FINAL REPORT

BIOASSESSMENT OF THE FISHES AND MACROINVERTEBRATES

OF THE LOWER MAINSTEM OF BUCK CREEK,

PULASKI COUNTY,

KENTUCKY

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Scope of Study

A bioassessment of the lower mainstem of Buck Creek, using the fish and macroinvertebrate fauna, was conducted to determine the integrity of the stream and to provide baseline data for any future biological monitoring in the watershed. Five sites were sampled in May and July of 1996, and several collecting and analysis techniques were used to provide a thorough evaluation of each site and of the drainage as a whole. In conjunction with a concurrent study of the upper section of Buck Creek an overall analysis of the mainstem of Buck Creek was conducted.

Findings and Conclusions

The analysis of the fish data using the Index of Biotic Integrity indicated an overall water quality for the lower mainstem of Buck Creek to be Good. The Jaccard Coefficient of Community comparisons did show a distinct longitudinal trend when the results of site 3 were overlooked. The diversity (H') and evenness (J) values indicated the lower mainstem of Buck Creek had good diversity with a fairly even distribution of taxa in the fish fauna. The overall analysis of the macroinvertebrate data by both the Invertebrate Community Index and the Hilsenhoff Biotic Index classified the lower mainstem of Buck Creek to be Excellent. The Proportional Community Similarity values did not show a distinct longitudinal trend but indicated there was a shift in the macroinvertebrate fauna from the most upstream site to downstream sites. The H' and J values for the macroinvertebrates indicated the lower mainstem of Buck Creek exhibited good diversity and that the taxa were evenly distributed. The proportions of the macroinvertebrate functional feeding groups followed the predictions of the River Continuum Concept, except for site 1, which had a higher abundance of shredders than expected for a mid-size stream. This study found the overall water quality of the lower mainstem of Buck Creek using all of the metrics to be classified as Good-Excellent. In conjunction with a concurrent study of the upper section of Buck Creek the overall water quality classification of the mainstem of Buck Creek is Good-Excellent.

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CHAPTER I

INTRODUCTION

It has been reported that Buck Creek had high water quality and received minimal anthropogenic impacts (Harker et al. 1979, 1980); thus, it has served as a refugium for many aquatic organisms, several of which have some form of conservation status. The purpose of this project was to assess the current water quality of the lower mainstem of Buck Creek, Pulaski County, Kentucky. This assessment was accomplished by surveying the fish and macroinvertebrate fauna (excluding Unionidae) inhabiting the stream. In addition, this project was to provide baseline data for future bioassessments on the lower half of the mainstem of the Buck Creek system.

Buck Creek is a fifth order stream which originates in Lincoln County and flows southward into the upper Cumberland River Basin (Figure 1). The stream drains 767 square kilometers and travels 107.2 km through Lincoln, Rockcastle, and Pulaski counties before draining into the Cumberland River at river km 858 (Cicerello and Butler

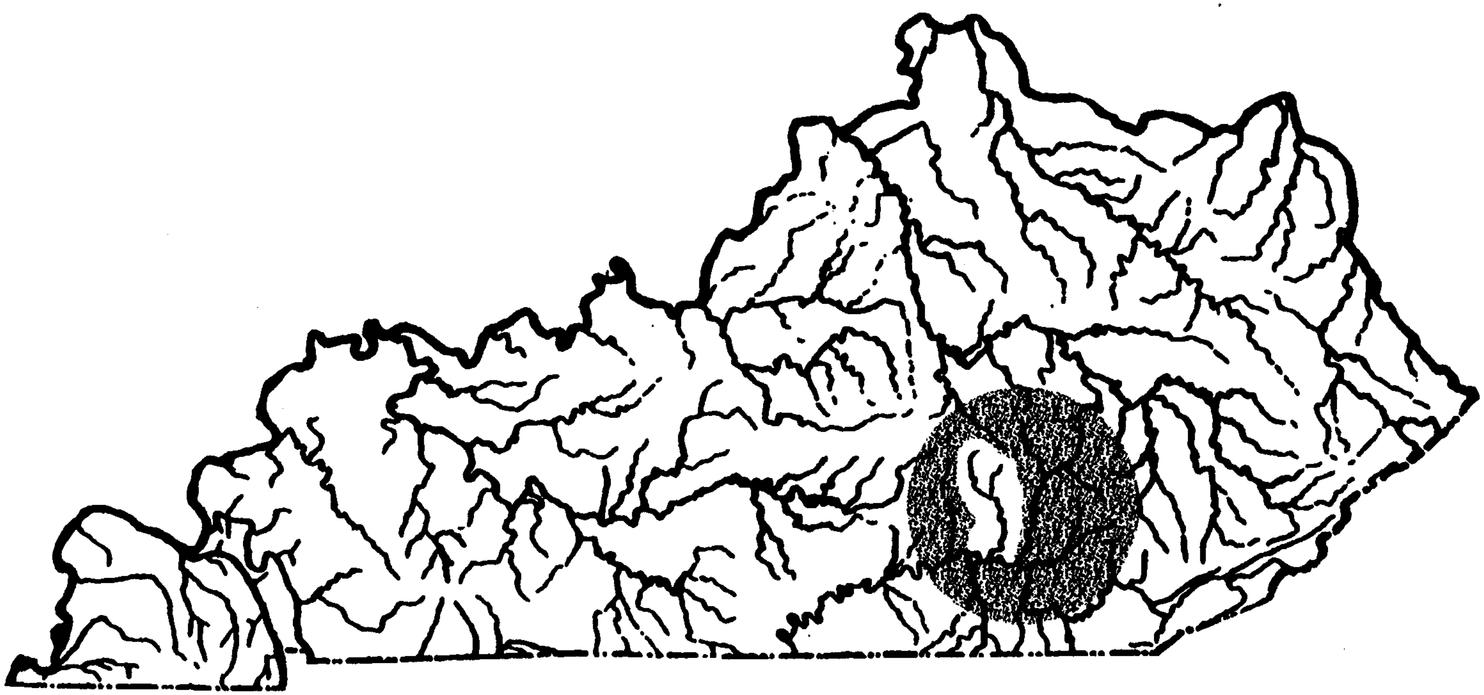

Figure 1. Map of the major Kentucky stream drainages with Buck Creek highlighted within the Upper Cumberland River Basin (modified from Burr and Warren 1986).

1985). The mouth of Buck Creek and several kilometers upstream are inundated by the impoundment of the Cumberland River. The upstream impact of the impoundment varies seasonally, however, the water may inundate as far as the State Route (SR) 192 bridge during extreme high water levels. The mean width of the stream is less than 20 meters and the stream has a mean depth of less than two meters. The maximum width and depth are 150 meters and 20 meters (at the mouth), respectively. The stream gradient is 1.25 m/km and the mean flow is 11.7 km^3/sec. as estimated by the U.S. Army Corps of Engineers (1976).

The surrounding geology of the stream north of SR 80 is almost entirely within the Eastern Highland Rim Subsection of the Interior Low Plateaus Physiographic Province (Quarterman and Powell 1978). At the surface the primary rock structure is Mississippian limestone with some shale bedrock found in the northern and eastern sections of the drainage (Schuster et. al. 1989). These areas are characterized by karst topography and sinking creeks associated with limestone which is most evident south of latitude 37 17' 00". South of SR 80 the stream is within the western limit of the Cumberland Plateau Section of the Appalachian Plateaus Physiographic Province (Cicerello and Butler 1985; Butler 1986). The hills in this section are formed by the erosion-resistant Lower Pennsylvania Lee Formation, which is a light gray or buff fine-grained siltstone (Devilbiss 1988).

The upper section of Buck Creek during the summer is comprised of several braids that become isolated and stagnant and some even dry up during times of low rainfall. The bed of the stream is made up of coarse sand, gravel, and small cobbles. Downstream from SR 1677 the substrate is primarily coarse limestone rubble and slab boulders with large sections of cracked bedrock (Schuster et. al. 1989).

In the upper portion of Buck Creek the surrounding land is used mostly for agricultural purposes such as corn, tobacco, grasses, legumes, and dairy and beef cattle. The lower portion is mostly forested and lies within the Daniel Boone National Forest (DBNF). Coal strip-mining and limestone quarry operations also have occurred in the lower portion of the stream, but are less than one percent of the watershed (Cicerello and Butler 1985). The local farmers have easy access to the stream, and gravel removal is evident near the SR 39 bridge and most recently at the old SR 461 bridge (Schuster, personal communication). Two small reservoirs (11 and 15 ha) for flood control were put in by the U.S. Soil Conservation Service within Lincoln County, Kentucky (Cicerello and Butler 1985).

Cicerello and Butler (1985) and Schuster et al.(1989) conducted surveys of the fish and unionids of Buck Creek, respectively, and they concluded that Buck Creek was an important refugium for some rare fishes and unionids. Prompted by the findings of Cicerello and Butler (1985) and Schuster et al.(1989), several other researchers have focused on the fauna within the stream. Some of the studies conducted on Buck Creek were surveys of the caddisflies and of the dragonflies and damselflies (Payne 1992), a study of the comparative feeding ecology of darters (Butler 1986), and a bioassessment of the upper section of the stream (Moeykens, 1997). It has been found that twenty-nine species of mussels, sixty-one species of caddisflies (Floyd 1989), thirty-four species of odonates (Payne 1992), and seventy-three species of fish inhabit Buck Creek. Four of the species of mussels found (*Epioblasma brevidens*, *E. capsaeformis*, *Villosa trabalis*, and *Pegias fabula*) are federally endangered, and several others have some form of state conservation status (KSNPC 1996, USFWS 1997). In addition the fish, *Etheostoma cinereum*, a state threatened species (KSNPC 1996), which had not been reported from Buck Creek since 1955. It was thought to have been extirpated from the drainage (Cicerello and Butler 1985, Burr and Warren 1986).

Biological monitoring (biomonitoring or bioassessment) is a systematic procedure used to determine the water quality of a stream or a particular portion of a stream, and is based on the presence or absence of biological indicator species within that stream. The principle behind biomonitoring and the advantage over water chemistry testing is that short-term critical events can occur (i.e., chemical spill) that are often not revealed by chemical testing, but can be detected by biomonitoring (NCDEHNR 1995). However, biomonitoring sampling should not be used by itself, but should be supplemented with chemical and physical sampling on a yearly basis to provide for a more complete water quality assessment (Hirsch et al. 1988).

To make bioassessments more cost efficient and less time consuming the United States Environmental Protection Agency (USEPA) proposed a series of Rapid Bioassessment Protocols (RBP) (Plafkin et al. 1989). There are several RBPs, and they include RBP I, II, and III which use the macroinvertebrate fauna, while RBP IV and V use the fish fauna. Several state agencies utilizes one or more of these protocols or modified versions for their water quality monitoring programs. Variation from the published RBPs involve the specific indices used to analyze the data. Some standard indices used to assess biological integrity of a stream are the Index of Biotic Integrity, the Hilsenhoff Biotic Index, and the Invertebrate Community Index.

The Index of Biotic Integrity (IBI), which uses fish as water quality indicators, was first proposed by Karr (1981). The IBI is beneficial in that it incorporates the aspects of the fishes' trophic levels, abundance, community structure, and the condition of the individual fishes. Another advantage of the IBI is the relative ease of fish identification (Karr et al. 1986). All of these allow for analysis of a study site to be consistent and disturbances to be pinpointed based on fish collected. Plafkin et al. (1989) recommended the use of the IBI for RBP V. The IBI uses twelve metrics based in three broad categories: Species Richness and Composition; Trophic Composition; and Fish Abundance and Condition. Each of the metrics are assigned a score of 1, 3, or 5 based on the obtained metric values compared to the expected values. The expected values are based on the drainage area of a site and will change from site to site along a stream. Originally the IBI was designed for small midwestern streams but is now used by many state agencies in water quality monitoring programs. Therefore, many states have modified the IBI and the scoring criteria for each metric to suit the geographical area. The Kentucky Division of Water (KDOW) on September 24, 1997, finished fine-tuning the IBI for usage in Kentucky and the analyses of the fish data from this study reflected these modifications (KDOW 1997).

The Hilsenhoff Biotic Index (HBI) uses the macroinvertebrate fauna to assess the biotic integrity of a stream. Macroinvertebrates exhibit a wide range of tolerance towards pollution, and pollution tolerance values for the HBI have been established for most macroinvertebrate taxa (Hilsenhoff 1987, Plafkin et al. 1989, Lenat 1993, NCDEHNR 1995). The HBI incorporates these pollution tolerance values for each macroinvertebrate taxon to assess the quality of a stream (Hilsenhoff 1977). The scale of possible tolerance values ranges from 0 to 10, with 0 being most intolerant to pollution while a value of 10 is most tolerant to pollution (Hilsenhoff 1982, 1987). This means as HBI values approach zero, the water quality of a stream increases and as values approach ten the water quality decreases.

There are several advantages to using macroinvertebrates as biological indicators. Macroinvertebrates are a main food source for higher trophic levels and their condition in a community can be used as a reflection of the overall community integrity (Klemm et al. 1992). The life history of many macroinvertebrates exhibits a one year life cycle (univoltine) and the effects of a perturbation are usually apparent in the following season or next generation (NCDEHNR 1995). In addition, macroinvertebrates are fairly immobile and their collection and identification has been well established.

The Ohio Invertebrate Community Index (ICI) also uses macroinvertebrates to assess water quality. The ICI was conceived from the principles of the IBI and applied to macroinvertebrates by the Ohio Environmental Protection Agency (OEPA) to assess the water quality of Ohio streams (OEPA 1987, 1989). The ICI uses ten metrics to determine water quality based on taxa tolerance to pollution, such as number of Diptera (tolerant) and Ephemeroptera, Plecoptera, and Trichoptera (EPT)(intolerant). Due to the sensitivity of the EPT insect orders, an increase of taxa within these orders represents an increase in the water quality and habitat diversity (KDOW 1993). Each calculated metric value is compared to expected values, which then are assigned scores of 0 (poor water quality), 2, 4, or 6 (exceptional water quality). As with the IBI, the expected values vary depending on the drainage size of a particular site. The Commonwealth of Kentucky does not yet use such an index, but due to its close proximity to Ohio the index proves useful for assessing Kentucky streams (Schuster et al. 1996).

Another aspect of biomonitoring, which was recommended in the RBPs II and III (Plafkin et al. 1989), was a classification of the macroinvertebrates by functional feeding groups (FFG). The FFG proportions have been used to detect the severity of disturbances in streams (Klemm et al. 1992). Functional Feeding Groups are based on the feeding habits of the organisms, which are based on their feeding mechanisms. Shredders feed on coarse particulate organic matter (CPOM) which can be defined as organic matter greater than 1 mm in diameter (Cummins and Klug 1979). Decomposition or mechanical breakdown of CPOM releases fine particulate organic matter (FPOM) which is less than 1 mm but greater than .45 um in size, and ultra-fine particulate organic matter (UPOM) which is less than .45 um in size. Collectors feed primarily on FPOM and UPOM by gathering or filtering the organic matter (Cummins and Klug 1979). Those organisms which filter organic matter are commonly called filter feeders. Scrapers (grazers) graze or scrape organic matter from substrates and primarily feed on periphyton (Cummins and Klug 1979). The last group are the predators, which actively seek out and capture prey (Cummins and Klug 1979).

Each community of macroinvertebrates in a stream may have different FFG proportions. The macroinvertebrate proportions are influenced by the characteristics or features found within the particular section of a stream. The River Continuum Concept (RCC), which was developed by Vannote et. al. (1980), is a paradigm that explains the changes seen along the gradient of a lotic system. The composition of the community shifts according to corresponding changes in a lotic ecosystem from the headwaters to the mouth. According to Vannote et. al. (1980), lotic systems can be broken into three main reaches:(1) the headwaters (orders 1-3), where riparian cover is the greatest, CPOM input is the greatest, and the macroinvertebrate community is comprised predominantly of shredders;(2) mid-size reach or transitional zone (orders 4-6), there is less shading, more periphyton growth, more FPOM than CPOM, the greatest species diversity and the macroinvertebrate community is predominantly scrapers; and (3) the large order (>6) streams, where there is little shading, and a large amount of FPOM and UPOM creating a macroinvertebrate community dominated by collectors. In the headwaters of the stream a heterotrophic community should exist and the P/R (productivity/ respiration) value is less than one. In the mid-size reach the community structure is autochthonous and the P/R is greater than one. Finally, in the large order reaches the community will become allochthonous and the P/R is less than one (Vannote et. al. 1980).

Each reach has a different macroinvertebrate community structure based on FFG proportions. For example, shredders, which eat CPOM, are predominately in the upper reaches of a stream. Shredders will break down the CPOM into FPOM and UPOM which will become food for the collectors in the lower reaches. Changes from the expected macroinvertebrate proportions within a given area can suggest some perturbation has occurred in that area causing a shift in the macroinvertebrate composition (Minshall et al. 1985).

Changes of FFG proportions and low water quality can result from several anthropogenic factors. Agricultural activities often result in dredging of the stream bed, cattle in the stream, the clearing of riparian vegetation, channelization, and runoff from adjacent dirt or gravel roads. All of these impacts tend to destabilize the stream banks and leads to an increase in the erosion of topsoil and eventually to higher concentrations of sediments in the stream bed.

Other activities that contribute to the increase of sedimentation in Buck Creek are local logging and gravel removal operations. The clearing of trees along the west bank of Site 3 was evident during the second period of sampling. Recently, there have been two reports of gravel removal from the stream. The first was approximately 0.3 km upstream from the SR 39 bridge. On 31 August 1996, a bulldozer was observed on a gravel bar loading a dump truck with the gravel. It was not observed if gravel was actually being removed from the stream or the bank (personal observation). The second was at Site 5, the aftermath of an operation was observed on 27 September 1997 along the banks of the stream (Ceas and Schuster, personal communication). Such operations destroy the habitat, increase erosion potential, and increase sedimentation.

Sedimentation may impact the density, diversity, productivity and distribution of the benthic biota within an area (Berkman and Rabeni 1987; Lenat et. al. 1981; McClelland and Brusven 1980; Taylor and Roff 1986). The change in substrate size could play an important factor in species distribution and composition, thus influencing the functional feeding groups in the stream (Culp et. al. 1983). Covering of the substrate will reduce surface heterogeneity and lower colonization of the substrate, thus decreasing abundance and diversity of macroinvertebrates (Corn and Bury 1989; Erman and Erman 1984). Sedimentation may induce a drift response among the macroinvertebrates, thus reducing densities (Culp et. al. 1986). The shifting of stream substrate characteristics will change the fish community, in that the less tolerant species will decline (Berkman and Rabeni 1987). For example, for fish eggs which are deposited into the gravel substrate (lithophilic) can become smothered by the sedimentation, thus prohibiting development. The sedimentation increase can also cause a shift in stream morphology by altering the channel with deposition zones, creating islands and bars (Harr and Nichols 1993). Garman and Moring (1991) stated that even the most careful deforestation can have significant influence to the streams thermal regime, benthic organic matter, substrate composition, and suspended particulate matter. The thermal regime is influenced by the increase of sunlight reaching the stream due to less surface shading by the riparian vegetation. This can cause the water temperatures during the summer to reach higher levels and the water temperatures in the winter to become more severe (Allan 1995). Therefore, organisms that cannot tolerate these extremes in temperature might be excluded from the stream community.

Cattle in a stream can directly and indirectly influence communities. Directly, the access of cattle to the stream bank and stream bed will increase the erosion potential, thus increasing sedimentation and reducing the habitat heterogeneity for benthic organisms (Armour et. al. 1991). It has been found that cattle can cause shifts in functional feeding groups; for example, densities of collectors/gathers and filter feeders may increase (Gary et. al. 1983; Owens et. al. 1983). Indirectly, the waste of the cattle from the pastures can increase nutrients for plant production thus increasing the food supply (periphyton) for algavores. However, increased nutrients have not shown to be a significant factor in increased primary productivity (Gary et. al. 1983; Owens et. al. 1983).

The construction and use of surrounding roads can result in an increase in sediment and in the introduction of various pollutants to the stream such as salt, petroleum, and heavy metals. Buck Creek has several nearby roads and some cross the creek directly. It has been found that direct crossing of a stream has the greatest impact to the stream. The crossings increase sedimentation and embeddedness of the existing substrate, while the relative abundance of cobble decreases with each road crossing

(Eaglin and Hubert 1993), creating a more a more homogenous habitat with lower abundance and diversity of biota (Corn and Bury 1989; Erman and Erman 1984).

Recently, a proposal of channelizing Buck Creek was requested by local farmers in order to decrease seasonal flooding on their land. Channelization may have serious detrimental effects on the stream. It will create a homozygous environment, increase sedimentation, and change the stream structure, along with their subsequent affects on the aquatic biota. Also, a shift in community structure could occur due to the reduction of allochthonous matter into the stream (Master et al. 1988).

CHAPTER II

DESCRIPTION OF THE STUDY SITES

Five sites were selected for analysis along the lower mainstem of Buck Creek in Pulaski County, Kentucky (Figure 2). Each site was sampled once on 24-25 May 1996 and on 13 July 1996. Sites were selected based on collection sites of previous studies (Floyd 1989 and Schuster et al.(1989)), suitable riffle areas, accessibility, and landowner permission. Descriptions of each of the five sites follows.

Site 1 was located approximately 0.1 km upstream of SR 192 bridge crossing, about 5.0 km NW of Mt. Victory and 16 km ESE of Somerset. Buck Creek at this site drained 655 km^2 (Bower and Jackson 1981) and was a fifth order stream. The riffle selected was composed mostly of gravel/pebbles with some cobbles. Upstream of the riffle was a large pool made of slab bedrock. The left upstream bank was well vegetated along the steep incline. The right bank was slightly vegetated and open areas were used by locals for

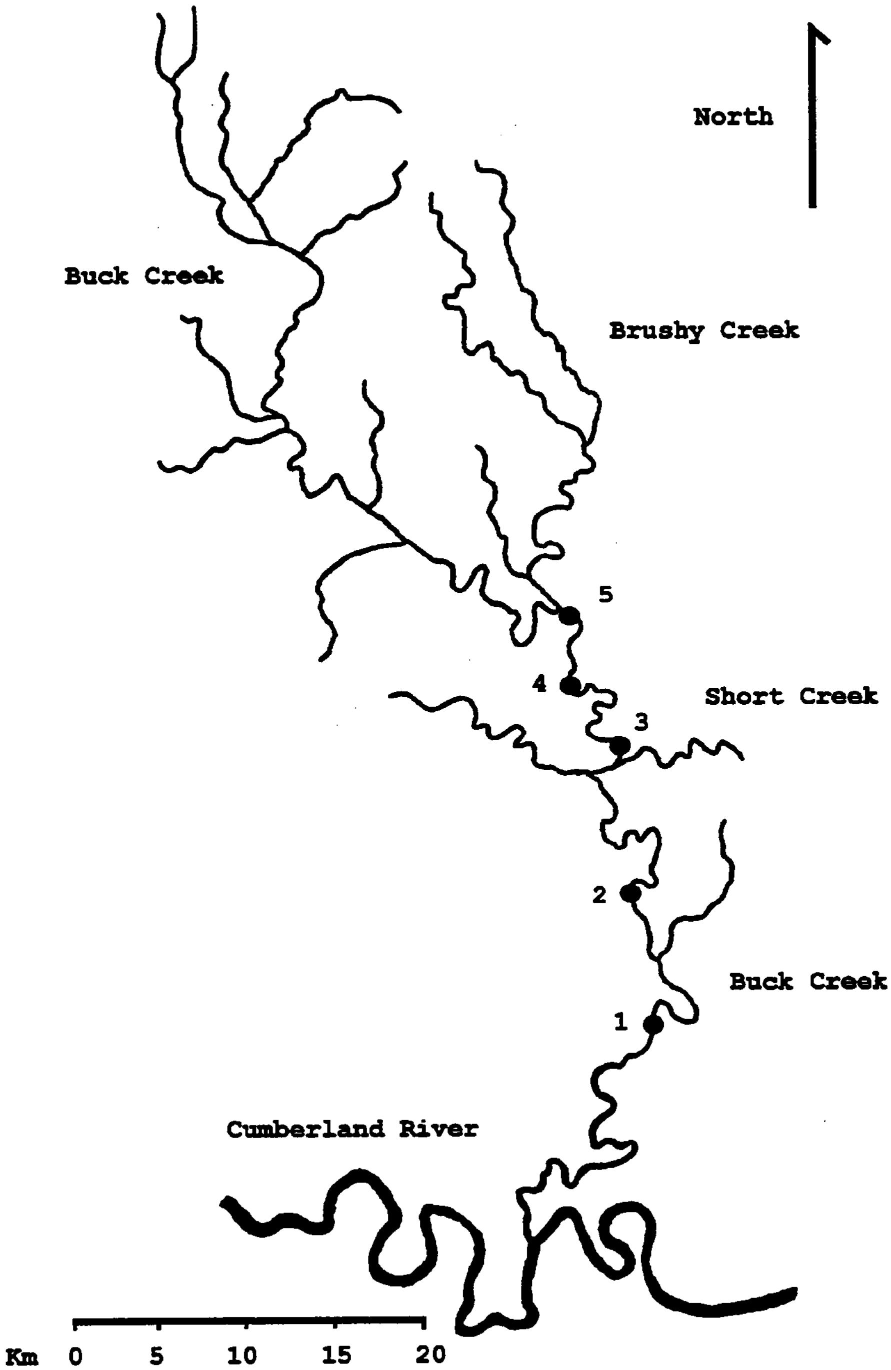

Figure 2. Map of the Buck Creek System Showing the Location of the Five Collecting Sites.

camping. Off-road vehicle tracks were observed along the bank.

Site 2 was located approximately 0.1 km downstream of SR 1003 bridge crossing, about 7.2 km S of Stab and 5.0 km N of Dykes. The stream at this site flowed between steeply inclined banks consisting of coarse limestone. The stream was classified as a fifth order stream and drained approximately 585 km^2. The riffle for the first sampling period was composed mainly of gravel/pebbles scattered over bedrock. The riffle for the second sampling period was composed mostly of gravel/pebbles with a few cobbles. Pools both upstream and downstream had mostly bedrock slabs with undercuts and some boulders were present. Each bank was well vegetated. The left bank seemed to be a favorite local dumping area about 20 meters from the stream.

Site 3 was located approximately 0.3 km upstream from the crossing of SR 1675 (old SR 80) bridge at Stab. The stream here drained approximately 500 km^2 and was a fifth order stream. The riffle was mostly composed of cobble, covered heavily with periphyton, and some boulders. Both upstream and downstream pools had slab bedrock with a few boulders along the edges. The left downstream bank had little vegetation and erosion was potentially high due to the recent removal of riparian vegetation. About 15 meters from the bank was a field. The right downstream bank was well vegetated along a steep incline.

Site 4 was located approximately 0.2 km downstream of SR 1677 bridge crossing, about 2.2 km W of Dahl and 4.0 km NW of Stab. The stream at this site drained 445 km^2 and was a fifth order stream. The riffle was composed mainly of gravel/pebbles. Pools both upstream and downstream were composed of gravel and cobble scattered over slab bedrock. The left downstream bank composition was mostly sand and had a 15 meter buffer strip of vegetation between it and the Bud Rainey Road. The right downstream bank was well vegetated along the hillside.

Site 5 was located approximately 0.1 km upstream of old SR 461 bridge crossing. This was about one km SSE of Elrod and 3.3 km ENE of Welbor, and about 0.2 km downstream from the Brushy Creek confluence. At this point Buck Creek drained 427 km^2 (Bower and Jackson 1981) and was a fifth order stream. The riffle was mainly composed of cobble with some gravel/pebbles. The pools both upstream and downstream were mostly fine sediments layered upon bedrock with a few boulders. The left downstream bank was well vegetated and showed minimal erosion. The right downstream bank was fairly vegetated and had a 30 meter buffer strip between Elrod Road and the stream.

CHAPTER III

MATERIALS AND METHODS

Sampling and Processing

Fish

Fish sampling was done qualitatively following the procedures outlined in KDOW (1993) and the United States Environmental Protection Agency Rapid Bioassessment Protocol V (Plafkin et al. 1989). A 3.4 m x 1.2 m, 0.3 cm mesh seine was used at each site. Seining techniques (e.g., hauls, kick sets, etc.) were used for one hour to standardize the catch effort. During collection all habitat types (riffle, run, and pool) were sampled to provide opportunity for all fish species to be collected, resulting in unbiased data (KDOW 1993).

Fish were preserved in the field with 10% buffered formalin. After at least three weeks fixating in the formalin solution, permanent preservation consisted of washing and soaking the fish in water for a few days and then transferring them into a 70% solution of ethanol (Etnier and Starnes 1993).

Specimens were identified to the lowest possible taxonomic level using Etnier and Starnes (1993), Page and Burr (1991), Robison and Buchanan (1988), and verification was by Dr. Patrick Ceas (Eastern Kentucky University). In addition, each specimen was scrutinized for any anomalies, such as sores, cuts, missing fins, or other deformities. The fish were curated and deposited in the Branson Museum of Zoology at Eastern Kentucky University.

Macroinvertebrates

Macroinvertebrate communities were sampled using semiquantitative and qualitative techniques outlined in KDOW (1993) and the United States Environmental Protection Agency Rapid Bioassessment Protocol III (Plafkin et al. 1989). The semi-quantitative sampling procedure was the modified traveling-kick net method (TKN) described by Pollard (1981). This method was used in the riffles of each site, and triplicate samples were collected. In the riffles a 3 m (10 ft.) longitudinal transect was measured and the ends marked with flags, which produced a sampling area of approximately 1 m^2. Triangular kicknets with a mesh of 800 x 900 microns were placed on the substrate at the downstream end. Then over a 60 second span the substrate was kicked in front of the net, working upstream in the measured length. For comparison and consistency between sites, the same riffle areas at each site were used, except at site 2. The change at site 2 was due to seasonal changes in the stream morphology.

The material accumulated in the net was washed into a bucket with water. The macroinvertebrates were then sorted and placed into quart jars containing 70% ethanol for preservation. The smaller macroinvertebrates were sieved using a metal mesh strainer (25 um) and placed in the quart jars for later identification in the lab.

The qualitative sampling technique was a one person hour timed collection and sorting period using a dipnet at each site. The one-hour effort was divided by three people into twenty minute segments per person. The time period allowed for equal effort among sites and enabled comparison between sites. The collection consisted of sampling all habitat types, such as riffles, runs, and pools, and the woody debris, rocks, macrophytes, roots, and leaf packs present. The sorting and preservation of macro-invertebrates was done in the same manner as described in semiquantitative sampling.

The preserved samples were brought to the Branson Museum of Zoology at Eastern Kentucky University and sorted into taxonomic groups using a 5x magnifying ring. Final identification of the macroinvertebrates was to the lowest taxonomic level possible using a variety of the most recent available keys that included: Bednarik and McCafferty (1979), Bode (1983), Brigham et al. (1982), Epler (1995, 1996), Flint (1984), Hilsenhoff (1995), Lenat (1994), Merritt and Cummins (1996), Schuster and Etnier (1978), Simpson and Bode (1980), Thorp and Covich (1991), and the assistance of Dr. Guenter Schuster (Eastern Kentucky University). Some of the chironomids were identified and verified by Mr. Greg Pond (KDOW). Most of the specimens were identified to the generic level, while some where taken to the species level if the appropriate keys were available. Some specimens were identified only to higher taxonomic levels because of the condition or instar of the specimen.

Due to the large abundance of chironomids in some samples, subsampling of these organisms was conducted. Sites that had an abundance of one hundred or more individuals for a collection period were subsampled. A grid of 154 squares was placed on the bottom of a square pan, and ten percent of the original sample was subsampled. The selection of the particular squares was obtained with the use of a random number table. The selected individuals were then mounted for identification.

Data Analysis

Fish

To assess the fish community at each site the Index of Biotic Integrity (IBI) was used. The IBI was composed of twelve metrics having equal weight (Table I). The different metrics were divided into three categories: species richness and composition; trophic composition; and fish abundance and condition (Karr et al. 1986). Each metric was assigned a score of 5, 3, or 1 depending on how close the obtained value was to the expected value, which was based on the drainage size of that site (KDOW 1997). The individual metric scores were summed to give the final IBI score. The scores ranged from 12 - 60, with 12 being very poor and 60 representing excellent water quality. The IBI classification scheme is shown in Table II. The IBI was calculated for each site and each collection period.

From the fish collected, a species list for the lower section of Buck Creek was developed, for each site and for each sampling period. In order to determine the fish species diversity, the Shannon - Wiener Diversity Index (H′) was calculated for each site and collection period. Using the H′ values, Evenness (J′) was calculated to estimate how evenly the species were distributed at each site (Krebs 1989).

The last index calculated for the fish was Jaccard's coefficient of similarity (Krebs 1989). This provided information on the similarity of fish communities between sites and was utilized to determine if longitudinal trends existed.

TABLE I

IBI SCORING SHEET PROPOSED BY KDOW (KDOW 1997).

IBI			
	SCORING CRITERIA		
SPECIES RICHNESS AND COMPOSITION	**1**	**3**	**5**
Number of Species	<8	8-15	>15
Darter Species	0-2	2-5	>5
Sunfish Species	0	1-2	>2
Sucker Species	0	1-2	>2
Intolerant Species	<4	4-9	>9
Tolerant Species (%)	>45	25-45	<25
TROPHIC COMPOSITION			
Omnivores (%)	>45	20-45	<20
Insectivores (%)	>55	20-55	>55
Top Carnivores (%)	<1	1-5	>5
FISH ABUNDANCE AND CONDITION			
Number of Indv. in Sample	<50	50-100	>100
Number of Simple Lithophils	0-2	3-5	>5
Percent of Diseased (%)	>1.3	0.1-1.3	<0.1

TABLE II

WATER QUALITY CLASSIFICATION BASED ON IBI SCORING VALUES (KARR ET AL. 1986).

WATER QUALITY CLASSIFICATION	EXCELLENT	GOOD	FAIR	POOR	VERY POOR
Total IBI Score	58-60	48-52	40-44	28-34	12-22

Macroinvertebrates

Using the semiquantitative macroinvertebrate data the integrity of the stream at each site was tested using the Hilsenhoff Biotic Index (HBI). The HBI used tolerance values and abundance for each taxon to measure the health of the stream for a given ecoregion (Lenat 1993). The tolerance values for each taxon were derived from Lenat (1993) and NCDEHNR (1995). The HBI values were obtained using the following equation and calculated using the spreadsheet program Quattro Pro (Corel Corp.):

$$HBI = \frac{\sum n_i \times a_i}{N}$$

Where:

n_i = number of individuals of a species
a_i = tolerance value for each species
N = Total number of individual organisms in the sample

The HBI value ranged from 0 to 10, with zero indicating exceptional water quality and ten indicating poor water quality. Because Kentucky has not yet developed a HBI classification system, the classification system established by Lenat (1993) for the Mountain Ecoregion was employed (Table III).

In addition, the semiquantitative data was used to calculate the Invertebrate Community Index (ICI) in order to assess the water quality. The ICI used ten metrics which can be scored as 0 (poor), 2, 4, or 6 (exceptional) (Table IV). The assigned values for each metric were summed to obtain a total ICI score which was employed to determine the water quality classification (Table V). The procedures applied to calculate the ICI followed the methods outlined in OEPA (1987, 1989).

In order to determine species diversity at each site, the Shannon - Wiener Diversity Index (H′) and the Evenness (J′) were determined from the semiquantitative sample data. In addition, the proportional similarity index was utilized to provide comparisons among the sites and to determine if longitudinal trends existed (Krebs 1989).

The data resulting from the qualitative sampling provided a macroinvertebrate taxa list (taxa richness)for each site and for the lower mainstem. In addition, the

TABLE III

HBI WATER QUALITY CLASSIFICATION FOR THE MOUNTAIN ECOREGION BASED ON HBI SCORING VALUES (LENAT 1993).

WATER QUALITY CLASS	EXCELLENT	GOOD	GOOD - FAIR	FAIR	POOR
HBI Score	<4.18	4.18-5.09	5.10-5.91	5.92-7.05	>7.05

FFGs of each taxon were determined, primarily using the designations of Cummins and Klug (1979). From these data the FFG composition was determined for each site and analyzed according to the tenets of the River Continuum Concept (Vannote et al. 1980).

TABLE IV
OHIO ICI SCORING CRITERIA (OEPA 1987).

METRIC	SCORING CRITERIA			
	0	2	4	6
Total Number of Taxa	<20	20-28	29-39	>39
Total Number of Mayfly Taxa	<3	3-5	6-8	>8
Total Number of Caddisfly Taxa	<1	1	2-4	>4
Total Number of Dipteran Taxa	<6	6-10	11-16	>16
Percent Abundance Mayflies	0%	>0-10%	>10-25%	>25%
Percent Abundance Caddisflies	0%	>0-9%	10-19%	>19%
Percent Abundance Tribe Tanytarsini Midges	0%	>0-10%	>10-25%	>25%
Percent Abundance Other Dipterans and Non-insects	>55%	41-55%	25-40%	<25%
Percent Abundance Tolerant Organisms	>13%	9-13%	4-<9%	<4%
Total Number of Ephemeroptera, Plecoptera, and Trichoptera (EPT) Taxa	<4	4-9	10-14	>14

TABLE V
WATER QUALITY CLASSIFICATION BASED ON

OHIO EPA ICI SCORING VALUES (OEPA 1987).

WATER QUALITY RATING	EXCEPTIONAL	GOOD	FAIR	POOR
ICI VALUE RANGES	48-60	34-47	14-33	<14

CHAPTER IV

RESULTS AND DISCUSSION

Fish

The fish collections from the May sampling totaled 892 individuals and represented eight families. A comprehensive list for the fish collected at each site in May is presented in Appendix A. The July collection period yielded a total of 1,116 individuals and also represented eight families. The comprehensive list of the fish collected at each site in July is shown in Appendix B.

The family Cyprinidae was the dominant family for both the May and July periods, representing over half the total individuals collected with 13 species for May and 15 species for July. The most abundant of the Cyprinidae species for May were *Lythrurus fasciolaris* and *Notropis telescopus*, with 362 and 95 individuals, respectively. In July the two most abundant cyprinids were *Notropis telescopus* having 246 individuals and *Lythrurus fasciolaris* having 171 individuals.

Site 5 for the May period was characterized by the most abundance of fish collected with 348, while in July the site with the most abundance of fish was site 1 with 359. Site 1 also exhibited the greatest species diversity of the sites in July with 28 species collected. During the May period, sites 2 and 4 were the most diverse; each with 20 species. In May and July a total of 31 species and 34 species were collected at sites 2 and 4, respectively. When the fish fauna for both collection periods and all of the sites were combined, a total of 35 species were collected from the lower mainstem of Buck Creek.

When the two sampling periods were examined by the Index of Biotic Integrity (IBI) separately, site 5 in May obtained the highest score with a 54 (Table VI) and received a classification of Good-Excellent. Sites 2 and 4 were both classified as being of Good water quality with values of 48 and 52, respectively. Site 1 and 3 were both classified as being of Fair water quality, each with values of 44. The average IBI score during May for the five sites was 48.4, indicating Buck Creek to be of Good water quality for that period.

During the July sampling period, site 4 possessed a water quality classification of Excellent with a value of 58. Site 1 was classified as Good-Excellent with a value of

54, sites 2 and 5 each were classified as Good water quality with a value of 52. Site 3 was again classified as Fair water quality with a value of 44. Site 3 exhibited the lowest water quality during both collecting periods, which might have been attributed to the difficulty of seining at this site. The substrate at this site was heavily covered with periphyton which made foot traction difficult during seining. In addition, the pools both upstream and downstream from the riffle were comprised of bedrock slabs which decreased the habitat heterogeneity and allowed the fish plenty of room to avoid capture. The average score for the July sampling period was 52 which indicated Good water quality.

TABLE VI

INDEX OF BIOTIC INTEGRITY (IBI) VALUES AND WATER QUALITY RATINGS ANALYSES FOR MAY AND JULY COLLECTIONS.

PERIOD	**SITE NUMBER**				
	1	2	3	4	5
MAY	44 FAIR	48 GOOD	44 FAIR	52 GOOD	54 GOOD-EXCELLENT
JULY	54 GOOD-EXCELLENT	52 GOOD	44 FAIR	58 EXCELLENT	52 GOOD
AVERAGE	48 GOOD	50 GOOD	44 FAIR	56 GOOD-EXCELLENT	53 GOOD-EXCELLENT

The overall IBI values which were calculated for both the May and July sampling periods (Table VI) indicated Good water quality for the lower mainstem of Buck Creek, with an average of 50.2. The overall IBI average for each site indicated that sites 4 and 5 were of Good-Excellent water quality, with values of 56 and 53, respectively. Site 4 was a Kentucky Division of Water (KDOW) reference site for fishes, and results of the present study were comparable to the division's results (KDOW 1997). The average IBI score reported by KDOW (1997) was 56 and the average taxa richness per sample period was 20, while this study revealed an average IBI score of 56 and a taxa richness average of 21.

Sites 1 and 2 were classified as Good water quality, with values of 48 and 50, respectively. Site 1 showed the greatest score difference between collection periods with a score of 44 (fair) in May and 54 (good) in July. The improved score was the result of the July period having more individuals and twelve more species collected than the May period. In addition, the darters were more prominent in July, with greater abundance and species richness. Therefore, an increase in the number of insectivores, intolerant species, and lithophils occurred, all of which resulted in higher IBI values. The darters Etheostoma _blenniodes_, _E_. _caeruleum_, and _E_. _stigmaeum_ were collected in July but not in May. These species were common and widely distributed throughout Buck Creek (KDOW 1997) and their absence in May could have been the result of collection error.

The results of the Shannon-Wiener Diversity and Evenness Index for the May and July sampling periods are shown in Tables VII and VIII, respectively. The results indicated fair diversity at these sites, and fairly even distribution of species throughout the sites. The results also indicated a higher degree of dominance at sites 2, 3, and 5. The dominant species at was _Lythrurus fasciolaris_. This species represented at least one-third of all fishes collected at these sites. The dominance of this species during the May sampling period was apparently a seasonal factor. In the July collection _L_. _fasciolaris_ was present at all of the sites, but the species made up less than twenty percent of all of the fishes collected. During the July period, all of the sites, except for site 1, exhibited increases in diversity and evenness. This was because _L_. _fasciolaris_ was less dominant during the July period. The decrease of evenness from May to July for site 1 (0.78 to 0.72) was due to the presence of _Notropis telescopus_ and _Labidesthes sicculus_. These two species comprised more than half of the entire fish collection. Site 3 had the lowest diversity of fishes for both collection periods and the difficult seining conditions might have contributed to the low diversity values at this site.

The results of the Jaccard Coefficient of Community (CCj) Similarity for May are shown in Table IX. No definite longitudinal trends were found among the five

TABLE VII

SHANNON-WIENER DIVERSITY INDEX (H′) AND EVENNESS (J) ANALYSES FOR THE MAY FISH SAMPLES.

METRIC	SITE NUMBER				
	1	2	3	4	5
H′	2.15	1.79	1.75	2.42	1.81
J	0.78	0.60	0.76	0.81	0.62

TABLE VIII

SHANNON-WIENER DIVERSITY INDEX (H′) AND EVENNESS (J) FOR THE JULY FISH SAMPLES.

METRIC	SITE NUMBER				
	1	2	3	4	5
H′	2.41	2.49	1.99	2.55	2.15
J	0.72	0.81	0.76	0.84	0.73

sites. Site 3 showed the least similarity to any of the sites, which could have been due to the difficult seining conditions at site 3. If the results for site 3 were to be overlooked, a longitudinal trend among the other sites was demonstrated (i.e., the closer sites were more similar and as sites were further apart the more dissimilar they were). This indicated that the fish assemblage at each site had the same core of species present. These core species included: Campostoma oligolepis, Cyprinella galactura, Luxilus chrysocephalus, Lythrurus fasciolaris, Notropis telescopus, Pimephales notatus, Lepomis megalotis, Micropterus punctulatus, Etheostoma blenniodes, and E. sanguifluum. Some of the less common species which were not found at all of the sites included: Ichthyomyzon bdellium, Erimystax dissimilus, Hybopsis amblops, and Labidesthes sicculus, and Moxostoma erythrurum. Sites 4 and 5 had the greatest similarity (0.73), with only a difference of six species between the two sites. Sites 1 and 5 had the greatest dissimilarity (0.36). These results followed the longitudinal trend that the closer sites are more similar and the distant sites less similar.

The results of the Jaccard Coefficient of Community (CCj) Similarity for July are shown in Table X. Again, if the results of site 3 were to be overlooked a trend similar to that observed for the May period was also demonstrated for the July period. Except for the similarity of sites 1 and 5, the longitudinal trend held true. As with the May period, the July period had a core of species present at each site with a few less common species scattered among the sites. The dissimilarity among the sites was an indication of species replacement between sites; thereby, increasing the overall fish diversity longitudinally in Buck Creek.

TABLE IX

JACCARD COEFFICIENT OF COMMUNITY (CCj) ANALYSES FOR THE MAY FISH SAMPLES.

Site Number	1	2	3	4
2	0.57	----	----	----
3	0.32	0.32	----	----
4	0.44	0.54	0.32	----
5	0.36	0.46	0.27	0.73

TABLE X

JACCARD COEFFICIENT OF COMMUNITY (CCj) ANALYSES FOR THE JULY FISH SAMPLES.

Site Number	1	2	3	4
2	0.61	----	----	----
3	0.41	0.52	----	----
4	0.49	0.54	0.46	----
5	0.52	0.58	0.52	0.61

Macroinvertebrates

A total of 13,222 macroinvertebrates were collected and identified from the semi-quantitative samples for the May collection with a total of 121 taxa from the semi-quantitative and qualitative samples. A comprehensive list of the macroinvertebrates collected from the five sites for the May period can be found in Appendix C. In the July period a total of 14,841 macroinvertebrates were collected and identified from the semi-quantitative samples. A total of 110 taxa were collected in July from the semiquantitative and qualitative samples. A comprehensive list of the macroinvertebrates collected from the five sites for the July period is presented in Appendix D. A combined total of 146 taxa were collected and identified for the two sampling periods (May and July). It should be pointed out that the sampling riffle selected for site 2 in July was switched to a riffle approximately 20 meters downstream from the riffle chosen in May, due to seasonal changes in the stream flow conditions.

The results of the ICI scores for the May and July collection periods are shown in Table XI. The overall water quality classification for all five sites for both sampling periods on the lower mainstem of Buck Creek was Exceptional, with an average score of 48. The average score for the May period was 45 (Good), the average score for July was 50 (Exceptional). For the May period, site 3 was classified as Exceptional while sites 1, 2, 4, and 5 were classified as Good. Sites 1 and 2 had scores of 46 which were the upper most score for the Good category. For the July period, all five sites were classified as Exceptional. The largest difference of scores between collection periods was with sites 4 and 5. Site 4 had a score of 40 in May then in July scored 52, while site 5 scored 42 in May then in July scored 52. The difference in scores was directly related to percent of dipterans and non-insects metric between the two periods. In May, 43% of the collection at site 4 were dipterans and non-insects as compared to 5% in July. In May, 44% of the collection were

TABLE XI
OHIO INVERTEBRATE COMMUNITY INDEX (ICI) VALUES AND WATER QUALITY RATINGS FOR THE MAY AND JULY COLLECTIONS.

PERIOD	SITE NUMBER				
	1	2	3	4	5
MAY	46 GOOD	46 GOOD	52 EXCEPTIONAL	40 GOOD	42 GOOD
JULY	48 EXCEPTIONAL	52 EXCEPTIONAL	48 EXCEPTIONAL	52 EXCEPTIONAL	52 EXCEPTIONAL
AVERAGE	47 EXCEPTIONAL	49 EXCEPTIONAL	50 EXCEPTIONAL	46 GOOD	47 GOOD

dipterans and non-insects at site 5 as compared to 9% in July. These data reflected a decline in the proportions of Ephemeroptera and Trichoptera, and thus lower scores resulted. For example, in May Ephemeroptera for sites 4 and 5 were 21% and 24%, respectively; while, in July, they were 51% and 67%, respectively. These higher proportions of Ephemeroptera resulted in higher scores and better water quality designations for sites 4 and 5. The abundance of the chironomids Cricotopus bicinctus and C. trifascia contributed to the large percentage of dipterans and non-insects in May for sites 4 and 5. Their high abundance in the May collection was in contrast to their low abundance in the July collection. These seasonal differences are probably related to their life cycle.

The results of the HBI scores for the May and July collection periods are shown in Table XII. The overall water quality classification for the lower section of Buck Creek was Excellent (< 4.18), with an average score of 4.16. The average HBI score for the May and July collections were 4.12 (Excellent) and 4.20 (Good), respectively. Sites 2 and 3 for the May period were classified as Excellent water quality, with scores of 3.48 and 3.72, respectively. Sites 1, 4, and 5 were all classified as Good water quality, with scores of 4.31, 4.31, and 4.79, respectively. The low score for site 2 (3.48) can be attributed to the presence of Brachycentrus sp. and Cricotopus trifascia. These two taxa made up 34% of the macroinvertebrates collected and had tolerance values of 0.85 and 2.84, respectively. Sites 1 and 3 for July were classified as Excellent water quality sites, with scores of 4.03 and 3.89, respectively. Sites 2, 4,and 5 were all classified as Good water quality, with scores of 4.27, 4.24, and 4.56, respectively. Site 2 had the most dramatic seasonal change in values, with a 0.79 increase. The cause for this difference could be that different riffles were used during the two periods. In addition, the proportion of Brachycentrus sp. and Cricotopus trifascia at site 2 was approximately 33% in May; whereas, only three

TABLE XII

HILSENHOFF BIOTIC INDEX (HBI) VALUES AND WATER QUALITY RATINGS FOR THE MAY AND JULY COLLECTIONS.

PERIOD	SITE NUMBER				
	1	2	3	4	5
MAY	4.31 GOOD	3.48 EXCELLENT	3.72 EXCELLENT	4.31 GOOD	4.79 GOOD
JULY	4.03 EXCELLENT	4.27 GOOD	3.89 EXCELLENT	4.24 GOOD	4.56 GOOD
AVERAGE	4.17 EXCELLENT	3.88 EXCELLENT	3.81 EXCELLENT	4.28 GOOD	4.68 GOOD

individuals of these taxa were collected in July. This resulted in an increased HBI score at site 2.

The Proportional (%) Community Similarity values for the May period did not show any distinct longitudinal trend (Tables XIII). It was expected that adjacent sites would be more similar then the more distant. The May period did show that site 4 was the most dissimilar site when compared to the other sites. Every other site when compared to site 4 was less than 50% similar. This lack of similarity was attributed to the difference in abundance of the following taxa at site 4: Rhithrogena sp., Ephoron sp., Ceratopsyche cheilonis, Cheumatopsyche sp., and Cryptochironomus fulvus. Ceratopsyche cheilonis and Cheumatopsyche sp. were in low abundance at site 4. The substrate at this site consisted mostly of pebbles and gravel, and these two taxa need larger substrate for attachment of their retreats. This was in contrast to the other three taxa which were found in greater abundance at site 4 than at any of the other sites. This too may have been due to the microhabitat available at site 4. The other four sites, when compared with each other, had similarities ranging from 50.88% for sites 2 and 5 to 70.87% for sites 3 and 5.

The July period also did not show the expected longitudinal trend between the five sites (Table XIV). However, sites 4 and 5 were more similar to each other than to the other three sites which indicated a major shift in macroinvertebrate composition between sites 3 and 4. This may have been due to the emergence of adults during this

TABLE XIII

PROPORTIONAL (%) COMMUNITY SIMILARITY ANALYSES FOR THE MAY MACROINVERTEBRATE SAMPLES.

Site Number	1	2	3	4
2	60.45	----	----	----
3	61.48	61.00	----	----
4	45.51	40.81	40.93	----
5	58.34	50.88	70.87	49.94

period. The taxa at sites 4 and 5 showed that no dipteran taxa had an abundance over 35 individuals, while sites 1, 2, and 3 had some dipteran taxa reaching several hundred individuals.

The Shannon-Wiener Diversity Index and Evenness values for May are shown in Table XV, and the values for July are shown in Table XVI. These evaluations revealed that the lower mainstem of Buck Creek was characterized by high diversity and an evenly distributed macroinvertebrate assemblage. According to Wilhm (1970) diversity values that range from 2.68 to 4.00 indicate clean water, while diversity values that range from 0.42 to 1.60 indicate polluted streams. All of the sites for May had diversity

TABLE XIV

PROPORTIONAL (%) COMMUNITY SIMILARITY ANALYSES FOR THE JULY MACROINVERTEBRATE SAMPLES.

Site Number	1	2	3	4
2	63.88	----	----	----
3	59.85	55.73	----	----
4	47.46	49.74	44.46	----
5	49.97	51.39	49.98	71.43

values above 2.68. The diversity values ranged from 2.71 (Site 2) to 3.12 (site 4). The July period also was characterized by high diversity of taxa, and an evenly distributed macroinvertebrate assemblage among the five sites. The diversity values ranged from 2.58 (site 4) to 3.11 (Site 2). The range extremes for July were the opposite for the May period. One factor that may have influenced this was the switch of riffles sampled at site

TABLE XV

SHANNON-WIENER DIVERSITY INDEX (H') AND EVENNESS (J) ANALYSES FOR MAY MACROINVERTEBRATE SAMPLES.

METRIC	SITE NUMBER				
	1	2	3	4	5
H'	3.08	2.71	2.92	3.12	3.05
J	0.80	0.77	0.78	0.84	0.79

TABLE XVI

SHANNON-WIENER DIVERSITY INDEX (H') AND EVENNESS (J) FOR JULY MACROINVERTEBRATE SAMPLES.

METRIC	SITE NUMBER				
	1	2	3	4	5
H'	3.07	3.11	3.05	2.58	2.61
J	0.81	0.82	0.82	0.71	0.71

2 between the May and July periods. The riffle in July had a greater habitat heterogeneity which could have provided more overall habitat. Sites 4 and 5 had the lowest diversity for the July period. Overall the lower section of Buck Creek had high species diversity, with an average diversity of 2.93, and an average evenness value of 0.79 which indicated low dominance.

The macroinvertebrates collected for each of the five sites for the May and July periods were divided into four different functional feedings groups (FFG). These included the predators, scrapers, shredders, and collectors (Vannote et al. 1980). The collectors were further subdivided into collector-gathers and filter feeders.

All of the sampling sites were located in the fifth order stream segment of Buck creek and were categorized in the mid-size stream reach (Vannote et al. 1980). According to the River Continuum Concept (RCC), the expected proportions of FFGs for a mid-size stream should include a dominance of the scrapers with a relatively high proportion of collectors and filter feeders, while the shredders and predators should make up a relatively low proportion of the macroinvertebrate assemblage.

The functional feeding group composition for the five sites for the May period are shown in Figure 3. The FFG proportions generally followed the tenets of the River Continuum Concept (RCC) with the following exceptions. At site 1 the shredders, which were 10.5% of the collection, were slightly higher than the expected. Site 3 showed a decline in the proportion of scrapers to 17.5%. The decrease was due to the lack of Elimia sp. in the collection. Site 4 had a high proportion of predators (14.7%) which was the highest percentage for that group of the five sites in May, and this increase was caused by the high abundance of Cryptochironomus fulvus (130 indv.). In addition, the filter feeders dropped dramatically to 6.7%. This drop was probably due to the small substrate size at this site which could not support the retreat-making caddisflies.

The functional feeding group composition for the five sites in the July period are shown in Figure 4. These data in general also supported the tenets of the RCC with the following exceptions. At site 1 the collectors were lower and the shredders were again higher than expected which is probably due to the available habitat at this site. Site 2 showed a decline of shredders and an increase in scrapers which is probably due to the more open canopy, revealing in more algae growth.

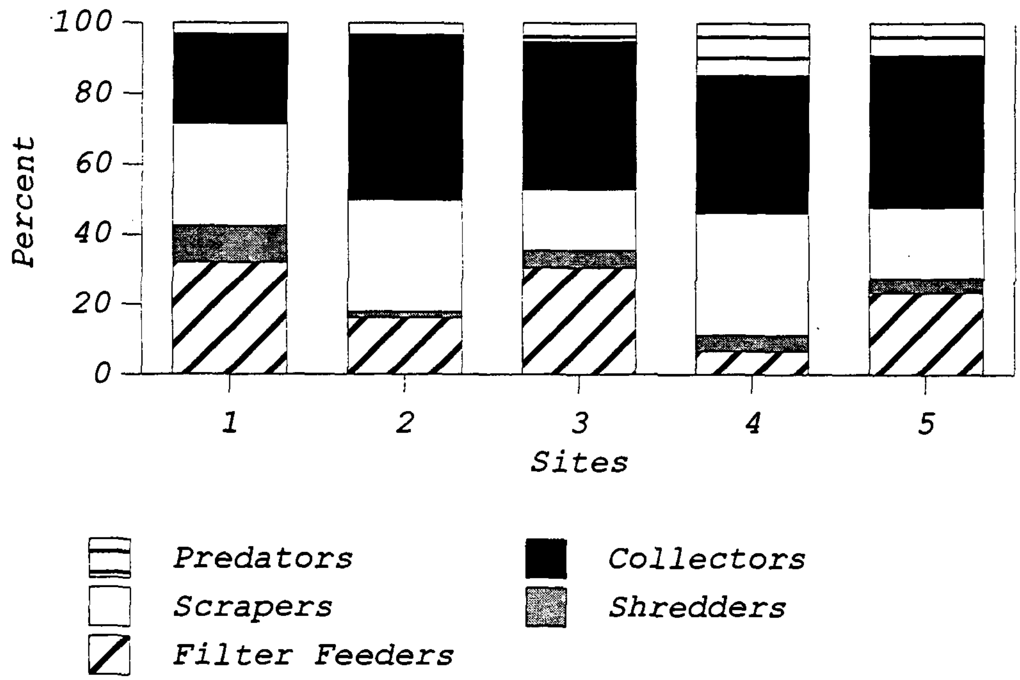

Figure 3. Functional Feeding Group Composition of Sites 1 - 5 for the May Period.

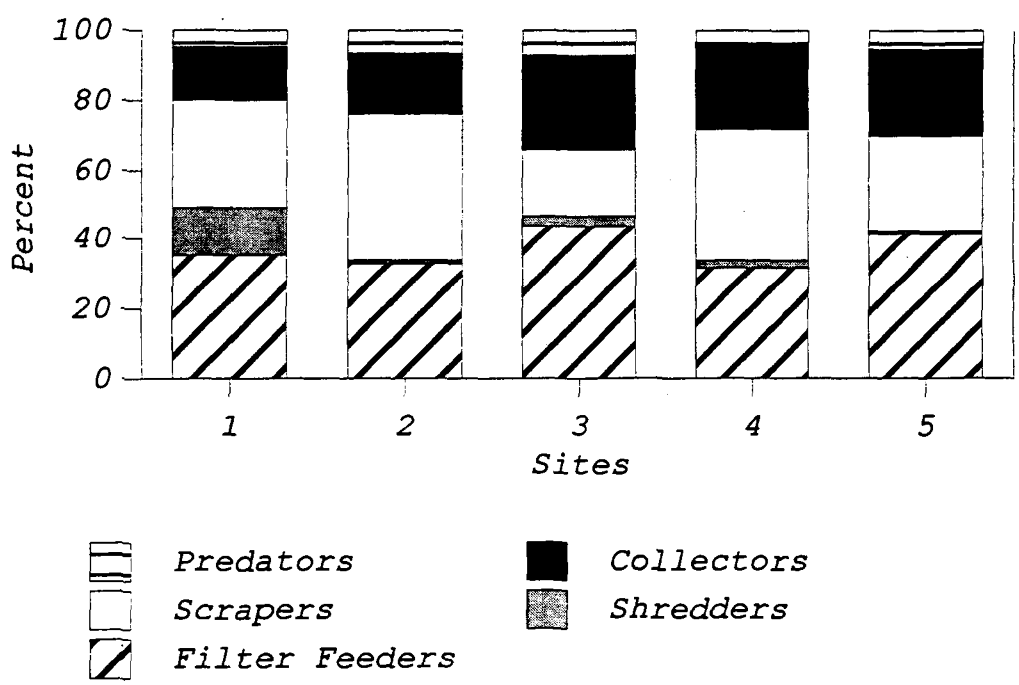

Figure 4. Functional Feeding Group Composition of Sites 1 - 5 for the July Period.

Overall Assessment of the Mainstem of the Buck Creek System

The present study, in conjunction with the current bioassessment of the upper section of Buck Creek (Moeykens 1997), represented a total bioassessment of the fish and macroinvertebrate fauna of the mainstem of Buck Creek. In order to facilitate a discussion of the results of both studies, the upper section sites were designated as sites 6 (most downstream site), 7, 8, 9, and 10 (most upstream site).

The results of the Index of Biotic Integrity for all ten sites for the May and July sampling periods are shown in Figures 5 and 6. The average score for site 1 to 5 was 48.4 (Good) for the May period. The average score for site 6 to 10 was 46.8 (Fair-Good). The overall IBI classification of Buck Creek was Fair-Good, with a value of 47.6.

For sites 1 to 5 for the July period the average, IBI score was 52 (Good). The average score for sites 6 to 10 was 48 (Good) for the July period. When combining data for both months the overall IBI classification of Buck Creek was Good, with a value of 50. The IBI results indicated that the July period had better water quality than the May period and sites 1 to 5 (i.e., downstream sites) were of

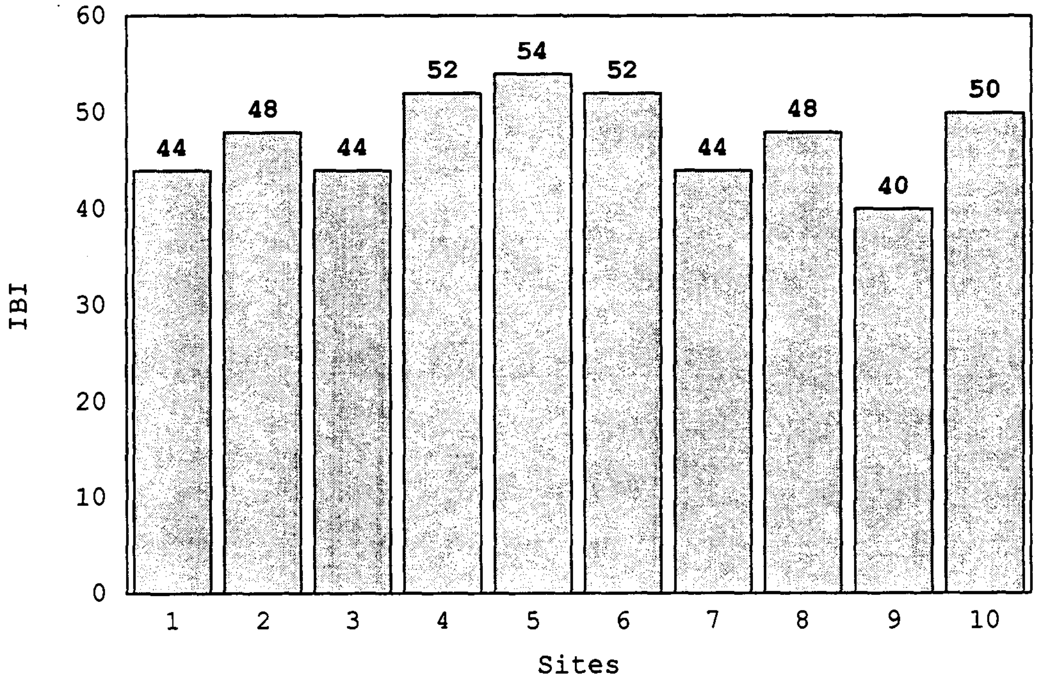

Figure 5. IBI Values of Sites 1 - 10 for the May Period.

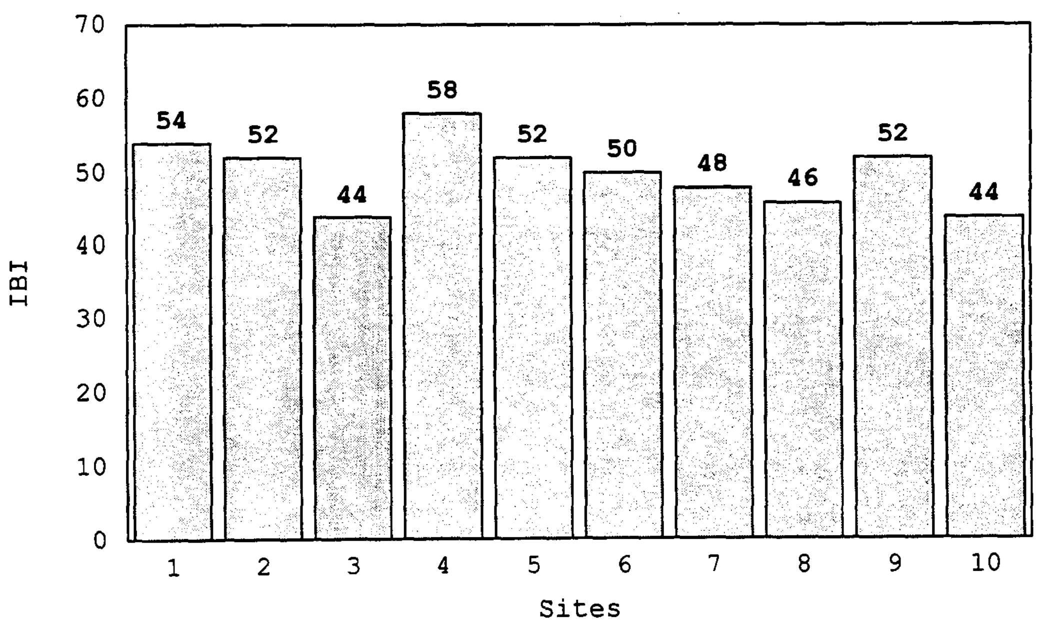

Figure 6. IBI Values of Sites 1 - 10 for the July Period.

better water quality than sites 6 to 10 (i.e., upstream sites), regardless of the sampling period.

The results for the Shannon-Wiener Diversity Index (H′) and Evenness (J) for the ten sites for the May and July sampling periods are shown in Figures 7 and 8. The average diversity value for sites 1 to 5 for May was 1.98 and for sites 6 to 10 the average diversity value was 2.09. The average diversity value in May for all ten sites was 2.04. The evenness average for sites 1 to 5 and for sites 6 to 10 for May was 0.71 and 0.72, respectively. The July period had an average diversity value for sites 1 to 5 of 2.32. For sites 6 to 10 the average diversity value was 2.15. The average diversity for the ten sites for July was 2.23. The evenness average for sites 1 to 5 and for sites 6 to 10 was 0.77 and 0.74, respectively.

These results for both periods showed that the July period had higher values of diversity and evenness than the May period as a result of the fish collections. For sites 6 to 10 in the May period, the diversity and evenness values were greater than at sites 1 to 5 which indicated the fauna might be affected seasonally in their dispersal. Overall the results indicated the fish fauna was diverse and fairly even in distribution throughout the mainstem of Buck Creek.

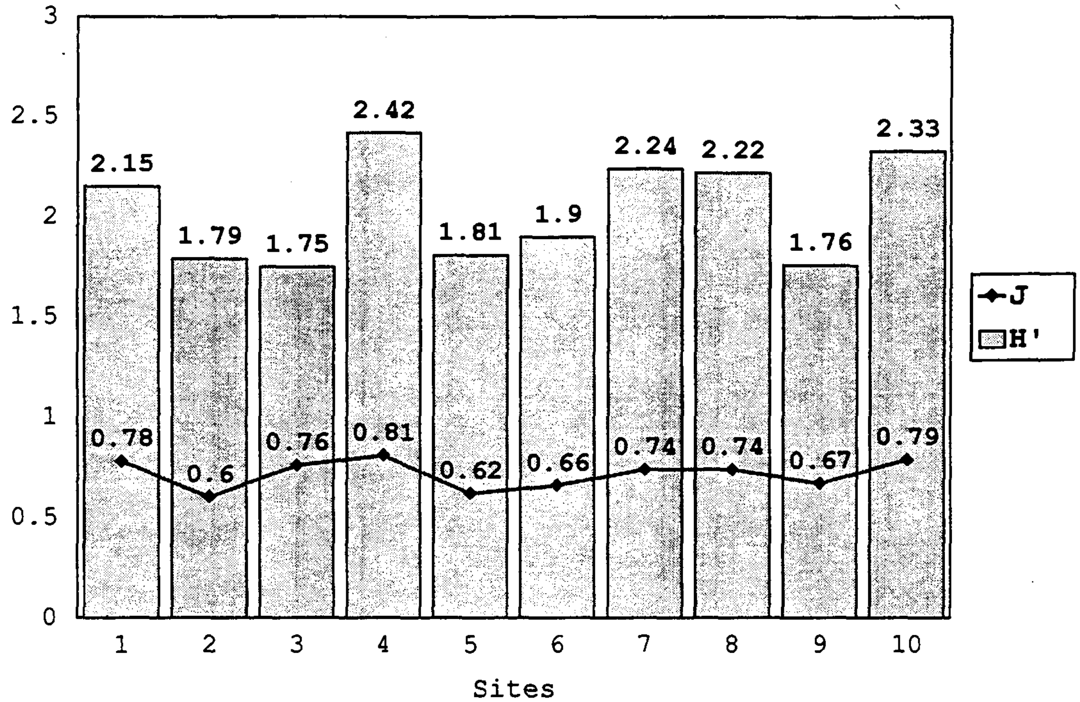

Figure 7. Shannon-Wiener Diversity (H’) and Evenness (J) Fish Values for Sites 1 - 10 for May.

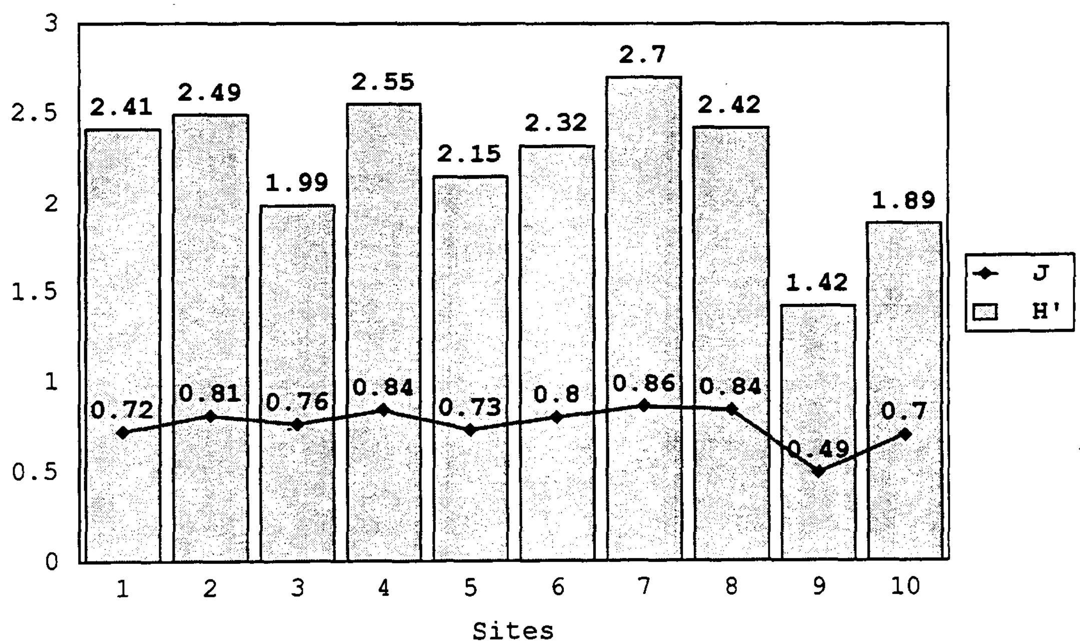

Figure 8. Shannon-Wiener Diversity (H’) and Evenness (J) Fish Values for Sites 1 - 10 for July.

The Jaccard Coefficient of Community (CCj) Similarity results were expected to show a greater similarity between closer sites than sites that were more distantly separated. The results for the May and July periods did not reflect this expected trend fully, but there was a general longitudinal shift in the fish composition (Tables XVII and XVIII). Site 3 for both the May and July periods was the periods was the most dissimilar in comparison with the other sites which was probably due to the difficult seining conditions at the site.

The results of the Invertebrate Community Index (ICI) for the May and July periods are shown in Figures 9 and 10. The average ICI score for sites 1 to 5 for the May period was 45.6 (Good). The average ICI score for the upper section of Buck Creek was 46.4 (Good). The overall ICI classification for Buck Creek was Good with an average score of 46. The July period indicated the water quality to be higher than during the May period. For sites 1 to 5 the average ICI score was 50.4 (Exceptional). Sites 6 to 10 were classified as Exceptional with a average score of 48. The overall average ICI score was 49.2 (Exceptional).

The results of the Hilsenhoff Biotic Index (HBI) for the May and July periods are shown in Figures 11 and 12. The average HBI score for the lower mainstem of Buck Creek

TABLE XVII

JACCARD COEFFICIENT OF COMMUNITY (CCj) ANALYSES OF SITES 1 - 10 FOR THE MAY FISH SAMPLES.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Site 2	0.57								
Site 3	0.32	0.32							
Site 4	0.44	0.54	0.32						
Site 5	0.36	0.46	0.27	0.73					
Site 6	0.43	0.45	0.29	0.58	0.55				
Site 7	0.41	0.43	0.19	0.50	0.52	0.65			
Site 8	0.46	0.38	0.26	0.44	0.39	0.58	0.54		
Site 9	0.36	0.44	0.19	0.39	0.40	0.52	0.55	0.48	
Site 10	0.39	0.46	0.34	0.54	0.50	0.61	0.44	0.63	0.44

TABLE XVII

JACCARD COEFFICIENT OF COMMUNITY (CCj) ANALYSES OF SITES 1 - 10 FOR THE JULY FISH SAMPLES.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Site 2	0.61								
Site 3	0.41	0.52							
Site 4	0.49	0.54	0.46						
Site 5	0.52	0.58	0.52	0.61					
Site 6	0.52	0.52	0.45	0.73	0.46				
Site 7	0.41	0.44	0.37	0.54	0.43	0.58			
Site 8	0.42	0.41	0.28	0.73	0.52	0.64	0.46		
Site 9	0.39	0.43	0.35	0.54	0.48	0.50	0.58	0.57	
Site 10	0.33	0.31	0.38	0.46	0.52	0.38	0.58	0.50	0.57

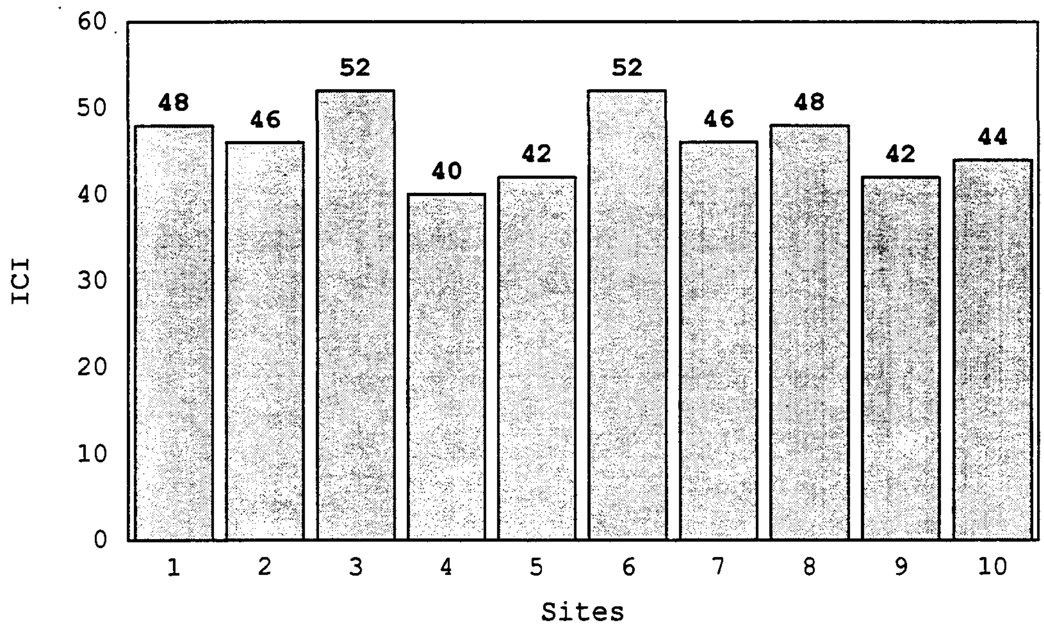

Figure 9. ICI Values of Sites 1 - 10 for the May Period.

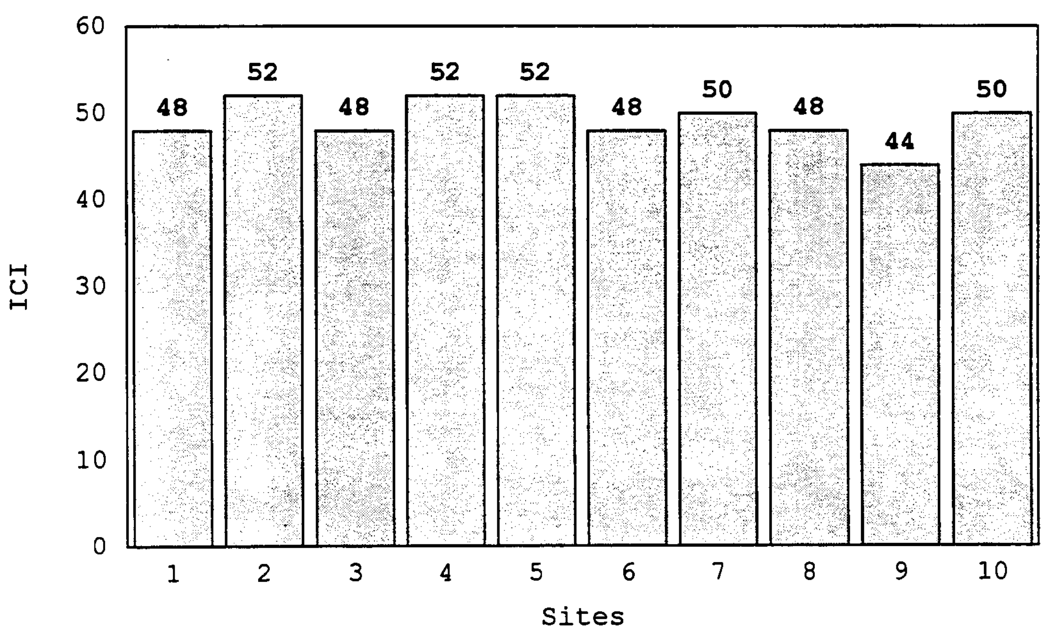

Figure 10. ICI Values of Sites 1 - 10 for the July Period.

for the May period was 4.12 (Excellent). The average HBI score for sites 6 to 10 was 4.15 and was classified as Excellent. The overall HBI classification for Buck Creek for May was Excellent, with an average score of 4.14. During the July period, the overall water quality for all ten sites was Excellent with an average HBI score of 4.09. For sites 1 to 5 the average HBI score was 4.20 (Good). This average was very close to the 4.18 required for an Excellent water quality classification. Sites 6 to 10 had the best HBI score with an average of 3.99 which classified the water quality as Excellent.

The results of the Shannon-Wiener Diversity Index (H') and Evenness (J) for the ten sites for the May and July sampling periods are shown in Figure 13 and 14. The average diversity value for sites 1 to 5 for May was 2.98 and for sites 6 to 10 the average diversity value was 2.84. The evenness averages for the lower mainstem and for the upper section of Buck Creek for May were 0.80 and 0.69, respectively. The July period had an average diversity value for site 1 to 5 of 2.88 and for sites 6 to 10 the average diversity value was 2.73. The average diversity for all ten sites for July was 2.81. The evenness averages for sites 1 to 5 and for sites 6 to 10 were 0.77 and 0.68, respectively. The average evenness value in July for the

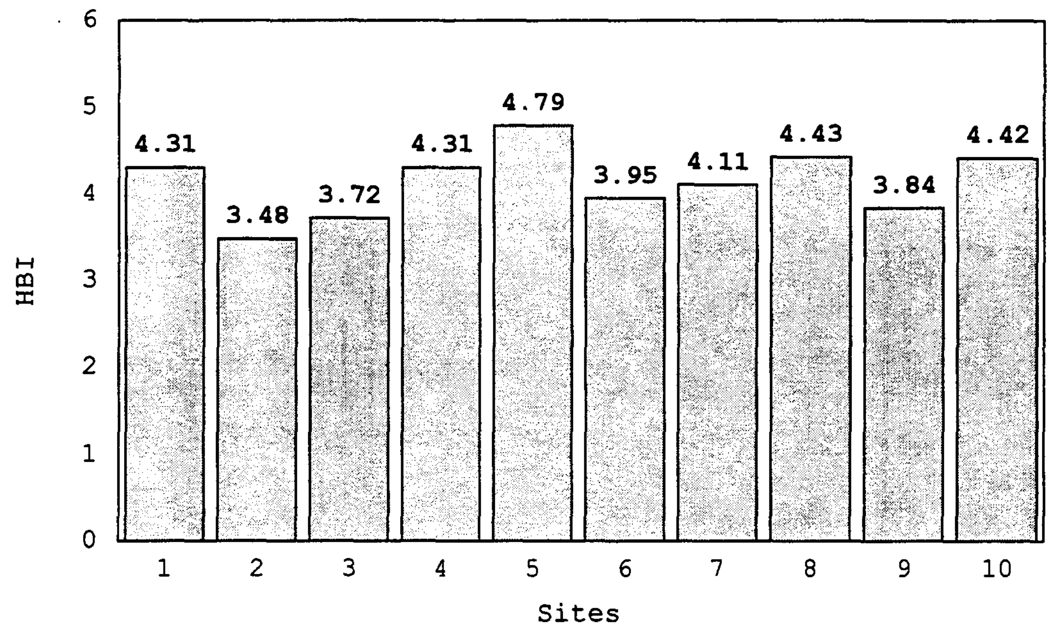

Figure 11. HBI Values of Sites 1 - 10 for the May Period.

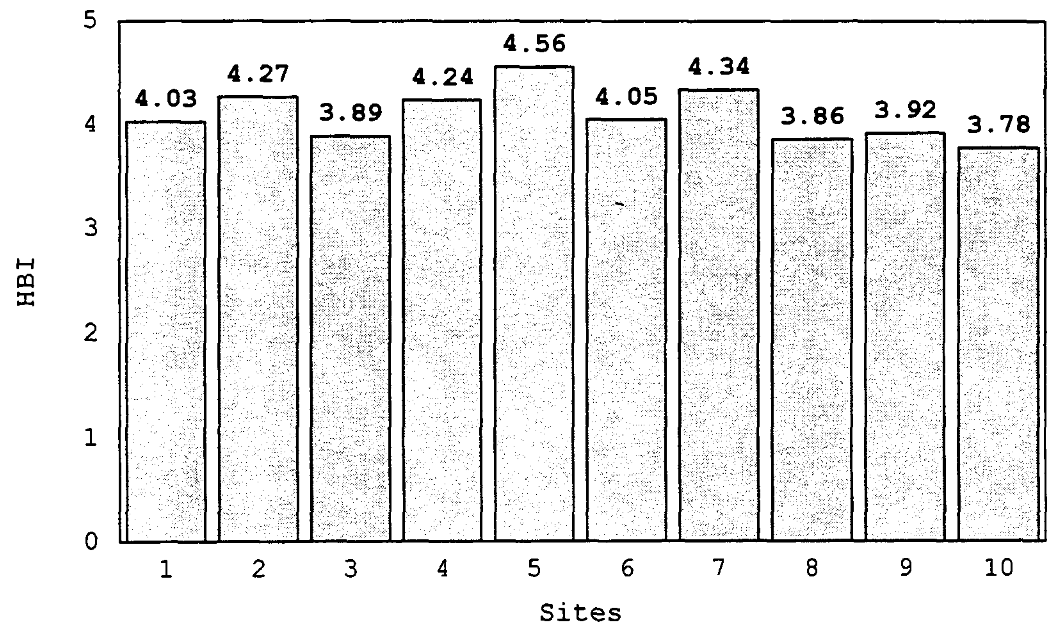

Figure 12. HBI Values of Sites 1 - 10 for the July Period.

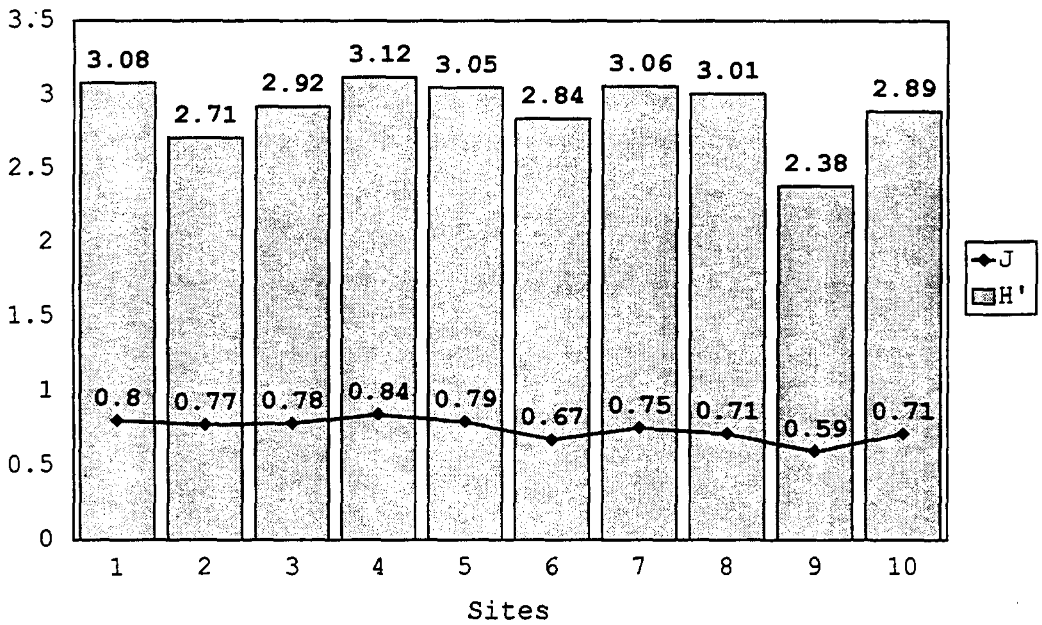

Figure 13. Shannon-Wiener Diversity (H') and Evenness (J) Macroinvertebrate Values for Sites 1 - 10 for May.

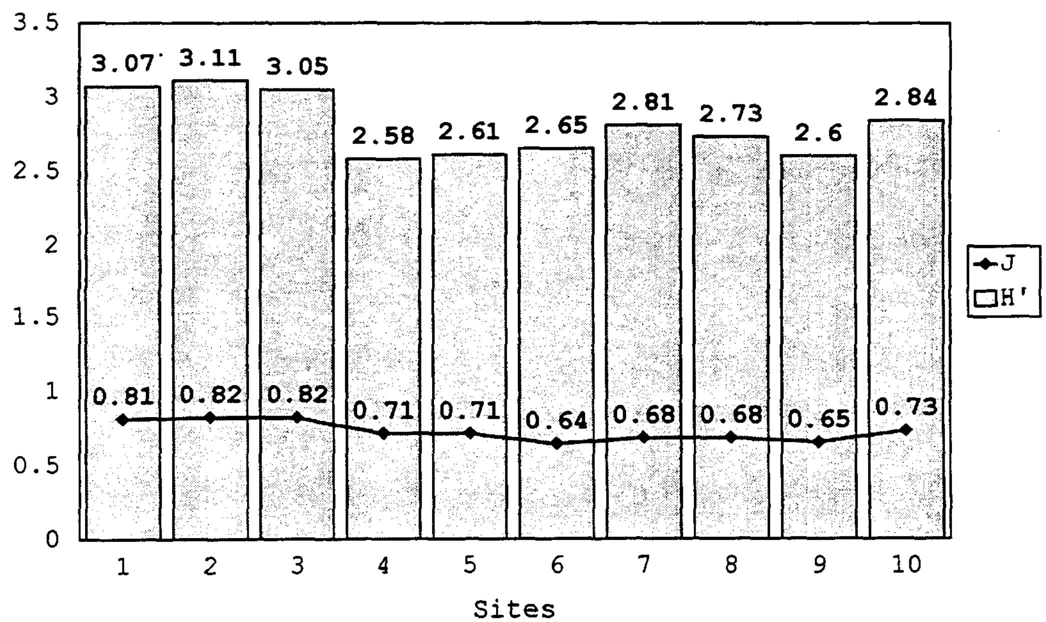

Figure 14. Shannon-Wiener Diversity (H') and Evenness (J) Macroinvertebrate Values for Sites 1 - 10 for July.

ten sites was 0.73. Overall these results indicated that the diversity and evenness of the macroinvertebrate fauna in Buck Creek increased slightly during July.

Except for a few site comparisons which had some extreme high and low similarity values, the results for the May period exhibited a general longitudinal shift in the macroinvertebrate composition (Tables XIX). The July period also exhibited a general shift in that the closer sites were more similar than the more distant sites (Table XX). In addition, sites 4, 5, and 6 displayed high similarity values during the July period, because all of the similarity values were above seventy percent. This was not the case in the May period, and this could be attributed to differences in the life history patterns of some taxa. These results corresponded with the results of the Shannon-Wiener diversity values for the three sites in July (Figure 14).

The Functional Feeding Group (FFG) Composition results of sites 1 - 10 for the May and July periods are shown in Figures 15 and 16. The results of the FFGs were expected to follow the principles of the River Continuum Concept (RCC) (Vannote et al. 1980). Except for site 10, all of the sites were considered to be mid-size stream reaches. Site ten was classified as a headwater stream reach. For

TABLE XIX

PROPORTIONAL (%) COMMUNITY SIMILARITY ANALYSES OF SITES 1 - 10 FOR THE MAY MACROINVERTEBRATE SAMPLES.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Site 2	60.45								
Site 3	61.48	61.00							
Site 4	45.51	40.81	40.93						
Site 5	58.34	50.89	70.87	50.10					
Site 6	46.45	37.90	49.94	36.06	50.57				
Site 7	33.66	27.39	34.31	43.35	38.87	36.41			
Site 8	45.32	30.15	46.21	34.95	52.67	49.98	63.01		
Site 9	29.22	26.92	37.48	26.34	37.84	40.80	56.77	59.83	
Site 10	40.39	32.63	35.66	40.09	42.42	43.71	55.68	60.89	56.84

TABLE XX

PROPORTIONAL (%) COMMUNITY SIMILARITY ANALYSES OF SITES 1 - 10 FOR THE JULY MACROINVERTEBRATE SAMPLES.

	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9
Site 2	63.88								
Site 3	59.85	55.73							
Site 4	47.46	49.74	44.46						
Site 5	49.97	51.39	49.98	71.43					
Site 6	46.23	50.23	46.64	75.45	71.08				
Site 7	47.31	43.91	42.68	58.65	71.35	62.05			
Site 8	38.97	42.62	36.21	59.89	59.51	68.31	57.35		
Site 9	24.93	32.22	25.95	53.44	51.28	51.89	43.37	60.45	
Site 10	41.23	44.29	39.43	52.14	57.06	57.45	58.49	65.73	55.73

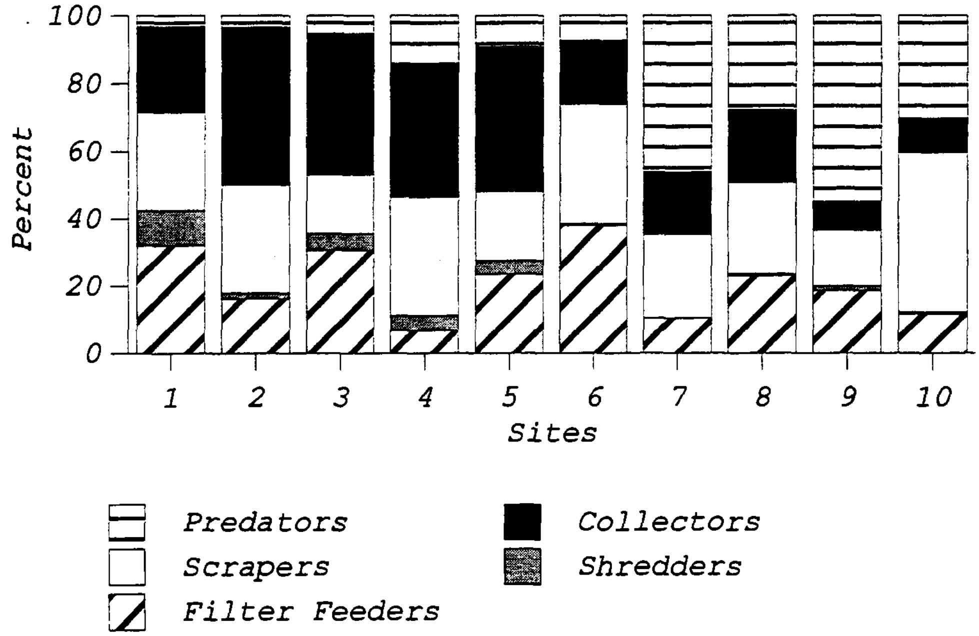

Figure 15. Functional Feeding Group Composition of Sites 1 - 10 for the May Period.

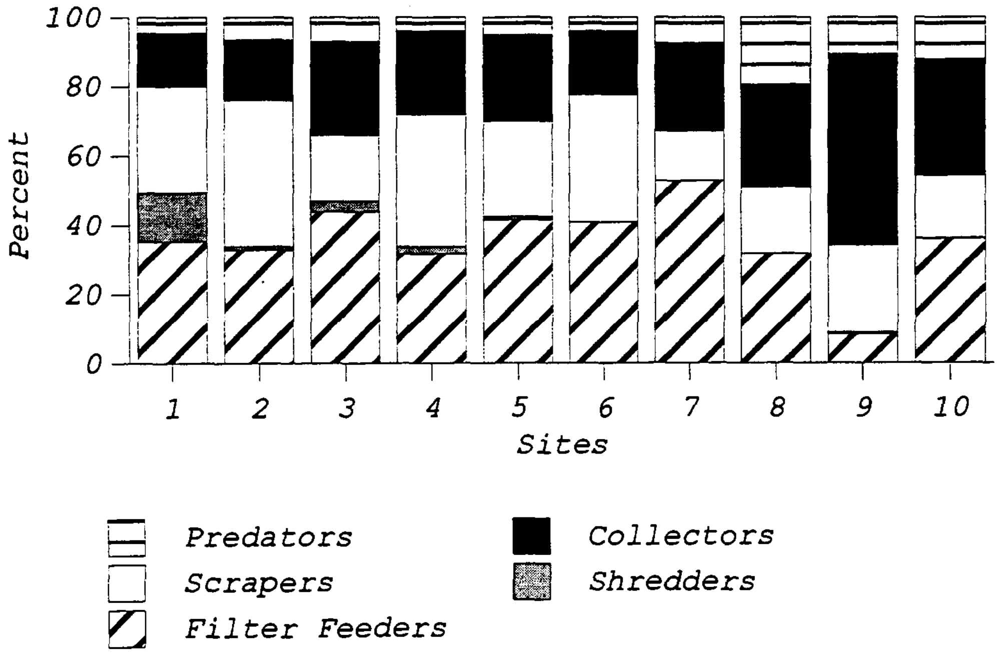

Figure 16. Functional Feeding Group Composition of Sites 1 - 10 for the July Period.

the lower mainstem of Buck Creek, the five sites followed the predictions of the RCC; that was, the scrapers and collectors were the dominant groups and the predators were fairly consistent throughout the lower mainstem of Buck Creek. The only difference from the RCC tenets was that the shredders had their highest abundance at site 1. Except for site 6, the upper section sites of Buck Creek did not follow the predictions of the RCC. The mid-size reach sites (7- 9) had very high proportions of predators which was related to a seasonal phenomenon resulting in an abundance of Perlesta sp. In addition, site 10 exhibited more characteristics of a mid or large size stream than a headwater site. For example, the scrapers were the most abundant, while the shredders had extremely low abundance. Overall the FFG proportions for all ten sites followed the predictions for a mid-size stream.

Seasonally the July FFG proportions for sites 1 - 5 mirrored the results of the May period. This pattern followed the predictions of the RCC. Seasonally for sites 6 - 9, the dominance of the predators during May shifted to the more predicted dominance of the scraper and collector group during July which was due to the reduction of Perlesta sp. Overall, FFG proportions throughout the mainstem of Buck Creek followed the predictions of the RCC (with the exception of the shredders). Therefore, no indication of an impact influencing the proportions of macroinvertebrates assembled within the stream.

CHAPTER V

SUMMARY AND CONCLUSIONS

Past studies have shown Buck Creek to have several unique and rare species. To assist with the conservation of these organisms the first intensive biological assessment of Buck Creek was conducted. This intensive bioassessment included the current study and a study by Moeykens (1997). This study was designed to determine the current status of the water quality of the lower mainstem (five sites) of Buck Creek analyzing the fish and macroinvertebrate fauna. In addition, this study provided baseline data for future biological monitoring of the stream.

At site 1 the Index of Biotic Integrity (IBI), the Invertebrate Community Index (ICI), and the Hilsenhoff Biotic Index (HBI) values indicated the overall water quality to be Good to Excellent. The Shannon Diversity (H′) and Evenness (J) values for both fishes and macroinvertebrates indicated diverse and evenly distributed assemblages. The Functional Feeding Group Composition followed the predictions of the River Continuum Concept for all of the groups, except for the shredders. The shredders were the most abundant at this site which was most likely the result of some influx and accumulation of coarse particulate organic matter (CPOM) into the stream at this site.

Site 2 was classified as Good to Excellent using the IBI, ICI, and HBI values. The Shannon Diversity (H') values for fish were variable between seasons as a result of the abundance of Lythrurus fasciolaris in the May period. Overall, however, the diversity and evenness of the fishes and macroinvertebrates assemblage were high, and the taxa were fairly evenly distributed. The Functional Feeding Group Composition followed the predictions of the River Continuum Concept for all of the groups, except that the May period had a much lower percentage of filter feeders which was probably due to the change in the riffles sampled between periods.

The Index of Biotic Integrity (IBI) for site 3 produced an overall water quality classification of Fair. However, both the ICI and HBI values indicated Excellent water quality. This discrepancy was the direct result of the difficult seining conditions which resulted in low Shannon Diversity and Evenness values for the fish data, while the macroinvertebrates results were much higher for both tests. The Functional Feeding Group Composition followed the predictions of the River Continuum Concept.

At site 4 the IBI results indicated the overall water quality to be Good-Excellent, while the ICI and HBI values indicated Good water quality. The Shannon Diversity (H') and Evenness (J) values were high for both the fish and the macroinvertebrates assemblages. The Functional Feeding Group Composition followed the predictions of the River Continuum Concept, with the exception of the low percentage of filter feeders in May.

At site 5 the IBI values indicated the overall water quality to be Good-Excellent, while the ICI and HBI values reflected Good water quality. The Shannon Diversity (H') and Evenness (J) values were high for both the fish and the macroinvertebrates assemblage. The Functional Feeding Group Composition followed the predictions of the River Continuum Concept.

Overall, the water quality of the lower mainstem of Buck Creek based on the fish and macroinvertebrates was classified as Good-Excellent. This was reinforced by the results of the Shannon-Wiener Diversity and Evenness Index values. The high diversity was also shown in the results of the Jaccard Coefficient of Community (CCj) Similarity and

Proportional (%) Community Similarity. The relative low similarity between sites indicated a taxa replacement upstream to downstream which resulted in greater diversity throughout the stream system. The tenets of the River Continuum Concept were generally followed, except for the high percentage of shredders at site 1.

This study was done in conjunction with a study of the upper section of Buck Creek (Moeykens 1997). Together two studies together provided an overall assessment of the mainstem of the Buck Creek system. Overall, the water quality of the entire mainstem of Buck Creek, based on the fish and macroinvertebrates, was classified as Good-Excellent. This was reinforced by the results of the Shannon-Wiener Diversity and Evenness Indexes. All of these data, including the Functional Feeding Group Composition, when taken together indicated a healthy and diverse system that currently has few perturbations.

Based on the all of the metrics for both the fish and macroinvertebrates no large scale disturbances on the mainstem of Buck Creek were detected. The analysis of data from site 9 did suggest that the road crossing had some impact on the fauna (Moeykens 1997). Overall, Buck Creek is a healthy stream with a very diverse assemblage of fish and macroinvertebrates. Conservation of this system is highly recommended and it is advised that a continuing biomonitoring program be established for Buck Creek to preserve its current state. A watchful eye should be kept on certain activities such as the removal of stream channel gravel and the proposed channelization. These and other impacts could not only put the endangered species living in Buck Creek at further risk, but the stability of the entire system could be threatened.

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APPENDIX A.

COMPREHENSIVE LIST OF ALL FISH COLLECTED IN BUCK CREEK AT THE FIVE SITES DURING MAY 1996.

	SITE NUMBER					
TAXA	**1**	**2**	**3**	**4**	**5**	**TOTAL**
Petromyzontidae						
Ichthyomyzon bdellium				1		1
Cyprinidae						
Campostoma oligolepis	34	4		2	11	51
Cyprinella galactura	2	11	26	18	5	72
C. spiloptera	6	10		12		28
C. whipplei	2	1				3
Erimystax dissimilus	2					2
Hybopsis amblops		8				8
Luxilus chrysocephalus	10	6		5	33	44
Lythrurus fasciolaris		119	30	36	177	362
Notropis ariommus	2	1				3
N. boops		2		3	9	14
N. telescopus	7	11	12	24	41	95
N. rubellus					1	1
Pimephales notatus	2	1	1	24	19	47
Catostomidae						
Hypentelium nigricans			10	1		11
Moxostoma erythrurum					1	1
Fundulidae						
Fundulus catenatus				6	23	29
Atherinidae						
Labidesthes sicculus		9				9
Centrarchidae						
Ambloplites rupestris				1	1	2
Lepomis macrochirus	5	16		4		25
L. megalotis	2	2		2	4	10
Micropterus dolomieu			2			2
M. punctulatus	2	1		4	1	8
Percidae						
Etheostoma blennioides		4	4	4	1	13
E. caeruleum				2	8	10
E. camurum	3			3	7	13
E. sanguifluum	3	1	1	1	1	7
E. stigmaeum		2		5	5	12
E. zonale	1	1	2			4
Percina caprodes	2		3			5
Cottidae						
Cottus carolinae		1				1
Total Species per site	16	20	10	20	18	31
Total Individuals:	84	211	91	158	348	892

APPENDIX B.

COMPREHENSIVE LIST OF ALL FISH COLLECTED IN BUCK CREEK AT THE FIVE SITES DURING JULY 1996.

	SITE NUMBER					
TAXA	**1**	**2**	**3**	**4**	**5**	**TOTAL**
Clupeidae						
Dorosoma cepedianum	1					1
Cyprinidae						
Campostoma oligolepis	11	10	17	20	18	76
Cyprinella galactura	1	2	12	13	11	39
C. spiloptera			13	1	7	21
C. whipplei	13	2		1	5	21
Erimystax dissimilus	1					1
Hybopsis amblops	3	4	2		1	10
Luxilus chrysocephalus	9	3	7	12	11	42
Lythrurus fasciolaris	9	31	24	38	69	171
Notropis athernoides	4	1				5
N. ariommus	4	19				23
N. boops	4	2	1			7
N. photogenis	31					31
N. telescopus	74	36	63	25	48	246
N. rubellus	6	3	4	1	41	55
Pimephales notatus	3		2	2		7
Catostomidae						
Hypentelium nigricans		5	4	4		13
Moxostoma erythrurum				3	1	4
Fundulidae						
Fundulus catenatus				22	5	27
Atherinidae						
Labidesthes sicculus	81					81
Centrarchidae						
Ambloplites rupestris	1			2		3
Lepomis macrochirus	2	4		12	7	25
L. megalotis	1	1		17	2	21
Micropterus dolomieu	1				1	2
M. punctulatus		1		6	1	8
M. salmoides	3					3
Percidae						
Etheostoma blennioides	8	3	10	6	3	30
E. caeruleum	2			1	2	5
E. camurum	5	17		2	3	27
E. sanguifluum	14	4	1	6	3	28
E. stigmaeum	2	1		2		5
E. zonale		4				4
Percina caprodes	2	3	2		3	10
Cottidae						
Cottus carolinae	3	6				9
Total Species per site	28	22	14	21	21	34
Total Individuals:	359	162	162	196	237	1116

APPENDIX C.

COMPREHENSIVE LIST OF ALL MACROINVERTEBRATES COLLECTED IN BUCK CREEK AT THE FIVE SITES DURING MAY 1996. ORGANISMS COLLECTED ONLY IN THE QUALITATIVE SAMPLES ARE DENOTED BY AN X.

	SITE NUMBER				
TAXA	**1**	**2**	**3**	**4**	**5**
Platyhelminthes					
Tricladia					
Planariidae sp.				2	
Gastropoda					
Ancylidae					
Ferrissia sp.			1	X	X
Physidae					
Physa sp.				X	
Planorbidae					
Helisoma sp.				X	
Pleuroceridae					
Elimia sp.	132	128	17	120	10
Viviparidae					
Campeloma sp.	X			X	
Pelecypoda					
Corbiculidae					
Corbicula *fluminea*	21	13	3	8	13
Sphaeriidae					
Sphaerium sp.	11	4	6	4	4
Annelida					
Oligochaeta sp.	107	44	X	32	1
Lumbriculidae					
Lumbriculis sp.	1		1	21	5
Crustacea					
Amphipoda					
Gammarus sp.	X	X			X
Decapoda					
Cambarus sp.		X			
Orconectes sp.	5	3	4		1
Isopoda					
Lirceus *fontinalis*	X				
Insecta					
Ephemeroptera					17
Baetidae					
Baetis spp. sensu latu	74	83	94	69	135
Centroptilum sp.				4	1
Caenidae					
Caenis sp.	8				
Ephemerellidae					
Atenella sp.					X
Ephemerella sp.	1				
Eurylophella sp.	1	1	X		
Serratella sp.	1	1	1	X	1
Dannella sp.	X	X	X	X	

APPENDIX C (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	
Ephemeridae						
Hexagenia sp.	X					
Heptageniidae					1	
Heptagenia sp.			2			
Leucrocuta sp.	4	1	34	34	19	
Rhithrogena sp.	12	1	2	105	32	
Stenonema sp.	85	30	39		32	
Stenonema mediopunctatum	72	7	168	12	192	
Stenonema modestum	31	3	20			
Stenacron sp.		X	X		3	
Isonychiidae						
Isonychia spp.	79	28	259	13	216	
Leptophlebiidae						
Leptophlebia sp.	X					
Polymitarcyidae						
Ephoron sp.	26	24	43	200	25	
Potamanthidae						
Anthopotamus sp.	X					
Odonata						
Aeshnidae						
Boyeria vinosa	1	X	1	X	X	
Calopterygidae						
Calopteryx sp.			X	X		
Coenagrionidae						
Argia sp.		X	X	X	X	
Enallagma sp.	X	X		X	X	
Corduliidae						
Macromia sp.	X	X	X	X		
Gomphidae						
Dromogomphus sp.	X	X	X			
Gomphus sp.	X	X	X	X		
Hagenius brevistylus		X			X	X
Lanthus sp.					1	
Stylogomphus albistylus	X			X	X	
Plecoptera						
Chloroperlidae						
Alloperla sp.				11		
Haploperla sp.				1		
Leutridae sp.	1					
Nemouridae						
Amphinemura sp.			3		5	
Perlidae	7	1	12	90	64	
Acroneuria sp.			X		X	
Beloneuria sp.	1			2	9	
Neoperla sp.	6	1	15	33	13	
Perlesta sp.	31	8	6	6	38	
Agnatina sp. (=*Phasganophora*)	34	19	44	14	65	
Perlodidae						
Isoperla sp.					2	
Heteroptera						
Corixidae			X			

APPENDIX C (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5
Gerridae					
Gerris sp.					X
Trepobates sp.			X		
Veliidae					
Rhagovelia sp.		X	1	X	X
Naucoridae					
Pelocoris sp.				X	
Nepidae					
Ranatra sp.		X			
Megaloptera					
Corydalidae					
Corydalus cornutus	13	14	9	1	31
Sialidae					
Sialis sp.				X	
Neuroptera					
Sisyridae					
Sisyra sp.				X	
Trichoptera					
Brachycentridae					
Brachycentrus sp.	21	183	215		5
Glossosomatidae					
Agapetus illini			X		
Glossosoma sp.	1				
Protoptila sp.	6	14	2		
Helicopsychidae					
Helicopsyche borealis	X	2		1	5
Hydropsychidae					
Ceratopsyche cheilonis	247	42	193	19	69
Cheumatopsyche sp.	501	118	266	65	391
Hydropsyche sp.			1		
H. betteni					2
H. frisoni	5	1			5
Macrostenum sp.	20	4			
Lepidostomidae					
Lepidostoma sp.(case)	X				
Leptoceridae				X	
Ceraclea sp.(case)	X				
Oecetis sp.				X	
Limnephilidae					
Pycnopsyche sp.	X	X		1	
Philopotamidae				3	
Chimarra sp.	35	2	8	4	17
Dolophilodes distinctus	2		11	4	6
Wormaldia sp.	1	1	1		3
Psychomyiidae					
Psychomyia flavida	1	X	1		
Ueonidae					
Neophylax sp.	2	X	X	12	2
Lepidoptera					
Pyralidae					
Petrophila fulicalis	5	X	1	X	1

APPENDIX C ·(CONT.)

TAXA	SITE NUMBER 1	2	3	4	5
Coleoptera					
Dryopidae					
Helichus sp.	X	X	1	X	X
Dytiscidae					
Uvarus sp.			X		
Elmidae					
Ancyronyx sp.				X	
Dubiraphia sp.	X	X		X	
Macronychus glabratus	X	X	X	X	1
Optioservus sp.	216	132	33	28	19
Stenelmis sp.	450	187	233	287	381
Gyrinidae					
Dineutus sp.	1	X	X	4	3
Haliplidae					
Peltodytes sp.	X		X		X
Hydrophilidae					
Sperchopsis tessellatus					X
Tropistrenus sp.		X			
Psephenidae					
Psephenus herricki	71	35	24	120	48
Staphylinidae					
Stenus sp.		1			X
Diptera					
Ceratopogonidae	2	1	4	22	37
Chironomidae				110	10
Tanypodinae					10
Nilotanypus sp.				10	
Orthocladiinae	50	20	30	30	150
Cardiocladius sp.		10	10		
C. bicinctus gp.	80	20	80	140	300
C. trifascia gp.	150	420	280	30	300
Cricotopus\Orthocladius spp.	80	60	100	110	230
Eukiefferiella sp.			10		20
E. claripennis		10			
E. potthasti	10		10		
Nanocladius sp.	10			10	
Orthocladius obumbratus			20		30
O. (Euorthocladius) sp.			20		
Thienemanniella sp.		10		20	
Tvetnia bavarica gp.	10				
T. discoloripes	20				20
Chironomini spp.				20	60
Cryptochironomus fulvus gp.				130	
Dicrotendipes neomodestus			10	60	30
Parachironomus sp.			10		
Polypedilum spp.	20				
P. convictum gp.	330	30	120	100	120
P. illinoense					10
Tanytarsini spp.					
Rheotanytarsus sp.	20			30	
Tanytarsus sp.	30	10			

APPENDIX C (CONT.)

TAXA	**SITE NUMBER** 1	2	3	4	5
Simuliidae					
Simulium sp.	103	68	29		49
Tabanidae					
Tabanus sp.			3		6
Tipulidae					
Dicranota sp.	8	1	13		1
Hexatoma sp.		2	3	7	14
Limnophila sp.		1	2	2	5
Tipula spp.			1	1	X
TOTAL NUMBER OF DISTINCT TAXA (121)	81	69	80	79	80
TOTAL NUMBER OF INDIVIDUALS	3283	1792	2541	2260	3346

APPENDIX D.

COMPREHENSIVE LIST OF ALL MACROINVERTEBRATES COLLECTED IN BUCK CREEK AT THE FIVE SITES DURING JULY 1996. ORGANISMS COLLECTED ONLY IN THE QUALITATIVE SAMPLES ARE DENOTED BY AN X.

	SITE NUMBER				
TAXA	**1**	**2**	**3**	**4**	**5**
Platyhelminthes					
Tricladia					
Planariidae sp.					1
Gastropoda					
Ancylidae					
Ferrissia sp.			1	1	5
Planorbidae					
Helisoma sp.		X		X	
Pleuroceridae					
Elimia sp.	279	204	43	42	14
Viviparidae					
Campeloma sp.	X				
Pelecypoda					
Corbiculidae					
Corbicula fluminea	35	91	12	3	15
Sphaeriidae					
Sphaerium sp.	4	9	6	X	
Annelida					
Branchiodella sp.			X		
Oligochaeta sp.	66	5	19	8	12
Lumbriculidae					
Lumbriculis sp.	1	X	1		
Crustacea					
Amphipoda					
Gammarus sp.	X	X	X	X	
Decapoda					
Cambarus sp.	X		X	X	
Orconectes sp.	3	5	X	X	4
Insecta					
Ephemeroptera					
Baetidae					
Baetis spp. sensu latu	128	108	126	386	371
Centroptilum sp.		3			
Caenidae					
Caenis sp.	91	88	41	84	173
Ephemerellidae					
Timpanoga sp.	X				
Heptageniidae					
Epeorus sp.	X				
Heptagenia sp.			X	X	2
Leucrocuta sp.	1	4		54	25
Rhithrogena sp.				1	1
Stenonema sp.	189	78	174	140	151
S. femoratum				X	
S. mediopunctatum	58	41	126	90	251
S. modestum	23	4	40	29	33

APPENDIX D (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5
Stenacron sp.		X	X	1	
Isonychiidae					
Isonychia spp.	486	174	332	290	316
Leptophlebiidae					
Choroterpes sp.				X	
Polymitarcyidae					
Ephoron sp.		15	14	X	1
Tricorythidae					
Tricorythodes sp.	1	6	7	2	
Odonata					
Aeshnidae					
Boyeria vinosa	X	X	X	X	X
Calopterygidae					
Calopteryx sp.				X	X
Coenagrionidae					
Argia sp.		X	X	1	X
Enallagma sp.		X		X	
Corduliidae					
Macromia sp.	1	X	X	1	X
Gomphidae					
Dromogomphus sp.	X	X	X	X	X
Gomphus sp.	X	X	X	X	
Hagenius sp.	X	1	X	X	X
Lanthus sp.	1				
Plecoptera					
Perlidae	10	3	3		2
Acroneuria sp.				X	X
Neoperla sp.	9	10	3	30	37
Agnatina sp. (=Phasganophora)	8	8	4	1	2
Heteroptera					
Gerridae					
Metrobates sp.	1	1	X	X	X
Rheumatobates sp.		1			X
Trepobates sp.	X	3	X		
Hydrometridae					
Hydrometra sp.					X
Veliidae					
Microvelia sp.	1				
Rhagovelia sp.			1		2
Mesoveliidae					
Mesovelia sp.					X
Nepidae					
Ranatra sp.	1	3		X	
Megaloptera					
Corydalidae					
Corydalus cornutus	20	17	32	5	46
Nigronia sp.	6	20	6	3	X
Sialidae					
Sialis sp.			2		X
Trichoptera					
Brachycentridae					
Brachycentrus sp.	1	X	110	X	X

APPENDIX D (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5
Glossosomatidae					
Protoptila sp.	6	2	1	1	
Helicopsychidae					
Helicopsyche borealis	X	2			
Hydropsychidae		63			
Ceratopsyche cheilonis	225	35	686	21	131
Cheumatopsyche sp.	305	174	313	173	561
Hydropsyche sp.	7	2			
H. betteni	1				1
H. frisoni	80	21	54	X	2
Macrostenum sp.	184	11		X	
Leptoceridae					
Oecetis sp.			X		X
Triaenodes sp.			X		
Limnephilidae					
Pycnopsyche sp.	X	X	X	X	X
Philopotamidae					
Chimarra sp.	91	4	7	15	26
Polycentropodidae					
Polycentropus sp.		2			
Psychomyiidae					
Psychomyia flavida	1	1	6		
Ueonidae					
Neophylax sp.	2	X	X	3	
Lepidoptera					
Pyralidae					
Petrophila fulicalis	1		1		2
Coleoptera					
Dryopidae					
Helichus sp.	X	X	X	1	1
Dytiscidae					
Lioporeus pilatai	X				
Elmidae					
Ancyronyx sp.	1			X	X
Dubiraphia sp.	1	2		X	X
Macronychus glabratus	1		1	1	X
Microcylloepus sp.	10	15			
Optioservus sp.	544	306	137	26	37
Stenelmis sp.	364	197	446	87	234
Gyrinidae					
Dineutus sp.	3	X		2	16
Gyrinus sp.	X				
Haliplidae					
Peltodytes sp.	X	X	X	X	X
Hydrophilidae					
Tropistrenus sp.	X			X	
Psephenidae					
Psephenus herricki	30	23	11	20	16
Staphylinidae					
Stenus sp.	2		1		

APPENDIX D (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5
Diptera					
Athricidae					
Atherix sp.	37	1	79	1	10
Chironomidae	30	6	10	5	4
Tanypodinae		1	10	5	1
Ablesmyia sp		1		5	1
Thienmannimyia gp.	30	2	10	3	1
Orthocladiinae	90	10	90	1	2
Cardiocladius sp.	70		130	1	
C. bicinctus gp.		2	40	3	4
C. trifascia gp.	20	3	80	5	4
*Cricotopus**Orthocladius* spp.	30	49	190	6	3
Eukiefferiella sp.	10		90	4	
Nanocladius sp.					2
Orthocladius obumbratus	10			1	
Synorthocladius sp.		5		2	
Thienemanniella sp.	20	28		6	3
Tventia sp.			10		
T. bavarica gp.	20		20		
Diamesinae spp.		10		1	
Chironomini spp.	10			2	2
Cryptochironomus fulvus gp.	10	48	10	4	5
Microtendipes pedellus			10	2	
Polypedium convictum gp.	640	23	130	33	26
P. illinoense				2	
P. scalaenum				1	
Tanytarsini spp.		12	20	1	1
Rheotanytarsus sp.	10	72	150	4	18
Tanytarsus sp.	20	2	10	5	3
Ephydridae spp.	2	3	2		
Simuliidae					
Simulium sp.	146	26	204		5
Tipulidae					
Antocha sp.	1	1			
Dicranota sp.	3	3		X	
Hexatoma sp.		1		1	10
Limnophila sp.					1
TOTAL NUMBER OF DISTINCT TAXA (110)	76	79	77	81	76
TOTAL NUMBER OF INDIVIDUALS	4496	2087	4044	1619	2592