THE EFFECTS OF CLEARCUTTING ON TROPHIC RELATIONS OF BENTHIC MACROINVERTEBRATES IN STREAMS OF SOUTHEAST OKLAHOMA

By

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PREFACE

This study was designed to evaluate the effects of clearcut logging on benthic macroinvertebrate diversity and trophic relations in riffles of streams in southeast Oklahoma. The Statistical Analysis System procedure 'Stepwise' and paired t-tests were the primary forms of mathematical analysis. Also, ratios were developed for family eqivalencies and amount of clear-cutting.

I would like to express my appreciation to my major adviser, Dr. Oren Eugene Maughan, for his guidance, assistance and friendship throughout the course of my graduate work. I would also like to thank Drs. Margaret Ewing and Jerry Wilhm for having served on my committee and for their critical review of my thesis.

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CHAPTER I

INTRODUCTION

An undisturbed or natural community is an assemblage of organisms with a unity of taxonomic composition, a relatively uniform appearance, and a definite trophic organization and metabolic pattern (Odum 1959). Perturbations such as logging operations could disrupt this pattern. The effects of logging operations include 1) introducing sediment and logging debris, 2) altering stream flow and temperature, 3) increasing nutrient concentrations, 4) altering forms and amounts of organic detritus, and 5) changing rates of aquatic primary production (Gibbons and Salo 1973). The effects of sedimentation probably have received the most study. Sedimentation reduces light penetration; smothers benthic forms; and introduces absorbed pollutants especially pesticides, metals, and nutrients (Lenat et al. 1981, Oschwald 1972). These physical impacts may be short term (Meghan 1972 a,b), but alter populations of benthic macroinvertebrates (Chutter 1969, Hansman and Phinney 1973, Barton 1977), reduce density of the benthic populations (Tebo 1955, Cordone and Kelly 1961, Chutter 1969 and Leudtke et al. 1976), and produce other alterations in community structure (Ellis 1936, Tebo 1955, Chapman 1962, Salo 1967).

Another effect attributed to clearcutting and streamside clearing is temperature change (Green 1950, Eschner and Larmoyeux 1963, Levlo and Rothacher 1967, Brown 1969, Gray and Edington 1969, Brown 1970, Brown and

Krygier 1971, Likens et al. 1970, Kopperdahl et al. 1971, Swift and Messer 1971, Burns 1972, Narver 1972, Moring 1975b, Newbold et al. 1980). These changes tend to be more severe in smaller than in larger streams (Brown and Krygier 1971). Increases in stream temperature may shift species composition toward warm water species and can result in high mortality rates for all species.

In Eastern Oklahoma, forests cover 4.9 million acres (Murphy 1977) with 4.3 million acres of state commercial forests located in southeast Oklahoma. Four counties, Choctaw, LeFlore, McCurtain and Pushmataha, produced 98% of the timber harvested in the state in 1980 (Rudis 1982). Commercial forestry began around 1910 in Oklahoma with selective cutting of pine, cypress, and oak (Honess 1923). Selective cutting was the dominant harvest method until the 1960's when intensive silivicultural activities including clearcutting and extensive road building began. Presently, over 40,014 acres are clearcut annually in southeast Oklahoma (Oklahoma State Deptment Agriculture 1982).

Clearcutting is removal of all trees in a stand and includes all activities associated with site preparation, harvesting, and access development. The clearcutting process takes from 6 months to 2 years and starts with the removal of all trees from a stand. The smaller trees are used for pulp and the larger ones for lumber. After removal, logging debris is piled and burned. Deep furrows are then made by a large tractor along the contours of the land, and plots are replanted to pines and sprayed with pesticides and broad-leaf herbicides. The harvest rotation time is 30 years.

The objective of this study was to assess the impacts of clearcutting on the diversity and composition of benthic communities in the Little River System of southeast Oklahoma.

CHAPTER II

DESCRIPTION OF STUDY AREA

The Little River originates in the Ouachita mountains in southwest Leflore County, flows in a southwesterly direction to its confluence with Blackfork Creek in Pushmataha County, and then flows southeasterly into McCurtain County. The drainage area is approximately 5700 km^2. The length of the river is about 241 km in Oklahoma and flows about 129 km in Arkansas before joining the Red River (Finnell et al. 1956) (Figure 1).

The two main Oklahoma tributaries of the Little River, Mountain Fork River and Glover Creek, both originate in the heavily wooded and mountainous Ouachita and Kiamichi mountains. The Mountain Fork originates in Polk county, Arkansas, and flows southwesterly through McCurtain county, Oklahoma, for approximately 155 km. The river drains an area of about 2180 km^2, ranges in elevation from about 95 m mean sea level at the mouth to 730 m mean sea level in the headwaters, and has an average stream gradient of 1.7 m/km (Ok. Biol. Surv. 1972; Finnell et al. 1956).

Glover Creek originates in the Beavers Bend Hills subsection of the Ouachita Mountains in the vicinity of the Leflore-McCurtain county line in Oklahoma. The creek flows south for about 90 km to its confluence with the Little River about 19 km west of Broken Bow, Oklahoma. The drainage basin is 56 km long and 32 km wide and drains about 876 km^2.

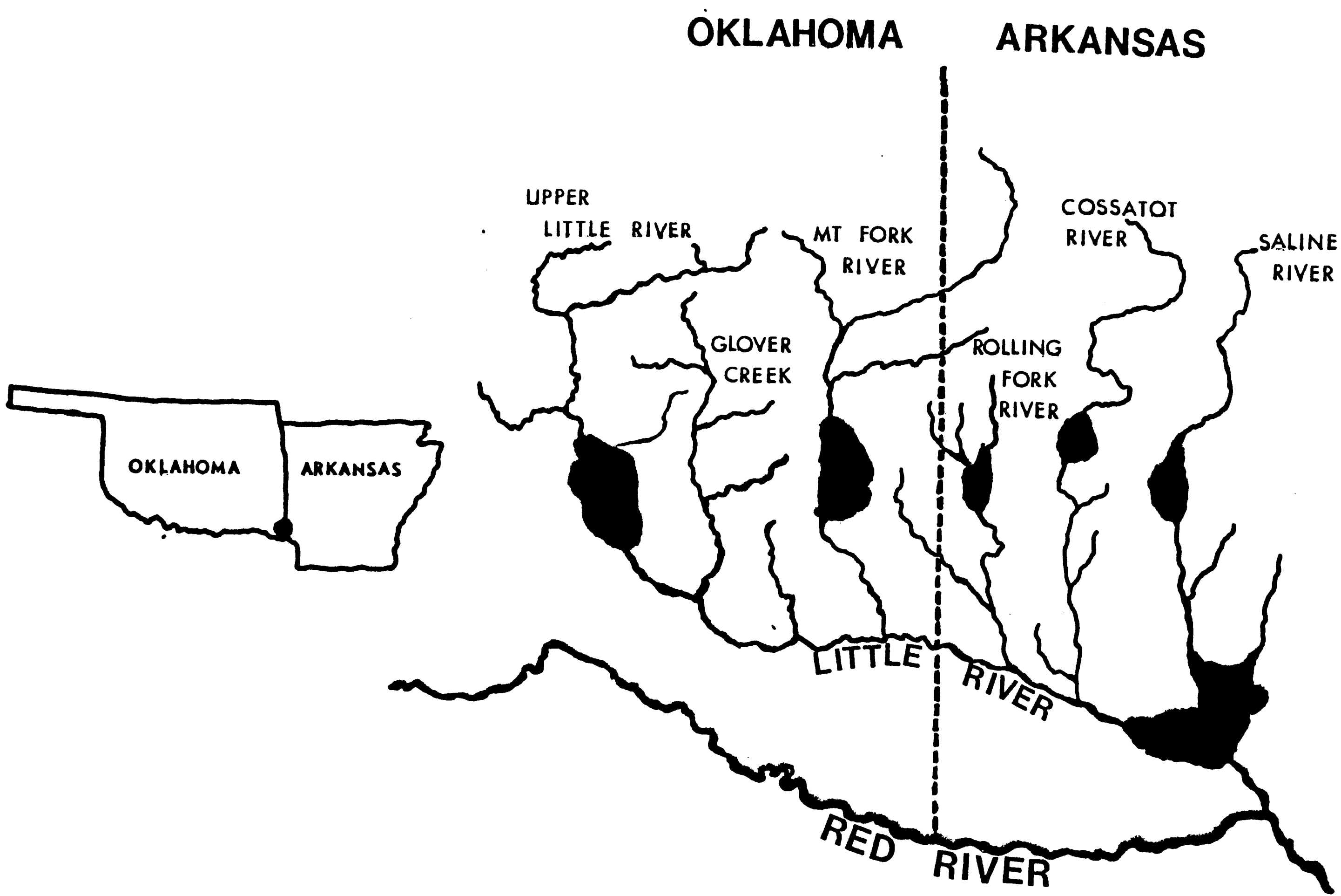

Figure 1. Little River System, Oklahoma and Arkansas.

Elevation ranges from 103 m mean sea level at the mouth to 610 m mean sea level at its source. The average stream gradient is 2.3 m/km, ranging from 19 m/km in the upper reaches to 1 m/km at the mouth (U. S. Army Corps of Engineers 1975).

The upper reaches of the Little River have irregularly shaped hills and mountains and short, steep, narrow, nearly parallel ridges. East-west folding of the terrain has produced a trellis-dendritic type of stream pattern. Mountains in the area range from 261 to 381 m above mean sea level (Finnell et al. 1956). Most of the area is heavily forested with oak and pine and commercial harvest of these forests is the principal economic activity in the area. Much of the watershed is privately owned or leased by the Weyerhaeuser Company.

The lower reaches of the region are low, fertile bottomlands used for livestock grazing and farming with most of the former woodlands converted to improved pasturelands. Streams in this area have long, deep pools separated by shallow riffles. Stream gradients are gentle with fine bottom materials and extensive silt deposits in the extreme lower reaches. Cut-off lakes in the Little River floodplain are common and surface area varies from 2.0 to 120 ha (Finnell et al. 1956).

Two main stream impoundments exist in the Little River drainage. Pine Creek Reservoir, on the Little River proper, is located about 5 km northwest of Wright City, Oklahoma. Broken Bow Reservoir, on the Mountain Fork River, is located about 14 km north of Broken Bow, Oklahoma (Maughan et al. 1983).

The climate of the Little River drainage area is humid and mesothermal with long, hot summers and short, mild winters. The average annual temperature is 18°C with a growing season of about 235 days.

Annual rainfall varies from 71 to 170 cm per year with a mean of 44 cm. In spring, intermittent heavy rain and daily showers cause heavy flooding in most stream areas. Stream flows are erratic in spring and winter, and peak discharges may occur from December through August. During summer, flows are typically low and subsurface flow exists between pools (Maughan et al. 1983).

CHAPTER III

METHOD AND MATERIALS

Physical Characteristics

The Little River System (LRS) in Oklahoma was divided into four segments, the Upper Little River (ULR), Lower Little River (LLR), Glover Creek (GLC), and Mountain Fork (MTF). A total of 43 sites (Table 1) were sampled, ten in the ULR, six in the LLR (Figure 2), 15 in the GLC (Figure 3), and 12 in the MTF (Figure 4).

The ULR sites were above Pine Creek Reservoir and had gradients ranging from 1.0 to 9.2 m/km. The altitudes ranged from 198.1 to 362.7 m and stream order from 2° to 5°.

The LLR sites were located below Pine Creek reservoir in tributaries on the north side of the river. Gradients ranged from 1.0 m/km to 10.5 m/km, altitudes from 118.9 m to 179.8 m, and stream orders from 2° to 5°.

In the GLC, seven sites were sampled on the mainstem and eight on the tributaries. Gradient ranged from 1.2 m/km to 12.2 m/km, altitudes from 185.9 m to 268.2 m, and stream orders from 1° to 5°.

In the MTF, all sites sampled were on tributaries. The gradient varied from 2.5 m/km to 22.9 m/km, altitudes ranged from 37.7 m to 281.9 m, and stream orders ranged from 1° to 4°.

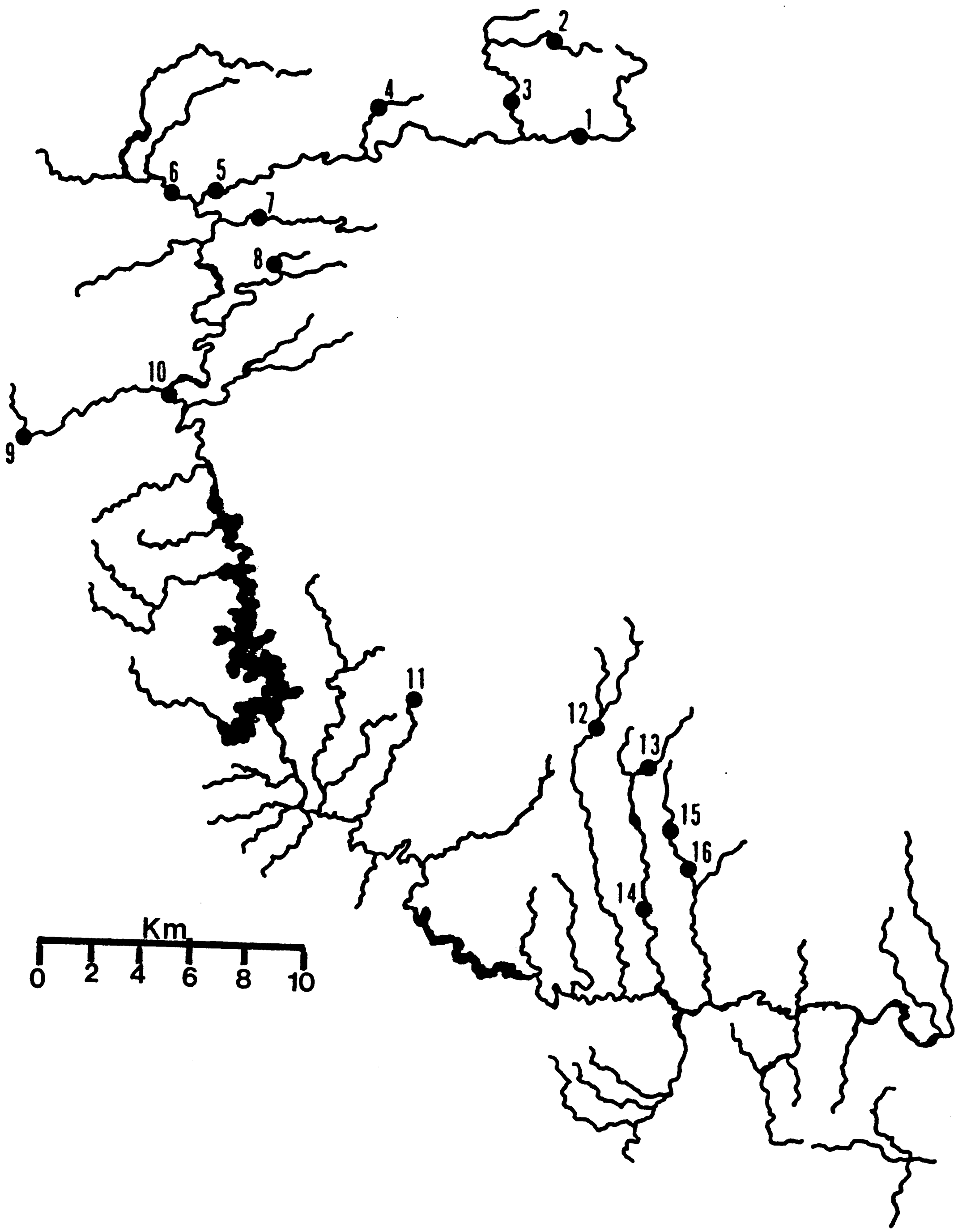

Figure 2. Sampling sites on the Upper and Lower Little River, McCurtain County, Oklahoma.

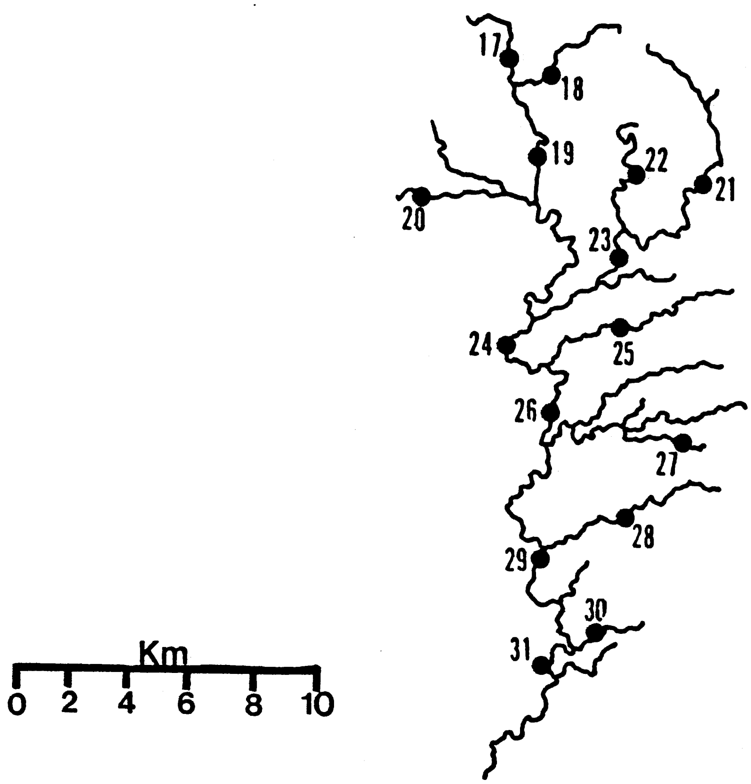

Figure 3. Sampling sites on the Glover Creek drainage, McCurtain County, Oklahoma.

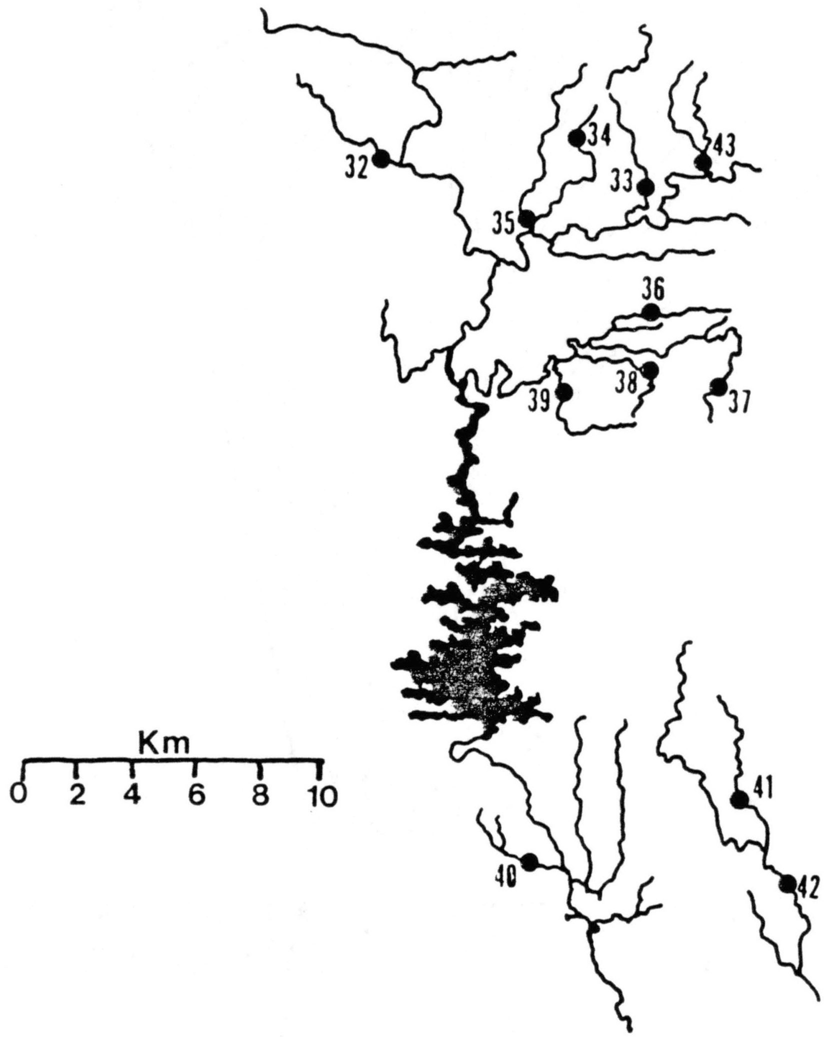

Figure 4. Sampling sites on the Mt. Fork Creek drainage, McCurtain County, Oklahoma.

Sampling Time and Method

Single samples were taken from 41 sites between 20-24 July 1982 and two additional sites on 11 August 1982. Benthic organisms were collected in riffles using a Circular Depletion Sampler (Carle and Maughan 1980). This sampler encloses an area of 0.25 m^2 of stream bottom. To obtain a sample the bottom edge of the sampler was buried in the substrate to a depth of 10 to 15 cm to prevent movement out of the sample area. The substrate was then agitated for 1 min and water currents carried organisms into the collecting net. The organisms were preserved in 10% formalin and the agitation process was repeated. Three units of effort were made at each site.

In the laboratory, samples were washed, the formalin and water replaced by 70% ethanol, and organic rose bengal stain. After staining, the samples were separated and identified to family using keys by Pennack (1953), Usinger (1968), Edmunds et al. (1976), Wiggins (1977), and Merritt and Cummins (1978).

Physical and Chemical Measurements

Water temperature, specific conductivity, pH, depth, velocity, and substrate type were measured at each site. Water temperature and specific conductivity were measured using a Yellow Springs Instrument (YSI) combination conductivity and temperature meter. The pH was measured with a YSI pH meter. Velocity was determined at 0.6 of the depth using a Pygmy-Gurly current meter, and substrates were classified using the Modified Wentworth Particle Size Scale (Bovee and Cochnauer 1977) Appendix A. Stream gradient, altitude of the stream, stream order

(Table IV), and percentage of each age clearcut (ages ranging 1-4+) in the catchment basin were also calculated.

Data Analysis

The Shannon-Weaver diversity index (Shannon and Weaver 1963) was used for analysis of the data.

$$\bar{d} = -\sum_{1}^{s} (n_i/n) \times \log_2 (n_i/n)$$

Diversity indices were analyzed by using the Statistical Analysis System (SAS) procedure 'Stepwise'. The Stepwise multiple regression procedure is an exploratory analysis for determining relationships between dependent and independent variables (Ray 1982) which identify the sources of variance in diversity. Diversity was set in the model statement as the dependent variable against values for pH, conductivity, velocity, depth, substrate type, gradient, altitude, stream order, and CC1, CC2, CC3, and CC4 (the percentage of age 1, 2, 3, and 4 year old clearcuts contained within the catchment basin of each stream site). The option used with the model was MaxR, a procedure which develops the multi-variable model that gives the best R-square (R^2) improvement. This procedure starts with one variable and builds sequentially by switching and adding variables until $R^2 = 1.0$ or until all the variables are used.

Diversity values were calculated from total numbers of organisms collected for the three combined sampling efforts and streams which had age 1 clearcuts were compared using the Student's t-test with those with no age 1 clearcuts. Community structure was also analyzed using the presence and absence of families in relationship to clearcutting and trophic structure. The null hypothesis was that no differences existed in the means whether the site category was CC1=0.0 (site with no age 1 clearcuts) or CC1>0 (site with age 1 clearcuts). For further analysis, $\overline{d}$ was converted to Pielou's H' and family equivalency values derived (Pielou 1975). These values were then used to identify taxa that were important in the variance of $\overline{d}$(H') values and to identify those taxa that dominated the benthic populations.

A ratio was also developed between family equivalency (FE) and number of taxa present (NTP). In this ratio the higher the FE:NTP value, the fewer the number of important families. Ratios for CC1 were compared with CC2 sites. Trophic levels of dominant families (excluding chironomidae) were compared based on feeding mechanisms and general particle size range of food ingested (Cummins 1973). The four categories used were shredders (>10^3 microns), collectors (<10^3 microns), scrapers (<10^3 microns), and predators (>10^3 microns). Each important family was assigned to a trophic level following Pennack (1953), Merritt and Cumming (1978), and Cummins (1973), and the numbers of families in each trophic level for each site classification were averaged over the number of sites. Data from the sites with no age 1 or age 2 clearcuts (-,-) were compared with those containing age 1 and age 2 clearcuts (+,+); those containing age 1 but not age 2 clearcuts (+,-); and those containing age 2 but no age 1 clearcuts (-,+).

CHAPTER IV

RESULTS

None of the models for the data from the entire Little River System (Table I) were significant (p=0.05) and evaluation of linear relationships showed that no variables were strongly correlated to diversity (Table II). The model that provided the the highest R^2 accompanied by the highest significane level was a two variable model based on conductivity and substrate (Table I). The seven variable model (conductivity, substrate, CC3, CC4, altitude, order, and depth) accounted for 83% of the variance. Substrate had the strongest correlation to diversity and each significant model included substrate.

A five variable model (R^2 of 100%) for relating diversity to physical factors in the Upper Little River contained the variables pH, conductivity, CC3, CC4, and altitude (Table I). Substrate was again the variable most strongly correlated with diversity (.69) followed by CC1 (.38) and CC2 (.38).

Data from the Lower Little River (Table I) yielded a significant (p=0.05) seven-variable model (conductivity, velocity, CC1, CC2, altitude, gradient, and order) that accounted for 100% of the variance in diversity. Conductivity and pH were the factors most strongly correlated (.72 and .48, respectively) with diversity (Table II).

For Glover Creek, seven models produced significant correlation between diversity and physical factors (Table I). Model 8 accounted for

TABLE I

STEPWISE MODELS FOR ALL SEGMENTS OF LITTLE RIVER DRAINAGE; LR = LITTLE RIVER, ULR = UPPER LITTLE RIVER, LLR = LOWER LITTLE RIVER, GLC = GLOVER CREEK, AND MFR = MOUNTAIN FORK RIVER. X INDICATES WHERE A VARIABLE WAS USED IN THE MODEL

Loc. Model #	R^2 (%)	Variables: Altitude	Conductivity	CC1	CC2	CC3	CC4	Depth	Gradient	Order	pH	Substrate	Velocity
LR													
1.										X			
2.										X		X	
3.			X							X		X	
4.*			X							X		X	X
5.			X				X			X		X	X
6.		X	X				X			X		X	X
7.		X	X				X		X	X		X	
8.		X	X		X		X	X		X		X	X
8.		X	X		X		X		X	X		X	X
9.		X	X		X		X	X	X	X		X	X
10.		X	X		X		X	X	X	X	X	X	X
11.		X	X	X	X		X	X	X	X	X	X	X
12.		X	X	X	X	X	X	X	X	X	X	X	X
ULR & LLR													
1.												X	
2.*	52		X									X	
3.		X	X									X	
4.		X	X						X			X	
5.		X	X			X			X			X	
6.		X	X			X	X	X				X	
7.		X	X			X	X		X	X		X	
7.*	83	X	X			X	X	X		X		X	

TABLE I (Continued)

Loc. Model #	R^2(%)	Altitude	Conductivity	CC1	CC2	CC3	CC4	Depth	Gradient	Order	pH	Substrate	Velocity
						Variables							
8.		X	X			X	X	X		X		X	X
9.		X	X	X		X	X	X	X	X			
9.		X	X	X		X	X		X	X		X	X
10.		X	X		X	X		X	X	X		X	X
10.		X	X	X		X	X	X	X		X	X	X
11.		X	X	X		X	X	X	X	X	X	X	X
12.		X	X	X	X	X	X	X	X	X	X	X	X
ULR													
1.												X	
2.		X										X	
2.		X	X										
3.		X	X				X						
4.		X	X			X	X						
5.*	100	X	X			X	X				X		
LLR													
1.			X										
2.			X									X	
3.			X	X								X	
4.			X	X					X			X	
4.			X		X				X			X	
5.			X		X				X	X		X	
6.			X		X				X	X		X	X
6.			X	X	X				X	X			X
6.		X	X	X	X				X	X			
7.*	100	X	X	X	X				X	X			X

TABLE I. (Continued)

Loc. Model #	R^2(%)	Altitude	Conductivity	CC1	CC2	CC3	CC4	Depth	Gradient	Order	pH	Substrate	Velocity
						Variables							
GLC													
1.							X						
2.			X				X						
3.			X				X				X		
4.			X	X			X				X		
5.			X	X			X			X	X		
6.			X	X			X			X	X	X	
7.			X	X		X	X			X	X	X	
7.			X	X		X	X	X			X	X	
8.*	86		X	X		X	X	X			X	X	X
9.			X	X	X	X	X	X			X	X	X
10.		X	X	X	X	X	X	X			X	X	X
10.		X		X	X	X	X	X	X		X		X
11.		X	X	X	X	X	X	X		X	X	X	X
11.		X	X	X	X	X	X	X	X		X	X	X
12.		X	X	X	X	X	X	X	X	X	X	X	X
MTF													
1.										X			
2.			X							X			
3.			X	X						X			
3.*				X			X			X			
4.*			X	X			X			X			
5.*			X	X			X			X		X	
6 *		X	X	X			X			X		X	
7.*		X	X	X			X		X	X		X	
7.*			X	X			X	X		X	X	X	
8.*			X	X	X		X	X	X		X	X	
9.*	100		X		X	X	X	X			X		X

* sig. at $p<0.05$ ** $R2=1.00$

TABLE II

CORRELATION COEFFICIENTS BETWEEN DIVERSITY AND PHYSICAL VARIABLES IN THE LITTLE RIVER SYSTEM
NUMBERS IN PARENTHESES EQUAL SAMPLE SIZE

Variable	Little River System	Upper and Lower Little River	Upper Little River	Lower Little River	Glover Creek	Mountain Fork
Altitude	0.02 (42)	-0.05 (16)	0.16 (7)	0.13 (9)	-0.00 (15)	0.03 (11)
CC1	0.11 (39)	0.17 (14)	-0.14 (7)	0.72 (9)	0.02 (15)	0.00 (12)
CC2	-0.05 (39)	0.00 (14)	0.38 (6)	0.08 (8)	0.20 (15)	-0.09 (10)
CC3	0.07 (39)	0.09 (14)	0.38 (6)	-0.21 (8)	0.17 (15)	-0.09 (10)
CC4	0.18 (39)	-0.12 (14)	0.09 (6)	0.32 (8)	0.25 (15)	-0.16 (10)
Conductivity	0.18 (43)	0.37 (16)	-0.30 (6)	0.19 (8)	0.43 (15)	0.40 (10)
Depth	0.17 (43)	0.16 (16)	0.22 (7)	0.15 (9)	0.17 (15)	0.23 (12)
Gradient	-0.05 (42)	0.06 (16)	0.16 (7)	-0.01 (9)	0.03 (15)	-0.24 (11)
Order	0.28 (43)	0.08 (16)	0.10 (7)	0.08 (9)	0.39 (15)	0.55 (12)
pH	0.14 (43)	0.21 (16)	-0.17 (7)	0.48 (9)	0.15 (15)	0.11 (12)
Substrate	0.10 (43)	0.46 (16)	0.18 (7)	0.38 (9)	-0.14 (15)	-0.19 (12)
Velocity	0.13 (43)	-0.02 (16)	0.69 (7)	0.17 (9)	0.39 (15)	0.20 (12)

86% of the variance and included pH, conductivity, velocity, CC1, CC3, CC4, substrate, and depth. Linear comparisons showed CC4 (.43), order (.39), and velocity (.39) had the highest correlations with diversity (Table II).

A nine variable model (pH, conductivity, velocity, CC2, CC3, CC4 and depth) accounted for 100% of the variance (Table I) in the corrleation between diversity and physical factors in the Mountain Fork River. Seven of nine other models were also significant. Stream order (.55), CC4 (.40), and depth (.23) had the highest correlations with diversity (Table II).

When all the data was considered, diversity was not significantly different between the CC1>0 and CC1=0 sites (80% confidence level). When the data from the 4° and 5° streams were deleted from the analysis, (the CC1=0.0 category contained no data from 4° or 5° streams), the confidence level was reduced to 75%. Number of organisms and families were significantly higher at CC1>0.0 sites for all stream orders and when stream orders, 4° and 5° were excluded from the analysis.

Conductivity was significantly lower ($p<0.0005$) and depth and velocity were significantly higher in all stream order categories at CC1>0.0 than at CC1=0.0 sites , but differences between pH and substrate type in the two types of sites were not significant. Depth was significantly higher (99.095% confidence level for all streams and 90% confidence level for stream orders 1° to 3°) for CC1>0.0 sites vs CC1=0.0 sites (Tables III-IV).

T-test comparisons made within drainages (Table V) of pH, conductivity, velocity, and depth showed that only conductivity was significantly different for each comparison. In the ULR and LLR, CC1>0 sites had significantly higher conductivity values than CCl=0 sites. However, in the GLC and MTF CCl>0.0 had significantly lower conductivity values than CCl=0 sites.

TABLE III

T-TEST COMPARISONS OF PHYSICAL AND BIOLOGICAL CHARACTERISTICS BETWEEN CCl>0 SITES AND CCl=0 SITES

Factor	CCl = 0 ($\bar{x}$) N=15	CCl > 0 ($\bar{x}$) N=24	Significance level
Diversity	3.16	3.34	0.200
No. of individuals	1700.67	2882.17	***
No. of families	30.20	31.58	0.050
Conductivity (μmhos/cm)	83.40	67.75	***
Velocity (cfs)	17.47	23.42	0.025
pH	6.41	6.31	ns
Substrate type	5.63	5.66	ns
Depth (cm)	9.07	11.75	0.0005

*** highly significant: $p < 0.0005$

Mean velocity (Table V) was significantly lower for CCl>0 sites in both the ULR and LLR than for CCl=0 sites in these areas. However, in the GLC and MTF, CCl>0 velocity means were significantly higher than those at CCl=0 sites. Depth was significantly higher in CCl>0.0 sites than in CC1=0 areas in GLC and MTF, but was significantly lower at CC1>0 than at CC1=0 sites in the LLR.

Both number of individuals and families of insects were significantly higher at CC1>0 sites than at CC1=0 sites . Within drainage comparisons using data from all streams resulted in higher numbers of families in the ULR and LLR in CC1>0 sites than in CC1=0, but the reverse occurred in the GLC and MTF . Comparisons using data for only stream orders of 1° to 3° generally produced similar results (Table VI).

TABLE IV

T-TEST COMPARISONS OF PHYSICAL AND BIOLOGICAL CHARACTERISTICS BETWEEN CC1>0 SITES AND CC1=0 SITES FOR 1°, 2°, AND 3° STREAMS

Factor	CC1 = 0 ($\bar{x}$) N=15	CC1 > 0 ($\bar{x}$) N=14	Significance level
Diversity	3.16	3.35	0.25
No. of individuals	1700.67	1895.43	***
No. of families	30.20	31.78	0.050
Conductivity (μmhos/cm)	83.40	74.71	0.010
Velocity (cfs)	17.47	19.93	0.005
pH	6.41	6.20	ns
Substrate type	5.63	5.71	ns
Depth (cm)	9.07	11.50	0.1

*** highly significant: $p < 0.0005$

Most families were represented in both CCl=0 and CCl>0 sites (Table VI). Exceptions to this generalization were Gyrinidae, Limnichidae, three families of unidentified Coleoptera, one unidentified Arachnoidea, Diptera A, Baetiscidae, Tricorythidae, Planorbidae, Mesoveliidae, Saldidae, Veliidae and Limnephilidae. Excluding families that occurred at only one site, only Baetiscidae and Tricorythidae were collected exclusively at CCl>0.0 sites. Both mayfly families are typically found among the fine sand and gravel from small creeks to large rivers and are collectors and gathers.

Within drainage comparisons for presence and absence of families showed nearly as many families were present in CCl>0, but absent in CCl=0 as vice versa. The families, Amphipoda (45.87% vs 13.33%), Lumbriculidae (70.89% vs 53.33%), Siphlonuridae (91.74% vs 73.33), Isopoda (62.55% vs 40.00%), Sialidae (29.19% vs 13.33%), Turbellaria (75.06 vs 53.55%), Hydroptilidae (83.40% vs 53.33%), and Philopotomidae (95.83% vs 80.00%) were more prevalent in the CCl>0.0 than in CCl=0.0 sites. Five families, Coenagrionidae (86.66% vs 75.06%), Coryduligastridae (73.33% vs 66.72%), Helicopsychidae (53.33% vs 37.53%), Hydropsychidae (100.00% vs 50.00%) and Polycentropodidae (93.33% vs 79.23%) were more prevalent in the CCl=0.0 then in the CCl>0.0 sites. The families that were more prevalent at the CCl>0.0 sites were predominantly collectors and scrapers and those families more prevalent at the CCl=0.0 were predominantly predators and collectors (Table VI).

TABLE V

DRAINAGE COMPARISONS BETWEEN MEAN DIVERSITY, NUMBER OF INDIVIDUALS, NUMBER OF TAXA, AND PHYSICAL AND CHEMICAL VALUES FOR ALL STREAM ORDERS AND STREAM ORDERS, 1°, 2°, and 3°. SIGNIFICANCE LEVEL IS GIVEN IN PARENTHESIS. ULR= UPPER LITTLE RIVER, LLR= LOWER LITTLE RIVER, GLC = GLOVER CREEK AND MTF = MOUNTAIN FORK RIVER

Drain.	N		Diversity		# Individuals		# Families		pH		Conductivity (µmhos/cm)		Velocity (cfs)		Depth (cm)	
	=0	>0	=0	>0	=0	>0	=0	>0	=0	>0	=0	>0	=0	>0	=0	>0
All Stream Orders																
ULR	2	4	3.0	3.6	1241	2375	24	37	6.2	6.2	41	54	32	14	10	12
					(0.0005)		(0.05)				(0.025)		(0.005)			
LLR	2	6	3.2	3.8	1481	2081	29	34	6.1	6.5	32	127	19	14	15	11
					(0.0005)		(0.005)				(0.005)				(0.025)	
GLC	7	8	3.1	3.2	1985	4201	31	28	6.4	6.2	96	56	17	14	10	13
					(0.0005)		(0.025)				(0.005)		(0.005)		(0.005)	
MTF	4	6	3.2	3.4	1543	2264	32	31	6.5	6.5	51	48	10	18	6	11
					(0.0005)										(0.005)	
1°, 2° and 3° Order Streams																
ULR	2	3	3.0	3.7	1241	1666	24	35	6.2	6.1	52	32	22	19	9	15
					(0.0005)		(0.005)				(0.005)				(0.025)	
LLR	2	6	3.3	3.4	1481	2081	30	34	6.6	6.4	138	123	32	15	14	8
					(0.0005)		(0.05)				(0.0005)					

TABLE V (Continued)

All Stream Orders

Drain.	N =0	N >0	Diversity =0	Diversity >0	# Individuals =0	# Individuals >0	# Families =0	# Families >0	pH =0	pH >0	Conductivity (μmhos/cm) =0	Conductivity (μmhos/cm) >0	Velocity (cfs) =0	Velocity (cfs) >0	Depth (cm) =0	Depth (cm) >0
GLC	7	2	3.1	3.0	1985	2358	31	26	6.4	5.5	96	41	17	27	10	15
					(0.025)		(0.025)								(0.025)	
MTF	4	3	3.2	3.2	1543	1445	32	29	6.5	6.5	51	44	10	26	6	10
					(0.005)		(0.05)						(0.005)		(0.025)	

TABLE VI

FREQUENCY OF OCCURRENCE OF MACROINVERTEBRATE FAMILIES IN THE LITTLE RIVER SYSTEM. N=43 FOR ALL SITES; 24 CC1>0 SITES AND 15 CC1=0. NUMBER OF SITES AT WHICH THE TAXA OCCURRED IS SHOWN IN PARENTHESIS.

Taxa	All sites	CC1>0	CC1=0
Amphipoda	33 (14)	46 (11)	13 (2)
Annelida			
Annelida 'A'	36 (15)	38 (9)	33 (5)
Hirudinea	16 (7)	17 (4)	13 (2)
Lumbriculidae	61 (27)	71 (17)	53 (8)
Oligocheata	56 (24)	54 (13)	60 (9)
Arachnoidea			
Hydracarina	100 (43)	100 (24)	100 (15)
Mite 'A'	5 (2)	8 (2)	0 (0)
Cladocera			
Daphnia sp.	14 (6)	8 (2)	20 (3)
Cnidaria	12 (5)	13 (3)	13 (2)
Coleoptera			
'A'	12 (5)	8 (2)	13 (2)
'B'	5 (2)	0 (0)	7 (1)
'C'	5 (2)	0 (0)	7 (1)
Dytiscidae	16 (7)	17 (4)	13 (2)
Elmidae	100 (43)	100 (24)	100 (15)
Gyrinidae	2 (1)	0 (0)	7 (1)
Haliplidae	14 (6)	8 (2)	27 (4)
Limnichidae	2 (1)	0 (0)	7 (1)
Psephnidae	98 (42)	96 (23)	100 (15)
Unidentified	2 (1)	4 (1)	0 (0)
Decapoda	70 (30)	71 (18)	67 (10
Diptera			
Blepharceridae	5 (2)	4 (1)	7 (1)
Ceratopogonidae	49 (21)	50 (12)	47 (7)
Chironomidae	100 (43)	100 (24)	100 (15)
'A'	16 (17)	38 (9)	40 (6)
'B'	14 (6)	21 (5)	7 (1)
'C'	2 (1)	4 (1)	0 (0)
Psychodidae	12 (5)	8 (2)	20 (3)
Ptychopteridae	7 (3)	0 (0)	20 (3)
Pupae	98 (42)	98 (23)	100 (15)
Simuliidae	38 (17)	29 (7)	53 (8)

TABLE VI (Continued)

Taxa	All sites	CC1>0	CC1=0
Tabanidae	49 (21)	50 (12)	53 (8)
Tipulidae	78 (34)	83 (20)	80 (12)
Empheroptera			
Baetidae	9 (38)	92 (22)	80 (12)
Baetiscidae	14 (6)	21 (5)	0 (0)
Caenidae	91 (39)	88 (21)	100 (15)
Ephemeridae	38 (17)	42 (10)	33 (5)
Heptagenidae	100 (43)	100 (24)	100 (15)
Leptophlebidae	81 (35)	71 (17)	100 (15)
Siphlonuridae	86 (37)	92 (22)	73 (11)
Tricorythidae	14 (6)	21 (5)	0 (0)
Eucopepoda	57 (28)	67 (16)	67 (10)
Gastropoda			
Ancylidae	54 (23)	54 (13)	53 (8)
Planorbidae	7 (3)	13 (3)	0 (0)
Unidentified	23 (0)	29 (7)	20 (3)
Hemiptera			
'A'	56 (24)	46 (11)	67 (10)
Mesoveliidae	2 (1)	0 (0)	7 (1)
Saldidae	2 (1)	0 (0)	7 (1)
Veliidae	5 (2)	4 (1)	7 (1)
Isopoda	56 (24)	63 (15)	40 (6)
Lepidoptera			
Pyralidae	72 (31)	67 (16)	87 (13)
Megaloptera			
Corydalidae	81 (35)	80 (19)	80 (12)
Sialidae	21 (9)	29 (7)	13 (2)
Mollusca	56 (24)	71 (17)	27 (4)
Nematoda	61 (26)	67 (16)	53 (8)
Odonata			
Aeshnidae	7 (3)	4 (1)	7 (1)
Agrionidae	2 (1)	0 (0)	0 (0)
Coenagrionidae	78 (34)	75 (18)	87 (13)
Cordulidae	5 (2)	4 (1)	7 (1)
Coryduligastridae	70 (30)	67 (16)	73 (11)
Gomphidae	12 (5)	8 (2)	13 (2)
Libellulidae	35 (16)	38 (9)	40 (6)

TABLE VI (Continued)

Taxa	All sites	CC1>0	CC1=0
Ostracoda	36 (16)	38 (9)	40 (6)
Platyhelminthes			
Turbellaria	60 (29)	75 (18)	53 (8)
Plecoptera			
Chloroperlidae	30 (13)	29 (7)	27 (4)
Perlidae	61 (26)	54 (13)	60 (9)
Perlodidae	2 (1)	0 (0)	0 (0)
Unidentified	14 (6)	17 (4)	13 (2)
Trichopteridae			
Helicopsychidae	47 (20)	38 (9)	53 (8)
Hydropsychidae	72 (31)	50 (12)	100 (15)
Hydroptilidae	72 (31)	83 (20)	53 (8)
Limnephilidae	2 (1)	0 (0)	7 (1)
Molanidae	7 (3)	8 (2)	7 (1)
Philopotomidae	91 (39)	96 (23)	80 (12)
Polycentropodidae	81 (35)	79 (19)	93 (14)
Pupae	60 (29)	79 (19)	47 (7)

The family equivalency was highest (fewest number of important families) for those sites having no age 1 and 2 clearcuts. Sites with age 1 and any 2 clearcuts (+,+) tended to show high numbers of important families. Comparison of sites containing no clearcut (-,-) to sites with age 1 clearcut but no age 2 (+,-) clearcuts, revealed the family equivalency increased following logging. Sites with no clearcuts (-,-) and those with only age 2 clearcut (-,+) were similar in family equivalency (Figure 5).

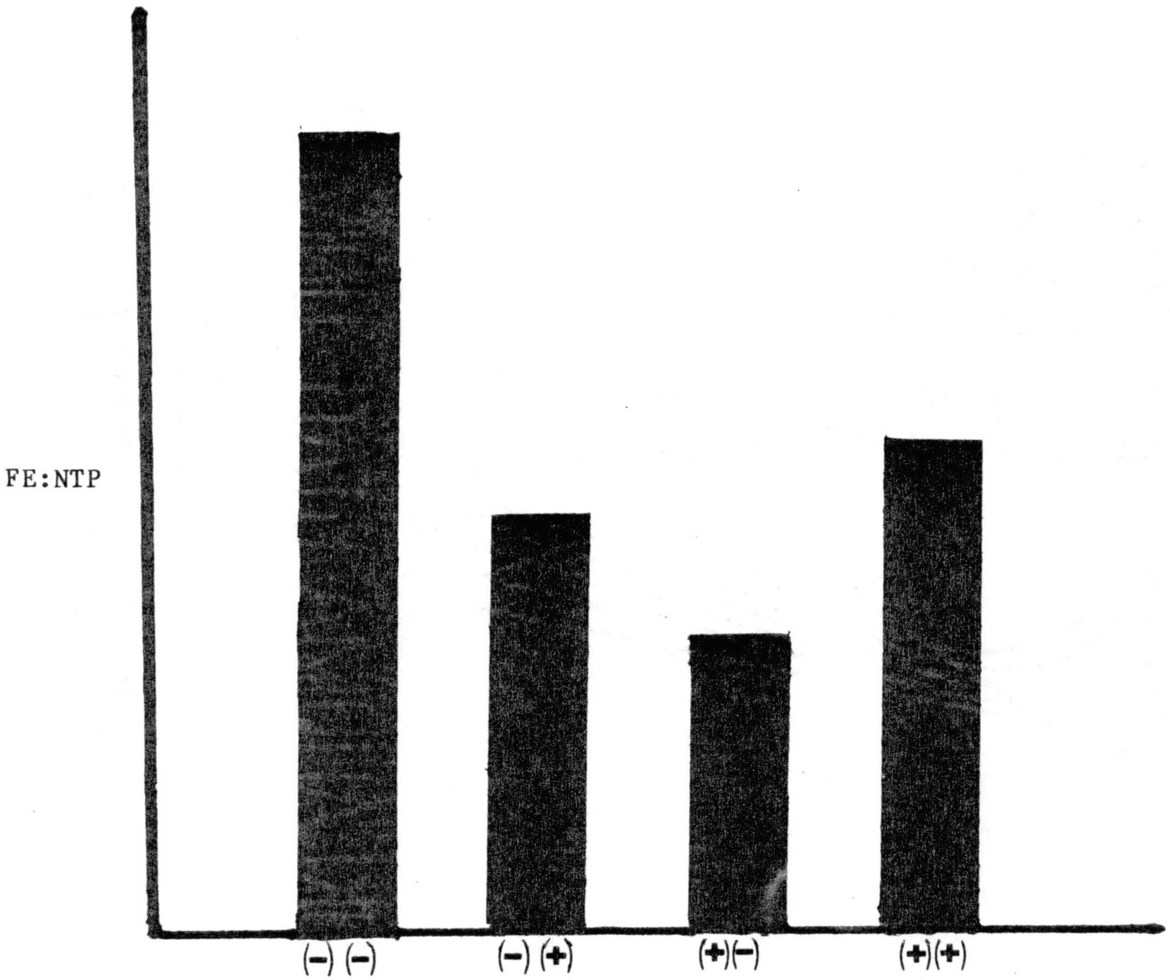

Figure 5. Ratio between family equivalency (FE) of benthic invertebrates and and number of taxa present (NTP) for sites in the Little River Drainage

Trophic structure analysis indicated that disturbed sites (+,+) showed increased scraper, shredder, and predator populations when compared to uncut sites. Shredders were not present in the sites where clearcuts did not occur. Sites with age 1 clearcuts were dominated by collectors; whereas, those with no clearcuts showed a balance of scrapers and collectors plus high numbers of predators. Sites with only age 2 clearcuts were similar in trophic structure to those with no clearcuts (Figure 6).

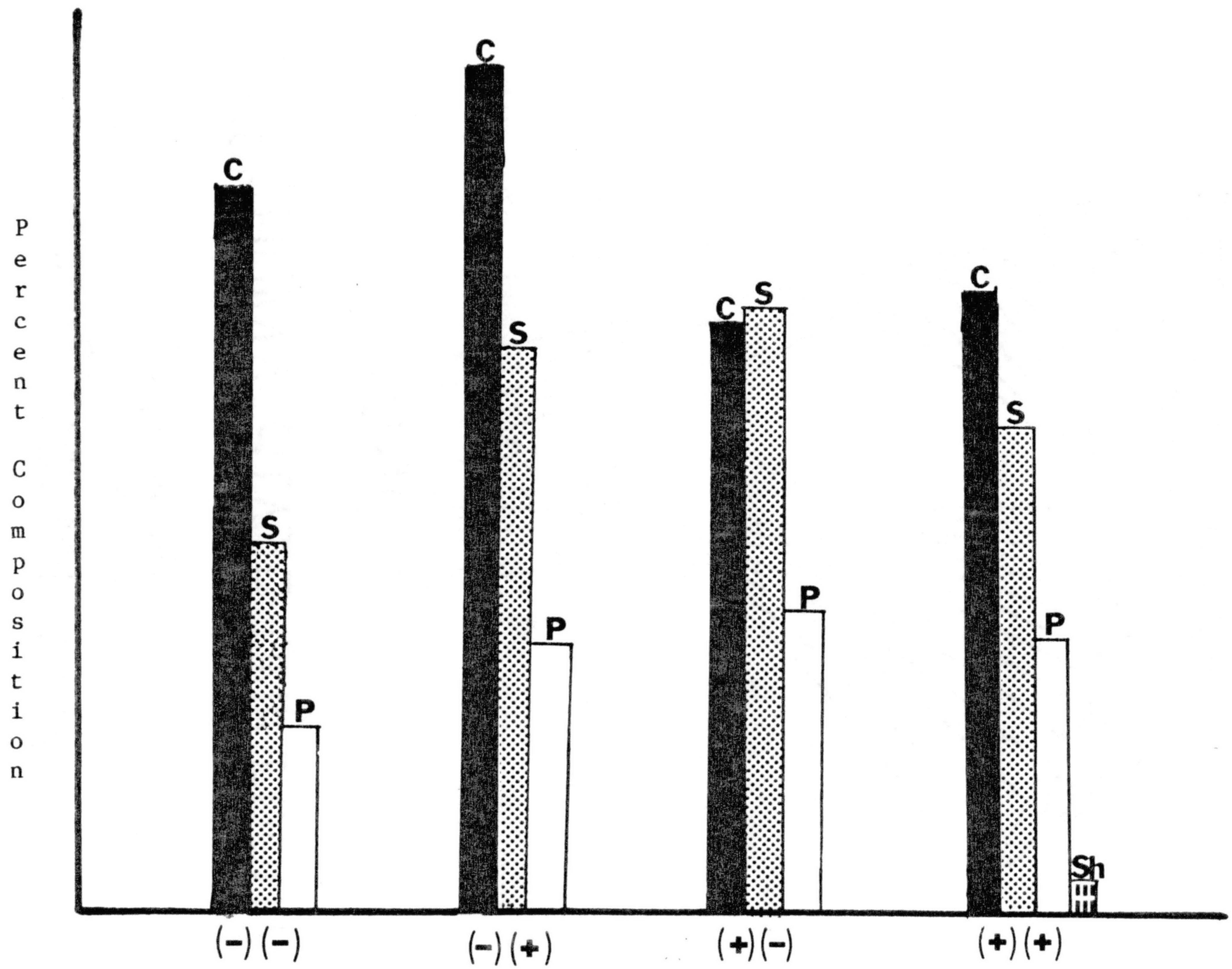

Figure 6. Trophic composition of (CC1)(CC2) communities. C=collectors, S=scrapers, P=predators and Sh=shredders.

CHAPTER V

DISCUSSION

Clearcutting resulted in few dramatic effects on benthic populations, but subtle differences occurred in physicochemical conditions and benthos following clearcutting. For example, on a drainage-wide basis, water depth and velocity were greater in CC1>0 than at CC1=0 sites. Increased depth and velocity could result from increased summer flows from clearcuts as has been reported by Reinhart et al. (1963) but may have also been the result of a sampling artifact caused from most of the CC1>0 sites being located on higher order streams. In contrast, conductivity was significantly higher in CC1=0 than in CC1>0 sites. This finding is unexpected because higher levels of soil litter in uncut sites should result in greater retention time of runoff so that sediments are not readily flushed out of the system. Significant difference did not exist in benthic diversity between clearcut and uncut sites, but greater numbers of organisms and families were found in the CC1>0 sites than in the CC1=0 sites. Newbold et al. (1980) also found an increased total benthic abundance but lower diversity of stream invertebrates following logging. The changes in diversity reported in Newbold et al. (1980) study seemed to be related to increased numbers of primary consumers.

The trends identified in the basin-wide analysis were not entirely consistent within each of the drainages studied. In the ULR and LLR, conductivity and number of families collected were significantly higher in the CC1>0 sites than at the CC1=0 sites while depth and velocity were higher at the CC1=0 sites than at the CC1>0 sites. In the MTF and GLC this trend was reversed. These differences may be due to the small sample sizes in the ULR and LLR. Larger sample sizes from GLC and MTF seem to indicate that data from these sites are more representative of changes produced by clearcutting.

Shifts in trophic structure such as those reported by Cummins (1979) and alterations in community structure such as those reported by Ellis (1936), Tebo (1957), Chapman (1962) , and Salo (1967) in clearcut areas were also seen. Baetiscidae and Tricorythidae were present in CC1>0 sites, but absent from CC1=0 sites. In addition, scrapers and collectors dominated the benthos in CC1>0 sites whereas collectors dominated the CC1=0.0 sites. Examples of collectors dominating the population were Elmidae, Philopotamidae, Baetidae, and Heptagenidae. Collectors can be filter or sediment feeders feeding on living algal cells or decomposing organic matter (Cummins 1973). Examples of scrapers were Siphlonuridae, Caenidae, Helicopsychidae, Hydroptilidae, and Eucopepoda. Scrapers fall into two categories mineral (substrate feeders) or organic (plant feeders), both of which are herbivores and feed on algae and periphyton (Cummins 1973). Conditions in CC1=0 sites resembled undisturbed communities (Odum 1959). Also an increase in predators such as Gomphidae, Corydalidae, Coenagrionidae, Perlidae, and Hydracarina was seen at the CC1>0.0 sites. Murphy and Hall (1981) and Gurtz (1981) reported similar changes in benthos after logging. Cummins (1974) hypothesized that predators increase in numbers when the members of lower trophic levels increase in numbers. The number within the lower trophic levels increase when the primary production is increased by opening up the canopy as reported by Murphy and Hall (1981).

The absence of dramatic differences in benthos between logged and unlogged sites could be used to hypothesize that changes did not occur or that recovery was rapid. The data discussed would seem to indicate that changes in benthos did occur after logging but that these changes were followed by rapid recovery. Rapid recovery is a common phenomenon and recolonization studies on running water benthos have shown that organisms reappear within 28 days after disturbance (Muller 1954, Waters 1964). Recovery of taxonomic diversity and population densities take longer and are dependent upon the severity and duration of the stress and availablity of organisms for recolonization (Cairns et al. 1971). Rapid recovery of benthos would be compatible with the hypotheses generated by Webster et al. (1975), O'Neil et al. (1975), and Webster and Patten (1979) that benthic communities in headwater streams of forested regions are resilient. These authors also hypothesized benthos in such streams have low resistance to perturbations. High resistance to perturbations might be expected in benthos in the present study because of the regularity of occurrence of seasonal catastrophes such as flash floods and drought.

Another possible explanation other than resilience for minimal long term changes in benthos, is rapid recovery of the terrestrial vegetation. Gurtz et al. (1980) reported recovery of benthos in small streams is controlled by the recovery rate of the surrounding terrestrial vegetation and Haefner and Wallace (1981) related recovery to the restoration of the quality, quantity, and timing of allochthonous organic inputs. This explanation does not seem to fit the data from my study because vegetative recovery was delayed by site preparation and burning and chemical removal of regrowth hardwoods. However, baseline data is not available on the community composition before clearcutting, and the possibility can not be entirely discounted.

Conclusions

Benthic diversity was not significant different between clearcut sites and non-clearcut sites. However, analysis of benthic populations at these sites revealed shifts in dominance of trophic levels that were connected with clearcutting.

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APPENDIXES

APPENDIX A

MODIFIED WENTWORTH PARTICLE SIZE SCALE

APPENDIX A

MODIFIED WENTWORTH PARTICLE SIZE SCALE (BOVEE AND COCHNAUER 1977) USED TO CLASSIFY SUBSTRATES

Substrate description	Size range	Numerical code value
Muck	Black, finely divided organic matter; completely decomposed	1
Detritus	Material recognizable as herbaceous or woody vegetation in various stages of decomposition	
Mud/clay	Compacted particles less than 0.004 mm in diameter; smooth, slick feeling between fingers	2
Silt	Non-compacted particles 0.004 mm to 0.06 mm in diameter	3
Sand	Particles 0.06 mm to 2.0 mm in diameter; gritty texture between fingers	4
Gravel	Rocks 2.0 mm to 64 mm in diameter (0.08 in. to 2.5 in.)	5
Rubble	Rocks 64 mm to 256 mm in diameter (2.5 in. to 10.0 in.)	6
Boulder	Rocks over 256 mm in diameter (> 10.0 in.)	7
Bedrock	Large mass of rock	8

APPENDIX B

SITE NUMBER, CREEK NAME, LEGAL DESCRIPTION, DATE OF COLLECTION, TIME OF DAY, GRADIENT, ALTITUDE AND STREAM ORDER OF COLLECTIONS SITES

APPENDIX B

SITE NUMBER, CREEK NAME, LEGAL DESCRIPTION, DATE OF COLLECTION, TIME OF DAY, GRADIENT, ALTITUDE AND STREAM ORDER OF COLLECTION SITES

Drainage	Site	Name	Legal description	Date	Time (mil.)	Gradient m/km	Altitude m	Stream Order °
Little River	1	Upper Little River	R23E T1N Sec. 27	7/23	0741	5.1	280.4	3
	2	Honobia Creek	R23E T2N Sec. 32	7/22	1751	9.2	362.7	3
	3	Honobia Creek	R22E T1N Sec. 13	7/22	1906	5.9	277.4	3
	4	Uphill Creek	R21E T1N Sec. 24	7/23	0915	6.3	253.0	2
	5	Little River	R20E T1S Sec. 17	8/11	1212	1.0	193.5	4
	6	Black Fork Creek	R20E T1S Sec 16	7/23	1330	3.3	195.1	4
	7	Watson Creek	R21E T1S Sec. 20	7/23	0937	5.7	198.1	3
	8	Pickens Creek	R21E T1S Sec. 33	8/11	0837	10.5	243.7	2
	9	Cloudy Creek	R19E T3S Sec. 16	7/23	1505	3.4	179.8	3
	10	Little River	R20E T3S Sec. 3	7/23	1654	1.0	155.4	5
	11	Horsepen Creek	R22E T5S Sec. 24	7/20	1630	6.3	149.3	3
	12	Lukfata Creek	R24E T5S Sec. 17	7/21	0900	2.1	155.4	3
	13	Yashau Creek	R24E T5S Sec. 23	7/21	0805	4.5	158.5	3
	14	Yashoo Creek	R24E T6S Sec. 20	7/20	0940	1.9	118.9	3
	15	Yunubbee Creek	R24E T5S Sec. 36	7/20	0809	4.8	138.7	3
	16	Yunubbee Creek	R25E T6S Sec. 7	7/20	1330	3.2	123.4	3
Glover Creek	17	W. Fork Glover Cr.	R22E T1S Sec. 11	7/22	1557	12.2	268.2	3
	18	East Creek	R22E T1S Sec. 18	7/22	1459	10.8	301.7	3
	19	W. Fork Glover Cr.	R23E T1S Sec. 31	7/22	1104	7.5	265.2	4
	20	Silver Creek	R22E T2S Sec. 17	7/22	1230	2.9	185.9	1
	21	E. Fork Glover Cr.	R24E T2S Sec. 5	7/22	0905	12.2	262.1	3
	22	Coon Creek	R23E T2S Sec. 2	7/22	1022	9.3	246.9	3

Drainage	Site	Name	Legal Description	Date	Time (mil.)	Gradient m/km	Altitude m	Stream Order °
Glover Cr.	23	E. Fork Glover Cr.	R23E T2S Sec. 24	7/22	0801	2.4	208.8	4
	24	Glover Creek	R23E T3S Sec. 13	7/21	1630	2.3	176.8	5
	25	Pine Creek	R23E T3S Sec. 11	7/22	0715	6.6	210.3	3
	26	Glover Creek	R23E T3S Sec. 32	7/22	1503	7.5	246.9	2
	27	Mid. Fork Carter Cr.	R23E T3S Sec. 31	7/21	1403	1.2	164.6	5
	28	Cedar Creek	R23E T4S Sec. 24	7/21	1300	6.7	179.8	3
	29	Glover Creek	R23E T4S Sec. 29	7/21	1120	2.7	131.1	5
	30	Lost Spring Creek	R23E T5S Sec. 14	7/21	1015	9.3	125.0	2
	31	Glover Creek	R23E T5S Sec. 14	7/20	1717	1.4	121.6	5
Mountain Fork River	32	Little Eagle Creek	R24E T1N Sec. 36	7/24	1550	5.9	247.2	4
	33	Beach Creek	R26E T1N Sec. 12	7/24	1249	7.5	237.7	3
	34	Hurricane Creek	R26E T1N Sec. 28	7/24	1446	22.9	281.9	2
	35	Hurricane Creek	R25E T1N Sec. 11	7/24	1210	3.1	217.9	4
	36	Little Dry Creek	R26E T2N Sec. 2	7/24	1021	4.6	254.5	2
	37	Rock Creek	R27E T2N Sec. 20	7/24	0914	10.3	271.3	2
	38	Mine Creek	R26E T2N Sec. 24	7/23	0828	6.6	256.0	2
	39	Big Hudson Creek	R26E T2N Sec. 20	7/24	0730	7.4	231.6	3
	40	Cooper Creek	R25E T6N Sec. 1	7/20	1145	6.0	120.4	3
	41	Pedro Creek	R27E T5N Sec. 8	7/20	1032	14.4	173.7	3
	42	Rock Creek	R27E T5N Sec. 33	7/20	0940	2.5	112.8	4
	43	Big Cow Creek	R27E T1N Sec. 20	7/24	1359	-	-	1

APPENDIX C

NUMBER OF OBSERVATIONS, MEANS, MINIMUMS AND MAXIMUMS FOR PHYSICAL VARIABLES FOR STUDY SITES IN THE LITTLE RIVER SYSTEM

APPENDIX C

NUMBER OF OBSERVATIONS, MEANS, MINIMUMS AND MAXIMUMS FOR PHYSICAL VARIABLES FOR STUDY SITES IN THE LITTLE RIVER SYSTEM

	Little River System				Upper and Lower Little River			
Variable	N	Mean	Minimum	Maximum	N	Mean	Minimum	Maximum
Altitude	42	201.98	37.7	362.7	16	198.96	118.9	362.7
Conductivity	43	71.23	28.0	365.0	16	85.31	28.0	287.0
CC1	39	2.65	0.0	10.1	14	3.11	0	6.6
CC2	39	4.00	0.0	18.0	14	3.24	0	9.0
CC3	39	1.83	0.0	9.0	14	2.39	0	5.8
CC4	39	19.71	0.0	73.3	16	18.14	0	32.7
Depth	43	10.65	2.0	21.0	16	11.56	6.0	21.0
Diversity	43	3.25	2.4	4.0	16	3.34	2.5	4.1
Gradient	42	6.20	1.0	22.9	16	4.64	1.0	10.5
Order	43	3.12	1.0	5.0	16	3.13	2.0	5.0
pH	43	6.37	5.2	7.5	16	6.36	5.8	7.0
Substrate	43	5.64	5.0	6.5	14	5.63	5.0	6.5
Velocity	43	23.61	0.0	80.0	16	23.67	0.0	80.0

APPENDIX C (Continued)

Variable	Upper Little River				Lower Little River			
	N	Mean	Minimum	Maximum	N	Mean	Minimum	Maximum
Altitude	7	251.46	193.0	362.7	9	158.12	118.9	243.7
Conductivity	7	41.86	28.0	59.0	9	119.11	35.0	287.0
CC1	6	1.90	0.0	4.9	8	4.01	0.0	6.6
CC2	6	1.25	0.0	5.5	8	4.74	0.0	9.0
CC3	6	1.42	0.0	4.1	8	3.13	0.0	5.8
CC4	6	13.23	0.0	26.2	8	21.81	12.3	32.7
Depth	7	12.57	6.0	20.0	9	10.78	6.0	21.0
Diversity	7	3.27	2.5	4.0	9	3.33	2.8	4.0
Gradient	7	5.21	1.0	9.2	9	4.19	1.0	10.5
Order	7	3.14	2.0	4.0	9	3.11	2.0	5.0
pH	7	6.20	5.9	6.5	9	6.48	5.8	7.0
Substrate	7	5.93	5.0	6.5	9	5.39	5.0	5.5
Velocity	7	20.57	0.0	44.0	9	25.89	0.0	80.0

APPENDIX C (Continued)

Variable	Glover Creek N	Mean	Minimum	Maximum	Mountain Fork N	Mean	Minimum	Maximum
Altitude	15	206.33	121.6	301.7	11	200.45	37.7	281.9
Conductivity	15	74.27	33.0	365.0	12	48.67	40.00	59.0
CC1	15	2.80	0.0	10.1	10	1.78	0.0	7.0
CC2	15	3.19	0.0	10.8	10	6.29	0.0	18.0
CC3	15	1.33	0.0	5.2	10	1.81	0.0	9.0
CC4	15	22.96	0.0	73.3	10	17.03	0.0	43.0
Depth	15	11.20	2.0	20.0	12	8.75	3.0	18.0
Diversity	15	3.18	2.5	3.6	12	3.25	2.4	3.9
Gradient	15	6.33	1.2	12.2	11	8.29	2.5	22.9
Order	15	3.40	1.0	5.0	12	2.75	1.0	4.0
pH	15	6.29	5.2	7.5	12	6.48	6.2	6.7
Substrate	15	5.70	5.0	6.5	12	5.58	5.0	6.5
Velocity	15	25.53	0.0	69.0	12	18.75	0.0	49.0

APPENDIX D

PERCENT (HA) OF DRAINAGE BASIN CLEARCUT ABOVE EACH OF THE STUDY SITES

APPENDIX D

PERCENT (HA) OF DRAINAGE BASIN CLEARCUT ABOVE EACH OF THE STUDY SITES

		Age in years			
Drainage	Site	1	2	3	4
Little River	1	4.3	5.5	0.0	25.5
	2	0.8	0.0	4.1	0.0
	3	1.4	0.0	1.4	2.7
	4	0.0	0.0	0.0	26.2
	5	-	-	-	-
	6	4.9	2.0	3.0	10.7
	7	0.0	0.0	0.0	14.3
	8	5.3	0.0	4.1	12.4
	9	0.0	6.9	2.8	12.3
	10	-	-	-	-
	11	0.0	0.0	5.8	32.7
	12	4.3	5.3	4.6	21.7
	13	5.7	5.5	0.0	22.6
	14	0.1	0.1	0.0	0.3
	15	6.6	6.5	4.5	20.7
	16	4.7	4.7	3.2	20.9
Glover Creek	17	3.6	10.8	0.0	0.0
	18	0.0	0.0	1.6	19.7
	19	4.7	4.8	2.9	21.1
	20	0.0	0.0	0.0	0.0
	21	0.0	3.5	0.0	24.3
	22	10.1	2.2	2.6	30.9
	23	5.3	2.6	0.6	24.9
	24	5.5	3.2	2.5	24.8
	25	0.0	4.7	0.0	24.3
	26	5.0	3.2	2.4	24.6
	27	0.0	8.9	0.0	15.2
	28	0.0	0.0	0.0	16.2
	29	4.2	3.0	2.5	22.1
	30	0.0	0.0	0.0	73.3
	31	4.1	2.7	5.2	22.0

APPENDIX D (Continued)

Drainage	Site	Age in years			
		1	2	3	4
Mountain Fork	32	1.6	4.3	0.0	22.9
	33	1.7	1.2	0.0	0.0
	34	0.0	18.0	0.0	0.0
	35	1.2	4.1	2.6	5.2
	36	0.0	0.0	0.0	0.3
	37	-	-	-	-
	38	0.0	12.0	0.0	25.4
	39	1.0	0.0	2.9	11.9
	40	7.0	10.5	9.0	43.0
	41	0.0	7.2	0.0	28.0
	42	5.3	5.6	3.6	33.6
	43	-	-	-	-

APPENDIX E

PHYSICAL AND CHEMICAL MEASUREMENTS TAKEN

AT EACH OF THE STUDY SITES

APPENDIX E

PHYSICAL AND CHEMICAL MEASUREMENTS TAKEN AT EACH OF THE STUDY SITES

Drainage	Site	Spec. Cond. (μmhos/cm)	pH	Depth (cm)	Vel. (cfs)	Substrate	Water Temp. (°C)
Little River	1	32	5.9	10	29	6.5 (B-R)	23
	2	28	6.0	14	20	6.5 (B-r)	29
	3	36	6.3	20	9	6.5 (B-R)	30
	4	49	6.1	12	0	5.5 (G-R)	25
	5	35	6.5	12	34	5.0 (B-S)	29
	6	59	6.2	14	8	6.0 (R)	31
	7	54	6.3	6	44	5.5 (G-R)	28
	8	35	5.8	9	12	5.5 (G-R)	25
	9	79	6.6	21	0	5.5 (G-R)	32
	10	60	6.8	12	80	5.0 (R-S)	35
	11	197	6.6	6	63	5.5 (G-R)	28
	12	287	6.9	16	0	5.5 (G-R)	26
	13	102	5.9	9	14	5.5 (G-R)	24
	14	129	6.4	10	0	5.5 (G-R)	28
	15	91	7.0	8	13	5.5 (G-R)	25
	16	92	6.3	6	51	5.0 (G)	30
Glover Creek	17	33	5.2	20	0	6.5 (B-R)	27
	18	48	6.5	15	0	6.5 (B-R)	30
	19	50	6.4	10	7	5.5 (G-R)	28
	20	61	5.6	2	0	5.5 (G-R)	29
	21	40	6.1	19	18	6.5 (G-R)	28
	22	48	5.7	10	53	5.5 (G-R)	27
	23	42	5.8	11	46	5.5 (G-R)	26
	24	55	7.1	12	43	5.0 (G)	33
	25	67	6.4	8	0	5.5 (G-R)	24
	26	60	7.5	10	51	5.5 (G-R)	33
	27	45	6.4	8	4	5.5 (R-G)	31
	28	43	6.1	7	69	5.5 (G-R)	27
	29	61	6.2	16	48	6.0 (R)	30
	30	365	7.4	8	25	5.5 (G-R)	24
	31	85	6.7	12	56	5.5 (G-R)	34

APPENDIX E (Continued)

Drainage	Site	Spec. Cond. (μmhos/cm)	pH	Depth (cm)	Vel. (cfs)	Substrate	Water Temp. (°C)
Mountain Fork	32	43	6.4	8	31	5.5 (G-R)	29
	33	42	6.6	10	23	5.5 (G-R)	30
	34	51	6.7	7	0	5.5 (B-S)	28
	35	55	6.4	18	0	6.5 (B-R)	28
	36	55	6.4	3	0	5.5 (G-R)	26
	37	51	6.6	8	45	5.5 (G-R)	23
	38	44	6.4	7	39	5.5 (G-R)	25
	39	50	6.4	7	49	5.0 (G)	25
	40	41	6.4	12	6	5.5 (G-R)	26
	41	53	6.5	7	0	5.5 (G-R)	29
	42	59	6.7	10	0	5.0 (G)	28
	43	40	6.2	8	32	6.5 (B-G)	27

APPENDIX F

DIVERSITY, TOTAL NUMBER AND NUMBER OF TAXA BY DRAINAGE AND STREAM ORDER AT EACH OF THE STUDY SITES

APPENDIX F

DIVERSITY, TOTAL NUMBER OF INDIVIDUALS AND NUMBER OF TAXA BY DRAINAGE AND STREAM ORDER AT EACH OF THE STUDY SITES

Stream Order	Site	N	$\bar{d}$	FE	Number of taxa	FE:NTP
1° Stream - none sampled		----	---	---	--	---
2°	ULR 4	1176	2.5	5.65	23	4.07
	ULR 8	983	3.3	9.84	28	2.84
3°	ULR 1	1870	3.8	13.92	38	2.73
	ULR 2	2096	3.1	8.57	31	3.62
	ULR 3	1031	4.1	17.14	35	2.04
	ULR 7	1306	3.5	11.31	25	2.21
	ULR 9	1342	3.0	8.00	28	3.50
4°	ULR 5	3591	2.6	6.06	36	5.94
	ULR 6	4496	3.3	9.84	43	4.37
5°	ULR 10	2319	3.6	12.12	25	2.06
1° Stream - none sampled		----	---	----	--	----
2° Stream - none sampled		----	---	----	--	----
3°	LLR 11	1620	3.5	11.31	33	2.92
	LLR 12	1619	4.0	16.00	40	2.50
	LLR 13	2071	3.5	11.31	32	2.83
	LLR 14	3632	3.1	8.57	35	4.08
	LLR 15	1552	3.6	12.12	32	2.64
	LLR 16	2632	2.8	7.00	25	3.57
4° Stream - none sampled		----	---	----	--	----

APPENDIX F (Continued)

Stream Order	Site		N	$\bar{d}$	FE	Number of taxa	FE:NTP
1°	GLC	20	2077	2.6	6.06	35	5.77
2°	GLC	27	249	3.2	9.18	22	2.40
	GLC	30	2909	3.2	9.18	42	4.58
3°	GLC	17	2105	2.7	6.50	25	3.85
	GLC	18	2975	3.0	8.00	31	3.88
	GLC	21	1861	3.6	12.12	30	2.48
	GLC	22	2611	3.3	9.84	26	2.64
	GLC	23	1787	3.3	9.84	27	2.74
	GLC	25	2037	3.1	8.57	28	3.27
4°	GLC	19	3186	3.5	11.31	32	2.83
	GLC	23	1199	3.4	10.55	30	2.84
5°	GLC	24	4552	3.2	9.18	30	3.27
	GLC	26	7968	3.1	8.57	30	3.50
	GLC	29	9055	3.2	9.18	29	3.16
	GLC	31	2933	3.3	9.84	23	2.34
1°	MTF	43	1703	2.4	5.28	32	6.06
2°	MTF	34	2166	2.7	6.50	31	4.77
	MTF	36	1442	2.8	7.00	33	4.71
	MTF	37	1111	3.6	12.12	34	2.81
	MTF	38	1817	3.7	13.00	33	2.54
3°	MTF	33	2507	3.3	9.84	33	3.35
	MTF	39	1156	3.1	8.57	22	2.56
	MTF	40	671	3.2	9.18	33	3.59
	MTF	41	746	3.7	13.00	32	2.46
4°	MTF	32	3871	3.9	14.92	40	2.68
	MTF	35	1791	3.5	11.31	31	2.74
	MTF	42	3585	3.1	8.57	25	2.91
5°	None sampled		----	---	----	--	----

APPENDIX G

NUMBER OF INDIVIDUALS PER TAXA COLLECTED FROM STUDY SITES

IN THE LITTLE RIVER DRAINAGE

APPENDIX G

NUMBER OF INDIVIDUALS PER TAXA COLLECTED FROM STUDY SITES IN THE LITTLE RIVER DRAINAGE

	Sites															
Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Amphipoda	1	-	1	-	1	11	-	-	-	-	-	1	-	-	1	1
Annelida																
Annelida "A"	163	-	24	-	-	-	-	-	1	8	23	51	2	6	-	30
Hirudinea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
Lumbriculidae	20	20	17	224	-	-	7	-	-	17	-	21	10	34	4	-
Oligocheates	-	-	1	-	-	134	-	30	59	31	27	9	99	5	25	35
Arachnoidea																
Hydracarina	302	60	149	17	211	103	119	127	44	106	227	98	35	209	52	89
Cladocera																
Daphnia	-	-	-	-	-	1	-	-	11	-	-	-	-	-	-	-
Cnidaria																
Hydra	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Coleoptera																
Coleoptera "A"	1	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-
Coleoptera "B"	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elmidae	25	171	66	1	1425	753	311	38	18	283	22	17	455	296	48	22
Haliplidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
Psephenidae	174	202	75	18	1	31	36	152	85	1	234	312	64	4	111	113

APPENDIX G (Continued)

Taxa	Sites 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Decapoda																
Crayfish	–	7	5	3	–	3	–	3	4	–	–	2	5	1	–	1
Diptera																
Ceratopogonidae	1	3	1	2	4	11	–	6	5	3	–	–	1	–	–	–
Chironomidae	276	900	162	478	1020	1578	127	348	218	216	260	239	365	816	161	183
Diptera "A"	30	2	3	–	–	1	–	1	2	–	13	1	–	24	3	–
Diptera "B"	2	–	–	–	–	2	–	–	1	–	–	1	–	1	2	–
Diptera "C"	1	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Psychodidae	–	–	–	–	–	14	–	–	6	–	6	–	–	1	–	–
Ptychopteridae	–	–	–	–	–	–	–	–	–	–	3	–	–	–	–	–
Pupae	15	13	2	3	74	8	29	34	5	4	9	22	15	52	22	12
Simuliidae	–	–	–	–	–	–	–	–	–	35	2	–	–	2	4	27
Tabanidae	–	1	–	–	–	2	–	2	–	–	–	8	1	–	–	–
Tipulidae	1	–	1	–	15	32	17	13	–	–	2	6	–	–	1	–
Ephmeroptera																
Baetidae	35	64	12	3	8	209	46	–	–	158	38	54	107	110	90	192
Baetiscidae	–	–	–	–	1	1	–	–	–	–	–	1	–	–	–	–
Caenidae	15	137	49	178	23	79	24	9	181	–	22	79	123	–	1	–
Ephemeridae	–	2	–	–	2	1	–	–	11	1	–	–	–	2	–	–
Heptagenidae	46	113	95	176	5	218	59	51	544	283	66	71	62	59	20	35
Leptophlebiidae	–	91	13	31	8	78	7	2	42	–	3	25	249	11	37	1
Siphlonuridae	39	18	40	–	317	388	189	20	10	267	76	93	177	495	325	325
Tricorythidae	–	–	–	–	43	–	–	–	–	–	–	2	–	–	2	–
Eucopepoda	62	11	78	3	1	3	1	49	33	–	10	26	16	–	–	–

APPENDIX G (Continued)

Taxa	Sites 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Gastropoda																
Ancylidae	6	–	5	–	–	31	–	–	6	3	–	28	–	10	–	13
Planorbidae	–	–	–	–	–	–	–	–	–	–	–	4	–	–	–	–
Spiral Form (unidentified)	–	–	–	–	–	1	–	–	1	–	–	242	–	–	–	–
Hemiptera																
Hemiptera "A"	2	–	2	–	2	1	2	–	2	1	2	1	1	1	1	–
Hemiptera "B"	–	–	–	–	–	–	–	–	–	–	–	1	–	–	1	–
Isopoda	2	1	–	–	–	2	–	2	1	1	21	4	200	8	5	–
Lepidoptera																
Pyralidae	24	4	5	1	–	2	1	–	–	1	4	23	2	1	29	–
Megaloptera																
Corydalidae	15	–	6	–	1	15	13	1	–	93	35	–	4	22	–	34
Sialidae	–	–	1	21	–	1	–	–	10	–	–	–	–	–	1	–
Mollusca	2	2	7	–	41	21	1	–	23	–	–	11	–	5	–	–
Nematoda	24	1	30	–	–	19	–	20	–	7	–	9	1	2	3	–

APPENDIX G (Continued)

Taxa	Sites 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Odonata																
Aeshnidae	1	2	–	1	1	–	–	–	–	–	–	–	–	–	–	–
Agrionidae	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
Coenagrionidae	107	32	86	4	6	40	71	12	2	–	2	33	8	–	–	1
Coyduliidae	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Coydulegastridae	–	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
Gomphidae	30	16	18	6	2	12	–	4	7	–	3	15	6	–	–	1
Libellulidae	–	–	–	2	–	–	–	–	–	–	–	–	–	–	–	–
Ostracoda	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–	–
Platyhelminthes																
Turbellaria	–	–	14	–	7	22	1	9	–	12	8	3	–	25	–	1
Plecoptera																
Chloroperlidae	2	5	1	–	–	–	–	1	–	4	–	–	–	–	–	–
Perlidae	–	3	–	–	5	8	24	–	–	30	1	1	6	4	2	–
Unknown	3	–	5	–	–	2	–	–	–	–	2	–	–	–	–	–
Trichoptera																
Brachycentridae	–	–	–	–	28	–	–	–	–	–	–	–	–	–	–	–
Helicopsychidae	318	122	23	1	112	45	–	11	–	–	–	63	2	8	6	1
Hydropsychidae	96	7	31	1	119	454	63	24	3	219	385	28	14	638	390	767
Hydroptilidae	12	45	8	–	71	22	1	1	–	–	3	2	1	18	12	–
Philopotomidae	2	–	1	–	10	104	153	2	–	530	78	2	7	748	169	818
Polycentropodidae	25	34	6	1	–	26	–	11	13	–	27	9	34	1	9	–
Pupae	2	–	–	–	1	7	3	2	–	3	5	2	1	9	9	28

APPENDIX G (Continued)

Taxa	Sites															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Unident. Order	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-
N	1793	1510	946	900	1754	3638	692	806	1059	1990	1169	1035	1226	2777	1057	1902
Diversity	3.4	3.0	4.0	2.5	2.6	3.3	3.6	3.3	3.0	3.4	3.4	4.0	3.5	3.1	3.3	2.8
No. Taxa	34	32	34	19	30	42	21	28	28	26	27	33	25	30	26	21

APPENDIX H

RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES COLLECTED AT STUDY SITES IN THE LITTLE RIVER

APPENDIX H

RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES COLLECTED AT STUDY SITES IN THE LITTLE RIVER DRAINAGE

Taxa	Sites															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Amphipoda	0.05	-	0.10	-	0.03	0.24	-	-	-	-	-	0.06	0.05	-	0.06	0.04
Annelida																
Annelida "A"	8.72	-	2.33	-	-	-	-	-	0.07	0.35	1.42	3.15	0.10	0.17	-	1.14
Hirudinea	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.06	0.04
Lumbriculidae	1.07	0.95	1.65	19.05	-	-	0.54	-	-	0.73	-	1.30	0.48	0.94	0.26	-
Oligocheates	-	-	-	-	-	2.98	-	3.05	4.40	1.34	1.67	0.56	4.78	0.15	1.61	1.33
Arachnoidea																
Hydracarina	16.15	2.86	13.48	1.45	5.88	2.29	9.11	12.92	3.28	4.57	14.01	6.05	1.69	5.75	3.35	3.38
Cladocera																
Daphnia	-	-	-	-	0.06	-	-	-	0.82	-	-	-	-	-	-	-
Cnidaria																
Hydra	-	-	-	-	-	0.02	0.08	-	-	-	-	-	-	-	-	-
Coleoptera																
Coleoptera "A"	0.05	-	-	-	0.03	-	-	-	-	-	-	-	-	0.03	-	-
Coleoptera "B"	-	-	-	-	0.03	-	-	-	-	-	-	-	-	-	-	-
Dytiscidae	0.05	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elmidae	1.34	8.16	6.40	0.09	28.40	16.75	23.81	3.87	1.34	12.42	1.36	1.05	3.09	8.15	3.09	0.84
Haliplidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.04
Psephenidae	9.30	9.64	7.30	1.53	-	0.69	2.76	15.46	6.33	0.04	14.44	19.27	21.97	0.11	7.48	0.49

APPENDIX H (Continued)

Taxa	Sites 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Decapoda																
Crayfish	0.05	0.33	0.49	0.26	-	0.07	-	0.30	0.30	-	-	0.12	0.24	0.03	-	0.04
Gastropoda																
Ancylidae	0.32	-	0.49	-	-	0.69	-	-	0.45	0.13	-	1.73	-	0.28	-	0.49
Planorbidae	-	-	-	-	-	-	-	-	-	-	-	0.25	-	-	-	-
Spiral Form (unidentified)	-	-	-	-	-	0.02	-	-	0.08	-	-	14.95	-	-	-	-
Hemiptera																
Hemiptera "A"	0.11	-	0.19	-	0.06	0.01	0.15	-	0.15	0.04	0.12	0.06	0.05	0.03	0.06	-
Hemiptera "B"	-	-	-	-	-	-	-	-	-	-	-	0.06	-	-	0.06	-
Isopoda	0.11	0.05	-	-	-	0.04	-	0.20	0.08	0.04	1.30	0.25	9.66	0.22	0.32	-
Lepidoptera																
Pyralidae	1.28	0.19	0.49	0.09	-	0.04	0.08	-	-	-	0.25	1.42	0.10	0.03	1.87	-
Megaloptera																
Corydalidae	0.80	-	0.58	-	0.03	0.33	1.00	0.10	-	4.01	2.16	-	0.20	0.61	-	1.29
Sialidae	-	-	0.10	1.79	-	0.02	-	-	0.75	-	-	-	-	-	0.06	-
Mollusca	0.11	0.10	0.68	-	1.14	0.47	0.08	-	1.71	-	-	0.68	-	0.14	-	-
Nematoda	1.28	0.10	2.91	-	-	0.42	-	2.03	-	0.30	-	0.56	0.05	0.06	0.19	-

APPENDIX H (Continued)

Taxa	Sites 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Diptera																
Ceratopogonidae	0.05	0.14	0.10	0.17	0.11	0.24	-	0.61	0.37	0.13	-	-	0.05	-	-	-
Chironomidae	14.76	42.94	15.71	40.65	28.40	33.10	9.72	35.40	16.24	8.88	16.05	14.76	17.62	22.47	10.37	6.95
Diptera "A"	1.60	0.10	0.30	-	-	0.02	-	0.10	0.15	-	0.80	0.06	-	0.66	0.19	-
Diptera "B"	0.11	-	-	-	-	0.04	-	-	0.08	-	-	0.06	-	0.03	0.13	-
Diptera "C"	0.05	-	-	-	-	-	-	-	0.45	-	-	-	-	-	-	-
Psychodidae	-	-	-	-	-	-	-	-	0.37	-	0.37	-	-	0.03	-	-
Pupae	0.80	0.62	0.19	0.26	2.06	0.31	2.22	3.46	0.28	0.17	0.19	1.36	0.72	1.43	1.42	0.46
Simuliidae	-	-	-	-	-	0.18	-	-	-	1.51	0.56	-	-	0.06	0.26	1.03
Tabanidae	-	0.05	-	-	-	0.04	-	0.20	-	-	-	0.49	0.05	-	-	-
Tipulidae	0.05	-	0.10	-	0.42	0.71	1.30	1.32	-	-	0.12	0.37	-	0.08	0.06	-
Ephmeroptera																
Baetidae	1.87	3.05	1.16	0.26	0.22	4.65	3.52	-	-	6.81	2.35	3.34	5.17	3.03	5.80	7.29
Baetiscidae	-	-	-	-	0.03	0.02	-	-	-	-	-	0.06	-	-	-	-
Caenidae	0.80	6.54	4.75	15.14	0.64	1.76	1.84	0.92	13.49	-	1.36	4.88	5.94	-	-	-
Ephemeridae	-	0.10	-	-	0.06	0.02	-	-	0.82	0.04	-	-	-	0.06	0.06	-
Heptagenidae	2.46	5.40	9.21	14.97	0.14	4.85	4.52	5.19	40.54	12.63	4.07	4.39	3.00	1.62	1.29	1.33
Leptophlebiidae	-	4.82	1.26	2.64	0.22	1.73	0.54	0.20	3.13	-	0.19	1.54	12.02	0.30	2.38	0.04
Siphlonuridae	2.09	0.86	3.88	-	8.83	8.63	14.47	2.03	0.75	11.51	4.69	5.74	8.55	13.63	20.94	12.35
Tricorythidae	-	-	-	-	1.20	-	-	-	-	-	-	0.12	-	-	0.13	-
												1.61				-
Eucopepoda	3.32	0.52	7.57	0.26	0.03	0.69	0.08	4.98	2.46	-	0.62	1.93	0.77	-	-	

APPENDIX H (Continued)

Taxa	Sites 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Odonata																
Aeshnidae	0.05	0.10	–	0.09	0.03	–	–	–	–	–	–	–	–	–	–	–
Agrionidae	–	–	–	–	0.03	–	–	–	–	–	–	–	–	–	–	–
Coenagrionidae	5.72	1.53	8.34	0.34	0.17	0.89	5.44	1.22	0.15	–	0.12	2.04	0.39	–	–	0.04
Corduliidae	–	0.10	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Corduligastridae	–	–	–	–	0.06	–	–	–	–	–	–	–	–	–	–	–
Gomphidae	1.60	0.76	1.75	0.51	–	0.27	–	0.41	0.52	–	0.19	0.93	0.29	–	–	0.04
Libellulidae	–	–	–	0.17	–	–	–	–	–	–	–	–	–	–	–	–
Ostracoda	–	–	–	0.09	–	–	–	–	–	–	–	–	–	–	–	–
Platyhelminthes																
Turbellaria	0.11	–	1.36	–	0.19	0.49	0.08	0.92	–	0.52	0.49	0.19	–	0.69	–	0.04
Plecoptera																
Chloroperlidae	0.11	0.24	0.10	–	–	–	–	0.10	–	0.17	–	–	–	–	–	–
Perlidae	–	0.14	–	–	0.14	0.18	1.84	–	–	1.29	0.06	0.06	0.29	0.11	0.13	–
Unknown	0.16	–	0.49	–	–	0.04	–	–	–	–	0.12	–	–	–	–	–
Trichoptera																
Brachycentridae	–	–	–	–	0.78	–	–	–	–	–	–	–	–	–	–	–
Helicopsychidae	17.01	5.82	2.23	0.09	3.12	1.00	–	1.12	–	–	0.06	3.89	0.10	0.22	0.39	0.04
Hydropsychidae	5.13	0.33	3.01	0.09	3.31	10.10	4.82	2.44	0.22	9.44	23.77	1.73	0.68	17.57	25.13	29.14
Hydroptilidae	0.64	2.15	0.78	–	2.00	0.49	0.08	0.10	–	–	0.19	0.12	0.05	0.50	0.77	–
Philopotomidae	0.11	–	0.10	–	0.28	2.31	11.72	0.20	–	22.85	4.81	0.12	0.34	20.59	10.89	31.08
Polycentropodidae	1.34	1.62	0.58	0.09	–	0.58	–	1.12	0.97	–	1.67	0.56	1.64	0.03	0.60	–
Pupae	0.11	–	–	–	0.03	0.16	0.23	0.20	–	0.13	0.31	0.12	0.05	0.25	0.60	1.06
Unident. Order	–	–	–	–	–	0.05	–	–	–	–	–	–	–	–	–	–

APPENDIX I

NUMBER OF INDIVIDUALS PER TAXA COLLECTED FROM STUDY SITES IN THE GLOVER CREEK DRAINAGE

APPENDIX I

NUMBERS OF INDIVIDUALS PER TAXA COLLECTED FROM STUDY SITES IN THE GLOVER CREEK DRAINAGE.

	Sites														
Taxa	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Amphipoda	-	-	-	-	-	9	1	-	-	-	-	-	-	8	-
Annelida															
Annelida "A"	-	-	-	-	-	-	-	-	-	47	-	-	-	36	-
Hirudinea	-	1	-	12	-	-	-	-	-	1	-	-	-	-	2
Lumbriculidae	26	1	4	16	-	-	13	39	7	-	1	-	122	-	32
Oligocheates	-	37	35	-	108	9	-	-	362	109	-	12	-	15	-
Arachnoidea															
Hydracarina	4	23	113	27	113	111	114	173	8	80	7	10	535	46	56
Cladocera															
Daphnia	-	5	-	-	-	-	-	-	-	-	-	-	-	-	-
Cnidaria	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-
Coleoptera															
Coleoptera "A"	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
Coleoptera "B"	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
Coleoptera "C"	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
Dytiscidae	-	-	-	1	-	-	-	-	-	-	-	-	-	4	-
Elmidae	7	184	308	192	37	392	83	307	92	659	14	11	1750	111	95
Gyrinidae	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Haliplidae	-	1	-	-	-	-	-	-	-	-	1	-	-	2	1
Limnichidae	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-

APPENDIX I (Continued)

Taxa	Sites 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Psephenidae	223	10	181	23	42	87	29	9	137	5	16	40	1	21	-
Unidentified	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Decapoda															
Crayfish	5	16	-	-	-	-	1	-	2	1	1	1	-	-	-
Diptera															
Blephariceridae	-	-	-	30	-	-	-	-	-	-	-	-	-	-	-
Ceratopogonidae	-	-	-	-	-	-	-	-	1	1	-	-	-	10	-
Chironomidae	859	868	817	1039	446	844	297	342	288	430	18	156	1391	603	297
Diptera "A"	-	-	-	1	-	-	-	-	1	-	-	-	-	15	-
Psychodidae		-	-	-	-	32	-	2	-	-	-	-	-	-	-
Ptychopteridae	-	-	-	25	3	-	-	-	-	-	-	4	-	-	-
Pupae	6	36	42	44	36	43	43	33	16	12	1	3	12	35	44
Simuliidae	-	1	-	2	-	-	2	20	-	2	4	27	262	1	-
Stratiomyidae	-	-	-	-	-	-	-	-	-	18	-	-	-	6	-
Tabanidae	-	2	-	4	6	-	1	32	1	2	-	11	13	6	-
Tipulidae	2	8	12	4	3	9	15	6	2	-	1	3	6	14	1
Ephmeroptera															
Baetidae	80	63	226	51	119	115	3	156	1	336	96	108	141	-	142
Baetiscidae	-	-	-	-	-	3	-	1	-	-	-	-	-	-	-
Caenidae	56	182	513	21	27	157	12	1	556	-	7	88	1	66	48
Ephemeridae	1	9	1	-	7	-	-	12	2	1	-	-	6	-	-
Heptagenidae	494	794	45	2	192	20	67	403	177	608	20	189	239	10	355
Leptophlebiidae	40	426	179	18	55	10	9	2	262	-	7	3	-	10	-
Siphlonuridae	-	-	252	36	50	59	54	519	4	952	-	300	258	114	308
Tricorythidae	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1

APPENDIX I (Continued)

Taxa	Sites 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Eucopepoda	156	–	–	–	–	–	2	–	16	–	–	–	1	2	–
Gastropoda															
Ancylidae	–	2	–	10	1	–	–	2	7	3	–	–	–	–	1
Planorbidae	1	–	–	–	–	–	–	–	–	–	–	–	–	–	12
Unidentified	–	–	–	–	–	–	–	–	–	–	–	–	1	59	–
Hemiptera															
Mesoveliidae	–	–	–	2	–	–	–	–	–	–	–	1	–	–	1
Saldidae	–	–	–	1	–	–	–	–	–	–	–	–	–	–	–
Unidentified	–	–	–	4	–	–	–	–	–	–	1	–	–	5	–
Veliidae	–	–	3	–	–	–	–	–	–	–	–	–	–	–	–
Isopoda	1	–	–	–	–	–	–	–	4	–	–	8	3	22	–
Lepidoptera															
Pyralidae	1	4	4	13	4	10	–	35	18	28	–	–	–	13	–
Megaloptera															
Corydalidae	6	–	2	12	14	42	16	61	2	471	3	45	511	134	164
Sailidae	–	–	1	–	–	–	1	–	–	–	–	–	–	–	–
Mollusca	–	5	3	–	–	–	–	1	–	4	–	–	6	1	–
Nematoda	–	127	3	2	7	2	5	–	5	–	–	–	12	3	–
Odonata															
Coenagrionidae	50	4	140	7	12	11	4	1	33	–	–	–	–	2	–

APPENDIX I (Continued)

Taxa	Sites 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Gomphidae	10	10	7	–	369	1	–	–	–	–	7	2	–	5	–
Libellulidae	6	–	–	–	–	–	1	–	–	–	–	–	–	–	–
Platyhelminthes															
Turbellaria	1	–	1	–	1	–	4	9	–	1	–	23	2	47	–
Plecoptera															
Chloroperlidae	–	–	–	–	5	–	–	–	–	13	–	2	–	–	–
Perlidae	–	1	24	–	1	–	–	65	1	25	–	4	135	–	118
Unidentified	–	–	1	–	–	–	–	–	1	–	–	–	–	–	–
Trichoptera															
Helicopsychidae	–	4	–	–	13	10	8	–	–	1	–	–	–	33	–
Hydropsychidae	–	22	42	412	34	378	267	1149	31	2173	30	530	2001	1167	279
Hydroptilidae	–	–	96	15	27	153	1	12	–	1	–	–	7	9	–
Molanidae	–	2	–	–	–	–	–	–	–	–	–	–	–	–	–
Philopotomidae	–	1	54	1	4	77	102	1109	6	1773	4	177	1398	217	857
Polycentropodidae	39	14	2	24	50	32	39	42	–	168	8	22	221	23	93
Pupae	–	–	4	1	–	1	4	8	–	44	1	–	4	5	25
N	2105	2975	3186	2077	1861	2611	1787	4552	2037	7968	249	1787	9055	2909	2933
$\bar{d}$	2.7	3.0	3.5	2.6	3.6	3.3	3.3	3.2	3.1	3.1	3.2	3.3	3.2	3.2	3.3
No. taxa	25	31	32	35	30	26	27	30	28	30	22	27	29	42	23

APPENDIX J

RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES COLLECTED AT STUDY SITES IN THE GLOVER CREEK DRAINAGE

APPENDIX J

RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES COLLECTED AT STUDY SITES IN THE GLOVER CREEK DRAINAGE

	Sites														
Taxa	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Amphipoda	-	-	-	-	-	0.34	0.08	-	-	-	-	-	-	0.28	-
Annelida															
Annelida "A"	-	-	-	-	-	-	-	-	-	0.60	-	-	-	1.24	-
Hirudinea	-	0.03	-	0.58	-	-	-	-	-	0.01	-	-	-	-	0.07
Lumbriculidae	1.24	0.03	0.13	0.77	-	-	1.08	0.86	0.34	-	0.40	-	1.35	-	1.09
Oligocheates	-	1.24	1.10	-	5.80	0.34	-	-	17.77	1.37	-	0.67	0.09	0.52	-
Arachnoidea															
Hydracarina	0.19	0.77	3.55	1.30	6.07	4.25	9.51	3.80	0.39	1.00	2.81	0.56	5.91	1.58	1.91
Cladocera															
Daphnia	-	0.171	-	-	-	-	-	-	-	-	-	-	-	-	-
Cnidaria	-	0.03	-	-	-	-	0.08	-	-	-	-	-	-	-	-
Coleoptera															
Coleoptera "A"	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	-
Coleoptera "B"	-	-	-	-	-	-	-	-	-	-	-	-	-	0.17	-
Coleoptera "C"	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	-
Dytiscidae	-	-	-	0.05	-	-	-	-	-	-	-	-	-	0.14	-
Elmidae	0.33	6.18	9.67	9.24	1.99	15.01	6.92	6.74	4.52	8.27	5.62	0.62	19.33	3.82	3.24
Gyrinidae	-	-	-	0.10	-	-	-	-	-	-	-	-	-	-	-
Haliplidae	-	0.034	-	-	-	-	-	-	-	-	0.40	-	-	0.07	0.03

APPENDIX J (Continued)

Taxa	Sites 17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Limnichidae	-	-	-	-	-	-	-	-	-	-	-	-	-	0.10	-
Psephenidae	10.59	0.34	5.68	1.10	2.26	3.33	2.42	0.20	6.73	0.06	6.43	2.24	0.01	0.63	-
Unidentified	-	-	-	0.05	-	-	-	-	-	-	-	-	-	-	-
Decapoda															
Crayfish	0.24	0.54	0.03	-	-	-	0.08	-	0.10	0.01	0.40	0.06	-	-	-
Diptera															
Blephariceridae	-	-	-	1.44	-	-	-	-	-	-	-	-	-	-	-
Ceratopogonidae	-	-	-	-	-	-	-	-	0.05	0.01	-	-	-	0.34	-
Chironomidae	40.81	29.18	25.64	50.02	23.97	32.32	24.77	7.51	14.31	5.40	7.23	8.73	15.36	20.73	10.13
Diptera "A"	-	-	-	0.05	-	-	-	0.04	0.05	-	-	0.39	-	0.52	-
Psychadidae	-	-	-	-	-	1.23	-	-	-	-	-	-	-	-	-
Ptychopteridae	-	-	-	1.20	0.16	-	-	-	-	-	-	0.22	-	-	-
Pupae	0.29	1.21	1.32	2.12	1.93	1.65	3.59	0.73	0.54	0.15	0.40	0.17	0.13	1.20	1.50
Simuliidae	-	0.03	-	0.10	-	-	0.17	0.44	-	0.03	1.61	1.51	2.89	0.03	0.03
Stratiomyidae	-	-	-	-	-	-	-	-	-	-	-	-	-	0.21	-
Tabanidae	-	0.07	-	0.19	0.32	-	0.38	0.70	0.05	0.23	-	0.62	0.14	0.21	-
Tipulidae	0.10	0.27	0.38	0.19	0.16	0.34	1.25	0.13	0.10	-	0.40	0.17	0.07	0.48	0.03
Ephmeroptera															
Baetidae	3.80	2.12	7.09	2.46	6.39	4.40	0.25	3.43	0.05	4.22	38.55	6.04	1.56	-	4.84
Baetiscidae	-	-	-	-	-	0.11	-	0.02	-	-	-	-	-	-	-
Caenidae	2.66	6.12	16.10	1.01	1.45	6.32	1.00	0.02	27.30	-	2.81	4.92	0.01	2.27	1.64
Ephemeridae	0.05	0.30	0.03	-	0.38	-	-	0.26	0.10	0.01	-	-	0.07	-	-
Heptagenidae	23.47	26.69	1.41	0.10	10.32	0.77	5.59	8.85	8.69	7.63	8.03	10.58	2.64	0.34	12.10
Leptophlebiidae	1.90	14.31	5.62	0.87	2.96	0.38	0.75	0.04	12.86	-	2.81	0.17	-	0.34	-

APPENDIX J (Continued)

Taxa	Sites														
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Siphlonuridae	-	-	7.91	1.73	2.69	2.26	4.50	11.40	0.20	11.95	-	16.79	2.85	3.92	10.50
Tricorythidae	-	-	-	-	-	-	-	0.02	-	-	-	-	-	-	0.03
Eucopepoda	7.41	-	-	-	-	-	0.17	-	0.34	-	-	-	0.01	0.07	-
Gastropoda															
Ancylidae	-	0.07	-	0.48	0.05	-	-	0.4	0.34	0.04	-	-	-	-	0.03
Planorbidae	0.05	-	-	-	-	-	-	-	-	-	-	-	-	-	0.41
Unidentified	-	-	-	-	-	-	-	-	-	-	-	-	0.01	2.03	-
Hemiptera															
Mesoveliidae	-	-	-	0.19	-	-	-	-	-	-	-	0.06	-	-	0.03
Saldidae	-	-	-	0.10	-	-	-	-	-	-	-	-	-	-	-
Unidentified	-	-	-	0.05	-	-	-	-	-	-	-	-	-	0.17	-
Veliidae	-	-	0.09	-	-	-	-	-	-	-	0.04	-	-	-	-
Isopoda	0.05	-	-	-	-	-	-	-	0.20	-	0.04	-	0.03	0.76	-
Lepidoptera															
Pyralidae	0.05	0.13	0.13	0.63	0.21	0.38	-	0.77	0.88	0.35	-	0.45	-	0.45	-
Megaloptera															
Corydalidae	0.29	-	0.06	0.58	0.75	1.61	1.33	1.34	0.10	5.91	1.20	2.52	5.64	4.61	5.59
Sailidae	-	-	0.03	-	-	-	0.08	-	-	-	-	-	-	-	-
Mollusca	-	0.17	0.09	-	-	-	-	0.02	-	0.05	-	-	0.07	0.03	-
Nematoda	-	4.27	0.09	0.10	0.38	0.08	0.42	-	0.25	-	-	-	0.13	0.10	-

APPENDIX J (Continued)

Taxa	Sites														
	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Odonata															
Coenagrionidae	2.38	0.13	4.39	0.34	0.64	0.42	0.33	-	1.62	-	-	-	-	0.07	-
Gomphidae	0.48	0.34	0.22	-	19.83	0.04	-	-	-	-	2.81	0.11	-	0.17	-
Libellulidae	0.30	-	-	-	-	-	0.08	-	-	-	-	-	-	-	-
Ostracoda	1.43	3.90	2.20	1.16	4.03	0.11	-	-	-	0.01	-	-	0.08	0.52	-
Platyhelminthes															
Turbellaria	0.05	-	0.03	-	0.05	-	0.33	0.20	-	0.01	-	1.29	0.02	1.62	-
Plecoptera															
Chloroperlidae	-	-	-	-	0.27	-	-	-	-	0.16	-	0.11	-	-	-
Perlidae	-	0.03	0.75	-	0.05	-	-	1.43	0.05	0.31	-	0.22	1.49	-	4.02
Unidentified	-	-	0.03	-	-	-	-	-	-	-	-	-	-	-	-
Trichoptera															
Helicopsychidae	0.05	0.13	-	-	0.70	0.38	0.67	-	-	0.01	-	-	-	1.13	-
Hydropsychidae	-	0.74	1.32	19.84	1.83	14.48	22.27	25.24	1.52	27.27	12.05	29.66	22.10	40.12	9.51
Hydroptilidae	-	-	3.01	0.72	1.45	5.86	0.08	0.26	-	0.01	-	-	0.08	0.31	-
Molanidae	-	0.07	-	-	-	-	-	-	-	-	-	-	-	-	-
Philopotomidae	-	0.03	1.69	0.05	0.21	2.95	8.51	24.36	0.29	22.25	1.61	9.90	15.44	7.46	29.22
Polycentropodidae	1.85	0.47	0.06	1.16	2.69	1.23	3.25	0.92	-	2.11	3.21	1.23	2.44	0.79	3.17
Pupae	-	-	0.13	0.05	-	0.04	0.33	0.18	-	0.55	0.04	-	0.04	0.17	0.85

APPENDIX K

NUMBER OF INDIVIDUALS PER TAXA COLLECTED FROM STUDY SITES IN THE MOUNTAIN FORK DRAINAGE

APPENDIX K

NUMBERS OF INDIVIDUALS PER TAXA COLLECTED FROM STUDY SITES IN THE MOUNTAIN FORK DRAINAGE

Taxa	Sites											
	32	33	34	35	36	37	38	39	40	41	42	43
Amphipoda	1	–	–	–	–	–	–	–	5	1	–	–
Annelida												
Annelida "A"	–	5	–	–	–	25	4	1	–	51	–	–
Hirudinea	–	–	–	–	–	2	–	–	–	–	–	–
Lumbriculidae	22	53	–	186	3	–	–	–	–	60	–	19
Oligocheates	–	–	37	–	–	121	27	27	–	–	18	–
Arachnoidea												
Hydracarina	135	622	14	10	10	245	107	21	12	65	71	89
Mite "A"	1	–	–	–	–	–	–	–	1	–	–	1
Cladocera												
Daphnia	–	–	–	–	47	–	–	–	–	–	7	–
Cnidaria												
Hydra	1	–	–	–	–	–	–	–	1	–	–	–
Coleoptera												
Dytiscidae	–	–	–	–	–	2	–	–	1	–	–	–
Elmidae	483	189	35	14	33	35	63	2	15	8	802	41
Haliplidae	–	–	–	–	3	–	–	–	–	–	–	–
Psephenidae	32	9	22	310	67	80	214	–	141	89	17	219

APPENDIX K (Continued)

Taxa	Sites											
	32	33	34	35	36	37	38	39	40	41	42	43
Decapoda												
Crayfish	3	1	1	7	4	4	2	–	1	2	–	7
Diptera												
Blephariceridae	–	–	–	–	–	–	–	1	–	–	–	–
Ceratopogonidae	9	48	16	5	1	–	2	4	1	–	–	–
Chironomidae	462	611	1018	197	691	33	432	87	84	37	523	994
Diptera "A"	–	–	–	1	–	2	–	–	–	2	–	1
Diptera "B"	–	–	–	–	–	–	–	–	–	–	–	–
Psychadidae	–	–	–	–	–	–	1	–	–	–	–	–
Pupae	46	21	70	–	17	1	24	6	10	2	32	11
Simuliidae	–	–	–	–	1	2	–	–	–	2	–	–
Tabanidae	2	4	–	–	4	–	5	–	5	–	–	2
Tipulidae	58	27	17	2	9	–	3	–	6	–	18	8
Ephmeroptera												
Baetidae	201	32	109	6	–	121	60	47	124	23	296	87
Baetiscidae	–	–	–	4	–	–	–	–	–	–	–	–
Caenidae	188	92	358	204	39	41	57	30	1	190	35	6
Ephemeridae	1	–	5	49	–	–	–	–	–	–	–	–
Heptagenidae	808	271	200	355	277	119	160	164	24	33	437	57
Leptophlebiidae	205	–	142	126	33	10	107	–	–	3	842	34
Siphlonuridae	261	148	–	–	19	144	222	234	155	48	186	18
Tricorythidae	–	2	–	–	–	–	–					
Eucopepoda	14	4	3	88	7	–	8	5	5	8	71	4

APPENDIX K (Continued)

Taxa	Sites 32	33	34	35	36	37	38	39	40	41	42	43
Gastropoda												
Ancylidae	2	–	–	32	2	2	2	11	1	43	5	–
Spiral Form (unidentified)	1	–	1	–	–	–	–	–	1	–	2	–
Hemiptera												
Hemiptera "A"	–	2	12	1	6	3	1	–	1	2	–	–
Isopoda	5	1	–	–	1	5	–	–	3	–	–	6
Lepidoptera												
Pyralidae	5	10	1	7	–	1	1	–	3	6	–	–
Megaloptera												
Corydalidae	73	19	4	2	1	8	6	78	–	1	–	2
Sialidae	2	–	–	10	–	–	–	–	–	–	–	–
Mollusca	16	1	–	46	–	2	–	2	–	7	1	1
Nematoda	7	6	12	6	2	–	–	–	–	4	–	1
Odonata												
Coenagrionidae	40	30	10	87	2	2	2	–	14	15	63	1
Corduliidae	–	–	2	–	–	–	–	–	–	–	–	–
Gomphidae	5	–	15	8	3	15	23	5	1	–	1	1
Libellulidae	–	–	–	–	14	–	–	–	–	–	–	14
Ostracoda	13	–	–	8	33	5	–	1	6	–	–	–

APPENDIX K (Continued)

Taxa	Sites 32	33	34	35	36	37	38	39	40	41	42	43
Platyhelminthes												
Turbellaria	12	1	3	1	–	–	8	–	1	1	2	1
Plecoptera												
Chloroperlidae	5	1	1	–	–	2	–	–	–	1	–	–
Perlidae	102	20	–	6	19	1	5	–	–	2	119	–
Perlodidae	–	–	–	–	–	–	–	–	–	–	–	6
Unidentified	–	–	–	–	–	–	1	–	–	–	–	1
Trichoptera												
Helicopsychidae	179	15	47	8	26	16	58	–	1	–	8	24
Hydropsychidae	190	175	1	–	17	44	92	250	40	31	5	6
Hydroptilidae	3	26	4	–	–	2	12	1	1	2	12	19
Limnephilidae	–	–	–	–	1	–	–	–	–	–	–	–
Molanidae	–	–	–	4	–	–	–	–	–	–	–	–
Philopstomidae	242	56	1	1	–	13	72	177	1	4	2	4
Polycentropodidae	31	3	4	–	49	2	34	–	4	2	–	18
Pupae	5	1	–	–	–	1	2	2	1	1	–	–
Unidentified order	–	–	–	–	–	–	–	–	–	–	1	–
Number	3871	2057	2166	1791	1442	1111	1817	1156	671	746	3585	1703
Diversity	3.9	3.3	2.7	3.5	2.8	3.6	3.7	3.1	3.2	3.1	3.1	2.4
No. Taxa	40	33	31	31	33	34	33	22	33	25	25	32

APPENDIX L

RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES COLLECTED AT STUDY SITES IN THE MOUNTAIN FORK DRAINAGE

APPENDIX L

RELATIVE ABUNDANCE (%) OF BENTHIC MACROINVERTEBRATES COLLECTED AT STUDY SITES IN THE MOUNTAIN FORK DRAINAGE

Taxa	Sites											
	32	33	34	35	36	37	38	39	40	41	42	43
Amphipoda	0.03	-	-	-	-	-	-	-	-	0.13	-	-
Annelida												
Annelida "A"	-	0.20	-	-	-	2.25	0.33	0.09	-	6.84	-	-
Hirudinea	-	-	-	-	-	0.18	-	-	-	-	-	-
Lumbriculidae	0.57	2.15	-	10.39	0.21	-	-	-	-	8.04	-	1.12
Oligocheates	-	-	1.71	-	-	10.89	1.49	2.34	-	-	0.50	-
Arachnoidea												
Hydracarina	3.49	24.81	0.65	0.56	0.69	22.05	5.89	1.82	1.79	8.71	1.98	5.23
Mite "A"	0.03	-	-	-	-	-	-	-	0.15	-	-	0.06
Cladocera												
Daphnia	-	-	-	-	3.26	-	-	-	-	-	0.20	-
Cnidaria												
Hydra	0.03	-	-	-	-	-	-	-	0.15	-	-	-
Coleoptera												
Coleoptera 'A'	-	-	-	-	0.07	-	-	-	-	-	-	-
Dytiscidae	-	-	-	-	-	0.18	-	-	0.15	-	-	-
Elmidae	12.48	7.54	1.62	0.78	2.29	3.15	3.47	0.17	2.24	1.07	22.37	2.41
Haliplidae	-	-	-	-	0.21	-	-	-	-	-	-	-
Psephenidae	0.83	0.36	1.02	17.31	4.65	7.20	11.78	-	21.01	11.93	0.47	12.86

APPENDIX L (Continued)

Taxa	Sites 32	33	34	35	36	37	38	39	40	41	42	43
Hemiptera												
Hemiptera "A"	–	0.08	0.55	0.06	0.42	0.27	0.06	–	0.15	0.27	–	–
Isopoda	0.13	0.04	–	–	0.07	0.45	–	–	0.45	–	–	0.35
Lepidoptera												
Pyralidae	0.13	0.40	0.05	0.39	–	0.09	0.06	–	0.45	0.80	–	–
Megaloptera												
Corydalidae	1.89	0.76	0.05	0.11	0.07	0.72	0.33	6.75	–	0.13	–	0.12
Sialidae	0.05	–	–	0.56	–	–	–	–	–	–	–	–
Mollusca	0.41	0.04	0.18	2.57	–	0.18	–	0.17	–	0.94	0.03	0.06
Nematoda	0.18	0.24	0.55	0.33	0.14	–	–	–	–	0.54	–	0.06
Odonata												
Coenogrionidae	1.03	1.20	0.46	4.86	0.14	0.18	0.11	–	2.09	2.01	1.76	0.06
Corduliidae	–	–	0.10	–	–	–	–	–	–	–	–	–
Gomphidae	0.13	–	0.69	0.45	0.21	1.35	1.27	0.43	0.15	–	0.03	0.06
Libellulidae	–	–	–	–	0.97	–	–	–	–	–	–	0.82
Ostracoda	0.34	–	–	0.45	–	0.45	–	0.09	1.27	–	–	–
Platyhelminthes												
Turbellaria	0.31	0.04	0.14	0.06	–	–	0.44	–	–	0.13	0.06	0.06

Appendix L. (Continued)

Taxa	Sites 32	33	34	35	36	37	38	39	40	41	42	43
Diptera												
Blephariceridae	-	-	-	-	-	-	-	0.09	-	-	-	-
Ceratopogonidae	0.23	1.91	0.74	0.28	0.07	-	0.11	0.35	0.15	-	-	-
Chironomidae	11.93	24.37	47.00	11.00	47.92	2.97	23.78	7.53	12.52	4.96	14.59	58.37
Diptera "A"	-	-	-	0.06	-	0.18	-	-	-	0.27	-	0.06
Diptera "B"	-	-	-	-	-	-	-	-	-	-	-	-
Psychodidae	-	-	-	-	-	-	0.06	-	-	-	-	-
Pupae	1.18	0.84	3.23	-	1.18	0.09	1.32	0.52	1.49	0.27	0.89	0.65
Simuliidae	-	-	-	-	0.07	0.18	-	-	-	0.27	-	-
Tabanidae	0.05	0.16	-	-	0.28	-	0.28	-	0.75	-	-	0.12
Tipulidae	1.50	1.10	0.78	0.11	0.62	-	0.28	-	0.89	-	0.50	0.47
Ephmeroptera												
Baetidae	5.19	1.28	5.03	0.33	-	10.89	3.30	4.07	18.48	3.08	8.26	5.11
Baetiscidae	-	-	-	0.22	-	-	-	-	-	-	-	-
Caenidae	4.86	3.67	16.53	11.39	2.70	3.69	3.14	2.60	0.15	25.47	0.98	0.35
Ephemeridae	0.03	-	0.23	2.74	-	-	-	-	-	-	-	-
Heptagenidae	20.87	10.81	9.23	19.82	19.21	10.71	8.81	14.19	3.58	4.42	12.19	3.35
Leptophlebiidae	5.30	-	6.56	7.04	2.29	0.90	5.89	-	-	0.40	23.49	2.00
Siphlonuridae	6.74	5.90	-	-	1.32	12.69	12.22	20.24	23.10	6.43	5.19	1.06
Tricorythidae	-	0.08	-	-	-	-	-	-	-	-		
Eucopepoda	0.36	0.16	0.14	4.91	0.49	-	0.44	0.43	0.75	1.07	1.98	0.23
Gastropoda												
Ancylidae	0.05	-	-	1.79	0.14	0.18	0.11	0.95	0.15	5.76	0.14	-
Spiral Form (unidentified)	0.03	-	0.05	-	-	-	-	-	0.15	-	0.06	-

APPENDIX L (Continued)

Taxa	Sites											
	32	33	34	35	36	37	38	39	40	41	42	43
Plecoptera												
Chloroperlidae	0.13	0.04	0.05	-	-	0.18	-	-	-	0.13	-	-
Perlidae	2.64	0.80	-	0.33	1.32	0.09	0.28	-	-	0.27	3.32	0.06
Perlodidae	-	-	-	-	-	-	-	-	-	-	-	0.35
Unidentified	-	-	-	-	-	-	0.06	-	-	-	-	0.07
Trichoptera												
Helicopsychidae	4.62	0.60	2.17	0.45	1.80	1.44	3.19	-	0.15	-	0.22	1.41
Hydropsychidae	4.91	6.98	0.05	-	1.18	3.96	5.06	21.63	5.96	4.16	0.14	0.35
Hydroptilidae	0.08	1.04	0.18	-	-	0.18	0.66	0.09	0.15	0.27	0.33	1.12
Limnephilidae	-	-	-	-	0.07	-	-	-	-	-	-	-
Molanidae	-	-	-	0.22	-	-	-	-	-	-	-	-
Philopotomidae	6.25	2.23	0.05	0.06	-	1.17	3.96	15.31	0.15	0.54	0.06	0.23
Polycentropodidae	0.80	0.12	0.18	-	3.40	0.18	1.87	-	0.60	0.27	-	1.06
Pupae	0.13	0.04	-	-	-	0.09	0.11	0.17	0.15	0.13	-	-
Unidentified order	-	-	-	-	-	-	-	-	-	-	0.03	-

VITA 2

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Master of Science

Thesis: THE EFFECTS OF CLEARCUTTING ON TROPHIC RELATIONS OF BENTHIC MACROINVERTEBRATES IN STREAMS OF SOUTHEAST OKLAHOMA

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