FINAL REPORT

BIOASSESSMENT OF THE FISH AND MACROINVERTEBRATES OF THE UPPER MAINSTEM OF BUCK CREEK, LINCOLN AND PULASKI COUNTIES, KENTUCKY

Michael D. Moeykens and Guenter A. Schuster
Department of Biological Sciences
Eastern Kentucky University
Richmond, KY 40475

Prepared for:

The Kentucky Division of Water
14 Reilly Rd.
Frankfort, KY 40601

December 8, 1997

Funding for this report was provided by a grant from the U.S. Environmental Protection Agency, as authorized by Section 319(h) of the Federal Clean Water Act Amendments of 1987 (PL 100-4). The mention of trade names or commercial products does not constitute endorsement. Nothing in this document shall be used as a means to circumvent existing laws or regulations. This document was printed on recycled paper. The Natural Resources and Environmental Protection Cabinet does not discriminate on the basis of race, color, national origin, sex, age, religion, or disability and provides, on request, reasonable accommodations including auxiliary aids and services necessary to afford an individual with a disability an equal opportunity to participate in all services, programs, and activities. These materials can be provided in alternative formats to any individual with a disability. To request materials in an alternative format, please contact: Kentucky Division of Water, Nonpoint Source Section, 14 Reilly Road, Frankfort, Kentucky 40601 Telephone: (502)564-3410.

FINAL REPORT

BIOASSESSMENT OF THE FISH AND MACROINVERTEBRATES OF THE UPPER MAINSTEM OF BUCK CREEK, LINCOLN AND PULASKI COUNTIES, KENTUCKY

Michael D. Moeykens and Guenter A. Schuster
Department of Biological Sciences
Eastern Kentucky University
Richmond, KY 40475

Prepared for:

The Kentucky Division of Water
14 Reilly Rd.
Frankfort, KY 40601

December 8, 1997

Scope of Study

The objectives of this study were to assess the water quality of the upper section of Buck Creek using fish and macroinvertebrates as water quality indicators and to provide baseline data for future biological monitoring of the drainage.

Findings and Conclusions:

The analyses of the macro-invertebrate data by both the Invertebrate Community Index and the Hilsenhoff Biotic Index indicated the overall water quality rating of the upper section of Buck Creek to be Excellent. The Proportional Community Similarity values indicated no distinct longitudinal trends. The diversity (H') and evenness (J) values were lowest at Site 4 which was probably due to the presence of a road crossing at that site. The analyses of the functional feeding groups generally agreed with predictions of the River Continuum Concept, with the exception of Site 5 (most upstream and of the third order) which was more similar to a medium-sized river. The Index of Biotic Integrity for fish resulted in the water quality being classified as Fair-Good. The Jaccard Coefficient of Community comparisons did not show any distinct longitudinal trends. The H' and J values for the fish data were lowest for Site 4 due to the road crossing. This study found the overall water quality of the upper section of Buck Creek using all metrics to be Good-Excellent.

ACKNOWLEDGMENTS

We would like to thank Dr. Gary Ritchison and Dr. Donald Batch for serving on the senior author's advisory committee, and for their helpful critiques of this manuscript. We wish to acknowledge all of the people who helped with this project: Vicki Bishop, Stephen McMurray, Daniel Peake, Chris Kirk, Tom Oliver, Chris Peters, Jennifer Board, and Adrian Nix who were all of invaluable help. Dr. Patrick Ceas helped with verification of my fish identification; Bryce Daniels provided help with sorting macroinvertebrate samples; and Gregory Pond helped with chironomid identifications. We would like to especially thank Michael C. Compton for his invaluable help on this project, both in the field and in the lab.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Appendix Page

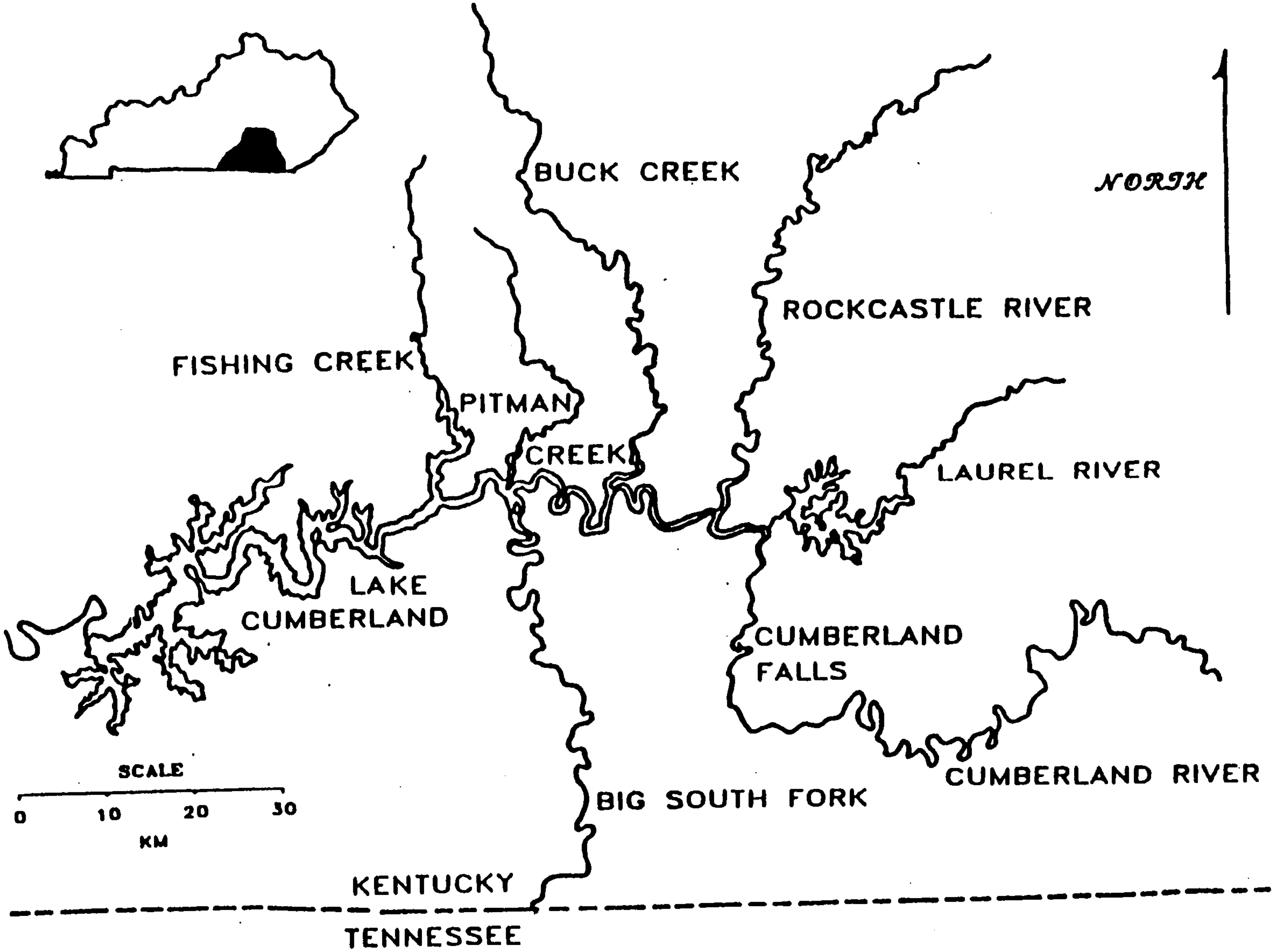
CHAPTER I

INTRODUCTION

The purpose of this study was to assess the condition of the upper section of Buck Creek using fish and macroinvertebrates as water quality indicators. An additional goal of this study was to provide baseline data that could be used in any future biological monitoring of the Buck Creek system, which has been shown to be an important refugium for some endangered fish and unionids (Cicerello and Butler 1985, Schuster et al. 1989).

Buck Creek is a fifth order tributary to the Cumberland River (Lake Cumberland) in southeastern Kentucky (Figure 1). The stream originates in Lincoln County, Kentucky, with the majority of its drainage in Pulaski County. Buck Creek drains approximately 767 km^2, is approximately 107.2 km long, and is generally less than 20 m wide with a mean depth of 2 m (Cicerello and Butler 1985). The lower 21 km of the stream are often inundated by Lake Cumberland, especially after heavy periods of rain (Cicerello and Butler 1985). The U.S. Army Corps of

Figure 1. Map of Kentucky Showing the Location of Buck Creek within the Upper Cumberland River Drainage (Butler 1985).


BUCK CREEK
NORTH
ROCKCASTLE RIVER
FISHING CREEK
PITMAN
CREEK
LAUREL RIVER
LAKE
CUMBERLAND
CUMBERLAND
FALLS
SCALE
0
10
20
30
KM
CUMBERLAND RIVER
BIG SOUTH FORK
KENTUCKY
TENNESSEE

Engineers (1976) estimated the mean flow to be 11.7 meters^3/second, and the mean stream gradient was estimated at 1.25 m/km.

Buck Creek was shown to be a high quality, relatively unimpacted stream with clear, well-oxygenated and buffered water (Harker et al. 1979, 1980). In recent years, the stream has been the focus of a number of studies, including surveys of unionids (Schuster et al. 1989), fish (Cicerello and Butler 1985), caddisflies (Floyd 1989), dragonflies and damselflies (Payne 1992), a study of the comparative feeding ecology of darters (Butler 1986), and currently a bioassessment of the lower section of the creek (Compton, in prep.). The fauna of Buck Creek was found to include: 29 species of unionids, 10 of which are members of the Cumberlandian fauna (Schuster et al. 1989) and four of which are federally endangered species (*Epioblasma capsaeformis*, *Epioblasma brevidens*, *Villosa trabalis*, and *Pegias fabula*) (KSNPC 1996, USFWS 1997); 61 species of caddisflies (Floyd 1989); 73 species of fishes (Cicerello and Butler 1985), with *Etheostoma cinereum* listed as threatened by the Kentucky State Nature Preserves Commission (KSNPC 1996); and 34 species of odonates (Payne 1992). Such diversity and numbers of species suggest a stream with good water quality; however, no intensive assessment study has previously been conducted.

There are several impacts on the water quality of Buck Creek that may affect the species inhabiting the stream. Butler (1986) reported a streambed gravel removal operation near State Route (SR) 39 that decreased macroinvertebrate diversity. An operation of this type would almost definitely affect the fish composition in the immediate area by disturbing the substrate upon which many fish spawn. A bank gravel removal operation was also observed on 31 August 1996, approximately 0.3 km upstream of the SR 39 bridge (pers. observ.). Gravel was being removed from a gravel bar, but was not actually seen being removed from the stream bed itself. These disturbances of the stream bed and banks could increase the sedimentation and turbidity levels. Excessive sediments that covered the habitats of fishes and macroinvertebrates had been found to lead to a decrease in species densities (Branson and Batch 1971, Lenat et al. 1981). Other factors adding to the sedimentation problem were roads that pass through the stream (Eaglin and Hubert 1993), logging on and near the stream banks, and farming practices such as plowing to the stream bank.

Farmers and homeowners along Buck Creek have recently been interested in having the stream channelized. This would result in a deeper stream channel, a stream that is less susceptible to flooding the surrounding area, and an increased amount of usable farmland. However, channelization has also been found to result in a loss of aquatic habitat due to the physical uniformity created by channelization (Allan 1995). The loss of aquatic habitat would result in a decrease in the types, overall abundance, and biomass of taxa that the stream can support. The increased turbidity that was found to frequently result from channelization (Allan 1995) could also cause a decrease to the number of taxa by decreasing water quality.

Agricultural practices seemed to be the major impact on the upper section of Buck Creek. Riparian vegetation is commonly removed by farmers to maximize planting and grazing space. The loss of riparian shade trees has been found to have lead to higher water temperatures in summer and lower water temperatures in the winter (Allan 1995). Removal of trees from the edge of the stream could also weaken the bank structure, and the resulting erosion could increase siltation and turbidity in the stream. Cattle permitted to walk in streams also caused bank erosion, increased sedimentation (Armour et al. 1991), and could increase levels of organic waste in the streams. The use of fertilizers, herbicides, and pesticides within the drainage might also be harmful to many species in the stream. The chemicals could lead to a decrease in the numbers of taxa present by causing a decrease to the overall water quality.

One way to monitor changes in water quality over time is to use biological monitoring or, simply, biomonitoring. Biomonitoring involves the systematic sampling of biological communities to determine if changes are taking place, especially from anthropogenic sources (Karr et al. 1986). The advantage of sampling aquatic organisms to determine water quality is that such sampling permits detection of short-term critical events (NCDEHNR 1995). An example of a short-term critical event would be the introduction of a pesticide into a stream. Although a pesticide could quickly be transported downstream and be difficult to detect, aquatic organisms would either have to disperse away from the disturbance or they risk being affected in some detrimental way. Sampling the aquatic communities and detecting a decrease in taxa from a previous sample period, or, in the case of a first time sample, obtaining results that indicated poor water quality would indicate that something detrimental had happened. However, this would not identify the cause of the perturbation.

A comprehensive water quality assessment program would include chemical, physical, and biological monitoring of the stream on usually a yearly basis (Hirsch et al. 1988).

A water quality assessment program would usually be initiated for one of three reasons: monitoring (a long-term observation and evaluation to determine trends), surveillance (a continuous measurement and observation program usually to monitor some human activity), and survey (an intensive program to measure the water quality for a specific purpose over a finite duration) (Meybeck et al. 1992). Traditional methods of monitoring streams were expensive and time consuming, so methods were developed that allowed states to monitor the water quality of streams in a faster, more cost-effective way (Plafkin et al. 1989, Rosenberg and Resh 1993).

The United States Environmental Protection Agency (USEPA) developed five protocols for assessing the biological integrity of a stream, known as Rapid Bioassessment Protocols (RBP)(Plafkin et al. 1989). Three macroinvertebrate protocols (RBPs I, II, and III) and two fish protocols (RBPs IV and V) were developed. Many states now use one or more of these protocols in their water quality monitoring programs (Davis et al. 1996). These protocols are relatively easy and cost-effective ways to determine the biological condition of a stream by assessing fish or macroinvertebrate communities.

The Index of Biotic Integrity (IBI) is one method of assessing the biotic integrity or water quality of a site, and the IBI is what RBP V is primarily based on (Plafkin et al. 1989). The IBI, as first described by Karr (1981), uses fish as indicators of water quality. Advantages to using fish as a measure of the biological condition of a stream include their widespread distribution, use of a wide range of trophic levels, and relative ease of identification (Karr et al. 1986). The IBI has been modified for use in different geographical regions. The IBI used for this project was a modification of the one published by the Kentucky Division of Water (KDOW) (1993). The KDOW has been modifying the IBI to be more accurate in Kentucky (K. Smathers, pers. comm.) and, therefore, the analyses of stream data from this study utilized these modifications. A sample IBI scoring sheet is shown in Table I.

The IBI is a multi-metric index that incorporates aspects from the entire fish community of a site into three categories and twelve different metrics (Karr et al. 1986). Fish collection data from a site are compared to the expected values for that site for each of the twelve metrics. The expected values will change from site to site along a stream, depending on the drainage area of the stream at each site. Each metric is given a value of 5, 3, or 1, depending on whether the value measured at the site is similar to, slightly different from, or highly

TABLE I

SAMPLE IBI SCORING SHEET PROPOSED BY KDOW (MODIFICATION OF KARR ET AL. 1986).

IBI	SCORING CRITERIA		
SPECIES RICHNESS AND COMPOSITION	1	3	5
Number of Species	<4	4-6	>6
Darter Species	0	1	>1
Sunfish Species	0	1-2	>2
Sucker Species	0	1	>1
Intolerant Species	<1	2-3	>3
Tolerant Species (%)	>20%	5-20%	<5%
TROPHIC COMPOSITION			
Omnivores (%)	>45%	20-45%	<20%
Insectivores (%)	>20%	20-45%	>45%
Top Carnivores (%)	>1%	1-5%	>5%
FISH ABUNDANCE AND CONDITION			
Number of Individuals in Sample	<50	50-100	>100
Number of Simple Lithophils	>1	0-1	0
Number of Diseased	>1	0-1	0

TABLE II

WATER QUALITY DESIGNATIONS (INTEGRITY CLASSES) FOR THE IBI SCORES (KARR ET AL. 1986).

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

different from the values expected at an undisturbed, high water quality site (Karr et al. 1986). The values assigned to each metric are tallied and the total, which can range from 12 to 60, is given a qualitative designation (Table II). This qualitative designation describes the biotic integrity of the site and indicates the overall health of the stream or its water quality (Plafkin et al. 1989).

The Hilsenhoff Biotic Index (HBI) is another means of assessing the biotic integrity of a stream. The HBI is useful because it uses macroinvertebrate pollution tolerance values to assess the quality of a river (Hilsenhoff 1977). Conventional water quality surveys do not integrate short-term fluctuations in water quality between the sampling periods, and short-term critical events may be missed (NCDEHNR 1995). The effects of a pollutant will be reflected quickly by many benthic macroinvertebrates, and because many species have life cycles of one year, the effects will usually be apparent until the next generation appears (NCDEHNR 1995). Pollution tolerance values for the HBI have been developed for a variety of macroinvertebrates (Hilsenhoff 1987, Plafkin et al. 1989, Lenat 1993, NCDEHNR 1995), and the scale of possible values ranged from 0 to 10, with 0 being most intolerant to pollution and 10 being most tolerant to pollution (Hilsenhoff 1982, 1987). The tolerance values for each taxon are used to obtain an overall HBI value by using the following equation:

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

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 obtained is then compared to target values for a specific ecoregion and given a qualitative rating (Table III). The qualitative rating is an indication of the water quality of the stream, with values closer to zero indicating the highest quality water.

TABLE III

HBI WATER QUALITY CLASSES FOR THE MOUNTAIN ECOREGION (LENAT 1993).

WATER QUALITY CLASS	**EXCELLENT**	**GOOD**	**GOOD - FAIR**	**FAIR**	**POOR**
HBI Score	<4.17	4.17-5.09	5.10-5.91	5.92-7.05	>7.05

The Ohio Invertebrate Community Index (ICI) also uses macroinvertebrates to assess water quality. The ICI, which was developed by the Ohio Environmental Protection Agency (OEPA) to assess Ohio streams, is an index derived from ten different metrics (OEPA 1987, 1989). The ten metrics are each determined separately, compared to the expected values for the site, and then assigned an ICI scoring value of 0 (poor), 2, 4, and 6 (exceptional) points. Expected values could change from site to site along a stream, depending on the drainage size at each site. The scores for each metric are then summed to provide the total ICI metric. A sample ICI scoring sheet is shown in Table IV. The ICI metric is then compared to a range of values that rate the water quality as Poor, Fair, Good, or Exceptional (Table V).

The ICI, although developed for use in Ohio, was used in this study because KDOW has not developed a water assessment index. The ICI was used for a project conducted on the Green River in Mammoth Cave National Park, and appears to be adequate for use in biological assessment studies in Kentucky (Schuster et al. 1996).

Different taxa of macroinvertebrates can have different feeding habits, and these feeding habits (i.e., functional feeding groups) can be used to help determine the degree to which a stream is being impacted by

TABLE IV

OHIO ICI SCORING CRITERIA FOR THE TEN METRICS (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 DESIGNATIONS BASED ON OHIO EPA ICI VALUES (OEPA 1987).

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

disturbance. The EPA RBPs for macroinvertebrates (RBPs II and III) use some functional feeding groups and their proportions in a community to provide insight into the type and degree of disturbance (Plafkin et al. 1989, Klemm et al. 1990). Macroinvertebrates have been separated into functional feeding groups based on feeding mechanisms and broad food size categories (Cummins 1973, Cummins and Klug 1979). According to Cummins and Klug (1979), the four major functional feeding groups included: (1) shredders, which fed on coarse particulate organic matter (CPOM) and in the process broke it down into fine particulate organic matter (FPOM) and ultra-fine particulate organic matter (UPOM); (2) collectors, which fed on FPOM and UPOM by either filtering or gathering; (3) scrapers, which fed or grazed on food matter (most often periphyton) that was attached to a surface; and (4) predators, which included macroinvertebrates with adaptations for capturing live prey.

The relative abundance of organisms in each functional feeding group can be used to show if the stream is being impacted because of predictions based on the River Continuum Concept (RCC). The RCC (Vannote et al. 1980) made predictions on the community makeup of a natural river as it increased in stream order from the headwaters (orders 1-3) to medium-size streams (orders 4-6) to the large river sections (orders >6). According to Vannote et al. (1980), the headwater section would be composed mainly of shredders, due to the high degree of riparian cover which provided shading and allochthonous detritus (CPOM) to the system, and the primary production (P) would be less than the community respiration (R). The medium-sized river section would be composed mainly of grazers and collectors, would have the greatest species diversity, would have more FPOM than CPOM, and it would have a P/R ratio greater than one. This was due to the decreasing percentage of riparian cover and decreased input of allochthonous detritus (CPOM). In the large river section, the macroinvertebrate community would be composed mainly of collectors, because of the large amounts of UPOM and FPOM, and a P/R ratio less than one due to suspended solids and water depth. The proportion of the predator functional feeding group was predicted to remain the same from the headwaters to the large river section. Any strong variation from the expected macroinvertebrate community trophic structure would be an indication of an unstable, disturbed stream (Minshall et al. 1985).

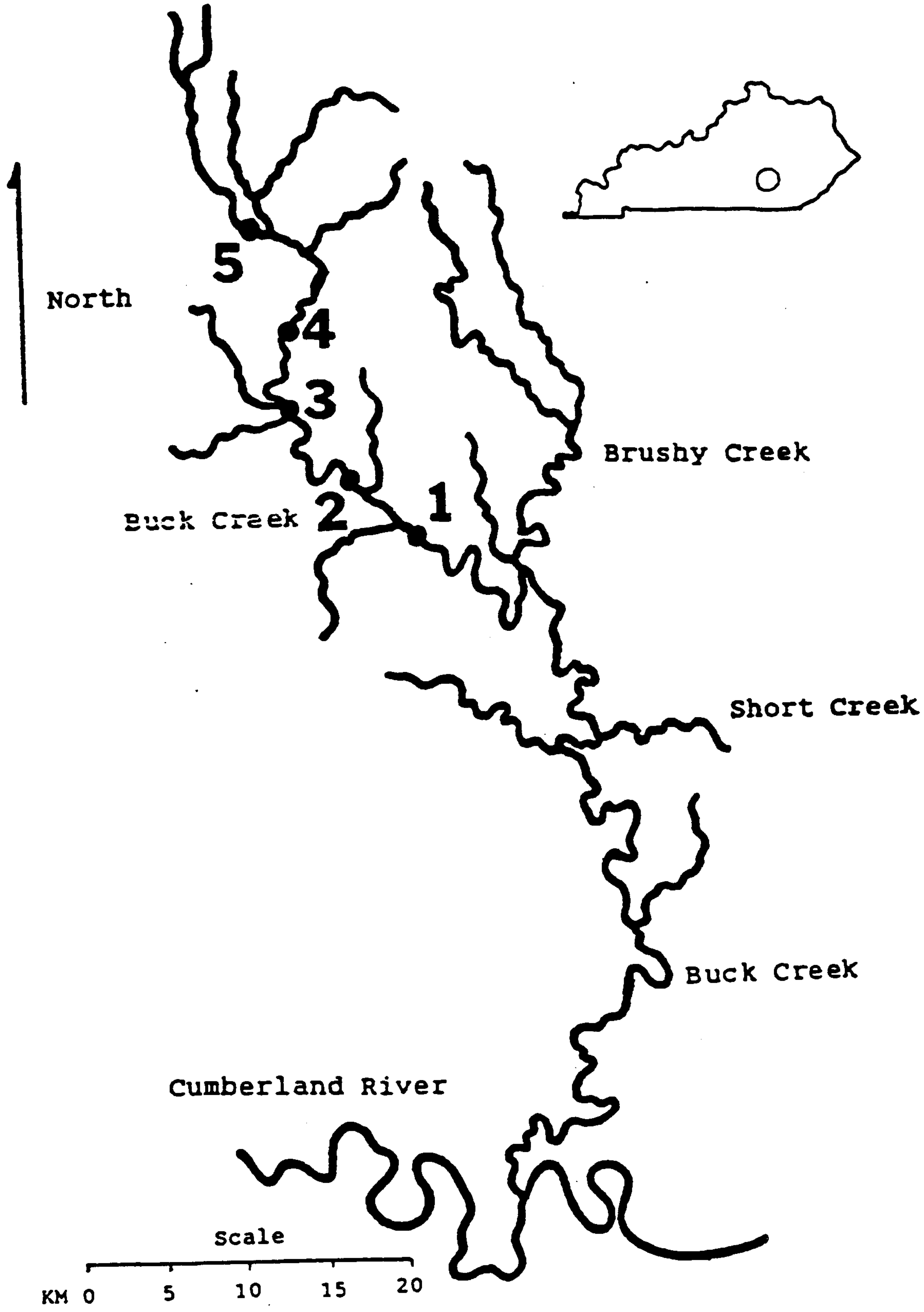
CHAPTER II

DESCRIPTION OF STUDY SITES

Five sites were selected along the upper section of Buck Creek in Lincoln and Pulaski counties, Kentucky (Figure 2). Each site was sampled once on 24-25 May 1996, and again on 12-13 July 1996. Sites were selected by considering collection sites used during previous studies, suitable riffle areas, accessibility, and landowner permission. Most important was the presence of a suitable riffle at each site for macroinvertebrate sampling. The following are descriptions of each of the five sites.

Site 1 was located 1.3 stream km downstream from KY SR 39 bridge, which was approximately 3.3 km south of Woodstock and 7.2 km east-southeast of Clarence, Pulaski County, Kentucky. Buck Creek drained approximately 247 km^2 and was a fourth order stream at this site, which was a riffle located just below a long pool/run bordered by a sand and gravel beach on the right upstream bank. The riffle was comprised mainly of cobble and gravel, with some sand and large rocks present. A riparian zone was located on the left upstream bank, but riparian cover had recently

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


North
5
4
3
2
1
Buck Creek
Brushy Creek
Short Creek
Buck Creek
Cumberland River
Scale
KM 0 5 10 15 20

been removed from the right upstream bank so little canopy cover remained on that side of the stream.

Site 2 was located 2.6 km upstream from the SR 39 bridge and just below the confluence with Lick Branch. The site was approximately 3.2 km SW of Woodstock and 4.8 km south-southeast of Clarence, Pulaski County, Kentucky. The stream drained approximately 221 km^2 and was of the fourth order at this site. The riffle at this site was bordered both upstream and downstream by a section of long, deep pool. The substrate in the pools above and below the riffle was mainly silt and sand, with the riffle being mainly cobble and gravel. The pool sections were largely unshaded, although the riffle was about 50% shaded. There was a cornfield on the right downstream bank of the stream, which left about 4 m of riparian buffer zone.

Site 3 was located 60 m downstream of the SR 70 bridge crossing, which was approximately 2.5 km south of Clarence and 5.8 km west of Woodstock, Pulaski County, Kentucky. Buck Creek drained approximately 189 km^2 and was a fourth order stream at this site. The riffle at this site was located just downstream of the confluence with Briary Creek and at the base of a long, deep pool. The substrate was mostly sand and silt in the pool and gravel and smaller cobble in the riffle. Riparian cover was not present near the bridge, but increased at and below the riffle.

Site 4 was located 0.3 stream km upstream from the confluence with Bear Den Hollow tributary at the Goodhope-Goochtown Road crossing, which was approximately 2.2 km southeast of Goochtown, Pulaski County, Kentucky. The stream was fourth order at this site and drained approximately 104 km^2. The riffle at this site was located about 2 m upstream of the gravel road crossing. There was a run/pool section just above the riffle, and above the pool was a beaver dam and another pool. The substrate was mostly gravel and sand at the riffle, with silt and sand in the pools. Some erosion of the stream banks was apparent where vehicles wandered from the road, and the riparian area was non-existent near the road crossing.

Site 5 was located in Lincoln County, Kentucky, 50 m upstream from the Broughtentown Road bridge, which was approximately 2.9 km north of Goochtown and 0.8 km west of the confluence of Buck Creek and Gilmore Creek. The stream drained approximately 49 km^2 and was third order at this site. This site's riffle was located downstream of a deep pool, just upstream of a long run, which became a deep pool near the bridge. The substrate around and in the riffle was composed mainly of gravel and cobble, with some large slabs of rock present. The riparian zone was larger at this site than at the other four sites, and the riffle was completely shaded, although shading did decrease both above and below the riffle.

CHAPTER III

MATERIALS AND METHODS

Macroinvertebrate Sampling and Processing

Macroinvertebrate sampling was both qualitative and semi-quantitative. The methods were taken from the Kentucky Division of Water procedure manual (KDOW 1993) and the United States Environmental Protection Agency Rapid Bioassessment Protocol III for benthic macroinvertebrates (Plafkin et al. 1989).

Qualitative sampling was conducted at each site to compile a species presence/absence list used to help determine taxa richness, a parameter (used in the ICI) closely correlated with water quality (Lenat 1988). All available habitat types were sampled using dip nets, or handpicking rocks and logs, and by looking in the leaves and detritus to find as many species as possible. Sampling was conducted for a total of one hour per site. Samples were preserved in glass jars containing 70% ethyl alcohol and transported to the laboratory for processing.

Semi-quantitative sampling was accomplished using the traveling-kick method described by Pollard (1981) to obtain a measure of abundance. Three samples were taken in the riffle area at each site, and the samples were taken next to one another within the same riffle. The collectors worked upstream for 3 meters in 60 seconds using an A-frame dip net with a mesh of 800 x 900 micrometers and a vertical net height of 22.6 cm. The net was held in the water immediately downstream of the collector's feet so that, as the collector kicked the substrate, dislodged macroinvertebrates were captured in the net. The nets were washed out in a bucket of clean water and then any attached macroinvertebrates were removed using forceps. The water was strained through a fine mesh sieve and all specimens were placed in a glass jar with 70% ethyl alcohol.

Preserved macroinvertebrates were sorted and identified in the laboratory. Each sample was poured into a white tray, covered with fresh 70% ethyl alcohol, and sorted using a 5x light ring magnifier. The specimens were sorted to family or order taxa, and then placed into shell vials for later identification.

Macroinvertebrates (non-chironomids) were identified to the lowest possible taxonomic level using Merritt and Cummins (1996), Thorp and Covich (1991), Epler (1995, 1996), Schuster and Etnier (1978), Brigham et al. (1982), Bednarik and McCafferty (1979), and the help of Dr. Guenter Schuster (Eastern Kentucky University). The majority of specimens were identified to genus, with the exception of specimens in early instars. Most chironomids were identified by Greg Pond (Environmental Consultant) using Epler (1995), Simpson and Bode (1989), and other current taxonomic keys.

Macroinvertebrates were assigned to a functional feeding group using Merritt and Cummins (1996), Thorp and Covich (1991), and Simpson and Bode (1980). All identified specimens were retained for curation into the Branley A. Branson Museum of Zoology at Eastern Kentucky University.

Fish Sampling and Processing

Sampling methods for fish were similar to those in Methods for Assessing Biological Integrity of Surface Waters (KDOW 1993) and the USEPA's Rapid Bioassessment Protocol V (Plafkin et al. 1989). At each site, a run, riffle, and pool were seined using a 3.4 m x 1.2 m fish seine with a mesh size of 0.3 cm. Each site was seined for one hour. Collections were preserved in the field in 10% formalin; however, some fish over 20 cm that were easily identified were counted and released. Preserved fish were transported to the laboratory for enumeration and identification.

In the laboratory, fish were kept in formalin solution for two weeks before being transferred to tap water. After one day in tap water, fish were placed in 70% ethanol for permanent storage.

The fish in each sample were identified using Page and Burr (1991), Etnier and Starnes (1993), and the assistance of Dr. Patrick Ceas (Eastern Kentucky University). After being identified, fish were examined for any anomalies such as sores, deformities, parasites, etc. All identified specimens were retained as voucher specimens, and deposited for permanent storage into the Branley A. Branson Museum of Zoology at Eastern Kentucky University.

Data Analysis

Macroinvertebrates

The HBI was calculated using Quattro Pro (Corel), and the tolerance values for identified taxa were derived from Lenat (1993) and NCDEHNR (1995). The ICI was calculated according to the methods of the OEPA (1987, 1989).

The Shannon-Weiner Diversity Index, the Shannon-Wiener Evenness Index, and the Proportional Similarity Index were calculated using ECOSTAT (Trinity Software). These were used to determine community structure and degree of taxonomic similarity between the sites sampled (Krebs 1989).

The macroinvertebrates were separated into functional feeding groups, and the relative abundance of each functional feeding group was determined for each site using Quattro Pro (Corel). These data were used to determine if Buck Creek followed the predictions of the River Continuum Concept.

Fish

The fish data were used to calculate the IBI which was used to assess the biotic integrity of each site (KDOW 1993). The similarities of fish communities among sites were determined using the Jaccard Coefficient of Community (Brower et al. 1990). Values for this index range from 0 to 1, with a value of 1 indicating the two communities are identical. The Jaccard Coefficient of Community, Shannon-Wiener Diversity, and Evenness indices were all calculated using the ECOSTAT computer program (Trinity Software).

CHAPTER IV

RESULTS AND DISCUSSION

Macroinvertebrates

A total of 9,380 macroinvertebrates was collected and identified from the traveling-kick samples of the May collections, and a comprehensive list of the macroinvertebrates collected (semi-quantitative and qualitative data combined) is provided in Appendix A. The July collection yielded 9,431 macroinvertebrates from the traveling-kick samples, and a comprehensive list is provided in Appendix B.

The ICI values obtained for the May and July collection periods indicated that the water quality of the upper section of Buck Creek was Exceptional (Table VI). Four of the May values were in the Exceptional category (Sites 1, 3, 4, 5), and one site was in the Good water quality category (Site 2). The July ICI values were all in the Exceptional category, and July had a slightly higher overall average ICI.

TABLE VI

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

PERIOD	SITE NUMBER				
	1	2	3	4	5
MAY	52 EXCEPTIONAL	46 GOOD	52 EXCEPTIONAL	50 EXCEPTIONAL	48 EXCEPTIONAL
JULY	50 EXCEPTIONAL	54 EXCEPTIONAL	48 EXCEPTIONAL	48 EXCEPTIONAL	52 EXCEPTIONAL

Site 2 demonstrated the highest variation between sampling periods, with scores of 46 (Good) in May and 54 (Exceptional) in July. This eight unit change was slightly higher than the six unit difference that might have occurred due to natural environmental conditions (DeShon 1995). The 66 taxa found at Site 2 in May (Appendix A) were lower than the nearby sites, and it was also lower than the number of taxa found in the July collection for that same site (74 taxa in July). The lower ICI score in May could have been an indication of some impact affecting the water quality; although, it did not seem to indicate a long-term perturbation since the ICI value increased to 54 in July. The low score might have been related to the crop planting (pesticide and fertilizer application) that was occurring in the nearby fields at the time of the May collection. It was also possible that the low scores were simply due to the riffle location. The riffle was located in the middle of two slow-moving, pooled sections of Buck Creek which could have caused lower oxygen content (Allan 1995).

The HBI values obtained from the May and July collections indicated that the water of the upper section of Buck Creek was in the Excellent water quality class (Table VII). The May values were in the Excellent category for Sites 1 and 4, and in the Good water quality category for Sites 2, 3, and 5. The July values were all in the Excellent category with the exception of Site 2 which was in the Good water quality category. Even though Sites 2, 3, and 5 were in the Good category for May, the values were very close to being in the Excellent category (Excellent is <4.17), and the average for May (4.23) was very close to being in the Excellent category. The July average for the five sites was 4.03, and when the two seasons were averaged together, it resulted in a value of 4.13. This was an overall Excellent water quality rating, with the May period values being lower than the July values.

Site 2 was the only site that didn't obtain a score of Excellent for at least one of the collection periods, and it was also the site that scored the lowest scores within each collection period. The May HBI score (4.51) was

TABLE VII

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

PERIOD	SITE NUMBER				
	1	2	3	4	5
MAY	3.96 EXCELLENT	4.51 GOOD	4.34 GOOD	4.04 EXCELLENT	4.30 GOOD
JULY	4.12 EXCELLENT	4.41 GOOD	3.87 EXCELLENT	4.01 EXCELLENT	3.76 EXCELLENT

slightly higher than the July score (4.41), and these results coincided with the ICI results for that site. The secluded location of the riffle within the long pooled section of the river was a possible explanation for the reduced scores. Some human impact could have been affecting the nearby area (crop field in immediate area); although, these HBI scores were closer to the Excellent category than they were to the Good-Fair category (midpoint in the Good range is 4.63)(Lenat 1993).

The Proportional (%) Community Similarity values for May and July did not show any distinct downstream trends (Tables VIII and IX). It was expected that the sites closest together would be more similar and those furthest apart would be more dissimilar; however, this was not the case. During the May collection period, Sites 1 and 2 were

TABLE VIII

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

Site Number	1	2	3	4
2	36.41	----	----	----
3	49.88	63.01	----	----
4	40.80	56.77	59.83	----
5	43.71	55.68	60.89	56.84

TABLE IX

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

Site Number	1	2	3	4
2	62.05	----	----	----
3	68.31	57.35	----	----
4	51.89	43.37	60.45	----
5	57.45	58.49	65.73	55.73

most dissimilar with only 36.41% similarity. All of the lowest similarity values for May were associated with Site 1, and all of the Site 1 similarity values were less than 50% similar. The July similarity values were much different, all of the Site 1 comparisons resulted in values greater than 50%. The lowest degree of similarity occurred between Sites 2 and 4 (43.37), and the overall similarity values among sites were higher than in May.

The Shannon-Wiener Diversity Index and Evenness values for May are shown in Table X, and the values for July are illustrated in Table XI. There were no distinct longitudinal trends for either May or July; although, Site 4 had the lowest diversity and evenness values for both of the sampling periods. This was probably due to the presence of the road crossing at this site, and the disturbances to the stream from the crossing might have reduced species richness and increased the dominance of a few taxa. Wilhm (1970) reported that diversity values from clean water streams ranged from 2.68 to 4.00, while diversity values from polluted streams ranged from 0.42 to 1.60. With the exception of the May Site 4 score (2.38), all the diversity scores were in the range of clean water scores, and the May Site 4 score was still well above what was considered to be in the polluted water range (Wilhm 1970). The location of the Site 4 riffle could have caused

TABLE X

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

METRIC	SITE NUMBER				
	1	2	3	4	5
H′	2.84	3.06	3.01	2.38	2.89
J	0.67	0.75	0.71	0.59	0.71

TABLE XI

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

METRIC	SITE NUMBER				
	1	2	3	4	5
H′	2.65	2.81	2.73	2.60	2.84
J	0.64	0.68	0.68	0.66	0.73

the local macroinvertebrate community to be different than the other sites without being an indication of low water quality.

The functional feeding group composition for each of the five sites for May are shown in Figures 3-7. The community at each site was divided into five different functional feeding groups (predators, scrapers, shredders, collectors, and filter feeders), and each group is shown in the figures as a percentage of the whole community. The collector and filter feeder groups were actually subdivisions of the collector group as used in the RCC (Vannote et al. 1980). The relative abundance of both collectors and filter feeders increased downstream which followed the expected longitudinal trend. The shredder functional feeding group was almost completely absent from all five sites in May. The lack of shredders at Site 5 indicated that this portion of the stream was more like a medium-size river than a headwater stream (Vannote et al. 1980).

The predator functional feeding groups were also not in the proportions that were expected. The predator group was expected to remain at constant proportions as the stream increased in stream order (Vannote et al. 1980); but for May, the predator group ranged from 7.18% to 54.91% of the community composition at the sites. Most of these predators were stoneflies (_Perlesta_ spp.), which were in highest abundances in the spring just prior to their emergence. The scraper group did not show any longitudinal trend, although it was in fairly high abundance at Site 5. According to the RCC, scrapers should have been in higher abundance at the more downstream sites where there should be more algae. Therefore, the high percentage of scrapers

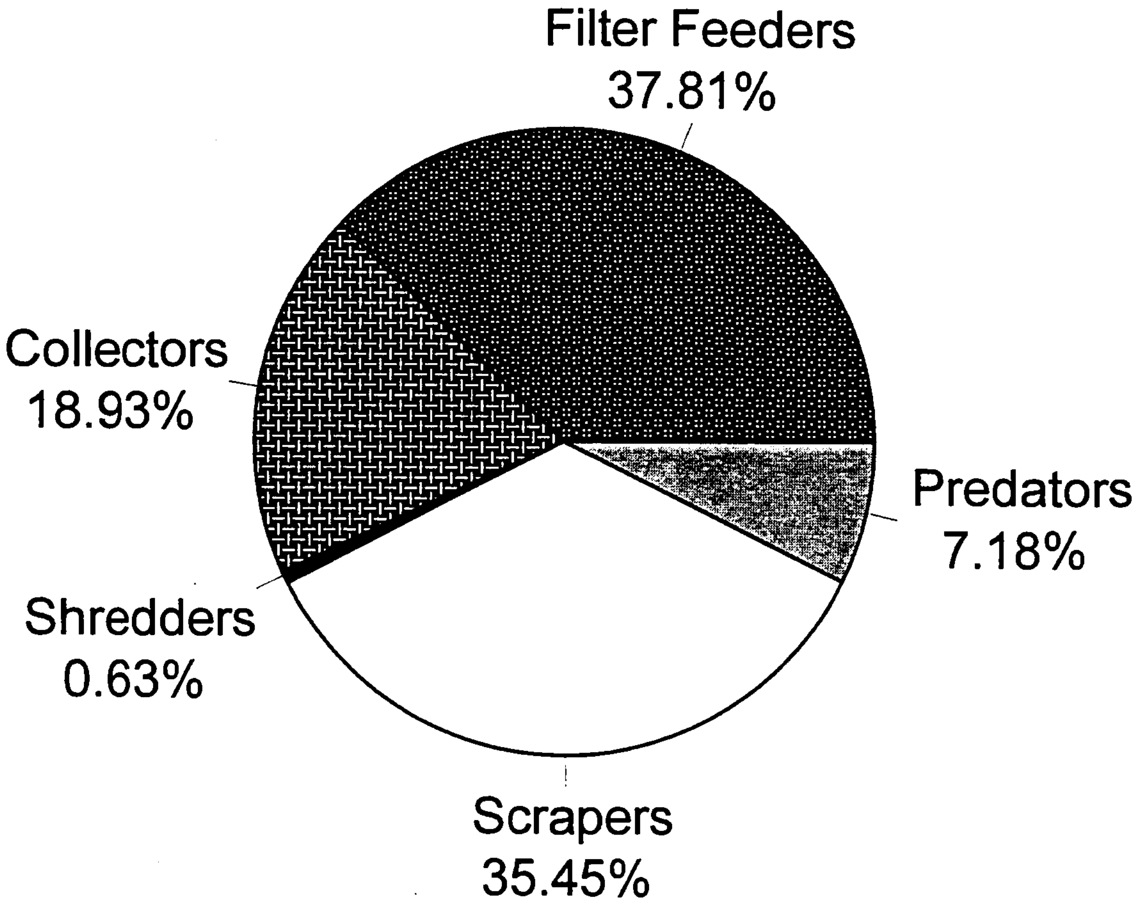


Figure 3. Functional Feeding Group Composition of Site 1 for May 1996 Collection Period.

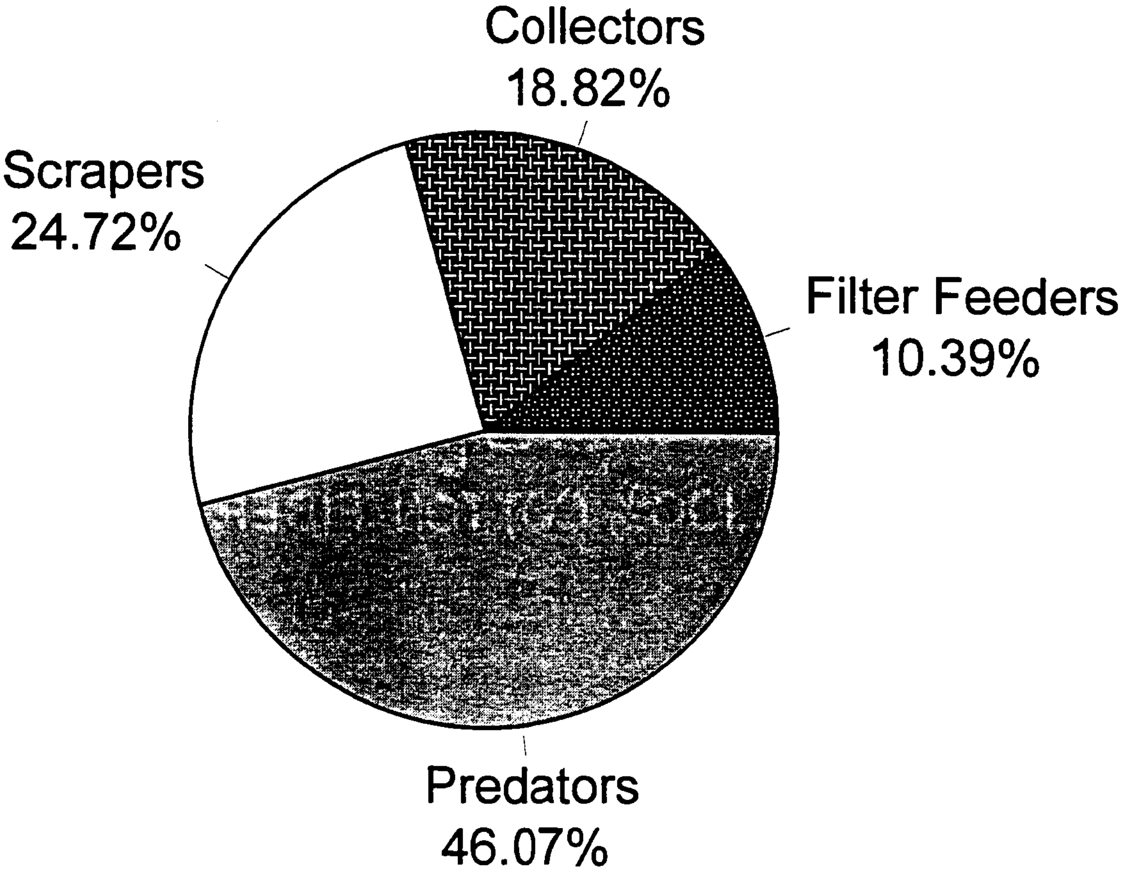


Figure 4. Functional Feeding Group Composition of Site 2 for May 1996 Collection Period.

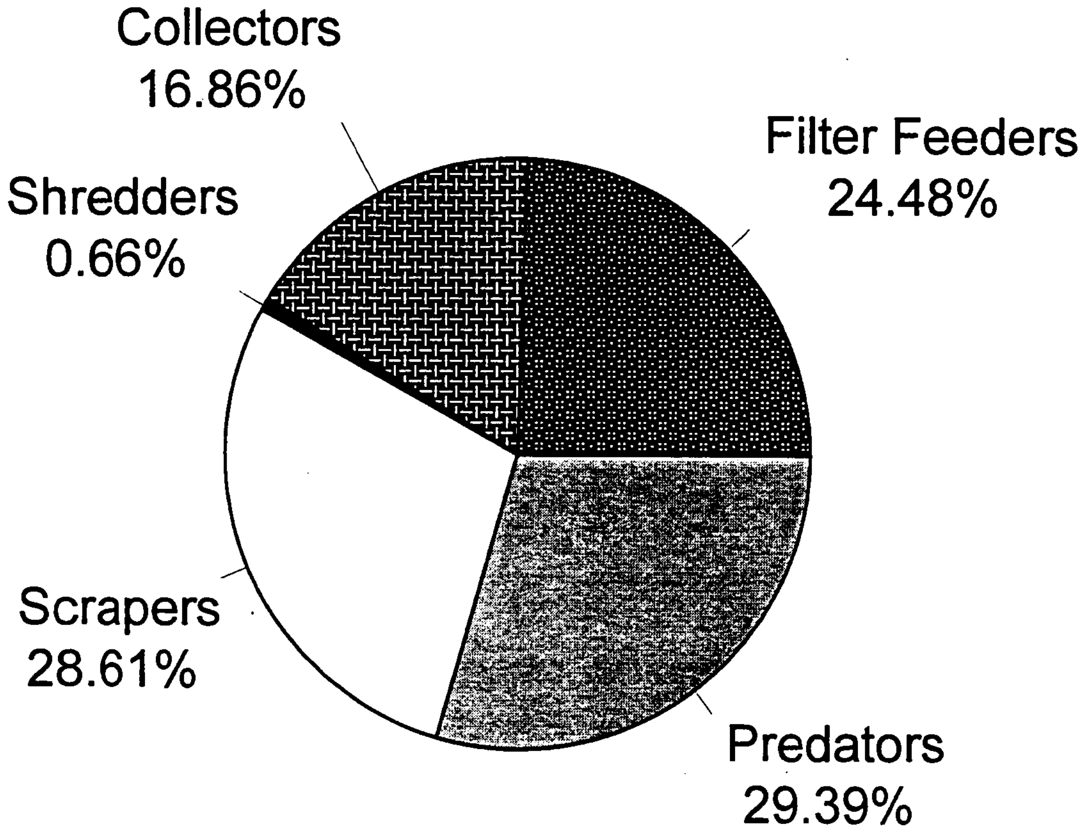


Figure 5. Functional Feeding Group Composition of Site 3 for May 1996 Collection Period.

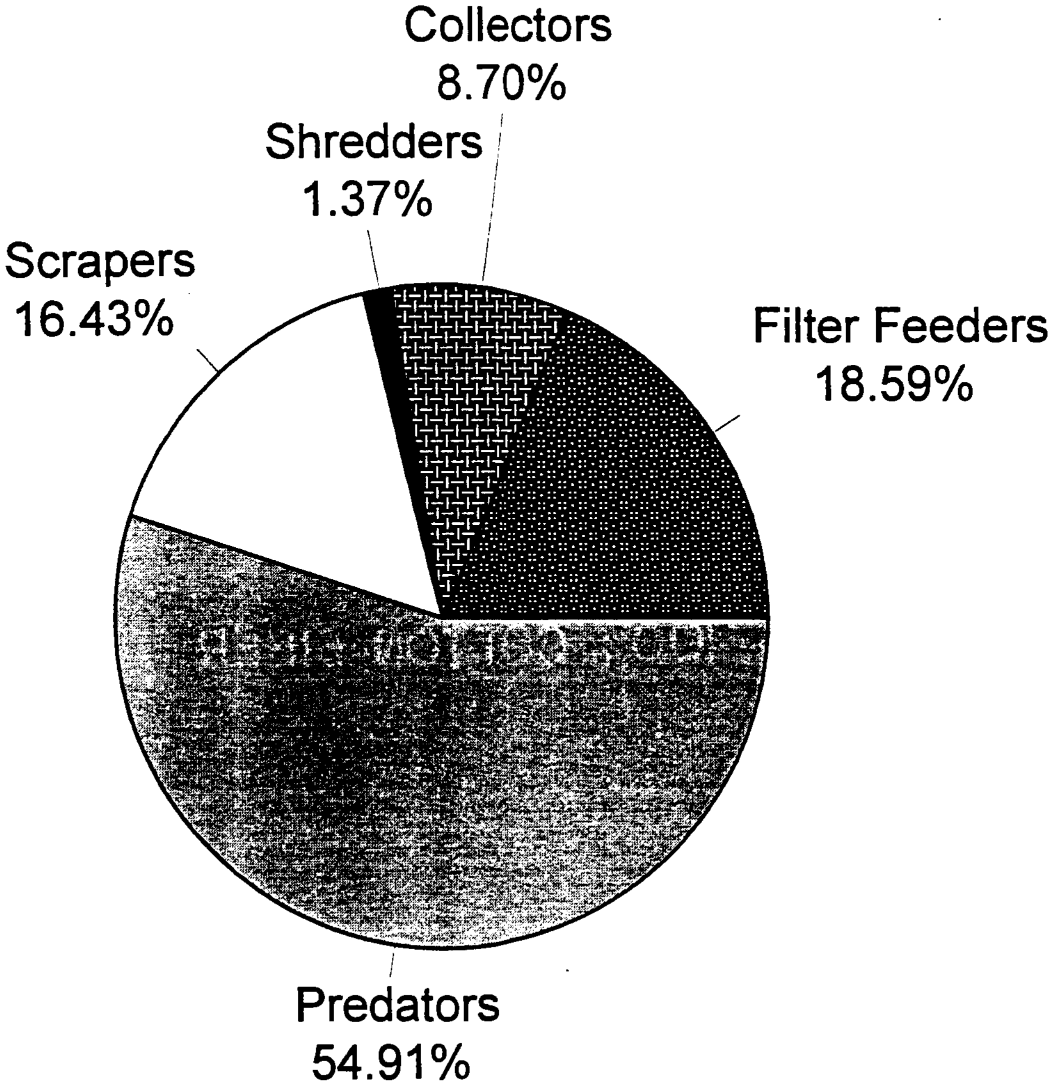


Figure 6. Functional Feeding Group Composition of Site 4 for May 1996 Collection Period.

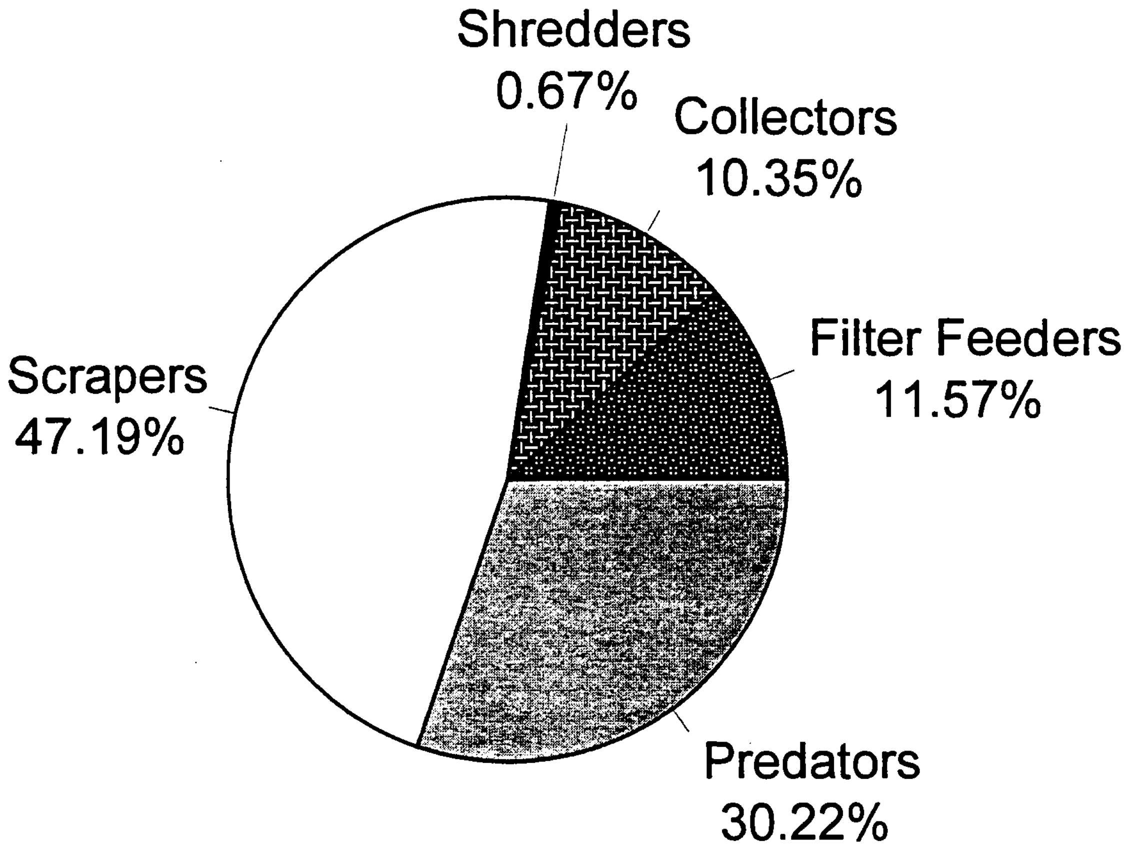


Figure 7. Functional Feeding Group Composition of Site 5 for May 1996 Collection Period.

at Site 5 could have been an indication of an increased amount of fertilizer runoff in the water in that section of the stream.

The composition of the functional feeding groups for each of the five sites for July are presented in Figures 8-12. The shredder group was poorly represented during this collection period and almost absent at all sites. The 0.13% shredders at Site 5 (most upstream site) was more characteristic of a larger river and not of a third order stream (Vannote et al. 1980). The scrapers increased in abundance downstream, while both collectors and filter feeders were in high abundance at all five of the sites (>50% at all sites). The percentages of the predator functional feeding group remained fairly constant at all five of the sites, with the exception of a low value of 3.98% at Site 1 (most downstream site).

The functional feeding group data for Site 5 were more consistent with a medium-size river than with a headwater section of a river for both the May and July collection periods. The almost complete lack of shredders and the high abundance of collectors and filter feeders at all sites for both collection periods were also more consistent with RCC theory (Vannote et al. 1980). The lack of CPOM, as indicated by the lack of shredders, was expected in areas with small riparian zones. However, there was a high

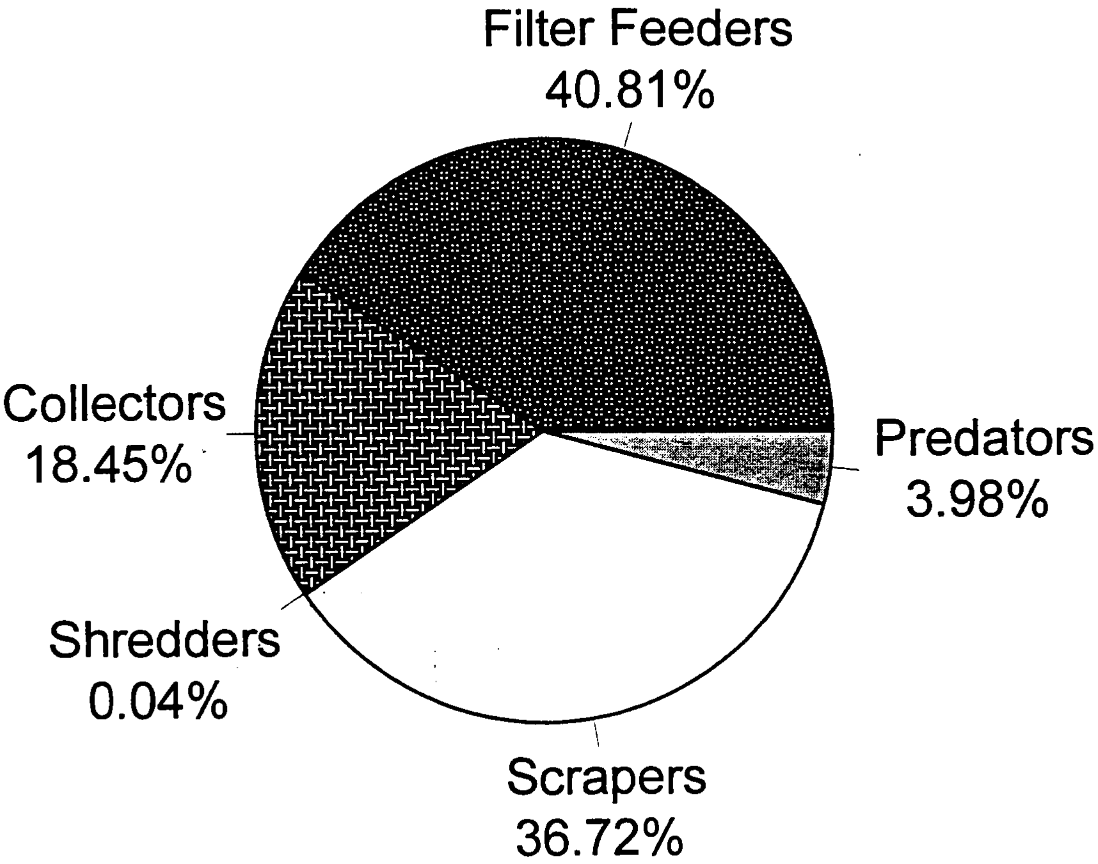


Figure 8. Functional Feeding Group Composition of Site 1 for July 1996 Collection Period.

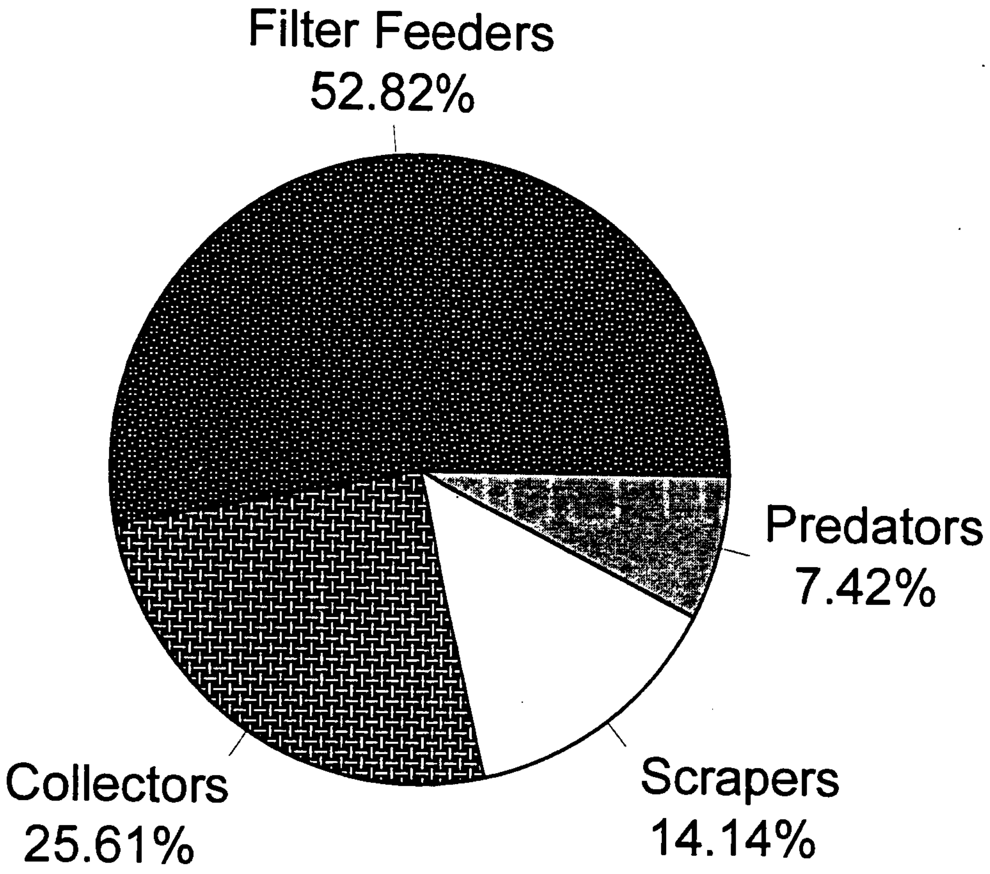


Figure 9. Functional Feeding Group Composition of Site 2 for July 1996 Collection Period.

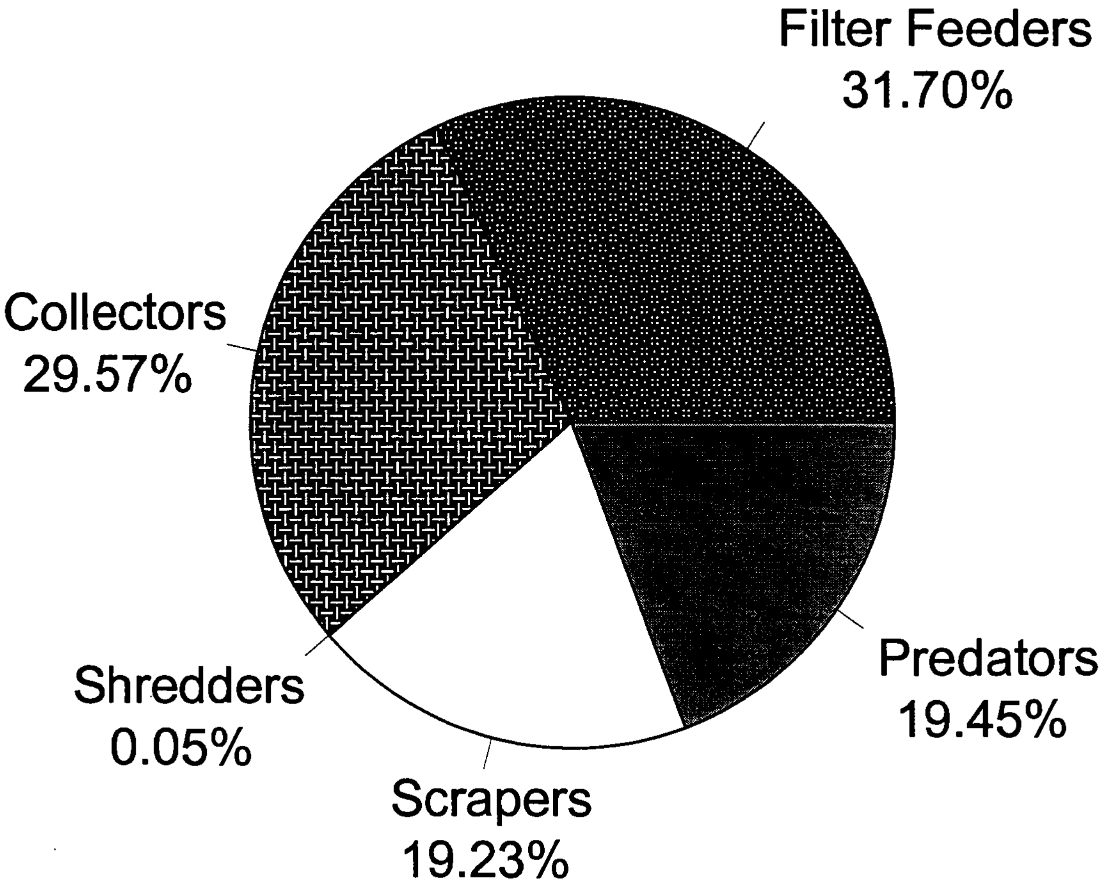


Figure 10. Functional Feeding Group Composition of Site 3 for July 1996 Collection Period.

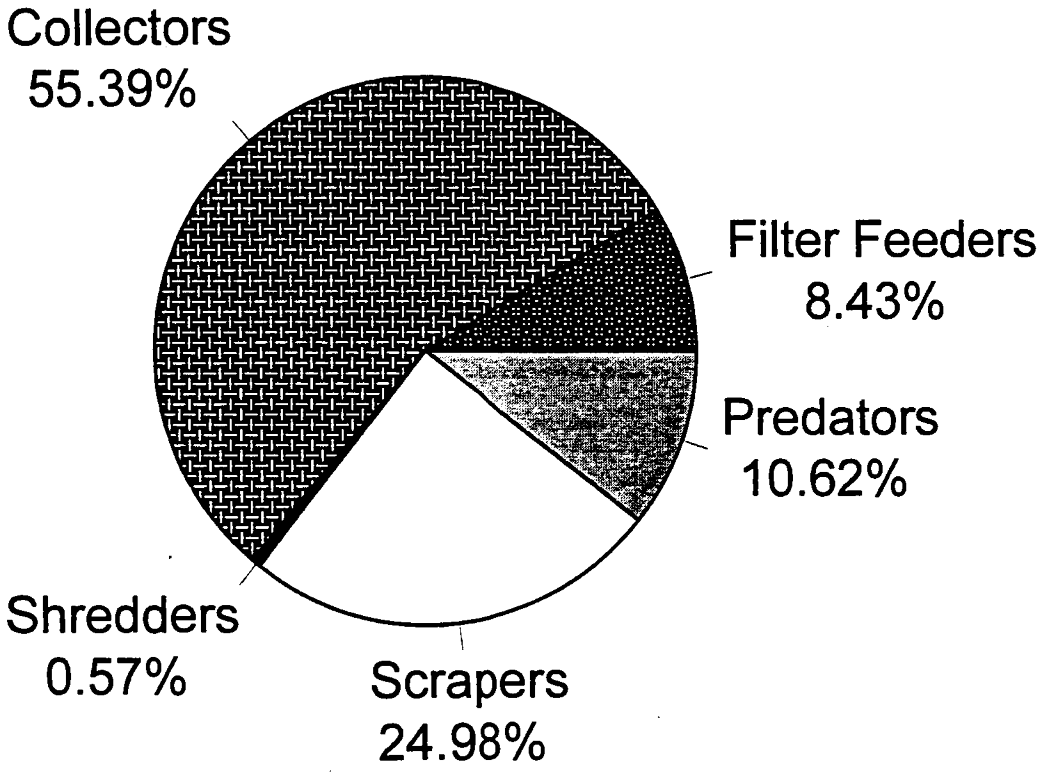


Figure 11. Functional Feeding Group Composition of Site 4 for July 1996 Collection Period.

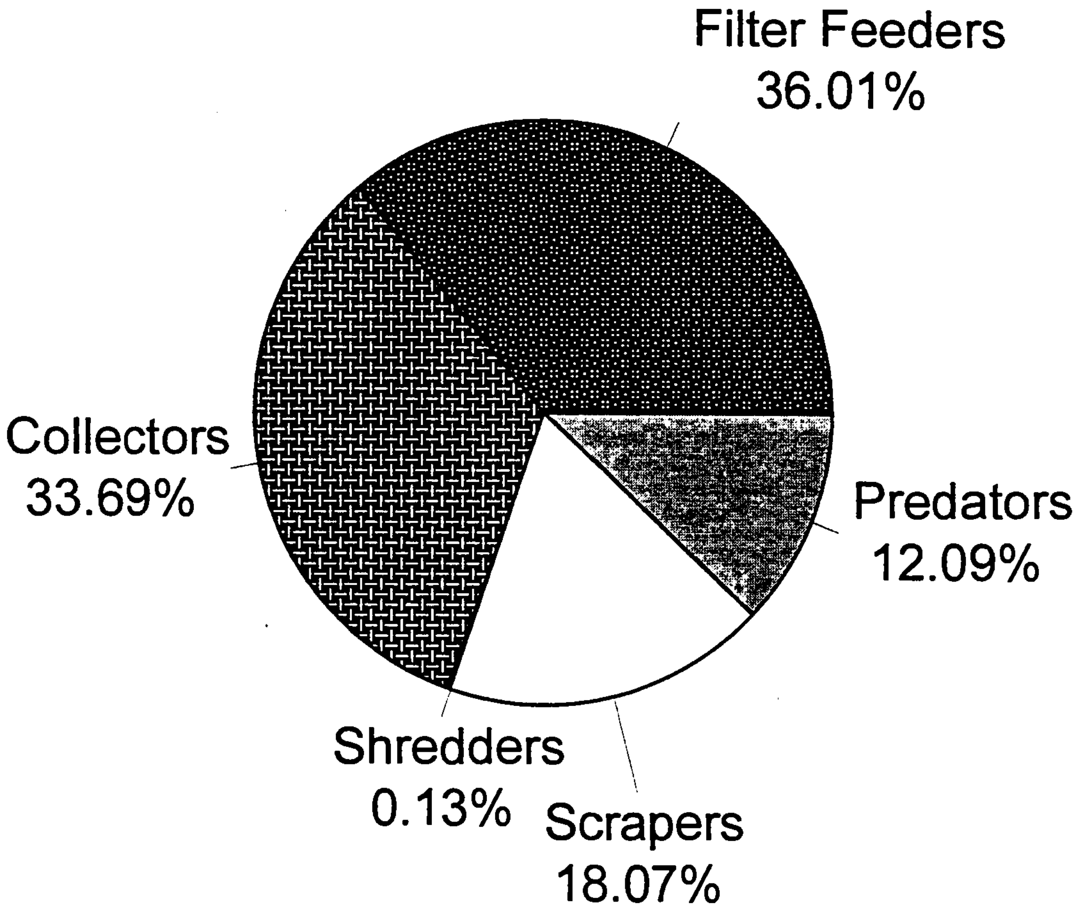


Figure 12. Functional Feeding Group Composition of Site 5 for July 1996 Collection Period.

degree of riparian cover at Site 5 and should have had a greater amount of CPOM. The lack of CPOM and shredders could have been due to some microhabitat or macrohabitat differences at Site 1 which resulted in a lower percentage of shredders. Differences in the percentage composition of the functional feeding group from those expected (especially for shredders) might have been an indication of a water quality problem, but this could not have been determined without further quantitative studies conducted during additional collection periods (Lenat and Barbour 1994). The water quality values obtained from the ICI and the HBI indicated that the river was in the Good-Excellent range. Therefore, the functional feeding group results might have been typical for this river, while not totally complying with the RCC.

Fish

A total of 1,026 fish representing seven families was collected during the May collection period. A list of the fish collected is presented in Appendix C. The July collection period yielded 1,232 individuals from eight families (Appendix D). The specimens were identified to species level, with the exception of one Lepomis hybrid collected during May.

The most interesting fish species found during the study was *Etheostoma cinereum* Storer, the ashy darter. Two specimens were collected during the study, and this was important because the ashy darter was listed as possibly extirpated from Buck Creek by Burr and Warren (1986). Cicerello and Butler (1985) surveyed the fishes of Buck Creek and did not collect *E. cinereum* from any sampling locations in the stream. They reported that the last known specimens from Buck Creek had been collected in 1955. Prior to my study, ashy darters had been collected at two sites in the Buck Creek drainage: near the confluence of Buck Creek and Brushy Creek, and upstream of the confluence of Buck Creek and Short Creek (Cicerello and Butler 1985). The specimens of *E. cinereum* collected during this study were from Site 2 on 24 May 1996. They were just downstream of the riffle in approximately 0.8 m of water along the right downstream side of the stream, and out of the direct water current. The substrate in the immediate area was sand and silt, with some sticks and other debris present. During September 1996, Dr. Patrick Ceas, Michael C. Compton, and Adrian Nix also collected ashy darters from the same location using a backpack shocker. Other areas in Buck Creek were sampled; however, no additional specimens were collected.

TABLE XII

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	52 GOOD	44 FAIR	48 GOOD	40 FAIR	50 GOOD
JULY	50 GOOD	48 GOOD	46 FAIR-GOOD	52 GOOD	44 FAIR

The Index of Biotic Integrity (IBI) values and water quality designations obtained from the May and July collection periods (Table XII) indicated that the water quality of the upper section of Buck Creek was in the Good water quality class. The May collection yielded two Fair ratings (Sites 2 and 4) and three Good ratings (Sites 1, 3, and 5). The July collection yielded one Fair rating (Site 5), one Fair-Good rating (Site 3), and three Good ratings (Sites 1, 2, and 4). The overall average rating using the IBI resulted in a Fair-Good rating for May (46.8) and a Good rating for July (48), with no site receiving a rating of less than Good for both collection periods.

The largest difference observed between collection periods was at Site 4, the Goodhope-Goochtown Road crossing. One possible explanation of this difference

(40 in May and 52 in July) was tractor traffic by a local farmer through the stream at Site 4. The fish might have dispersed downstream to avoid the disturbance. The water level and other physical factors of the stream and surrounding area appeared to be similar for the two collection periods, so changes in physical factors were ruled out as reasons for changed IBI scores. Another reason might be attributed to collector error in that different people operated the seine during each collection period, and the July seine team was more experienced. The number of species per site was lowest for May at Site 4, and there were four less species recorded in May at Site 4 than were found during the July collection. The low species count at Site 4 in May could also have been a result of both increased disturbance to the site and the use of different seine teams.

The Jaccard Coefficient of Community (CCj) did not show any distinct longitudinal trends for the May collection (Table XIII). Sites 1 and 2 had the highest degree of similarity (0.65), while Sites 3 and 5 showed the second highest degree (0.63). The lowest degree of similarity was between Sites 2 and 5 (0.44) and between Sites 4 and 5 (0.44).

The highest CCj similarity for July existed between Sites 1 and 3 which had a similarity of 0.64 (Table XIV).

TABLE XIII

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

Site Number	1	2	3	4
2	0.65	----	----	----
3	0.58	0.54	----	----
4	0.52	0.55	0.48	----
5	0.61	0.44	0.63	0.44

TABLE XIV

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

Site Number	1	2	3	4
2	0.58	----	----	----
3	0.64	0.46	----	----
4	0.50	0.58	0.57	----
5	0.38	0.58	0.50	0.57

The lowest similarity was found between Sites 1 and 5 (0.38) and between Sites 2 and 3 (0.46). The remaining comparisons had similarities greater than 0.49. There was a distinct upstream trend of decreasing similarity between Site 1 and the other sites (with a slightly higher similarity between sites 1 and 3 than between 1 and 2).

No two sites showed a similarity value below 0.50 for both May and July, indicating little seasonal differences in community similarity between sites. Some of the low similarity values between sites could have been only temporal differences, explaining why low values didn't occur for both the May and July collection periods.

The Shannon-Wiener Diversity Index and Evenness values for fish data for May are illustrated in Table XV, and the values for July are shown in Table XVI. There were no notable longitudinal trends for May, and July had a slight downstream trend of increased diversity per site. The evenness values were higher in July than in May, except at Site 4. Site 4 had the lowest diversity and evenness values for both of the sampling periods which were the same results obtained from the analyses of the macroinvertebrate data. The low values at Site 4 for both May and July could have indicated an impacted fish community, most probably due to the presence of the road crossing at this site. The disturbance to the stream could have caused some fish

TABLE XV

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

METRIC	SITE NUMBER				
	1	2	3	4	5
H′	1.90	2.24	2.22	1.76	2.33
J	0.66	0.74	0.74	0.67	0.79

TABLE XVI

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

METRIC	SITE NUMBER				
	1	2	3	4	5
H′	2.32	2.70	2.42	1.42	1.89
J	0.80	0.86	0.84	0.49	0.70

species to disperse away from the disturbance, which reduced species richness and increased dominance by a few tolerant taxa.

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to assess the water quality of the upper section of Buck Creek by using fish and macroinvertebrates as biological indicators. Several previous biological studies of Buck Creek had been completed, but this study on the upper section and the continuing study by Michael C. Compton on the lower section were the first intensive biological assessment studies that had been conducted. This study provided baseline data for future biological monitoring of the stream.

The Invertebrate Community Index (ICI) and Hilsenhoff Biotic Index (HBI) values for the May and July 1996 collection periods indicated that the upper section of Buck Creek was in the Excellent water quality category. Site 2 showed the most variation for ICI values between sampling periods, ranging from 46 (Good) in May to 54 (Exceptional) in July. Site 2 was the only site that did not receive an HBI score of Excellent for at least one of the collection periods, and it was also the site that had the worst HBI scores for each collection period. The isolation of the riffle at Site 2, located in the middle of two slow moving pooled sections of the stream, was one possible explanation for the reduced scores.

The Proportional (%) Community Similarity, Shannon-Wiener Diversity Index, and Evenness values for the macroinvertebrate communities did not exhibit any longitudinal trends for either the May or July collection periods. The majority of the similarity values were above 50%, and the greatest indication of dissimilarity occurred between Site 1 and the other four sites during the May collection. The lowest diversity and evenness values were characteristic of Site 4, which was probably due to the presence of a road crossing through the stream at this site. The remaining sites had diversity and evenness values indicative of clean water streams.

The analyses of functional feeding groups supported the basic premises of the River Continuum Concept (RCC); although, the most upstream site (Site 5, a third order stream) indicated that the proportions of the functional feeding groups were more characteristic of a medium-sized river than a headwater stream. The proportions of some of the functional feeding groups (i.e., predators) were not in the expected proportions at some of the other sites. This might have been due to life history patterns of some of the species.

The most notable fish species collected during this study was Etheostoma cinereum Storer, the ashy darter. The two specimens collected from Site 2 were important because the ashy darter was thought to have been extirpated from the Buck Creek system.

The Index of Biotic Integrity (IBI) values for the May and July collection periods indicated that the water quality of the upper section of Buck Creek was in the Fair-Good water quality class. No site received a rating of less than Good for both collection periods, with the largest difference between periods occurring at Site 4. The twelve point difference that occurred might have been the result of collector error and the presence of the road crossing through the stream at that site, since the water levels and other physical characteristics of the stream habitat did not appear to have changed.

The Jaccard Coefficient of Community (CCj) analyses for the May fish collection did not exhibit any distinct longitudinal trends. The July fish collection exhibited an upstream trend of decreasing similarity between Site 1 and the other sites; although, most sites showed relatively the same degree of similarity between sites. There were minimal seasonal differences in community structure between sites, and the low similarity values were probably only temporal.

The Shannon-Wiener Diversity Index and Evenness values for May did not demonstrate any longitudinal trends, while the July data exhibited a slight downstream trend of increased diversity per site. Site 4 was characterized by the lowest diversity and evenness values for May and July, probably due to the presence of the road crossing through the stream at this site.

The overall water quality of the upper section of Buck Creek, using both fish and macroinvertebrate analyses, was considered to be Good to Excellent for the May and July sampling periods. The most impacted site was Site 4, where a road crossed through the stream. It is recommended that periodic bioassessments of Buck Creek be conducted in the future to track possible changes and trends in water quality.

LITERATURE CITED

Allan, J.D. 1995. Stream Ecology, Structure and function of running waters. Chapman & Hall, New York. 388 pp.

Armour, C.L., D.A. Duff, and W. Elmore. 1991. The effects of livestock grazing on riparian and stream ecosystems. Fisheries 16:7-11.

Bednarik, A.F. and W.P. McCafferty. 1979. Biosystematic Revision of the Genus Stenonema (Ephemeroptera: Heptageniidae). Canadian Bulletin of Fisheries and Aquatic Sciences, No. 201. 74 pp.

Branson, B.A. and D.L. Batch. 1971. Effects of strip mining on small-stream fishes in East-Central Kentucky. Proc. Biol. Soc. Wash. 84:507-518.

Brigham, A.R., W.U. Brigham, and A. Gnilka, eds. 1982. Aquatic insects and Oligochaetes of North and South Carolina. Midwest Aquatic Enterprises, Mahomet, IL.

Brower, J.E., J.H. Zar, and C.N. von Ende. 1990. Field and laboratory methods for general ecology. Brown Publ., Dubuque. 237 pp.

Burr, B.M. and M.L. Warren, Jr. 1986. A Distributional Atlas of Kentucky Fishes. Kentucky Nature Preserves Commission. Sci. and Tech. Series Number 4. 398 pp.

Butler, R.S. 1986. Comparative feeding ecology of darters (Percidae: Etheostoma) in Buck Creek, Pulaski county, Kentucky. Unpubl. M.S. Thesis. Eastern Kentucky University, Richmond. 247 pp.

Cicerello, R.R. and R.S. Butler. 1985. Fishes of Buck Creek, Cumberland River Drainage, Kentucky. Brimleyana 11:133-159.

Compton, M.C. In Prep. Bioassessment of the fish and macroinvertebrate communities of the lower section of Buck Creek, Pulaski County, Kentucky. Unpubl. M.S. Thesis. Eastern Kentucky University, Richmond.

Cummins, K.W. 1973. Trophic relationships of aquatic invertebrates. Ann. Rev. Entomol. 18:183-206.

Cummins, K.W. and M.J. Klug. 1979. Feeding ecology of stream invertebrates. Annu. Rev. Ecol. Syst. 10:147-172.

Davis, W.S., B.D. Snyder, J.B. Stribling, and C. Stoughton. 1996. Summary of State Biological Assessment Programs for Streams and Wadeable Rivers. EPA 230-R-96-007. U.S. Environmental Protection Agency; Office of Policy, Planning, and Evaluation; Washington, DC.

DeShon, J.E. 1995. Development and application of the Invertebrate Community Index (ICI). Pages 217-243 in Davis, W.S. and T.P. Simon, eds. Biological assessment and criteria. Tools for water resource planning and decision making. Lewis Publishers, Boca Raton, FL. 415 pp.

Eaglin, G.S. and W.A. Hubert. 1993. Effects of logging and roads on substrate and trout in streams of the Medicine Bow National Forest, Wyoming. N. Am. J. Fish. Mgt. 13:844-846.

Epler, J.H. 1995. Identification Manual for the Larval Chironomidae (Diptera) of Florida. Revised Edition. Florida Department of Environmental Protection, Division of Water Facilities, Tallahassee, FL. 317 pp.

Epler, J.H. 1966. Identification Manual for the Water Beetles of Florida (Coleoptera: Dryopidae, Dytiscidae, Elmidae, Gyrinidae, Haliplidae, Hydraenidae, Hydrophilidae, Noteridae, Psephenidae, Ptilodactylidae, Scirtidae). Florida Department of Environmental Protection, Division of Water Facilities, Tallahassee, FL. 257 pp.

Etnier, D.A. and W.C. Starnes. 1993. The Fishes of Tennessee. University of Tenn. Press, Knoxville. 681 pp.

Floyd, M.A. 1989. The caddisflies (Insecta: Trichoptera) of the Buck Creek Drainage, Pulaski County, Kentucky. Unpubl. Thesis. Eastern Kentucky University, Richmond. 48 pp.

Harker, D.F. Jr., M.L. Warren Jr., K.E. Camburn, S.M. Call, J.G. Fallo, and P. Wigley. 1979. Aquatic biota and water quality survey of the Appalachian Province, eastern Kentucky. Tech. Rep. Ky. Nat. Pres. Comm., Frankfort. 1152 pp.

Harker, D.F. Jr., M.L. Warren Jr., K.E. Camburn, S.M. Call, J.G. Fallo, and P. Wigley. 1980. Aquatic biota and water quality survey of the upper Cumberland River Basin. Ky. Nat. Pres. Comm. Tech. Rep., Frankfort. 679 pp.

Hilsenhoff, W.L. 1977. Use of arthropods to evaluate water quality of streams. Tech. Bull. No. 100., Dept. Nat. Res., Madison, WI.

Hilsenhoff, W.L. 1982. Using a biotic index to evaluate water quality in streams. Tech. Bull. 132., Dept. Nat. Res., Madison, WI.

Hilsenhoff, W.L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomol. 20:31-39.

Hirsch, R.M., W.M. Alley, and W.G. Wilber. 1988. Concepts for a National Water-quality Assessment Program. U. S. Geological Survey circular 1021. U.S. Geological Survey, Denver, CO. 42 pp.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6:21-27.

Karr, J.R., K.D. Faush, P.L. Angermeier, P.R. Yant, and I.J. Schlosser. 1986. Assessing biological integrity in running waters: A method and its rationale. Illinois Natural History Survey Special Publication 5. 28 pp.

Kentucky Division of Water (KDOW). 1993. Methods for Assessing Biological Integrity of Surface Waters. Water Quality Branch, Frankfort, KY. 139 pp.

Kentucky State Nature Preserves Commission (KSNPC). 1996. Rare and Extirpated Plants and animals of Kentucky. Trans. Ky. Acad. Sci. 57:69-91.

Klemm, D.J., P.A. Lewis, F. Fulk, and J.M. Lazorchak. 1992. Macroinvertebrate field and laboratory methods for evaluating the biological integrity of surface waters. U.S. Environmental Protection Agency, Environmental Monitoring Systems Laboratory, Cincinnati, U.S. EPA Report 600/4-90/030.

Krebs, C.J. 1989. Ecological Methodology. Harper Collins Publishers, New York. 654 pp.

Lenat, D.R. 1988. Water quality assessment of streams using a qualitative collection method for benthic macroinvertebrates. J. N. Am. Benth. Soc. 7:222-233.

Lenat, D.R. 1993. A biotic index for the Southeastern United States; derivation and list of tolerance values, with criteria for assigning water-quality ratings. J. N. Am. Benth. Soc. 12:279-290.

Lenat, D.R. and M.T. Barbour. 1994. Using benthic macroinvertebrate community structure for rapid, cost-effective, water quality monitoring: rapid bioassessment. Pages 187-215 in S.L. Loeb and A. Spacie eds. Biological Monitoring of Aquatic Systems. CRC Press, Inc. Boca Raton, FL. 381 pp.

Lenat, D.R., D.L. Penrose, and K.W. Eagleson. 1981. Variable effects of sediment addition on stream benthos. Hydrobiologia 79:187-194.

Merritt, R.W. and K.W. Cummins, eds. 1996. An Introduction to the Aquatic Insects of North America, 3rd ed. Kendall/Hunt Publishing Co., Dubuque, Iowa. 862 pp.

Meybeck, M., V. Kimstach, and R. Helmer. 1992. Strategies for water Quality Assessment. Pages 19-50 in D. Chapman (editor). Water Quality Assessments, A guide to the use of biota, sediments and water in environmental monitoring. Chapman and Hall, New York, NY. 585 pp.

Minshall, G.W., K.W. Cummins, R.C. Petersen, C.E. Cushing, D.A. Bruns, J.R. Sedell, and R.L. Vannote. 1985. Developments in stream ecosystem theory. Can. J. Fish. Aquat. Sci. 42:1045-1055.

North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR). 1995. Standard operating procedures, biological monitoring. Water Quality Section. Raleigh. 43 pp.

Ohio Environmental Protection Agency (OEPA). 1987. Biological Criteria for the Protection of Aquatic Life: Volume II. Users Manual for Biological Field Assessment of Ohio Surface Waters. Division of Water quality Monitoring and Assessment, Surface Water Section. Columbus, OH. 257 pp.

Ohio Environmental Protection Agency (OEPA). 1989. Addendum to Biological Criteria for the Protection of Aquatic Life: Volume II. Users Manual for Biological Field Assessment of Ohio Surface Waters. Division of Water quality Monitoring and Assessment, Surface Water Section. Columbus, OH. 21 pp.

Page, L.M. and B.M. Burr. 1991. A field guide to freshwater fishes, North America North of Mexico, The Peterson Field Guide Series. Houghton Mifflin Co., Boston, MA. 432 pp.

Payne, R.G. 1992. The dragonflies and damselflies (Insecta: Odonata) of Buck Creek, Pulaski County, Kentucky with ecological observations. Unpubl. M.S. Thesis. Eastern Kentucky University, Richmond. 66 pp.

Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers; Benthic Macroinvertebrates and Fish. U.S. E.P.A., Washington, D.C.

Pollard, J.E. 1981. Investigator differences associated with a kicking method for sampling macroinvertebrates. J. Freshwater Ecol. 1:215-224.

Rosenberg, D.M. and V.H. Resh. 1993. Introduction to Freshwater Biomonitoring and Benthic Macroinvertebrates. Pages 1-9 _in_ D.M. Rosenberg and V.H. Resh, eds. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York, NY. 488 pp.

Schuster, G.A., and D.A. Etnier. 1978. A Manual for the Identification of the Larvae of the Caddisfly Genera _Hydropsyche_ Pictet and _Symphitopsyche_ Ulmer in Eastern and Central North America (Trichoptera: Hydropsychidae). U. S. Environmental Protection Agency. Cincinnati, OH. EPA-600/4-78-060. 128 pp.

Schuster, G.A., R.S. Butler, and D.H. Stansbery. 1989. A survey of the unionids (Bivalvia: Unionidae) of Buck Creek, Pulaski County, Kentucky. Trans. Ky. Acad. Sci. 50:79-85.

Schuster, G.A., G.J. Pond, and E.J. Kimsey. 1996. A benthic macroinvertebrate inventory and the development of a monitoring program for the Green River within Mammoth Cave National Park, Kentucky. Mammoth Cave National Park, KY. 244 pp.

Simpson, K.W and R.W. Bode. 1980. Common larvae of Chironomidae (Diptera) from New York state streams and rivers with particular reference to the fauna of artificial substrates. New York State Museum, Albany, NY. Bull. No. 439. 105 pp.

Thorp, J.H. and A.P. Covich (eds.). 1991. Ecology and Classification of North American Freshwater Invertebrates. Academic Press, New York, NY.

United States Army Corps of Engineers. 1976. Water quality conditions in Lake Cumberland. U.S. Army Corps of Engineers, Nashville District, Nashville. 106 pp.

United States Fish and Wildlife Service (USFWS). 1997. Endangered and Threatened Wildlife and Plants; Determination of Endangered Status for the Cumberland Elktoe, Oyster Mussel, Cumberlandian Combshell, Purple Bean, and Rough Rabbitsfoot. Federal Register. Vol 62 No 7:1647-1658.

Vannote, R.L., G.W. Minshall, K.W. Cummins, J.R. Sedell, and C.E. Cushing. 1980. The River Continuum Concept. Can. J. Fish. Aquat. Sci. 37:130-137.

Wilhm, J.L. 1970. Range of diversity index in benthic macroinvertebrate populations. J. Wat. Poll. Contr. Fed. 42:R221-225.

APPENDIX A.

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**
Porifera					
Spongillidae					
Spongilla sp.	1				
Platyhelminthes					
Tricladida					
Planariidae	1			1	36
Nematoda		1			
Nematomorpha	1				
Gastropoda					
Ancylidae					
Ferrissia sp.	7	4	1	2	
Lymnaeidae					
Lymnaea sp.		1	X		
Physidae					
Physella sp.		1	3		
Planorbidae					
Gyraulus sp.		2	X	1	
Pleuroceridae					
Elimia sp.	71		11	19	36
Leptoxis praerosa			X		
Pelecypoda					
Corbiculidae					
Corbicula fluminea	116	X	4	2	
Sphaeriidae					
Sphaerium sp.	1	6			2
Oligochaeta	4	4	5		1
Lumbriculidae					
Lumbriculis sp.	3	6	4	1	32
Hydrachnida			1	2	4
Crustacea					
Amphipoda					
Gammarus sp.				X	
Decapoda					
Cambarus sp.		X	X		X
Orconectes sp.	2	X	7	6	8
Isopoda					
Lirceus fontinalis		1	14	X	2

APPENDIX A (CONT.)

	SITE NUMBER				
TAXA	**1**	**2**	**3**	**4**	**5**
Insecta					
Ephemeroptera					
Baetidae			2		
Baetis spp. sensu latu	303	10	22	84	119
Caenidae					
Caenis sp.	12	15	3		18
Ephemerellidae					
Attenella attenuata		3			
Ephemerella sp.					1
Eurylophella sp.		X			
Ephemeridae					
Hexagenia sp.	X		X		X
Heptageniidae	21	1	9	10	
Leucrocuta sp.	18	32	13	6	3
Rhithrogena sp.	34	3			5
Stenonema sp.	61	6	27	16	3
Stenonema femoratum			1	X	2
Stenonema mediopunctatum	485	46	131	52	58
Stenonema modestum	1				
Stenonema ithica	1				
Stenonema vicarium			7	12	3
Stenacron interpunctatum			1		1
Leptophlebiidae				1	
Paraleptophlebia sp.			X		
Isonychiidae					
Isonychia spp.	721	16	113	155	80
Polymitarcyidae					
Ephoron sp.	91	32	3		
Tricorythidae					
Tricorythodes sp.		2			1
Odonata					
Aeshnidae					
Boyeria sp.	X	X	X		X
Calopterygidae					
Calopteryx sp.	X	X		X	
Coenagrionidae					
Argia sp.	1	1	4		
Enallagma sp.	X		X	X	X
Corduliidae					
Macromia sp.	X	X		X	X
Gomphidae					
Gomphus sp.		X	X	X	
Hagenius sp.	X			X	
Lanthus sp.	7	2	21	3	57
Stylogomphus sp.	1		1		
Plecoptera					
Chloroperlidae				1	
Alloperla sp.	4	14	3	5	1
Haploperla sp.		1	2	1	
Leutridae			1		
Leuctra sp.			4	13	3

APPENDIX A (CONT.)

TAXA	**SITE NUMBER** **1**	**2**	**3**	**4**	**5**
Nemouridae					
Amphinemura sp.	14		6	6	8
Perlidae	26	39	52	87	84
Acroneuria sp.	X	1	3	3	1
Beloneuria sp.	31	12	11	61	38
Neoperla sp.	33	7	2		
Perlesta sp.	34	161	327	650	318
Phasganophora sp.	24				
Perlodidae					
Isoperla sp.	1				
Heteroptera					
Corixidae	X				
Gerridae					
Gerris sp.			X	X	X
Trepobates sp.				X	X
Veliidae					
Rhagovelia sp.	2	X			
Nepidae					
Ranatra sp.		X	X		
Megaloptera					
Corydalidae					
Corydalus cornutus	13		6	2	6
Nigronia sp.	1			1	4
Sialidae					
Sialis sp.			1		
Neuroptera					
Sisyridae					
Sisyra sp.	1				
Trichoptera					
Glossosomatidae					
Agapetus sp.				X	
Protoptila sp.	49		1		2
Helicopsychidae					
Helicopsyche borealis	1		1		
Hydropsychidae	21		8	3	1
Ceratopsyche cheilonis	149				
Cheumatopsyche sp.	303	39	205	94	43
Hydropsyche sp.					1
Hydropsyche betteni	1				
Leptoceridae					
Oecetis sp.	X				
Limnephilidae					
Pycnopsyche spp.	1		X	X	
Philopotamidae					
Chimarra sp.	39		25	9	13
Dolophilodes distinctus	4		19	1	2
Wormaldia sp.	6	1	7	7	2
Ueonidae					
Neophylax sp.	7	10	134	2	

APPENDIX A (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5
Coleoptera					
Curculionidae			1		
Dryopidae					
Helichus sp.	X	X			X
Dytiscidae					
Desmopachria sp.				1	
Elmidae					
Ancyronyx sp.		1	1	1	
Dubiraphia sp.	2	1		1	1
Macronychus glabratus	X	1	1	X	
Optioservus sp.	24	2	2		4
Stenelmis sp.	662	91	237	98	506
Gyrinidae					
Dineutus sp.	9	4	1	5	
Haliplidae					
Peltodytes sp.	X				
Hydrophilidae					
Enochrus sp.	X				
Sperchopsis sp.			X		
Helophorus sp.					X
Psephenidae					
Ectopria sp.					1
Psephenus herricki	102	10	21	21	78
Staphylinidae					
Stenus sp.	2			1	
Diptera					
Ceratopogonidae					
Ceratopogoninae	15	54	30	11	16
Forcipomyiinae	X				
Chironomidae					
Tanypodinae					
Ablabesmyia mallochi			2		
Conchapelopia sp.		1	2	3	8
Nilotanypus sp.		3	1		
Orthocladiinae					
Cricotopus bicinctus gp.		1	8	1	5
Cricotopus trifascia gp.	1	3	6		72
*Cricotopus**Orthocladius* spp.		3	12	13	16
Eukiefferiella graciei				1	
Nanocladius sp.			8		2
Parakiefferiella sp.				1	
Parametriocnemus lundbecki	6			2	2
Rheocricotopus sp.	3	1	1		
Thienemanniella sp.		3	9	3	
Tvetnia bavarica gp.				4	
Diamesinae					
Diamesa sp.	2				
Potthastia sp.	19				
Chironominae					
Cryptochironomus fulvus gp.	5	26	5	2	5
Dicrotendipes neomodestus		2	8		
Microtendipes pedellus gp.	2	3	13	3	10

APPENDIX A (CONT.)

TAXA	**SITE NUMBER** 1	2	3	4	5
Phaenopsectra sp.		1			
Polypedilum convictum gp.	5	8	45	26	52
Polypedilum scalaenum gp.	1			1	1
Paratanytarsus sp.		2			
Rheotanytarsus sp.	4	8	11	8	10
Tanytarsus sp.		1	3	1	8
Simuliidae	1				
Simulium sp.	20				
Tabanidae					
Chrysops sp.	1	1	1		1
Tipulidae					
Hexatoma sp.	52		14		
Tipula spp.	7	X	1	2	1
TOTAL NUMBER OF DISTINCT TAXA	**79**	**66**	**75**	**65**	**62**

APPENDIX B.

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					
Tricladida					
Planariidae	4		5	2	16
Nematoda					1
Gastropoda					
Ancylidae					
Ferrissia sp.	25	10	2	8	1
Lymnaeidae					
Lymnaea sp.	X			1	
Physidae					
Physella sp.		X	X		
Planorbidae					
Gyraulus sp.		1		X	1
Helisoma sp.			1		
Pleuroceridae					
Elimia sp.	26	X	1	5	6
Pelecypoda					
Corbiculidae					
Corbicula fluminea	51	4	2	2	X
Sphaeriidae					
Sphaerium sp.	2	X	2		1
Oligochaeta	2		4	4	2
Lumbriculidae					
Lumbriculus sp.		4			2
Hirudinea					
Glossiphoniidae	X	X	6		
Hydrachnida	2	1	1	1	1
Crustacea					
Amphipoda					
Gammarus sp.	X			1	
Decapoda					
Cambarus sp.				X	X
Orconectes sp.	X	1	4		3
Isopoda					
Lirceus fontinalis	1				

APPENDIX B (CONT.)

TAXA	**SITE NUMBER** **1**	**2**	**3**	**4**	**5**
Insecta					
Ephemeroptera					
Baetidae					
Baetis spp. sensu latu	573	142	167	219	68
Caenidae					
Caenis sp.	26	62	70	62	40
Ephemeridae					
Ephemera sp.			5	2	
Heptageniidae	53	52	60	62	32
Heptagenia sp.	1				
Leucrocuta sp.	13	6	20	4	2
Nixe sp.	1				
Rhithrogena sp.	2				
Stenonema sp.	158	82	159	213	115
Stenonema femoratum		X	X	X	X
Stenonema mediopunctatum	213	178	215	267	212
Stenonema modestum		2			
Stenonema vicarium	7	2	31	48	92
Stenacron interpunctatum				2	X
Isonychiidae					
Isonychia spp.	601	343	451	78	186
Polymitarcyidae					
Ephoron sp.	7	1	1		
Tricorythidae					
Tricorythodes sp.	1	21	3	14	1
Odonata					
Aeshnidae					
Boyeria sp.	X		X	X	
Calopterygidae					
Calopteryx sp.	X		X		
Coenagrionidae					
Argia sp.	1		7	1	1
Enallagma sp.	X				
Corduliidae					
Macromia sp.	X	X	X	X	X
Didymops sp.			X	X	
Neurocordulia sp.			X		
Gomphidae					
Dromogomphus sp.				X	
Gomphus sp.		X			
Hagenius sp.	X	X		X	X
Lanthus sp.	8	1	10	1	33
Progomphus sp.	1				
Stylogomphus sp.	X		X	X	
Plecoptera					
Chloroperlidae					
Alloperla sp.				3	1
Leutridae					
Leuctra sp.			1	7	2

APPENDIX B (CONT.)

TAXA	**SITE NUMBER**				
	1	**2**	**3**	**4**	**5**
Perlidae	1	1	10	6	2
Acroneuria sp.	18	15	188	32	35
Attaneuria sp.			1		
Beloneuria sp.		1	2	1	2
Neoperla sp.	2	50	13	12	50
Phasganophora sp.	1				
Heteroptera					
Corixidae		X		X	
Gerridae					
Gerris sp.			X	X	X
Metrobates sp.	X	X	X		
Trepobates sp.	1	X	1	X	1
Rheumatobates sp.		X		X	
Veliidae					
Microvelia sp.					X
Rhagovelia sp.					2
Nepidae					
Ranatra sp.	X				
Notonectidae					
Notonecta sp.		X	X		
Megaloptera					
Corydalidae					
Corydalus cornutus	6	2	16	3	4
Nigronia sp.	15	36	68	43	36
Sialidae					
Sialis sp.			2	4	X
Trichoptera					
Brachycentridae					
Brachycentrus sp.				1	
Glossosomatidae					
Protoptila sp.	5				
Hydropsychidae	43	16	1	2	11
Ceratopsyche cheilonis	89	117	6		2
Cheumatopsyche sp.	252	484	82	5	118
Hydropsyche betteni		13	1	1	1
Hydropsyche dicantha		1			
Hydropsyche frisoni	1				
Leptoceridae					
Mystacides sp.				X	
Triaenodes sp.	X				
Limnephilidae					
Pycnopsyche spp.	1				
Philopotamidae		5			
Chimarra sp.	35	108	22	4	200
Dolophilodes distinctus	1				
Polycentropodidae					
Polycentropus sp.		X			
Psychomyiidae					
Psychomyia flavida	1				
Ueonidae					
Neophylax sp.	1	35	1	X	X

APPENDIX B (CONT.)

	SITE NUMBER				
TAXA	**1**	**2**	**3**	**4**	**5**
Coleoptera					
Dryopidae					
Helichus sp.		1		1	
Dytiscidae					
Hygrotus sp.		X			
Elmidae					
Ancyronyx sp.	2	1	X		X
Dubiraphia sp.		4			
Macronychus glabratus	X	X	1		
Microcylloepus sp.	4	1	1		
Optioservus sp.	35	7	2	1	4
Stenelmis sp.	270	65	151	55	141
Gyrinidae					
Dineutus sp.	19	16	24	5	1
Gyrinus sp.	X	X	X	X	
Haliplidae					
Peltodytes sp.	X				
Hydrophilidae					
Helophorus sp.	1	2			
Tropisternus sp.	X			X	
Psephenidae					
Ectopria sp.		2			
Psephenus herricki	25	16	14	8	48
Scirtidae					
Cyphon sp.		1			
Staphylinidae			X		
Stenus sp.				X	
Diptera					
Ceratopogonidae					
Ceratopogoninae		1			
Chironomidae					
Tanypodinae					
Ablabesmyia mallochi		1		1	
Conchapelopia sp.	9	21	10	14	9
Nilotanypus sp		1		1	2
Procladius sp.			2		
Orthocladiinae					
Cricotopus sp.	6	1			
Cricotopus trifascia gp.		1			
*Cricotopus**Orthocladius* spp.	4	6			
Parametriocnemus lundbecki	1	2			
Rheocricotopus sp.		4			8
Synorthocladius sp.				5	
Thienemanniella sp.	1	1			
Diamesinae					
Diamesa sp.				1	1
Chironominae					
Cryptochironomus fulvus gp.	8	8	2		1
Microtendipes pedellus gp.				2	
Phaenopsectra sp.			1	7	

APPENDIX B (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5
Polypedilum convictum gp.	18	121	2	1	
Polypedilum scalaenum gp.		9		1	
Rheotanytarsus sp.	7	15	6	8	
Tanytarsus sp.					2
Empididae					
Hemerodromia sp.				1	
Simuliidae					
Simulium sp.	6	18	16		4
Prosimulium sp.	5		1		1
Syrphidae					
Canace sp.			X		
Tipulidae					
Hexatoma sp.	15	2	2	1	
TOTAL NUMBER OF DISTINCT TAXA	**73**	**74**	**66**	**65**	**55**

APPENDIX C

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

	SITE NUMBER				
TAXA	**1**	**2**	**3**	**4**	**5**
Cyprinidae					
Campostoma oligolepis	1	63	37	4	31
Cyprinella galactura	3	2			3
C. whipplei	3	11	4	1	
Ericymba buccata				2	
Luxilus chrysocephalus	14	25	31	98	55
Lythrurus fasciolaris	74	42	26	116	29
Notropis boops	1	4		10	
N. telescopus	11	9	9	3	24
N. rubellus	1	1			
Pimephales notatus	5	37	29	41	37
Semotilus atromaculatus			1		4
Catostomidae					
Hypentelium nigricans	1		1		1
Moxostoma erythrurum			1		
Ictaluridae					
Ameiurus natalis	1	1			
Fundulidae					
Fundulus catenatus			50	4	25
Atherinidae					
Labidesthes sicculus		3		1	
Centrarchidae					
Ambloplites rupestris	1		1		1
Lepomis cyanellus		2	2		
L. macrochirus	5	2	3	10	8
L. megalotis	1	4	3	14	4
Lepomis hybrid *		1			
Micropterus punctulatus		1			2
M. salmoides		1			
Percidae					
Etheostoma blennioides	3				1
E. caeruleum	15	7	9	19	16
E. camurum	8	10	2		
E. flabellare			1		1
E. stigmaeum	1	2	2		5
E. virgatum					1
Percina caprodes	2	2	1	2	4
Total Species per site (29 combined)	**18**	**20**	**20**	**14**	**19**
Total Individuals:	150	230	214	325	252

*The *Lepomis* hybrid was not used in the species count, but it was used in the individual count.

APPENDIX D

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

	SITE NUMBER				
TAXA	1	2	3	4	5
Cyprinidae					
Campostoma oligolepis	35	31	42	11	18
Cyprinella galactura	2	7	1	1	2
C. whipplei	21	12	7		
Ericymba buccata		19			
Luxilus chrysocephalus	19	5	14	77	57
Lythrurus fasciolaris	28	10	9	276	79
Notropis boops	6	3		8	
N. telescopus	50	2	7	8	7
N. rubellus	1	1			2
Pimephales notatus	14	16	16	5	2
Semotilus atromaculatus		3		3	3
Catostomidae					
Catostomus commersoni		5		1	2
Hypentelium nigricans	2	4			
Moxostoma duquesnei				1	
M. erythrurum				2	
Ictaluridae					
Ameiurus natalis			1		
Fundulidae					
Fundulus catenatus		1	3	9	15
Poecilidae					
Gambusia affinis		1			
Atherinidae					
Labidesthes sicculus	1	1			
Centrarchidae					
Ambloplites rupestris	1		3		
L. macrochirus		10	7	8	6
L. megalotis	1	23	6	9	2
Micropterus punctulatus	3	9	5	2	
Percidae					
Etheostoma blennioides	14		1	2	
E. caeruleum	14	18	13	21	36
E. camurum	6		7		
E. cinereum		2			
E. flabellare			2		2
E. stigmaeum	1	4	2	1	
Percina caprodes		1			1
Total Species per site (30 combined)	**18**	**23**	**18**	**18**	**15**
Total Individuals:	219	188	146	445	234