FINAL REPORT

BIOASSESSMENT OF THE AQUATIC MACROINVERTEBRATES OF THE HORSE LICK CREEK WORLD BIORESERVE IN EASTERN KENTUCKY

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Scope of Study

The objectives of this study were to assess: (1) the biological water quality of Horse Lick Creek using macroinvertebrates as water quality indicators, and (2) to provide baseline data for future biological monitoring of the drainage.

Findings and Conclusions

The analyses of the macro-invertebrate data by both the modified Hilsenhoff Biotic Index and EPT Index indicated the overall water quality rating of Horse Lick Creek to be Good. Water quality was higher in the spring than in the fall. Shannon-Wiener Diversity (H') and Evenness (J) values indicated excellent water quality and high species diversity and evenness with low dominance. Diversity and Evenness were lower at sites impacted by cattle and road crossing activities. Functional feeding group composition showed longitudinal trends in community composition, which agreed with the hypothetical predictions of the River Continuum Concept. Proportional Community Similarity values indicated a distinct longitudinal trend in community composition for the Spring 1994 collections, but no distinct trends were seen for subsequent collection periods. Sites impacted by road crossings showed higher similarity for one another than for unimpacted sites. The Jaccard Coefficient of Community comparisons showed distinct longitudinal trends in community similarity for the Spring 1994 collections and slight longitudinal trends for subsequent collection periods. The sites seemed to be more similar taxonomically than in percent composition.

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CHAPTER I

INTRODUCTION

The purpose of the proposed work was to undertake a bioassessment study of the macroinvertebrates (excluding the freshwater mussels, Unionidae) of the Horse Lick Creek Bioreserve. Nine sites on the creek were selected and sampled. It was the first intensive study done on macroinvertebrates in the Horse Lick drainage and, therefore, provided baseline data for any future studies that will be done in the drainage. These data may also be used to assess any future impacts that may occur in the drainage.

Horse Lick Creek is a major tributary of the Rockcastle River in the Upper Cumberland River Basin. The stream originates in northwestern Jackson County, Kentucky, 300 m east of the Rockcastle-Jackson County line and flows for 27 km south to where it enters the Rockcastle River (KNPC

1980). The drainage basin has karst topography with many caves and subterranean streams (KNPC 1980). The watershed is unique and valuable because of the large numbers of species of mussels, fish, plants, and mammals inhabiting the drainage system, many of which are endangered or threatened (KCTNC 1992).

Twenty-two species of mussels, including the endangered Cumberland bean pearly mussel (Villosa trabalis (Conrad)), the elktoe (Alasmidonta marginata Say), the fluted kidneyshell (Ptychobranchus subtentum (Say)), the purple lilliput (Toxolasma lividus (Rafinesque)), Pegias fabula (Lea), and the Tennessee clubshell (Pleurobema oviforme (Conrad)) are found within the Horse Lick drainage (KCTNC 1992). Over 30 species of fish inhabit the Horse Lick Creek system including the ashy darter (Etheostoma cinereum Storer) and the olive darter (Percina squamata (Gilbert and Swain)), both of which are threatened throughout their range(KCTNC 1992).

Environmental Impacts Affecting Benthic Macroinvertebrates

The relative inaccessability of the creek accounts for its high water quality and aesthetics (KCTNC 1992).

However, the rugged terrain makes it attractive to off-road vehicle (ORV) users which impact the stream through physical destruction of the stream bed and downstream sedimentation of habitats. Other impacts known to affect the watershed are coal mining and logging operations, and some agriculture.

The effects of coal mining are one of the significant impacts on the water-quality of many streams in Eastern Kentucky. Strip mining is the method of choice in the area, and this method involves completely exposing the underlying coal. The main problem with this method is that it involves large quantities of top soil (overburden) removal which can then wash into the streams, causing sedimentation problems (Branson and Batch 1971). Sediment covers the habitats of benthic macroinvertebrates and fishes and therefore, reduces their densities (Branson and Batch 1971; Branson et al. 1984; Lenat et al. 1981; Taylor and Roff 1986). Also, sediment addition causes a drift response in some macroinvertebrates which reduces density due to migration and also leads to mortality by the scouring of the organisms against the sediment (Culp et al. 1986).

Increasing acidity of streams is also a major water-quality problem associated with strip mining. When iron sulfide reacts with water, it forms ferrous sulfate ($FeSO_4$) and hydrosulfuric acid (H_2SO_4) which drastically lowers the pH (Harrison 1958; Dyer and Curtis 1977; Dick et al. 1983). This increase in acidity greatly reduces the species richness and densities of macroinvertebrates (Rosemond et al. 1992) as well as fishes.

Logging operations also has had an effect on streams in the Horse Lick Creek Bioreserve. There is evidence that the cutting of trees increases sediment input, reduces substrate particle size and also reduces the taxa richness of fauna in the streams (Corn and Bury 1989). Sedimentation causes the stream channels to shift in morphology by depositing materials on bars and islands. (Harr and Nichols 1993).

The roads used to transport logs out of the forest also can contribute sediment to the stream. In the Horse Lick Creek Bioreserve, logging roads are also used by ORVs. The greatest impact these roads have on water-quality is where they cross the streams. Eaglin and Hubert (1993) found that the embeddedness and amount of fine sediment increased, while the relative abundance of cobble decreased as the number of road crossings increased. Runoff from the roads running adjacent to streams was not found to have a significant effect on the densities of macroinvertebrates or fishes (Smith and Kaster 1983; Bilby 1985).

The close proximity of cattle pastures to streams could also have a pronounced effect on macroinvertebrate community composition. Cattle increase nutrient input via runoff from pastures and by being allowed direct access into streams. However, the nitrate levels in cattle-impacted streams did not increase significantly; therefore, did not alter primary stream productivity (Gary et al. 1983; Owens et al. 1983). Cattle with direct access to streams cause bank erosion and riparian zone trampling which leads to increased sedimentation (Armour et al. 1991).

Biomonitoring Using Benthic Macroinvertebrates

Biomonitoring was utilized as a way to detect organic pollution in lotic and lentic ecosystems (Hilsenhoff 1977; Cairns and Pratt 1993). Benthic macroinvertebrates are used in biomonitoring studies because they are a very diverse group with great abundance, are relatively long-lived, are primarily sedentary, and are easily collected and identified (Hilsenhoff 1977; Cairns and Pratt 1993). Benthic macroinvertebrates are excellent organisms to use in biomonitoring because they react strongly and, often, predictably to major perturbations, and they can provide detection of short-term critical events (Cairns and Pratt 1993; NCDEHNR 1995).

When biomonitoring was in its infancy, the procedure used the indicator species concept to determine the health of the stream (Lenat et al. 1981). This concept proved to be insensitive to the density of taxa and to community structure (Hilsenhoff 1977). In addition, "tolerant" species can be found in a wide range of habitats, so that the absence of intolerant organisms is more significant than the presence of tolerant organisms in an aquatic ecosystem. Research then focused on the community diversity of streams with the pioneering work of Dr. Ruth Patrick. She studied biological measures of stream conditions which used the numbers and kinds of species in community indicator groups (Patrick 1949). This study led to the idea that communities were dynamic with a constant immigration and extinction of species occurring in local patches (MacArthur and Wilson

1967). The continual turnover of species invalidated the indicator species concept (Cairns and Pratt 1993).

Biotic indices were then developed to measure the amount of pollution in waters according to the arthropods present. The first indices measured community diversity (Margalef 1957; Wilhm and Dorris 1968), but these were not universal indices because they did not take into account stream size (Hilsenhoff 1977). Smaller streams typically have a lower diversity than larger streams, even if they were similar in other parameters (Hilsenhoff 1977). So, Chutter (1972) developed a biotic index that used both community structure and the indicator species concept. He collected species from both knowingly clean and polluted streams and assigned them tolerance values according to the conditions that they were able to tolerate: a value of zero to species found in the clean streams and a value of 10 to species found in the most polluted streams. Hilsenhoff (1977) also developed a biotic index for streams using a 0-5 scale, called the Hilsenhoff Biotic Index (HBI). For both of these studies, tolerance values were assigned according to "previous experience and knowledge" and errors may have been made when rare species were encountered (Hilsenhoff 1977).

The HBI had its limitations. For one, it was only designed to monitor organic pollution. Also, it was limited regionally to Wisconsin. Therefore, a new biotic index was developed for the southeastern U.S., and was designed to measure any stress, not just organic pollution (Lenat 1993). The new North Carolina Biotic Index (NCBI), or modified HBI, utilized tolerance values on a 0-10 scale calculated from a 75th percentile figure (Lenat 1993). Biotic index values were calculated for each collection by using the 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 values also seem to vary with ecoregion even when compared to streams of similar water quality, because mountain ecoregions support more cold-water habitats than do Piedmont and Coastal ecoregions (Lenat 1993). Criteria were developed to assign a water quality class for the HBI value calculated in a specific ecoregion (Table I).

TABLE I

MODIFIED HBI WATER QUALITY CRITERIA FOR ECOREGIONS (LENAT 1993)

WATER QUALITY CLASS	MOUNTAIN	PIEDMONT/COASTAL
Excellent	<4.17	<5.24
Good	4.17-5.09	5.25-5.95
Good-Fair	5.10-5.91	5.96-6.67
Fair	5.92-7.05	6.68-7.70
Poor	>7.05	>7.70

Good water quality is associated with high taxa richness, and calculating the numbers of taxa in the most sensitive or intolerant taxa groups can lead to a measure of water quality (NCDEHNR 1995). The most sensitive groups of taxa counted are Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) and this index of water quality is called the EPT Index. As the level of disturbance or pollution increases, the more sensitive taxa will be eliminated. Therefore, counting the numbers of taxa in these groups can assign water quality class criteria for the site(s) sampled (Table II).

TABLE II

CRITERIA FOR EPT INDEX FOR ECOREGIONS (NCDEHNR 1995)

WATER QUALITY CLASS	MOUNTAIN	PIEDMONT	COASTAL PLAIN
EXCELLENT	>35	>27	>23
GOOD	28-35	21-27	18-23
GOOD-FAIR	19-27	14-20	12-17
FAIR	11-18	7-13	6-11
POOR	0-10	0-6	0-5

Different groups of macroinvertebrates have different feeding habits so that they do not compete directly with one another. These groups are classified into functional feeding groups which stress the feeding mechanism rather than the types of food eaten (Cummins and Klug 1979). The shredder group eats coarse particulate organic matter (CPOM) which is defined as any organic substance less than 1mm in diameter (Cummins and Klug 1979). Shredders break down the CPOM into fine particulate organic matter (FPOM) and ultra-fine particulate organic matter (UPOM) which is assimilated by the collector functional feeding group (Cummins and Klug 1979). Cattle that are allowed direct access to streams increase the levels of FPOM and UPOM and are directly associated with an increase in the number of collectors found in that segment of the stream (Gary et al. 1983; Owens et al. 1983). The scraper/grazer functional feeding group had modified mouth parts that allow them to graze on periphyton growing on stream substrates (Cummins and Klug 1979). Finally, the predators specialize in the capture of live prey and can either engulf their prey whole or pierce their bodies and ingest their fluids (Cummins and Klug 1979).

The relative abundance of organisms in each functional feeding group can show if the stream is being impacted using the River Continuum Concept (RCC). This predictive model was developed by Vannote et al. (1980) to explain how changes in community structure related to the physical, geomorphic and chemical factors in a lotic ecosystem from the headwaters to the mouth. There are three main reaches of a stream: (1) the headwaters (orders 1-3), where riparian cover is the greatest, CPOM input is the greatest, and the macroinvertebrate community is dominated by shredders; (2)

the mid-sized reach (orders 4-6) is a transition zone in which there is a lessened degree of shading, more periphyton growth, more FPOM than CPOM, the greatest species diversity and the macroinvertebrate community is dominated by grazers; and (3) a large order (>6) stream where there is very little riparian shading and a large amount of FPOM and UPOM so that the macroinvertebrate community is dominated by collectors (Vannote et al. 1980). The headwaters of a stream are characterized by a heterotrophic community with a P/R (productivity/respiration) value of less than one. An autotrophic community characterizes the mid-sized reaches (P/R>1), and finally, a heterotrophic community is established in the large ordered reaches with a P/R<1 value (Vannote et al. 1980). Therefore, there is a predicted longitudinal gradient in macroinvertebrate community trophic structure and any variation from the expected would have indicated an impacted stream (Minshall et al. 1985).

The primary objective of this study was to assess the current health of the Horse Lick Creek system using the modified Hilsenhoff Biotic Index (HBI) which assigns macroinvertebrates tolerance values ranging from zero (very intolerant) to 10 (very tolerant) based on the amount of pollution they could withstand (Lenat 1993). The EPT Index also measures stream water quality by counting the number of sensitive taxa found at each site (NCDEHNR 1995). Another way used to assess the health of the stream system was to calculate relative abundance of organisms within their functional feeding groups and compare the abundances with those expected in the River Continuum Concept which predicts a longitudinal pattern of community composition (Vannote et. al. 1980).

The Shannon-Wiener Diversity (H')and Evenness (J) indices were also used to assess the health of Horse Lick Creek. Shannon-Wiener Diversity is a weighted index of species diversity that is more sensitive to changes in the abundances of rare species in a community (Krebs 1989). Generally, a value of around 2.5 shows a high diversity of organisms. Shannon-Wiener Evenness is a measure of how evenly distributed species are in relation to one another (Krebs 1989). Values range from zero to one where a value of one indicates the species are very evenly distributed with low dominance, and zero indicates the species are less evenly distributed with high dominance of one or more taxa groups.

Jaccard's similarity coefficient was used to measure the similarity between sites by using presence/absence data (qualitative), so longitudinal zonation patterns could be detected. In healthy streams, communities sampled are less similar to each other the farther upstream or downstream they are away from each other.

Percentage similarity, or the Renkonen Index, also gives a measure of community similarity using quantitative data (Krebs 1989). Horse Lick Creek is thought to harbor an excellent community of macroinvertebrates with a good-to-excellent rating on the HBI scale at the time of this study.

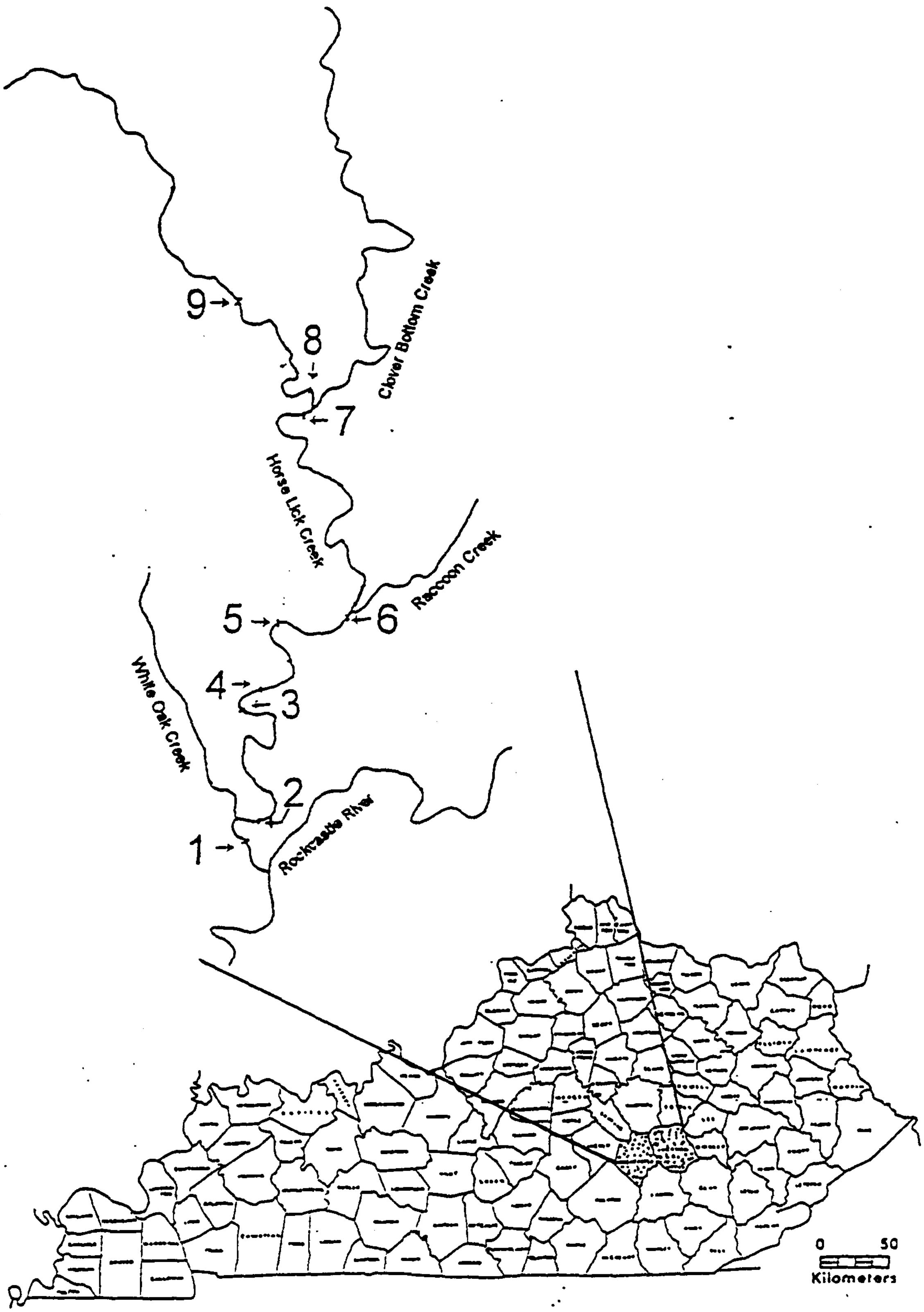
CHAPTER II

DESCRIPTION OF STUDY SITES

Nine sites in Horse Lick Creek in Jackson and Rockcastle counties, Kentucky, were selected for macroinvertebrate sampling in conjunction with those sites already selected for water quality sampling by The Nature Conservancy (Figure 1). Sampling was conducted over a two year period and two sampling periods were designated for each site within each year. Each site was sampled once on 11,12 and 14 May 1994, again on 30 September and 1 October 1994, and then again the following year on 10-11 June 1995 and 22-23 September 1995.

Site 1 was located about 1 km upstream from the confluence of the Rockcastle River and about 0.5 km downstream from the White Oak Creek tributary confluence. Along this tributary, logging operations were evident during the time of this study. Horse Lick Creek was a fifth order

Figure 1. Map of Horse Lick Creek Showing the Location of Nine Collection Sites.



stream with excellent riparian cover at site 1. A riffle, composed primarily of cobble and gravel, was located just below a long pool/run with a gravel bar on the right downstream bank. The site was on the Jackson County and Rockcastle County border.

Site 2 was located 1 km upstream from site 1 above the White Oak Creek tributary and 1 km downstream from the Laurel Branch tributary confluence on the Jackson-Rockcastle county border. This site also had excellent riparian cover, although a large field bordered the right downstream bank. There was a narrow, gravel riffle area in the center of the site bordered by beds of Justicia americana (Linnaeus)(water willow). A wide and long run was upstream of the riffle, while a deep pool with fine sediment substrate was immediately below the riffle.

Site 3 was located about 4.5 km upstream from site 2 and just downstream of the intermittent Red Dog Creek inlet on the Jackson-Rockcastle county border. Iron precipitate was draining into the stream from a strip mine located to the west at the time of this study, and a road crossed Horse Lick Creek at this site just upstream of the sampled riffle area. The substrate at and below the stream crossing was flat limestone bedrock. Riparian cover was excellent at the fast-flowing riffle, and the substrate was primarily composed of boulders and large cobble.

Site 4 was located just upstream of Red Dog Creek inlet and about 0.25 km downstream from the Trace Branch tributary confluence. This site also had a road crossing the stream just downstream from the sampled riffle. The riparian cover at the riffle was fairly open, and a large field was adjacent to the right downstream bank of the stream. The riffle, located in the middle of the stream channel, was bordered by shallow beds of Justicia americana (Linnaeus) and had a gravel, with some cobble, and sand substrate. A long, wide run was upstream and downstream of the site.

Site 5 was located about 2.5 km upstream from site 4 and was just downstream from the confluence of Horse Lick Creek and the Dry Fork tributary. At site 5, there was a road intersecting a cobble beach on the right bank and crossing the stream at the head of the riffle. Off-road vehicles (ORVs) were known to use this road. Riparian cover was only about 50% at this site and even less above the riffle area at the stream crossing. The left downstream bank was extremely eroded with little vegetation. The substrate of the riffle was primarily gravel with fine sediment that had been washed downstream from the crossing.

Site 6 was located 2.0 km upstream from site 5 in Jackson County and was just downstream of the Raccoon Creek inlet. A new concrete road crossing had been constructed at this site, just upstream of the riffle, and an increase of sedimentation was observed below the road during the sampling periods. The substrate of the riffle was primarily boulders and cobble. The stream was approximately 75% shaded with riparian cover at the riffle and the water was flowing swiftly.

Site 7 was located 0.5 km upstream from site 6 in Jackson County and was just downstream of the confluence of Clover Bottom Creek with Horse Lick Creek. A gravel and cobble substrate road crossing also bisected the riffle that was sampled at this site and ORVs and trucks had been seen using this crossing at the time of sampling. Horse Lick Creek was a fourth order tributary at this site and riparian cover provided approximately 70% shading even though there was a road crossing and exposed dirt banks on both sides of the stream. The substrate of the riffle at the stream crossing was composed primarily of sand and gravel, and the water temperature was lower compared to other sites because of the addition of the cold water from Clover Bottom Creek (personal observation).

Site 8 was located in Horse Lick Creek in Jackson County just upstream of the confluence of Clover Bottom Creek. Horse Lick Creek was a third order stream at this site. The road, which also crossed site 7, went through site 8 at the sampled riffle area. The exposed dirt banks of both sides of the stream were extremely eroded with little vegetation. There was a cobble island in between the two riffles. The riffle closest to the left downstream bank had mostly gravel and sand substrate, while the riffle on the right bank had cobble and gravel substrate with some downed trees in it. There was a long, deep run upstream of the riffle.

Site 9, the most upstream site, was located 5.0 km upstream of site 8 and just upstream of the Little Clover Creek inlet into Horse Lick Creek. The right downstream bank of this site had a 10 m buffer zone between the bank and County Highway 1955, while the left bank was adjacent to a cattle pasture where cattle have access to the stream. The left bank was eroded and the vegatation was trampled and removed in spots due to the impact of cattle. The grass and shrub-covered right bank was not significantly eroded. There were agricultural fields about 50m from the left bank and a house across the road on the right bank. The riffles which were sampled were separated by a gravel and cobble island. Both riffles had a gravel and cobble substrate, but the riffle to the right of the island had a large established bed of Justicia americana (Linnaeus). Riparian cover was very limited at this site (approximately 25% covered) as a result of agricultural fields and the closeness of County Highway 1955 to the sample site. A long, deep run was upstream of the riffle, and a bridge crossing was approximately 50m downstream.

CHAPTER III

MATERIALS AND METHODS

Macroinvertebrate Sampling and Processing

Two methods were employed to collect macroinvertebrates at each study site in Horse Lick Creek: semiquantitative and qualitative methods. Semiquantitative samples followed procedures outlined by the Kentucky Division of Water (KDOW 1993) Method Number Two. Modified traveling kicknet samples (TKN) were taken in triplicate. A 3m length of riffle was measured, and a triangular kicknet with a mesh of 800 x 900 μm was used. Over a period of 60 seconds, the kicknet was moved upstream, while the substrate was kicked directly in front of the net. The area sampled was approximately 1m^2. The net was then washed in a bucket of water and picked clean of any attached macroinvertebrates. The bucket was strained using a metal mesh "milk" strainer (25μm)and the macroinvertebrates were preserved in jars containing 70%

ethanol. Traveling kicknet samples were taken in comparable habitats within and among sites for each sampling period.

Qualitative samples were taken using a method modified from KDOW (1993) and EPA Rapid Bioassessment Protocol III (Plafkin et al. 1989). A 1.0 person hour timed sample was collected at each site to ensure that all sites were given equal collection effort. During the hour of collecting, all identifiable habitats and microhabitats were examined for macroinvertebrates. Samples were taken from kicknets in the riffle habitats, depositional areas, macrophytes, leaf packs, roots, rocks, wood, snags, and undercut banks. All macroinvertebrates collected were preserved in 70% ethanol.

Preserved samples of macroinvertebrates were transported back to the laboratory where they were picked and sorted according to recognizable groups. The organisms were identified to the lowest possible taxonomic level using the most current keys available for each taxon. Verification by experts was sought on the more difficult taxa. The organisms are stored in the Branley A. Branson Museum of Zoology at Eastern Kentucky University.

Data analysis

For semiquantitative samples, all taxa were enumerated and various indices were calculated. The Shannon-Wiener Diversity Index (H′) was calculated to provide a measure of species diversity for each site (Krebs 1989). Evenness (J′) was calculated using the Shannon-Wiener diversity value to estimate how evenly species were distributed within a community. The modified Hilsenhoff Biotic Index (HBI) or North Carolina Biotic Index (NCBI) provided a measure of the biological health and water quality of the stream at each study site using tolerance values and abundances for each species (Lenat 1993). The EPT Index represented the total number of taxa within the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) (Plafkin et al. 1989). This index gave a good indication of water quality since the taxa used were considered to be pollution intolerant (Plafkin et al. 1989). Taxa richness and the total number of individuals in each sample were summed according to the procedures outlined in the EPA Rapid Bioassessment Protocol III (Plafkin et al. 1989), and by the Kentucky Division of Water (KDOW 1993) and the North Carolina Department of Environment, Health and Natural

Resources (NCDEHNR 1995). Data from traveling kicknets for each site were compared to other sites using the Proportional Similarity Index which provided a measure of the percentage of similarity between the sites (Krebs 1989). The macroinvertebrates were separated into their respective functional feeding groups and relative abundances of each were measured for each site to determine if Horse Lick Creek followed the tenets of the River Continuum Concept (Vannote et al. 1980).

Qualitative samples were analyzed differently from semiquantitative. For these samples, all taxa were identified and taxa richness was determined for each site by summing the total number of distinct taxa found within the TKN's plus the distinct taxa found in the qualitative sample. Using these samples in addition to the TKN's should provide a much better indication of taxa richness since all identifiable habitats were sampled. Jaccard's similarity coefficient was used for qualitative data to compare taxa composition of sites (Krebs 1989).

CHAPTER IV

RESULTS AND DISCUSSION

During the four sampling periods of 1994 and 1995, 233 distinct taxa were found within Horse Lick Creek (Appendix A) and 51,583 macroinvertebrates were collected, enumerated and identified from the semi-quantitative traveling kicknets (TKN). During the May 1994 collection period, 14,051 macroinvertebrates were collected and identified from the TKN's with 139 taxa (Appendix B). The September and October 1994 collection period yielded 8,974 macroinvertebrates from the semi-quantitative TKN's and 141 taxa (Appendix C). The June 1995 sampling period enumerated and identified 12,881 macroinvertebrates from the TKN's and 132 taxa (Appendix D). Finally, 15,677 macroinvertebrates were collected in the TKN's during the September 1995 collection period with 158 taxa (Appendix E).

The modified Hilsenhoff Biotic Index (HBI) values obtained from the Spring and Fall of 1994 and 1995 indicated that the water of Horse Lick Creek was in the Excellent, Good, and Good-Fair water quality classes (Table III). The Spring 1994 values were all in the Excellent category with the exception of sites 4 and 9, which were in the Good water quality class. The values for sites 4 and 9 were very close to being in the Excellent category (Excellent is <4.17) and their higher values could be attributed to dominance by one or more "tolerant" taxa. The most dominant taxon of site 4 was Polypedilum sp. which comprised 11.4% of the taxa and it had a "Fair" tolerance value of 6.67. Site 9 was dominated by Baetidae, comprising 42% and having a "Good" tolerance value of 5.04. The high relative abundance of these "tolerant" taxa might have increased the HBI values for those sites.

The Fall HBI 1994 values placed sites 1, 3, 4, 5, and 9 in the Excellent water quality class, site 8 in the Good water quality class, and sites 2, 5, and 7 in the Good-Fair water quality class. Again, dominance by selected taxa might have raised HBI values. Sites 2, 5, 7, and 8 were dominated by Polypedilum sp. which comprised 40.0%, 39.8%, 45.4%, and 37.2%, respectively. Also, sites 5, 7, and 8 all had unpaved roads crossing the stream, which might have led to increased sedimentation of the stream bed and caused the intolerant taxa to drift to more suitable habitat (Eaglin and Hubert 1993).

TABLE III

MODIFIED HILSENHOFF BIOTIC INDEX (HBI) VALUES AND WATER QUALITY CLASS RATINGS BY THE SPRING AND FALL OF 1994 AND 1995 COLLECTIONS. EX. = EXCELLENT AND G/F = GOOD-FAIR WATER QUALITY CLASSES.

SAMPLING PERIOD	SITE NUMBER								
	1	2	3	4	5	6	7	8	9
Spring 1994	3.19 EX.	3.15 EX.	3.68 EX.	4.23 GOOD	3.93 EX.	4.11 EX.	3.64 EX.	3.96 EX.	4.20 GOOD
Fall 1994	3.55 EX.	5.93 G/F	3.35 EX.	3.90 EX.	5.45 G/F	3.79 EX.	5.33 G/F	5.04 GOOD	3.20 EX.
Spring 1995	4.99 GOOD	5.00 GOOD	4.42 GOOD	4.51 GOOD	4.84 GOOD	5.03 GOOD	4.08 EX.	4.48 GOOD	3.39 EX.
Fall 1995	3.42 EX.	3.88 EX.	3.42 EX.	3.52 EX.	4.54 GOOD	3.44 EX.	4.57 GOOD	4.59 GOOD	3.43 EX.

The HBI values for the Spring of 1995 were all in the Good water quality class with the exception of sites 7 and 9 which were in the Excellent water quality class. The sites with "Good" water quality all were highly dominated by the "tolerant" midge, Polypedilum sp., with dominance ranging from 25.5% to 46.2%. The midge was not dominant at sites 7 and 9. Site 7 for the Spring 1995 period also had a very low number of individuals and taxa due to heavy rains that washed out the sampled riffle (Appendix D). The high water flow might have washed away the most dominant taxa groups leading to a inaccurate "Excellent" water quality class assignment.

The Fall 1995 values were mostly in the Excellent water quality class with the exception of sites 5, 7, and 8. Sites 7 and 8 were dominated by Polypedilum sp. which comprised 23.8% and 20.6% of the taxa, respectively. Site 5 was not dominated by any "tolerant" taxa, but it had a larger number of "tolerant" taxa as a whole which might have been a result of some local, isolated perturbation such as the road crossing and observed heavy off-road vehicle usage.

EPT (Ephemeroptera, Plecoptera, and Trichoptera) Index values for 1994 and 1995 ranged from "Fair" to "Excellent" bioclassification levels (Table IV). These water quality assignments roughly approximated the HBI values for the

Springs of 1994 and 1995, but did not seem to correspond with the HBI values from the Fall collection periods of 1994 and 1995 (Table III). Spring (1994 and 1995) EPT taxa values were higher than Fall values. The seasonal variation could be attributed to life history patterns of the insects.

Good water quality has been associated with high taxa richness (NCDEHNR 1995), but some sites with low EPT taxa richness had low HBI values (Good to Excellent water quality). The small numbers of "intolerant" EPT taxa might have had higher relative abundance leading to lowered HBI values. In most instances, low EPT taxa values correlated with low numbers of distinct taxa for each site (Appendices B, C, D, E). Insect taxa might have been a better indicator of anthropogenic stresses than changes in relative abundance of taxa (Schindler 1987). Therefore, EPT bioclassification values might have given better indication of overall water quality than HBI values which used relative abundance to calculate values.

TABLE IV

EPT INDEX VALUES AND BIOCLASSIFICATION FOR THE SPRING AND FALL COLLECTIONS OF 1994 AND 1995. EX. = EXCELLENT AND G/F = GOOD-FAIR WATER QUALITY CLASSES.

SAMPLING PERIOD	SITE NUMBER								
	1	2	3	4	5	6	7	8	9
SPRING 1994	39 EX.	42 EX.	47 EX.	43 EX.	44 EX.	36 EX.	30 GOOD	30 GOOD	35 GOOD
FALL 1994	18 FAIR	22 G/F	24 G/F	24 G/F	21 G/F	25 G/F	25 G/F	23 G/F	26 G/F
SPRING 1995	26 G/F	29 GOOD	34 GOOD	38 EX.	32 GOOD	31 GOOD	14 FAIR	27 G/F	31 GOOD
FALL 1995	25 G/F	21 G/F	27 G/F	22 G/F	19 G/F	24 G/F	30 GOOD	24 G/F	27 G/F

Shannon-Wiener Diversity Index values for Spring 1994 collections are shown in Table V. Sites 1-7 had a high taxonomic diversity with even distribution and low dominance. Sites 8 and 9 had lower diversity and the taxa were less evenly distributed with greater dominance. The low diversity and evenness at site 9 could have been attributed to the agricultural impacts observed at this site. Nutrient addition from the cattle and the crop fields might have caused certain taxa to increase in relative abundance leading to higher dominance.

Diversity values could also have been correlated with water quality. Clean water streams have values that range from 2.68 to 4.00, while polluted streams have diversity values that range from 0.42 to 1.60 (Wilhm 1970). Sites 3 and 4 had diversity values that indicated clean water. Sites 1, 2, 5, 6, and 7 had values lower than 2.68, but well above the upper limit of polluted streams. Sites 8 and 9 had the lowest diversity values, but they were higher than that characteristic of polluted streams.

TABLE V

SHANNON-WIENER DIVERSITY INDEX (H') AND EVENNESS (J) ANALYSES FOR SPRING 1994 COLLECTIONS.

METRIC	SITE NUMBER								
	1	2	3	4	5	6	7	8	9
H'	2.55	2.55	2.78	2.77	2.59	2.30	2.43	2.06	1.90
J	0.74	0.69	0.71	0.72	0.71	0.70	0.70	0.59	0.50

The Shannon-Wiener Diversity Index and Evenness values for Fall 1994 collections are shown in Table VI. Sites 1, 3, 4 and 9 had values indicating high taxonomic diversity. Sites 2, 5, 6, 7, and 8 had values indicating lower taxonomic diversity. The lower values at sites 5, 6, 7, and 8 might have been caused by the road crossings at these sites. Site 6 with a concrete road crossing had a higher value of 2.38. The cement road crossing might have reduced sedimentation of the riffle at site 6 and contributed to an increase in diversity.

Sites 1, 3 and 4 during the Fall of 1994 had diversity values that indicated a clean water stream (Wilhm 1970). The diversity value at site 9 (2.59) was not far below that of clean water streams (>2.68). Sites 2, 5, 6, 7 and 8 had diversity values that were below that of clean water streams but above that of polluted waters.

Evenness values for all sites during the Fall 1994 period showed a fairly evenly distributed community with low dominance. The lower evenness values were observed at sites 2, 5, 6, 7, and 8, attributable to road crossings, with the exception of site 2 where there was no road crossing. The low diversity and evenness values at site 2 might have been caused by the location of the riffle between a long, wide, slow-flowing run and low water levels. The combination of the two physical features might have reduced dissolved oxygen content and lowered diversity.

TABLE VI

SHANNON-WIENER DIVERSITY INDEX (H') AND EVENNESS (J) ANALYSES FOR FALL 1994 COLLECTIONS.

METRIC	SITE NUMBER								
	1	2	3	4	5	6	7	8	9
H'	3.55	2.10	2.71	2.68	1.96	2.38	2.24	2.04	2.59
J	0.76	0.61	0.77	0.82	0.67	0.69	0.74	0.70	0.71

Shannon-Wiener Diversity and Evenness values for Spring 1995 collections are shown in Table VII. Diversity values were highest at sites 2, 3, 4 and 9 and indicated aclean water system (Wilhm 1970). At sites 1, 5, 6, 7 and 8, diversity values were lower but were well above the values that indicated polluted water (<1.60).

The lower diversity values at sites 5, 6, 7 and 8 were probably caused by the road crossings at those sites. The lower values at site 1 might have been caused by logging next to the White Oak Creek tributary which joins Horse Lick Creek just upstream of site 1. Logging could have added to the sediment load of the stream and reduced habitat leading to lower diversity (Corn and Bury 1989).

Evenness values were highest at sites 2, 3, 4, 7 and 9. Site 7 had lower diversity of taxa with higher evenness and low dominance. These values might have been attributable to the high water which washed out the riffle during this collection period.

TABLE VII

SHANNON-WIENER DIVERSITY INDEX (H′) AND EVENNESS (J) ANALYSES FOR SPRING 1995 COLLECTIONS.

METRIC	SITE NUMBER								
	1	2	3	4	5	6	7	8	9
H′	2.25	2.83	2.70	2.94	2.31	2.39	2.17	2.10	3.20
J	0.66	0.77	0.72	0.75	0.64	0.67	0.89	0.59	0.79

Both the Shannon-Wiener Diversity and Evenness values indicated high water quality for the Fall 1995 collection period (Table VIII). Only three diversity values (sites 1, 3 and 8) were below those that indicated clean water streams (Wilhm 1970). Evenness values showed that all sites exhibited even distribution of organisms with low dominance.

TABLE VIII

SHANNON-WIENER DIVERSITY INDEX (H') AND EVENNESS (J) ANALYSES FOR FALL 1995 COLLECTIONS.

METRIC	SITE NUMBER								
	1	2	3	4	5	6	7	8	9
H'	2.48	3.10	2.66	2.79	2.87	2.85	2.79	2.43	2.91
J	0.74	0.79	0.69	0.75	0.79	0.75	0.72	0.67	0.76

Functional feeding group composition for each of the nine sites for Spring 1994 collections are shown in Figure 2. The community at each site was divided into five different functional feeding groups (predators, scrapers, collectors, filter feeders, and shredders). The collector and filter feeder groups were subdivisions of the collector group as used in the RCC (Vannote et al. 1980). The functional feeding group composition showed longitudinal trends in community composition as expected using the RCC (Vannote et al. 1980). The relative abundance of filter feeders and collectors increased downstream, but these groups were more abundant at site 9 than in subsequent downstream sites. Nutrient addition from the adjacent cattle pasture and agricultural fields might have led to an increase in filter feeders at this site.

Scrapers were dominant at sites 6, 7, and 8 which was expected for mid-sized reaches (Vannote et al. 1980). Also, the relative abundance of scrapers might have been elevated due to seasonal variation. More light could reach the stream in the spring when the canopy was not as thick, resulting in more algal growth and greater abundance of scrapers to use that food source. Shredders were also in low relative abundance because of seasonal variation.

Functional feeding group compositions for Fall 1994 collections are shown in Figure 3. Longitudinal trends in community composition were seen at all sites. The relative abundance of collectors and filter feeders increased downstream. However, mid-sized reaches were supposed to be dominated by scrapers, but were instead dominated by collectors and filter feeders at most sites. This community composition might have been due to seasonal variation. Scrapers were dominant at site 9 because the reduced canopy might have increased algal growth. Shredders had greater relative abundance at sites 2 and 8, though they were not dominant. Site 9 showed lower relative abundance of

Figure 2. Functional Feeding Group Composition for Spring 1994 Collections.

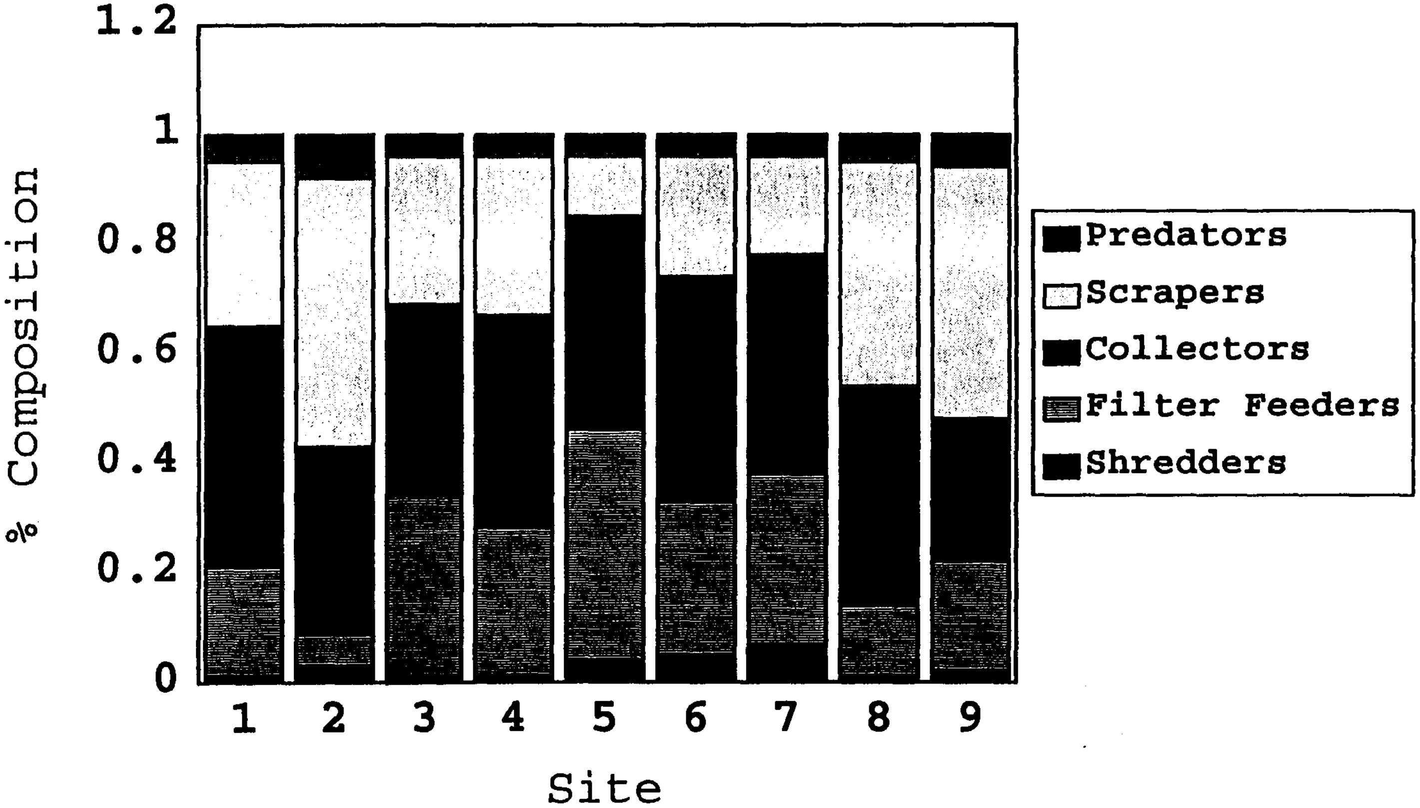


Figure 3. Functional Feeding Group Compositions for Fall 1994 Collections.

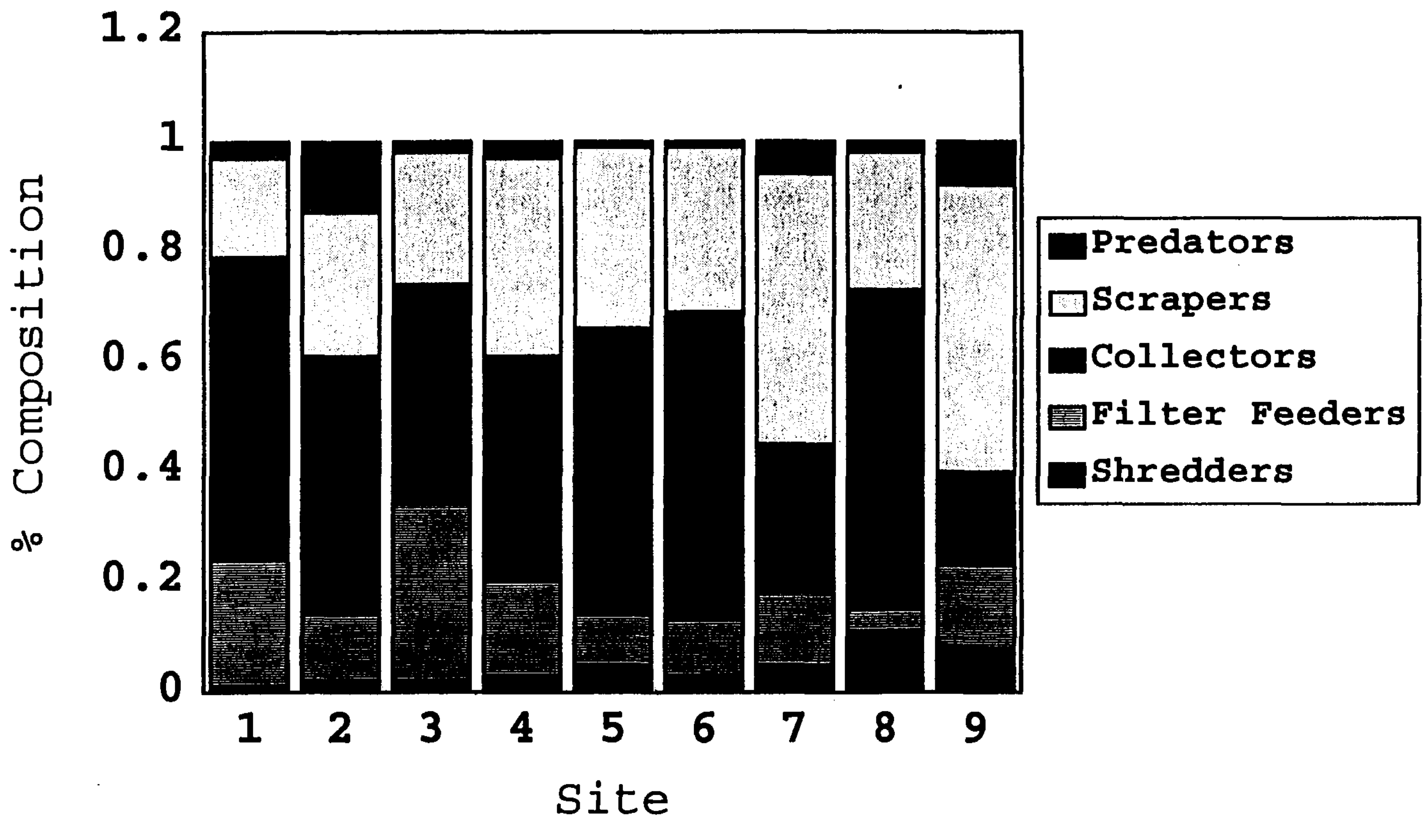


Figure 4. Functional Feeding Group Composition for Spring 1995 Collections.

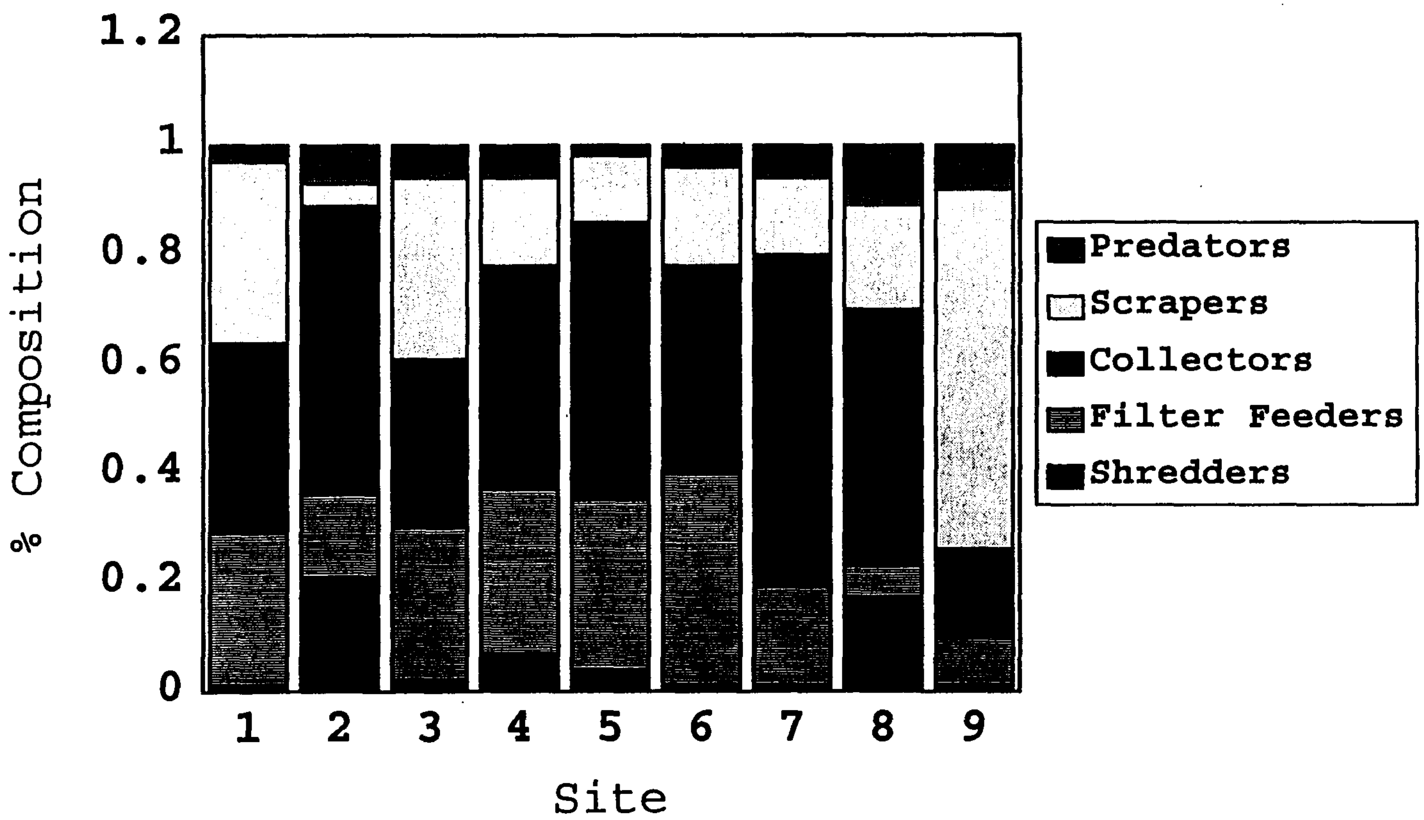
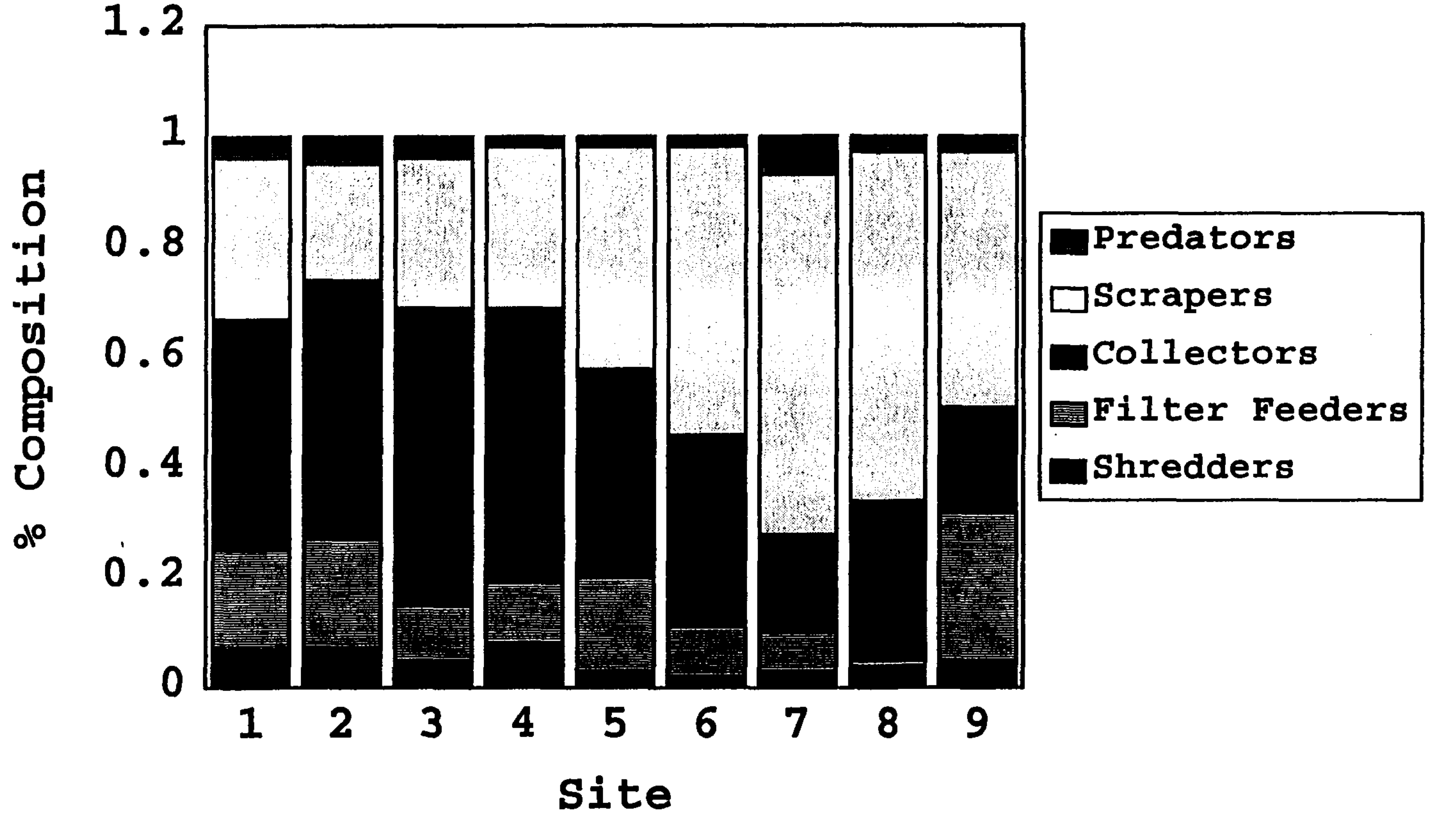


Figure 5. Functional Feeding Group Composition for Fall 1995 Collections.



collectors and filter feeders during the Fall of 1994 than the Spring of that year.

Functional feeding group composition for Spring 1995 showed longitudinal trends in community composition (Figure 4). Collectors and filter feeder abundance increased downstream and scraper abundance decreased. Shredder abundance also decreased downstream. Site 9 had lower relative abundance of collectors and filter feeders than what was found in the Spring of 1994. This observation might have been a result of sampling time variation and changes in life history stages of macroinvertebrates.

Functional feeding group compositions for Fall 1995 collections are shown in Figure 5. Longitudinal trends in community composition were seen with the exception of one site. The relative abundance of collectors and filter feeders increased downstream and the relative abundance of scrapers decreased. Site 8 had a lower relative abundance of collectors and filter feeders and was dominated by scrapers. Shredder abundance was low at all nine sites.

Proportional (%) community similarity for Spring 1994 collections showed longitudinal trends in community composition (Table IX). However, the community composition of site 9 showed greater similarity for sites further downstream. This might have been a result of nutrient addition which increased the collector and filter feeder groups and caused the community composition of site 9 to shift to one more akin to a larger downstream site. Site 2 also showed a dip in community similarity. It was expected that the sites closest together would be more similar and those furthest apart would be more dissimilar. This was the case for most sites; however, site 1 was more similar to sites furthest upstream than to site 2, which was physically closer to those sites. Site 2 might have shown more dissimilarity to other sites because of the location of the riffle.

Community composition at each site might have been affected by current velocity, substratum particle size, temperature, food availability, silt, or detritus (Rabeni and Minshall 1977; Andrews and Minshall 1979; Lamberti and Resh 1979). These physical variables were not constant at each site, which could have led to differences in community composition.

TABLE IX

PROPORTIONAL (%) COMMUNITY SIMILARITY ANALYSES FOR SPRING 1994 COLLECTIONS.

SITE	1	2	3	4	5	6	7	8
2	74.9	----	----	----	----	----	----	----
3	69.3	65.7	----	----	----	----	----	----
4	63.3	57.7	70.3	----	----	----	----	----
5	55.0	49.6	53.2	68.0	----	----	----	----
6	47.8	41.9	49.3	62.6	69.5	----	----	----
7	38.8	35.4	39.0	43.3	51.2	57.5	----	----
8	40.0	36.2	44.9	55.3	61.7	64.2	66.6	----
9	43.9	43.2	44.3	49.8	51.3	59.2	59.8	67.0

Proportional (%) community similarity values for Fall 1994 collections did not show any distinct longitudinal trends in community composition. Sites 2, 5, 7 and 8 were most similar to each other and most dissimilar to other sites. With the exception of site 2, this similarity might have been caused by unpaved road crossings at sites 5, 7 and 8. The similarity of site 2 to other impacted sites might have been caused by the location of the riffle at site 2.

TABLE X

PROPORTIONAL (%) COMMUNITY SIMILARITY ANALYSES FOR FALL 1994 COLLECTIONS.

SITE	1	2	3	4	5	6	7	8
2	17.6	----	----	----	----	----	----	----
3	65.0	17.9	----	----	----	----	----	----
4	46.6	22.5	55.0	----	----	----	----	----
5	21.7	54.2	21.2	27.6	----	----	----	----
6	44.2	29.9	62.0	45.4	32.4	----	----	----
7	17.1	12.9	15.8	18.7	56.7	32.2	----	----
8	16.4	50.4	13.0	14.0	48.5	28.1	60.6	----
9	34.7	16.2	32.5	19.0	13.1	33.7	25.9	27.6

Proportional (%) community similarity analyses for Spring 1995 collections showed no distinct longitudinal trends in community composition (Table XI). Sites 3 and 4 were the most similar to each other (79.3%), and sites 1 and 9 were the most dissimilar (33.1%). Site 7 showed the overall most dissimilarity to other sites. This was probably caused by the destruction of the riffle area due to high water levels and swift currents during sampling at this site.

TABLE XI

PROPORTIONAL (%) COMMUNITY SIMILARITY ANALYSES FOR SPRING 1995 COLLECTIONS.

SITE	1	2	3	4	5	6	7	8
2	61.0	----	----	----	----	----	----	----
3	66.2	59.4	----	----	----	----	----	----
4	56.9	56.8	79.3	----	----	----	----	----
5	59.0	54.6	61.6	64.7	----	----	----	----
6	68.4	57.0	65.7	69.7	75.4	----	----	----
7	33.9	29.5	29.0	36.1	32.1	31.0	----	----
8	59.0	49.8	49.8	49.6	64.4	64.4	39.6	----
9	33.1	33.5	42.3	51.9	35.0	38.9	40.2	41.9

Proportional (%) community similarity analyses for Fall 1995 collections exhibited no distinct longitudinal trends in community composition (Table XII). Sites 3 and 4 were the most similar to one another (76.3%), and sites 5 and 9 were the most dissimilar (25.0%). The most dissimilarities were seen at sites 5, 7 and 8 where road crossings were present. The presence of road crossings at site 6 and between sites 3 and 4 did not seem to have an affect on the similarity values because site 6 had a concrete road crossing and the substrate of the crossing between sites 3

TABLE XII

PROPORTIONAL (%) COMMUNITY SIMILARITY ANALYSES FOR FALL 1995 COLLECTIONS.

SITE	1	2	3	4	5	6	7	8
2	46.1	----	----	----	----	----	----	----
3	65.1	43.2	----	----	----	----	----	----
4	61.6	49.6	76.3	----	----	----	----	----
5	32.7	28.3	44.1	46.4	----	----	----	----
6	46.1	34.2	65.1	66.8	40.0	----	----	----
7	32.8	31.6	37.4	44.6	42.3	54.3	----	----
8	38.3	39.5	34.6	39.2	30.9	44.7	67.3	----
9	41.9	41.3	44.1	42.8	25.0	45.5	43.1	53.1

and 4 was bedrock. These types of road crossings could have resulted in a reduced sedimentation load downstream of these crossings, compared to crossings with gravel and cobble substrates.

Jaccard's coefficient of community (CCj) was used to measure community similarity of qualitative data between sites. Analyses for Spring 1994 collections showed longitudinal trends in community composition (Table XIII). The macroinvertebrate community at site 9 was slightly more similar to downstream sites than adjacent upstream sites (sites 6 and 7). Again, increased nutrient input from cattle adjacent to the site increased collector and filter feeder functional feeding groups which could have caused the macroinvertebrate community at site 9 to be more similar to communities found further downstream.

The Jaccard coefficient of Community (CCj) showed few longitudinal trends in community composition for Fall 1994, Spring 1995, and Fall 1995 collections (Tables XIV, XV, and XVI). For the Fall of 1994, qualitative data (CCj) showed more similarity among sites than did semi-quantitative data (Proportional community similarity). There was also more of an indication of longitudinal trends in Jaccard's analyses than there were seen in the proportional community similarity analyses. This indicated that the communities might have been more similar in taxonomic composition, but not in relative abundances of those taxa.

TABLE XIII

JACCARD COEFFICIENT OF COMMUNITY (CCj) ANALYSES FOR SPRING 1994 COLLECTIONS.

SITE	1	2	3	4	5	6	7	8
2	0.58	----	----	----	----	----	----	----
3	0.47	0.48	----	----	----	----	----	----
4	0.45	0.54	0.52	----	----	----	----	----
5	0.40	0.42	0.50	0.49	----	----	----	----
6	0.40	0.42	0.49	0.49	0.55	----	----	----
7	0.35	0.33	0.41	0.39	0.49	0.44	----	----
8	0.34	0.36	0.38	0.45	0.53	0.43	0.42	----
9	0.35	0.40	0.40	0.43	0.55	0.47	0.41	0.55

TABLE XIV

JACCARD COEFFICIENT OF COMMUNITY (CCj) ANALYSES FOR FALL 1994 COLLECTIONS.

SITE	1	2	3	4	5	6	7	8
2	0.43	----	----	----	----	----	----	----
3	0.45	0.43	----	----	----	----	----	----
4	0.32	0.37	0.44	----	----	----	----	----
5	0.36	0.37	0.51	0.39	----	----	----	----
6	0.38	0.43	0.45	0.36	0.43	----	----	----
7	0.32	0.37	0.39	0.37	0.40	0.52	----	----
8	0.28	0.32	0.30	0.26	0.34	0.39	0.50	----
9	0.34	0.31	0.35	0.36	0.36	0.41	0.43	0.41

TABLE XV

JACCARD COEFFICIENT OF COMMUNITY (CCj) ANALYSES FOR SPRING 1995 COLLECTIONS.

SITE	1	2	3	4	5	6	7	8
2	0.44	----	----	----	----	----	----	----
3	0.49	0.42	----	----	----	----	----	----
4	0.48	0.42	0.59	----	----	----	----	----
5	0.49	0.41	0.51	0.56	----	----	----	----
6	0.47	0.35	0.51	0.55	0.56	----	----	----
7	0.30	0.26	0.25	0.32	0.31	0.32	----	----
8	0.35	0.34	0.38	0.38	0.37	0.40	0.36	----
9	0.32	0.37	0.41	0.50	0.39	0.39	0.28	0.45

TABLE XVI

JACCARD COEFFICIENT OF COMMUNITY (CCj) ANALYSES FOR FALL 1995 COLLECTIONS.

SITE	1	2	3	4	5	6	7	8
2	0.40	----	----	----	----	----	----	----
3	0.51	0.51	----	----	----	----	----	----
4	0.47	0.45	0.64	----	----	----	----	----
5	0.41	0.46	0.47	0.51	----	----	----	----
6	0.33	0.34	0.46	0.43	0.43	----	----	----
7	0.36	0.33	0.40	0.47	0.43	0.42	----	----
8	0.40	0.40	0.47	0.45	0.46	0.44	0.54	----
9	0.42	0.40	0.50	0.45	0.41	0.45	0.46	0.55

CHAPTER V

SUMMARY AND CONCLUSIONS

The purpose of this study was to assess the existing water quality of the Horse Lick Creek World Bioreserve. It was the first intensive study which surveyed the aquatic macroinvertebrates in the Horse Lick Creek drainage and which could provid baseline data for future assessment studies conducted.

The modified Hilsenhoff Biotic Index (HBI), EPT (Ephemeroptera, Plecoptera, and Trichoptera) Index, and taxa richness parameters indicated that Horse Lick Creek was in the Good water quality category for both the Spring and Fall of 1994 and 1995. Water quality classifications and EPT values were generally higher in the Spring than in the Fall due to seasonal variation in taxa life cycles and lower taxa richness.

Shannon-Wiener Diversity (H') and Evenness (J) values showed high diversity, indicated a clean water stream, and very even distribution of organisms with low dominance. Lower diversity and evenness were characteristic of sites with road crossings (sites 5, 6, 7 and 8). Low diversity and evenness were also obtained at site 9 during the Spring of 1994.

Functional feeding group composition supported the hypothetical predictions of the River Continuum Model. Longitudinal trends in community composition were seen for all four sampling events with collectors and filter feeders increasing in relative abundance downstream, while scrapers decreased in relative abundance. The relative abundance of shredders was low for all collections. These findings fit the predictive model of a mid-sized river (4^{th} through 6^{th} order). The community composition of site 9 (3^{rd} order) resembled a larger order stream as the collector and filter feeder group were in higher abundance than expected in the Spring of 1994. The scraper functional feeding group was higher in relative abundance for the Fall of 1994 and the Spring and Fall of 1995 due to agriculture. The banks were cleared of vegetation from the cattle trampling the vegetation. This resulted in reduced canopy cover which increased algal growth because more light was able to reach the stream.

Proportional (%) Community Similarity values exhibited longitudinal trends in community composition for the Spring of 1994. Site 9 was characteristic of a further downstream site. Values obtained for the Fall of 1994 and the Spring and Fall of 1995 showed no distinct longitudinal trends in community composition. Sites with road crossings of gravel and cobble substrate showed the most dissimilarity (sites 5, 7 and 8).

The Jaccard Coefficient of Community (CCj) illustrated definite longitudinal trends in community composition for the Spring of 1994. This analysis also indicated that site 9 was more characteristic of a downstream site as a result of nutrient addition by cattle. Greater longitudinal trends in community composition (albeit slight) were seen for the Fall of 1994 and the Spring and Fall of 1995 using CCj than were seen in the Proportional Community Similarity analyses. Since Jaccards Coefficient measures qualitative taxa richness and Proportional Community Similarity measured quantitative relative abundance of taxa, it was determined that the sites were more similar taxonomically than in percent composition.

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APPENDIX A.

COMPREHENSIVE TAXA LIST OF MACROINVERTEBRATES COLLECTED IN HORSE LICK CREEK DURING THE SPRING AND FALL OF 1994 AND 1995. DISTINCT TAXA ARE DENOTED BY AN ATERISK (*).

Porifera
 Spongillidae
  *Spongilla sp.
Platyhelminthes
 *Turbellaria
***Nematoda**
Rhyncocoela
 *Prostoma sp.
Mollusca
 Gastropoda
  Pulmonata
   Ancylidae
    *Ferrissia sp.
   Physidae
    *Physa sp.
   Planorbidae
    *Gyraulus sp.
    *Helisoma anceps (Menke)
  Prosobranchia
   Pleuroceridae
    *Elimia sp.
   Viviparidae
    *Campeloma sp.
 Pelecypoda
  Corbiculacea
   Corbiculidae
    *Corbicula fluminea (Müller)
   Sphaeriidae
    *Sphaerium sp.
Annelida
 *Oligochaeta
 Hirudinea
  Glossiphoniidae
   *Helobdella sp.
  *Erpobdellidae
Arthropoda
 *Hydrachnidia
 Crustacea
  Amphipoda

*<u>Gammarus</u> sp.
Decapoda
Cambaridae
*<u>Cambarus</u> sp.
*<u>Orconectes</u> sp.
Isopoda
*<u>Lirceus</u> sp.
Insecta
*Collembola
Ephemeroptera
*Baetidae
*<u>Paracloeodes</u> sp.
Baetiscidae
*<u>Baetisca</u> sp.
Caenidae
*<u>Brachycercus</u> sp.
*<u>Caenis</u> sp.
Ephemerellidae
<u>Attenella</u> sp.
*<u>Attenella</u> <u>attenuata</u> (McDunnough)
<u>Drunella</u> sp.
*<u>Drunella</u> <u>cornutella</u> (McDunnough)
*<u>Ephemerella</u> spp.
*<u>Ephemerella</u> <u>needhami</u> McDunnough
*<u>Eurylophella</u> spp.
*<u>Serratella</u> sp.
<u>Timpanoga</u> sp.
*<u>Timpanoga</u> <u>lita</u> (Burks)
*<u>Timpanoga</u> <u>simplex</u> (McDunnough)
Ephemeridae
*<u>Ephemera</u> sp.
*<u>Hexagenia</u> sp.
Heptageniidae
*<u>Cinygmula</u> <u>subaequalis</u> (Banks)
*<u>Epeorus</u> sp.
*<u>Heptagenia</u> sp.
*<u>Leucrocuta</u> sp.
*<u>Nixe</u> sp.
<u>Stenonema</u> sp.
*<u>Stenonema</u> <u>carlsoni</u> Lewis
*<u>Stenonema</u> <u>femoratum</u> (Say)
*<u>Stenonema</u> <u>mediopunctatum</u> (McDunnough)
*<u>Stenonema</u> <u>modestum</u> (Banks)
*<u>Stenonema</u> <u>pudicum</u> (Hagen)
*<u>Stenonema</u> <u>pulchellum</u> (Walsh)
*<u>Stenonema</u> <u>terminatum</u> (Walsh)
*<u>Stenonema</u> <u>vicarium</u> (Walker)
<u>Stenacron</u> sp.
*<u>Stenacron</u> <u>interpunctatum</u> (Say)
Isonychiidae
*<u>Isonychia</u> sp.

Leptohyphidae
*Tricorythodes sp.
Leptophlebiidae
*Leptophlebia sp.
Paraleptophlebia sp.
*Paraleptophlebia guttata (McDunnough)
Odonata
Aeshnidae
*Basiaeschna janata (Say)
*Boyeria grafiana Williamson
*Boyeria vinosa (Say)
Calopterygidae
*Calopteryx sp.
*Calopteryx dimidiata Burmeister
Coenagrionidae
*Amphiagrion sp.
*Argia sp.
Cordulegastridae
*Cordulegaster sp.
Corduliidae
Macromiinae
*Macromia sp.
*Neurocordulia sp.
Gomphidae
*Arigomphus sp.
Dromogomphus sp.
*Dromogomphus spinosus Selys
*Gomphus sp.
*Gomphus cavillaris Needham
*Hagenius brevistylus Selys
*Lanthus sp.
*Stylogomphus albistylus (Hagen)
Libellulidae
*Perithemis sp.
Plecoptera
*Capniidae
Chloroperlidae
*Alloperla sp.
*Haploperla sp.
*Suwallia marginata (Banks)
*Sweltsa sp.
Leuctridae
*Leuctra sp.
Nemouridae
Amphinemura sp.
*Amphinemura delosa (Ricker)
Peltoperlidae
*Peltoperla sp.
*Tallaperla sp.
Perlidae
*Acroneuria sp.

*Agnetina sp.
*Attaneuria ruralis (Hagen)
*Beloneuria sp.
*Eccoptura xanthenes (Newman)
*Neoperla sp.
*Perlesta sp.
Perlodidae
*Isoperla sp.
Pteronarcyidae
*Pteronarcys sp.
Taeniopterygidae
*Taeniopteryx sp.
Heteroptera
*Corixidae
Gerridae
*Aquarius sp.
*Gerris sp.
*Rheumatobates sp.
*Metrobates sp.
*Trepobates sp.
Hebridae
*Hebrus sp.
Hydrometridae
*Hydrometra sp.
Nepidae
*Ranatra sp.
Notonectidae
*Notonecta sp.
*Saldidae
Veliidae
*Microvelia sp.
*Rhagovelia sp.
*Veliinae
Megaloptera
Corydalidae
*Corydalus cornutus (Linnaeus)
*Nigronia serricornis (Say)
Sialidae
*Sialis sp.
Trichoptera
Calamoceratidae
*Anisocentropus pyraloides (Walker)
Glossosomatidae
Agapetus sp.
*Agapetus illini Ross
Glossosoma sp.
*Glossosoma nigrior Banks
*Protoptila sp.
*Goeridae
*Goera sp.
Helicopsychidae

Helicopsyche borealis (Hagen)
Hydroptilidae
Hydroptila sp.
Ochrotrichia sp.
Hydropsychidae
Ceratopsyche sp.
Ceratopsyche cheilonis (Ross)
Ceratopsyche sparna (Ross)
Cheumatopsyche sp.
Diplectrona modesta Banks
Hydropsyche sp.
Hydropsyche betteni Ross
Hydropsyche frisoni Ross
Parapsyche sp.
Lepidostomatidae
Lepidostoma sp.
Leptoceridae
Ceraclea sp.
Ceraclea flava (Banks)
Mystacides sepulchralis (Walker)
Oecetis sp.
Oecetis persimilis (Banks)
Triaenodes sp.
Limnephilidae
Ironoquia sp.
Pycnopsyche sp.
Odontoceridae
Psilotreta sp.
Philopotamidae
Chimarra sp.
Chimarra aterrima Hagen
Dolophilodes distinctus (Walker)
Wormaldia sp.
Phryganeidae
Ptilostomis sp.
Polycentropodidae
Cernotina sp.
Cyrnellus fraternus (Banks)
Neureclipsis sp.
Paranyctiophylax sp.
Phylocentropus sp.
Polycentropus sp.
Psychomyiidae
Lype diversa (Banks)
Psychomyia flavida Hagen
Rhyacophilidae
Rhyacophila sp.
Rhyacophila ledra Ross
Uenoidae
Neophylax sp.
Lepidoptera

*Pyralidae
*Petrophila fulicalis (Clemens)
*Paraponyx sp.
Coleoptera
*Carabidae
*Chrysomelidae
*Curculionidae
Dryopidae
*Helichus basalis LeConte
*Helichus lithophilus (Germar)
*Dytiscidae
Elmidae
*Ancyronyx variegata (Germar)
Dubiraphia sp.
*Dubiraphia quadrinotata (Say)
*Dubiraphia vittata (Melsheimer)
*Macronychus glabratus Say
*Microcylloepus pusillus (LeConte)
Optioservus sp.
*Optioservus ovalis (LeConte)
*Optioservus trivittatus (Brown)
*Oulimnius latiusculus (LeConte)
*Stenelmis sp.
Gyrinidae
*Dineutus sp.
*Gyrinus sp.
Haliplidae
*Peltodytes sp.
*Heteroceridae
Hydraenidae
*Ochthebius sp.
Hydrophilidae
*Sperchopsis tessellata (Ziegler)
*Tropisternus sp.
Psephenidae
*Ectopria sp.
*Psephenus herricki (DeKay)
Ptilodactylidae
*Anchytarsus bicolor (Melsheimer)
*Staphylinidae
*Stenus sp.
Diptera
Brachycera
Athericidae
*Atherix sp.
*Dolichopodidae
Empididae
Chelifera/Hemerodromia sp.
*Clinocera sp.
*Hemerodromia sp.
*Ephydridae

Stratiomyidae
*Stratiomys sp.
Tabanidae
*Chrysops sp.
*Tabanus sp.
Nematocera
Blephariceridae
*Blepharicera sp.
*Ceratopogonidae
Chironomidae
Tanypodinae
*Ablablesmyia sp.
*Clinotanypus sp.
*Nilotanypus sp.
*Procladius sp.
*Thienemannimyia gr.
Orthocladiinae
*Brillia sp.
*Cardiocladius sp.
*Corynoneura sp.
*Cricotopus/Orthocladius sp.
*Eukiefferiella/Tvetenia sp.
*Krenosmittia sp.
*Nanocladius sp.
*Parachaetocladius sp.
*Parakiefferiella sp.
*Parametriocnemus sp.
*Pseudorthocladius sp.
*Rheocricotopus sp.
*Synorthocladius sp.
*Thienemanniella sp.
Chironominae
*Chironomus sp.
*Cladotanytarsus sp.
*Cryptochironomus sp.
*Dicrotendipes sp.
*Micropsectra sp.
*Microtendipes sp.
*Microtendipes pedellus gr.
*Paracladopelma sp.
*Paralauterborniella sp.
*Paratendipes sp.
*Phaenopsectra sp.
*Polypedilum sp.
*Pseudochironomus sp.
*Rheotanytarsus sp.
*Stempellina sp.
*Stenochironomus sp.
*Stictochironomus sp.
*Sublettea sp.
*Tanytarsus sp.

Tribelos sp.
Culicidae
Anopheles sp.
Dixidae
Dixella sp.
Simuliidae
Prosimulium sp.
Simulium sp.
Tanyderidae
Protoplasa fitchii Osten Sacken
Tipulidae
Antocha sp.
Dicranota sp.
Helius sp.
Hexatoma sp.
Limnophila sp.
Molophilus sp.
Ormosia sp.
Pilaria sp.
Pseudolimnophila sp.
Tipula sp.

APPENDIX B.

COMPREHENSIVE LIST OF ALL MACROINVERTEBRATES COLLECTED IN HORSE LICK CREEK AT THE NINE SITES DURING MAY 1994. ORGANISMS COLLECTED ONLY IN THE QUALITATIVE SAMPLES ARE DENOTED BY AN X.

	SITE NUMBER								
TAXA	1	2	3	4	5	6	7	8	9
Rhyncocoela									
Prostoma sp.	7	43							
Nematoda	X	X	X		1	X	1		
Oligochaeta	17	9	9	132	10		2	4	1
Gastropoda									
Pulmonata									
Physidae									
Physa sp.									X
Planorbidae									
Gyraulus sp.		1	1						
Prosobranchia									
Pleuroceridae									
Elimia sp.	31	7	11	5	3	11	6	7	22
Pelecypoda									
Corbiculidae									
Corbicula fluminea	1	2	2	1	3				
Crustacea									
Amphipoda									
Gammarus sp.							2		
Decapoda									
Cambaridae	1	X		4			1		
Cambarus sp.					X	1	X		
Orconectes sp.	X		3		X		X	X	X
Isopoda									
Lirceus sp.		5		1	2	X	2	1	1
Insecta									
Ephemeroptera									

Appendix B (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Baetidae	77	170	169	340	432	262	303	653	1447
Baetiscidae									
Baetisca sp.			1	1		X			
Caenidae									
Caenis sp.		7	24	21	2			1	1
Ephemerellidae									
Attenella spp.							1		
Dannella sp.	X								
Dannella lita		X		X	X				
Dannella simplex		X	1						
Drunella sp.	1								
Drunella cornutella	2	1	1	3	6	6			
Ephemerella spp.	186	522	402	378	319	104	55	227	361
Ephemerella needhami	16	65	20	8		1			1
Eurylophella sp.	3	X	1	1	X	X	X	1	1
Serratella sp.		X	1	1	X	X	X		
Ephemeridae									
Ephemera sp.			15	7	1	1	15	1	1
Heptageniidae					1				
Cinygmula subaequalis	24	26	11	59	88	25	10		2
Epeorus sp.		2		1	2	2	X	2	17
Heptagenia sp.	2	X	4	1					
Leucrocuta sp.	2	3	3			X		110	13
Stenonema sp.	4	4	8	14	21	5	4	12	
Stenonema carlsoni	X	X							
Stenonema femoratum	1		1		1	2	1		
Stenonema mediopunctatum	2	9	20	16	27	10	2	9	9
Stenonema modestum				2					
Stenonema pudicum			1		4		2	1	
Stenonema pulchellum			1		1	X			

Appendix B (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Stenonema terminatum			2		12				
Stenonema vicarium	7	21	21	20	19	6		1	
Stenacron sp.			2		X				X
Isonychiidae									
Isonychia spp.	57	109	29	42	99	27	24	1	11
Leptophlebiidae									
Leptophlebia sp.					X				
Paraleptophlebia guttata	2		4	23	10	10	X	11	62
Odonata									
Aeshnidae									
Boyeria vinosa	X	X	X	1	X	X	X		X
Calopterygidae									
Calopteryx sp.				X	X		X	X	X
Calopteryx dimidiata	X	X	X						
Cordulegastridae									
Cordulegaster sp.				X		X			
Corduliidae									
Macromia sp.	X	X		X					
Gomphidae									
Dromogomphus sp.					X				
Dromogomphus spinosus		X							
Gomphus sp.			3						
Gomphus cavillaris	X								
Lanthus sp.					2			1	1
Stylogomphus albistylus	1			1					X
Plecoptera									
Chloroperlidae				2	4	1		5	12
Haploperla sp.			2						
Suwallia sp.					1				
Leuctridae				2	37	7	10	48	15

Appendix B (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Leuctra sp.	3	8		23	3			5	1
Nemouridae									
Amphinemura sp.	X	X	X		X	X			
Amphinemura delosa	31	99	71	141	19	3	12	4	129
Peltoperlididae			1	1					
Perlidae									
Acroneuria sp.					1	1			8
Attaneuria ruralis	1	X							27
Neoperla sp.						1			
Perlesta sp.					X			X	3
Perlodidae									
Isoperla sp.	2		3		X				1
Pteronarcyidae									
Pteronarcys sp.			1						
Heteroptera									
Corixidae					X				
Gerridae									
Trepobates sp.						X			
Megaloptera									
Corydalidae									
Corydalus cornutus				X		1			
Nigronia serricornis	3	4	3	2	3	1	14	2	5
Sialidae									
Sialis sp.	X	X							
Trichoptera		7	5		10	4	13	6	4
Calamoceratidae									
Anisocentropus sp.							X		
Glossosomatidae	X	7							
Agapetus sp.	23	30	9	60	23	10	64	34	32
Glossosoma sp.				3	7		15	7	10

Appendix B (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Protoptila sp.			9	10	52	3	1		
Helicopsychidae									
Helicopsyche borealis			7						1
Hydroptilidae		1				X			1
Hydroptila sp.	7	7	10	10					
Ochrotrichia sp.		1		24	X				4
Hydropsychidae							1		
Ceratopsyche sp.							1		
Ceratopsyche cheilonis	1	X	3	3	1	1			1
Ceratopsyche sparna	3	1							
Cheumatopsyche sp.	2	5	1	6	2	2	7	6	12
Diplectrona modesta				1					1
Hydropsyche sp.			1		X		X		
Hydropsyche betteni		1							
Hydropsyche frisoni			1	0					
Parapsyche sp.			1						
Goeridae									
Goera sp.			2	1	1		2		
Lepidostomatidae									
Lepidostoma sp.			X						
Leptoceridae		1							
Ceraclea flava	X								
Oecetis sp.		X		1					X
Limnephilidae									
Ironoquia sp.	X		X		X				
Pycnopsyche sp.	X	X	3	X	X	X	X	X	1
Philopotamidae									
Chimarra sp.	X							1	12
Chimarra aterrima		X							
Dolophilodes distinctus		1	2	6	8	4		2	6

Appendix B (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Wormaldia sp.	1	24		1					
Polycentropodidae									
Cernotina sp.					X	X	X		3
Nyctiophylax sp.	X			X					
Paranyctiophylax sp.							X		
Polycentropus sp.	1	X							
Psychomyiidae									
Lype diversa			1			1		X	
Psychomyia flavida	X	X	X		X			X	
Rhyacophilidae									
Rhyacophila sp.	4	X	6	2		2			
Rhyacophila ledra	4	24	3	10	19	6	22	3	22
Ueonidae									
Neophylax sp.	X	X	1	X	X	X	1	X	X
Lepidoptera									
Pyralidae									
Petrophila fulicalis	X	X	1	X	X	1		X	X
Coleoptera									
Chrysomelidae									
Agasicles sp.									X
Dryopidae									
Helichus basalis	X	13	20	14	2	1	X		X
Helichus lithophilus	1	2	14	7	X		X		
Dytiscidae					X		X	X	X
Elmidae									
Dubiraphia vittata		1	16	3					
Macronychus glabratus	X								
Optioservus sp.	1	1	5	16	7	6	7	29	3
Optioservus ovalis		1	2	1				1	1
Optioservus trivittatus		5	10	3	50	4	4	13	8

Appendix B (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Oulimnius latiusculus			1	8					
Stenelmis sp.	1	9	17	17	7	18		6	23
Heteroceridae		1							
Psephenidae									
Ectopria sp.			1				1		2
Psephenus herricki	7	8	41	54	29	108	32	68	14
Staphylinidae									
Stenus sp.	X		X	X	X	X			
Diptera		1		1					
Brachycera									
Athericidae									
Atherix sp.			3		2	1	6		
Empididae									
Chelifera/Hemerodromia sp.			1				1	2	7
Clinocera sp.		1	5	1	1			1	
Hemerodromia sp.	1	1	2	3			1	1	
Stratiomyidae									
Stratiomys sp.				X				1	
Tabanidae									
Chrysops sp.						2		3	
Tabanus sp.			1						
Nematocera									
Blephariceridae									
Blepharicera sp.	2	3	1	1	1	X	26	X	2
Ceratopogonidae	1			8				8	
Chironomidae	2	50	21	23	22	6		12	4
Tanypodinae									
Nilotanypus sp.					X				X
Thienemannimyia gr.				7	2	X		4	10
Orthocladiinae									

Appendix B (CONT.)

	SITE NUMBER								
TAXA	1	2	3	4	5	6	7	8	9
Corynoneura sp.				1	1			1	
Cricotopus/*Orthocladius* sp.	2	15	131	134	6	11		15	16
Eukiefferiella/*Tvetenia* sp.	2	27	8	3			3		
Parametriocnemus sp.	2	14			X		2		1
Pseudorthocladius sp.	1								
Thienemanniella sp.					1			1	3
Chironominae									
Microtendipes sp.						1	1		
Polypedilum sp.	27	5	57	244	209	145	26	108	197
Rheotanytarsus sp.		2						X	
Tanytarsus sp.	X		22	45	146	4	5	21	8
Simuliidae		20	7	8	3	1	11	2	7
Prosimulium sp.	2	3					1		
Simulium sp.	49	142	75	119	45	40	2		876
Tanyderidae									
Protoplasa sp.							2		
Tipulidae		X							
Antocha sp.	X	1			X	X	9	X	
Helius sp.								X	
Hexatoma sp.							3	7	4
Limnophila sp.			2	3			2		1
Molophilus sp.				1					
Ormosia sp.			1						
Pilaria sp.									4
Tipula sp.	X	8	4	4		2			4
TOTAL NUMBER OF INDIVIDUALS	645	1561	1386	2132	1791	869	739	1475	3453
TOTAL NUMBER OF DISTINCT TAXA	73	79	81	81	78	62	61	61	68

APPENDIX C.

COMPREHENSIVE LIST OF ALL MACROINVERTEBRATES COLLECTED IN HORSE LICK CREEK AT THE NINE SITES DURING SEPTEMBER AND OCTOBER 1994. ORGANISMS COLLECTED ONLY IN THE QUALITATIVE SAMPLES ARE DENOTED BY AN X.

	SITE NUMBER								
TAXA	1	2	3	4	5	6	7	8	9
Porifera									
Spongillidae									
Spongilla sp.	X								
Rhyncocoela									
Prostoma sp.	6		1		1				
Turbellaria									1
Oligochaeta	95	5	1		2	1	1		1
Gastropoda									
Pulmonata									
Physidae									
Physa sp.	1	X	X			X		X	1
Planorbidae									
Gyraulus sp.		X		X					
Helisoma anceps				X					
Prosobranchia									
Pleuroceridae									
Elimia sp.	36	2	1	X	X	8	4	9	91
Viviparidae									
Campeloma sp.									X
Pelecypoda									
Corbiculidae									
Corbicula fluminea	5	1	X	X	2	1			
Sphaeriidae									
Sphaerium sp.							X	X	
Crustacea									
Amphipoda									

APPENDIX C (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Gammarus sp.	1					X			
Decapoda									
Cambaridae									
Cambarus sp.		1	1	1					
Orconectes sp.	X	2				2			3
Isopoda									
Lirceus sp.	5								
Insecta									
Ephemeroptera									
Baetidae	39	19	13	1	2	37	17	26	41
Paracloeodes sp.						X			
Baetiscidae									
Baetisca sp.	14		5	4	4				1
Caenidae									
Brachycercus sp.									
Caenis sp.		2		31	3		4	3	1
Ephemerellidae						1			
Attenella spp.		1					X		3
Ephemerella spp.									5
Ephemerella needhami									
Eurylophella sp.			1	2	1				
Serratella sp.									
Ephemeridae									
Ephemera sp.			3	21	3		9		14
Heptageniidae									
Heptagenia sp.			3						
Leucrocuta sp.							1	4	19
Nixe sp.			3	1		1			X
Stenonema sp.	59	16	95	14	X	309	4	5	44

APPENDIX C (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Stenonema femoratum	X			X	1		4	4	1
Stenonema mediopunctatum	42	9	39	7	1	90	1	X	27
Stenonema modestum						23	2		
Stenonema terminatum									
Stenonema vicarium	172	11	89	84	7	73		1	1
Stenacron sp.	X	X	X	4	X	2	4		X
Stenacron interpunctatum							X	X	
Isonychiidae									
Isonychia spp.	185	65	161	90	48	625	1	2	26
Leptohyphidae									
Tricorythodes sp.		1							
Leptophlebiidae									
Paraleptophlebia sp.								2	
Paraleptophlebia guttata			X	1					45
Odonata		X							
Aeshnidae									
Boyeria sp.									1
Boyeria vinosa	X	2	X	1	X			X	1
Calopterygidae									
Calopteryx sp.			X		X				
Calopteryx dimidiata		8	X		1	X	X		
Coenagrionidae									
Amphiagrion sp.	X	X							
Cordulegastridae									
Cordulegaster sp.		X			X	X	X	X	
Corduliidae									
Macromia sp.	X		X						
Neurocordulia sp.	X								
Gomphidae									

APPENDIX C (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Dromogomphus spinosus		X							
Gomphus sp.						X		X	X
Hagenius brevistylus		X							
Lanthus sp.	1			1	1	3			10
Stylogomphus albistylus			X	1		X			X
Plecoptera									
Chloroperlidae									
Alloperla sp.	1								
Sweltsa sp.									4
Leuctridae							3	52	
Nemouridae	12	8							
Perlidae							X		
Acroneuria sp.	4		2		X	3	X	X	35
Neoperla sp.									3
Perlodidae									
Isoperla sp.		68	2	4	X	3	2		
Taeniopterygidae									
Taeniopteryx sp.		7	5		10				
Heteroptera									
Gerridae									
Aquarius sp.							X		
Gerris sp.								X	
Metrobates sp.	X	X	2						
Rheumatobates sp.	1	X							
Trepobates sp.		X			1			X	
Saldidae									1
Veliidae									
Microvelia sp.					X	1		X	2
Rhagovelia sp.					X	5	X	X	1

APPENDIX C (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Megaloptera									
Corydalidae									
Corydalus cornutus	6	4	6			1			
Nigronia serricornis	3	7	3	3		7	2	2	26
Sialidae									
Sialis sp.		X	X	1					
Trichoptera									
Calamoceratidae									
Anisocentropus sp.				X					
Glossosomatidae						X			
Glossosoma sp.					X		1	X	
Helicopsychidae									
Helicopsyche borealis		X	1	X	X	X	X	X	13
Hydropsychidae			2						
Ceratopsyche cheilonis	3	6	11		X	7	X		1
Ceratopsyche sparna		2				10	X	X	5
Cheumatopsyche sp.	2	42	3	2	3	64	26	5	117
Hydropsyche sp.	5	8	6	5		31	5		
Hydropsyche betteni							X	X	
Hydropsyche frisoni									3
Goeridae									
Goera sp.						X	2	X	
Leptoceridae	1	1							
Ceraclea sp.				X					
Ceraclea flava	X	X	X		X				
Mystacides sp.					1				
Triaenodes sp.								X	
Limnephilidae	1			1					
Pycnopsyche sp.			X						

APPENDIX C (CONT.)

	SITE NUMBER								
TAXA	1	2	3	4	5	6	7	8	9
Odontoceridae									
Psilotreta sp.									1
Philopotamidae									
Chimarra sp.	1	10				3	2	3	8
Dolophilodes distinctus		1				6			
Wormaldia sp.			1						
Phryganeidae		1							
Ptilostomis sp.				1					
Polycentropodidae									
Cernotina sp.		1	X	1				X	
Cyrnellus fraternus							2		
Phylocentropus sp.						X			
Polycentropus sp.						1			
Psychomyiidae									
Lype diversa								X	
Ueonidae		11	2						
Neophylax sp.	X	X	X	X	41	3	1	2	4
Lepidoptera									
Pyralidae								3	
Petrophila fulicalis			X	X			X	X	
Coleoptera									
Curculionidae		1							
Dryopidae									
Helichus basalis	3	4	14	8	X	5	X		1
Helichus lithophilus	5	3	27	13	X	3	X	X	6
Dytiscidae		1				X	X	X	X
Elmidae									
Dubiraphia sp.		6		1					
Dubiraphia quadrinotata				3		X	X		

APPENDIX C (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Dubiraphia vittata				1			X		2
Macronychus glabratus	x	X	X			X	X		
Optioservus sp.	115	15	50	17	2	96	13	3	153
Optioservus ovalis									3
Optioservus trivittatus	149	1	82	X		16	X	4	184
Stenelmis sp.	3		53	2		64	1		61
Gyrinidae									
Dineutus sp.	X	X		X					
Haliplidae									
Peltodytes sp.									X
Hydraenidae					X				
Hydrophilidae									
Tropisternus sp.			X		X				
Psephenidae									
Ectopria sp.	1							1	9
Psephenus herricki	19		17	19	3	113	5	14	681
Staphylinidae									
Stenus sp.	1	2				X		1	
Diptera									
Brachycera									
Athericidae									
Atherix sp.			32	7	X	56	3		7
Dolichopodidae									1
Empididae									
Chelifera/*Hemerodromia* sp.	X		X		1				
Clinocera sp.	2								
Hemerodromia sp.	1								
Ephydridae					X				
Tabanidae									

APPENDIX C (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Chrysops sp.	X	X		3			1		1
Nematocera									
Ceratopogonidae								8	46
Chironomidae		18	1		8	4	11	13	10
Tanypodinae									
Ablabesmyia sp.		4		2	1				X
Nilotanypus sp.		5							
Thienemannimyia gr.		8	1		2	1	8	3	
Orthocladiinae								X	
Corynoneura sp.		137						1	1
Cricotopus/*Orthocladius* sp.							1		X
Eukiefferiella/*Tvetenia* sp.						1			
Nanocladius sp.				2		2	1	X	
Parametriocnemus sp.							17	3	
Rheocricotopus sp.	1								
Synorthocladius sp.									1
Thienemanniella sp.			1		12	4	1	2	22
Chironominae									
Cryptochironomus sp.				3	2				
Dicrotendipes sp.									X
Micropsectra sp.								2	42
Microtendipes sp.				1					
Microtendipes pedellus gr.									X
Phaenopsectra sp.			1						
Polypedilum sp.	10	632	7	5	158	251	166	130	92
Rheotanytarsus sp.	4	2	3	4	X	2	1		
Stenochironomus sp.		6		1		1			
Tanytarsus sp.	13	51	1	24	68	17	26	6	12
Culicidae									

APPENDIX C (CONT.)

TAXA	1	2	3	4	5	6	7	8	9
					SITE NUMBER				
Anopheles sp.					X				
Simuliidae	1								
Simulium sp.	102	53	23		2	22	6	4	
Tipulidae									
Antocha sp.						1	1	X	2
Hexatoma sp.	9		X				2	25	17
Limnophila sp.							1		
Tipula sp.	1	308	15	28	3	9	3	6	4
TOTAL NUMBER OF INDIVIDUALS	1141	1579	799	427	397	1990	366	349	1926
TOTAL NUMBER OF DISTINCT TAXA	57	62	58	54	51	61	58	55	68

APPENDIX D.

COMPREHENSIVE LIST OF ALL MACROINVERTEBRATES COLLECTED IN HORSE LICK CREEK AT THE NINE SITES DURING JUNE 1995. ORGANISMS COLLECTED ONLY IN THE QUALITATIVE SAMPLES ARE DENOTED BY AN X.

	SITE NUMBER								
TAXA	1	2	3	4	5	6	7	8	9
Rhyncocoela									
Prostoma sp.		3							
Nematoda									1
Oligochaeta	26	10	1	1	7		11	1	4
Hirudinea									
Glossiphoniidae									
Helobdella sp.								X	9
Gastropoda									
Prosobranchia									1
Pleuroceridae									
Elimia sp.	50	27	11	16	1	4	11	18	194
Pelecypoda									
Corbiculidae									
Corbicula fluminea	7		8	7	14	3			
Sphaeriidae									
Sphaerium sp.			2						1
Hydrachnidia									1
Crustacea									
Amphipoda									
Gammarus sp.	1						1		
Decapoda									
Cambaridae								1	1
Cambarus sp.									1
Orconectes sp.	1	X	2	3	1	X			4
Isopoda									
Lirceus sp.	5	X		2	1	1	2		

APPENDIX D (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Insecta									
Collembola			1						
Ephemeroptera									
Baetidae	51	31	102	172	359	128	6	92	158
Baetiscidae									
Baetisca sp.		4		X		X			
Caenidae									
Caenis sp.		4						1	X
Ephemerellidae									
Attenella spp.		1	X						
Drunella cornutella	1		2	1	4	5			
Ephemerella spp.	9	4	47	78	65	27	11	9	88
Ephemerella needhami		2							
Eurylophella sp.		14	2	5	X	X		1	2
Serratella sp.						X			
Ephemeridae									
Ephemera sp.		X		1	X		2		2
Hexagenia sp.			1						
Heptageniidae								1	13
Cinygmula subaequalis					1				
Epeorus sp.			X	2	3	3		4	10
Heptagenia sp.			3	3					
Leucrocuta sp.	21	10	12	16	102	43	3	32	35
Nixe sp.		1							
Stenonema sp.	5	1	22	25	6	3		19	45
Stenonema femoratum	1		X	1	3	1			X
Stenonema mediopunctatum	38	6	33	17	9	5		2	
Stenonema modestum			1	13	10	24	1	10	9
Stenonema vicarium	23	2	16	23	16	2	1	1	

APPENDIX D (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Stenacron sp.	X								
Stenacron interpunctatum	X		X	X		2			
Isonychiidae									
Isonychia spp.	126	13	219	116	61	26	2	13	2
Leptophlebiidae									
Paraleptophlebia sp.								11	43
Paraleptophlebia guttata		1		1	2	1			
Odonata									
Aeshnidae									2
Boyeria sp.		8				1			
Boyeria vinosa		1		3			X		X
Calopterygidae									
Calopteryx sp.		X	X						
Calopteryx dimidiata					X	X	X		X
Coenagrionidae									
Amphiagrion sp.				X					
Cordulegastridae									
Cordulegaster sp.								X	X
Gomphidae									3
Arigomphus sp.				X					
Gomphus sp.	X	3							X
Gomphus cavillaris		X							
Hagenius brevistylus	X	1							
Lanthus sp.	6	2	2	1		1	2		9
Stylogomphus albistylus		1							X
Libellulidae									
Perithemis sp.			X						
Plecoptera									1
Capniidae/Leuctridae	9	4	24	48	81	28	8	186	

APPENDIX D (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Capniidae	1				2				9
Leuctridae	1								255
Nemouridae									
Amphinemura sp.								3	1
Amphinemura delosa	X	3	1	3					
Peltoperlidae									
Peltoperla sp.					1				
Perlidae			2					3	89
Acroneuria sp.	1		4	11	8	4		7	33
Agnetina sp.	1		2						
Attaneuria ruralis					X				
Beloneuria sp.							1	1	
Eccoptura xanthenes								3	
Perlesta sp.	7	47	5	3	1			X	41
Perlodidae									
Isoperla sp.		1							
Pteronarcyidae									
Pteronarcys sp.			2		1	1			
Heteroptera									
Veliidae									
Rhagovelia sp.		1				1		X	
Megaloptera									
Corydalidae									
Corydalus cornutus	1		2	2	X				1
Nigronia serricornis	4	4	1	8		1	3	12	10
Trichoptera					4				
Glossosomatidae	X	X						5	1
Agapetus sp.	2	4	2	8	1	X		4	51
Agapetus illini									24

APPENDIX D (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Glossosoma sp.			2	4	11	5	32	166	104
Protoptila sp.		1							
Helicopsychidae									
Helicopsyche borealis			4	3				1	12
Hydropsychidae								18	246
Ceratopsyche sp.				2				2	86
Ceratopsyche cheilonis	5	3	7	5	2	3			
Ceratopsyche sparna	9	7	39	38	18	33	2	4	25
Cheumatopsyche sp.	38	15	17	18	7	13	10	8	18
Diplectrona modesta			1			1			
Hydropsyche sp.		3					1	1	
Hydropsyche betteni			2	1					8
Hydropsyche frisoni			2	4					2
Leptoceridae									
Oecetis sp.		1	X						1
Oecetis persimilis		1		1					
Limnephilidae									
Pycnopsyche sp.		1		X	X				1
Philopotamidae								3	3
Chimarra sp.	1					1		4	62
Chimarra aterrima									
Dolophilodes distinctus	7	X	32	22	8	20		2	
Wormaldia sp.	4	1	4	2	1	1			24
Polycentropodidae									
Cyrnellus fraternus				1					
Psychomyiidae									
Lype diversa				1					
Psychomyia flavida						3			
Rhyacophilidae									

APPENDIX D (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Rhyacophila sp.				1		X			1
Rhyacophila ledra							1		
Ueonidae									
Neophylax sp.	X			X	X	X			
Lepidoptera									
Pyralidae								1	
Petrophila fulicalis			1						
Coleoptera									
Carabidae		X						1	
Curculionidae	X			1					
Dryopidae									
Helichus basalis	X	2	2	16	1	1	3	1	5
Helichus lithophilus	1	15	3	12	1				
Dytiscidae		X			X				X
Elmidae									185
Dubiraphia sp.		11							
Dubiraphia quadrinotata		1							
Dubiraphia vittata		17	1	1					1
Macronychus glabratus		3							
Microcylloepus pusillus									4
Optioservus sp.	41	14	37	79	13	53	11	42	144
Optioservus ovalis				2	4				3
Optioservus trivittatus	5	6	36	47	81	8	5	29	250
Stenelmis sp.	1	6	69	169	14	32		10	380
Gyrinidae									
Dineutus sp.	3	1	X						
Gyrinus sp.				X					
Hydrophilidae									
Sperchopsis sp.							X		

APPENDIX D (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Psephenidae									
Ectopria sp.		X			1		X		10
Psephenus herricki	3	4	32	55	15	52	3	10	171
Ptilodactylidae									
Anchytarsus sp.								1	
Staphylinidae									
Stenus sp.						2			1
Diptera							1	7	
Brachycera		X	1	2					1
Athericidae									
Atherix sp.									9
Empididae									
Chelifera/*Hemerodromia* sp.				2					5
Hemerodromia sp.			2	1	4	1			
Tabanidae									
Tabanus sp.						1			2
Nematocera									
Ceratopogonidae			8	5	X	2		4	9
Chironomidae	18	6	7	16	14	11		5	8
Tanypodinae									
Nilotanypus sp.									1
Thienemannimyia gr.			2	3	5	3	1	6	13
Orthocladiinae									
Brillia sp.		3						X	1
Cardiocladius sp.									
Corynoneura sp.						1		1	1
Cricotopus/*Orthocladius* sp.	X	27	11	36	38	32			4
Eukiefferiella/*Tvetnia* sp.		1	3	2					25
Parachaetocladius sp.									1

APPENDIX D (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Parametriocnemus sp.				10	88	23	5	108	15
Rheocricotopus sp.				21			X	3	2
Synorthocladius sp.							2	4	3
Thienemanniella sp.		2	2	4	19	7		11	X
Chironominae									
Chironomus sp.					X				
Cryptochironomus sp.					X				
Microtendipes sp.	1	1			X				
Polypedilum sp.	405	186	388	435	704	460	6	783	332
Rheotanytarsus sp.	6	8	15	9	1	29			19
Stictochironomus sp.		X							
Tanytarsus sp.	7						3	5	
Simuliidae			4						4
Simulium sp.	5	33	77	72	55	10	2	12	26
Tipulidae								1	
Antocha sp.				2		1			2
Dicranota sp.	6	2	5	8	1			1	3
Hexatoma sp.				1			1		24
Pilaria sp.	X							2	
Pseudolimnophila sp.				1			1		9
Tipula sp.	2			1		X	X		3
TOTAL NUMBER OF INDIVIDUALS	966	599	1348	1706	1875	1124	155	1695	3413
TOTAL NUMBER OF DISTINCT TAXA	52	75	64	76	60	58	38	55	81

APPENDIX E.

COMPREHENSIVE LIST OF ALL MACROINVERTEBRATES COLLECTED IN HORSE LICK CREEK AT THE NINE SITES DURING SEPTEMBER 1995. ORGANISMS COLLECTED ONLY IN THE QUALITATIVE SAMPLES ARE DENOTED BY AN X.

	SITE NUMBER								
TAXA	1	2	3	4	5	6	7	8	9
Porifera									
Spongillidae									
Spongilla sp.				X			1		
Rhyncocoela									
Prostoma sp.	1								
Nematoda		3	2	1	3		1		4
Turbellaria						2	1		21
Oligochaeta	154	18	1	2	2			1	8
Hirudinea									
Glossiphoniidae									
Helobdella sp.	1	1	X						
Erpobdellidae									1
Gastropoda									
Pulmonata									
Ancylidae									
Ferrissia sp.		1		1					
Physidae									
Physa sp.		X	X	1	X		1	1	1
Planorbidae									
Gyraulus sp.		2		2		1			
Helisoma anceps	X	X		X					
Prosobranchia									
Pleuroceridae									
Elimia sp.	38	10	4	15	2	10	22	41	14
Pelecypoda									
Corbiculidae									

APPENDIX E (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Corbicula fluminea	6	9	70	39	30	1			1
Sphaeriidae									
Sphaerium sp.							1		1
Hydrachnidia	1		X				2	1	2
Crustacea									
Amphipoda									
Gammarus sp.	1								
Decapoda									
Cambaridae	1	4	2	2	X	1		X	X
Cambarus sp.	1	1	X	1	X	2		X	
Orconectes sp.	X	2	X	X	X		X	X	X
Isopoda									
Lirceus sp.							1	4	
Insecta									
Collembola		1	1						
Ephemeroptera									
Baetidae	76	17	24	13	10	22	10	23	16
Baetiscidae									
Baetisca sp.	10	13	3	5	1		2	2	
Caenidae									
Brachycercus sp.	X								
Caenis sp.	1	16	5	14	110	1	4	5	2
Ephemerellidae	X	2	1						18
Ephemerella spp.						1	2	6	
Eurylophella sp.				3			1		X
Ephemeridae									
Ephemera sp.	X	3	9	43	124	5	19	11	5
Hexagenia sp.		X							
Heptageniidae	55	12	79	64	16	206	139	122	168

APPENDIX E (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Heptagenia sp.			X			X			
Leucrocuta sp.			5			2		2	7
Nixe sp.	1		1						
Stenonema sp.	191	26	392	205	14	401	77	83	171
Stenonema femoratum	X	3	1	4	12		1		X
Stenonema mediopunctatum	45		X					1	
Stenonema vicarium	275	69	266	141	15	56			
Stenacron sp.	2	6	14	14	X	8	X	X	2
Stenacron interpunctatum			1	X		X	X		X
Isonychiidae									
Isonychia spp.	281	13	565	256	198	302	293	92	137
Leptohyphidae									
Tricorythodes sp.	X								
Leptophlebiidae						8	6		
Paraleptophlebia sp.			1					19	315
Odonata									
Aeshnidae									
Basiaeschna janata	X	X			X		X		
Boyeria grafiana			X					X	4
Boyeria vinosa	X	1		3	X		X	X	
Calopterygidae									
Calopteryx sp.	X	1	X	2	X	X	X	X	2
Coenagrionidae	X		2	3		2			6
Amphiagrion sp.		X							X
Argia sp.	9		8	8					7
Cordulegastridae									
Cordulegaster sp.				X			X	X	
Corduliidae									
Macromiinae	X		X						

APPENDIX E (CONT.)

TAXA	SITE NUMBER								
	1	2	3	4	5	6	7	8	9
Macromia sp.		X							
Neurocordulia sp.		X	X						
Gomphidae	12	6	9	3		4	6	3	56
Dromogomphus sp.		X							
Gomphus sp.	X	1	1	X	X	X	X	X	X
Hagenius brevistylus		X							
Stylogomphus albistylus		X		X	1	X			X
Libellulidae									
Perithemis sp.		X							
Plecoptera									
Leuctridae									
Leuctra sp.							1	1	
Perlidae									
Acroneuria sp.	2		3	3	1	15	17	6	51
Neoperla sp.									1
Perlodidae							1		
Pteronarcyidae									
Pteronarcys sp.	1		1						
Heteroptera									
Gerridae						3			
Aquarius sp.									X
Gerris sp.							X	X	
Metrobates sp.		X							
Rheumatobates sp.			X		X				
Trepobates sp.	X	X	X	X					X
Hydrometridae									
Hydrometra sp.			1			1			
Nepidae									
Ranatra sp.	X								X

APPENDIX E (CONT.)

TAXA	SITE NUMBER								
	1	2	3	4	5	6	7	8	9
Notonectidae									
Notonecta sp.								X	
Veliidae									
Microvelia sp.	X				X		X	2	3
Rhagovelia sp.	X	X	X	1	X		12	4	2
Veliinae					X				
Megaloptera									
Corydalidae									
Corydalus cornutus	22	1	28	5	15	14		6	1
Nigronia sp.									
Nigronia serricornis	28	17	9	15	1	4		10	12
Sialidae									
Sialis sp.	X	X							X
Trichoptera									
Calamoceratidae									
Anisocentropus sp.	1	1	X						
Glossosomatidae									
Glossosoma sp.						1	1	8	2
Glossosoma nigrior						X		2	5
Helicopsychidae									
Helicopsyche borealis		1	3	11	X		4	3	8
Hydropsychidae			11	9		29	33	6	3
Ceratopsyche sp.	2		11			14	56	2	2
Ceratopsyche cheilonis	6		15	1	4	53	2		
Ceratopsyche sparna						45			1
Cheumatopsyche sp.	25	2	16	31	20	43	109	39	173
Hydropsyche sp.	1		8	4		2	7	1	1
Hydropsyche betteni							3		
Hydropsyche frisoni			X	1		1	1	3	

APPENDIX E (CONT.)

	SITE NUMBER								
TAXA	1	2	3	4	5	6	7	8	9
Goeridae							1		
Goera sp.		2						9	
Leptoceridae		1							
Ceraclea sp.	X								
Limnephilidae				1	1				
Pycnopsyche sp.					X	X	X	X	X
Philopotamidae							3		
Chimarra sp.	14	2	6	8	21	31	46	12	274
Chimarra aterrima						1	2		
Dolophilodes distinctus							11		
Phryganeidae				1					
Ptilostomis sp.									
Polycentropodidae						X		1	1
Cernotina sp.		2							
Cyrnellus fraternus									1
Neureclipsis sp.					X				
Paranyctiophylax sp.				X			X		
Phylocentropus sp.		3							
Polycentropus sp.	1	X	1	1			X	X	6
Psychomyiidae									
Lype diversa		X					X		
Ueonidae									
Neophylax sp.	X		X	X	X	X			X
Lepidoptera						1			
Pyralidae				1	1		6	3	
Petrophila fulicalis								1	X
Paraponyx sp.				1					
Coleoptera									
Dryopidae									

APPENDIX E (CONT.)

TAXA	1	2	3	4	5	6	7	8	9
	SITE NUMBER								
Helichus basalis	3	6	17	5	1	7	7	3	2
Helichus lithophilus	4	22	28	85	8	12	7	5	
Dytiscidae	X		X	X	X	X	X	X	X
Elmidae					20	6	24	25	
Ancyronyx variegata				X					
Dubiraphia sp.		14	X						
Dubiraphia vittata		56		2				X	3
Macronychus glabratus		3				1			
Microcylloepus pusillus	1								3
Optioservus sp.	173	54	156	46	39	45	51	33	384
Optioservus ovalis			1	1					11
Optioservus trivittatus	170	8	120	21	1	20	40	241	289
Oulimnius latiusculus	1						1		
Stenelmis sp.	9	3	175	92	27	156	10	9	311
Gyrinidae									
Dineutus sp.	X		X	X					
Gyrinus sp.			X						
Haliplidae									
Peltodytes sp.									X
Hydrophilidae									
Tropisternus sp.					X				
Psephenidae									
Ectopria sp.									2
Psephenus herricki	34	89	78	88		127	178	233	381
Staphylinidae				1					
Stenus sp.		1	X			X	2	X	4
Diptera									
Brachycera									
Athericidae									

APPENDIX E (CONT.)

	SITE NUMBER								
TAXA	1	2	3	4	5	6	7	8	9
Atherix sp.	5		27	11		33	3	1	9
Dolichopodidae		1						1	
Empididae									
Chelifera/*Hemerodromia* sp.				1	3	1	3		
Clinocera sp.								3	
Hemerodromia sp.						1	1		4
Ephydridae									1
Tabanidae									
Chrysops sp.		11	X		X		2	X	3
Nematocera									
Ceratopogonidae	1	1					2	4	1
Chironomidae		2	4	3	5	3	15	9	6
Tanypodinae									
Ablabesmyia sp.		2	X						
Clinotanypus sp.			X						
Nilotanypus sp.									2
Procladius sp.				X				X	
Thienemannimyia gr.		3	5	3	18	4	12	3	11
Orthocladiinae									
Brillia sp.							1		
Corynoneura sp.		2	1		1	4	10	3	1
Corynoneura/Thienemanniella sp.					1		4		
Cricotopus/*Orthocladius* sp.	X			1	16		X	1	1
Eukiefferiella/*Tvetenia* sp.							6		1
Nanocladius sp.			1			X			9
Parachaetocladius sp.					1			1	6
Parametriocnemus sp.					2	3	45	36	21
Rheocricotopus sp.		1	3		1	2		2	6
Synorthocladius sp.						X			

APPENDIX E (CONT.)

TAXA	SITE NUMBER 1	2	3	4	5	6	7	8	9
Thienemanniella sp.		X	1	1	2	3	12		X
Chironominae									
Chironomus sp.	X							X	X
Cladotanytarsus sp.			1				X		
Cryptochironomus sp.		1	1		2	1			
Paracladopelma sp.			1						
Paralauterborniella sp.				1					
Paratendipes sp.		1	X		2				
Phaenopsectra sp.		1	5		5			1	4
Polypedilum sp.		18	11	17	56	90	494	323	54
Pseudochironomus sp.		1							
Rheotanytarsus sp.	4	1	32	1	23	12	25	6	3
Stempellina sp.			1	2			2		
Stenochironomus sp.	5	4	4	2	3	2			
Stictochironomus sp.						1			
Sublettea sp.					4				
Tanytarsus sp.	X	2	12	17	59	6	47	46	11
Tribelos sp.	X				1				
Culicidae									
Anopheles sp.		1							
Dixidae									
Dixella sp.								X	
Simuliidae						3			
Simulium sp.	3	3	15	1			6	3	1
Tipulidae						29			
Hexatoma sp.	5						9	28	8
Tipula sp.		18	21	10	39	64	133	15	50

APPENDIX E (CONT.)

	SITE NUMBER								
TAXA	1	2	3	4	5	6	7	8	9
TOTAL NUMBER OF INDIVIDUALS	1683	605	2301	1381	1009	1935	2072	1571	3120
TOTAL NUMBER OF DISTINCT TAXA	69	76	83	71	63	64	79	75	85