FISH AND MACROINVERTEBRATE COMMUNITIES IN MILLER CREEK, ROBERTSON COUNTY, TENNESSEE

JENNIFER J. KINSEY

Fish and Macroinvertebrate Communities in Miller Creek, Robertson County, Tennessee

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Degree

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Dr. Mack T. Finley, Major Professor

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DEDICATION

This thesis is dedicated to my parents

Charles and Arlene,

and to my sisters

Debbie, Michele, Susie and Charlene

for their encouragement and support

during my pursuit of higher education.

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ABSTRACT

Nonpoint source pollution in aquatic ecosystems degrades streams and decreases fish and aquatic macroinvertebrate communities. Excessive siltation from erosion is a primary factor limiting usable fish habitat. This study is a descriptive stream study of Miller Creek in Robertson County, Tennessee. Miller Creek is representative of the many low order streams that comprise the Sulphur Fork Creek/Red River Watersheds. The emphasis was on describing the fish and macroinvertebrate communities, assessing the streambank habitat, and determining general water quality of Miller Creek.

Sampling was conducted at five sites on Miller Creek during the spring, summer, and fall of 1995. Fish were seined at each of the five sites during spring and summer. During the fall fish were collected at two sites by electroshocking. Fish were described using abundance, richness, and feeding guilds. Seven families and 26 species of fish were collected. Of the 26 fish species, 80.8% were insectivores, 11.6% piscivores, 3.8% herbivores, and 3.8% omnivores. The total abundance was 930.

Macroinvertebrates were sampled at three sites during June 1995 by kicksampling riffles and sweepnetting bank habitats. The macroinvertebrates were described using abundance, richness, EPT abundance, EPT richness, EPT/Chironomidae ratio, Chironomidae abundance, and Family Biotic Index. The 37 invertebrate taxa represented 11 insect orders. Two-thousand nine-hundred thirty organisms were collected. The richness and abundance of macroinvertebrates in riffles were not significantly different among sites. The EPT abundance and Family Biotic Index of the macroinvertebrates in the riffles were also not significantly different among sites. There was a significant

difference between chironomid abundance in riffles at site B (lower Miller Creek) when compared to chironomid abundance in riffles at sites D and E (uppermost Miller Creek); however, there was no significant difference of chironomid abundance between sites D and E. Miller Creek maintains fish and macroinvertebrate diversity, but this study only contains descriptive baseline data. Future studies on the Sulphur Fork Creek watershed may assess the impact non-point source pollution and siltation have had on the watershed.

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SECTION 1: INTRODUCTION

Effects Of Nonpoint Source Pollution and Siltation

Nonpoint source pollution in aquatic ecosystems degrades streams and decreases fish and aquatic macroinvertebrate communities. With the increase in agricultural activities, more Best Management Practices (BMPs) need to be implemented on erodible lands. Poor land management is a primary factor associated with the decline of fishery resources in streams of Middle Tennessee (WPR,SFCW, 1988). Excessive siltation from erosion occurs in 46% of streams across the United States. This is considered the primary factor limiting usable fish habitat (Judy et al., 1984). In the central United States, Menzel et al. (1984) observed that the intensity of siltation increased with increased agricultural activity.

Land use practices influence the terrestrial-aquatic interface (Schlosser, 1991). Agricultural development changes the original fish fauna of a stream due to increased soil erosion, which in turn increases the siltation of the stream. Siltation increases physiological stress on fish by clogging gills, disrupting regular feeding, and impeding other activities dependent on vision and substrate contact. Silt also smothers eggs and larvae (Rabeni and Smale, 1995).

Siltation in agricultural areas can be reduced if the riparian buffer zone is wide enough and contains adequate amounts of natural shrubs and trees with well-developed root systems. Riparian ecotones act as sediment traps to prevent sediment overload during overbank flow, and they stabilize stream banks and channels (Rabeni and Smale, 1995). This in return maintains good water quality that supports healthy biotic communities. Biotic integrity refers to the ability of a biological system to function and maintain itself, and ultimately evolve as environmental conditions change (Kay, 1991; Angermeier and Karr, 1994).

Aquatic biotic communities are often sensitive to low-level disturbances. They effectively function as continuous monitors, and thus are useful in assessing water quality (Chandler, 1970). Biological communities reflect chemical, physical, and biological integrity. They integrate the effects of various pollutant stressors and provide a measure of the impact of these pollutants on overall ecological integrity. Assessment of community response to pollutants offers a useful approach for monitoring nonpoint-source impacts and the effectiveness of BMPs (EPA, 1989).

Macroinvertebrate communities are often used as indicators of water quality. It is advantageous to use benthic macroinvertebrates since they are abundant in most streams and are a primary food source for many recreational and commercially-important fish. Sampling is easy and relatively inexpensive. Macroinvertebrates are good indicators of short-term environmental effects, and of localized, site-specific habitat conditions because they are short-lived and have limited migration patterns. Fish communities are good indicators of long-term effects and general habitat conditions (EPA, 1989). Ross et al. (1985) and Matthews (1986) found that stream fish communities were persistent and stable for ten years and recovered quickly from natural environmental phenomena such as droughts and floods, indicating that natural phenomena are unlikely to be the sole basis of large fish assemblage fluctuations. The use of fish communities as monitors may become more common (Hocutt, 1981) as researchers come to recognize the importance of fish in aquatic ecosystems for fisheries and for recreation (Berkman and Rabeni, 1986). "Fish account for nearly half of the endangered vertebrate species and subspecies in the United States (EPA, 1989)."

Healthy watersheds increase the value of the adjacent land and enhance the livelihood of the human residential community. Once a watershed and its ground water have become polluted it is difficult and costly to reverse the effects. Fish populations of large rivers are not easily sampled quantitatively (Schlosser, 1991), so it is easier and less costly to work with smaller streams.

The Sulphur Fork Creek Watershed

The Sulphur Fork Creek watershed drains nearly half of Robertson County (Figure 1). The Tennessee Department of Environment and Conservation has designated Sulphur Fork Creek water for domestic, industrial, fish and other aquatic life, recreation, irrigation, livestock, and wildlife uses (WPR,SFCW, 1988).

The Sulphur Fork Creek Watershed is in Robertson, Montgomery, Cheatham, and Sumner Counties in northern Middle Tennessee, within the north-central portion of the Highland Rim Physiographic Province. The soil is of limestone origin and consists mainly of Baxter, Dickson, Cherty Mountview, and Pembroke soils (WPR,SFCW, 1988). Approximately 95 percent of this 55,847-hectare watershed is in southern Robertson County. Landownership is nearly 100 percent private. Approximately 1,000 farms, averaging 59 hectares, are located in the watershed. Only 40.4 hectares are wetlands (WPR,SFCW, 1988). At the time of this study (1995), about 26,710 hectares (48%)

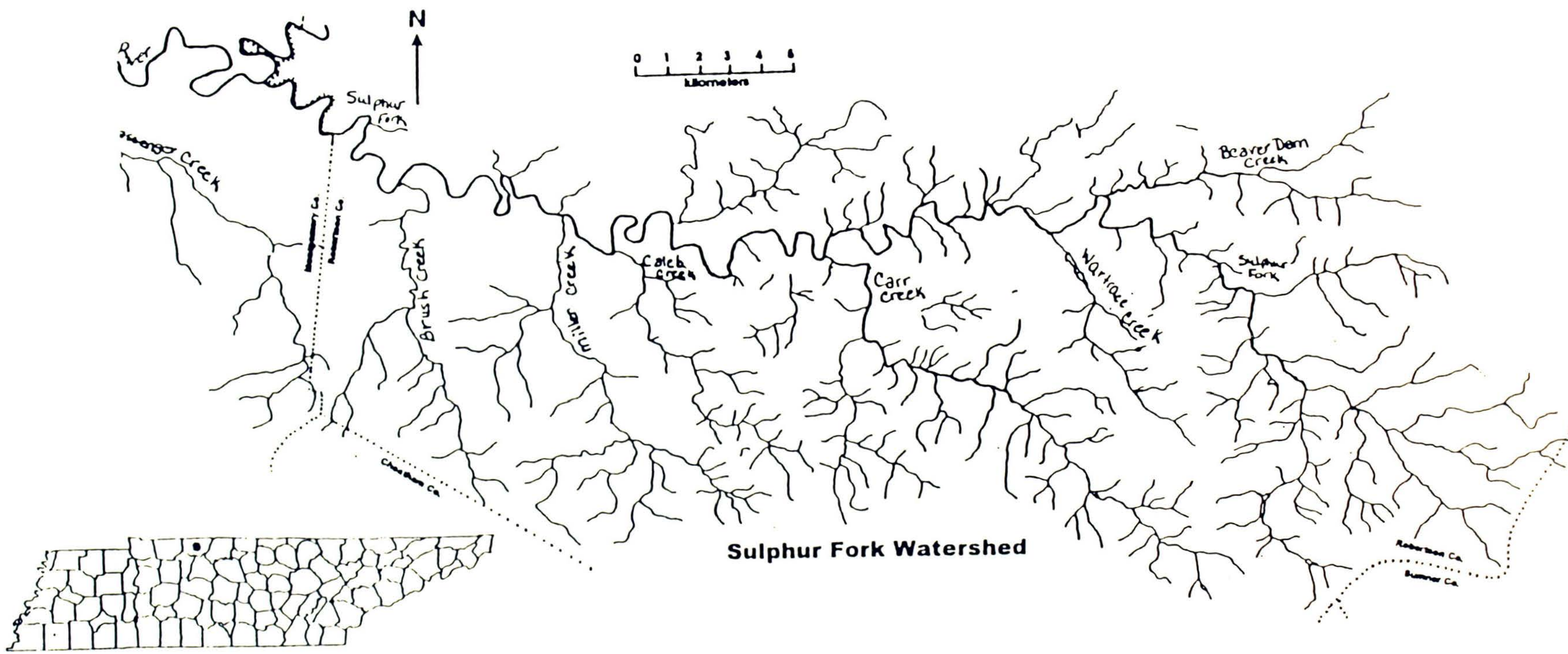

Figure 1. Map of Sulphur Fork Creek Watershed.

were in cropland, 14,560 hectares (26%) in pasture, 9,712 hectares (17%) in forest land, 2,428 hectares (4.5%) in roadsides, and 2,428 hectares (4.5%) in other uses (WPR,SFCW, 1988).

Sulphur Fork Creek (main stem) is 63 kilometers long, with an average width of 11 meters. At normal flow its surface area is 69.3 hectares. It flows into the Red River, a tributary of the Cumberland River. Most of the tributaries of Sulphur Fork Creek flow south to north. The mean annual precipitation is 122 cm, and the growing season is about 206 days (WPR,SFCW, 1988).

Siltation and bacteria associated with livestock are the two major pollution problems of the Sulphur Fork Creek Watershed. Excessive erosion causes "damages such as reduced crop and pasture yields, increased production costs, increased roadbank maintenance costs,...killed or damaged timber, impaired water quality, damaged wetlands and lower quality fish and wildlife habitats (WPR,SFCW, 1988)." The agricultural economy of the region is based largely on cultivated crops such as tobacco, soybeans, wheat, and corn. The erosion of cropland averages about 5 metric tons per hectare annually. An estimated 68,039 metric tons of sediment per year are either deposited in the bottomlands or enter the Red River (WPR,SFCW, 1988). This excessive sediment deposition kills riparian wildlife plant foods. Aquatic habitats also are perturbed by sediment scour and burial of benthic macroinvertebrate habitat. Water quality is affected indirectly by adsorbed chemical pollutants such as agricultural nutrients (i.e., nitrogen and phosphorus) and agricultural chemicals present in insecticides and herbicides. Intermittent water quality problems occur when cattle have free access to stream waters

(WPR,SFCW, 1988).

These stresses on the aquatic system have adverse effects on the fish fauna. Warm-water fishing comprises 16 percent of Robertson County's recreational activities. Popular species sought by fishermen include smallmouth bass (*Micropterus dolomieu*), rockbass (*Ambloplites rupestris*), bluegill (*Lepomis macrochirus*), and channel catfish (*Ictalurus punctatus*) (WPR,SFCW, 1988). The fisheries in the watershed will deteriorate if the watershed continues to be affected by nonpoint source pollution due to agricultural practices and suburban-urban development.

The purpose of this study is to perform a descriptive stream study on Miller Creek in Robertson County, Tennessee. Miller Creek is a major tributary to Sulphur Fork Creek. The emphasis is on describing the fish and macroinvertebrate communities and assessing the streambank habitat.

Goals of This Study

The goals of this study were to perform a descriptive stream study by conducting fish, macroinvertebrate, and habitat assessments, and to determine general water quality and patterns of land use management on Miller Creek within the Sulphur Fork Creek Watershed.

The goals were accomplished by performing an analysis of both faunal groups (fish and aquatic macroinvertebrates) using measurements of abundance and richness. Abundance is the total number of individuals collected per sample. Richness is the total number of taxa collected per sample. The physical habitat was assessed by walking the stream and mapping it on paper by hand, and by reference to aerial photographs.

Significance of Study

Little data is available regarding the tributaries of Sulphur Fork Creek. If the water quality of the tributaries can be improved, then Red River water quality will be improved. This study assesses the effects of land use practices in the watershed and may encourage landowners to adopt better practices. This study will contribute to the data base for future studies of the Sulphur Fork Creek and Red River Watersheds in Middle Tennessee. The vouchers and residue samples are being held at Austin Peay State University Center for Field Biology for availabilty.

SECTION 2: DESCRIPTION OF THE STUDY SITE

Sampling was conducted at five sites on Miller Creek during the spring, summer, and fall of 1995 (Figure 2). This region was approximately 75% agricultural--50% cropland and 25% pasture (WPR,SFCW 1988). Miller Creek is a natural stream 12.8 km long, with an average width of 5.5 m, and a surface area of 7.04 hectares. Miller Creek is a first, second, or third order stream with a limestone bedrock. Drainage area includes a 63.5 km^2 watershed.

All sampling sites experienced stream flow throughout the year. According to Karr et al. (1986), sampling near the mouth of the tributary that enters a large body of water should be avoided since the habitat will be more typical of the larger body of water. He also stresses that unless assessing the effects of a locally modified site, sampling near a bridge should be avoided. This study was a descriptive study emphasizing all major habitat types within Miller Creek including the mouth entering Sulphur Fork Creek (Site A) and the Carr Road Bridge (Site B).

This stream carries a bedload of chert gravel and a moderate amount of sand; limestone controls the thalweg grade at frequent intervals (the thalweg is the path traced by the flow that follows the deepest part of the channel). The banks of most of Miller Creek were 3-4 m above thalweg and exposed moderately lithified old floodplain deposits. The chert was probably derived from chert concretions that occur in the Mississippian limestones that structurally support the Highland Rim Plateau.

Site A:

This sampling site was located approximately 40 m upstream from Miller's

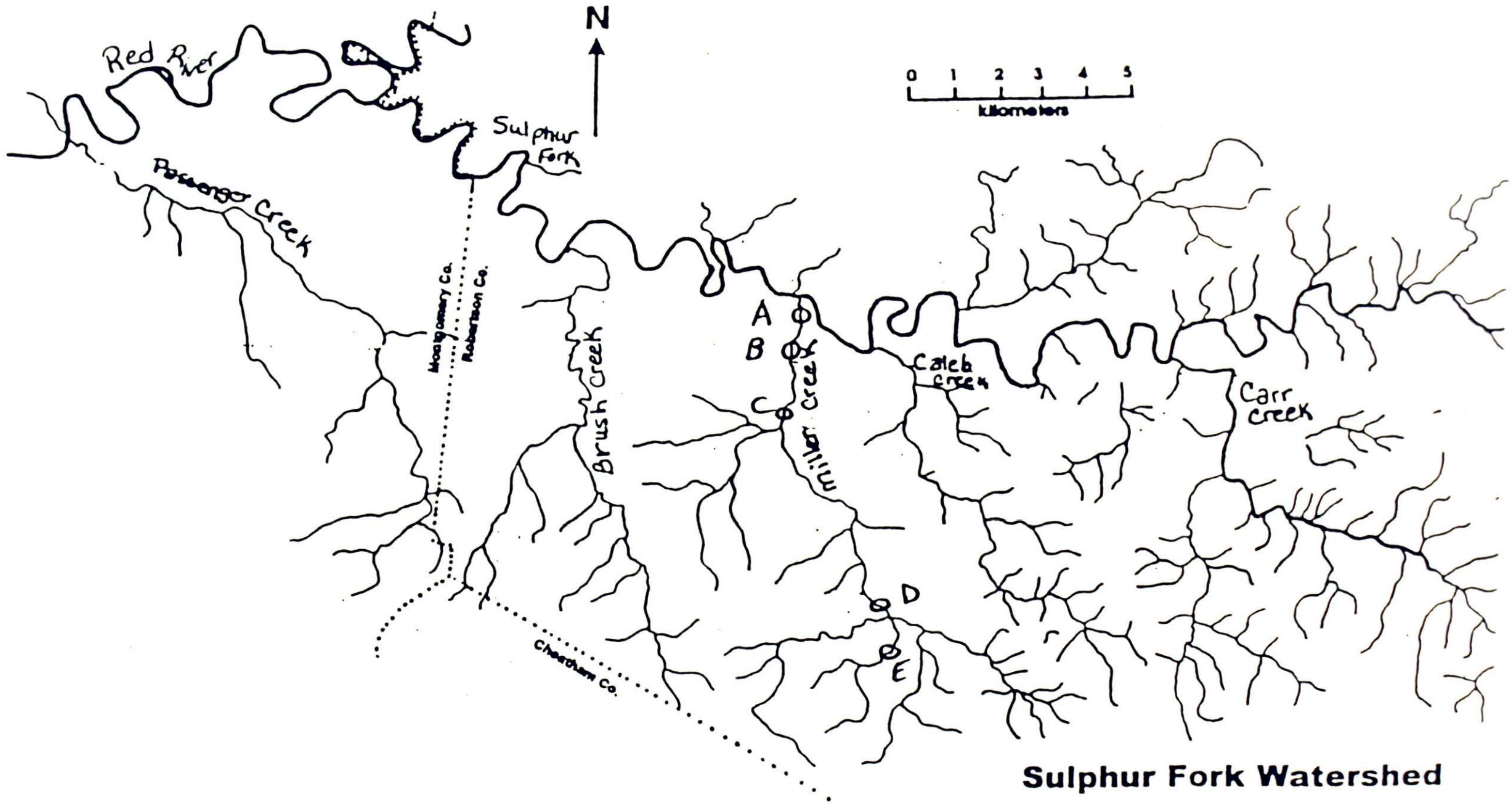

Figure 2. Miller Creek subwatershed sampling sites (A-E).

confluence with Sulphur Fork Creek. The stream bedload consisted of chert gravel mixed with sand. The banks of lower Miller were 3-4 m above the stream thalweg and were highly eroded. Numerous trees along the north bank had root masses that were undermined in the exposed bank. Cattle had direct access to the stream. This stream section was characterized by alternating pool/riffle with diverse habitat types.

Site B:

This site was located approximately 50 m downstream from Carr Road Bridge. The streambank riparian zone was narrow with extensive damage from cattle access. The streambed was rocky with extensive reaches of gravel bars. This area was disturbed in November due to bridge construction.

Site C:

This site was located near Turnersville, Tennessee below the bridge at the junction of Maxie Road and Ed Ross Road. The streambed was primarily limestone bedrock with limited habitat diversity. The stream had a narrow riparian zone on both banks. Due to safety reasons (slippery rocks), the fish were not electroshocked at this site in November.

Site D:

This fourth site was located just above the bridge at Sandy Springs and Head Church Roads. Miller Creek had several pools and shallow riffles characterized by numerous root wads. The stream sampling area contained a heavy zone of riparian growth on both stream banks, and therefore was heavily shaded.

Site E:

This site represented the upper section of Miller Creek. Its stream flow was narrow and shallow year round. Heavy riparian vegetation covered the area and heavily shaded the stream. Narrow gravel bars characterized the streambed.

SECTION 3: MATERIALS AND METHODS

Fish

Fish were seined at each of the five sites during the spring and summer of 1995. Two persons holding a 15 foot seine (mesh size, 6 mm) sampled three riffles, three runs, and three pools per site. According to EPA protocol (1989) a representative sampling station should include at least one, preferably two, riffle, run, and pool habitats. Representative samples were preserved in 10% formalin for laboratory identification. Each sample was labeled by site code and date.

During the fall, fish were collected at two sampling sites (Site A and Site D) using a Colfelt BP-4 pulsed, direct current backpack-shocker with two pole-mounted electrodes. Block nets with weights (mesh size, 6 mm) were placed at the downstream end and at the upper end of a 60 m sampling area to trap the fish. Small amounts of a salt tablet were placed at the upper end of the sampling segment to increase the conductivity levels to increase the flow of electric current through the water. The conductivity levels were monitored downstream using a Hydrolab multiparameter water quality meter. Seine sampling began at the downstream end and moved upstream with a side-to-side pattern to ensure sampling of all micro-habitats. The crew included the electroshocker, followed closely by several members using dip nets and two members using a 10-ft seine to collect escaping fish.

Electrofishing is the most common method for collecting and monitoring fish communities (EPA, 1989). Samples at Site E were to be collected via electroshocking, but the shocker broke down at Site D. Therefore a November sample was collected at Site E, via seining. Sampling in November at Site B was canceled due to a state construction project on Carr Road Bridge. Site C was very slippery, with deep pools; therefore, for safety reasons, samples were not collected via electroshocking. All fish samples were preserved in 10% formalin for lab identification. A list of species was compiled using Etnier and Starnes (1993) as a primary reference for identification.

Fish samples were described using abundance, richness, and feeding guilds. The fish were assigned to one of four feeding guilds, each defined by particular food types: insectivores, which consume surface, midwater, and benthic insects; omnivores, which consume plant, animal, and detrital material; herbivores, which consume plant material; and piscivores, which consume other fish (Rabeni and Smale, 1995). Feeding guild assignments followed the guidelines of EPA (1989), Etnier and Starnes (1993), and Berkman and Rabeni (1987).

Macroinvertebrates

Macroinvertebrates were sampled at sites B, D, and E during June 1995 using two methods: kicksampling (3-1m^2/site) and sweepnetting (1/site). At Site B and Site D, two kicksamples of 1 m^2 were collected at one lower riffle and one kicksample of 1 m^2 was collected at a second riffle upstream. The samples were labeled with site code and date [i.e.,Riffle 1 (R1), Riffle 2 (R2), and Riffle 3 (R3), respectively]. At Site E, three kicksamples were collected from three different riffles downstream-to-upstream because of the narrowness of the stream. They were labeled Riffle 1 through Riffle 3, respectively. Riffle/run habitats in a stream with cobble substrate are the most productive habitats available in stream systems. They support pollution-sensitive taxa feeding groups including scrapers and filtering collectors (EPA, 1989).

A fourth sample was collected at each site by sweeping a net with a 500μm mesh along both sides of the stream, reaching three varied microhabitats, for approximately one minute per microhabitat. These random microhabitats included areas near fallen logs, dense vegetation along the bank, or areas near bridges. All the collections were placed into one jar and labeled "Bank" and coded for site and date. All samples were preserved in 80% isopropyl alcohol. The macroinvertebrates were taken to the laboratory and preserved in a fresh solution of 80% isopropyl. Later, agitation of the samples was performed to make each sample homogeneous prior to mechanically splitting into quarter samples using a Folson Plankton Splitter. The representative quarter samples were identified to family. Merritt and Cummins (1984) was the primary reference for macroinvertebrate identification.

A tolerance value was assigned to each family according to Hilsenhoff (1988) and from personal consultation with Dr. Steven Hamilton (APSU). The macroinvertebrates were described using abundance, richness, EPT abundance, EPT richness, EPT/Chironomidae ratio, Chironomidae abundance, and Family Biotic Index. Ephemeroptera, Plecoptera, and Trichoptera (EPT) are the three orders most sensitive to aquatic pollution. A low representation from these orders usually indicates poor water quality. High EPT abundance (the total number of organisms collected from these three orders per sample) is usually an indication of good water quality. High EPT richness, the total number of taxa collected from these three orders per sample, is also an indication of good water quality.

Chironomids can usually withstand poor water conditions. They are generally more pollutant-tolerant. The EPT abundance and Chironomidae abundance ratio is a measure of degree of pollution. A high abundance of pollutant-sensitive EPTs to a low abundance of chironomids is usually an indication of good water quality, and the inverse an indicator of poor water quality. The Family Biotic Index is used as a basis for classifying family-level tolerances to aquatic pollution. Tolerance values range from 0 to 10 for families, and increase as degree of pollution decreases. Hilsenoff developed the Family Biotic Index as a means of detecting organic pollution (EPA, 1989).

The computer program Keystat and the nonparametric Kruskal-Wallis test were used to statistically compare the macroinvertebrate riffle samples at sites B, D, and E. The comparisons included total abundance, total richness, EPT abundance, and the Family Biotic Index of the macroinvertebrate riffle populations. The Tukey Nonparametric Multiple Comparison Test was performed to compare the abundance of chiromomids of the riffle macroinvertebrate samples at sites B, D, and E.

Habitat Assessment

To better assess overall stream habitat, Miller Creek was characterized by walking the streambed and mapping every 30.5 m interval. Examining aerial photographs aided this assessment. Bank erosion, livestock access, riparian zone width, stream width, and stream depth were measured and recorded. The flow class and adjacent land use were determined for all sampling locations.

SECTION 4: RESULTS AND DISCUSSION

Fish

The following fish results and subsequent discussions are based on the raw data found in the appendix (Table A1). Table A1 provides a summary of all taxa found at each site, and the functional feeding group assignment to each taxon. Seven families and 26 species of fish were collected (Table 1). All the species were native to the region (Etnier and Starne 1993). Of the 26 fish species, 80.8% were insectivores, 11.6% piscivores, 3.8% herbivores and 3.8% omnivores. Electrofishing appeared to be a more effective method of collecting fish, when fall collections were compared to spring and summer collections. Few vouchers were collected at Site A during the spring due to deep water (confluence with Sulphur Fork Creek and high flow). No fish were collected at Site B in the fall due to bridge construction on Carr Road. No fish were collected at Site C in the fall because the rocks were too slippery for safe electrofishing. During the fall, Site E had a larger collection, probably due to the narrowness and shallowness of the stream. Site E had water flow year-round but it was slight during fall. One species of darter was found at Site E. The majority of the fish collected throughout the stream were insectivores. The total abundance was 930 (Table 2).

Insectivores are the dominant trophic guild of the majority of North American surface waters. As the invertebrate food source decreases in abundance and diversity due to habitat deterioration, the fish species mix shifts from insectivores to omnivores (EPA, 1989). The majority of the fish species in Miller Creek were insectivores. The sediment

Table 1: Summary of fish richness found at each site during the spring, summer, and fall seasons of 1995 in Miller Creek, Robertson County, Tennessee. A, B, C, D, and E represent each of the five sites; TR/S = total richness per taxon per season; TR = the total richness of the taxon for all three seasons.

TAXA	SPRING						SUMMER						FALL						
	A	B	C	D	E	TR/S	A	B	C	D	E	TR/S	A	B	C	D	E	TR/S	TR
TOTAL RICHNESS	2	8	12	8	5	15	9	10	11	8	4	20	18			11	8	23	26

Table 2: Summary of fish abundance found at each site during the spring, summer, and fall seasons of 1995 in Miller Creek, Robertson County, Tennessee. A, B, C, D, and E represent each of the five sites; TA/S = total abundance per taxon per season, TA = the total abundance of the taxon for all three seasons

TAXA	SPRING						SUMMER						FALL						
	A	B	C	D	E	TA/S	A	B	C	D	E	TA/S	A	B	C	D	E	TA/S	TA
TOTAL ABUNDANCE	3	49	45	69	66	232	95	81	60	50	14	300	258			47	93	398	930

bar at Site B grew larger as the bridge work continued. Sediment bars tend to increase in size with continued watershed disturbances (EPA, 1989). Sediment deposition affects much bottomland cropland, pastureland, and hardwood forest lands each year. The adsorbed chemicals transported by the sediment degrade water quality. Sedimentation results in burial of benthic macroinvertebrates which decreases fish food (WPR,SFCW, 1988).

Macroinvertebrates

The following macroinvertebrate results and subsequent discussions are based on the raw data found in the Appendix (Table A2). Table A2 provides a summary of all taxa found at each site. The 37 invertebrate families were divided among 11 insect orders. I collected 2,930 organisms. Table 3 summarizes macroinvertebrate total abundance, total richness, EPT abundance, EPT richness, EPT/Chironomidae ratio, and Family Biotic Index per site on Miller Creek. According to the Kruskal-Wallis Test (nonparametric), the richness and abundance of macroinvertebrates in riffles were not significantly different ($p > 0.05$) among sites B, D, and E. The EPT Abundance and Family Biotic Index of the macroinvertebrates in the riffles were also not significantly different ($p > 0.05$) among sites B, D, and E according to the Kruskal-Wallas Test.

Table 3: Summary of macroinvertebrate taxa found at each site on 2 June 1995 in Miller Creek, Robertson County, Tennessee. R1, R2, R3 = three kicksamples at riffles per site; B = sweepnetting of the bank sample per site; TA/S = total abundance of the taxon per site; TA = total abundance of the taxon for all three sites; ∞ = infinity amount of EPTs since there were no chironomids collected.

TAXA		SITE B					SITE D					SITE E					
		R1	R2	R3	B	TA/S	R1	R2	R3	B	TA/S	R1	R2	R3	B	TA/S	TA
TOTAL ABUNDANCE		200	160	131	217	708	184	382	251	274	1091	238	488	329	76	1131	2930
TOTAL RICHNESS		14	17	14	14		18	23	18	14		16	18	15	7		
EPT ABUNDANCE		128	97	78	23		99	186	187	15		133	348	270	17		
EPT RICHNESS		8	8	8	3		9	11	11	5		9	9	10	3		
EPT/CHIRONOMIDAE		4	2.5	2.8	3.8		16.5	46.5	31.2	1.4		∞	58	∞	∞		
FAMILY BIOTIC INDEX		4.81	4.74	3.65	7.20		3.68	4.37	2.65	6.89		4.49	3.23	3.55	6.38		

According to the Tukey Multiple Comparison Test (nonparametric), there was a significant difference between chironomid abundance in riffles at Site B when compared to chironomid abundance in riffles at sites D and E; however, there was no significant difference of chironomid abundance between riffles at sites D and E ($p > 0.05$). Total riffle chironomid abundance of sites B, D, and E were respectively, 99, 16, and 6. Chironomidae and Oligochaeta taxa are generally pollutant-tolerant macroinvertebrate organisms (EPA, 1989). Site B had more direct cattle access and a poorer riparian zone, both of which may increase the chironomids when compared to sites D and E. This free cattle access to the stream waters at site B allowed intermittent water quality problems to occur during warmer months. Streambank restoration with a larger riparian zone and keeping cattle fenced away from the creek will improve water quality.

Riparian ecotones link a stream to its watershed. Riparian zones influence solar radiation and water temperature, regulate nutrient levels, provide organic energy, and stabilize the banks (Karr et al., 1985). Streamside vegetation is important in regulating sediment dynamics, minimizing the sediment depositions (Williams and Nicks, 1988), and lowering the amount of siltation from soil erosion (Menzel et al., 1984). During warmer months, excess algae on the bedrocks usually indicates excess nutrient levels. Biological "impairment may also be indicated by an overabundance of fungal slimes or filamentous algae, or an absence of expected populations of fish (EPA, 1989)."

Habitat Assessment

There is a strong need for erosion control and streambank restoration throughout the Sulphur Fork/Red River Watersheds. Soil erosion from cropland averages about 6 tons per hectare annually within the Sulphur Fork Creek Watershed (WPR,SFCW, 1988). Lower Miller Creek has 600-700 m of significantly eroded banks, and shows evidence of cattle-access damage. Damage of the soil resource base results in reduced crop yields and fertilizer losses. Fertilizer losses add to the increased nutrient levels of the water. To help protect the watershed, BMP's such as grass and legume based rotation, field strip cropping, and conservation tillage need to be reinforced (WPR,SFCW, 1988). Establishment of riparian buffer strips, and enhancing acreages of no-till cropland practices are the most critical BMPs for protecting water quality.

Miller Creek is representative of the many low order streams that comprise the Sulphur Fork Creek/Red River Watersheds. Miller Creek maintains a diversity of fish and macroinvertebrates, but this study only contains descriptive baseline data. Future studies on the Sulphur Fork Creek Watershed may assess the impact non-point source pollution and siltation has had on the watershed. Without implementing BMPs and focusing on erosion control, the deterioration of water quality will continue.

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APPENDIX

Raw data of the fish and macroinvertebrate communities sampled in Miller Creek, Robertson County, Tennessee in 1995

Table A1: Summary of fish taxa found at each site during the Spring,Summer, and Fall seasons of 1995 in Miller Creek, Robertson County, Tennessee. A, B, C, D, and E represent each of the five sites; TA/S = total abundance per taxon per season; TA = the total abundance per taxon for all three seasons. FG = The feeding guilds, represented by I for insectivore, H for herbivore, O for omnivore, and P for piscivore. The * = fish identified and released on site.

TAXA	FG	SPRING (APRIL AND MAY)						SUMMER (JUNE)						FALL (NOVEMBER)						
		A	B	C	D	E	TA/S	A	B	C	D	E	TA/S	A	B	C	D	E	TA/S	TA
CATOSTOMIDAE																				
Hypentelium nigricans	I																	2	2	2
CENTRARCHIDAE																				
Ambloblites rupestris	P													2			2		4	4
Lepomis cyanellus	I													1			1		2	2
Lepomis macrochirus	I			2			2			1			1	5					5	8
Lepomis megalotis	I													1					1	1
Micropterus dolomieu	P								1*				1							1
Micropterus salmoides	P								1*		2*		3							3
COTTIDAE																				
Cottus carolinae	I	1		1	5		7	2		5	5		12	10			18	1	29	48

Table A1: continued

TAXA	F G	SPRING (APRIL AND MAY)						SUMMER (JUNE)						FALL (NOVEMBER)						
		A	B	C	D	E	TA/S	A	B	C	D	E	TA/S	A	B	C	D	E	TA/S	TA
CYPRINIDAE																				
Campostoma anomalum	H		3	2	8	6	19	11	8	8	2		29	42				4	46	94
Hybopsis amblops	I									12			12				3		3	15
Luxilus chrysocephalus	I		6	7	8		21	12	10	3	6		31	41					41	93
Lythrurus ardens	I		16		32		48	45	43	21	23		132	32					32	212
Phoxinus erythrogaster	I			4		34	38					5	5					27	27	70
Pimephales notatus	O							6		2			8	50				1	51	59
Rhynichthys atratulus	I			9	8	11	28					5	5	1			3	34	38	71
Semotilus atromaculatus	I			7	4	10	21			2		2	4	1				11	12	37
Cyprinella galactura	I									2			2	6					6	8
FUNDULIDAE																				
Fundulus catenatus	I		12	3	1		16	5		1			6	44					44	66
Fundulus olivaceus	I																1		1	1
PERCIDAE																				
Etheostoma caeruleum	I		4				4	2	1	3	3		9	2			1		3	16

Table A1: continued

TAXA	FG	SPRING (APRIL AND MAY)						SUMMER (JUNE)						FALL (NOVEMBER)						
		A	B	C	D	E	TA/S	A	B	C	D	E	TA/S	A	B	C	D	E	TA/S	TA
Etheostoma flabellare	I		1	2			3		4				4	3			3		6	13
Etheostoma flavum	I	2	5		3		10	1	4		7		12	4			12		16	38
Etheostoma rufilineatum	I		2	5			7	11	1				12	11					11	30
Etheostoma simoterum	I			1			1		8				8				2		2	11
Etheostoma squamiceps	I			2		5	7				2	2	4				1	13	14	25
POECILLIDAE																				
Gambusia affinis	I													2						2
TOTAL ABUNDANCE		3	49	45	69	66	232	95	81	60	50	14	300	258			47	93	398	930
TOTAL RICHNESS		2	8	12	8	5		9	10	11	8	4		18			11	8		

Table A2: Summary of macroinvertebrate taxa found at each site on 2 June 1995 in Miller Creek, Robertson County, Tennessee. TV = tolerance value per taxon; R1, R2, R3 = three kicksamples at riffles per site; B = sweepnetting of the bank sample per site; TA/S = total abundance of the taxon per site; TA = total abundance of the taxon for all three sites; ∞ = infinity amount of EPTs since there were no chironomids collected.

TAXA		SITE B					SITE D					SITE E					
	TV	R1	R2	R3	B	TA/S	R1	R2	R3	B	TA/S	R1	R2	R3	B	TA/S	TA
BASOMMATOPHORA																	
Planoribidae	7				1	1											1
COLEOPTERA																	
Dytiscidae	9									3	3						3
Elmidae	4	34	5	4	14	57	43	90	21	11	165	48	74	40	7	169	391
Psephenidae	4	2	2	1		5	5	9	4		18	31	22	6		59	82
DECAPODA																	
Cambaridae	6	1	1		2	4	5	21	5	37	68	31	22	6		59	131
DIPTERA																	
Ceratopogonidae	6									1	1						1
Chironomidae	6	32	39	28	6	105	6	4	6	11	27		6			6	138
Culicidae	7	1	3	2	2	8											8
Rhagionidae	2						1	2			3						3
Simuliidae	6	2		4	2	8	1	4			5	1				1	14
Tabanidae	6							1			1						1

Table A2: continued

TAXA		SITE B					SITE D					SITE E					
	TV	R1	R2	R3	B	TA/S	R1	R2	R3	B	TA/S	R1	R2	R3	B	TA/S	TA
EPHEROPTERA																	
Baetidae	4		4	7		11	3		10		13	24	5	2		31	55
Caenidae	7	53	26	9	10	98	4	4		3	11				5	5	114
Ephemerellidae	1	8	9	17		34	8	5	12		25	5	34	19		58	117
Ephemeridae	4									1	1						1
Heptageniidae	4	9	4	9		22	12	30	13	3	58	24	137	96	11	268	348
Leptophelebiidae	2											5	12			17	17
Oligoneuriidae	2	2		12		14			4		4	1	9	2	1	13	31
Tricorythidae	4	2			1	3		1		2	3						6
ISOPODA																	
Asellidae	8		9	4	160	173	22	60	7	173	262	19	19	8	47	93	528
MEGALOPTERA																	
Cordalidae	0				1	1	1	3	1		5		6		2	8	14
MESOGASTROPODA																	
Pleuroceridae	3		2		4	6		3	2	21	26		1			1	33
Physidae	9		1		1	2											2
ODONATA																	
Aeshnidae	3				1	1								1		1	2

Table A2: continued

TAXA		SITE B					SITE D					SITE E					
	TV	R1	R2	R3	B	TA/S	R1	R2	R3	B	TA/S	R1	R2	R3	B	TA/S	TA
Calopterygidae	5									1	1						1
Gomphidae	1		1			1		1		1	2	1	4			5	8
PLECOPTERA																	
Leutridae	0	10		7		17	33	16	38		87		84			84	188
Perlidae	1		14			14	1	1	3		5	35	14	13		62	81
Perlododae	2		7	8		15	3	17	51		71			48		48	134
TRICHOPTERA																	
Glossosomatidae	0						2	10	1		13						13
Helicopsychidae	3							1			1	1	4	4		9	10
Hydropsychidae	4	42	32	9	12	95	33	98	50	6	187	34	49	80		163	445
Hydroptilidae	4								1		1						1
Leptoceridae	4													2		2	2
Limnephilidae	4							3	4		7			4		4	11
Philopotamidae	3	2	1			3											3
Polycentropodidae	6											4				4	4
TOTAL ABUNDANCE		200	160	131	217	708	184	382	251	274	1091	238	488	329	76	1131	2930
TOTAL RICHNESS		14	17	14	14		18	23	18	14		16	18	15	7		

Table A2: continued

TAXA		SITE B					SITE D					SITE E					
	TV	R1	R2	R3	B	TA/S	R1	R2	R3	B	TA/S	R1	R2	R3	B	TA/S	TA
EPT ABUNDANCE		128	97	78	23		99	186	187	15		133	348	270	17		
EPT RICHNESS		8	8	8	3		9	11	11	5		9	9	10	3		
EPT/CHIRONOMIDAE		4	2.5	2.8	3.8		16.5	46.5	31.2	1.4		∞	58	∞	∞		
FAMILY BIOTIC INDEX		4.81	4.74	3.65	7.20		3.68	4.37	2.65	6.89		4.49	3.23	3.55	6.38		

VITA

Jennifer J. Kinsey was born in Fairmont, West Virginia on January 16, 1972. She attended elementary school in Pruntytown and graduated from Grafton High School in June, 1990. The following August she entered West Virginia University and in May, 1994 received the degree of Bachelor of Arts in Biology, with a minor in Communication and an emphasize in the Japanese language. She entered Austin Peay State University, Clarksville, Tennessee in August, 1994 and received a Master of Science degree in Biology.

She is presently working with High School Upward Bound at Austin Peay State University.