RELATIONSHIPS BETWEEN BENTHIC MACROINVERTEBRATES AND SILVICULTURE IN SOUTHEASTERN OKLAHOMA

BY

STEVEN ROBERT ADAMS

Bachelor of Science
Northeastern Oklahoma State University
Tahlequah, Oklahoma
1980

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
December, 1983

Name: Steven Robert Adams Date of Degree: December, 1983

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Study: RELATIONSHIPS BETWEEN BENTHIC MACROINVERTEBRATES AND SILVICULTURE IN SOUTHEASTERN OKLAHOMA

Pages in Study: 96 Candidate for Degree of Master of Science

Major Field: Zoology

Scope of Study: The study involved an investigation of the community structure of benthic invertebrates in southeastern Oklahoma. The objective of this study was to evaluate changes in benthic invertebrate communities associated with silviculture activities in drainage basin of streams in southeastern Oklahoma. Similarities and differences in communities were evaluated by comparing total density/m^2, diversity, percent similarity, Euclidean distance, functional groups and the number of taxa.

Findings and Conclusions: Significant differences in total density, diversity, Euclidean distances, percent similarity and the number of taxa were indicated between reference and treatment sites. Differences in functional groups were also observed, however, they were not statistically significant. These changes were consistent with changes associated with stressed communities and appeared to decrease downstream from the logging area.

ADVISER'S APPROVAL O. Eugene Maughan

RELATIONSHIPS BETWEEN BENTHIC MACROINVERTEBRATES AND SILVICULTURE IN SOUTHEASTERN OKLAHOMA

Thesis Approved:

O. Eugene Maughan
Thesis Adviser

Sterling L. Burks

Anthony A. Echelle

Norman N. Durham
Dean of the Graduate College

PREFACE

This research was funded by the United States EPA, water quality management 208 program, Task 1107. Funding was also provided by the Oklahoma Department of Wildlife Conservation.

I thank Dr. O. Eugene Maughan, who served as chairman of my committee, for his guidance and unlimited patience during this research and for his careful reviews of the thesis. My sincere thanks to Dr. Sterling L. Burks for serving on my committee and for reviewing the thesis, constructive criticisms, technical assistance, and most of all for always taking time to discuss the project. Also my sincere thanks to Dr. Anthony A. Echelle who served on my committee, for being helpful in all phases of the research, from reviewing the thesis to helping with the field work.

Special thanks to Ruby Collins for her patience and understanding during the long months of collecting and sorting samples, recording data, standing in line at the computer center, and for keeping me from becoming discouraged. I also thank James and Nancy Layzer, Glen Gebhart, Conrad Klienholz, Ken Collins, Allen Rutherford, Ray Jones, Ken Williams, Bill Layher, Sharon Bontrager, Bonnie Bilodeau, and Margaret Thompson.

TABLE OF CONTENTS

Chapter Page

LIST OF TABLES

CHAPTER I

INTRODUCTION

Several authors (Tebo 1955, Luedtke et al. 1976, Lee and Samuel 1976, Graynoth 1979) report significantly lower standing crops of invertebrates below areas of logging activity and attribute this condition to accumulations of silt and sand, probably originating from roads and skid trails. Woodall and Wallace (1972) found the same results but attribute changes in benthos to modifications in detritus composition, and the associated decreased food available for shredders (primarily Peltoperla), brought on by conversion of hardwood to pines. Gurtz (1981) partially supported the latter theory empirically when he found the degree of change in Peltoperla following logging differed over varying substrate types (moss, cobble, pebble, sand). In the moss substrate taxa increased in abundance relative to the other habitats and, conversely in the sand substrate, a decrease in number and variety of taxa was observed.

In contrast, other authors have reported an increased number of invertebrates and changes in community structure following logging (Murphy et al. 1981; Burns 1972). Woodall and Wallace (1972) and Gurtz (1981) reported increased abundance of grazers and decreased abundance of shredders following logging. However, after ten years invertebrate density at this site was above that of the control sites and shredders

again dominated the system (Haefner and Wallace 1981). The conclusion, also arrived at by Gurtz et al. (1980), is that the response of the invertebrate community to logging was linked to the type of terrestrial vegetation present prior to removal.

Newbold et al. (1980) likewise reported increased total benthic abundance but also found lower diversity of stream invertebrates following logging. These effects were attributed to changes in only three taxa; Baetis, Nemoura, and Chironomidae. The changes seemed to be related to increased numbers of primary consumers. Similar effects have been reported by other authors but were attributed to density of predatory insects (28-88% greater in a clear-cut stream than in a control area) (Murphy and Hall 1981).

Communities in varying stream habitats apparently respond differently to silvicultural activities. Gurtz (1981) and Murphy and Hall (1981) found that Population density generally decreased in pools but increased in riffles following clear-cutting. In addition, changes were greater in higher gradient than in lower gradient pools. The taxa which inhabited the riffle areas appeared to be less susceptible to deposition of sediment than the pool inhabitants.

In addition to these affects upon density, logging may lead to increased primary production from increased availability of sunlight, increased stream temperature (Burns 1972, Feller 1981), and increased nutrient levels (Brown and Krygier 1970, Likens et al. 1969). However, increased sediment loads may also act to depress primary production (Tebo 1955, Burns 1972, Chutter 1969 and Murphy et al. 1981).

The purpose of this study was to evaluate changes in stream benthic macroinvertebrate communities associated with silviculture activities

drainage in basin of streams in southeastern Oklahoma. Logging and associated industries in the region provide a large portion of the economic base but conservation groups and local residents have recently become concerned about possible degradation of streams from silvicultural activities. The concern prompted this study.

CHAPTER II

MATERIALS AND METHODS

All samples were collected with a Circular Depletion Sampler which encloses an area of approximately 0.2452 m^2 (Carle and Maughan 1980). Openings on both the upstream and downstream sides of the sampler allowed the water flow to carry dislodged organisms into a capture net of 400 micron Nitex affixed to a detachable collection bottle. The upstream opening of the sampler was likewise covered with 400 micron netting to prevent escape from the sample area.

Three samples, each composed of three 2-minute units of effort, were collected quarterly from the riffle area at each site. After each unit of effort the collection bottle was removed and its contents were preserved as described below. Each successive sample was collected upstream from the previous one so that disturbance of the substrate and associated drift would not affect the results.

Samples were fixed in the field with 10 percent formalin, washed in water after return to the laboratory and preserved in 70 percent alcohol. Rose Bengal stain was added to facilitate sorting, and the samples were allowed to set for approximately two weeks to allow the stain to penetrate the organisms.

After sorting, the organisms were identified to the lowest possible taxonomic level (usually to genus). Identifications were made according to: Pennak (1978), Usinger (1956), Merrit and Cummins (1978), Wiggins

(1977), Williams (1976), Lewis (1974), Brown (1976), and Flint (1960).

Population estimates, following Carle's (1976) method, were made from the pooled data for the three samples made for each collection. Density and diversity values were based on population estimates rather than on the actual number of organisms captured.

Three basic assumptions must be satisfied when employing depletion sampling. These assumptions are: 1) the population must be closed, 2) the capture effort must be constant, and 3) the probability of capture must be the same for all individuals in the population (Raleigh and Short 1981). Emigration out of or immigration into the sample was greatly reduced by burying the sampler in the substrate. A constant capture effort was maintained by sampling for a predetermined period of time, two minutes, and by having the same investigator take all samples. Factors such as age, sex, size and variation among individual organisms can affect the assumption of equal probability of capture of all members of the population. We divided each taxon into adult and larval forms but no attempt was made to distinguish between sexes or size classes. Data were compared among sites, thus any biases from sex or size class were constant and the effect on the interpretation should be minimal.

Descriptions of Study Area

Each of the study sites used in this study are located in southern LeFlore County, Oklahoma. Little Cow Creek is a tributary of the Mountain Fork River and is located near the town of Zafra. Sites 1, 2, and 3 are all found within T1N, R27E, Section 29 of LeFlore County.

Upper Little River is the headwater region of the Little River. Both of the sites on this stream are found northeast of the community of

Octavia in T1N, R23E. Site 1 is located in Section 1 and site 2 in Section 12.

Big Eagle Creek is also a tributary of the Mountain Fork River. The study sites on this stream is located north of the community of Octavia in T1N, R24E, Section 1.

Transformations

Analysis of samples of benthic invertebrates is often difficult due to clumped distribution patterns and the associated large variance of these samples. Because of the failure of these populations to meet the assumptions of standard parametric techniques, either non-parametric tests or data transformations prior to the use of parametric tests should be used (Elliot 1977, Downing 1979, Snedecor and Cochran 1980).

A wide variety of data transformations has been proposed for analysis of benthic data. Downing (1979) attempted to produce a non-significant relationship between variance and mean value by determining the overall slope of the regression of the log10 of the mean and the variance, then applying this value to Taylor's (1961) equation $x'=x^{1-b/2}$. A fourth root transformation seemed to accomplish this objective (overall b=1.5). Gurtz et al. (1980) tested Downing's procedure on data from an Appalachian stream and concluded that natural log transformation was more appropriate. Elliot (1977) did likewise and recommended a natural log or a square root transformation. Based on these studies I transformed the data by square root (x), fourth root ($x^{\cdot 25}$), natural log (ln x+1) and Taylor's transformation ($x'+x^{1-b/2}$).

My objective was to see which of these transformations were most applicable for data analysis. Only data from the first five sampling

periods (Spring 1981-Spring 1982) on Little Cow Creek were used in this analysis. The overall slope for the Taylor transformation ($x'=x^{1-b/2}$, where b equals the slope of the regression of log10 of the mean and log10 of the variance), was determined by combining the mean and variance values for all species collected over all five sampling periods. The overall slope of 0.4370 gave a transformation relationship of $x'=x^{.2815}$.

None of the data transformations made the variance independent of the mean for all of the species (Table 1). The Taylor transformation was most effective, but more than fifteen percent of the species means were still significantly correlated with the variances. To overcome this problem analysis of density was performed on ranks (Wilcoxon, 1945).

Total Density

Analysis of variance of ranks was used to test for differences between population densities. To accomplish this analysis, the data were first ranked by magnitude, and ties were given the mean value for the ranks.

Two analyses were made. In the first analysis, Little Cow Creek site #1 was used as a reference for sites on Big Eagle Creek and Upper Little River. Locating a reference on another stream generally requires the meeting of certain assumptions. The conditions at the reference site are presumed to be typical of the pre-treatment conditions at the treatment sites. Each of the streams studied was a third order stream and soil type, substrate size and other stream characteristics were similar between streams (Table 2). Little Cow Creek sites #2 and #3

TABLE I

THE EFFECT OF DATA TRANSFORMATIONS ON THE INDEPENDENCE OF THE VARIANCE AND THE MEAN

TAXA	UNTRANSFORMED	X	ln (X+1)	$X^{.25}$	$X^{.2815}$
Acroneuria	-	*	**	**	**
Agapetus	**	-	-	-	-
Ameletus	**	-	-	-	-
Amphipoda	**	-	-	-	-
Ancylidae	**	**	**	**	**
Asellus	-	-	-	-	-
Baetis	-	-	-	*	-
Caenis	**	*	-	-	-
Ceratopogonidae	**	-	-	-	-
Cheumatopsyche	**	*	-	-	-
Chimarra	**	-	-	-	-
Chironomidae	-	-	-	-	-
Chloroperlidae	-	-	-	-	-
Argia	**	-	-	-	-
Collembola	**	*	-	-	-
Copepoda	**	**	-	-	-
Nigronia	*	-	*	**	**
Corydalus cornutus	**	**	-	-	-
Decapoda	-	-	-	-	-
Hydroporus	**	-	-	-	-
Ephemera	*	-	-	-	-
Eurylophella	-	-	-	-	-
Hagenius	**	-	-	-	-
Helicopsyche	**	-	-	-	-
Heptagenia sp#1	**	**	-	-	-
Heptagenia sp#3	-	-	-	-	-
Heterelmis (L)	**	*	-	-	-
Hirudinea	**	*	-	-	-
Hydracarina	**	-	-	-	-
Isonychia	**	**	-	-	-
Lanthus parvulus	**	-	-	-	-
Pyralidae	**	**	-	-	-
Leptophelbia	**	*	-	-	-
Lirceus	*	**	**	**	**
Lumbriculidae	**	-	-	-	-
Nematoda	*	-	-	-	-
Ochrotrichia	-	-	-	**	-
Paraleptophlebia sp.#1	**	-	-	-	-
Paraleptophlebia sp.#2	**	-	-	-	-
Pelecypoda	-	**	**	-	**
Perlesta	*	-	-	-	-
Polycentropus	**	-	-	**	*
Psephenus	**	-	*	-	-
Pseudocloen	**	-	-	-	-
Sialis	**	*	-	-	-
Simuliidae	**	*	-	-	-

TABLE I (Continued)

TAXA	UNTRANSFORMED	$\sqrt{X}$	ln (X+1)	$X^{.25}$	$X^{.2815}$
Stenacron	*	-	**	**	*
Stenelmis (A)	**	**	**	-	**
Stenelmis (L)	**	*	*	*	-
Stenonema	-	-	*	*	-
Tabanidae	**	**	**	**	**
Taenionema	**	-	-	-	-
Tipulidae	**	-	-	-	-
Vellidae	-	-	-	-	-

TABLE II

PHYSICAL CHARACTERISTICS (1981) AT THE SAMPLING LOCATIONS

LOCATION	STREAM ORDER	SOIL TYPE	MAXIMUM WIDTH (M)	HABITAT DIVERSITY DEPTH	HABITAT DIVERSITY SUBSTRATE
LCC #1	3	1*	9	2.83	1.52
LCC #2	3	1	-	1.92	1.00
LCC #3	3	1	-	2.23	1.81
ULR #1	3	2**	14.25	2.86	1.62
ULR #2	3	2	15.00	2.27	1.44
BEC #2	3	2	15.00	2.98	1.71

* Kenn-Ceda

** Ceda-Rubble

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

were not used in these comparisons because the size of the pool above the riffle was much smaller than at the other sites and because heavy streamside vegetation reduced solar radiation at these sites.

Pre-and post-treatment population values were also tested for differences. Little Cow Creek were again used as a reference. Data from Little Cow Creek was compared to corresponding seasons (e.g. Spring 1980 and Spring 1981) for the two years of the study. Where these data showed no yearly variations between years at Little Cow Creek, the variation between equivalent seasons at the experimental sites was assumed to be the result of the treatment. This approach assumes homogeneity between all sites and it assures that pre-treatment data is predictive of subsequent years. Because of weaknesses of these assumptions, this method was used only to further verify results obtained in the first analysis.

Community Indices

Measurement of community diversity is designed to provide an index to community structure within the ecosystem understudy. There are a variety of formulas for diversity, but all include some measure of the number of species present and the distribution of individuals among those species (Shannon 1948, Hutchison 1953, MacArthur 1957, Odum, et al. 1960, Pianka 1966, Wilhm 1967, Wilhm and Dorris 1968, Sanders 1968, Menhinik 1976, Hughes 1978). Shannon-Weaver diversity was used in this study because of its wide acceptance by other workers.

Diversity was measured at each site with the Shannon-Weaver index in which $d = n_i \log_2 n_i$ and n_i = density of species i. Comparisons were made on both a yearly and seasonal basis.

As one measure of community similarity between sites Euclidean distances between samples were calculated using Little Cow Creek data as a reference by the formula:

$$D_{jk} = [\ i\ (X_{ij}-X_{ik})^2]^{1/2}$$

where X_{ij} = Density/M^2 of species i at station j.

X_{ik} = Density/M^2 of species i at station k.

A Friedman test, in which values for the seasonal data in each year were used as cells in the block design, was used in tests of significance (Conover 1971).

As a second measure of community similarity, percent similarity values were obtained by the formula:

$$Psc = 100-0.5\ |a-b|$$

in which a and b are the relative frequency of a given species at stations A and B. The Friedman test was again employed to test for significance.

Population Densities

With t-tests, population densities of individual species (ranked values) at test sites were examined for deviation from those at the reference site (Little Cow Creek #1).

Functional Groups

Insects were classified into four groups (Scrapers, collector-gatherers, predators and shredders) based on the trophic information of Merrit and Cummins (1978). Mean density/m^2 of each taxon was summed across each group, and the totals were used as a measure of relative density of each group at each site per season. Yearly means of

each group were then computed and t-tests were used to test for differences between years.

Number of Taxa

The mean number of taxa present at each study site was calculated for both 1981 and 1982, and t-tests were used to compare values at reference (LCC #1) and the treatment sites.

CHAPTER III

RESULTS

Total Density

In 1981, statistical differences in total density occurred between sites and between seasons. In 1982 significant differences existed only between seasons (Table 3). Total density at Little Cow Creek #1 (LCC#1) in 1981 was significantly different from density at both LCC#2 and LCC#3, but LCC#2 and LCC#3 were not significantly different from each other (Table 3). In 1982 there were no significant differences in density among the Little Cow Creek sites. The difference between densities at LCC#1 and LCC#3 for spring 1981 was the only statistically significant seasonal difference. Tests between sites for all seasons of both years showed no statistical differences among Upper Little River sites in 1981, but significant differences in 1982 (Table 5).

Significant differences in total density occurred between the benthic communities in the reference site and both Upper Little River #1 and Big Eagle Creek #2 (Tables 6 and 7) in 1981 and 1982. Values for ULR #2 were similar to those at the reference site in 1981 but not statistically different in 1982. Significant seasonal (Spring and Summer 1981) differences were also found between communities at the reference site and both ULR#1 and BEC#2. The community from ULR#2 was significantly different from that at the reference during the

TABLE III

SITE AND SEASONAL ANALYSIS OF VARIANCE OF RANKED TOTAL DENSITY AMONG SITES ON LITTLE COW CREEK IN 1981 AND 1982

1981

R^2 = .6379

	df	SS	F	PR>F
SITE	2	391.88	3.49	0.0476*
SEASON	3	1494.63	8.86	0.0004*
SITE*SEASON	6	442.34	1.31	0.2916

1982

R^2 = .6875

	df	SS	F	PR>F
SITE	2	0.25	0.00	0.9958
SEASON	3	439.56	4.89	0.0190
SITE*SEASON	6	350.86	1.95	0.1525

TABLE IV

ANALYSIS OF VARIANCE OF YEARLY RANK TOTAL DENSITY
AMONG SITES ON LITTLE COW CREEK.
HO: MEAN (I)=MEAN (J)

LOCATION	1981 PR>|T|	1982 PR>|T|
LCC#1-LCC#2	0.0597	0.4591
LCC#1-LCC#3	0.0164	0.9794
LCC#2-LCC#3	0.5373	0.4744
LCC#1-ULR#1	0.0006	- **
LCC#1-ULR#2	0.8252	0.5909
LCC#1-BEC#2	0.0043	0.0464
ULR#1-ULR#2	0.0007	- **

** Analysis was not possible due to missing values at UL#1 during the summer of 1982.

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

TABLE V

SITE AND SEASONAL ANALYSIS OF VARIANCE ON RANK TOTAL DENSITY ON UPPER LITTLE RIVER IN 1981 AND 1982

1981

R^2 = .7791

	df	SS	F	PR>F
SITE	1	280.17	17.65	0.0007
SEASON	3	540.33	11.35	0.0003
SITE*SEASON	3	75.50	1.59	0.2320

1982

R^2 = .6786

	df	SS	F	PR>F
SITE	1	25.78	2.29	0.1685
SEASON	3	117.35	3.48	0.0705
SITE*SEASON	2	27.38	1.22	0.3456

spring of 1982. The BEC#2 community was significantly different from that of the reference site during the winter of 1982. Pre-and post-treatment comparisons (Spring data for Upper Little River and Winter data for Big Eagle Creek) showed no significant difference between samples from BEC#2 or ULR#1.

Diversity

There were no between-site differences in diversity among the three Little Cow Creek sites in 1981 or 1982 but significant seasonal differences occurred in both years (Table 8). With the exception of spring 1981, diversities at the two Upper Little River sites significantly differed during all seasons (Tables 10 and 11). Yearly means were also significantly different (Table 9). In 1981 there were also significant differences in diversity between the reference site and the site at ULR#1 in 1981 but no significant differences in 1982.

The reference site showed no significant differences between data collected in the spring of 1981 and that collected in the spring of 1982 However, there were significant differences in data collected in the winters of the two years. Diversity at ULR#1 was significantly different between spring 1981 and spring 1982 but was statistically similar at Big Eagle Creek during the winter of each year.

Euclidean Distance

There were no significant differences (Friedman tests) in Euclidean distance (a measure of community simularity) between the communities in the reference stream for either year or both years combined. On the basis of these results two sites, LCC#1 and LCC#2, were used for

TABLE VI

SITE AND SEASONAL ANALYSIS OF VARIANCE OF TOTAL DENSITY

LOCATIONS	SPRING	SUMMER	FALL	WINTER
		PR>|T|		
1981				
LCC#1-LCC#2	0.1159	0.3401	0.1866	1.0000
LCC#1-LCC#3	0.0074	0.0637	0.9142	0.9142
LCC#2-LCC#3	0.2041	0.2874	0.2230	0.9142
LCC#1-ULR#1	0.0036	0.0002	0.6301	0.6301
LCC#1-ULR#2	0.2420	0.2633	0.0914	0.2420
LCC#1-BEC#2	0.0036	0.0282	0.2527	0.0866
1982				
LCC#1-LCC#2	0.0763	0.0610	0.8993	0.4700
LCC#1-LCC#3	0.1615	0.8004	0.8004	0.1432
LCC#2-LCC#3	0.6624	0.0955	0.8993	0.4278
LCC#1-ULR#1	0.0285	-	0.2026	0.0007
LCC#1-ULR#2	0.0666	0.6192	0.3238	0.6256
LCC#1-BEC#2	0.5285	0.9206	0.6906	0.0001

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

TABLE VII

PRE VS. POST-TREATMENT ANALYSIS OF VARIANCE OF TOTAL DENSITY

SITE	SEASON	PRE-TREATMENT DENSITY/M^2	POST-TREATMENT DENSITY/M^2	PR>F
BEC#2	Winter	2067.6998	1268.3523	0.5692
ULR#1	Spring	989.6683	1578 .3034	0.6628

ULR = Upper Little River

BEC = Big Eagle Creek

TABLE VIII

SITE AND SEASONAL ANALYSIS OF VARIANCE OF DIVERSITY FOR LITTLE COW CREEK IN 1981 AND 1982

1981

R^2 = .4807

	df	SS	F	PR>F
SITE	2	0.2091	0.51	0.6042
SEASON	3	2.0622	3.39	0.0353
SITE*SEASON	6	2.0517	1.68	0.1700

1982

R^2 = .8856

	df	SS	F	PR>F
SITE	2	0.0666	0.86	0.4464
SEASON	3	2.9782	25.73	0.0001
SITE*SEASON	6	0.5389	2.33	0.1003

TABLE IX

SITE ANALYSIS OF VARIANCE OF YEARLY DIVERSITY
HO: MEAN (I)=MEAN (J)

LOCATION	1981 PR>|T|	1982 PR>|T|
LCC#1-LCC#2	0.3246	0.3728
LCC#1-LCC#3	0.7843	0.5346
LCC#2-LCC#3	0.4596	0.7793
LCC#1-ULR#1	0.0001	0.2756
LCC#1-ULR#2	0.9959	0.1298
LCC#1-BEC#2	0.1573	0.3374
ULR#1-ULR#2	0.0001	0.0001

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

TABLE X

SITE AND SEASONAL ANALYSIS OF VARIANCE OF DIVERSITY FOR UPPER LITTLE RIVER IN 1981 AND 1982

1981

R^2 = .9129

	df	SS	F	PR>F
SITE	1	2.8085	53.82	0.0001
SEASON	3	4.4686	28.54	0.0001
SITE*SEASON	3	1.4786	9.44	0.0008

1982

R^2 = .9255

	df	SS	F	PR>F
SITE	1	1.7010	32.61	0.0004
SEASON	3	3.5688	22.80	0.0003
SITE*SEASON	2	0.1458	1.40	0.3016

TABLE XI

SITE ANALYSIS OF VARIANCE OF DIVERSITY BY SEASON
FOR BOTH 1981 AND 1982

LOCATIONS	SPRING	SUMMER	FALL	WINTER
		PR>|T|		
1981				
LCC#1-LCC#2	0.3558	0.3254	0.0160	0.4868
LCC#1-LCC#3	0.7270	0.7792	0.6104	0.5438
LCC#2-LCC#3	0.2079	0.4282	0.0484	0.9286
LCC#1-ULR#1	0.5953	0.3295	0.0001	0.0841
LCC#1-ULR#2	0.6101	0.5687	0.3514	0.4264
LCC#1-BEC#2	0.8648	0.3248	0.0010	0.1437
ULR#1-ULR#2	0.9719	0.0102	0.0001	0.0006
1982				
LCC#1-LCC#2	0.3286	0.9438	0.1032	0.2082
LCC#1-LCC#3	0.1771	0.0757	0.1164	0.4334
LCC#2-LCC#3	0.9438	0.6850	0.0858	0.0535
LCC#1-ULR#1	0.3064	-	0.1053	0.0395
LCC#1-ULR#2	0.0686	0.8505	0.0569	0.2180
LCC#1-BEC#2	0.5389	0.1659	0.3997	0.2594
ULR#1-ULR#2	0.0206	-	0.0071	0.0055

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

TABLE XII

PRE AND POST-TREATMENT ANALYSIS OF VARIANCE OF DIVERSITY

SITE	SEASON	PRE-TREATMENT DIVERSITY	POST-TREATMENT DIVERSITY	PR>F
BEC#2	Winter	3.28	3.25	0.9228
ULR#1	Spring	3.15	3.64	0.0154
LCC#1	Spring	3.32	3.83	0.1118
LCC#1	Winter	2.82	3.46	0.0471

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

TABLE XIII

FRIEDMAN ANALYSIS OF EUCLIDEAN DISTANCES BETWEEN SEASONAL VALUES AT LITTLE COW CREEK IN 1981 AND 1982

LOCATIONS	SPRING	SUMMER	FALL	WINTER
		EUCLIDEAN DISTANCE		
1981				
LCC#1-LCC#2	598	657	406	1468
LCC#1-LCC#3	824	1138	205	1377
LCC#2-LCC#3	405	712	428	740
1982				
LCC#1-LCC#2	742	3204	122	387
LCC#1-LCC#3	864	2186	204	731
LCC#2-LCC#3	662	1813	200	742

1981	T=0.50
1982	T=1.50
BOTH	T=1.75

LCC = Little Cow Creek

TABLE XIV

FRIEDMAN ANALYSIS OF EUCLIDEAN DISTANCES BETWEEN THE SEASONAL VALUES FOR THE REFERENCE SITES AND UPPER LITTLE RIVER #1

LOCATIONS	SPRING	SUMMER	FALL	WINTER
		EUCLIDEAN DISTANCE		
1981				
LCC#1-LCC#2	598	657	406	1468
LCC#1-ULR#1	1067	1846	1582	3077
LCC#2-ULR#1	639	1534	1553	2230
1982				
LCC#1-LCC#2	742	3204	122	387
LCC#1-ULR#1	511	-	838	838
LCC#2-ULR#1	756	-	836	778
1981	T=8.00*			
1982	T=2.00			
BOTH	T=8.86*			

LCC = Little Cow Creek

ULR = Upper Little River

TABLE XV

FRIEDMAN ANALYSIS OF EUCLIDEAN DISTANCES BETWEEN THE SEASONAL VALUES FOR THE REFERENCE SITES AND UPPER LITTLE RIVER #2

LOCATIONS	SPRING	SUMMER	FALL	WINTER
		EUCLIDEAN DISTANCE		
1981				
LCC#1-LCC#2	598	657	406	1468
LCC#1-ULR#2	699	1309	1896	2465
LCC#2-ULR#2	474	952	2128	1989
1982				
LCC#1-LCC#2	742	3204	122	387
LCC#1-ULR#2	547	2879	343	1075
LCC#2-ULR#2	809	962	360	1078

1981	T=4.50
1982	T=0.88
BOTH	T=3.06

LCC = Little Cow Creek

ULR = Upper Little River

TABLE XVI

FRIEDMAN ANALYSIS OF EUCLIDEAN DISTANCES BETWEEN THE SEASONAL VALUES FOR THE REFERENCE SITES AND BIG EAGLE CREEK #2

LOCATIONS	SPRING	SUMMER	FALL	WINTER
		EUCLIDEAN DISTANCE		
1981				
LCC#1-LCC#2	598	657	406	1468
LCC#1-BEC#2	995	1978	2539	1758
LCC#2-BEC#2	554	1464	2781	1182
1982				
LCC#1-LCC#2	742	3204	122	387
LCC#1-BEC#2	623	1551	464	995
LCC#2-BEC#2	815	2995	411	1041

1981	T=3.50
1982	T=1.00
BOTH	T=0.58

LCC = Little Cow Creek

BEC = Big Eagle Creek

reference in the analysis of Euclidean distances (Tables 13-16).

There were no significant differences between values at reference sites and either ULR#2 or BEC#2 for individual years or for both years combined. However data from ULR#1 showed a significant difference from that at the reference site for 1981 and for both years combined.

Percent Similarity

No significant differences were found in percent similarity between the Little Cow Creek sites for either year or for both years combined (Tables 17-20). Both LCC#1 and LCC#2 were therefore used as reference sites in analysis of data from the treatment sites.

Data from both Upper Little River sites was not significantly different from those at the reference site for either year but combining the data for both years resulted in significant differences. Data from BEC#2 were significantly different from those at the reference site in 1981 and for both years combined.

Density of Species

During 1981, a statistical difference between the diversity values from the reference and Upper Little River #1 was found for the following taxa: Psephenus, Chironomidae, Caenis, Lirceus, Asellus and Cheumatopsyche (Tables 21-22). In 1982, densities of Lirceus, Asellus and Stenonema were statistically greater at ULR#1 than at the reference. No other significant differences were seen in 1982.

At ULR#2, 1981 densities of Caenis, Nigronia, Acroneuria, and Cheumatopsyche were statistically different from levels at the reference site; there were no significant differences in 1982. Densities at BEC#2

TABLE XVII

FRIEDMAN ANALYSIS OF SEASONAL PERCENT SIMILARITY OF LITTLE COW CREEK SITES FOR BOTH 1981 AND 1982

LOCATIONS	SPRING	SUMMER	FALL	WINTER
		PERCENT SIMILARITY		
1981				
LCC#1-LCC#2	76	73	60	54
LCC#1-LCC#3	72	61	78	59
LCC#2-LCC#3	79	78	64	69
1982				
LCC#1-LCC#2	64	73	71	79
LCC#1-LCC#3	43	67	66	64
LCC#2-LCC#3	65	54	62	66

1981	T=3.50
1982	T=4.63
BOTH	T=1.19

LCC = Little Cow Creek

TABLE XVIII

FRIEDMAN ANALYSIS OF PERCENT SIMILARITY BY SEASON BETWEEN THE REFERENCE SITES AND UPPER LITTLE RIVER #1

LOCATIONS	SPRING	SUMMER	FALL	WINTER
		PERCENT SIMILARITY		
1981				
LCC#1-LCC#2	76	70	60	54
LCC#1-ULR#1	49	26	10	31
LCC#2-ULR#1	49	36	8	62
1982				
LCC#1-LCC#2	64	73	71	79
LCC#1-ULR#1	59	-	37	50
LCC#2-ULR#1	55	-	38	60

1981	T=3.88
1982	T=4.50
BOTH	T=7.99*

LCC = Little Cow Creek

ULR = Upper Little River

TABLE XIX

FRIEDMAN ANALYSIS OF PERCENT SIMILARITY BY SEASON BETWEEN THE CONTROL SITES AND UPPER LITTLE RIVER #2

LOCATIONS	SPRING	SUMMER	FALL	WINTER
		PERCENT SIMILARITY		
1981				
LCC#1-LCC#2	76	70	60	54
LCC#1-ULR#2	64	55	52	51
LCC#2-ULR#2	67	62	42	73
1982				
LCC#1-LCC#2	64	73	71	79
LCC#1-ULR#2	57	62	57	61
LCC#2-ULR#2	56	73	61	58

1981	T=4.50
1982	T=4.88
BOTH	T=9.19*

LCC = Little Cow Creek

ULR = Upper Little River

TABLE XX

FRIEDMAN ANALYSIS OF PERCENT SIMILARITY BY SEASON BETWEEN THE REFERENCE SITES AND BIG EAGLE CREEK #2

LOCATIONS	SPRING	SUMMER	FALL	WINTER
		PERCENT SIMILARITY		
1981				
LCC#1-LCC#2	76	70	60	54
LCC#1-BEC#2	61	23	34	48
LCC#2-BEC#2	60	39	30	52
1982				
LCC#1-LCC#2	64	73	71	79
LCC#1-BEC#2	51	68	26	57
LCC#2-BEC#2	46	74	30	57
1981	T=6.13*			
1982	T=4.88			
BOTH	T=10.94*			

LCC = Little Cow Creek

BEC = Big Eagle Creek

in 1981 were statistically different from those at the reference for Psephenus, Stenelmis, Chironomidae, Caenis, Stenacron, Lirceus, Acroneuria, and Cheumatopsyche but there were no significant differences for any taxa in 1982.

Functional Groups

Relative densities were not significantly different (t-test) between sites on Little Cow Creek for any group in either 1981 or 1982. There were also no significant differences between yearly means for functional groups at the reference site and those at any of the treatment sites.

Number of Taxa

The mean number of taxa present at each of the study sites was determined for both 1981 and 1982 and t-tests were used to compare values at the control and treatment sites. Little Cow Creek #1 was used as the reference for comparisons with the treatment sites.

TABLE XXI

DENSITY OF SPECIES (M^2) AND MEAN RANK VALUES
AT EACH SITE DURING 1981

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
BIG EAGLE CREEK #2					
Amphipoda	13.59	4	19.50	20.17	2.24
Annelida					
Hirudinea	4.08	3	6.5	0.50	0.50
Lumbriculidae	76.47	4	29.75	14.92	1.93
Cladocera	2.72	1	10.50	-	-
Coleoptera					
Hydroporus	1.36	1	4.50	-	-
Psephenus	65.71	4	21.38	150.90	6.14
Stenelmis (A)	2.72	3	9.50	0.75	0.50
Stenelmis (L)	10.42	3	14.33	71.58	4.88
Collembola	72.50	3	14.17	326.08	10.43
Copepoda	87.00	2	18.25	378.13	13.75
Decapoda	11.56	4	17.50	29.67	2.72
Diptera					
Ceratopogonidae	53.36	4	24.38	81.23	4.51
Chironomidae	1248.64	4	35.25	4.25	1.03
Simuliidae	6.80	3	16.67	2.33	0.88
Tabanidae	4.76	2	10.75	66.13	5.75
Tipulidae	25.83	4	23.00	38.00	3.08
Ephemeroptera					
Ameletus	31.27	2	15.00	242.00	11.00
Baetis	21.07	2	22.25	10.13	2.25
Caenis	2.72	1	8.50	-	-
Eurylophella	11.56	2	21.00	40.50	4.50
Heptagenia sp.#1	16.99	2	20.25	91.13	6.75
Heptagenia sp.#2	2.72	1	10.00	-	-
Paraleptophlebia sp.#1	39.08	4	18.25	149.42	6.11
Paraleptophlebia sp.#2	76.13	4	25.88	87.06	4.67
Pseudocloen	12.91	2	21.00	32.00	4.00
Stenacron	2.72	3	9.67	18.58	2.49
Stenonema	157.01	4	30.63	22.56	2.38

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Hemiptera					
Unidentified	1.36	1	5.00	-	-
Vellidae	1.36	1	3.00	-	-
Hydracarina	64.57	4	28.50	14.83	1.93
Isopoda					
Asellus	85.19	3	29.83	13.08	2.08
Lirceus	36.70	2	23.25	6.13	1.75
Megaloptera					
Corydalus cornutus	1.36	1	4.50	-	-
Sialis	2.72	1	10.00	-	-
Nematoda	9.52	4	18.38	6.23	1.25
Odonata					
Argia	2.72	2	9.50	2.00	1.00
Lanthus parvulus	2.04	2	6.25	10.13	2.25
Pelecypoda	1.36	1	4.50	-	-
Turbellaria	5.44	1	14.50	-	-
Plecoptera					
Acroneuria	2.72	2	9.00	32.00	4.00
Chloroperlidae	17.67	1	25.50	-	-
Isoperla	46.22	2	18.00	392.00	14.00
Zapada	8.16	1	19.00	-	-
Perlesta	1.36	1	4.00	-	-
Taenionema	32.63	4	22.75	66.25	4.07
Tricoptera					
Agapetus	469.01	1	38.00	-	-
Atopsyche	4.08	1	12.00	-	-
Cheumatopsyche	8.16	3	14.50	27.25	3.01
Chimarra	1.36	1	4.50	-	-
Genus #1	4.08	1	13.50	-	-
Lepidostoma	51.66	1	30.00	-	-
Ochrotrichia	30.81	3	22.50	54.25	4.25
Polycentropus	18.01	4	17.50	87.00	4.66
Pycnopsyche	1.36	1	5.00	-	-
Wormaldia	2.72	1	10.00	-	-
Turbellaria	2.72	1	8.50	-	-

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
LITTLE COW CREEK #1					
Amphipoda	50.12	4	30.63	183.23	6.77
Annelida					
Hirudinea	19.54	4	25.00	152.17	6.17
Lumbriculidae	418.54	4	44.50	35.00	2.96
Coleoptera					
Carabidae	4.08	1	17.50	-	-
Helichus	2.72	1	12.00	-	-
Hydroporus	4.08	2	13.25	6.13	1.75
Ectopria nervousa	2.72	1	11.00	-	-
Heterelmis (A)	10.88	1	26.00	-	-
Heterelmis (L)	8.16	1	21.50	-	-
Hydrophilidae	1.36	2	5.00	0.00	0.00
Psephenus	618.71	4	44.00	6.67	1.29
Staphylinidae	4.08	1	17.50	-	-
Stenelmis (A)	16.14	4	17.75	219.42	7.41
Stenelmis (L)	63.21	4	35.88	61.73	3.93
Collembola	2.72	3	9.17	13.08	2.09
Copepoda	144.95	4	28.88	344.40	9.28
Decapoda	13.93	4	24.88	113.73	5.33
Diptera					
Ceratopogonidae	33.30	4	33.13	65.40	4.04
Chironomidae	817.53	4	48.00	12.67	1.78
Simuliidae	8.38	3	15.83	290.33	9.84
Tabanidae	11.55	2	23.75	28.125	3.75
Tipulidae	19.03	4	27.50	129.50	5.69
Ephemeroptera					
Ameletus	70.69	3	32.67	186.33	7.88
Baetis	109.66	3	29.83	249.08	9.11
Caenis	498.06	4	46.75	14.25	1.89
Ephemera	5.44	3	15.33	152.33	7.13
Eurylophella	10.88	1	29.00	-	-
Heptagenia sp.#1	113.51	2	39.00	98.00	7.00
Heptagenia sp.#2	4.08	1	11.50	-	-
Heptagenia sp.#3	2.72	1	6.50	-	-
Isonychia	45.20	4	32.63	165.23	6.43
Leptophlebia	24.92	3	22.17	106.58	5.96

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Paraleptophlebia sp.#1	98.90	2	31.25	496.125	15.75
Paraleptophlebia sp.#2	65.76	4	33.13	178.73	6.68
Pseudocloen	39.65	3	37.33	36.33	3.48
Stenacron	59.99	4	35.63	21.90	2.33
Stenonema	63.21	4	37.75	67.58	4.11
Gastropoda					
Ancylidae	3.40	3	10.33	77.58	5.08
Hemiptera					
Vellidae	12.24	1	21.50	-	-
Hydracarina	53.19	4	34.13	145.73	6.04
Isopoda					
Asellus	2.72	1	11.00	-	-
Lepidoptera					
Pyralidae	9.86	2	16.50	264.50	11.50
Megaloptera					
Corydalus cornutus	8.38	3	14.67	343.58	10.70
Nigronia	11.10	3	23.17	80.33	5.18
Sialis	10.20	2	22.75	10.13	2.25
Nematoda	7.31	4	18.50	80.50	4.49
Odonata					
Argia	8.50	4	16.63	182.06	6.75
Coryphaeshna	1.36	1	5.00	-	-
Hagenius brevistylus	4.93	4	14.25	130.08	5.70
Lanthus parvulus	10.88	2	21.75	36.13	4.25
Ostracoda	1.36	1	2.50	-	-
Pelecypoda	6.29	4	17.63	98.23	4.96
Plecoptera					
Acroneuria	12.24	4	25.00	1.50	0.61
Allocapnia	13.59	1	32.50	-	-
Chloroperlidae	11.33	3	20.17	212.58	8.42
Isoperla	8.16	1	24,50	-	-
Perlesta	5.44	1	17.50	-	-
Taenionema	16.31	3	29.33	25.08	2.89

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Trichoptera					
Agapetus	935.29	1	49.00	-	-
Atopsyche	1.36	1	5.00	-	-
Cheumatopsyche	64.74	4	33.00	101.50	5.04
Chimarra	41.63	4	25.25	206.25	7.18
Genus #1	1.36	1	2.50	-	-
Helicopsyche	6.97	4	15.50	78.17	4.42
Lepidostoma	1.36	1	5.00	-	-
Polycentropus	13.25	4	22.13	153.06	6.19
Pycnopsyche	2.72	1	6.50	-	-
Turbellaria	10.88	1	29.00	-	-
LITTLE COW CREEK #2					
Amphipoda	4.53	3	12.50	78.25	5.11
Annelida					
Hirudinea	5.89	3	14.67	68.58	4.78
Lumbriculidae	155.32	4	37.75	35.58	2.98
Coelenterata	1.36	1	5.00	-	-
Coleoptera					
Helichus	1.36	1	4.50	-	-
Hydroporus	4.99	3	16.50	13.00	2.08
Heterelmis (L)	1.36	1	6.00	-	-
Hydrophilidae	1.36	1	5.00	-	-
Psephenus	591.01	4	39.00	32.00	2.83
Stenelmis (A)	2.72	3	10.67	30.33	3.18
Stenelmis (L)	17.22	3	24.67	30.33	3.18
Collembola	6.80	3	17.83	39.08	3.61
Copepoda	14.61	4	24.63	24.06	2.45
Decapoda	24.47	4	28.25	25.42	2.52
Diptera					
Ceratopogonidae	29.00	3	26.00	96.75	5.68
Chironomidae	818.72	4	40.50	51.67	3.59
Simuliidae	23.11	1	29.00	-	-
Tabanidae	2.04	4	7.50	25.50	2.53
Tipulidae	5.78	4	16.75	25.58	2.53

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Ephemeroptera					
Ameletus	22.66	3	22.83	277.58	9.62
Baetis	68.88	3	34.17	16.58	2.35
Caenis	130.05	3	38.67	37.33	3.53
Eurylophella	8.16	1	20.50	-	-
Heptagenia sp.#1	48.94	2	22.25	630.13	17.75
Heptagenia sp.#2	4.08	1	15.00	-	-
Heptagenia sp.#3	5.44	1	18.50	-	-
Isonychia	65.93	2	24.25	378.13	13.75
Leptophlebia	15.86	3	27.00	13.00	2.08
Paraleptophlebia sp.#1	67.97	2	23.25	703.13	18.75
Paraleptophlebia sp.#2	51.66	3	23.50	334.75	10.56
Pseudocloen	12.24	3	17.50	131.25	6.61
Stenacron	56.42	4	31.50	24.17	2.46
Stenonema	122.01	4	36.50	49.67	3.52
Gastropoda					
Ancylidae	1.70	4	6.62	8.90	1.49
Hemiptera					
Gerridae	1.36	1	4.50	-	-
Vellidae	4.53	3	14.00	48.25	4.01
Hydracarina	80.55	4	31.88	85.40	4.62
Isopoda					
Asellus	4.99	3	15.00	61.75	4.54
Lirceus	2.04	2	7.75	15.13	2.75
Lepidoptera					
Pyralidae	65.61	2	22.00	578.00	17.00
Megaloptera					
Corydalus cornutus	1.36	1	4.50	-	-
Nigronia	11.22	4	20.63	38.56	3.11
Sialis	6.12	2	14.25	136.13	8.25
Nematoda	18.35	4	23.75	149.75	6.12
Odonata					
Argia	7.25	3	18.33	12.33	2.03
Boyeria	2.72	1	11.00	-	-
Coryphaeshna	2.72	1	13.50	-	-
Nagenius brevistylus	1.36	1	4.50	-	-
Lanthus parvulus	13.59	2	19.25	351.13	13.25

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Pelecypoda	16.99	2	19.50	364.50	13.50
Plecoptera					
Acroneuria	25.49	4	24.13	93.73	4.84
Allocapnia	24.47	1	30.50	-	-
Chloroperlidae	32.63	1	33.50	-	-
Perlesta	4.08	1	15.00	-	-
Taenionema	11.90	4	18.63	135.73	5.83
Taeniopteryx	6.80	1	19.00	-	-
Trichoptera					
Agapetus	229.07	2	26.75	528.13	16.25
Cheumatopsyche	47.58	1	34.00	-	-
Chimarra	1.36	1	4.50	-	-
Genus #1	2.04	2	7.75	15.13	2.75
Lepidostoma	8.16	1	20.50	-	-
Polycentropus	25.15	4	30.25	30.42	2.76
Pycnopsyche	2.72	1	11.50	-	-
Turbellaria	5.44	1	17.50	-	-
LITTLE COW CREEK #3					
Amphipoda	4.08	1	19.50	-	-
Annelida					
Hirudinea	4.42	4	16.63	84.73	4.60
Lumbriculidae	261.35	4	38.75	42.92	3.28
Coleoptera					
Dineutus	1.36	1	6.50	-	-
Hydroporus	4.76	2	12.50	72.00	6.00
Heterelmis (L)	2.72	1	13.50	-	-
Psephenus	455.07	4	39.25	35.58	2.98
Stenelmis (A)	1.81	3	6.33	5.33	1.33
Stenelmis (L)	6.80	4	20.75	6.92	1.32
Collembola	2.72	2	11.25	10.13	2.25
Copepoda	4.08	4	12.75	28.92	2.69
Decapoda	22.77	4	30.25	34.25	2.93

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Diptera					
Ceratopogonidae	6.12	4	19.50	61.50	3.92
Chironomidae	633.84	4	40.75	48.92	3.50
Simuliidae	44.86	1	42.00	-	-
Tabanidae	1.36	2	5.75	1.13	0.75
Tipulidae	10.20	4	19.75	208.08	7.21
Ephemeroptera					
Ameletus	21.75	3	22.17	166.58	7.45
Baetis	29.57	4	27.00	67.83	4.12
Caenis	129.83	4	37.00	31.33	2.80
Cinygma	2.72	1	14.00	-	-
Ephemera	2.04	2	7.50	24.50	3.50
Eurylophella	5.44	2	18.25	276.13	11.75
Heptagenia sp.#1	68.43	3	29.17	248.08	9.09
Isonychia	4.76	4	12.38	60.40	3.89
Leptophlebia	14.95	2	24.25	1.13	1.13
Paraleptophlebia sp.#1	32.63	1	34.50	-	-
Paraleptophlebia sp.#2	18.69	4	26.63	111.23	5.27
Pseudocloen	12.92	2	27.50	18.00	3.00
Stenacron	92.78	4	34.38	10.90	9.60
Stenonema	119.29	4	36.50	35.00	2.96
Gastropoda					
Ancylidae	7.48	4	19.88	162.40	6.37
Planorbidae	1.36	1	5.00	-	-
Unidentified	2.72	1	14.00	-	-
Hemiptera					
Dipsocoridae	1.36	1	4.00	-	-
Vellidae	1.36	1	5.00	-	-
Hydrácarina	77.49	4	29.88	156.73	6.26
Isopoda					
Asellus	1.36	2	5.75	1.13	0.75
Lirceus	1.36	1	5.00	-	-
Lepidoptera					
Pyralidae	4.08	3	11.83	35.58	3.44
Megaloptera					
Corydalus cornutus	2.04	2	10.00	24.50	3.50
Nigronia	16.65	4	25.50	224.50	3.50
Sialis	2.72	3	12.83	53.58	4.23

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Nematodaa	26.17	4	31.13	49.73	3.53
Odonata					
Argia	19.03	2	26.25	6.13	6.13
Hagenius brevistylus	6.34	3	11.67	154.33	7.17
Lanthus parvulus	16.99	2	26.00	0.00	0.00
Boyeria	1.36	1	4.00		
Pelecypoda	3.63	3	14.33	105.08	5.92
Plecoptera					
Acroneuria	23.11	4	30.25	22.75	2.39
Allocapnia	10.88	1	32.50	-	-
Chloroperlidae	5.44	1	24.50	-	-
Perlesta	4.08	1	18.50	-	-
Taenionema	4.08	4	15.13	154.06	6.21
Taeniopteryx	4.08	1	19,50	-	-
Trichoptera					
Agapetus	657.97	1	49.00	-	-
Atopsyche	1.36	1	5.00	-	-
Cheumatopsyche	5.44	2	15.25	1.13	0.75
Chimarra	1.36	2	5.75	1 13	0.75
Helicopsyche	1.36	2	5.75	1.13	0.75
Lepidostoma	2.72	1	13.50	-	-
Polycentropus	10.42	3	23.50	14.25	2.18
Pycnopsyche	10.88	1	32.50	-	-
UPPER LITTLE RIVER #1					
Amphipoda	21.07	2	15.00	242.00	11.00
Annelida					
Hirudinea	3.63	3	10.17	59.08	4.44
Lumbriculidae	20.05	4	17.75	104.92	5.12
Coleoptera					
Helichus	76.13	1	23.00	-	-
Hydroporus	6.46	4	16.75	22.92	2.39
Heterelmis (A)	1.36	1	4.00	-	-
Narpus	2.72	1	9.00	-	-
Psephenus	5.10	4	13.25	68.25	4.13
Staphylinidae	4.08	1	19.00	-	-
Stenelmis (A)	1.36	1	6.50	-	-

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Stenelmis (L)	2.72	1	9.00	-	-
Collembola	3.17	3	10.50	18.25	2.47
Copepoda	11.33	3	17.00	52.00	4.16
Decapoda	5.89	3	13.50	40.75	3.69
Diptera					
Ceratopogonidae	35.35	3	23.50	70.75	4.86
Chironomidae	1005.30	4	31.00	31.33	2.80
Simuliidae	3.40	1	13.00	-	-
Tabanidae	1.36	1	5.00	-	-
Tipulidae	4.98	3	15.17	85.08	5.33
Ephemeroptera					
Ameletus	6.80	2	12.00	162.00	9.00
Baetis	137.30	3	26.67	74.33	4.98
Caenis	4.53	3	13.00	33.25	3.33
Eurylophella	12.23	1	22.00	-	-
Heptagenia sp.#1	63.89	3	21.83	60.58	4.49
Heptagenia sp.#2	2.72	1	11.00	-	-
Heptagenia sp.#3	16.31	1	24.00	-	-
Isonychia	2.04	2	8.25	6.13	1.75
Paraleptophlebia sp.#1	75.45	2	17.00	392.00	14.00
Paraleptophlebia sp.#2	151.35	3	25.33	202.33	8.21
Pseudocloen	16.99	2	22.00	72.00	6.00
Stenacron	12.92	2	15.25	253.13	11.25
Stenonema	49.85	3	23.33	26.33	2.96
Gastropoda					
Planorbidae	1.36	1	6.50	-	-
Hemiptera					
Vellidae	1.36	1	4.00	-	-
Hydracarina	76.81	2	28.50	40.50	4.50
Isopoda					
Asellus	410.89	4	30.67	8.33	1.67
Lirceus	7.48	2	21.25	1.13	1.13

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Megaloptera					
Corydalus cornutus	8.16	1	18.00	-	-
Nigronia	1.36	1	5.00	-	-
Nematoda	10.54	4	11.63	94.56	4.86
Odonata					
Argia	1.36	1	3.00	-	-
Hagenius brevistylus	1.36	1	4.00	-	-
Orthoptera					
Acrididae	1.36	1	5.00	-	-
Pelecypoda	1.36	1	6.50	-	-
Plecoptera					
Acroneuria	42.82	2	26.00	8.00	2.00
Chloroperlidae	24.47	4	17.89	137.90	5.87
Perlesta	9.52	1	19.00	-	-
Perlinella	2.72	1	10.00	-	-
Taenionema	63.89	3	17.33	89.33	5.46
Trichoptera					
Agapetus	96.52	1	32.00	-	-
Cheumatopsyche	1.36	2	4.00	2.00	1.00
Chimarra	1.36	1	6.50	-	-
Genus #1	4.76	2	12.25	66.13	5.75
Lepidostoma	9.52	1	20.50	-	-
Ochrotrichia	4.08	1	13.00	-	-
Polycentropus	9.86	4	15.63	38.63	3.11
Pycnopsyche	31.27	1	25.00	-	-
UPPER LITTLE RIVER #2					
Amphipoda	24.02	3	28.83	11.58	1.96
Annelida					
Hirudinea	3.40	2	9.50	0.50	0.50
Lumbriculidae	113.17	4	33.25	96.25	4.91
Coleoptera					
Hydroporus	12.23	1	25.00	-	-
Helichus	1.36	1	10.50	-	-
Heterelmis (A)	4.76	2	13.00	0.00	0.00

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Heterelmis (L)	4.76	2	11.50	60.50	5.50
Psephenus	389.82	4	40.13	25.73	2.53
Stenelmis (A)	6.80	4	12.25	82.92	4.55
Stenelmis (L)	91.08	4	34.75	22.25	2.36
Collembola	4.53	3	12.83	49.08	4.05
Copepoda	14.50	3	18.00	154.75	7.18
Decapoda	9.86	4	19.25	61.75	3.93
Diptera					
Ceratopogonidae	129.15	4	35.13	30.06	2.74
Chironomidae	1597.00	4	43.50	12.33	1.76
Simuliidae	3.17	3	8.33	44.33	3.84
Tabanidae	5.44	4	12.50	40.33	3.18
Tipulidae	15.63	4	19.63	115.06	5.36
Ephemeroptera					
Ameletus	11.56	2	21.50	84.50	6.50
Baetis	197.80	4	32.25	156.25	6.25
Caenis	249.46	4	38.00	31.33	2.80
Cinygmula	4.08	1	15.00	-	-
Heptagenia sp.#1	58.91	3	27.67	89.33	5.46
Heptagenia sp.#2	9.52	1	23.00	-	-
Heptagenia sp.#3	10.88	1	24.00	-	-
Isonychia	35.69	4	23.63	164.56	6.41
Leptophlebia	43.50	1	26.00	-	-
Paraleptophlebia sp.#1	240.62	1	38.00	-	-
Paraleptophlebia sp.#2	161.32	3	38.33	4.33	1.20
Pseudocloen	28.09	3	21.50	49.75	4.07
Stenacron	70.69	3	33.00	73.00	4.93
Stenonema	93.12	4	32.25	26.25	2.56
Gastropoda					
Ancylidae	3.40	2	10.25	0.13	0.25
Unidentified	2.72	1	6.00	-	-
Hemiptera					
Gerridae	1.36	1	5.00	-	-
Hydracarina	87.91	3	29.00	97.00	5.69
Isopoda					
Asellus	24.81	4	24.63	70.23	4.19

TABLE XXI (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Lirceus	5.44	4	13.75	60.92	3.90
Lepidoptera					
Pyralidae	7.48	2	13.75	153.13	8.75
Megaloptera					
Corydalus cornutus	6.80	3	16.00	37.75	3.55
Nigronia	1.36	3	3.50	1.75	0.76
Nematoda	21.07	4	20.50	118.33	5.44
Odonata					
Argia	142.06	4	31.50	147.00	6.06
Hagenius brevistylus	43.50	1	33.00	-	-
Lanthus parvulus	46.22	2	22.00	288.00	12.00
Pelecypoda	1.36	1	5.00	-	-
Plecoptera					
Acroneuria	3.63	3	10.33	86.33	5.37
Allocapnia	5.44	1	13.00	-	-
Chloroperlidae	72.05	2	27.75	210.13	10.25
Neoperla	79.53	2	36.25	1.13	0.75
Perlesta	13.59	1	26.50	-	-
Taenionema	24.02	3	23.67	92.33	5.55
Trichoptera					
Agapetus	1605.49	1	46.00	-	-
Cheumatopsyche	5.44	4	12.25	38.42	3.10
Chimarra	12.91	2	21.25	6.13	1.75
Genus #1	4.76	2	13.00	32.00	4.00
Helicopsyche	10.88	4	15.25	90.42	4.75
Lepidostoma	5.44	1	13.00	-	-
Polycentropus	27.87	4	27.75	36.75	3.03
Pycnopsyche	2.72	1	6.00	-	-
Triaenodes	1.36	2	3.50	4.50	1.50
Turbellaria	10.20	2	20.50	24.50	3.50

TABLE XXII

DENSITY OF SPECIES (M^2) AND MEAN RANK VALUES
AT EACH SITE DURING 1982

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
BIG EAGLE CREEK #2					
Amphipoda	62.19	4	17.25	46.75	3.42
Annelida					
Hirudinea	1.36	1	2.00	-	-
Lumbriculidae	110.11	4	20.50	23.00	2.40
Coelenterata	4.08	1	6.50	-	-
Coleoptera					
Dineutus	4.08	1	6.50	-	-
Hygrotus	8.16	1	8.00	-	-
Psephenus	26.51	4	17.38	100.40	5.01
Stenelmis (A)	2.72	1	6.00	-	-
Stenelmis (L)	6.12	2	9.75	21.13	3.25
Copepoda	346.66	4	20.75	38.25	3.09
Decapoda	26.28	3	13.50	87.75	5.41
Diptera					
Ceratopogonidae	8.16	2	11.75	45.13	4.75
Chironomidae	1050.84	4	28.00	92.67	4.81
Simuliidae	4.08	2	7.25	3.13	1.25
Tipulidae	16.99	2	17.00	50.00	5.00
Ephemeroptera					
Ameletus	3.40	2	6.25	0.13	0.25
Baetis	4.76	2	8.00	4.50	1.50
Caenis	9.06	3	9.00	55.75	4.31
Choroterpes	4.08	1	6.50	-	-
Eurylophella	24.92	3	15.33	20.58	2.62
Heptagenia sp.#1	362.97	2	33.00	32.00	4.00
Heptagenia sp.#3	58.46	1	29.00	-	-
Leptophlebia	6.80	2	9.00	72.00	6.00
Paraleptophlebia sp.#1	32.63	1.	24.00	-	-
Paraleptophlebia sp.#2	236.99	3	27.67	30.33	3.18
Pseudocloen	52.11	3	20.83	255.58	9.23
Stenacron	16.31	1	16.00	-	-
Stenonema	423.80	4	19.63	109.90	5.24

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Gastropoda					
Planorbidae	1.36	1	3.00	-	-
Hemiptera					
Unidentified	****	1	2.00	-	-
Hydracarina	58.46	4	21.50	70.83	4.21
Isopoda					
Asellus	87.34	4	22.88	77.06	4.39
Lirceus	63.89	4	13.25	36.42	3.02
Megaloptera					
Sialis	4.08	1	6.50	-	-
Nematoda	22.43	2	17.75	3.13	1.25
Odonata					
Argia	4.08	1	6.50	-	-
Hagenius brevistylus	4.08	1	3.50	-	-
Lanthus parvulus	4.08	1	6.50	-	-
Pelecypoda	89.72	1	23.00	-	-
Plecoptera					
Acroneuria	17.67	2	15.50	112.50	7.50
Allocapnia	27.19	2	10.00	98.00	7.00
Capnia	21.75	1	17.00	-	-
Chloroperlidae	28.55	2	21.50	24.50	3.50
Isoperla	91.08	2	23.25	28.13	
Zapada	1.36	2	2.50	0.50	0.35
Perlesta	63.89	1	30.00	-	-
Taenionema	74.32	3	22.67	57.33	4.37
Trichoptera					
Agapetus	21.75	3	14.33	98.58	5.73
Cheumatopsyche	4.08	1	6.50	-	-
Genus #1	2.72	1	6.00	-	-
Lepidostoma	8.84	2	9.25	66.13	5.75
Nyctiophylax	48.94	1	20.00	-	-
Ochrotrichia	252.86	1	36.00	-	-
Pycnopsyche	8.16	1	13.50	-	-
Wormaldia	2.72	1	6.00	-	-

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Turbellaria	27.64	3	13.17	59.08	4.44
LITTLE COW CREEK #1					
Amphipoda	20.39	1	13.00	-	-
Annelida					
Hirudinea	72.96	3	20.67	197.33	8.11
Lumbriculidae	290.92	4	29.50	39.00	3.12
Cladocera	36.70	1	15.50	-	-
Coelenterata	4.08	2	4.75	3.13	1.25
Coleoptera					
Dineutus	1.36	1	5.00	-	-
Helichus	4.08	1	6.00	-	-
Ectopria nervousa	8.16	1	9.50	-	-
Heterelmis (A)	25.83	2	17.75	406.13	14.25
Hydrophilidae	2.72	1	9.50	-	-
Psephenus	165.17	4	29.63	85.23	4.62
Stenelmis (A)	14.05	3	20.17	66.08	4.69
Stenelmis (L)	15.86	3	14.17	198.58	8.14
Collembola	1.36	1	5.00	-	-
Copepoda	109.43	4	18.00	91.17	4.77
Decapoda	24.47	3	17.00	121.00	6.35
Diptera					
Ceratopogonidae	9.06	3	17.17	69.08	4.80
Chironomidae	1295.54	4	35.50	86.33	4.65
Simuliidae	334.42	1	41.00	-	-
Tabanidae	4.08	2	15.00	2.00	1.00
Tipulidae	10.88	2	22.25	3.13	1.25
Ephemeroptera					
Ameletus	33.99	3	20.00	108.00	6.00
Baetis	87.00	2	29.75	210.13	10.25
Caenis	132.21	4	21.75	184.92	6.80
Choroterpes	212.07	1	24.00	-	-
Eurylophella	3.40	2	7.75	6.13	1.75
Heptagenia sp.#1	430.94	2	42.50	0.50	0.50
Heptagenia sp.#3	13.59	1	25.50	-	-
Hexagenia	8.16	1	9.50	-	-

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Isonychia	64.57	2	24.25	435.13	14.75
Paraleptophlebia sp.#1	88.36	1	35.00	-	-
Paraleptophlebia sp.#2	190.77	3	34.00	93.00	5.57
Pseudocloen	236.09	3	29.67	233.33	8.82
Stenacron	147.50	2	24.25	1.13	0.75
Stenonema	288.20	4	23.00	67.33	4.10
Gastropoda					
Ancylidae	55.74	2	11.00	128.00	8.00
Hemiptera					
Vellidae	1.36	1	5.00	-	-
Hydracarina	213.09	4	27.00	48.00	3.46
Isopoda					
Lirceus	1.36	1	5.00	-	-
Lepidoptera					
Pyralidae	156.33	2	23.00	18.00	3.00
Megaloptera					
Corydalus cornutus	2.72	1	12.00	-	-
Nigronia	9.52	3	17.00	34.75	3.40
Sialis	97.88	1	18.00	-	-
Nematoda	6.80	3	12.83	129.33	6.57
Odonata					
Argia	19.03	2	9.25	78.13	6.25
Boyeria	8.16	1	9.50	-	-
Hagenius brevistylus	2.72	2	3.25	0.13	0.25
Pelecypoda	2.72	2	5.50	0.50	0.50
Plecoptera					
Acroneuria	6.80	3	15.50	75.25	5.01
Allocapnia	4.76	2	11.00	50.00	5.00
Capnia	29.91	1	30.50	-	-
Choroterpes	48.03	3	25.50	87.25	5.39
Isoperla	142.74	2	28.00	288.00	12.00
Perlesta	106.04	1	37.00	-	-
Taenionema	50.75	3	26.17	105.58	5.93
Zapada	23.11	1	28.00	-	-

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Trichoptera					
Agapetus	41.69	3	21.33	212.33	8.41
Cheumatopsyche	205.28	2	25.00	722.00	19.00
Chimarra	2.72	2	4.25	1.13	0.75
Genus #1	2.72	1	12.00	-	-
Helicopsyche	2.72	1	9.50	-	-
Lype	2.72	1	9.50	-	-
Ochrotrichia	2.72	1	12.00	-	-
Polycentropus	7.82	4	14 63	73.40	4.28
Pycnopsyche	1.36	1	3.00	-	-
Wormaldia	6.80	1	17.50	-	-
Turbellaria	4.08	1	14.00	-	-
LITTLE COW CREEK #2					
Amphipoda	39.42	2	11.50	112.50	7.50
Annelida					
Hirudinea	51.21	3	21.00	325.00	10.41
Lumbriculidae	165.51	4	30/38	154.23	6.21
Coelenterata	1.36	1	4.50	-	-
Coleoptera					
Dineutus	4.08	1	13.00	-	-
Dubiraphia	4.08	1	6.00	-	-
Heterelmis (L)	4.08	1	6.00	-	-
Hydrophilidae	4.08	1	3.50	-	-
Psephenus	178.77	4	31.75	116.92	5.41
Stenelmis (A)	1.36	2	4.25	0.13	0.25
Stenelmis (L)	33.31	2	16.75	3.13	1.25
Collembola	1.36	1	4.00	-	-
Copepoda	81.91	4	25.25	64.25	4.01
Decapoda	20.05	4	18.38	98.56	4.96
Diptera					
Ceratopogonidae	11.56	2	22.00	18.00	3.00
Chironomidae	605.63	4	34.75	144.25	6.01
Simuliidae	45.54	2	19.50	480.50	15.50
Tabanidae	1.36	1	4.50	-	-
Tipulidae	19.94	3	20.50	59.25	4.44

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Ephemeroptera					
Ameletus	290.92	2	30.50	612.50	17.50
Baetis	41.24	3	21.00	297.75	9.96
Caenis	36.37	4	22.63	166.23	6.45
Choroterpes	16.31	1	14.50	-	-
Eurylophella	8.16	1	21.00	-	-
Heptagenia sp.#1	442.50	2	43.50	12.50	2.50
Heptagenia sp.#2	6.80	1	18.50	-	-
Heptagenia sp.#3	6.80	1	18.50	-	-
Isonychia	2.72	2	9.75	0.13	0.25
Leptophlebia	1.36	1	4.50	-	-
Paraleptophlebia sp.#1	111.47	1	39.00	-	-
Paraleptophlebia sp.#2	155.66	4	27.13	364.73	9.55
Pseudocloen	251.95	3	29.50	255.25	
Stenacron	54.04	4	25.75	53.58	3.66
Stenonema	152.26	4	24.50	13.67	1.85
Gastropoda					
Ancylidae	4.08	1	6.00	-	-
Hydracarina	53.02	4	25.38	99.23	4.98
Isopoda					
Asellus	8.61	3	14.67	92.33	5.55
Lirceus	2.04	2	7.00	18.00	3.00
Lepidoptera					
Pyralidae	3.17	3	7.83	20.58	2.62
Megaloptera					
Corydalus cornutus	4.08	1	3.50	-	-
Nigronia	4.76	2	14.25	45.13	4.75
Sialis	15.63	2	19.00	40.50	4.50
Nematoda	12.69	3	17.33	145.33	6.96
Odonata					
Argia	2.72	1	9.50	-	-
Boyeria	4.08	1	3.50	-	-
Hagenius brevistylus	6.12	2	7.00	2.00	1.00
Lanthus parvulus	12.24	2	16.75	231.13	10.75
Orthoptera					
Acrididae	4.08	1	6.00	-	-

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Pelecypoda	14.95	2	17.00	242.00	11.00
Plecoptera					
Acroneuria	6.34	3	10.50	31.00	3.22
Allocapnia	28.55	1	15.00	-	-
Capnia	29.91	1	30.50	-	-
Chloroperlidae	29.23	2	27.50	60.50	5.50
Isoperla	107.40	1	38.00	-	-
Perlesta	122.35	1	40.00	-	-
Taenionema	83.38	3	29.67	120.33	6.33
Zapada	6.80	1	19.00	-	-
Trichoptera					
Agapetus	40.78	3	22.00	159.25	7.29
Cheumatopsyche	17.67	1	26.00	-	-
Genus #1	2.72	1	9.50	-	-
Helicopsyche	1.36	2	4.25	0.13	0.25
Ochrotrichia	20.39	1	27.50	-	-
Polycentropus	10.88	3	17.67	71.08	4.87
Pycnopsyche	4.08	1	13.00	-	-
Rhyacophylia	4.08	1	3.50	-	-
Wormaldia	2.72	1	10.00	-	-
Turbellaria	4.08	1	13.00	-	-
LITTLE COW #3					
Amphipoda	19.49	3	13.83	46.58	3.94
Annelida					
Hirudinea	18.58	3	21.50	150.75	7.09
Lumbriculidae	154.30	4	35.50	329.00	9.07
Coleoptera					
Helichus	2.72	1	18.50	-	-
Dineutus	3.40	2	14.00	200.00	10.00
Ectopria nervousa	6.80	2	6.50	12.50	2.50
Heterelmis (A)	2.72	2	5.00	2.00	1.00
Heterelmis (L)	3.40	2	7.50	24.50	3.50
Hydroporus	6.80	1	22.50	-	-
Psephenus	242.99	4	35.63	330.23	9.09
Stenelmis (A)	9.52	3	18.17	105.58	5.93
Stenelmis (L)	24.92	3	22.17	19.08	2.52

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Collembola	1.36	1	4.00	-	-
Copepoda	151.24	4	33.50	147.67	6.08
Decapoda	24.92	3	24.50	248.25	9.10
Diptera					
Ceratopogonidae	24.92	3	25.50	347.25	10.76
Chironomidae	965.54	4	39.25	254.25	7.97
Simuliidae	11.56	2	25.25	136.13	8.25
Tabanidae	3.40	2	7.50	24.50	3.50
Tipulidae	15.86	3	24.33	189.58	7.95
Ephemeroptera					
Ameletus	156.34	2	30.50	924.50	21.50
Baetis	31.27	3	22.83	455.08	12.32
Caenis	341.22	4	34.38	213.56	7.31
Choroterpes	28.55	1	13.50	-	-
Dannella	1.36	1	6.00	-	-
Eurylophella	10.42	3	21.17	82.33	5.24
Heptagenia sp.#1	118.95	2	46.00	2.00	1.00
Heptagenia sp.#3	4.08	1	17.00	-	-
Isonychia	6.80	2	22.75	36.13	4.25
Leptophlebia	10.88	2	17.75	378.13	13.75
Paraleptophlebia sp.#1	57.10	1	40.50	-	-
Paraleptophlebia sp.#2	112.38	3	38.33	226.33	8.69
Pseudocloen	61.63	3	31.17	264.58	9.39
Stenacron	39.76	4	28.13	225.73	7.51
Stenonema	76.13	4	32.63	160.23	6.33
Gastropoda					
Ancylidae	14.95	2	11.00	50.00	5.00
Planorbidae	4.08	1	4.00	-	-
Hemiptera					
Unidentified	1.36	1	4.00	-	-
Hydracarina	187.60	4	32.38	241.56	7.77
Isopoda					
Asellus	2.72	1	11.00	-	-
Lirceus	4.08	2	17.75	1.13	0.75
Lepidoptera					
Pyralidae	12.24	2	8.00	32.00	4.00

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Megaloptera					
Corydalus cornutus	2.04	2	8.50	12.50	2.50
Nigronia	12.24	3	21.83	100.33	5.78
Sialis	1.36	1	6.00	-	-
Nematoda	28.10	3	27.83	431.08	11.99
Odonata					
Argia	4.08	2	14.25	136.13	8.25
Boyeria	2.72	1	11.00	-	-
Hagenius brevistylus	34.44	3	30.50	79.00	5.13
Lanthus parvulus	16.99	2	19.75	378.13	13.75
Ophiogomphus	4.08	1	4.00	-	-
Pelecypoda	4.99	3	14.00	111.00	6.08
Plecoptera					
Acroneuria	4.53	3	10.33	55.08	4.29
Allocapnia	12.24	1	29.50	-	-
Capnia	50.30	1	40.00	-	-
Chloroperlidae	8.84	2	26.50	0.50	0.50
Isoperla	146.82	1	48.00	-	-
Perlesta	53.02	1	38.00	-	-
Taenionema	35.80	3	28.50	105.25	5.92
Zapada	2.72	2	11.25	105.13	7.25
Trichoptera					
Agapetus	72.96	3	24.17	500.58	12.92
Cheumatopsyche	8.16	2	16.50	312.50	12.50
Genus #1	2.72	1	11.00	-	-
Helocopsyche	4.08	1	17.00	-	-
Lepidostoma	1.36	1	6.00	-	-
Ochrotrichia	5.44	1	20.00	-	-
Polycentropus	2.72	2	5.00	2.00	1.00
Pycnopsyche	9.52	1	27.00	-	-
Wormaldia	2.72	1	13.00	-	-
Turbellaria	19.03	2	19.75	36.13	4.25
UPPER LITTLE RIVER #1					
Amphipoda	35.35	3	19.00	43.00	3.79
Annelida					
Lumbriculidae	14.05	3	19.17	49.08	4.05

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Coleoptera					
Dineutus	1.36	1	5.00	-	-
Hydroporus	2.72	1	9.25	15.13	1.94
Helichus	1.36	1	6.50	-	-
Psephenus	4.08	2	13.00	84.50	6.50
Stenelmis (A)	8.16	1	19.50	-	-
Stenelmis (L)	4.08	1	4.00	-	-
Collembola	4.08	1	4.00	-	-
Copepoda	8.84	2	13.50	4.50	1.50
Diptera					
Ceratopogonidae	13.59	3	17.67	149.08	7.05
Chironomidae	461.30	3	30.67	57.33	4.37
Simuliidae	1.36	1	5.00	-	-
Tipulidae	6.80	3	11.17	56.08	4.33
Ephemeroptera					
Ameletus	5.44	1	15.00	-	-
Baetis	27.64	3	22.33	114.08	6.17
Caenis	7.70	3	11.83	131.58	6.62
Eurylophella	53.02	1	18.00	-	-
Heptagenia sp.#1	324.23	2	35.00	18.00	3.00
Heptagenia sp.#2	2.72	1	10.00	-	-
Heptagenia sp.#3	8.16	1	19.50	-	-
Isonychia	1.36	1	5.00	-	-
Paraleptophlebia sp.#1	246.06	1	37.00	-	-
Paraleptophlebia sp.#2	159.05	2	29.25	190.13	9.75
Pseudocloen	44.86	3	26.50	90.25	5.48
Stenacron	1.36	1	5.00	-	-
Stenonema	42.60	3	25.83	38.08	3.56
Hydracarina	22.20	3	22.50	60.25	4.48
Isopoda					
Asellus	295.00	3	28.33	22.33	2.73
Lirceus	10.42	3	16.67	121.33	6.36
Megaloptera					
Corydalus cornutus	1.36	1	6.50	-	-
Nematoda	4.08	1	12.00	-	-

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Odonata					
Argia	1.36	1	5.00	-	-
Dorocordulia	1.36	1	5.00	-	-
Plecoptera					
Acroneuria	21.30	3	21.33	114.08	6.17
Capnia	1.36	1	6.50	-	-
Chloroperlidae	14.27	2	22.75	3.13	1.25
Isoperla	88.36	1	31.00	-	-
Zapada	1.36	1	6.50	-	-
Perlesta	20.39	1	26.00	-	-
Perlinella	1.36	1	6.50	-	-
Taenionema	52.11	3	23.33	76.33	5.04
Trichoptera					
Agapetus	214.79	2	25.00	128.00	8.00
Cheumatopsyche	27.19	1	29.00	-	-
Chimarra	1.36	1	5.00	-	-
Genus #1	5.44	1	15.00	-	-
Lepidostoma	6.80	2	12.50	24.50	3.50
Ochrotrichia	2.72	2	4.50	0.50	0.50
Polycentropus	5.44	3	12.33	52.33	4.18
Pycnopsyche	1.36	1	6.50	-	-
Wormaldia	2.72	1	13.50	-	-
Turbellaria	6.80	2	9.25	15.13	2.75
UPPER LITTLE RIVER #2					
Amphipoda	34.33	4	25.13	45.73	3.38
Annelida					
Hirudinea	5.89	3	14.67	12.58	2.05
Lumbriculidae	103.66				
Coleoptera					
Helichus	1.36	1	4.50	-	-
Ectopria nervousa	1.36	1	5.50	-	-
Hydroporus	4.08	1	14.00	-	-
Psephenus	154.30	4	34.25	96.92	4.92
Stenelmis (A)	14.05	3	22.67	3.32	
Stenelmis (L)	53.02	4	26.88	237.73	7.71
Collembola	4.08	2	5.50	0.50	0.50

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Copepoda	162.68	3	23.83	96.58	5.67
Decapoda	9.52	4	15.00	38.67	3.11
Diptera					
Ceratopogonidae	23.45	4	23.63	124.06	5.57
Chironomidae	624.32	4	37.25	44.25	3.33
Simuliidae	9.52	2	21.25	15.13	2.75
Tipulidae	21.30	3	24.00	39.00	3.61
Ephemeroptera					
Ameletus	21.75	3	13.33	86.08	5.36
Baetis	29.91	3	25.17	280.58	9.67
Caenis	136.28	4	33.50	43.00	3.28
Choroterpes	28.55	1	21.00	-	-
Eurylophella	1.36	1	4.50	-	-
Heptagenia sp.#1	230.42	2	43.00	2.00	1.00
Heptagenia sp.#3	14.95	1	25.50	-	-
Hexagenia	16.31	1	16.50	-	-
Isonychia	8.61	3	13.33	172.58	7.58
Paraleptophlebia sp.#1	84.29	1	41.00	-	-
Paraleptophlebia sp.#2	141.38	4	30.00	147.33	6.07
Pseudocloen	68.88	3	29.83	204.08	8.25
Rithrogenia	1.36	1	4.50	-	-
Stenacron	77.49	3	22.00	75.00	2.89
Stenonema	371.47	4	29.50	33.67	2.90
Gastropoda					
Ancylidae	3.17	3	5.50	0.25	0.29
Planorbidae	1.36	2	5.00	0.50	0.50
Hemiptera					
Veliidae	4.08	1	5.00	-	-
Hydracarina	80.55	4	28.25	32.92	2.87
Isopoda					
Asellus	9.06	3	17.50	127.75	6.53
Lirceus	4.08	3	9.00	37.00	3.52
Lepidoptera					
Pyralidae	4.08	1	5.00	-	-
Megaloptera					
Corydalus cornutus	2.72	1	9.50	-	-

TABLE XXII (Continued)

TAXA	DENSITY/m^2	N	RANK	VARIANCE	STANDARD ERROR
Sialis	10.88	2	11.50	98.00	7.00
Nematoda	11.78	3	15.00	159.25	7.29
Odonata					
Argia	19.71	4	12.38	75.23	4.34
Boyeria	8.16	1	11.50	-	-
Hagenius brevistylus	14.95	4	15.50	203.83	7.14
Lanthus parvulus	4.08	2	9.50	40.50	4.50
Pelecypoda	13.59	1	25.00	-	-
Plecoptera					
Acroneuria	22.43	2	18.00	32.00	4.00
Allocapnia	73.41	1	24.00	-	-
Capnia	21.75	1	27.00	-	-
Chloroperlidae	87.68	2	34.00	32.00	4.00
Isoperla	98.56	2	23.00	578.00	17.00
Perlesta	14.95	1	25.50	-	-
Taenionema	54.38	2	33.00	162.00	9.00
Trichoptera					
Agapetus	363.42	3	28.33	226.33	8.69
Cheumatopsyche	54.38	1	38.00	-	-
Chimarra	1.36	1	5.50	-	-
Genus #1	4.08	1	14.00	-	-
Helicopsyche	9.52	2	21.25	1.13	0.75
Lepidostoma	2.72	1	12.50	-	-
Lype	1.36	1	5.50	-	-
Nyctiphylax	4.08	1	5.00	-	-
Ochrotrichia	3.17	3	9.00	14.25	2.18
Polycentropus	5.44	3	12.67	46.08	3.92
Pycnopsyche	2.72	2	5.75	0.13	0.25
Turbellaria	16.65	4	15.63	61.23	3.91

TABLE XXIII

RELATIVE DENSITY OF ORGANISMS CLASSIFIED AS SCRAPERS FOR EACH SEASON AT EACH SITE

SITE	MEAN	SPRING	SUMMER	FALL	WINTER
		RELATIVE DENSITY			
1981					
LCC#1	0.3113	0.0467	0.4535	0.4726	0.2723
LCC#2	0.3518	0.0959	0.4272	0.6711	0.2131
LCC#3	0.3019	0.0899	0.3198	0.3792	0.4185
BEC#2	0.1147	0.0822	0.0424	0.0463	0.2880
ULR#1	0.1827	0.0015	0.0109	0.6992	0.0193
ULR#2	0.1303	0.0537	0.2543	0.1853	0.0278
1982					
LCC#1	0.1615	0.1120	0.0207	0.4096	0.1037
LCC#2	0.1861	0.1442	0.1326	0.3846	0.0831
LCC#3	0.2392	0.1493	0.0289	0.5380	0.2406
BEC#2	0.1106	0.0478	0.0043	0.2121	0.1783
ULR#1	0.1500	0.0511	-	0.1761	0.2227
ULR#2	0.2440	0.3451	0.0503	0.2138	0.3668

LCC = Little Cow Creek

ULR = Upper Little Creek

BEC = Big Eagle Creek

TABLE XXIV

RELATIVE DENSITY OF ORGANISMS CLASSIFIED AS COLLECTORS FOR EACH SEASON AT EACH SITE

SITE	MEAN	SPRING	SUMMER	FALL	WINTER
			RELATIVE DENSITY		
1981					
LCC#1	0.6358	0.8861	0.5195	0.4616	0.6760
LCC#2	0.5750	0.8298	0.4959	0.2819	0.6923
LCC#3	0.7336	0.8509	0.5964	0.9536	0.5334
BEC#2	0.7977	0.8207	0.8478	0.9314	0.5907
ULR#1	0.7720	0.8976	0.9399	0.3278	0.9227
ULR#2	0.6893	0.9099	0.5674	0.6472	0.6326
1982					
LCC#1	0.7498	0.8089	0.9078	0.5301	0.7524
LCC#2	0.7341	0.7738	0.8500	0.4793	0.8334
LCC#3	0.6653	0.7590	0.9487	0.3333	0.6201
BEC#2	0.7296	0.8320	0.9829	0.5000	0.6035
ULR#1	0.7807	0.8779	-	0.7784	0.6858
ULR#2	0.6489	0.5419	0.9107	0.6483	0.4945

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

TABLE XXV

RELATIVE DENSITY OF ORGANISMS CLASSIFIED AS PREDATORS FOR EACH SEASON AT EACH SITE

SITE	MEAN	SPRING	SUMMER	FALL	WINTER
			RELATIVE DENSITY		
1981					
LCC#1	0.0437	0.0602	0.0214	0.0563	0.0370
LCC#2	0.0561	0.0724	0.0341	0.0422	0.0756
LCC#3	0.0509	0.0561	0.0795	0.0420	0.0258
BEC#2	0.0669	0.0905	0.0921	0.0122	0.0726
ULR#1	0.0595	0.0979	0.0492	0.0420	0.0489
ULR#2	0.1123	0.0352	0.1688	0.1605	0.0846
1982					
LCC#1	0.0687	0.0725	0.0244	0.0542	0.1236
LCC#2	0.0526	0.0780	0.0130	0.0592	0.0602
LCC#3	0.0773	0.0830	0.0167	0.1111	0.0983
BEC#2	0.0921	0.1064	0.0114	0.0758	0.1746
ULR#1	0.0577	0.0700	-	0.0227	0.0804
ULR#2	0.0801	0.1042	0.0378	0.0586	0.1197

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

TABLE XXVI

RELATIVE DENSITY OF ORGANISMS CLASSIFIED AS SHREDDERS FOR EACH SEASON AT EACH SITE

SITE	MEAN	SPRING	SUMMER	FALL	WINTER
			RELATIVE DENSITY		
1981					
LCC#1	0.0092	0.0069	0.0056	0.0094	0.0147
LCC#2	0.0171	0.0019	0.0428	0.0048	0.0189
LCC#3	0.0087	0.0038	0.0044	0.0044	0.0223
BEC#2	0.0207	0.0066	0.0176	0.0100	0.0486
ULR#1	0.0082	0.0029	0.0000	0.0210	0.0090
ULR#2	0.0056	0.0012	0.0094	0.0070	0.0047
1982					
LCC#1	0.0200	0.0065	0.0470	0.0060	0.0203
LCC#2	0.0271	0.0039	0.0043	0.0769	0.0233
LCC#3	0.0182	0.0086	0.0056	0.0175	0.0410
BEC#2	0.0677	0.0138	0.0014	0.2121	0.0436
ULR#1	0.0116	0.0009	-	0.0227	0.0002
ULR#2	0.0271	0.0088	0.0011	0.0793	0.0190

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

TABLE XXVII

NUMBER OF TAXA PRESENT AT EACH OF THE SAMPLE SITES DURING 1981 AND 1982

SITE	MEAN	SPRING	SUMMER	FALL	WINTER
		NUMBER OF TAXA			
1981					
LCC#1	49	52	45	48	51
LCC#2	41.25	46	44	31	44
LCC#3	41.75	42	39	35	51
BEC#2	35.75	33	37	35	38
ULR#1	31.75	33	26	29	39
ULR#2	44.25	42	41	46	48
1982					
LCC#1	36.25	45	32	24	44
LCC#2	35	49	26	22	43
LCC#3	39.75	55	27	24	53
BEC#2	30.50	41	31	21	29
ULR#1	32.33	40	-	23	34
ULR#2	39	48	33	31	44

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

TABLE XXVIII

PRESENCE OR ABSENCE OF TAXA AT EACH SITE IN 1981 AND 1982

TAXA	LCC#1		LCC#2		LCC#3		ULR#1		ULR#2		BEC#2	
	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982
Amphipoda	+	+	+	+	+	+	+	+	+	+	+	+
Annelida												
Hirudinea	+	+	+	+	+	+	+	-	+	+	+	+
Lumbriculidae	+	+	+	+	+	+	+	+	+	+	+	+
Coleoptera												
Carabidae	+	-	-	-	-	-	-	-	-	-	-	-
Helichus	+	+	+	+	-	+	+	+	-	+	-	-
Hydroporus	+	-	+	-	+	+	+	+	+	+	+	-
Ectopria nervousa	+	+	-	-	-	+	-	-	-	+	-	-
Heterelmis (A)	+	+	-	-	-	+	+	-	+	-	-	-
Heterelmis (L)	+	-	+	+	+	+	-	-	+	-	-	-
Hydrophilidae	+	+	+	+	-	-	-	-	-	-	-	-
Psephenus	+	+	+	+	+	+	+	+	+	+	+	+
Staphylinidae	+	-	-	-	-	-	+	-	-	-	-	-
Stenelmis (A)	+	+	+	+	+	+	+	+	+	+	+	+
Stenelmis (L)	+	+	+	+	+	+	+	+	+	+	+	+
Dubiraphia	-	-	-	+	-	-	-	-	-	-	-	-
Narpus	-	-	-	-	-	-	+	-	-	-	-	-
Hygrotus	-	-	-	-	-	-	-	-	-	-	-	+
Dineutus	-	+	-	+	+	+	-	+	-	-	-	+
Phytobius	-	+	-	-	-	-	-	-	-	-	-	-
Collembola	+	+	+	+	+	+	+	+	+	+	+	-

TABLE XXVIII (Continued)

TAXA	LCC#1		LCC#2		LCC#3		ULR#1		ULR#2		BEC#2	
	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982
Coelenterata	-	+	+	+	-	-	-	-	-	-	-	+
Copepoda	+	+	+	+	+	+	+	+	+	+	+	+
Decapoda	+	+	+	+	+	+	+	-	+	+	+	+
Diptera												
Ceratopogonidae	+	+	+	+	+	+	+	+	+	+	+	+
Chironomidae	+	+	+	+	+	+	+	+	+	+	+	+
Simuliidae	+	+	+	+	+	+	+	+	+	+	+	+
Tabanidae	+	+	+	+	+	+	+	-	+	-	+	-
Tipulidae	+	+	+	+	+	+	+	+	+	+	+	+
Ephemeroptera												
Ameletus	+	+	+	+	+	+	+	+	+	+	+	+
Baetis	+	+	+	+	+	+	+	+	+	+	+	+
Caenis	+	+	+	+	+	+	+	+	+	+	+	+
Choroterpes	-	+	-	+	-	+	-	-	-	+	-	+
Ephemera	+	-	-	-	+	-	-	-	-	-	-	-
Eurylophella	+	+	+	+	+	+	+	+	-	+	+	+
Heptagenia sp.#1	+	+	+	+	+	+	+	+	+	+	+	+
Heptagenia sp.#2	+	-	+	+	-	-	+	+	+	-	+	-
Heptagenia sp.#3	+	+	+	+	-	+	+	+	+	+	-	+
Hexagenia	-	+	-	-	-	-	-	-	-	+	-	-
Isonychia	+	+	+	+	+	+	+	+	+	+	-	-
Leptophlebia	+	-	+	+	+	+	-	-	+	-	-	+
Paraleptophlebia sp.#1	+	+	+	+	+	+	+	+	+	+	+	+
Paraleptophlebia sp.#2	+	+	+	+	+	+	+	+	+	+	+	+
Pseudocloen	+	+	+	+	+	+	+	+	+	+	+	+
Stenacron	+	+	+	+	+	+	+	+	+	+	+	+

TABLE XXVIII (Continued)

TAXA	LCC#1		LCC#2		LCC#3		ULR#1		ULR#2		BEC#2	
	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982
Stenonema	+	+	+	+	+	+	+	+	+	+	+	+
Dannella	-	-	-	-	-	+	-	-	-	-	-	-
Rithrogenia	-	-	-	-	-	-	-	-	-	+	-	-
Cinygmula	-	-	-	-	+	-	-	-	+	-	-	-
Gastropoda												
Ancylidae	+	+	+	+	+	+	-	-	+	+	-	-
Planorbidae	-	-	-	-	+	+	+	-	-	+	-	+
Hemiptera												
Gerridae	+	-	+	-	-	-	-	-	+	-	-	-
Vellidae	+	+	+	-	+	-	+	-	-	+	+	-
Hydracarina	+	+	+	+	+	+	+	+	+	+	+	+
Isopoda												
Asellus	+	-	+	+	+	+	+	+	+	+	+	+
Lirceus	-	+	+	+	+	+	+	+	+	+	+	+
Lepidoptera												
Pyralidae	+	+	+	+	+	+	-	-	+	+	-	-
Megaloptera												
Corydalus cornutus	+	+	+	+	+	+	+	+	+	+	-	-
Nigronia	+	+	+	+	+	+	+	-	+	-	-	-
Sialis	+	+	+	+	+	+	-	-	-	+	-	+
Nematoda	+	+	+	+	+	+	+	+	+	+	+	+

TABLE XXVIII (Continued)

TAXA	LCC#1		LCC#2		LCC#3		ULR#1		ULR#2		BEC#2	
	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982
Odonata												
Argia	+	+	+	+	+	+	+	+	+	+	-	+
Coryphaeshna	+	-	+	-	-	-	-	-	-	-	-	-
Hagenius brevistylus	+	+	+	+	+	+	+	-	+	+	-	+
Lanthus parvulus	+	-	+	+	+	+	-	-	+	+	-	+
Boyeria	-	+	-	+	+	+	-	-	-	+	-	-
Ophiogomphus	-	-	-	-	-	+	-	-	-	-	-	-
Dorocordulia	-	-	-	-	-	-	-	+	-	-	-	-
Orthoptera												
Acrididae	-	-	-	+	-	-	+	-	-	-	-	-
Ostracoda	+	-	-	-	-	-	-	-	-	-	-	-
Pelecypoda	+	+	+	+	+	+	+	-	+	+	-	+
Plecoptera												
Acroneuria	+	+	+	+	+	+	+	+	+	+	-	+
Allocapnia	+	+	+	+	+	+	-	-	+	+	-	+
Capnia	-	+	-	+	-	+	-	+	-	+	-	+
Chloroperlidae	+	+	+	+	+	+	+	+	+	+	+	+
Isoperla	+	+	-	+	-	+	-	+	-	+	-	+
Neoperla	-	-	-	-	-	-	-	-	+	-	+	-
Perlesta	+	+	+	+	+	+	+	+	+	+	-	+
Perlinella drymos?	-	-	-	-	-	-	+	+	-	-	-	-
Taenionema	+	+	+	+	+	+	+	+	+	+	-	+
Taeniopteryx	-	-	+	-	+	-	-	-	-	-	-	-
Zapada	-	+	-	+	-	+	-	+	-	-	-	+

TABLE XXVIII (Continued)

TAXA	LCC#1		LCC#2		LCC#3		ULR#1		ULR#2		BEC#2	
	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982	1981	1982
Trichoptera												
Agapetus	+	+	+	+	+	+	+	+	+	+	+	+
Atopsyche	+	-	-	-	+	-	-	-	-	+	-	-
Cheumatopsyche	+	+	+	+	+	+	+	+	+	+	-	+
Chimarra	+	+	+	-	+	-	+	+	+	+	-	-
Genus #1	+	+	+	+	-	+	+	+	+	+	-	+
Helicopsyche	+	+	-	+	+	+	-	-	+	+	-	-
Lepidostoma	+	-	+	-	+	+	+	+	+	+	-	+
Lype	-	+	-	-	-	-	-	-	-	+	-	-
Nyctiophylax	-	-	-	-	-	-	-	-	-	+	-	+
Ochrotrichia	-	+	-	+	-	+	+	+	-	+	-	+
Polycentropus	+	+	+	+	+	+	+	+	+	+	-	-
Pycnopsyche	+	+	+	+	+	+	+	+	+	+	-	+
Rhyacophila	-	-	-	+	-	-	-	-	-	-	-	-
Triaenodes	-	-	-	-	-	-	-	-	+	-	-	-
Wormaldia	-	+	-	+	-	+	-	+	-	-	-	+
Turbellaria	+	+	+	+	-	+	-	+	+	+	+	+

\+ Taxa present at this site.
\- Taxa not found at this site.
LCC = Little Cow Creek
ULR = Upper Little River
BEC = Big Eagle Creek

TABLE XXIX

SEASONAL DENSITY AND YEARLY MEANS AT EACH SAMPLE SITE

SITE	MEAN	SPRING	SUMMER	FALL	WINTER
			DENSITY/m^2		
1981					
LCC#1	3804.69	3310.22	4363.79	2173.74	5557.37
LCC#2	2633.22	2316.48	3442.09	1246.60	3527.73
LCC#3	2304.58	1387.98	2509.52	1907.29	3413.54
BEC#2	2476.21	957.04	2650.90	4229.20	2067.70
ULR#1	2331.09	989.67	705.54	1757.75	5871.40
ULR#2	4475.94	2434.75	2805.87	4842.31	7820.83
1982					
LCC#1	3629.69	2531.27	9057.91	787.11	3866.24
LCC#2	2979.71	3545.41	2483.69	815.66	3300.71
LCC#3	3005.20	3357.80	4743.07	884.99	2780.04
BEC#2	2430.67	2195.49	8022.02	1031.81	1268.35
ULR#1	1760.66	1578.30	-	1635.40	1984.78
ULR#2	2675.37	1601.41	4335.24	1549.76	3571.23

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

TABLE XXX

SEASONAL DIVERSITY AND YEARLY MEANS AT EACH SAMPLE SITE

SITE	MEAN	SPRING	SUMMER	FALL	WINTER
			DIVERSITY		
1981					
LCC#1	3.11	3.32	3.24	3.10	2.82
LCC#2	2.93	3.67	2.83	2.15	3.08
LCC#3	3.07	3.19	3.12	2.91	3.05
BEC#2	2.89	3.37	2.89	2.01	3.28
ULR#1	2.44	3.15	2.89	1.42	2.27
ULR#2	3.12	3.16	3.44	2.81	3.07
1982					
LCC#1	3.50	3.83	3.09	3.06	3.46
LCC#2	3.54	3.99	3.07	3.55	3.25
LCC#3	3.63	4.06	2.55	3.53	3.59
BEC#2	3.36	3.72	2.64	3.33	3.25
ULR#1	3.01	3.64	-	2.53	2.53
ULR#2	3.63	4.18	3.15	3.69	3.23

LCC = Little Cow Creek

ULR = Upper Little River

BEC = Big Eagle Creek

CHAPTER IV

DISCUSSION

Total Density

Clear seasonal differences in density (e.g., Spring-Summer) appeared in the data from both treatment and reference sites. However, previous workers have attributed differences of the magnitude observed to emergence of later instars and hatching.

Significant differences occurred between densities at Little Cow Creek #1 and LCC#2 and LCC#3 in 1981 and the same general trend, although non-significant, occurred in 1982. The differences between the sites may be ascribed to natural variability or to differences in physical characteristics at each site. Little Cow Creek #1 is characteristic of all of the treatment sites since the riffle area is preceded by a large pool. However the pools at LCC#2 and LCC#3 are much smaller than at LCC#1. In addition, the density of overhanging streamside vegetation was greater at LCC#2 and LCC#3 and they received less solar radiation than did LCC#1 and the other sites that were examined.

During both years Upper Little River #1 and Big Eagle Creek #2 had lower densities of organisms than did the reference site. Both of these sites are located below areas of logging activity and in 1981 extensive road construction also occurred above these sites. In addition, a new

clearcut was created upstream from ULR#1 in 1981 and approximately 100 meters of the stream was channelized between the summer and fall of that year. The channelized portion of the stream included the riffle area where samples were collected during this study. A clearcut was also created upstream from BEC#2 late in 1982.

The lower density of organisms at ULR#1 and BEC#2 relative to the reference site may have resulted from silvicultural activity and resultant increased amounts of sediment entering the stream. Similar data have been explained in this manner by other authors (Tebo 1955, Hynes 1973, Lee and Samuel 1976, Luedtke et al. 1976, and Graynoth 1979).

During 1982 the density of organisms at BEC#2 was similar to the reference site for every season except winter (Table 6). The winter data correspond to the completion of a clear cut at this location. Although the data are far from conclusive, the reduced density may have resulted from lowered productivity or changes in the habitat brought on by deposition or turbidity.

In addition to the changes already noted, both of the sites at Upper Little River showed a decreased invertebrate density in 1982 relative to 1981 (Table 28). Density values at all other sites remained close to those of 1981. This common decrease in density at both sites indicates that whatever affected ULR#1 also affected ULR#2.

Decreased density of organisms at the treatment sites could be due to natural variability, however if random events were responsible for changes we might expect increases as well as decreases in density. In addition we would not expect the timing of the appearance of decreased density to correspond so well with periods of silvicultural activity.

Considering the response of each of the treatment sites collectively, it seems reasonable to conclude that decreased density was either the direct consequence of silvicultural activity or of some factor resulting from silvicultural activity.

Diversity

Diversity was lower at Upper Little River #1 than at Upper Little River #2 during every season except spring. The greatest difference occurred in the fall after channelization had taken place (Fall 1981). This decrease in diversity after channelization resulted from the domination of the community by the isopod Asellus and increased abundance of the stonefly Taenionema. Both of these organisms have been classified as grazers (Merrit and Cummins 1978, Williams 1976).

An increase in the abundance of grazers could reflect an increase in primary production at the site following channelization. Primary productivity normally results from an increase in solar radiation and an increase in nutrient levels. Little disturbance of streamside vegetation occurred, so increased solar radiation seems improbable. A more realistic explanation is that when channelization occurred, the substrate was disturbed and nutrients which were bound in the soil became available. This increase in available nutrients could have created a "temporary surplus" of nutrients which ultimately resulted in the increased abundance of Asellus and Taenionema.

Lower diversity at ULR#1 could either result from variability or from the effects of silvicultural activity. However, the fact that the periods of decreased diversity corresponded to periods when various types of silvicultural activity occurred above this site makes the explanation of natural variability less probable.

Euclidean Distance and Percent Similarity

Euclidean distance and percent similarity were comparable at all three sites in Little Cow Creek. However, slight differences in total density were seen and probably reflect a small increase in the abundance of taxa at LCC#1 (Tables 21-22).

In contrast Euclidean distance was significantly greater at ULR#1 than at the reference site, and percent similarity showed that all three treatment sites were different from the reference site. It appeared that few taxa were completely eliminated at the treatment sites but that there was a shift in the community structure. Again the consistent direction of these changes argues against the possibility of causality by random environmental factors.

Functional Groups

There were no statistical differences in the functional groups or densities of individual taxa present at any of the sites during either year. However, the presence of large variations in the data between seasons would require very large differences in order to attain statistical significance.

In spite of the lack of statistical significance in these data, there were lower relative densities of scrapers at all of the treatment sites during 1981 than in 1982. The large relative density of scrapers (possibly the result of increased primary productivity) at ULR#1 during the fall of 1981 following channelization, was the only factor that kept the mean density at this site near the values at the other sites. In addition, the relative density (1981) of predators was also higher at ULR#2 than at the reference site. Murphy and Hall (1981) and Gurtz

(1981) have hypothesized that increased abundance of predators and scrapers is an indication of logging activity and can be attributed to increased prey availability. However, in this study increased prey populations were found only after channelization.

Number of Taxa

The numbers of taxa at Upper Little River #1 and Big Eagle Creek #2 were lower than at the reference site in 1981. A similar trend is present in the data for the spring and winter of 1982. The values of winter 1982 at BEC#2 were relatively low and represent the first season after logging was completed at this site.

These results show a distinctly lower mean number of species present at logged sites than at other sites. However, it is impossible to determine unequivocally whether differences are due to logging effects or seasonal variation.

In spite of the complexity of the data, several trends seem to support the conclusion that moderate logging induced change in community structure. For example, Tabanids in which included at least two species of Tabanus, were absent from all three treatment sites in 1982. Also Nigronia, Corydalus cornutus, Pyralidae, Ancylidae, and Isonychia were never collected at BEC#2. Each of these species was collected both years at all three sites on Little Cow Creek.

At ULR#1 Ancylidae, Pyralidae, Sialis, and Allocapnia were absent during 1981 and 1982. Each of these species was collected at ULR#2 and was present at all three Little Cow Creek sites both years. Absence of these species in the collections may be attributable to low population density. However, these species were collected from all three Little

Cow Creek sites in both 1981 and 1982. In addition, collections were made quarterly (twenty samples at each site over the study period) over a two-year period and the results were combined. Considering these factors, it appears unreasonable to assume that these species were present at the treatment site but were not collected. It seems more reasonable to conclude that some similarities between ULR#1 and BEC#2 precluded their occurrence at these locations. The only factor common to both sites, yet differing from the reference site, was silvicultural activity. Little is known on the ecology of these species and it is difficult to speculate on how logging might affect their occurrence.

Density of Species

The isopod Asellus apparently increased in number in response to site disturbance. The density of Asellus and the frequency of occurrence were greater at the treatment sites than at the sites in Little Cow Creek (Tables 21 and 22). In addition, after the channelization of ULR#1 in the fall of 1981 Asellus dominated the system. One possibility is that Asellus rapidly colonizes a system after disturbance. The presence of Asellus at all Little Cow Creek sites in the fall of 1982 verifies that the species has access throughout the drainage. The fact that the population explosion occurred only at the channelized site during the fall seems to point away from seasonal causes, reinforcing the hypothesis that the density of Asellus in these streams increases in response to disturbance.

Conclusion

Consistent point changes in measures of community structure were

observed immediately downstream from areas of logging activity. These changes were consistent with changes associated with stressed communities, and appeared to decrease downstream from the logging area. Changes in communities which were channelized were more severe than those below areas of logging activity.

Literature Cited

Brown, G. W., and J. T. Krygier. 1971. Clear-cut logging and sediment production in the Oregon Coast Range. Water Resour. Res. 7:1189-1198.

Brown, H. P. 1976. Aquatic Dryopaid Beetles (Coleoptera) of the United States. United States EPA 18050 ELD04/72. 82 pp.

Burns, J. W. 1972. Some effects of logging and associated road construction on northern California streams. Trans. Am. Fish. Soc. 101:1-17.

Carle, F. L. 1976. An evaluation of the removal method for estimating benthic populations and diversity. Unpublished thesis, Virginia Polytechnic Institute and State University, Blacksburg, Virginia.

Carle, F. L. , and O. E. Maughan. 1980. A comparison of removal and conventional sieving methods for estimating benthic populations. Hydrobiologia 20(1,2):181-187.

Chutter, F. M. 1969. The effects of silt and sand on the invertebrate fauna of streams and rivers. Hydrobiologia 34(1):57-76.

Conover, W. J. 1971. Practical Nonparametric Statistics. John Wiley & Sons, Inc. 462 pp.

Downing, J. A. 1979. Aggregation, transformation and the design of benthos sampling programs. J. Fish. Res. Bd. Can. 36:1454-1463.

Elliot, J. M. 1977. Some methods for the statistical analysis of samples of benthic invertebrates. Freshwater Biological Association Scientific Publication No. 25, 1-157.

Feller, M. C. 1981. Effects of clearcutting on stream temperature in southwestern British Columbia. Water Resources Bulletin 17(5):863-867.

Flint, O. S. 1960. Taxonomy and Biology of Nearctic Limnephelid Larvae (Trichoptera), with special reference to species in eastern United States. Entomologica Americana XL:1-117.

Graynoth, E. 1979. Effects of logging on stream environments and faunas in Nelson. New Zealand Journal of Marine & Freshwater Research. 13(1):79-109.

Gurtz, M. E., J. R. Webster, and J. B. Wallace. 1980. Seston dynamics in southern Appalachian streams: effects of clear-cutting. Can. J. Fish. Aquat. Sci. 37:624-631.

Gurtz, M. E. 1981. Ecology of stream invertebrates in a forested and a commercially clear-cut watershed. Ph.D. Thesis, Univ. of Georgia, Athens, Georgia. 146 pp.

Haefner, J. D., and J. B. Wallace. 1981. Shifts in aquatic insect populations in a first-order southern Appalachian stream following a decade of old field succession. Can. J. Aquat. Sci. 38:353-359.

Hughes, B. D. 1978. The influence of factors other than pollution on the value of Shannon's diversity index for benthic-macroinvertebrates in streams. Water Research 11:689.

Hutchinson, G. E. 1953. The concept of pattern in ecology. Proc. Nat. Acad. Sci. Phil.

Lee, R., and D. E. Samuel. 1976. Some thermal and biological effects of forest cutting in West Virginia. J. Environ. Qual. 5(4):362-366.

Lewis, P. A. 1974. Taxonomy and ecology of Stenonema mayflies (Heptageniidae:Ephemeroptera). U.S. EPA, Environmental Monitoring Ser. Rept. EPA-670/4-74-006. 81 pp.

Likens, Gene E., F. H. Bormann, and Noye M. Johnson. 1969. Nitrifications importance to nutrient losses from a cutover forested ecosystem. Science 163(3872):1205-1206.

Luedtke, R. J., M. A. Brusuen, and F. J. Watts. 1976. Benthic insect community charges in relation to in-stream alterations of a sediment-polluted stream. Melanderia 23:21-39.

MacArthur, R. H. 1957. On the relative abundance of bird species. Proc. Nat. Acad. Sci. 43:293.

Menhinik, E. F. 1976. A comparison of some species-individuals diversity indices applied to field insects. Ecology 45:859.

Merrik, R. W. and K. W. Cummins (eds.). 1978. An introduction to the Aquatic Insects of North America. Kendall/Hunt Publ. Co., Dubuque, Iowa.

Murphy, M. L., and J. D. Hall. 1981. Varied effects of clear-cut logging on predators and their habitat in small streams of the Cascade Mountains, Oregon. Can. J. Fish. Aquat. Sci. 38:137-145.

Murphy, M. L., C. P. Hawkins, and N. H. Anderson. 1981. Effects of canopy modification and accumulated sediment on stream communities. Trans. Am. Fish. Soc. 110:460-478.

Newbold, J. D., D. C. Erman, and K. B. Roby. 1980. Effects of logging on macroinvertebrates in streams with and without buffer strips. Can. J. Fish. Aquat. Sci. 37:1076-1085.

Odum, H. T., J. E. Cantlor, and L. S. Kornicker. 1960. An organizational hierarchy postulate for the interpretation of species individual distributions, species entropy, ecosystem evolution, and the meaning of a species variety index. Ecology 41:395.

Pennak, R. W. 1978. Freshwater Invertebrates of the United States. John Wiley and Sons, New York.

Pianka, E. R. 1966. Latitudinal gradients in species diversity: A review of concepts. Am. Natur. 100:463.

Raleigh, Robert F. and Cathleen Short. 1981. Depletion sampling in stream ecosystems: Assumptions and techniques. Prog. Fish Cult. 43(3):115-120.

Sanders, H. L. 1968. Marine benthic diversity: A comparative study. Am. Natur. 102:243.

Shannon, C. E. 1948. A mathematical theory of communication. Bell Syst. Tech. J. 27:379.

Taylor, L. R. 1961. Aggregation, variance, and the mean. Nature 189:732-735.

Tebo, L. B. Jr. 1955. Effects of siltation, resulting from improper logging, on the bottom fauna of a small trout stream in the southern Appalachians. Prog. Fish Cult. 17(2):64-70.

Usinger, R. L. (ed.). 1956. Aquatic Insects of California. Univ. Calif. Press, Berkeley, California.

Wiggins, G. B. 1977. Larvae of North American Caddisfly Genera (Trichoptera). Univ. of Toronto Press, Toronto.

Wilcoxon, F. 1945. Individual comparison by ranking methods. Biometrics Bulletin 1:80-83.

Wilhm, J. L. 1967. Comparison of some diversity indices applied to populations of benthic macroinvertebrates in a stream receiving organic wastes. J. Water Poll. Cent. Fed. 39:1673.

Wilhm, J. L. and T. C. Dorris. 1968. Biological parameters for water quality criteria. Bioscience 18(6):477-481.

Williams, W. D. 1976. Freshwater Isopods (Asellidae) of North America. United States EPA 18050 ELD05/72. 45 pp.

Woodall, W. R. Jr. and J. B. Wallace. 1972. The benthic fauna in four small southern Appalachian streams. Am. Midl. Nat. 88:393-407.

APPENDIX A

STATISTICAL ANALYSIS SYSTEM (SAS) PROGRAM FOR DENSITY OF SPECIES, TOTAL DENSITY, SHENNON-WEAVER DIVERSITY, AND RELATIVE DENSITY OF SPECIES

APPENDIX A

STATISTICAL ANALYSIS SYSTEM (SAS) PROGRAM FOR DENSITY OF SPECIES, TOTAL DENSITY, SHENNON-WEAVER DIVERSITY, AND RELATIVE DENSITY OF SPECIES

```
//BENTHICS JOB (XXXXX,SSN-  -     ),NAME,TIME=(0,20),CLASS=A
// EXEC SAS
//SYSIN DD *
DATA ONE;
INPUT SITE 1 DRAINAGE $ 3-5 SEASON $ 7-9 YEAR 10-11 ORDER $ 15-18
SPECIES $ 20-27 POPEST1 30-33 POPEST2 40-43 POPEST3 50-53;
DENSITY1=POPEST1/.2452;
DENSITY2=POPEST2/.2452;
DENSITY3=POPEST3/.2452;
CARDS;
PROC SORT DATA=ONE PUT=TWO;BY DRAINAGE SITE SEASON;
PROC SORT DATA=ONE OUT=FOUR;BY DRAINAGE SITE SEASON SPECIES;
DATA THREE; SET TWO;
ARRAY DENSITY (I) DENSITY1-DENSITY3;
DO OVER DENSITY;
  ABUNDANC=DENSITY;OUTPUT;
END;
PROC SORT;BY DRAINAGE SITE SEASON;
PROC SORT;BY DRAINAGE SITE SEASON SPECIES;
PROC MEANS NOPRINT; BY DRAINAGE SITE SEASON SPECIES;
VAR ABUNDANC;
OUTPUT OUT=AVERAGE
MEAN=MDENSITY
```

APPENDIX A (Continued)

```
VAR=VDENSITY;
DATA NEW; MERGE AVERAGE FOUR;
BY DRAINAGE SITE SEASON SPECIES;
PROC SORT;BY DRAINAGE SITE SEASON ORDER;
PROC PRINT; BY DRAINAGE SITE SEASON;
TITLE 'MEAN DENSITY OF SPECIES';
DATA FIVE; SET TWO;
PROC MEANS NOPRINT;BY DRAINAGE SITE SEASON;
VAR DENSITY1 DENSITY2 DENSITY3;
OUTPUT OUT=OVERALL
SUM=TOTAL1 TOTAL2 TOTAL3;
PROC SORT; BY DRAINAGE SITE SEASON;
DATA SIX;SET OVERALL;
ARRAY TOTAL (J) TOTAL1-TOTAL3;
DO OVER TOTAL;
SEVEN=TOTAL;OUTPUT;
END;
PROC SORT;BY DRAINAGE SITE SEASON;
PROC MEANS;BY DRAINAGE SITE SEASON;
VAR SEVEN;
TITLE 'MEAN TOTAL DENSITY OF TAXA AT EACH SITE';
DATA EIGHT;SET TWO;
PROC MEANS NOPRINT;BY DRAINAGE SITE SEASON;
VAR POPEST1 POPEST2 POPEST3;
OUTPUT OUT=OLD
```

APPENDIX A (Continued)

```
SUM=ADD1 ADD2 ADD3;
DATA NINE; MERGE OLD TWO;
BY DRAINAGE SITE SEASON;
RELFREQ1=POPEST1/ADD1;
RELFREQ2=POPEST2/ADD2;
RELFREQ3=POPEST3/ADD3;
LOGP1=RELFREQ1*(LOG2(RELFREQ1));
LOGP2=RELFREQ2*(LOG2(RELFREQ2));
LOGP3=RELFREQ3*(LOG2(RELFREQ3));
DATA TEN;SET NINE;
PROC MEANS;BY DRAINAGE SITE SEASON;
VAR LOGP1 LOGP2 LOGP3;
OUTPUT OUT=SWDIVERS
SUM=DIVERSE1 DIVERSE2 DIVERSE3;
DATA ELEVEN;SET SWDIVERS;
DIVERSE=DIVERSE1;OUTPUT;
DIVERSE=DIVERSE2;OUTPUT;
DIVERSE=DIVERSE3;OUTPUT;
DATA TWELVE;SET ELEVEN;
PROC MEANS;BY DRAINAGE SITE SEASON;
VAR DIVERSE;
OUTPUT OUT=INDEX;
TITLE 'SHANNON WEAVER INDEX';
DATA SIMPLE;SET NEW;
PROC MEANS;BY DRAINAGE SITE SEASON;
```

APPENDIX A (Continued)

```
VAR MDENSITY;
OUTPUT OUT=STREAM
SUM=ADDITION;
DATA PIPE;MERGE STREAM NEW;BY DRAINAGE SITE SEASON;
RELFREQ=MDENSITY/ADDITION;
PROC PRINT;BY DRAINAGE SITE SEASON;
TITLE 'RELATIVE FREQUENCY OF SPECIES';
//
```

APPENDIX B

STATISTICAL ANALYSIS SYSTEM (SAS) PROGRAM FOR CALCULATING EUCLIDEAN DISTANCE VALUES BETWEEN SITES

APPENDIX B

STATISTICAL ANALYSIS SYSTEM (SAS) PROGRAM FOR CALCULATING EUCLIDEAN DISTANCE VALUES BETWEEN SITES

```
//DISTANCE JOB (XXXXX,SSN-  -     ),NAME,TIME=(0,40),CLASS=A
// EXEC SAS
//SYSIN DD*
DATA ONE;
INPUT SITE 1 DRAINAGE $ 3-5 SEASON $ 7-9 YEAR 10-11 ORDER $ 15-18
SPECIES $ 20-27 POPEST1 30-33 POPEST2 40-43 POPEST3 50-53;
DENSITY1=POPEST1/.2452;
DENSITY2=POPEST2/.2452;
DENSITY3=POPEST3/.2452;
CARDS;
PROC SORT DATA=ONE PUT=TWO;BY DRAINAGE SITE SEASON;
PROC SORT DATA=ONE OUT=FOUR;BY DRAINAGE SITE SEASON SPECIES;
DATA THREE; SET TWO;
ARRAY DENSITY (I) DENSITY1-DENSITY3;
DO OVER DENSITY;
  ABUNDANC=DENSITY;OUTPUT;
END;
PROC SORT;BY DRAINAGE SITE SEASON;
PROC SORT;BY DRAINAGE SITE SEASON SPECIES;
PROC MEANS NOPRINT; BY DRAINAGE SITE SEASON SPECIES;
VAR ABUNDANC;
OUTPUT OUT=AVERAGE
MEAN=MDENSITY
```

APPENDIX B (Continued)

```
VAR=VDENSITY;

DATA NEW; MERGE AVERAGE FOUR;

BY DRAINAGE SITE SEASON SPECIES;

DATA FIFTY;SET NEW;

X=1; Y='LCC';          *NOTE:  LCC and 1 are designations for a site and
                               drainage used in this study.
DATA FIFTY1;SET NEW;

X=2; Y='LCC';

MACRO MTITLE 'EUCLIDEAN DISTANCE LC1XLC2'%

MACRO CASE

DATA FORTY;SET FIFTY;

IF SITE=X AND DRAINAGE=Y;

PROC SORT; BY ORDER SPECIES;

DATA FORTYONE; SET FIFTY1;

IF SITE=X AND DRAINAGE=Y;

PROC SORT; BY ORDER SPECIES;

DATA FORTYTWO; MERGE FORTY(RENAME=(MDENSITY=SCORE1))

FORTYONE(RENAME=(MDENSITY=SCORE2));

BY ORDER SPECIES;

IF SCORE1=. THEN SCORE1=0;  IF SCORE2=. THEN SCORE2=0;

DATA FORTY3; SET FORTYTWO;

SCORE=(SCORE1-SCORE2)**2;

DATA FORTY4; SET FORTY3;

PROC MEANS NOPRINT;

VAR SCORE;

OUTPUT OUT=FORTY5
```

APPENDIX B (Continued)

```
SUM=BUG;

DATA FORTY6; SET FORTY5;

TITLE MTITLE;

DISTANCE=BUG**0.5;

PROC PRINT;%

CASE;
 ------------------------------------------------
DATA FIFTY;                                      *

SET NEW;

X=1; Y='LCC';

DATA FIFTY1;

SET NEW;

X=3; Y='LCC';

MACRO MTITLE 'EUCLIDEAN DISTANCE LC1XLC3';

CASE;
 ------------------------------------------------
 .

 .

//
```

* The portion of the program between the broken line is repeated with the site and drainage values changed for each combination. Also the MTITLE statement must be changed for each combination.

APPENDIX C

STATISTICAL ANALYSIS SYSTEM (SAS) PROGRAM FOR CALCULATING PERCENT SIMILARITY VALUES BETWEEN SITES

APPENDIX C

STATISTICAL ANALYSIS SYSTEM (SAS) PROGRAM for calculating percent similarity values between sites.

```
//SIMILAR  JOB (XXXXX,SSN-  -     ),NAME,TIME=(0,40),CLASS=A
// EXEC SAS
//SYSIN DD*
DATA ONE;
INPUT SITE 1 DRAINAGE $ 3-5 SEASON $ 7-9 YEAR 10-11 ORDER $ 15-18
SPECIES $ 20-27 POPEST1 30-33 POPEST2 40-43 POPEST3 50-53;
DENSITY1=POPEST1/.2452;
DENSITY2=POPEST2/.2452;
DENSITY3=POPEST3/.2452;
CARDS;
PROC SORT DATA=ONE PUT=TWO;BY DRAINAGE SITE SEASON;
PROC SORT DATA=ONE OUT=FOUR;BY DRAINAGE SITE SEASON SPECIES;
DATA THREE; SET TWO;
ARRAY DENSITY (I) DENSITY1-DENSITY3;
DO OVER DENSITY;
  ABUNDANC=DENSITY;OUTPUT;
END;
PROC SORT;BY DRAINAGE SITE SEASON;
PROC SORT;BY DRAINAGE SITE SEASON SPECIES;
PROC MEANS NOPRINT; BY DRAINAGE SITE SEASON SPECIES;
VAR ABUNDANC;
OUTPUT OUT=AVERAGE
MEAN=MDENSITY
```

APPENDIX C (Continued)

```
VAR=VDENSITY;
DATA NEW; MERGE AVERAGE FOUR;
BY DRAINAGE SITE SEASON SPECIES;
DATA SIMPLE;SET NEW;
PROC MEANS;BY DRAINAGE SITE SEASON;
VAR MDENSITY;
OUTPUT OUT=STREAM
SUM=ADDITION;
DATA PIPE;MERGE STREAM NEW;BY DRAINAGE SITE SEASON;
RELFREQ=MDENSITY/ADDITION;
DATA MACVAR; SET PIPE;
X=1; Y='LCC';
DATA MACONE; SET PIPE;
X=2; Y='LCC';
MACRO DTITLE 'PERCENT SIMILAR LC1XLC2'%
MACRO COMBO
DATA THIRTEEN; SET MACVAR;
IF SITE=X AND DRAINAGE=Y;
DATA FIURTEEN; SET MACONE;
IF SITE=X AND DRAINAGE=Y;
PROC SORT DATA=THIRTEEN; BY ORDER SPECIES;
PROC SORT DATA=FOURTEEN; BY ORDER SPECIES;
DATA FIFTEEN;MERGE THIRTEEN(RENAME=(RELFREQ=RELFREQ1))
FOURTEEN(RENAME=(RELFREQ=RELFREQ2));
BY ORDER SPECIES;
```

APPENDIX C (Continued)

```
IF RELFREQ1=. THEN RELFREQ1=0;

IF RELFREQ2=. THEN RELFREQ2=0;

TITLE DTITLE;

SCORE=ABS(RELFREQ1-RELFREQ2);

DATA SIXTEEN; SET FIFTEEN;

PROC MEANS NOPRINT;

VAR SCORE;

OUTPUT OUT=SIXTEEN2

SUM=BUG;

DATA SIXTEEN3;SET SIXTEEN2;

VALUE=BUG*100;

PSC=100-0.5*VALUE;

PROC PRINT;%

COMBO;
 ------------------------------------------------
DATA MACVAR; SET PIPE;          *

X=1; Y='LCC';

DATA MACONE; SET PIPE;

X=3; Y='LCC';

MACRO DTITLE 'PERCENT SIMILARITY LC1XLC2'%

COMBO;
 ------------------------------------------------
 .

 .

//
```

* The portion of the program between the broken line is repeated with the site and drainage values changed for each combination. Also the DTITLE statement must be changed for each combination.

VITA

Steven Robert Adams

Candidate for the Degree of

Master of Science

Thesis: RELATIONSHIPS BETWEEN BENTHIC MACROINVERTEBRATES AND SILVICULTURE IN SOUTHEASTERN OKLAHOMA

Major Field: Zoology

Biographical:

Personal Data: Born in Pryor, Oklahoma, June 26, 1957, the son of Mr. and Mrs. Ralph C. Adams; married Linda Marie Cole, May 22, 1978.

Education: Graduated Claremore High School, Claremore, Oklahoma, May 1975; received the Bachelor of Science degree in Biology from Northeastern Oklahoma State University, Tahlequah, Oklahoma, May 1980; completed requirements for the Master of Science degree at Oklahoma State University, Stillwater, Oklahoma, December, 1983.

Professional Experience: Research Technician with the Department of Natural Science, Northeastern Oklahoma State University, Tahlequah, Oklahoma, 1977 through 1980; Graduate Teaching Assistant with Oklahoma State University, Stillwater, Oklahoma, August 1980 throgh June 1981; Graduate Research Assistant with the Oklahoma Cooperative Fishery Research Unit, Oklahoma State University, Stillwater, Oklahoma, July 1981 through July 1983.

Professional Affiliations: American Fisheries Society; Oklahoma Academy of Science; Animal Research Council, Oklahoma City Zoo.