habitat sampling has been divided among the Illinois Natural History Survey (INHS) and the Illinois State Water Survey (ISWS). INHS is responsible for measuring site scale parameters 1- 4 (Table 1). Drainage area, stream order, and site length were measured in 1998. Temperature loggers were installed in spring of 1999 at all sites except in the Kaskaskia Basin in which temperature loggers were installed in autumn of 1999. ISWS is responsible for measuring and analyzing site-scale parameters 5-9 (Table 1). Gauging stations were installed in 1999 to measure these habitat variables.

FINDINGS

<u>Site-scale characteristics</u>

Pilot and reference site locations in each basin were based on drainage areas. Upstream sites were located at a drainage area approximately 10 sq. mi., and downstream sites were placed at approximately 30 sq. mi. One exception is the Embarras basin where upstream sites on the pilot and reference watershed are located at about 30 sq. mi. and downstream sites at 60 sq. mi. For upstream sites, stream order ranged from 3-4 while downstream sites ranged from 4-5.

In general, average monthly temperature was similar between pilot and reference watersheds with highest average temperatures in July. Due to failure or loss of temperature data loggers, temperature data are unavailable from some sites. In the upper sites of the Embarras, the pilot site (Hurricane) was slightly cooler on average than the reference with the biggest difference in average temperature occurring in August (Figure 2). The warmer temperature at the reference upper site (Kickapoo Upper) may be due to our observations of less canopy cover in that reach allowing sunlight to penetrate and increase temperature or due to effluent from a waste water treatment plant located upstream. At the lower sites in the Cache basin, we see an opposite pattern with the pilot site (Big) having a slightly higher average temperature than the reference site (Cypress) in late summer months (Figure 2). The upper site of Big Creek showed similar summer temperatures to the lower site of Big Creek with temperatures ranging from 19-23 $^{\circ}C$ (Figure 3). In the Kaskaskia basin, average temperatures between the lower sites were similar (Figure 2). Lost Creek (reference) showed slightly higher or similar temperatures to Lake Branch (pilot) in the fall and spring, but lower temperatures in winter months. In the Spoon basin, the lower site on Haw Creek (reference watershed) was the only site with temperature data recorded. Temperatures at this site ranged from about 27 $^{\circ}C$ in mid-summer to 13 $^{\circ}C$ in early fall (Figure 3). In addition to our temperature loggers, the ISWS is also collecting temperature at the gaging stations. This temperature data will be analyzed in future reports by the ISWS and the INHS.

Transect-scale characteristics

Channel Morphology

At each site, in-stream channel morphology measurements were taken to assess baseline differences between pilot and reference watersheds prior to BMPs. In the Embarras, upper sites had similar average width, but Kickapoo Upper (reference) had significantly greater average depth (t-test, $p < 0.05$) and smaller particle sizes (t-test, $p < 0.05$) in both 1998 and 1999 (Table 3). Lower sites also showed significantly different average depths with Kickapoo Lower (reference) being significantly deeper in 1998 but shallower in 1999 (t-tests, $p < 0.05$) than Hurricane Lower. The lower site of Kicakpoo was also significantly wider than Hurricane with differences in average width of 4.5m and 5.7m in 1998 and 1999, respectively. The Spoon basin generally showed similar channel characteristics between the two upper and two lower sites and between years within a site (Table 2). However, Court Upper (pilot) was significantly wider (t-test, $p < 0.05$) with differences in average width of 3m and 5.1m in 1998 and 1999, respectively. Average substrate was significantly larger in Court Upper in 1998 (t-test, $p < 0.05$), while particle size was found to be significantly larger in the lower site of Haw (reference) in 1999 (t-test, $p < 0.05$). In the Cache, the pilot upper site (Big Upper) was wider than the reference with differences in average width of 3.1m in 1998 and 3.4m in 1999 (t-test, $p < 0.05$) and was significantly deeper in 1998 (t-test, $p < 0.05$) (Table 3). At the lower sites in the Cache, pilot and reference sites were similar in width and depth for both years, but Big Lower had significantly larger substrate than Cypress Lower in 1999 (t-test, $p < 0.05$). For the Kaskaskia basin, average depth and substrate size was similar, but Lost Lower (reference) was significantly wider than Lake Branch (t-test, $p < 0.05$) (Table 3). In general, width was found to be more variable than depth or substrate with all four basins showing a significant difference in average width between either the upper and/or lower sites. Average depth was less variable between upper and lower sites with only the Embarras basin having differences in depth between upper and lower sites. Substrate was similar between most upper and lower sites within a basin and year; however, average particle sizes within a site tended to fluctuate between years. In these highly agricultural systems, rain events often cause rapid flooding and movement of large amounts of sediment, changing the streambed composition from year to year.

In-stream habitat

With flooding a common event in these flashy systems resulting in inputs of upland sediment and shifting streambed substrate, channel structure can often change in these watersheds. We examined differences in habitat types between pilot and reference watershed sites and examined annual variability. In the Embarras basin, Hurricane Upper (pilot) had a higher percentage of pool habitat and less diversity than Kickapoo Upper (reference) in both 1998 and 1999 (Figure 4). Across years, Kickapoo Upper showed a shift in habitats with an increase in percent fast riffles and decline in percent pools from 1998 to 1999, while Hurricane Upper remained relatively similar in percent pools with a decrease in percent of run habitat from 8% in 1998 to 0% in 1999. Lower sites in the Embarras showed a similar trend with Hurricane Lower (pilot) having a greater percent of pool habitats and less diversity of habitat than Kickapoo Lower (Figure 4). Between years, Hurricane Lower showed a decline in percent runs and an increase in pool habitat, while Kickapoo Lower showed an increase in run habitat and a decrease in pool areas.

In the Spoon basin, differences between upper and lower sites and between years was less evident (Figure 5). In the upper sites, percent pools were similar between Court Upper (pilot) and Haw Upper (reference) in 1998 and 1999 although Haw Upper tended to have higher percent run habitat than Court Upper in 1998. For the lower sites of the Spoon basin, very little difference was detected between the sites. Court Lower had higher percentage of run habitat than Haw Lower in 1999, but both were dominated by pool habitat. In the Spoon basin, shifting of habitat types within a site between years was not evident.

Habitat in the Cache basin was dominated by pool areas in both upper and lower sites in both 1998 and 1999 (Figure 6). Upper sites in Big (pilot) and Cypress (reference) were similar in both years with a slight decrease in pool habitat in 1999. Like the Cache basin, the lower sites in the Kaskaskia basin were completely dominated by slow flowing deeper pool areas with no other habitats evident (Figure 7). Overall, habitat types were found to be similar between the pilots and their reference watersheds with the Embarras showing the most variability between sites and the Kaskaskia showing the least variability.

As part of our baseline in-stream survey, we measured the amount of in-stream cover and vegetation. All basins showed very little in-stream cover and vegetation (Tables 4 and 5). In the Embarras, all cover was unembedded and consisted mostly of wood, while vegetation consisted mostly of filamentous algae (Table 4). In the upper sites, Kickapoo had higher amount of wood and round rock cover in both 1998 and 1999. At lower sites, Hurricane had higher percent of unembedded wood cover (13.3 percent of its area) in 1999 and higher amount of filamentous algae in 1998 (29.8%) and 1999 (5%) than Kickapoo. Cover in the Spoon basin consisted of unembedded and embedded cover, grass and terrestrial vegetation (Table 4). Upper sites were relatively similar in overall cover and vegetation in 1999 with the exception of higher embedded round rock cover in Court Upper. In 1998, a greater percent of unembedded wood, flat rock, and round rock was found in Court Upper than Haw Upper. Lower sites of the Spoon were even more similar in cover and vegetation than the upper sites, but Haw Lower did have higher percentage of unembedded wood cover than Court Creek.

In the Cache basin, cover in upper and lower sites were dominated by unembedded and embedded wood cover and terrestrial vegetation (Table 5). Upper sites were comparable in cover and vegetation, but Cypress Upper did contain about 10% more unembedded wood in 1998. At lower sites, unemebbed and embedded wood were higher in Big Creek but terrestrial vegetation was higher in Cypress in 1999. Like the Cache, the Kaskaskia basin was also dominated by wood cover and terrestrial vegetation along with filamentous algae (Table 5). Lost Lower had almost twice the percent of woody cover as Lake Branch but had no in-stream vegetation. Overall, there was low amounts of in-stream cover and vegetation in all basins. Within basins certain categories of cover or vegetation varied somewhat between upper and lower sites, but overall percent cover and vegetation were generally comparable between pilot and reference watersheds.

Bank Conditions

Because in-stream and on-field BMPs are used to reduce erosion, we also examined pre-BMP bank conditions (bank vegetation and bank angle) to assess changes in bank stability as BMPs are implemented in the pilot watersheds. Land from waters edge to 2m on either side of the stream (0-2m) was usually dominated by herbaceous vegetation or was bare in all basins (Table 6). Moving out to 100 m, we found a general progression from herbaceous to woody or mature trees to cultivated. Most sites had a very narrow buffer strip of grasses and/or trees, but agricultural land use was usually within 100m of the stream.

Bank angle measurements were used to evaluate bank stability for upper and lower sites of pilot and reference watersheds. A high bank stability rating indicates more stable banks. The Embarras had similar bank stability ratings between both upper and lower sites with slightly lower stability in the pilot sites (Hurricane); however, stability increased in the pilot upper site by 15 and in the reference site by 24 from 1998 to 1999 (Table 6, Figure 8). Lower sites also increased by 14 in the pilot and by 11 in the reference watershed from 1998 to 1999. We should note that bank angle was estimated in 1998 and not directly measured as in 1999, thus, bank stability rating may not be as accurate in 1998. Like the Embarras, the pilot watershed (Court) in the Spoon basin was found to have slightly less stable banks than the reference in both upper and lower sites (Table 6, Figure 8). In 1998, bank stability was much lower in the pilot sites (Court) than corresponding reference sites (Haw), while in 1999 bank stability tended to be more similar between Court and Haw. Again, these differences may be due to a categorization of bank angle in 1998, therefore, these apparently large changes in stability between years may not be accurate.

In both the Cache and Kaskaskia, the pilot sites showed higher stability than their corresponding reference sites (Table 6, Figure 8). Between the upper sites of the Cache in 1998, we found a large difference of 25 in stability index with Big Upper (pilot) having the more stable banks; but in 1999, there was very little difference in bank stability. In the lower sites of the Cache, the difference in stability between Big and Cypress was consistent for 1998 and 1999 with Big Lower having higher bank stability.

RECOMMENDATIONS

From our baseline data collected in 1998 and 1999, channel morphology was somewhat variable in terms of average width and depth, but substrate was similar between pilot and reference watersheds. Channel structure was generally similar within basins with the exception of the Embarras where habitat diversity was high and varied between the upper and lower sites more so than in other basins. In-stream cover and vegetation was low in all basins and latitudinal trends in bank vegetation was comparable between sites and across basins. In general, our baseline data indicates that the majority of in-stream habitat characteristics and bank vegetation conditions were similar between pilot and reference watersheds.

To better assess annual variation in habitat between pilot and reference watersheds, additional collection of pre-BMP habitat data is needed and will be collected during late summer 2000. Gaging stations were installed in or near both upstream and downstream sites in the pilots and in or near the downstream site in the reference watersheds. Two exceptions are the Kaskaskia basin where the pilot has only one gaging station and the Embarras where the reference station is located at the upstream site. It is important for future analysis of water quality that gaging stations be installed at these sites or that data be collected manually. Data from gaging stations will be used to assess changes in chemical parameters following implementation of BMPs.

Job 101.2 Effects of BMPs on fish assemblage structure, fish abundance, and population size structure.

OBJECTIVE

To determine the watershed-wide responses of the stream fish assemblage and fish populations of select species to the implementation of watershed management practices.

INTRODUCTION

Most studies on the effects of BMPs have been implemented on small spatial (e.g. reach-scale) and temporal scales (e.g., Magette et al. 1989). In the few studies that were performed at larger spatial (e.g., watershed) and temporal scales, the emphasis has been on effects of BMP implementation on physical parameters (e.g., nutrient concentration, sediment yield) (see Trimble and Lund 1982, Gale et al. 1993, Walker and Graczyk 1993, Park et al. 1994, Cook et al. 1996, Edwards et al. 1996, Meals 1996, Bolda and Meyers 1997). Responses of the biota to watershed-wide implementation of BMPs have been considered much less frequently, but a number of observational, correlative studies suggest that fish and invertebrates should respond strongly to changes in land use practices within watersheds (Lenat and Crawford 1994, Rabeni and Smale 1995, Richards et al. 1996, Roth et al. 1996, Allan et al. 1997, Barton and Farmer 1997, Wang et al. 1997).

Currently, there is a lack of understanding on how ecological processes operating at large spatial and temporal scales affect stream fish populations (Schlosser 1995). Most studies of stream fish have been conducted at relatively small spatial scales, but it is clear that processes operating at large scales (e.g., land use in a catchment) can strongly affect the integrity of stream fish communities (Roth et al. 1996).

Implementation of BMPs in watersheds should minimize the impacts of nonpoint source pollution on surface waters. Accomplishing this will require a much greater understanding of the large-scale effects of BMPs on biotic as well as the more traditionally used physical attributes of aquatic systems.

PROCEDURES

At each site, fish were collected with a single pass using a standard AC electric seine (Bayley et al. 1989; Bayley and Dowling 1990). The length of each site was approximately 20 times the mean bank full width (Lyons 1992, Gough 1997). Block nets were placed at locations upstream and downstream of the site to increase the effectiveness of the sampling. A single pass was used instead of a triple pass depletion method due to the extensive time and labor required for the latter method. Simonson and Lyons (1995) found that CPUE provided the same values for species richness and percent species composition as depletion sampling and took only one quarter the time of depletion sampling. Fish samples were collected in late summer of 1999 from August to September. Captured fish were identified to species, counted, and lengths and weights were taken. When the number of fish caught of a particular species was high, the first 100 fish were measured and the remaining fish were counted. For selected species, age structures (e.g. scales, fin rays, etc.) for age and growth analysis were collected (see Job 101.3). Fish larger than 10g were processed and released whereas smaller fish were fixed in 10% formalin and preserved in 70% ethanol in the laboratory for processing.

For assessment of fish assemblage structure and differences in structure between pilot and reference streams, species richness data and two separate similarity indices were used. The Jaccard Similarity Index (J), based on presence/absence data, was calculated using the formula:

$$J = C / (A+B-C)$$

where A is the number of species in site A, B is the number of species in site B, and C is the number of species in common. A second similarity index was the Similarity Ratio (SR_{ij}) which takes into account the abundance of each species within the two sites being compared and was calculated using the formula:

$$SR_{ij} = \Sigma_k y_{ki} y_{kj} / (\Sigma_k y_{ki}^2 + \Sigma_k y_{kj}^2 - \Sigma_k y_{ki} y_{kj})$$

where i and j are two sites, y_{ki} is the relative abundance of the k-th species at site i, and y_{kj} is the relative abundance of the k-th species at site j. For both similarity indices, a value of one indicates the species composition are exactly the same in both sites and a value of zero indicates no similarity in fish assemblages between the two sites being compared.

To analyze differences in overall fish abundance in pilot and reference sites, catch per unit effort (CPUE) was computed. Evaluating fish size structure, average length and weight for each species was computed and compared between corresponding pilot and reference sites. Using fish community data, we calculated the Index of Biotic Integrity (IBI) to estimate the overall health of the aquatic ecosystem at each study site.

FINDINGS

Fish Assemblages

Species Richness

In 1999, a total of 14,662 fish and 62 species were caught among all basins. The Embarras basin made up 56% (52% in 1998) of the total catch and included 36 (32 in 1998) species (Table 7). With the exception of the Hurricane Upper site, all sites in the Embarras basin were similar in species richness ranging from 24 to 30 species. Both upper and lower sites on Hurricane had higher numbers of individuals with the upper site having 3 times more fish than the upper site of Kickapoo. The Spoon basin contained 15% (35% in 1998) of the total fish catch and included 36 species (32 in 1998) (Table 8). Species richness was relatively similar between the upper sites of the Spoon basin, but the lower site of the pilot (Court) contained 8 more species than the reference. Numbers of fish were also highest in the Court lower site. The Cache basin contained 25% (12% in 1998) of the total catch and included 32 species (29 in 1998) (Table 9). Within the Cache basin, species richness was comparable between upper sites. The lower site of Big Creek had 12 fewer species than Cypress, although species richness in Big Lower was similar to that of Big Upper and Cypress Upper. Numbers of individuals were not comparable between upper sites with Big Upper having 5 times more fish than Cypress Upper. The Kaskaskia basin had the lowest number of individuals making up only 3% of the total catch (Table 10). Lower sites of the Kaskaskia basin were comparable in numbers of fish caught, but species richness was lower in Lake Branch.

Comparing numbers of fish caught and species richness within a site across years, we found that species richness was relatively stable, but numbers caught fluctuated between years (Table 11). In the Embarras, species richness was comparable between

1998 and 1999 for all four sites, but the Hurricane Lower site had twice as many fish while Kickapoo had about half as many in 1999. As in the Embarras, the Spoon showed similar richness across years, but showed a trend of low fish numbers in 1999 for all four sites. The lower sites of the Cache basin did show an increase in species richness in 1999 which may be due to the higher numbers caught at these sites in 1999. An increase in numbers caught in Big Upper for 1999 was also evident.

Combining upper and lower sites across all basins, pilot and reference streams were similar in average numbers of species present although reference streams showed a slightly higher species richness at both upper and lower sites (Table 12). As expected, sites lower in the watershed regardless of stream type (pilot or reference) contained a few more species on average than sites in the upstream location of the watershed. Species richness averaged across basins was similar across years for both upper and lower sites.

Assemblage Composition

To assess similarity in species composition between pilot and reference sites, Jaccard's Similarity Index and Similarity Ratios were calculated with a value of one indicating complete similarity between sites (Table 13). Based on Jaccard's index, the species composition between lower sites of the Embarras was relatively similar with a value of 0.66, while the upper sites were less similar with a value of 0.52. Lower sites in the Embarras decreased in community similarity from 1998, but fish communities in upper sites remained about as similar to that of 1998. Unlike the Embarras, the Spoon basin had higher similarity between the upper sites (0.60) in 1999 than the lower sites (0.43). In 1998, the opposite pattern was found in the Spoon where the lower sites had a high similarity of 0.75, while the community similarity in upper sites was comparable to 1999. The Cache basin had moderate similarity in assemblage composition between upper and lower sites with a similarity of 0.50 for both sites. Across years, the similarity index between the lower sites of the Cache increased in 1999, while the assemblage similarity index for the upper site remained comparable to 1998. In the Kaskaskia, the lower sites had good community similarity considering the low numbers caught and low species richness in the pilot site. Combining the three basins into an average Jaccard's Similarity Index for comparisons of upper and lower sites between pilot and reference streams, we found that the mean community similarity between lower sites of pilot and reference streams was not significantly different from the mean similarity of the upper sites (ANOVA, $p = 0.58$).

Similarity Ratios, which take into account abundances of each species, were lower overall than those based on Jaccard's index due to greater variability in abundance of species caught (Table 13). Comparisons of the upper sites within each basin using Similarity Ratios showed a slightly different pattern than that shown by Jaccard's index. With Jaccard's index, upper sites in all three basins had relatively similar index values, but comparing the Similarity Ratios, the Embarras and the Spoon basins had higher similarity in species composition between the two upper sites with values of 0.35 and 0.33, respectively, while the Cache had a ratio of 0.17. When taking into account relative abundances at lower sites, the Cache and Kaskaskia show higher similarity than the Embarras, which had a higher Jaccard's index. The Spoon had the lowest similarity for both Jaccard's and the Similarity Ratio.

Fish Abundance

To analyze the pre-BMP conditions in overall fish abundance in pilot and reference streams, catch per hour of shocking time was calculated for each site and mean CPUE was used to assess differences between the four sites (pilot upper, pilot lower, reference upper, reference lower) (Table 14, Figure 9). In all basins, pilot watersheds showed a pattern of higher CPUE in both upper and lower sites with the exception of the lower sites in the Kaskaskia (Table 14). The Kaskaskia basin showed the lowest CPUE at the lower pilot and reference sites, while the Embarras showed the highest CPUE at all sites followed next by the Cache basin (Table 14, Figure 9). Averaging across basins, the pilot upper sites had the highest CPUE followed by the pilot lower sites. Although the sites on the reference streams were found to be more species rich on average (Table 12), the reference sites showed lower mean CPUE than the pilots (Figure 9). However, the differences in mean CPUE were found to be similar between the pilot and reference sites.

Fish Size Structure

Lengths and weights of each species caught were averaged for each site and comparisons were made between upper and lower sites within each basin to determine differences in size structure between pilot and reference streams. Comparing the upper sites of the Embarras, average length and weight for all fish species was significantly higher (t-test, $p < 0.05$) in the Kickapoo Upper site (reference) except for johnny darter, largemouth bass, spotted bass, and steelcolor shiners (Table 15). Total biomass per area was also larger in the reference upper site than in the pilot. In the lower sites of the Embarras basin, most fish species in common between the sites were significantly larger (t-test, $p < 0.05$) in Kickapoo Lower, but the total biomass per area of fish was smaller than Hurricane due to large sucker species present only in Hurricane Lower as well as larger gizzard shad, largemouth bass, and longear sunfish (Table 15).

Size structure was similar in the Spoon Basin between the upper and lower sites of the pilot and reference watershed. Of the 15 species in common between upper sites of Court and Haw, average fish lengths and weights for most species were similar, but bigmouth shiner, bluegill, golden redhorse, striped shiner, and suckermouth minnow showed significantly different average lengths between sites (t-test, $p < 0.05$) (Table16). In the lower sites, only 3 of the 15 species in common (blacknose dace, bluntnose minnow, and white sucker) were significantly different in average length between the pilot (Court Lower) and reference site (Haw Lower) (t-test, $p < 0.05$), however, Court Lower had larger total biomass per area due to large species that were not present in Haw Lower.

For the Cache, average lengths in the upper sites were significantly different for 5 of the 12 species in common (t-test, $p<0.05$), but total biomass per area was similar between the upper pilot and reference sites. The lower sites of the Cache had 5 of the 14 species in common with significantly different average lengths (t-test, $p < 0.05$), but unlike the upper sites, the reference site (Cypress Lower) had a larger biomass than the pilot (Big Lower) due to large cyprinid (buffalo, carp), sucker, and ictalurid species (Table 17). In the Kaskaskia, lower sites showed similar size structure in terms of average lengths, with only 3 of the 9 species in common showing significantly different average lengths. Overall, there was no consistent pattern in variation of size structure for any individual species across all basins and overall size structure was comparable between pilot and reference watersheds with the exception of the Embarras Basin.

Fish Community

To assess the quality of the fish community, the Index of Biotic Integrity (IBI) was computed for each site. Of the 14 sites sampled in 1999, one site attained a score greater than 51 of a possible 60 (Table 19). Nine sites showed scores ranging from 41 to 50, two sites had scores between 31 and 40, and two ranged from 21 to 30. Overall, the sites in the Embarras basin had high IBI scores with a score of 50 for the both lower sites. For the upper sites, the IBI score was 8 points lower in Hurricane than in Kickapoo which is possibly due to the low species richness found at Hurricane Upper. Court and Haw Creeks in the Spoon basin had scores ranging from 40 to 50. Lower sites in this basin were found to be more similar in quality than the upper sites with lower sites having a difference of 7 points while upper sites differed by 10. The lowest score in the Spoon basin occurred in the Haw upper site, in which cattle have access to the stream increasing bank erosion, nutrient loading and turbidity. However, the quality of this site was still found to be relatively high. Sites in the Cache basin were also found to be relatively high in community quality with three of the four sites having scores greater than 41. Big Lower contained the lowest quality with a score of 34, possibly due to the low diversity of species caught at that site. Of all four basins, the Kaskaskia had the lowest stream quality with scores of 30 and 26 for the lower sites of the pilot and reference watershed, respectively. In general, most sites showed good stream quality. However, 4 of the 7 comparisons in IBI scores between upper and lower sites revealed a difference in scores greater than 4 points.

Comparing scores between 1998 and 1999, we found that most sites were stable in IBI scores. The two sites on Court Creek showed a large difference between years with Court Lower declining by 9 points and Court Upper increasing by 8 points. While the IBI scores for Haw sites remained stable between years, this difference in scores for Court Creek resulted in dissimilar IBI scores for upper and lower sites in the Spoon basin in 1999. Currently IBI metrics used in Illinois streams are being reevaluated and a new IBI scoring criteria will be established. This improved scoring criteria may cause scores to change slightly for some study streams.

RECOMMENDATIONS

The analysis of species richness, community composition and CPUE between pilot sites and their corresponding reference sites indicates that our pilot and reference watersheds are similar. With the exception of the Embarras Basin where most species were larger in the reference sites, size structure of most fish species was comparable between pilot and corresponding reference watersheds. Although the quality of the fish community was different in 4 of the 7 comparisons between upper and lower sites, IBI scores were found to be stable between years with the only exception being the Court Creek sites. From our analysis of composition, abundance, and size structure we found that our pairings are well matched for examining differences in fish assemblage composition and size after BMP implementation.

To assess the changes in fish assemblage in these pilot watersheds, further pre-BMP data will need to be collected and analyzed. Baseline data is key to the Before-After-Control-Impact-Pairs study design (BACIP) because the ability of the design to detect effects of a treatment depends strongly on the number of sampling dates Before and After the treatment is initiated, the size of the treatment effect (defined as the difference between the average before and after differences between the treatment and control sites), and the variability in the differences between the treatment and control sites in each period (Osenberg et al. 1994). Obtaining sufficient numbers of pre-treatment samples is critical, because additional before samples cannot be obtained after the treatment is implemented. This is especially important in the Kaskaskia where we have been unable to sample the upstream reaches the past two years of this study. In late summer 2000, additional fish data will be collected at all sites.

Job 101.3. Effects of BMPs on fish growth rates.

OBJECTIVE

To determine the local and watershed-wide responses of fish growth rates of select species to the implementation of watershed management practices.

INTRODUCTION

Only a small number of large-scale studies have addressed watershed management practices on fish populations and, thus, a greater understanding of how processes operating at large spatial and temporal scales affect stream fish is necessary. Our study will further examine the impacts of BMPs on fish populations by evaluating differences in growth rates before and after BMP implementation. In addition to species composition, abundance, and size structure of stream fish, growth rates are also a good indicator of improved stream quality. As we observed from our 1998 and 1999 data, species composition and numbers caught may change from year to year within a site, but growth rates can be tracked for the life of a fish providing us with a history of the stream conditions before the study began. Thus, growth rates may be a more effective measure of improvements in stream quality than species composition and abundances.

PROCEDURES

Growth rate changes will be evaluated for selected fish species associated with the implementation of watershed management practices at each of the sites. Based on the 1998 fish data, the most common species that are abundant across sites were chosen for analysis. These were: largemouth bass, smallmouth bass, bluegill, longear sunfish, green sunfish, creek chub, white sucker, golden redhorse, central stoneroller, and yellow bullhead. In 1998, various aging structures (i.e. scales, spines, and otoliths) were collected from all fish to determine which bony structure was most suitable for aging a particular species. Scales will be used for aging centrarchids, creek chub, central stonerollers and golden redhorse and pectoral fin rays/spines for white sucker and yellow bullhead. We hope to obtain a minimum of 30 individuals per species and site for age and growth analysis. Scales will be impressed on acetate slides and spines sectioned. Radii and interannular distances will be recorded with a digitizing tablet connected to a computer. A sub-sample will be aged by a second person to verify age estimates. Lengths at each previous year will be backcalculated from the averaged scale measurements using the Fraser-Lee method. Using backcalculated values, age-specific growth rates will be compared before and after implementation of the watershed management practices at both the pilot and reference sites. In addition, annual size-specific growth will be determined for two sizes for each selected species (Putman et al. 1995). Sizes chosen will encompass the range in which known ontogenetic diet and habitat shifts occur with a small size approximating growth of age-1 fish and large size approximating growth at the onset of maturity. These size-specific growth rates often provide more ecologically meaningful comparisons than age-specific growth rates (Putnam et al. 1995). These estimates will also be used to assess effects of watershed management practices on stream fish growth.

FINDINGS

Scales collected from centrarchids in 1998 and 1999 have been aged, but measurements of annular rings are currently being conducted. Creek chub, central stoneroller, golden redhorse, and white sucker scales are currently being aged and white sucker and yellow bullhead fin rays/spines will be processed and aged in the next few months. Because not all fish have been aged, a preliminary assessment of population age structure and growth trends of selected species in pilot and reference watersheds will be given in this report. We anticipate that these average ages will change as a result of further analysis. In the Embarras, average age was similar between the lower sites for most of the selected species. Largemouth bass and green sunfish were slightly older in Kickapoo Lower (reference), while bluegill and longear sunfish tended to be older in Hurricane Lower although longear had similar growth in both lower sites (Table 20, Figure 10). For the Spoon basin, we found that largemouth bass, white sucker, golden redhorse, and creek chub in upper sites of the reference watershed (Haw Creek) are on average a year older than those in the pilot upper site (Table 20). Between lower sites in the Spoon, average age of bluegill and green sunfish was higher in Haw Lower with bluegill showing little growth between ages 1 and 2 in Court Lower (Table 20, Figure 11). Smallmouth bass were on average 3 years older in Haw Lower, suggesting that this species may be slower growing in the reference than the pilot watershed. In the Cache basin, the upper sites showed similar mean ages for largemouth bass, white sucker, creek chub, and longear sunfish, although longear growth was higher in the Big Upper site (pilot) (Table 20, Figure 10). Mean ages for bluegill and green sunfish were higher in Cypress Upper, but growth was similar for bluegill between the upper sites of the Cache (Table 20, Figure 12). In the lower sites of the Cache, largemouth bass and bluegill show greater mean ages with bluegill having larger growth in the reference site (Cypress), while longear sunfish have higher mean age in the pilot lower site but slightly higher growth in the reference lower site. Average ages between the lower sites of the Kaskaskia basin were comparable for green sunfish, but bluegill were a year older in the reference due to the small sample size (n = 4) at this site (Table 20).

RECOMMENDATIONS

From our preliminary analysis, population age structure and growth of bluegill and longear among basins and between upper and lower sites within a basin appeared similar. As more bony structures are aged and annular rings measured for the 10 selected species, we will be able to better assess pre-BMP population age structure and growth rates. In the 2000 field season, additional structures will be taken for additional pre-BMP growth analysis.

Job 101.4. Effects of BMPs on benthic macroinvertebrate community structure and crayfish abundance.

OBJECTIVE

To determine the local and watershed-wide responses of benthic macroinvertebrates, including crayfish, to the implementation of watershed management practices.

INTRODUCTION

Most studies of stream biota have been conducted at relatively small spatial scales, but it is clear that processes operating at large scales (e.g., land use in a catchment) can strongly affect the integrity of stream fish (Roth et al. 1996) and invertebrate (Richards et al. 1996) assemblages. To further assess the effects of BMPs on stream quality in these Pilot watersheds, benthic macroinvertebrates are being monitored. There are a number of reasons to include benthic invertebrates in a monitoring program. First, because of short generation times and high intrinsic population growth rates, invertebrates should respond more quickly to improvements in water quality than fish. Second, as discussed above, the power of the BACIP design to detect treatment effects strongly depends on the number of sampling dates before and after implementation of BMPs. Because serial correlation associated with frequent sampling should be less of a concern with short-lived invertebrates than with fish (Stewart-Oaten et al. 1992, Osenberg et al. 1994), invertebrates can be sampled seasonally to increase the power of the BACIP design. Third, because most stream fish ultimately depend on benthic invertebrates as a food source, invertebrate monitoring will provide a mechanistic understanding of improvements observed in fish assemblage structure (Job 101.2).

PROCEDURES

Benthic macroinvertebrates were sampled at each site from riffle, glide/pool, and run habitats in fall (September – November) of 1998 and spring (May – early June), summer (July), and fall (October) 1999. At most sites large gravel – cobble substrates (riffle or run habitats) were sampled using a Surber sampler in 1998 (with exception of Kickapoo Creek) and a Hess sampler in 1999 equipped with a 300 μm mesh net. Fine gravel – sand/silt substrates (run or glide/pool habitats) were sampled with a coring device. Each habitat type was sampled in proportion to its relative availability in the site with a maximum of fifteen samples (cores and hess/surber samples combined) collected at a site. In 1999, depth and hydraulic head was also recorded at the location of each sample to help categorize habitat types. Samples were preserved in the field in their entirety with 4% formalin.

Procedures recommended by Wrona et al. (1982) and Thrush et al.(1994) were used in laboratory processing of the samples. All samples collected within the same habitat type (i.e. riffle, run, glide) at a site/date will be pooled. Samples are elutriated using various size sieves and sorted from organic debris using a dissecting microscope at 10X magnification. Samples with a large number of organisms were sub-sampled and macroinvertebrates were identified to the lowest possible taxonomic level using various taxonomic keys (Wiederholm 1983; Thorp and Covich 1991; Merritt and Cummins 1996)

All samples from glide/pool habitats have been processed and are currently being identified. Data presented in this report are from glide/pool habitats. Riffle samples are in the process of being sorted and identified and analysis will be presented in future reports. To analyze the community structure in glide/pool habitats we examined trends in taxa richness, %EPT, and macroinvertebrate abundance. We also assessed stream quality through Hilsenhoff's Family Biotic Index (Hilsenhoff, 1988).

FINDINGS

In general, glide/pool habitats were dominated by chironomids and oligocheates in all basins. The Hurricane Upper site in the fall of 1998 also consisted of ceratopogonids as well as chironomids and oligocheates, but had a low taxa richness of 15 (Table 21). In spring 1999, the lower sites of the Embarras had similar taxa richness of 28 for the pilot and 27 for the reference, but Hurricane (pilot) had twice as many individuals per square meter (Table 22). Comparing between habitat types within the spring 1999 sample of Hurricane Lower, we found that run habitats were also dominated by chironomids and oligocheates with greater numbers of individuals but a lower taxa richness (Table 23) than glide/pool habitats within the Hurricane Lower (Table 22).

In the upper sites of the Spoon basin, taxa richness was similar between pilot and reference watersheds for all seasons and years, however, numbers of individuals were consistently lower in Haw (reference) (Table 24). Comparing between seasons in the upper Spoon sites, fall 1998 had the highest taxa richness for both the pilot and the reference watershed, while spring 1999 and fall 1999 were similar in taxa richness. The lower sites of the Spoon also show similar taxa richness between pilot and reference sites within a season, although numbers of individuals differed between the lower sites (Table 25).

Taxa richness and number of individuals differed between the upper sites of the Cache in spring 1999 (Table 26). Across seasons, Cypress Upper ranged in taxa richness from 40 in fall of 1998 to 19 in summer 1999, although abundance stayed relatively stable. In the lower sites of the Cache, taxa richness was relatively similar within and between seasons (Table 27). In the Kaskaskia basin, the pilot lower site was dominated by ostracods, oligocheates, and ceratopogonid diptera with relatively high taxa richness and numbers of individuals (Table 28).

To further assess community structure as well as water quality, we computed FBI (Hilenshoff 1988; Lenat 1993) and %EPT scores. In general, FBI scores were high and %EPT was low for all basins and seasons, indicating poor water quality (Table 29). In the Embarras, spring samples showed poor water quality for upper and lower sites, while fall 1998 showed very poor quality in Kickapoo lower. In the Spoon basin, the upper and lower reference sites had higher FBI and lower %EPT scores than the pilot in both fall and spring samples, indicating lower water quality. The Cache basin had mostly very poor quality sites in all seasons, with the upper and lower pilot sites having slightly better quality than their respective reference sites. Percent similarity, which compares FBI scores between upper and lower sites, was high in all basins, indicating that pilot watersheds were very similar in FBI scores to their corresponding reference watershed (Table 30).

RECOMMENDATIONS

Baseline data from 1998 and 1999 revealed similar macroinvertebrate composition between pilot and reference watersheds with most glide/pool habitats dominated by chironomids and oligocheates. FBI scores were high and % EPT was low for glide/pool habitats at all sites suggesting poor water quality and room for improved stream quality after BMP implementation. Ongoing processing and identification of 1998 and 1999 samples will be carried out in the next several months. Collection of additional benthos samples will be necessary for analysis of pre-BMP conditions in macroinvertebrate communities in pilot and reference watersheds.

Job 101.5. Analysis and reporting.

OBJECTIVE

To prepare annual and final reports that summarize work accomplished and evaluate the effectiveness of watershed management practices for improving water quality.

Data were analyzed and reported within individual jobs of this report (see Job 101.1-101.4).

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Table 1. Summary of site-scale habitat variables. Each site is approximately 20 times the mean bankfull width (W_{bf}) in length (Gough 1997).

Variable	Sample Frequency	Method
1) Drainage area (km^2)	1 time only	1:24,000 topographic maps; GIS
2) Stream order	1 time only	1:24,000 topographic maps
3) Site length (m)	Annual	Site length = $20W_{bf}$; see method for W_{bf} (Table 2)
4) Water temperature (°C)	Continuous	Optic Stowaway temperature logger; Gaging Stations (ISWS)
5) Discharge (m^3/s)	Continuous	Gaging Stations (ISWS)
6) Total P and soluble reactive $PO_4 - P$	Once/week; Hourly during spates	Ascorbic acid method (APHA 1995); automatic pumping sampler at Gaging Stations (ISWS)
7) Total N and $NO_3 - N$	Once/week; Hourly during spates	Cadmium reduction method (APHA 1995); automatic pumping sampler at Gaging Stations (ISWS)
8) $NH_3 - N$	Once/week; Hourly during spates	Phenate method (APHA 1995); automatic pumping sampler at Gaging Stations (ISWS)
9) Suspended sediments	Once/week; hourly during spates	Depth-integrating DH-48 sampler (Gordon et al. 1992); automatic pumping sampler at Gaging Stations (ISWS)

Table 2. Summary of transect-scale habitat variables. Ten transects were sampled at each site. All variables will be sampled once/year when fish sampling is conducted.

Variable	Description
Bankfull width (m)	Horizontal distance along transect, measured perpendicular to stream flow, from top of low bank to a point of equal height on opposite bank (Gough 1997). Measured one time only for site length
Stream width (m)	Horizontal distance along transect, measured perpendicular to stream flow from bank to bank at existing water surface
Depth (mm)	Vertical distance from water surface to stream bottom, measured at 6 equally spaced points along transect
Hydraulic Head (mm)	Measurement of stream velocity at each point along transect. Taken as difference between water height on ruler facing upstream and water height on ruler facing downstream (Stanfield et al. 1998)
Bottom substrate type	Composition of stream bed measured at each point and in a 30 cm circle around each point where stream depth is measured; particle diameters in each category are: Clay: ≤0.004 mm Silt: 0.004 – 0.062 mm Sand: >0.062 – 2 mm Gravel: >2 – 64 mm Cobble: >64 – 256 mm Small boulder: >256 – 512 mm Large boulder: >512 mm
Cover (%)	Object(s) that are 10 cm wide along median axis and blocks greater than 75% of sunlight; the largest object which is partially or wholly within a 30 cm circle around each point along the transect are measured.
Shading (%)	Proportion of densiometer grid squares covered at the center of each transect.
Bank vegetation cover (%)	Proportion of bank which is covered with live vegetation; based on number of 5 X 6.25cm grids out of 16 grids that contain live vegetation.
Undercut bank (mm)	Distance at each side of transect between maximum extent that streamside overhangs channel to furthest point under the bank, to nearest millimeter.
Bank angle	Distance from bank to a tape measure that is strung level and extents 1.5 m on either bank; indicates amount of bank erosion.
Riparian land use (left and right bank)	Composition of riparian zone at distances of 1.5-10 m, 10-30 m, and 30-100 m along each transect: largest land use category is recorded and is estimated visually; categories are: Cultivated, Herbaceous, Woody, Mature Trees, Tree roots.

Table 3. Geomorphic variables for each study basin in 1998 and 1999. (P) denotes pilot site and (R) denotes reference site.
* denotes significant difference between pilot and reference sites. (t-test, P<0.05). Width/Depth Ratio and Sorting Index not tested for significance.

Embarras Basin	Hurricane Upper (P)	Kickapoo Upper (R)	Hurricane Upper (P)	Kickapoo Upper (R)	Hurricane Lower (P)	Kickapoo Lower (R)	Hurricane Lower (P)	Kickapoo Lower (R)
	1998		1999		1998		1999	
Average Width (m)	7.6	6.9	8.2	7.5	5.8	10.3*	6.3	12.0*
Average Depth (mm)	68.6	148.6*	50.8	234.4*	108.9	154.9*	253.5	200.2*
Width/Depth Ratio	110.8	46.3	161.1	32.1	52.9	66.4	24.9	60.1
Mean Particle Size (mm)	338.4	35.1*	18.4	0.6*	2.6	5.9	3.1	6.8
Sorting Index	125.0	50.5	2285.5	69.5	25.5	50.5	42.5	64.5

Spoon Basin	Court Upper (P)	Haw Upper (R)	Court Upper (P)	Haw Upper (R)	Court Lower (P)	Haw Lower (R)	Court Lower (P)	Haw Lower (R)
	1998		1999		1998		1999	
Average Width (m)	8.3	5.3*	10.8	5.7*	8.9	10.3	10.2	10.7
Average Depth (mm)	234.3	228.9	254.5	231.8	306.6	312.1	267.5	249.1
Width/Depth Ratio	35.3	23.2	42.2	24.7	28.9	33.1	38.3	42.8
Mean Particle Size (mm)	34.2	2.6*	12.0	5.2	3.9	3.2	5.0	12.8*
Sorting Index	231.0	1.5	93.0	61.0	50.6	100.5	69.1	51.2

Cache Basin	Big Upper (P)	Cypress Upper (R)	Big Upper (P)	Cypress Upper (R)	Big Lower (P)	Cypress Lower (R)	Big Lower (P)	Cypress Lower (R)
	1998		1999		1998		1999	
Average Width (m)	8.4	5.3*	7.9	4.5*	5.2	5.8	3.9	4.4
Average Depth (mm)	239.2	419.9*	210.4	369.1	507.4	312.6	306.8	234.6
Width/Depth Ratio	35.0	12.6	37.5	12.1	10.2	18.5	12.8	18.6
Mean Particle Size (mm)	52.9	36.5	29.9	68.3	0.4	0.2	2.2	0.4*
Sorting Index	5.5	3.3	2.2	5.1	5.1	2.8	13.1	1.7

Kaskaskia Basin	Lake Branch Lower (P)	Lost Lower (R)	Lake Branch Lower (P)	Lost Lower (R)
	1998		1999	
Average Width (m)			3.9	6.9*
Average Depth (mm)			230.0	318.1
Width/Depth Ratio			16.9	21.5
Mean Particle Size (mm)			0.03	0.5
Sorting Index			2.8	3.3

Table 4. Percent area of instream cover (unembedded and embedded)and vegetation in the Embarras and Spoon Basin sites in 1998 and 1999. Categories for unembedded and embedded cover: Wood, Flat Rock, Round Rock, Macrophyte, Bank. Categories for vegetation: Filamentous Algae, Non-Filamentous Algae, Moss, Macrophyte, Watercress, Grass, Terrestrial. Categories not listed were not present in a basin.

Embarras Basin	Hurricane Upper	Kickapoo Upper	Hurricane Upper	Kickapoo Upper	Hurricane Lower	Kickapoo Lower	Hurricane Lower	Kickapoo Lower
	1998		1999		1998		1999	
Unembedded								
Wood	0.0	2.0	0.0	8.6	0.0	1.7	13.3	5.4
Flat Rock	1.8	0.0	0.0	1.7	0.0	0.0	0.0	0.0
Round Rock	0.0	2.0	0.0	1.7	0.0	0.0	0.0	5.4
Embedded	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vegetation								
F. Algae	5.4	13.2	14.9	6.9	29.8	0.0	5.0	0.0
Grass	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.6
Terrestrial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8

Spoon Basin	Court Upper	Haw Upper	Court Upper	Haw Upper	Court Lower	Haw Lower	Court Lower	Haw Lower
	1998		1999		1998		1999	
Unembedded								
Wood	7.0	1.7	0.0	10.2	5.3	12.3	0.0	1.8
Flat Rock	7.0	1.7	1.8	0.0	0.0	0.0	0.0	1.8
Round Rock	5.3	0.0	5.4	0.0	0.0	0.0	0.0	0.0
Embedded								
Wood	0.0	0.0	0.0	1.7	1.8	0.0	0.0	0.0
Flat Rock	0.0	0.0	1.8	0.0	0.0	0.0	0.0	0.0
Round Rock	1.8	0.0	10.7	0.0	0.0	0.0	0.0	0.0
Vegetation								
F. Algae	0.0	0.0	0.0	0.0	1.8	0.0	0.0	0.0
Grass	0.0	0.0	3.6	0.0	0.0	0.0	2.0	0.0
Terrestrial	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8

Table 5. Percent area of instream cover (unembedded and embedded)and vegetation in the Cache and Kaskaskia Basin sites in 1998 and 1999. Categories for unembedded and embedded cover: Wood, Flat Rock, Round Rock, Macrophyte, Bank. Categories for vegetation: Filamentous Algae, Non-Filamentous Algae, Moss, Macrophyte, Watercress, Grass, Terrestrial. Categories not listed were not present in a basin.

Cache Basin	Big Upper	Cypress Upper	Big Upper	Cypress Upper	Big Lower	Cypress Lower	Big Lower	Cypress Lower
	1998		1999		1998		1999	
Unembedded								
Wood	3.7	13.8	5.7	5.1	5.0	6.7	16.7	8.9
Flat Rock	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0
Round Rock	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0
Embedded								
Wood	1.9	5.2	0.0	5.1	8.3	3.3	11.7	5.4
Flat Rock	0.0	0.0	0.0	6.8	0.0	0.0	0.0	0.0
Round Rock	1.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Vegetation								
Terrestrial	0.0	1.7	0.0	1.7	0.0	0.0	0.0	8.9

Kaskaskia Basin	Lake Branch Lower	Lost Lower	Lake Branch Lower	Lost Lower
	1998		1999	
Unembedded				
Wood			11.7	20.0
Flat Rock			0.0	1.7
Embedded				
Wood			0.0	1.7
Vegetation				
F. Algae			5.0	0.0
Terrestrial			3.3	0.0

Table 6. Dominant vegetation categories in the riparian zone from water's edge (0m) to 100m upland for left and right banks and average bank stability ratings for each basin in 1998 and 1999. Vegetation categories: N = None, C = Cultivated, H = Herbaceous, W = Woody (< 3in. dbh and tree roots), M = Mature Trees

			Left Bank				Right Bank				Average Bank
			30 - 100m	10 -30m	2 -10m	0 - 2m	0 - 2m	2 -10m	10 -30m	30 - 100m	Stability
1998	Hurricane	Upper	C	C	M	N	N	M	M	M	0.42
	Kickapoo	Upper	C	M	H	N	H	H	C	C	0.37
1999	Hurricane	Upper	C	M	M	H	N	M	C	C	0.57
	Kickapoo	Upper	C	C	M	W	N	M	C	C	0.62
1998	Hurricane	Lower	M	M	M	H	H	N	C	C	0.35
	Kickapoo	Lower	H	H	M	W	N	M	M	C	0.45
1999	Hurricane	Lower	C	M	H	N	N	M	M	M	0.49
	Kickapoo	Lower	N	M	M	H	H	H	C	C	0.56

			Left Bank				Right Bank				Average Bank
			30 - 100m	10 -30m	2 -10m	0 - 2m	0 - 2m	2 -10m	10 -30m	30 - 100m	Stability
1998	Court	Upper	M	M	W	H	H	W	M	M	0.43
	Haw	Upper	H	H	W	H	H	F	H	H	0.70
1999	Court	Upper	M	M	M	N	H	M	M	M	0.67
	Haw	Upper	H	H	M	H	H	M	H	C	0.67
1998	Court	Lower	C	W	W	H	H	W	M	C	0.35
	Haw	Lower	C	W	F	H	H	W	M	M	0.52
1999	Court	Lower	C	C	M	N	N	M	M	C	0.50
	Haw	Lower	C	C	M	H	H	M	C	C	0.60

Table 6. continued.

			Left Bank				Right Bank				Average Bank
			30 - 100m	10 -30m	2 -10m	0 - 2m	0 - 2m	2 -10m	10 -30m	30 - 100m	Stability
1998	Big	Upper	C	M	H	H	H	M	M	M	0.67
	Cypress	Upper	M	M	H	H	H	H	H	H	0.42
1999	Big	Upper	C	C	M	W	H	M	M	C	0.69
	Cypress	Upper	M	M	M	H	H	M	H	H	0.64
1998	Big	Lower	C	C	M	H	N	M	C	C	0.48
	Cypress	Lower	M	M	M	N	H	M	C	C	0.39
1999	Big	Lower	C	C	M	N	H	M	C	C	0.64
	Cypress	Lower	M	M	M	N	N	M	C	C	0.53

			Left Bank				Right Bank				Average Bank
			30 - 100m	10 -30m	2 -10m	0 - 2m	0 - 2m	2 -10m	10 -30m	30 - 100m	Stability
1999	Lake Branch	Lower	M	M	M	N	N	M	C	C	0.47
	Lost	Lower	C	C	M	N	N	M	C	C	0.40

Table 7. List of fish species and numbers collected in Upper and Lower sites of Hurricane (pilot) and Kickapoo (reference) Creeks in 1999.

Common Name	Scientific Name	Hurricane Upper	Kickapoo Upper	Hurricane Lower	Kickapoo Lower
Blackstripe topminnow	*Fundulus notatus*	0	0	4	0
Bluegill	*Lepomis macrochirus*	66	30	105	25
Bluntnose minnow	*Pimephales notatus*	91	53	506	119
Brindled madtom	*Noturus miurus*	0	9	0	12
Carp	*Cyprinus carpio*	0	0	3	0
Central stoneroller	*Campostoma anomalum*	1512	289	189	69
Channel catfish	*Ictalurus punctatus*	0	0	0	4
Creek chub	*Semotilus atromaculatus*	1017	175	50	47
Dusky darter	*Percina sciera*	0	0	0	4
Fathead minnow	*Pimephales promelas*	0	0	0	4
Flathead catfish	*Pylodictis olivaris*	0	0	0	1
Gizzard shad	*Dorosoma cepedianum*	0	1	15	56
Golden redhorse	*Moxostoma erythrurum*	0	0	16	0
Green sunfish	*Lepomis cyanellus*	0	5	14	7
Greenside darter	*Etheostoma blennioides*	1	0	16	3
Johnny darter	*Etheostoma nigrum*	175	1	22	3
Largemouth bass	*Micropterus salmoides*	2	5	10	3
Longear sunfish	*Lepomis megalotis*	0	11	17	22
Northern hog sucker	*Hypentelium nigricans*	0	5	34	11
Orangethroat darter	*Etheostoma spectabile*	86	10	32	6
Quillback	*Carpiodes cyprinus*	0	0	4	0
Rainbow darter	*Etheostoma caeruleum*	124	2	32	10
Redear sunfish	*Lepomis microlophus*	0	0	1	0
Redfin shiner	*Lythrurus umbratilus*	0	0	9	1
Sand shiner	*Notropis ludibundus*	0	45	398	176
Silverjaw minnow	*Notropis buccatus*	837	193	135	104
Silvery minnow	*Hybognathus nuchalis*	0	25	75	5
Spotfin shiner	*Cyprinella spiloptera*	49	229	99	195
Spotted bass	*Micropterus punctulatus*	1	4	8	4
Spotted sucker	*Minytrema melanops*	0	0	9	0
Steelcolor shiner	*Cyprinella whipplei*	3	95	92	96
Striped shiner	*Luxilus chrysocephalus*	0	25	69	0
Suckermouth minnow	*Phenacobius mirabilis*	0	4	5	2
Warmouth	*Lepomis gulosus*	0	1	0	0
White sucker	*Catostomus commersoni*	7	29	44	3
Yellow bullhead	*Ameiurus natalis*	4	2	2	1
Total Catch		3975	1248	2015	993
Species Richness		15	24	30	28

Table 8. List of fish species collected in Upper and Lower sites of Court (pilot) and Haw (reference) Creeks in 1999.

Common Name	Scientific Name	Court Upper	Haw Upper	Court Lower	Haw Lower
Bigmouth shiner	*Notropis dorsalis*	24	2	4	0
Blacknose dace	*Rhinichthys atratulus*	9	1	16	2
Bluegill	*Lepomis macrochirus*	11	2	24	4
Bluegill x Green sunfish hybrid	*Lepomis macrochirus x L. cyanellus*	0	0	2	0
Bluntnose minnow	*Pimephales notatus*	31	56	229	31
Central stoneroller	*Campostoma anomalum*	33	3	89	0
Channel catfish	*Ictalurus punctatus*	0	0	1	11
Creek chub	*Semotilus atromaculatus*	9	25	48	0
Fathead minnow	*Pimephales promelas*	0	1	0	1
Flathead catfish	*Pylodictis olivaris*	2	9	0	4
Golden redhorse	*Moxostoma erythrurum*	28	0	25	9
Green sunfish	*Lepomis cyanellus*	2	0	1	7
Highfin carpsucker	*Carpiodes velifer*	1	0	0	0
Hornyhead chub	*Nocomis biguttatus*	0	8	2	6
Johnny darter	*Etheostoma nigrum*	1	0	3	1
Largemouth bass	*Micropterus salmoides*	3	4	2	2
Northern hogsucker	*Hypentelium nigricans*	0	0	5	3
Orangethroat darter	*Etheostoma spectabile*	0	0	13	0
Quillback	*Carpiodes cyprinus*	7	0	10	0
Rainbow darter	*Etheostoma caeruleum*	0	0	13	0
Red shiner	*Cyprinella lutrensis*	315	46	43	191
Redfin shiner	*Lythrurus umbratilus*	0	0	5	0
River carpsucker	*Carpiodes carpio*	2	0	0	1
Sand shiner	*Notropis ludibundus*	198	29	109	41
Silver redhorse	*Moxostoma anisurum*	0	0	0	1
Silverjaw minnow	*Notropis buccatus*	0	0	1	0
Silvery minnow	*Hybognathus nuchalis*	0	0	1	0
Slenderhead darter	*Percina phoxocephala*	0	2	0	3
Smallmouth bass	*Micropterus dolomieu*	8	0	4	0
Spotfin shiner	*Cyprinella spiloptera*	0	0	200	0
Steelcolor shiner	*Cyprinella whipplei*	0	0	78	0
Stonecat	*Noturus flavus*	8	4	4	16
Striped shiner	*Luxilus chrysocephalus*	2	6	4	0
Suckermouth minnow	*Phenacobius mirabilis*	7	3	0	7
White sucker	*Catostomus commersoni*	15	39	6	4
Yellow bullhead	*Ameiurus natalis*	1	1	11	3
Total Catch		717	241	953	348
Species Richness		22	18	29	21

Table 9. List of fish species collected in Upper and Lower sites of Big (pilot) and Cypress (reference) Creeks in 1999.

Common Name	Scientific Name	Big Upper	Cypress Upper	Big Lower	Cypress Lower
Banded sculpin	*Cottus carolinae*	341	0	3	0
Bigmouth buffalo	*Ictiobus cyprinellus*	0	0	0	1
Black bullhead	*Ameiurus melas*	0	1	0	2
Blackside darter	*Percina maculata*	0	16	0	41
Blackspotted topminnow	*Fundulus olivaceus*	30	27	28	25
Bluegill	*Lepomis macrochirus*	28	36	38	39
Bluegill x Green sunfish hybrid	*Lepomis macrochirus x L. cyanellus*	1	0	0	0
Bluntnose darter	*Etheostoma chlorosomum*	0	1	0	0
Bluntnose minnow	*Pimephales notatus*	106	85	212	402
Carp	*Cyprinus carpio*	0	0	0	3
Central stoneroller	*Campostoma anomalum*	926	26	9	33
Channel catfish	*Ictalurus punctatus*	0	0	0	1
Creek chub	*Semotilus atromaculatus*	484	89	20	58
Creek chubsucker	*Erimyzon oblongus*	3	45	3	9
Fantail darter	*Etheostoma flabellare*	40	0	0	0
Fringed darter	*Etheostoma crossopterum*	21	0	0	0
Green sunfish	*Lepomis cyanellus*	6	5	1	3
Johnny darter	*Etheostoma nigrum*	0	0	0	7
Largemouth bass	*Micropterus salmoides*	16	1	3	12
Longear sunfish	*Lepomis megalotis*	4	23	53	48
Mosquitofish	*Gambusia affinis*	0	0	0	8
Pirate perch	*Aphredoderus sayanus*	0	31	2	4
Red shiner	*Cyprinella lutrensis*	0	0	1	4
Redfin shiner	*Lythrurus umbratilus*	10	13	31	4
Shorthead redhorse	*Moxostoma macrolepidotum*	0	1	0	2
Slough darter	*Etheostoma gracile*	0	1	0	3
Spotted bass	*Micropterus punctulatus*	2	0	0	3
Spotted sucker	*Minytrema melanops*	0	0	0	12
Suckermouth minnow	*Phenacobius mirabilis*	0	0	0	1
Tadpole madtom	*Noturus gyrinus*	0	1	8	2
White sucker	*Catostomus commersoni*	82	14	10	39
Yellow bullhead	*Ameiurus natalis*	4	4	0	10
Total Catch		2104	420	422	776
Species Richness		17	19	15	27

Table 10. List of fish species collected in Lower sites of Lake Branch (pilot) and Lost (reference) Creeks in 1999.

Common Name	Scientific Name	Lake Branch Lower	Lost Lower
Blackstripe topminnow	*Fundulus notatus*	20	30
Bluegill	*Lepomis macrochirus*	23	42
Bluegill x Green sunfish hybrid	*Lepomis macrochirus x L. cyanellus*	1	1
Bluntnose minnow	*Pimephales notatus*	0	8
Carp	*Cyprinus carpio*	31	12
Central stoneroller	*Campostoma anomalum*	0	2
Creek chub	*Semotilus atromaculatus*	0	3
Creek chubsucker	*Erimyzon oblongus*	0	1
Gizzard shad	*Dorosoma cepedianum*	1	15
Golden shiner	*Notemigonus crysoleucas*	7	19
Green sunfish	*Lepomis cyanellus*	41	48
Largemouth bass	*Micropterus salmoides*	20	2
Mosquitofish	*Gambusia affinis*	50	0
Pirate perch	*Aphredoderus sayanus*	1	7
Redfin shiner	*Lythrurus umbratilus*	0	27
Slough darter	*Etheostoma gracile*	0	1
Tadpole madtom	*Noturus gyrinus*	1	0
White sucker	*Catostomus commersoni*	0	24
Yellow bullhead	*Ameiurus natalis*	0	12
Total Catch		196	254
Species Richness		11	17

Table 11. Total fish catch and species richness for each basin sampled in both 1998 and 1999.

	1998		1999	
	Total catch	Richness	Total catch	Richness
Hurricane Upper	3470	15	3975	15
Kickapoo Upper	1323	23	1248	24
Hurricane Lower	1165	26	2015	30
Kickapoo Lower	1821	24	993	28
Court Upper	1366	22	717	22
Haw Upper	410	18	241	18
Court Lower	2687	26	953	29
Haw Lower	774	23	348	21
Big Upper	688	17	2104	17
Cypress Upper	477	19	420	19
Big Lower	111	10	422	15
Cypress Lower	490	20	776	27

Table 12. Average fish species richness (+- one standard error) in Pilot and Reference streams for 1998 and 1999.

	1998		1999	
	Upper	Lower	Upper	Lower
Pilot	18.0	20.7	18.0	21.3
	(2.1)	(5.3)	(2.1)	(4.8)
Reference	20.0	22.3	20.3	23.3
	(1.5)	(1.2)	(1.8)	(2.6)

Table 13. Jaccard's similiarity index and Similiarity Ratios comparing fish composition in Upper and Lower sites within each basin in 1998 and 1999. Similarity Ratios based on catch per area as a measure of relative abundance

Jaccard's Index

	1998		1999	
Basin	Upper	Lower	Upper	Lower
Embarras	0.52	0.72	0.56	0.66
Spoon	0.60	0.75	0.60	0.43
Cache	0.57	0.25	0.50	0.50
Kaskaskia				0.47
Average			0.55	0.52
Std. Error			0.03	0.05
P-value				0.58

Similiarity Ratio*

	1998		1999	
Basin	Upper	Lower	Upper	Lower
Embarras	0.29	0.38	0.35	0.24
Spoon	0.45	0.32	0.33	0.17
Cache	0.13	0.10	0.17	0.89
Kaskaskia				0.31
Average			0.28	0.4
Std. Error			0.06	0.16
P-value				0.58

Table 14. Catch per hour of electroshocking time (CPUE) for Upper and Lower sites in each basin sampled in 1999 and mean CPUE for Pilot and Reference streams.

	Upper		Lower	
Basin	Pilot	Reference	Pilot	Reference
Embarras	4500.0	1540.7	2119.8	1241.3
Spoon	1034.6	361.5	1010.3	453.9
Cache	1451.0	630.0	803.8	1164.0
Kaskaskia			268.4	280.5
Mean	2328.5	844.1	1050.6	784.9
Std. Error	1092.4	356.9	389.2	244.3

Table 15. Mean length and weight of fish species collected in the Embarras basin in 1999. * denotes significant difference (t-test, $p < 0.05$).

Common Name	Mean Length (mm) Hurricane Upper	Mean Length (mm) Kickapoo Upper		Mean Weight (g) Hurricane Upper	Mean Weight (g) Kickapoo Upper		Mean Length (mm) Hurricane Lower	Mean Length (mm) Kickapoo Lower		Mean Weight (g) Hurricane Lower	Mean Weight (g) Kickapoo Lower	
Blackstripe topminnow							42.0			0.6		
Bluegill	25.8	67.6	*	0.2	4.2	*	34.6	63.6	*	0.9	3.9	*
Bluntnose minnow	36.3	57.1	*	0.6	1.6	*	53.7	54.3		1.2	1.3	
Brindled madtom		49.9			2.1			59.6			2.5	
Carp							290.7			313.0		
Central stoneroller	46.3	57.2	*	1.0	2.2	*	48.8	53.9	*	1.2	1.9	*
Channel catfish								43.5			1.0	
Creek chub	43.7	68.6	*	0.9	6.0	*	46.1	56.8	*	1.0	3.3	*
Dusky darter								75.3			3.3	
Fathead minnow								60.0			2.0	
Flathead catfish								41.0			0.7	
Gizzard shad		69.0			2.8		218.0	63.4	*	121.7	2.6	*
Golden redhorse							227.9			130.4		
Green sunfish		91.2			14.8		92.7	103.7		15.1	24.8	
Greenside darter	54.0			1.2			48.9	56.7		0.9	1.7	
Johnny darter	44.9	57.0		0.6	1.2		43.1	50.7	*	0.5	1.1	*
Largemouth bass	65.5	85.8		2.8	8.6		188.0	69.3	*	177.3	3.1	
Longear sunfish		84.1			13.6		103.1	77.5	*	22.0	9.5	*
Northern hog sucker		191.6			83.3		96.6	180.3	*	19.4	72.7	*
Orangethroat darter	39.1	47.2	*	0.5	1.0	*	36.0	43.8	*	0.4	0.9	*
Quillback							98.3			10.8		
Rainbow darter	40.2	47.0	*	0.6	0.9	*	35.7	42.9	*	0.4	0.8	*
Redear sunfish							98.0			15.2		
Redfin shiner							55.7	46.0		1.0	0.6	
Sand shiner		52.4			1.0		45.9	51.6	*	0.7	1.1	*
Silverjaw minnow	58.3	65.9	*	1.5	2.2	*	55.4	58.4	*	1.3	1.7	*
Silvery minnow		84.8			5.0		83.1	88.8		5.3	6.6	*
Spotfin shiner	46.9	49.4		1.0	1.0		48.2	49.0		0.8	0.9	
Spotted bass	57.0	54.0		1.7	1.4		145.5	148.5		47.7	85.7	
Spotted sucker							221.4			114.8		
Steelcolor shiner	69.3	54.4		1.9	1.3		53.1	60.8	*	1.1	2.0	*
Striped shiner		126.2			23.5		115.6			17.3		
Suckermouth minnow		79.8			5.0		52.6	64.5		1.2	3.6	
Warmouth		97.0			12.5							
White sucker	61.7	122.4	*	2.3	33.9	*	191.7	77.0	*	82.4	4.5	*
Yellow bullhead	45.8	61.5	*	1.2	2.8	*	39.5	51.0		0.9	1.6	
Total Biomass/Area (g/m^2)				2.0	7.5					37.3	2.5	

Table 16. Mean length and weight of fish species collected in the Spoon basin in 1999. * denotes significant difference (t-test, $p < 0.05$).

Common Name	Mean Length (mm) Court Upper	Mean Length (mm) Haw Upper	Mean Weight (g) Court Upper	Mean Weight (g) Haw Upper	Mean Length (mm) Court Lower	Mean Length (mm) Haw Lower	Mean Weight (g) Court Lower	Mean Weight (g) Haw Lower
Bigmouth shiner	47.6	32.0 *	0.9	0.3 *	47.5		1.0	
Blacknose dace	50.4	69.0	1.4	3.0	58.5	44.0 *	2.4	0.8 *
Bluegill	84.0	50.0 *	11.7	1.8 *	78.3	59.3	7.9	5.9
Bluegill x Green sunfish hybrid					108.0		24.0	
Bluntnose minnow	54.0	59.5	1.7	1.9	57.6	45.6 *	1.7	1.0 *
Central stoneroller	66.7	60.7	3.2	2.5	75.1		4.5	
Channel catfish					220.0	59.4	171.0	1.8
Creek chub	105.9	123.5	19.1	21.5	72.5	48.0	5.0	0.9
Fathead minnow		56.0		1.6		58.8		2.5
Flathead catfish	64.0		3.8			101.0		4.1
Golden redhorse	218.0	266.6 *	98.0	200.8 *	275.2	273.7	225.8	14.7
Green sunfish	103.5		23.0		68.0		5.2	
Highfin carpsucker	206.0		100.0					
Hornyhead chub		108.9		15.2	80.0	78.0	6.0	6.9
Johnny darter	48.0		0.8		57.3	48.0	1.5	0.8
Largemouth bass	95.3	152.3	11.0	63.1	98.5	86.5	10.4	7.8
Northern hogsucker					253.2	253.7	175.2	100.3
Orangethroat darter					51.7		1.8	
Quillback	48.7		1.4		228.1		153.1	
Rainbow darter					44.5		0.9	
Red shiner	51.7	51.9	1.5	1.4	51.3	48.1	1.6	1.1 *
Redfin shiner					54.2		1.2	
River carpsucker	48.5		1.4			158.0		52.0
Sand shiner	53.5	53.2	1.4	1.2 *	51.9	49.8	1.1	1.0
Silver redhorse						207.0		97.0
Silverjaw minnow					67.0		2.0	
Silvery minnow					85.0		4.9	
Slenderhead darter		69.0		2.8		66.3		2.5
Smallmouth bass	151.0		53.9		212.5		185.8	
Spotfin shiner					48.2		0.9	
Steelcolor shiner					52.2		1.1	
Stonecat	87.3	87.3	8.2	13.2	55.3	46.7	2.0	1.1
Striped shiner	168.0	139.5 *	52.7	27.3	108.5		12.4	
Suckermouth minnow	62.4	89.3 *	2.6	6.5	124.2	63.1	19.5	2.4
White sucker	169.0	171.9	55.9	50.6	46.3	185.5 *	1.4	65.4 *
Yellow bullhead	68.0	53.0	4.4	0.8		83.3		11.8
Total Biomass/Area (g/m^2)			6.2	5.8			10.0	2.9

Table 17. Mean length and weight of fish species collected in the Cache basin in 1999. *denotes significant difference (t-test, $p < 0.05$).

Common	Mean Length (mm)		Mean Weight (g)		Mean Length (mm)		Mean Weight (g)	
Name	Big Upper	Cypress Upper	Big Upper	Cypress Upper	Big Lower	Cypress Lower	Big Lower	Cypress Lower
Banded sculpin	47.4		1.4		49.7		1.3	
Bigmouth buffalo						290.0		400.0
Black bullhead		111.0		16.2		123.0		21.6
Blackside darter		53.6		1.3		59.9		1.5
Blackspotted topminnow	51.4	53.6	1.6	1.5	52.1	57.0	1.2	1.7
Bluegill	70.5	59.1 *	5.2	4.8	42.4	73.5 *	2.8	9.3 *
Bluegill x Green sunfish hybrid	102.0		17.6					
Bluntnose darter		42.0		0.4				
Bluntnose minnow	57.7	56.4	1.9	1.7	45.9	49.7 *	1.1	1.2
Carp						483.0		2466.7
Central stoneroller	75.1	54.1 *	1.7	1.6	54.6	57.7	1.5	2.1
Channel catfish						441.0		800.0
Creek chub	57.0	60.1	2.7	3.5	44.4	66.1 *	0.8	3.6 *
Creek chubsucker	60.0	56.3	2.1	1.7	67.0	74.7 *	2.9	4.6 *
Fantail darter	46.2		0.9					
Fringed darter	47.0		1.0					
Green sunfish	118.2	71.8 *	26.4	9.5 *	127.0	97.0	23.6	17.5
Johnny darter						40.6		0.3
Largemouth bass	61.6	218.0	2.9	31.6	155.3	107.8	13.9	38.8
Longear sunfish	79.5	86.8	8.6	11.8	71.3	70.3	8.3	5.9
Mosquitofish						34.1		0.5
Pirate perch		60.6		3.4	62.5	70.0	3.4	5.6
Red shiner					35.0	33.5	0.4	0.3
Redfin shiner	73.0	57.0 *	3.0	1.5 *	47.0	30.3 *	1.0	0.2 *
Shorthead redhorse		130.0		25.6		138.0		33.8
Slough darter		42.0		0.5		42.7		0.5
Spotted bass						88.7		8.6
Spotted sucker						107.3		29.1
Suckermouth minnow						70.0		3.1
Tadpole madtom		31.0		0.3	40.3	51.5	1.7	1.9
White sucker	61.1	81.9	2.3	5.6	100.9	96.2	11.0	9.3
Yellow bullhead	122.8	45.3 *	8.6	1.2		78.3		7.2
Total Biomass/Area (g/m^2)			5.3	3.1			2.8	101.9

Table 18. Mean length and weight of fish species collected in the Kaskaskia basin in 1999. *denotes significant difference (t-test, $p < 0.05$).

Common Name	Mean Length (mm) Lake Branch Lower	Mean Length (mm) Lost Lower		Mean Weight (g) Lake Branch Lower	Mean Weight (g) Lost Lower	
Blackstripe topminnow	56.8	50.6		1.9	1.1	*
Bluegill	92.2	55.5	*	14.7	3.5	*
Bluegill x Green sunfish hybrid	94.0	102.0		10.0	18.0	
Bluntnose minnow		38.1			0.4	
Carp	200.2	293.4	*	112.3	428.4	*
Central stoneroller		116.5			30.0	
Creek chub		153.0			40.3	
Creek chubsucker		175.0			65.0	
Gizzard shad	178.0	212.7		69.0	108.5	
Golden shiner	124.3	122.5		18.0	17.3	
Green sunfish	73.2	59.7	*	8.0	7.9	
Largemouth bass	97.8	194.0		11.9	95.5	
Mosquitofish	34.9			0.5		
Pirate perch	104.0	65.0		16.0	4.2	
Redfin shiner		35.2			0.4	
Slough darter		47.0			0.7	
Tadpole madtom	85.0			6.4		
White sucker		217.1			116.6	
Yellow bullhead		199.3			112.9	
Total Biomass/Area (g/m^2)				5.9	8.7	

Table 19. Index of Biotic Integrity scores, individual metric values and actual values for each metric (in parenthesis) for all sites sample in 1999. Proportions are percents and number of individuals are catch per hour. *Note that IBI scores from 1998 have changed from the 1998 Annual Report due to changes in criteria for Proportion of piscivores and Proportion of diseased fish.

	Hurricane Upper	Kickapoo Upper	Hurricane Lower	Kickapoo Lower	Court Upper	Haw Upper	Court Lower	Haw Lower	Big Upper	Cypress Upper	Big Lower	Cypress Lower	Lake Branch Lower	Lost Lower
Species Richness and Composition														
Number of fish species	3 (15)	5 (24)	5 (30)	5 (28)	5 (22)	5 (18)	5 (29)	5 (21)	5 (17)	5 (19)	3 (15)	5 (27)	3 (11)	5 (17)
Number of darter species	5 (4)	3 (3)	5 (4)	5 (5)	1 (1)	1 (1)	3 (3)	3 (2)	3 (2)	3 (3)	1 (0)	3 (3)	1 (0)	1 (1)
Number of sunfish species	1 (1)	5 (4)	5 (4)	3 (3)	3 (2)	3 (1)	3 (2)	3 (2)	3 (3)	3 (3)	3 (3)	3 (3)	3 (2)	3 (2)
Number of sucker species	1 (1)	3 (2)	5 (5)	1 (2)	5 (5)	3 (2)	3 (4)	5 (5)	3 (2)	5 (3)	3 (2)	5 (5)	1 (0)	3 (2)
Number of intolerant species	3 (5)	5 (8)	5 (8)	5 (10)	3 (4)	3 (3)	5 (9)	3 (5)	3 (4)	3 (3)	1 (2)	3 (3)	1 (0)	1 (0)
Proportion of green sunfish	5 (0)	5 (0.4)	5 (0.7)	5 (0.7)	5 (0.3)	5 (0)	5 (0.1)	5 (2)	5 (0.3)	5 (1.2)	5 (0.2)	5 (0.4)	1 (20.9)	3 (18.9)
Trophic Composition														
Proportion of omnivores	5 (2)	5 (4)	3 (26)	5 (18)	5 (10)	3 (25)	3 (27)	5 (10)	5 (5)	3 (20)	1 (50)	1 (52)	5 (20)	3 (21)
Proportion of insectivores	5 (48)	5 (61)	3 (43)	5 (63)	5 (74)	5 (49)	5 (51)	5 (70)	3 (23)	3 (24)	1 (12)	1 (9)	1 (0)	1 (11)
Proportion of piscivores	1 (0.1)	1 (0.4)	1(0.5)	1(0.8)	3 (1.8)	3 (1.7)	1 (0.7)	3 (4.9)	1 (0.8)	1 (0.2)	1 (0.7)	3 (1.7)	5 (10.2)	1 (0.8)
Fish Abundance and Condition														
Number of individuals	5 (4500)	5 (1540)	5 (2120)	5 (1241)	5 (1034)	3 (362)	5 (1010)	3 (454)	5 (1451)	5 (630)	5 (804)	5 (1164)	1 (268)	1 (280)
Proportion of hybrids	5 (0)	5 (0)	5 (0)	5 (0)	5 (0)	5 (0)	3 (0.1)	5 (0)	3 (0.05)	5 (0)	5 (0)	5 (0)	3 (0.5)	3 (0.4)
Proportion of diseased fish	5 (0)	5 (0)	3 (0.2)	5 (0)	5 (0)	1 (2.9)	3 (0.3)	3 (0.6)	3 (0.6)	5 (0)	5 (0)	3 (0.1)	5 (0)	1 (2.4)
Total IBI Score 1999	44	52	50	50	50	40	41	48	42	46	34	42	30	26
Total IBI Score 1998 *	42	48	50	48	42	40	50	50	44	50	34	44		

Table 20. Mean age of major fish species caught at each site in 1998 and 1999 combined.

Species	Hurricane Upper	Kickapoo Upper	Hurricane Lower	Kickapoo Lower	Court Upper	Haw Upper	Court Lower	Haw Lower	Big Upper	Cypress Upper	Big Lower	Cypress Lower	Lk Branch Lower	Lost Lower
Largemouth bass		1.0	2.5	3.0	0.0	1.3		0.0	1.2	1.5	1.5	4.0		2.5
Smallmouth bass					1.7		2.3	5.0						
Bluegill		1.5	2.2	1.0	1.6		1.5	2.0	2.3	3.7	1.7	3.0	2.7	4.0
Green sunfish		2.0	3.0	3.3	2.0		1.0	2.8	3.0	5.0	1.0	1.5	2.6	2.4
Longear sunfish		3.0	3.5	2.7					3.6	3.4	3.2	1.6		1.5
White sucker			1.7		2.4	3.3		2.7	3.3	3.6		4.7		
Golden redhorse			1.6		2.3	3.9	3.2	3.6						
Creek chub			1.0		1.0	2.6			2.1	1.5				

Table 21. List of taxa collected in glide/pool habitats in Upper sites of the Embarras Basin in 1998 and 1999. Values for each taxa are in numbers per square meter.

Taxa				Fall 98 Hurricane Upper	Spring 99 Kickapoo Upper
Cyclopoida				80.2	46.8
Diptera				160.4	
	Ceratopogonidae		Dasyhelea	80.2	
			Probezzia	80.2	
	Chironomidae			1603.9	93.6
			pupae		467.8
		Chironominae			
			Chironomus		701.7
			Cladotanytarsus	47475.0	1122.7
			Cryptochironomus		140.3
			Dicrotendipes		93.6
			Endochironomus		46.8
			Krenopsectra		46.8
			Paracladopelma	12510.3	701.7
			Paratanytarsus		46.8
			Paratendipes	320.8	140.3
			Polypedilum	22133.6	935.6
			Tanytarsus	641.6	233.9
		Orthocladiinae			187.1
			Cricotopus		233.9
			Cricotopus/Orthocladius	320.8	1263.1
			Diplocladius		46.8
			Eukiefferiella		187.1
		Tanypodinae	Ablabesmyia	1283.1	
			Djalmabatista	320.8	
Odonata	Gomphidae		Progomphus		46.8
Oligocheata				9302.5	6596.0
Ostracoda					46.8
Plecoptera				80.2	
Trichoptera	Hydropsychidae				46.8
Total CPA				96393.4	13472.6
Total Taxa Richness				15	23

Table 22. List of taxa collected in glide/pool habitats in Lower sites of the Embarras Basin in 1998 and 1999. Values for each taxa are in numbers per square meter.

Taxa				Fall 98 Kickapoo Lower	Spring 99 Hurricane Lower	Spring 99 Kickapoo Lower
Bivalvia				20957.4		
	Corbiculidae		Corbicula			467.8
Coleoptera	Hydrophilidae				102.1	
	Elmidae					46.8
			Dubiraphia	62.4		
			Stenelmis	62.4		
Cyclopoida				62.4	1888.2	46.8
Diptera				62.4	612.4	
	Ceratopogonidae		Bezzia		102.1	280.7
			Culicoides	187.1		
			Dasyhelea	1871.2	153.1	
			Probezzia	187.1		
			Stilobezzia	62.4		
	Chironomidae			1497.0	408.3	46.8
			pupae			46.8
		Chironominae		249.5	306.2	46.8
			Apedilum		51.0	
			Chironomus		1582.0	
			Cladotanytarsus	21456.4	3215.1	
			Coryoneura		51.0	
			Cryptochironomus	249.5		
			Dicrotendipes	249.5	612.4	
			Einfeldia		51.0	
			Micropsectra		51.0	
			Parachironomus	998.0	204.1	
			Paracladopelma	1995.9	612.4	608.1
			Paralauterborniella	249.5	51.0	
			Paratendipes			46.8
			Polypedilum	12724.1	663.4	140.3
			Rheotanytarsus			93.6
			Subletta			46.8
			Tanytarsus	3991.9	1020.7	140.3
			Tribelos			93.6
		Orthocladiinae				280.7
			Coryoneura	249.5		
			Cricotopus		459.3	187.1
			Cricotopus/Orthocladius		255.2	654.9
			Eukiefferiella	249.5		93.6
			Orthocladius			46.8
			Rheocricotopus		51.0	
		Tanypodinae	Ablabesmyia	249.5		
	Culicidae		Culex		51.0	
	Empididae		Hemerodromia	62.4		
Ephemeroptera	Baetidae			187.1	459.3	46.8
	Caenidae		Caenis	62.4		
	Ephemerellidae					421.0
	Heptageniidae					93.6
			Stenacron	62.4		
			Stenonema		51.0	514.6
	Isonychiidae		Isonychia			46.8

Table 22. continued.

Taxa				Fall 98 Kickapoo Lower	Spring 99 Hurricane Lower	Spring 99 Kickapoo Lower
Gastropoda	Ancylidae		Ferissia	2931.5		
Harpacicoida					663.4	
Hydrachnida				62.4		
Oligocheata				36925.0	8930.7	7017.0
Ostracoda				4116.6		
Plecoptera	Nemouridae	Amphinemurinae	Amphinemura			46.8
Nematoda	Rhabditidae		Rhabditis		51.0	
Trichoptera	Hydropsychidae	Hydropsychinae	Hydropsyche			93.6
Total CPA				112334.3	22709.5	11695.0
Total Taxa Richness				30	28	27

Table 23. List of taxa collected in run habitat in Lower sites of the Embarras Basin in 1999. Values for each taxa are in numbers per square meter.

Taxa				Spring 99 Hurricane Lower
Diptera	Chironomidae		pupae	561.4
		Chironominae		1684.1
			Cladotanytarsus	10665.8
			Parachironomus	1122.7
			Polypedilum	5613.6
			Saetheria	3929.5
			Tanytarsus	1122.7
		Orthocladiinae		1684.1
			Cricotopus	6736.3
			Orthocladius	1684.1
			Psectrocladius	561.4
			Thienemanniella	6736.3
Ephemeroptera	Heptageniidae/Leptophlebiidae			561.4
Oligocheata				111710.5
Total CPA				154373.8
Total Taxa Richness				14

Table 24. List of taxa collected in glide/pool habitats in Upper sites of the Spoon Basin in 1998 and 1999. Values for each taxa are in numbers per square meter.

Taxa				Fall 98 Court Upper	Fall 98 Haw Upper	Spring 99 Court Upper	Spring 99 Haw Upper	Fall 99 Court Upper	Fall 99 Haw Upper
Bivalvia							204.1		56.1
Calanoida									112.3
Cladocera									2301.6
Coleoptera	Elmidae				62.4				
			Dubiraphia		374.2		102.1	102.1	842.0
			Optioservus					51.0	
			Stenelmis				51.0		
	Hydrophilidae						51.0		
Collembola						51.0			
Cyclopoida				2432.6	623.7		204.1	918.6	3368.2
Diptera								102.1	
	Ceratopogonida		Culicoides		124.7				
			Ceratopogon	187.1					
			Culicoides	62.4					
		Ceratopogoninae	Mallochohelea	124.7	62.4				
			Probezzia	311.9	686.1		51.0		
			Stilobezzia			102.1			
	Chironomidae			1746.5	249.5		408.3	1122.7	280.7
			pupae		311.9	102.1			
		Chironominae		249.5		102.1			
			Apedilum		311.9				
			Chironomus	499.0	5114.6		51.0	408.3	224.5
			Cladotanytarsus	7983.8	124.7	663.4		11635.4	449.1
			Constempellina			51.0			
			Corynoneura				51.0		
			Cryptochironomus	374.2	810.9		51.0	306.2	1291.1
			Cryptotendipes				51.0		
			Dicrotendipes	499.0	249.5			612.4	617.5
			Microtendipes		62.4				
			Parachironomus			51.0			
			Paracladopelma	623.7		153.1	102.1	102.1	168.4
			Paralauterborniella						336.8
			Paratendipes						112.3
			Polypedilum	13597.4	249.5	102.1	51.0	7348.7	4154.1
			Saetheria					612.4	
			Stempellinella	499.0				408.3	
			Tanytarsus	374.2	810.9		102.1	816.5	112.3
		Orthocladiinae				153.1	51.0		
			Cricotopus		62.4	102.1			
			Cricotopus /Orthocladius		187.1	51.0			168.4
			Eukiefferiella			153.1			
			Hydrobaenus			51.0			
			Parakiefferiella		686.1	153.1	561.4		112.3
			Rheocricotopus	124.7					
			Tvetenia			153.1			
		Tanypodinae	Larsia						56.1
			Nilotanypus					102.1	
			Procladius		62.4			102.1	
			Tanypus	124.7					
	Empididae				62.4				
			Hemerodromia	62.4					56.1

Table 24 continued.

Taxa				Fall 98 Court Upper	Fall 98 Haw Upper	Spring 99 Court Upper	Spring 99 Haw Upper	Fall 99 Court Upper	Fall 99 Haw Upper
	Simuliidae		Cnephia			51.0			
	Tabanidae		Chrysops		187.1				
	Tipulidae						51.0		
Ephemeroptera					62.4	102.1	51.0		
	Baetidae				124.8	51.0	51.0	51.0	
	Caenidae		Caenis	374.2				663.4	
	Ephemerellidae				62.4				
	Ephemeridae		Hexagenia	187.1					
	Heptageniidae			62.4					
			Stenonema	62.4	62.4				
	Tricorythidae		Tricorythodes		124.7				
Gastropoda					249.5				
	Ancylidae		Ferrissia		873.2				
Hemiptera	Corixidae			187.1				714.5	
		Corixinae			187.1				
Hirudinoidea	Glossiphoniidae		Batracohdella		62.4				
Hydrachnida						51.0	51.0		
Mysidacea						51.0			
Odonata	Coenagrionidae			62.4					
Oligocheata				1933.6	14907.2	2347.6	14493.3	6379.1	11283.3
Ostracoda				7297.7	124.7		51.0	102.1	168.4
Plecoptera					62.4	51.0			
Trichoptera					62.4				
	Hydropsychidae			62.4		51.0			56.1
			Cheumatopsyche		124.7				112.3
	Leptoceridae			187.1					
			Oecetis	62.4					
Total CPA				40356	28567	4950	16892	32660.9	26440
Total Taxa Richness				29	36	24	22	21	23

Table 25. List of taxa collected in glide/pool habitats in Lower sites of the Spoon Basin in 1998 and 1999. Values for each taxa are in numbers per square meter.

Taxa				Fall 98		Spring 99	
				Court Lower	Haw Lower	Court Lower	Haw Lower
Calanoida						56.1	
Coleoptera	Elmidae				62.4		
			Dubiraphia	187.1	623.7		
Collembola	Isotomidae				62.4		
Cyclopoida				374.2	187.1		62.4
Diptera	Chironomidae			798.4		56.1	
	Chironomidae		pupae	187.1		112.3	
		Chironominae			124.7	112.3	62.4
			Apedilum				187.1
			Chironomus		561.4	112.3	
			Cladotanytarsus	11177.3	311.9	112.3	873.2
			Cryptochironomus	4790.3	187.1		
			Cryptotendipes				62.4
			Dicrotendipes	798.4	62.4		
			Paracladopelma	2395.1		336.8	187.1
			Paralauterborniella	898.2			
			Paratendipes	798.4	62.4		
			Polypedilum	60277.5	249.5	112.3	
			Saetheria		62.4		
			Stempellina	598.8			
			Tanytarsus	3193.5			
		Orthocladiinae					62.4
			Cricotopus				124.7
			Cricotopus/ Orthocladius	299.4			187.1
			Limnophyes		62.4		
			Parakiefferiella				1808.8
			Rheosmitta	299.4		56.1	
			Thienemanniella			112.3	124.7
		Tanypodinae	Larsia	299.4			
			Macropelopia		62.4		
			Paramerina		62.4		
			Pentaneura		124.7		
			Procladius		62.4	56.1	
	Tipulidae					112.3	
Ephemeroptera	Caenidae				62.4		
	Ephemeridae		Hexagenia		124.7		
	Isonychiidae		Isonychia			56.1	
Ephemeroptera/Odonata [redacted]Plecoptera						56.1	
[redacted]arpacticoid				748.5			
Hemiptera	Corixidae			873.2			
		Corixinae			1684.1		
[redacted]ydrachnida					62.4		62.4
Oligocheata				6299.7	3742.4	1178.9	3680.0
[redacted]tracoda				187.1	62.4		
[redacted]choptera	Leptoceridae		Oecetis		124.7		
Total CPA				95481.0	8794.6	2638.4	7484.8
T[redacted]l Taxa Richness				20	24	15	13

Table 26. List of taxa collected in glide/pool habitats in Upper sites of the Cache Basin in 1998 and 1999. Values for each taxa are in numbers per square meter.

Taxa				Fall 98	Spring 99		Summer 99
				Cypress Upper	Big Upper	Cypress Upper	Cypress Upper
Acarina					18.7		
Amphipoda					517.6		
	Gammaridae		Gammarus		555.0		
Bivalvia					6.2		93.6
	Sphaeriidae	Pisidiinae	Pisidium			93.6	
		Sphaeriinae	Sphaerium				327.5
Calanoida							140.3
Coleoptera	Elmidae		Stenelmis	80.2	62.4		
			Dubiraphia				46.8
			Stenelmis				
Copepoda					6.2		
Cyclopoida				320.8	661.0	233.9	
Decopoda	Cambaridea				12.5		
Diptera					62.4		
	Chironomidae			320.8	24.9	93.6	46.8
	Chironomidae		pupae			140.3	
		Chironominae		240.6	12.5	280.7	
			Apedilum	80.2			
			Axarus				46.8
			Chironomus	80.2	149.7	1122.7	93.6
			Cladopelma				46.8
			Cladotanytarsus	1764.3	56.1	701.7	
			Cryptochironomus	1283.1		654.9	
			Cyptotendipes	80.2			
			Dicrotendipes	160.4	56.1		
			Glypototendipes	80.2	6.2		93.6
			Krensopsectra	80.2			
			Microtendipes	80.2	93.5		
			Nilothauma	80.2			
			Paracladopelma	80.2	6.2		
			Paralauterborniella	240.6		93.6	
			Paratanytarsus	401.0	24.9		
			Paratendipes	1363.3	274.4	2245.4	46.8
			Polypedilum	2967.2	149.7	608.1	46.8
			Rhotanytarsus	80.2			
Diptera	Chironomidae	Chironominae	Saetheria			140.3	
			Sergentia		6.2		
			Stempellinella	80.2			
			Stictochironomus	561.4	12.5	982.4	795.3
			Sublettea	80.2			
			Synendotendipes	80.2			
			Tanytarsus	1042.5	68.6	1684.1	140.3
			Tribelos			93.6	140.3
		Orthocladiinae			24.9	233.9	
			Brillia	160.4			
			Corynoneua		24.9		
			Cricotopus	80.2	18.7		
			Cricotopus/ Orthocladius		24.9		
			Cryptochironomus		49.9		
			Diplocladius			46.8	

Table 26. Continued.

Taxa				Fall 98 Cypress Upper	Spring 99 Big Upper	Spring 99 Cypress Upper	Summer 99 Cypress Upper
			Hydrobaenus			93.6	
			Nanocladius	80.2		93.6	
			Orthocladius		18.7	46.8	
			Parametrianemus	80.2			
			Thienmanniella	80.2	6.2		
			Tvetenia	80.2			
		Tanypodinae					46.8
			Ablabesmyia	160.4	37.4		
			Krenopelopia		24.9		
			Larsia			46.8	
			Natarsia			46.8	233.9
			Nilotanypus		6.2		
			Paramerina		24.9		
			Procladius		6.2	187.1	421.0
			Thienemanimyia	481.2			
			Trissopelopis		18.7		
	Simulidae				12.5	46.8	
	Stratiomyidae		Stratiomys			46.8	
	Tabanidae					93.6	
			Chrysops	80.2			
	Tipulidae			80.2			
Emphemeroptera	Baetidae			80.2	49.9		
	Heptageniidae		Stenonema		49.9		
	Heptageniidae/ Leptophlebiidae				31.2	46.8	
	Caenidae			160.4			
Harpacticiod					6.2		
Hirudinae					74.8		
Hydrachnida						46.8	
Isopoda	Asellidae		Caecidotea		124.7	46.8	
Megaloptera	Sialidae		Sialis		12.5		
Nematoda	Mermithidae					93.6	
	Tylenchidae						
Oligocheata				8099.6	1309.5	17074.7	31389.3
Ostracoda					18.7	140.3	46.8
Plecoptera						46.8	
	Perlodidae			240.6			
Trichoptera	Hydropsychidae	Hydropsychinae	Chematopsyche	80.2	6.2	46.8	
Total CPA				21732.6	4826.4	27693.7	34242.9
Total Taxa Richness				40	47	34	19

Table 27. List of taxa collected in glide/pool habitats in Lower sites of the Cache Basin in 1998 and 1999. Values for each taxa are in numbers per square meter.

Taxa				Fall 98 Big Lower	Fall 98 Cypress Lower	Spring 99 Big Lower	Spring 99 Cypress Lower	Fall 99 Cypress Lower
Acarina				46.8				
Amphipoda	Gammaridae		Gammarus			172.7		
Annelida						86.4		
Anomopoda	Chydoridae				46.8			
		Chydorinae	Alonopsis				46.8	
Bivalvia					280.7	43.2	561.4	5847.5
	Sphaeriidae				93.6		46.8	
Braciopoda						43.2		
Coleoptera	Elmidae		Dubiraphia	93.6	280.7	259.1	46.8	46.8
			Optioservus	46.8				
			Stenelmis		140.3		46.8	
Coleoptera/Megaloptera /Plecoptera						259.1		
Collembola					46.8		46.8	
Cyclopoida				467.8	46.8	604.6	233.9	140.3
Diptera				46.8		86.4		
Diptera	Ceratopogonidae			46.8		259.1		
			Bezzia	46.8				
			Ceratopogon					93.6
			Culicoides					93.6
			Mallochehelea		46.8			46.8
			Probezzia		327.5			514.6
			Serromyia					46.8
			Stilobezzia				140.3	
	Chironomidae			935.6	93.6	518.2	140.3	93.6
	Chironomidae		pupae			86.4	93.6	
		Chironominae		374.2		129.5	93.6	
			Axarus				46.8	
			Chironomus		421.0		280.7	1169.5
			Cladopelma		46.8			
			Cladotanytarsus	20396.1	233.9	863.6	140.3	
			Cryptochironomus	2432.6	467.8	302.3	280.7	46.8
			Dicrotanytarsus	561.4				
			Dicrotendipes		140.3			93.6
			Krenopsectra		46.8			
			Parachironomus		46.8		93.6	
			Parachironomus					
			Paralauterborniella	374.2	187.1	302.3	140.3	
			Paratanytarsus	187.1	46.8	1036.4	93.6	
			Paratendipes			172.7	140.3	
			Phaenopsectra				233.9	
			Polypedilum	7110.6	608.1	1597.7	467.8	
			Rheotanytarsus			172.7		
			Saetheria	2993.9		86.4		
			Stictochironomus		93.6		421.0	
			Subletta		46.8	43.2		
			Tanytarsus	2993.9	187.1	86.4	514.6	187.1
			Tribelos		93.6		888.8	

Table 27. Continued.

Taxa				Fall 98 Big Lower	Fall 98 Cypress Lower	Spring 99 Big Lower	Spring 99 Cypress Lower	Fall 99 Cypress Lower
		Orthocladiinae				43.2		
			Corynoneura			43.2		
			Cricotopus		46.8	43.2		
			Hydrobaenus	187.1				
			Nanocladius	187.1				
			Psectrocladius			43.2		
		Tanypodinae	Ablabesmyia	374.2	421.0	86.4	280.7	
			Alotanypus		46.8			
			Clinotanypus					140.3
			Labrundinia	374.2				
			Larsia	561.4	46.8		93.6	
			Paramerina		187.1			
			Procladius		140.3	86.4	1543.7	374.2
			Psectrotanypus			43.2		
			Tanypus					46.8
			Thienemannimyia group		46.8	43.2		
Ephemeroptera	Baetidae			140.3	46.8	86.4		
	Caenidae		Caenis	233.9	561.4	43.2	187.1	46.8
	Ephemerellidae	Ephemerellinae	Ephemerella			43.2		
	Heptageniidae			46.8				
	Heptageniidae		Stenacron		233.9		93.6	
Hemiptera	Corixidae							655.0
Hydrachnida						129.5	46.8	
Isopoda	Asellidae		Caecidotea			129.5	46.8	
Megaloptera	Sialidae		Sialis	46.8		215.9	280.7	
Odonata	Coenagrionidae			93.6				
			Argia	140.3				
Oligocheata				12162.8	14080.8	18611.2	24091.7	18665.2
Ostracoda				140.3			233.9	467.8
Plecoptera					46.8		93.6	46.8
Pulmonata	Physidae		Physa				46.8	
Rhynchobdellida	Glossiphoniidae		Batracobdella					46.8
Trichoptera	Hydropsychidae		Ceratopsyche	46.8	46.8			
	Hydroptilidae		Tascobia			43.2		
	Hydroptilidae	Hydroptilinae	Hydroptila			43.2		
	Polycentropodidae			93.6				
	Psychomyiidae		Psychomyia			43.2		
Total CPA				53984.1	20021.9	27031.8	32278.2	28910.1
Total Taxa Richness				32	37	40	36	22

Table 28. List of taxa collected in glide/pool habitats in Lower sites of the Kaskaskia Basin in 1999. Numbers of each taxa are in numbers per square meter.

Taxa				Fall 99 Lake Branch Lower
Bivalvia				421.0
Coleoptera	Scirtidae		Cyphon	46.8
Cyclopoida				280.7
Diptera	Ceratopogonidae	Ceratopogoninae	Ceratopogon	187.1
			Culicoides	233.9
			Mallochohelea	327.5
			Palpomyia	374.2
			Probezzia	327.5
			Serromyia	46.8
			Sphaeromias	140.3
			Stilobezzia	93.6
	Chaoboridae		Chaoborus	187.1
	Chironomidae	Chironominae	Chironomus	93.6
			Dicrotendipes	374.2
			Kiefferulus	187.1
			Polypedilum	46.8
		Tanypodinae	Clinotanypus	46.8
		Tanypodinae	Procladius	46.8
		Tanypodinae	Tanypus	140.3
Megaloptera				46.8
	Sialidae		Sialis	46.8
Nematoda	Mermithidae			46.8
Odonata	Corduliidae	Corduliinae	Somatochlora	46.8
Oligocheata				18103.8
Ostracoda				5239.4
Total CPA				27132.4
Total Taxa Richness				25

Table 29. Family Biotic Index (FBI) and Percent Emphemeroptera, Plecoptera, and Tricoptera (%EPT) for glide habitats at each site. Indices left blank are those sites in which macroinvertebrates have not yet been identified.

	Spring 99		Summer 99		Fall 98		Fall 99	
Site	FBI	%EPT	FBI	%EPT	FBI	%EPT	FBI	%EPT
Hurricane Upper					6.58	0.26		
Kickapoo Upper	6.97	0.35						
Hurricane Lower	6.96	2.25						
Kickapoo Lower	6.96	10			7.43	0.61		
Court Upper	6.78	5.15			6.86	3.7	6.82	3.42
Haw Upper	7.71	0.6			7.11	1.97	7.23	0.64
Court Lower	6.64	2.13			6.78	NA		
Haw Lower	6.98	NA			7.26	3.55		
Big Upper	6.91	2.23						
Cypress Upper	7.25	0.34	7.83	NA	6.7	2.58		
Big Lower	7.3	0.96			7.07	2.34		
Cypress Lower	7.52	1.16			7.38	4.23	7.8	0.32
Lake Branch Lower							7.75	NA
Lost Lower								
Hurricane Lower (Run)	7.44							

Water Quality based on FBI Scores*

FBI	Water Quality
0.00 - 3.75	Excelllant
3.76 - 4.25	Very Good
4.26- 5.00	Good
5.01 - 5.75	Fair
5.76 - 6.50	Fairly Poor
6.51 - 7.25	Poor
7.26 - 10.00	Very Poor

* from Hilsenhoff (1988)

Table 30. Percent Similarity values for Upper and Lower sites within each Basin. Similarity based on FBI. Values left blank can not be computed due to one or both sites within a basin not containing an FBI index value.

Basin	Spring 99	Fall 98
Embarras Upper		
Embarras Lower	100.03	
Spoon Upper	113.79	
Spoon Lower	105.2	107.18
Cache Upper	104.97	
CacheLower	103.06	

% Similarity	Condition
>= 85%	Very Similar
70-84%	Moderately Similar
50-69%	Slightly Similar
< 50%	Different

* modified from Plafkin (1989)

Figure 1. Location of the four river basins with their corresponding pilot and reference watersheds.

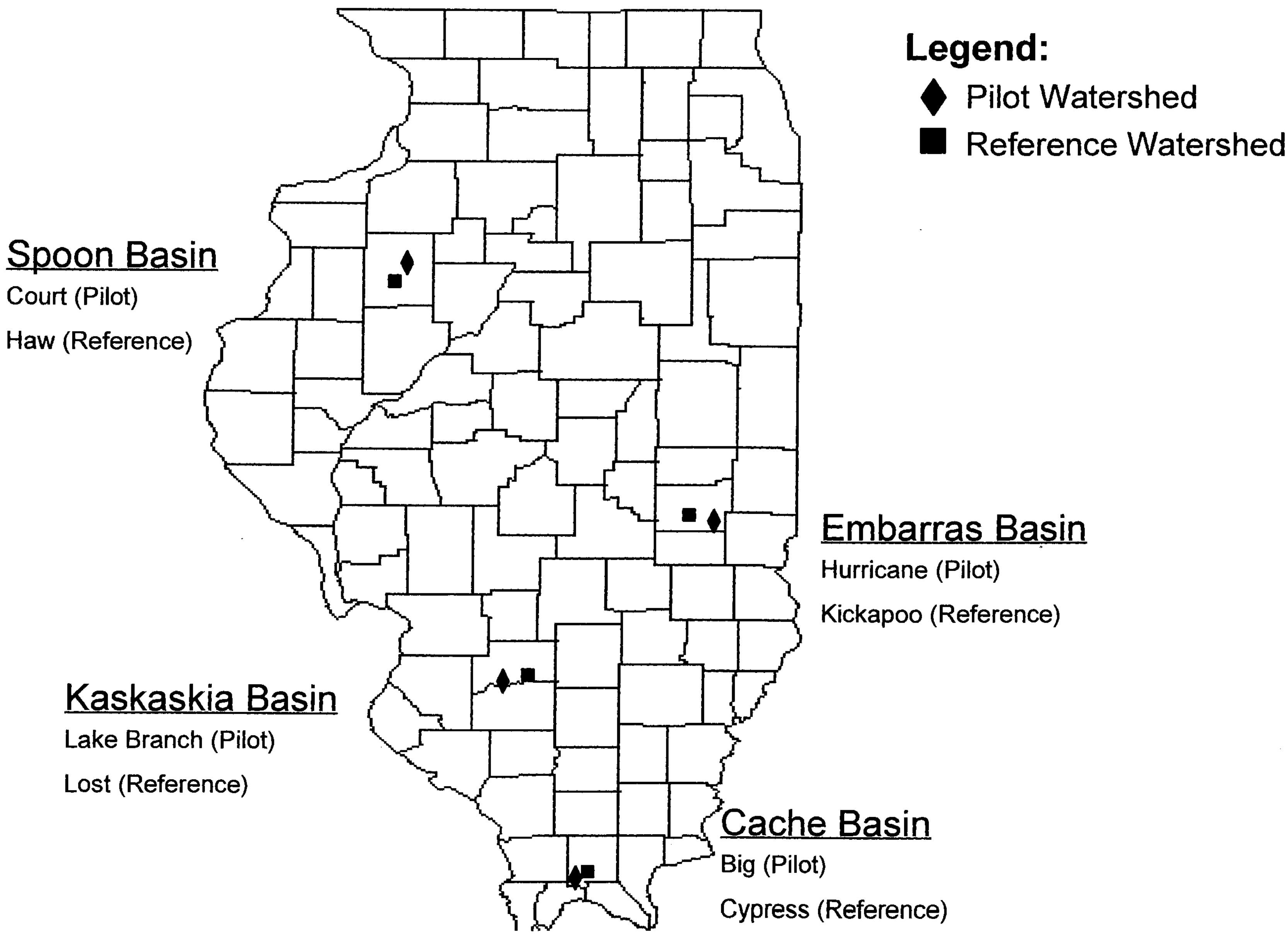
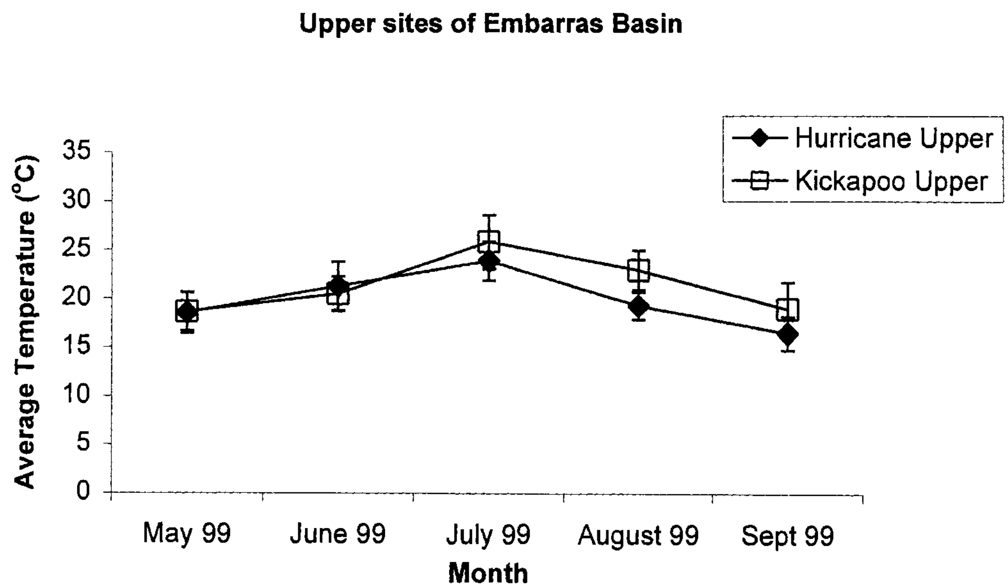
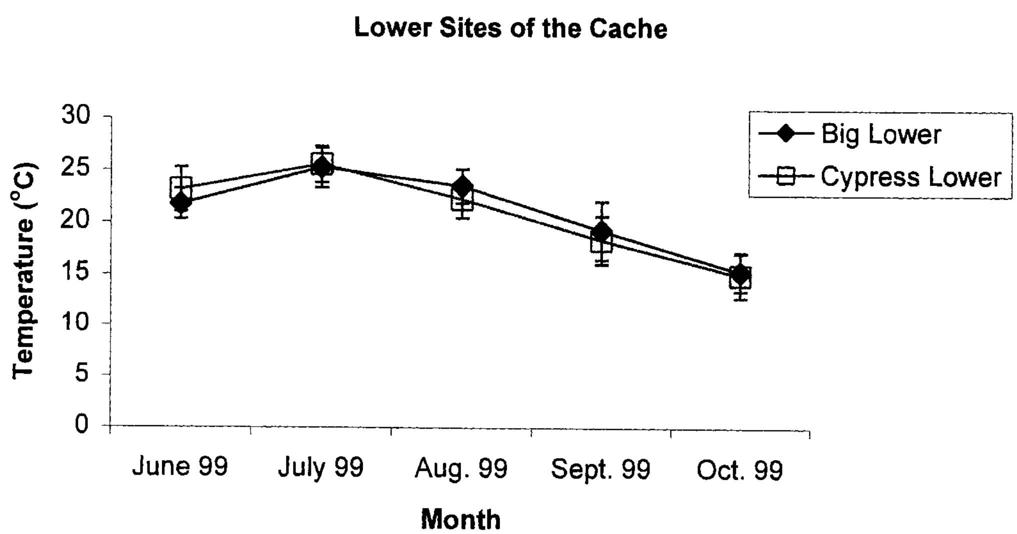


Figure 2. Average temperature (+- one standard error) for the Embarras, Cache, and Kaskaskia basins





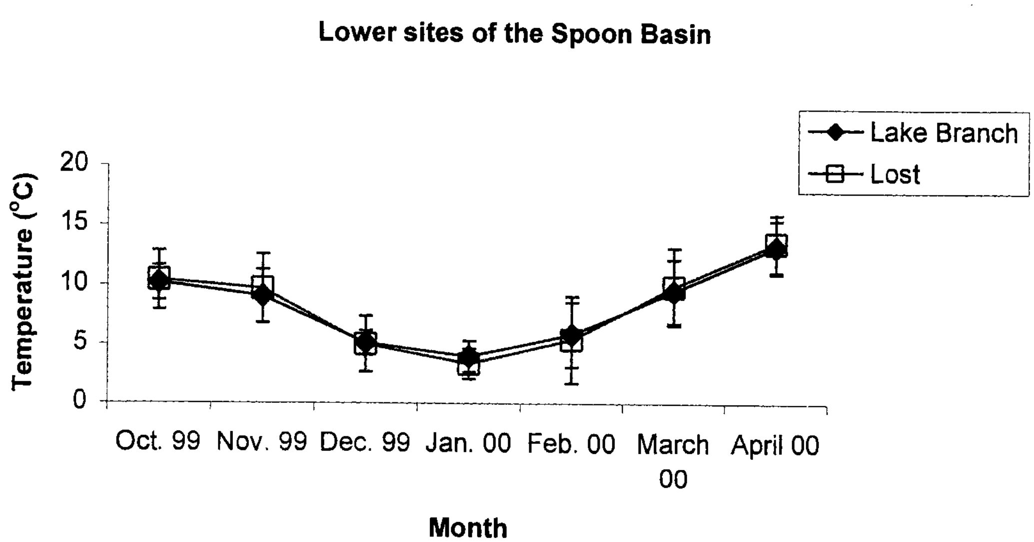
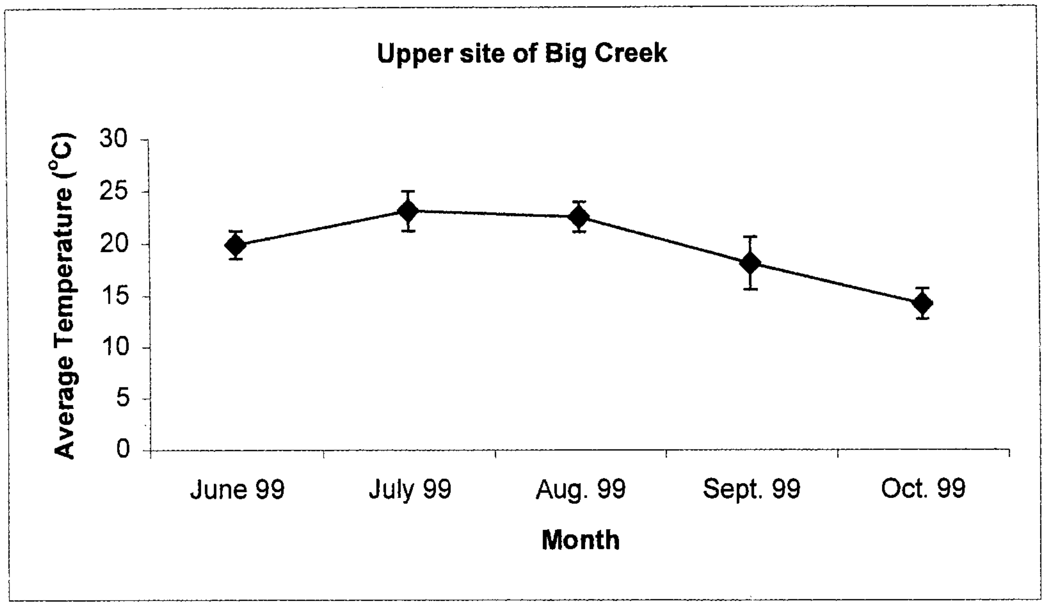


Figure 3. Average temperatures (+- one standard error) for the Big Creek Upper site and the Haw Lower site.



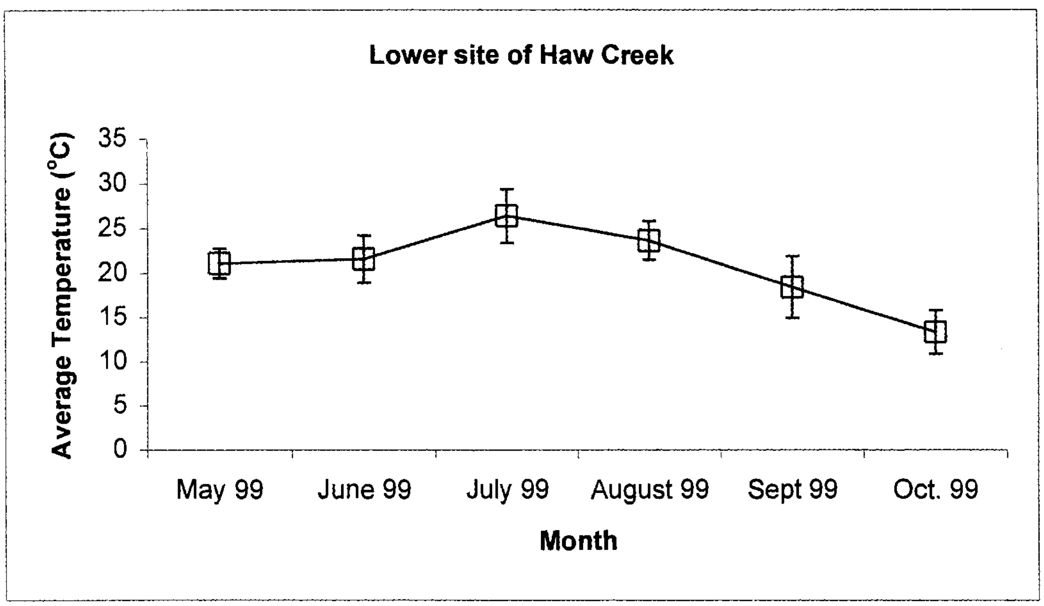


Figure 4. Percent habitat types for the Upper and Lower sites in the Embarras Basin in 1998 and 1999. (P) denotes pilot and (R) denotes reference.

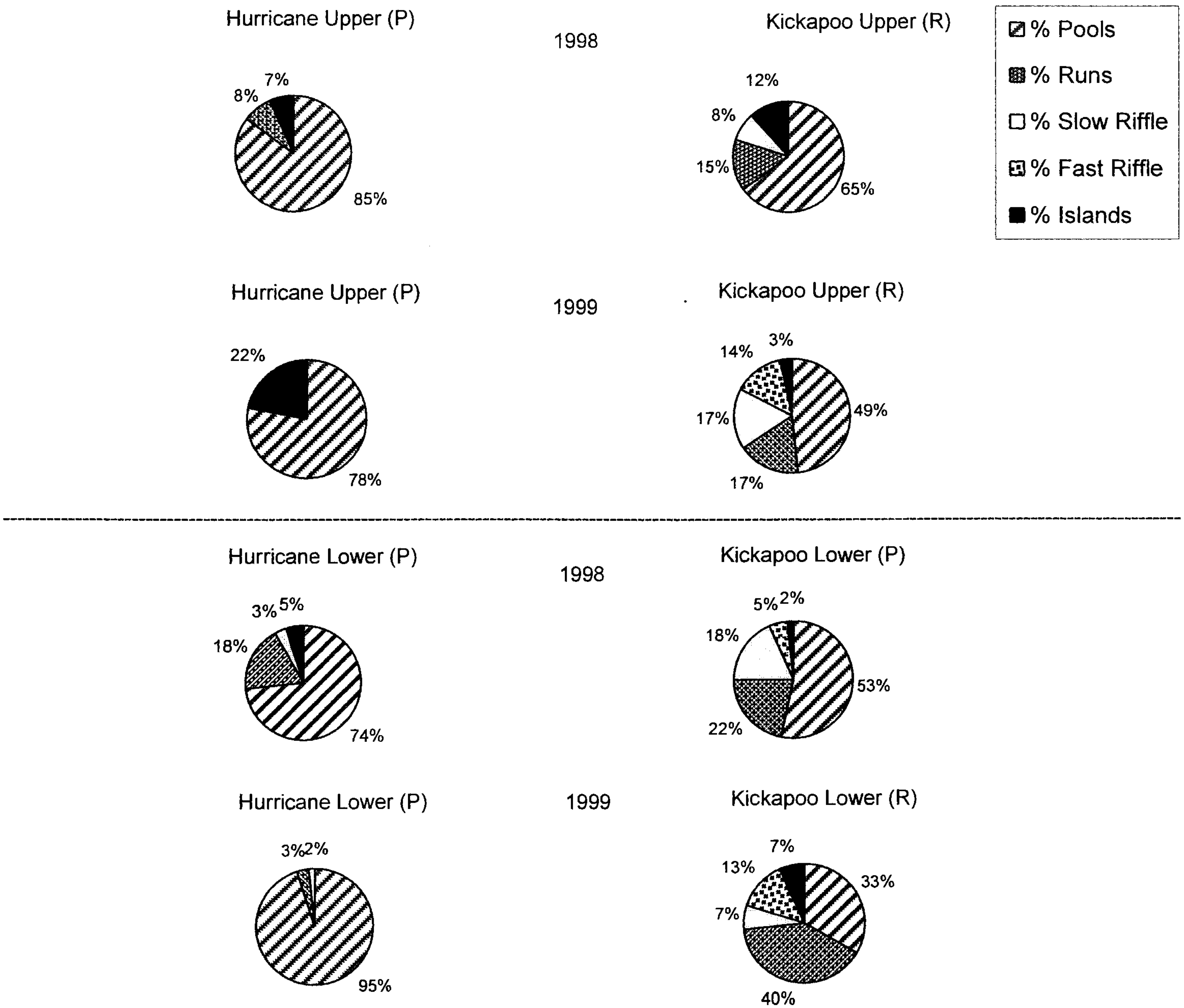


Figure 5. Percent habitat types for the Upper and Lower sites in the Spoon Basin in 1998 and 1999. (P) denotes pilot and (R) denotes reference.

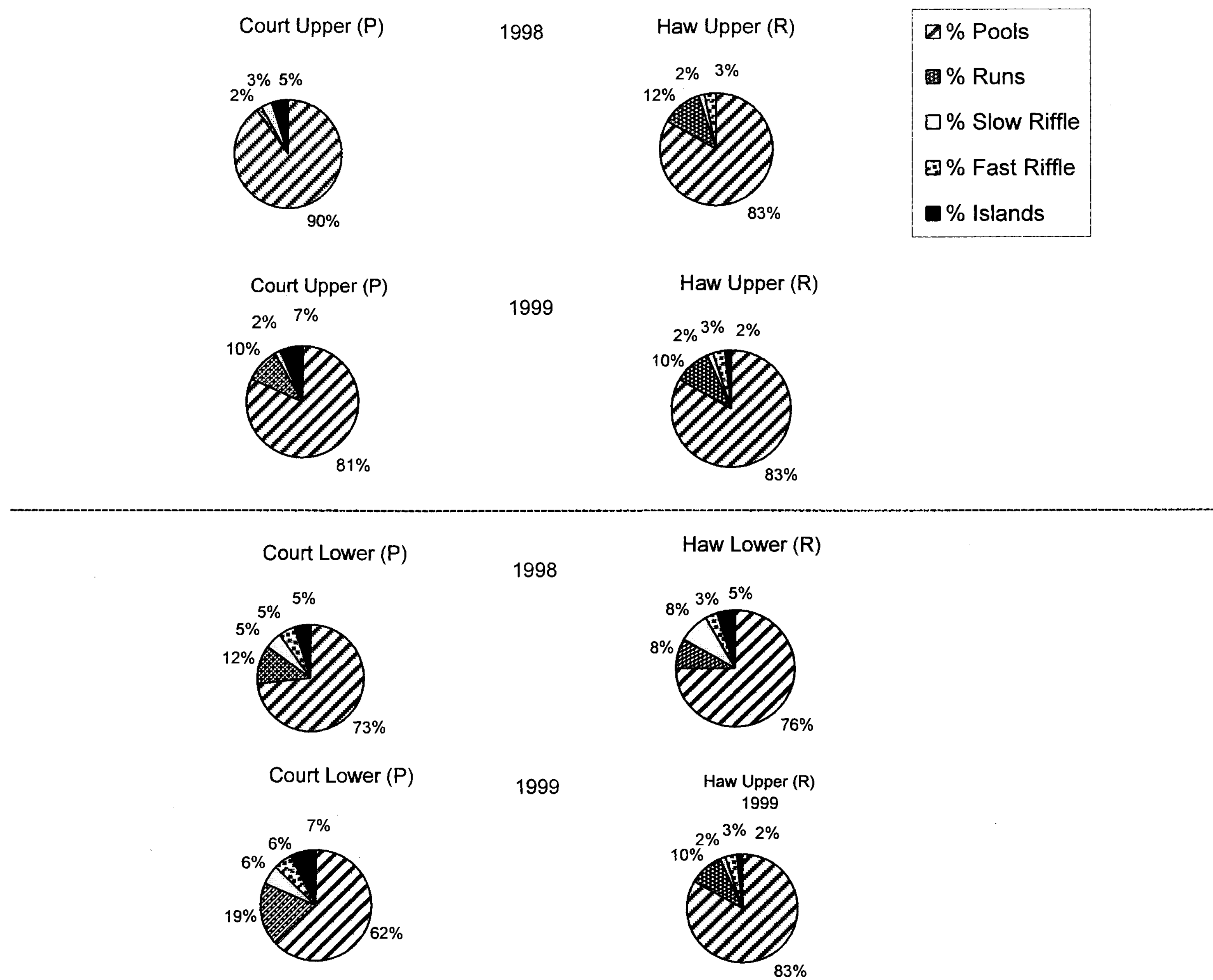


Figure 6. Percent habitat types for the Upper and Lower sites in the Cache Basin in 1998 and 1999. (P) denotes pilot and (R) denotes reference.

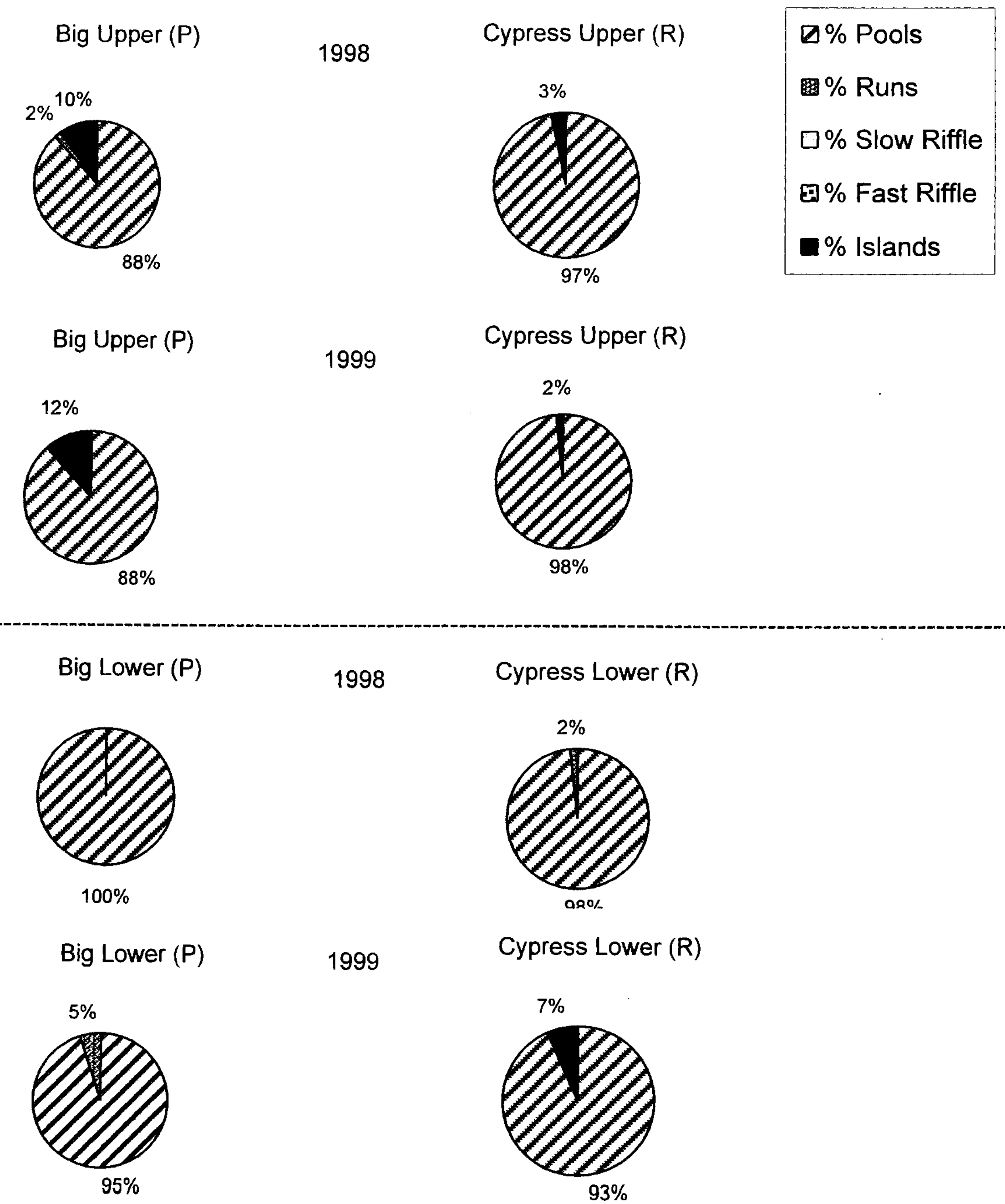


Figure 7. Percent habitat types for the Lower sites in the Kaskaskia Basin in 1999. (P) denotes pilot and (R) denotes reference.

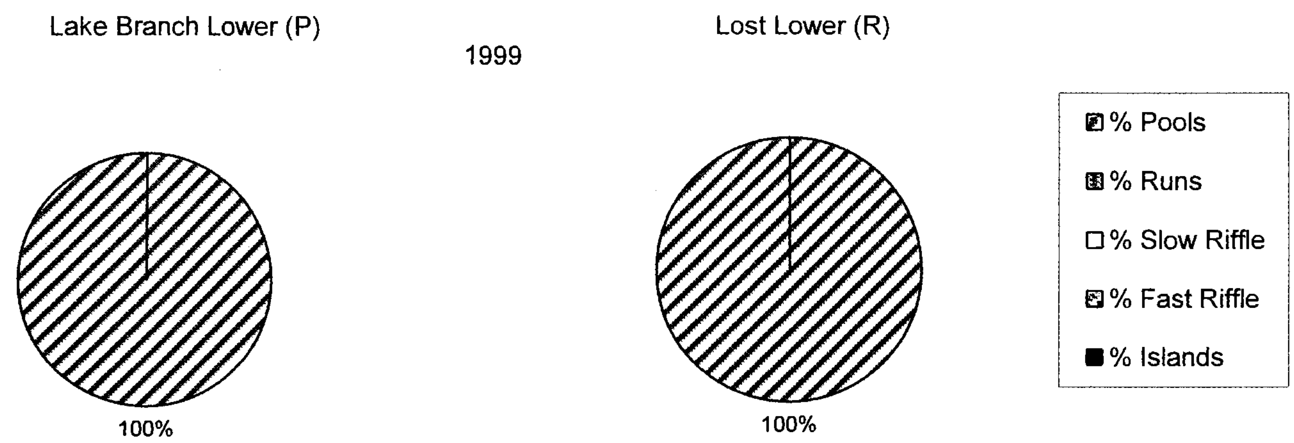


Figure 8. Bank stability index scores for Upper and Lower sites in all four study basins for 1998 and 1999.

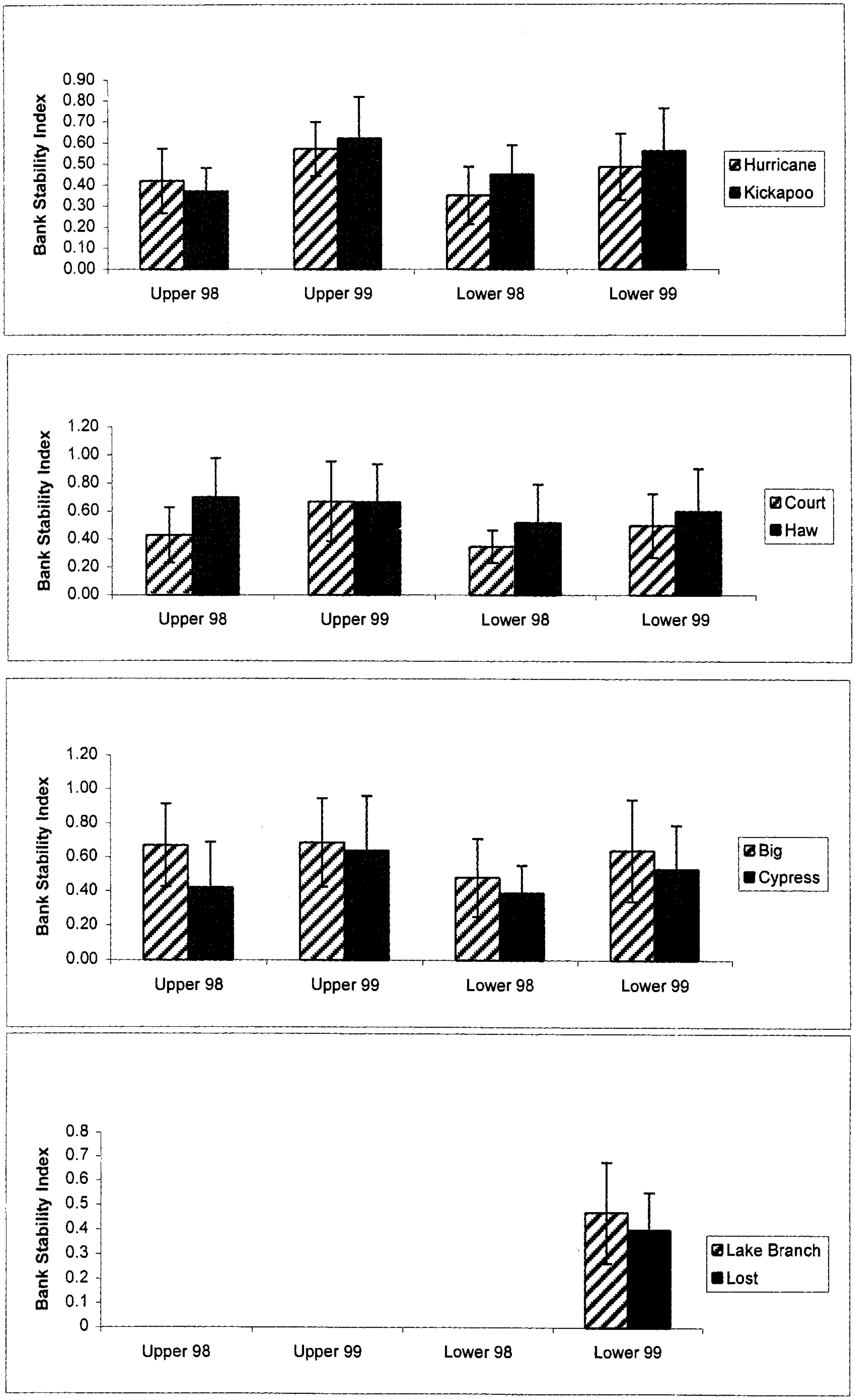


Figure 9. Mean catch per unit effort (+/- one standard error) for Upper (U) and Lower (L) sites of Pilot (P) and Reference (R) streams in 1999.

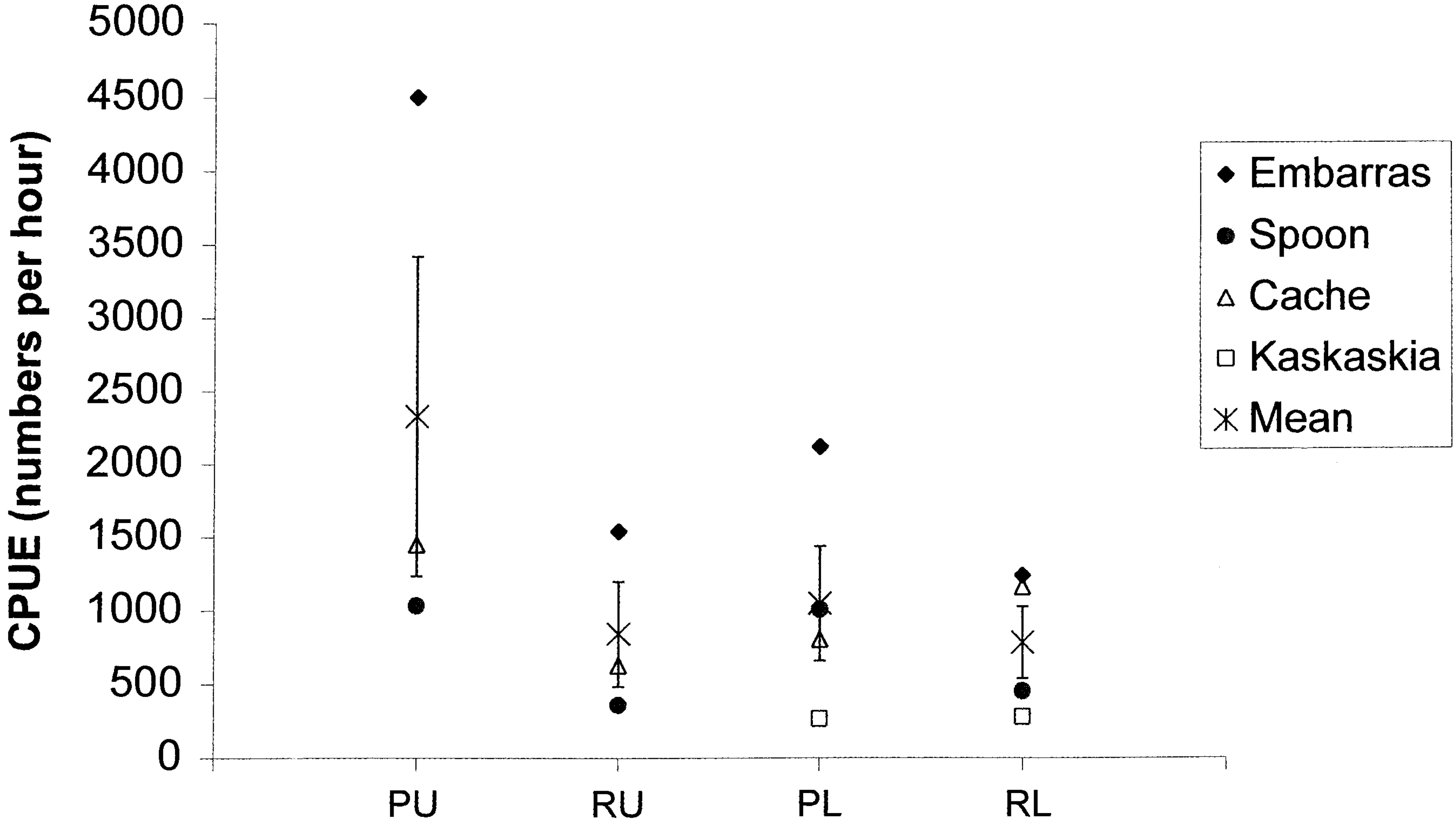


Figure 10. Growth curves for longear sunfish in the Embarras, Cache, and Kaskaskia Basin for 1998 and 1999 combined. Longear sunfish were not collected in the Spoon Basin.

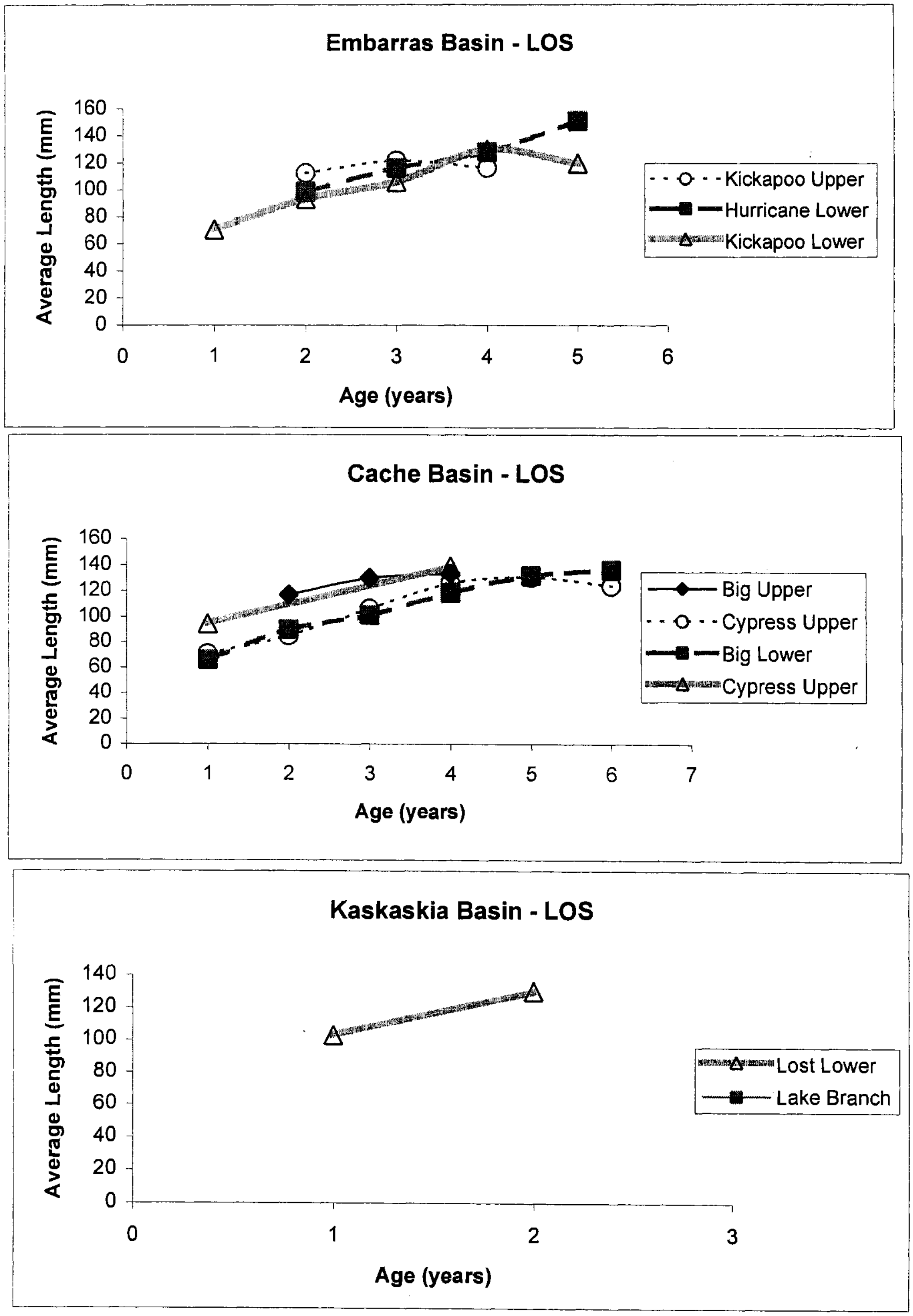
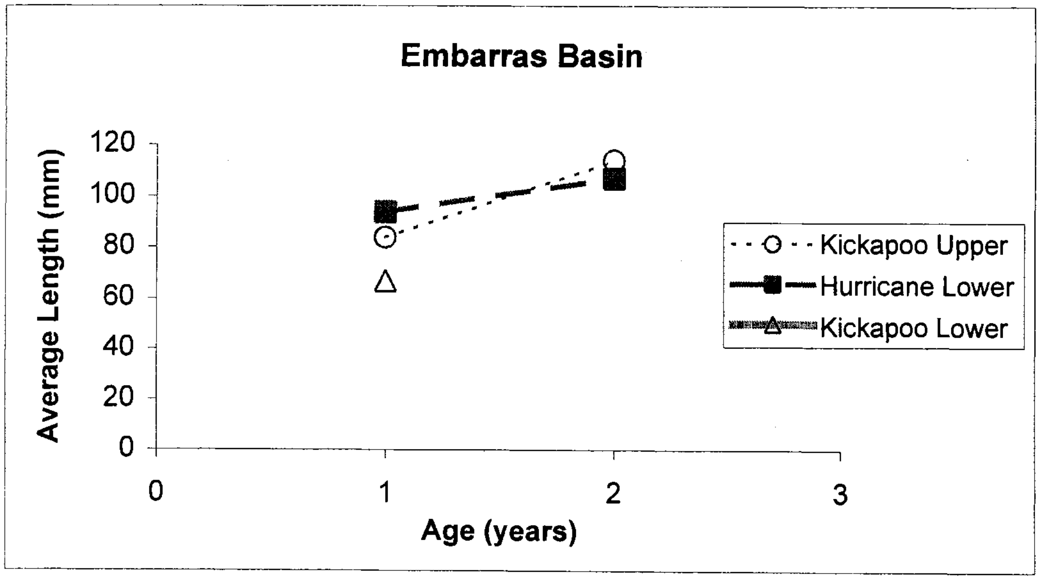


Figure 11. Growth curves for bluegill in the Embarras and Spoon Basins for 1998 and 1999 combined.



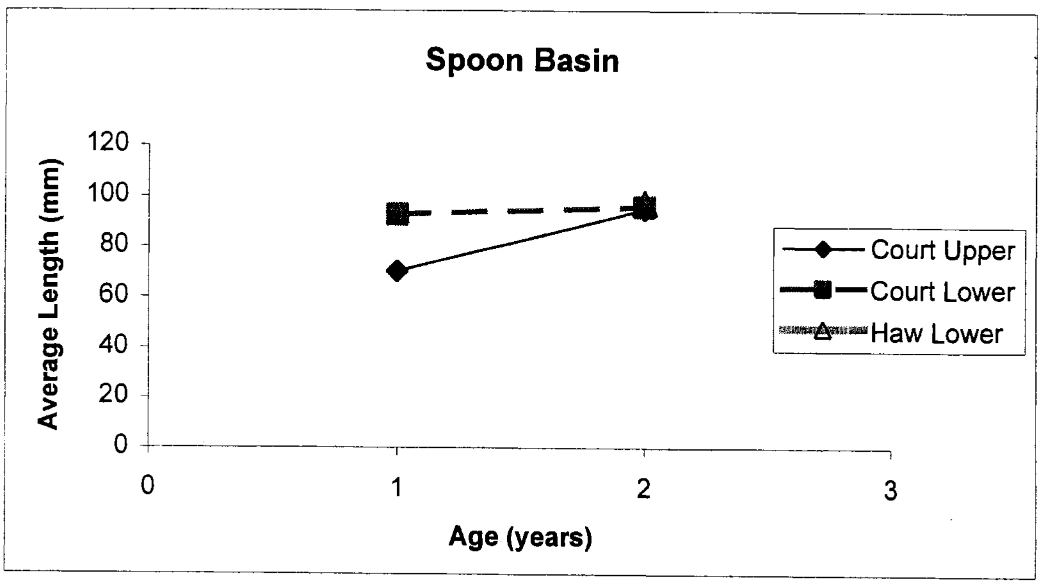


Figure 12. Growth curves for bluegill in the Cache and Kaskaskia Basins for 1998 and 1999 combined.