Sand Mountain / Lake Guntersville Watershed Project

Macroinvertebrate Bioassessment

May 31 - June 1, 1994

Ecological Studies Section

Field Operations Division

Alabama Department of Environmental Management

February 1, 1995

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INTRODUCTION

The purpose of the Sand Mountain/Lake Guntersville project is to provide demonstration in proper management of animal waste to farmers, scientists, and agricultural professionals as well as providing for water quality improvements through comprehensive educational efforts and assistance to selected producers within the project area.

The basic monitoring plan consists of sampling sites on 7 streams within the watershed. These sites are monitored using chemical/physical parameters and bacteriological studies in order to provide long-term water quality data and to demonstrate trends in water quality.

The stream water quality monitoring portion of the Sand Mountain/Lake Guntersville watershed project was initiated in April of 1988 by the ADEM. Biological monitoring of a selected portion of the sampling sites was incorporated into the final phase of the project as part of the continued water quality sampling. Macroinvertebrate data were collected at 7 sites during June of 1988, May of 1989, June of 1992 and June of 1993.

On May 31 and June 1, 1994, at the request of the Mining and Nonpoint Source Section of the Water Division, Ecological Studies Section personnel from Field Operations Division completed in-stream bioassessments utilizing aquatic macroinvertebrates. The assessments were conducted to document current water quality and any changes in water quality based on comparison of current data to historical data. In addition, one proposed ecoregional reference site was sampled for use as a least-impacted reference condition for comparison to the study sites to assist in assessing changes in water quality. Sampling of a second reference site as proposed in the current study plan could not be completed because the limited reconnaissance conducted in the spring of 1994 did not locate a second physically similar least-impacted site.

MATERIALS AND METHODS

Study Area

The Sand Mountain watershed is located in the Tennessee River Basin and occupies parts of DeKalb, Etowah, Jackson and Marshall counties in northeast Alabama. This study of the benthic macroinvertebrates in the Sand Mountain watershed focused on six streams: Shoal Creek, Little Shoal Creek, Scarham Creek, Short Creek, South Sauty Creek, and Town Creek. Bryant Creek in Jackson County was utilized as a least-impacted reference site (Figure 15).

The following stations were utilized to collect aquatic macroinvertebrate samples, stream flows and physical parameters. The station numbers are those utilized in the Macroinvertebrate Database. The numbers in parentheses () are the station numbers utilized by the Mining and Nonpoint Source Section. The stream orders were taken from the "Sand Mountain - Lake Guntersville Supplemental Water Quality Plan, February 1988" and from topographic maps:

TCD1	Town Creek at Dekalb Hwy. 40 (*Control Station*) (T5S R9E S11 SE¼ SE¼) third order stream
BYTJ1	Bryant Creek at Alabama 71 in Jackson Co. (*Ecoregional Reference Site*) (T4S R8E S31 SW¼ NE¼) fourth order stream
TCD3 (T3)	Town Creek at DeKalb County Road 50 (T7S R7E S14 NW¼ SE¼) third order stream
SCD3 (SC3)	Scarham Creek at DeKalb County Road 1 (T8S R5E S34 NE¼ SW¼) third order stream
SHM3a (SH3a)	Short Creek Marshall County (T9S R5E S9 SW¼ SW¼) fourth order stream
SSD3 (SS3)	South Sauty Creek at Dekalb County Rd 47 (T6S R7E S20 NW¼ SE¼) second order stream
SLM1	Shoal Creek at Marshall County Road 372 (T8S R5E S9 SW¼ SW¼) second order stream
LSLM1	Little Shoal Creek at Marshall County Road 372 (T8S R5E S9 SW¼ SW¼) second order stream

Sampling Methodology

Macroinvertebrates were collected using the "RBP-Multihabitat" method outlined in the Field Operations Standard Operating Procedures Manual Volume II - Macroinvertebrate Section (1992). Habitat assessments and physical characterization data collection were completed after the method of Plafkin et al. (1989), as outlined in the above referenced document.

Stream flows were measured at all station utilizing a "AA" or Pygmy current meter. Water quality field parameters were collected at all stations using collection and sample handling procedures outlined in the Field Operations Standard Operating Procedures Manual Volume I (1992). Duplicate field parameters were collected at Shoal Creek for Quality Assurance/Quality control purposes.

Chain of Custody

Sample handling and chain-of-custody for all macroinvertebrate samples collected were as per the appropriate section in the Field Operations Standard Operating Procedures Manual Volume II - Macroinvertebrate Section (1992).

Data Analysis

All macroinvertebrate data were entered into the mainframe PACE Macroinvertebrate Database where tabulation of taxa and calculation of biometrics were completed. Appropriate Quality Assurance/Quality Control procedures were followed to assure data accuracy.

RESULTS AND DISCUSSION

The Sand Mountain area is located within the Interior Plateau Ecoregion (71). Seven streams (eight stations) were assessed over a two day period using a multiple-habitat methodology to collect aquatic macroinvertebrates. These streams were generally characterized as having substrates of boulder and cobble, with lesser amounts of bedrock and gravel. This stream bed composition provided excellent habitat for colonization by macroinvertebrates. All sites had deposits of sand and silt to varying degrees in the run and pool areas. Most sites were estimated to have larger sand deposits than noted in 1993.

It should be noted that the control site for the study was located in the upper most part of the watershed to minimize the degree of adverse impact from nonpoint source pollution. The reference site was chosen to represent the quality of a least-impacted stream in the Sand Mountain area of Ecoregion 71. Additional reconnaissance was conducted in the spring of 1994 in an attempt to locate an additional ecoregional reference site. Several sites were located but no sites were comparable in size or proximity to Sand Mountain. Due to the large number of agricultural operations (poultry production, livestock) in the watershed, no unimpacted sites were found to utilize as control or ecoregional reference site. This should be considered when comparisons are made between the study sites and the reference/control sites.

Habitat assessments were completed at all sites to determine if the study sites had the habitat available to support a biological community comparable to the control or reference site. The quality of the habitat found in 1994, as illustrated in Figure 1, ranged from “Good” with a score of 86 (Good 71-103) to “Excellent” with a score of 111 (Excellent 104-135). Since no scores varied more than 20 percent from the control or reference station score, all study stations sampled during 1994 were comparable to the control and reference station in terms of habitat (Plafkin et al. 1989).

Bryant Creek (BYTJ1) (Reference site) showed improvement in habitat quality from "good to excellent" over the 1993 assessment. Stream flow at BYTJ1 was lower than in 1993 as was the estimated percent of the substrate composed of silt. Lower flows decreased the habitat assessment score due to a partial loss of productive habitat, while the decrease in the estimated percent silt was reflected in improvements in several categories of the habitat assessment ('Bottom Substrate/Available cover', 'Embeddedness' and 'Bottom Scouring and Deposition'). The habitat assessment scores at TCD1, SCD3 and SHM3a all decreased, but the habitat quality category did not change from the 1993 assessment. As with BYTJ1, lower stream flows contributed to the apparent deterioration. However, there was also an increase in the estimated percent sand substrate which was reflected in the deterioration of the same three assessment categories: 'Bottom Substrate/Available cover', Embeddedness', 'Bottom Scouring and Deposition'. Lower stream flows at Shoal (SLM1) and Little Shoal (LSLM1) Creeks during 1994 resulted in slightly lower assessment scores. TCD3 and SSD3 assessments and scores remained stable.

Field parameters were measured at all stations during the 1992-94 field studies (Table 1). Water temperatures, dissolved oxygen, pH and conductivity values showed little variation between sampling dates. Turbidity measurements showed no change with the exception of station SHM3a, which had a noticeable decrease in turbidity from 18 to 2.2 nephelometric turbidity units (ntu). With the exception of SSD3, flow in most of the larger streams had decreased each year since 1992. Stream flows measured in 1994 were less than half that measured in 1993.

A list of macroinvertebrate taxa collected at each station is located in Tables 2 and 3. When comparing macroinvertebrate data from different stations, the samples must be composed of comparable habitats. The data from all stations utilized in this report are composed of macroinvertebrates collected from the riffle, rock/log, CPOM and sand habitats. These are the habitats that were available and collected at all stations during the 1992 to 1994 studies. The biometrics used to analyze the macroinvertebrate data can be categorized as single station metrics or comparison metrics. Single station metrics are calculated for each of the study stations as well as the reference and control stations. The results obtained at the study stations are then compared to those obtained at the reference and control stations. Comparison metrics, which directly compare similarities between a study station and a reference or control, are calculated for each study station. All biometrics utilized in this report are located in Tables 4a - 4c. "Interpretation of Biometrics" - Table 5, may be referred to in the following discussion.

Single Station Metrics

- The total taxa richness biometric is the total number of taxa collected from comparable habitats at a station (Figure 2, Table 4a). In 1994, total taxa richness ranged from 42 to 56. At the control station (TCD1) 53 taxa were collected and at the proposed reference station (BYTJ1) 44 taxa were collected. As illustrated in Figure 2, total taxa richness decreased from 1993 to 1994 for all stations with the exception of stations SHM3a and SLM1. In general, a decrease in taxa richness suggests a decrease in water quality. However, natural variation in taxa richness due to changes in annual weather patterns may account for this trend. Figure 1 shows a general decrease in stream flows measured in 1994 over those in 1993.

- In 1994, the EPT taxa richness (Figure 2, Table 4a), which is the total number of the generally pollution-intolerant Ephemeroptera, Plecoptera and Trichoptera taxa, ranged from 11 to 18. The control station sample had 18 and the proposed reference station had 12 EPT taxa. Of the 8 stations in the study, station SCD3 had the largest change in the number of EPT taxa losing 12 taxa as compared to the 1993 sample. Station SHM3a gained four EPT taxa. Four stations lost from three to six EPT taxa. The remaining two stations lost one taxa each. As with the total taxa richness metric, changes in stream flow may partially account for this trend.

- The Biotic Index (Figure 3, Table 4a) considers the overall tolerance to pollution of each taxa identified using a scale of 0 to 10 (intolerant to tolerant) and weights the taxa based on its' dominance in the sample. In general, a change of 1.0 (Penrose, personal communication) indicates a change in water quality. In 1994, this metric ranged from 4.04 to 5.90 with an average of 5.49. The control station biotic index was 5.78 and the proposed reference site value was 4.04. All study station biotic indices for 1994 were similar (within 1.0) to the control station. Only TCD3 was within 1.0 of the reference site biotic index. Increased stress associated with low stream flows in 1994 could account for the generally higher biotic index values.

  Hilsenhoff (1987) established guidelines for evaluating the biotic index in Wisconsin. Utilizing that method of evaluation the reference station water quality was 'very good' with 'possible slight pollution'. Town Creek at TCD3, Scarham Creek at SCD3, South Sauty Creek at SSD3, and Shoal Creek at SLM1 all had "good" water quality with "some" degree of pollution. The Control Station (TCD1), Short Creek at SHM3a, and Little Shoal Creek at LSLM1 were considered of 'fair' water quality with ‘fairly significant’ pollution. It should be noted that this guideline may not be directly applicable to Alabama Waters.

- ♦ The metric EPT / (EPT + Chironomidae) expresses the relationship between the generally pollution-intolerant EPT organisms and the generally pollution-tolerant Chironomidae organisms (Figure 3, Table 4a). This ratio uses the relative abundances of these indicator groups as a measure of community balance. A good biotic condition is reflected in communities having a fairly even distribution among all four major groups and with substantial representation in the sensitive EPT groups (values 0.75 or greater). Skewed populations having a disproportionate number of the generally pollution-tolerant Chironomidae relative to the more sensitive EPT insect groups may indicate environmental stress. All stations sampled during 1994, with the exception of the reference site BYTJ1, have some degree of stress based on this metric.

- ♦ Chironomidae, in general are considered a pollution-tolerant group. In most circumstances this family should not dominate the taxa composition. The portion of the taxa collected representing the Chironomidae family (Figure 4, Table 4a) ranged from 29 to 39 percent during the 1994 study. This compares with the 1993 collections ranging from 29 to 41 percent Chironomidae taxa. In 1994, the control (TCD1) and reference (BYTJ1) stations’ samples were 34 and 39 percent Chironomidae taxa, respectively.

- ♦ The percent contribution of the numerically dominant taxon (Figure 4, Table 4a) is an indication of community balance at the lowest positive taxonomic level. These values were moderately low for each station sampled during this study. Based upon Ecological Studies Section sampling, least impacted streams often have the dominant taxon comprising less than 30 to 35 percent of the sample. Values much larger than this would indicate environmental stress in a stream. As shown in Figure 4, all study stations during 1994 had percentages below this level (range 18% to 30%). The reference and control sites had the dominant taxon comprising 35 percent and 36 percent of the sample, respectively.

- ♦ The percent contribution of the functional feeding groups indicates that the stations collected during 1992-1994 were generally dominated by the collector feeding type and most often the filtering-collector (Figures 9 - 12). This indicates that the dominant food source is located within the water column, in the form of algae and suspended solids.

<u>Station Comparison Metrics</u>

Several metrics were utilized to compare the study stations to the control or reference station.

- Shackleford's Indicator Assemblage Index (IAI) (Figure 5) uses the relative abundances of the generally pollution-intolerant Ephemeroptera, Plecoptera and Trichoptera, and the generally pollution-tolerant Chironomidae and Annelida for the control or reference station and the study station. Values range from 0 to >1 and are inversely proportional to the degree of environmental stress. The evaluation criteria utilized by Shackleford (1988) are as follows:

IAI >0.80	No impairment as compared to control
IAI 0.65-0.80	Minimal impairment as compared to control
IAI 0.50-0.64	Substantial impairment as compared to control
IAI <0.50	Excessive impairment as compared to control

  Utilizing these criteria to evaluate the study data indicates that there is "no impairment" in the study stations "as compared to the control" and "excessive impairment" as compared to the reference site. The apparent contradiction in the metric evaluations is the result of improvements in the reference site quality. The 1994 reference site sample was composed primarily of EPT organisms, and had a lower abundance of Chironomidae than in 1993. However, it should be noted that neither the control nor reference stations are unimpacted stream sites.

- The Sorenson's Community Similarity Index (Figure 6, Tables 4b, 4c) utilizes a ratio of the number of taxa from the study station that are similar to the control/reference station, to the total number of taxa at both stations. Values greater than or equal to 0.4 indicate that the stations being compared are similar. Values at all study stations in 1994 were greater than 0.4 when compared to the control or reference station (with the exception of TCD3 when compared to the reference station).

- The Community Similarity Index, QSI-Taxa (Figure 7, Tables 4b, 4c) compares two communities in terms of presence or absence, as well as relative abundance, of the individual taxa. Quality assurance work on an unrelated stream indicates that data collected on the same day at the same station by two different field crews had a community similarity index for taxa composition of approximately 70 percent. For the 1994 study, as compared to the control, the study stations ranged from 20 to 37 percent similar. Station LSLM1 had the highest similarity. When the reference site was utilized for comparison, the similarity index ranged from 12 to 23 percent. Station LSLM1 and SLM1 had the lowest percent similarities with 12 percent and 13 percent, respectively, indicating dissimilar communities. This would not be unexpected when comparing a fourth order stream to a second order stream.

- ♦ The Community Similarity Index for Functional Feeding Types (QSI-FFG) compares two communities in terms of presence or absence, as well as relative abundance, of the functional feeding types (Figure 8, Tables 4b, 4c). When compared to the control, stations of the 1994 study ranged from 74 to 85 percent similar as to the relative composition of the feeding types. As compared to the reference station, the study stations ranged from 39 to 79 percent similar. The control station was 57 percent similar. Quality assurance work by Ecological Studies Section personnel on an unrelated stream indicates that data collected on the same day at the same station by two different field crews had a community similarity index for functional feeding types of approximately 80 percent.

- ♦ The Biological Condition Category, advocated by EPA (Plafkin 1989), is assigned to a study station based on the overall percent comparability to a control or reference station. Each metric is given a score (Figure 13) based on the percent comparability to a reference/control station metric or on a preassigned range. Scores are totaled and a Biological Condition Category is assigned based on the percent comparability with the reference/control station score total. An improvement in any of the control/reference metrics utilized in the scoring categories, with no change in the study station, would lower the score for that particular metric, leading to a possible drop in the condition category for that study station. The reverse is also true for a worsening of the control/reference metrics.

  Using the Biological Condition Scoring Criteria with the 1994 data, station SHM3a continued to be "slightly impaired", as compared to the reference or control station. Stations SSD3 and LSLM1 were elevated to the "non-impaired" category as compared to the control or reference. The control station TCD1 fell into the "slightly impaired" category, as compared to the reference. No change in the Biological Condition Category since the 1993 report was indicated for the remaining stations.

SUMMARY AND CONCLUSIONS

Analysis of the data collected during the 1994 in-stream bioassessment of selected streams within the Sand Mountain watershed indicated that the study stations were all similar to the control and most were similar to the reference site. However, neither the control nor the reference station were unimpacted sites. All stations had "good" or "excellent" habitat quality and were physically comparable to the control and reference stations. The habitat quality category of the reference site, BYTJ1 improved from "good" to "excellent" while the habitat quality category of the remaining stations did not change from the 1993 study. There was, however, a general decrease in the assessment scores. The lower stream flows and increased estimates of the sand substrate composition in 1994 contributed to the lower scores. Field parameters measured during the study indicated little change in water quality from the 1992 or 1993 study.

The biological metrics used to analyze the data indicate that the macroinvertebrate communities of BYTJ1, SHM3a, and SSD3 showed improvement from 1993 - 1994. The ecoregional reference site, BYTJ1, showed some improvement in biotic quality over the 1993 study as indicated by several of the metrics. The apparent improvement in the macroinvertebrate community of this station may be partially attributable to an improvement in habitat quality as previously discussed. Using the Biological Condition Scoring Criteria with the 1994 data, station SHM3a continued to be "slightly impaired", when compared to the reference or control station. However, SHM3a did show improvement in several of the metrics. Stations SSD3 and LSLM1 were elevated to the "non-impaired" category as compared to the control or reference. The control station TCD1 fell into the "slightly impaired" category, as compared to the reference, with all metric values decreasing in quality. The metrics for all other stations generally showed a decrease in the quality of the biological community, however, no change in the Biological Condition Category since the 1993 report was indicated. This decrease in the quality of the biological community as reflected in the metrics may be partially attributable to the decreased stream flow at the time of the 1994 assessment.

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Hilsenhoff, W.L. 1987. An improved Biotic Index of Organic Stream Pollution. Great Lakes Entomologist. 20:31-39.

Plafkin, J. L., M.T. Barbour, K.D. Porter, S.K. Gross, R.M. Hughes. 1989. Rapid Bioassessment Protocols for Use in Streams and Rivers. Benthic Macroinvertebrates and Fish. Report No. 444/4-89-001, Office of Water, U.S. EPA, Washington, D.C.

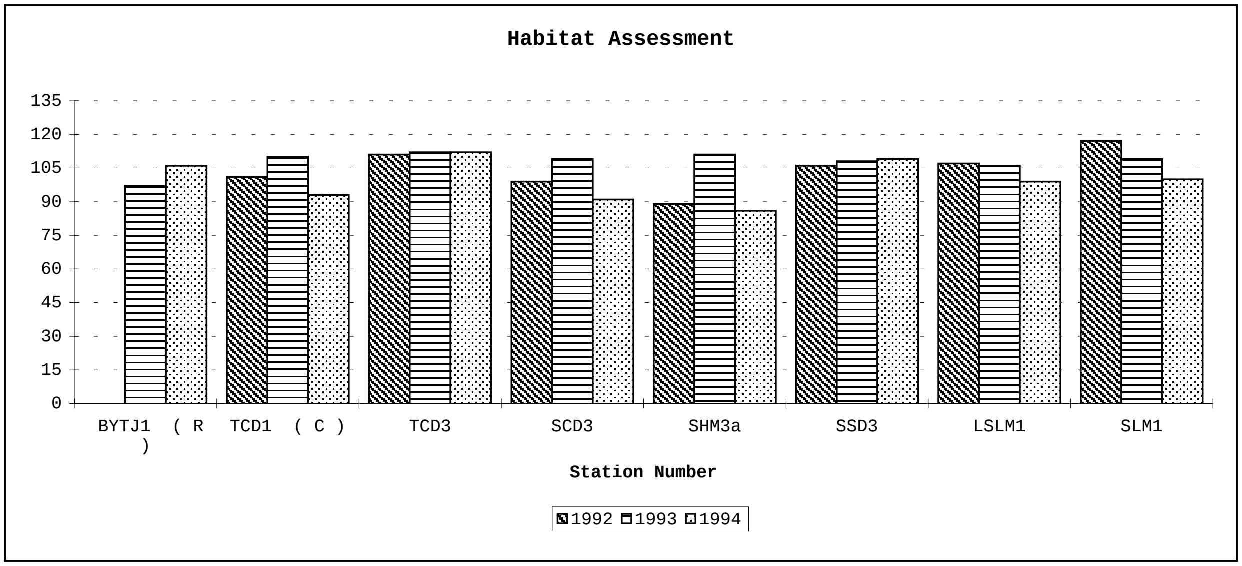
Shackelford, B. 1988. Rapid Bioassessments of Lotic Macroinvertebrate Communities: Biocriteria Development. Arkansas Department of Pollution control and Ecology, Little Rock, Arkansas.

TABLES

AND

FIGURES

FIGURE 1


Habitat Assessment
135
120
105
90
75
60
45
30
15
0
BYTJ1 (R)
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992 1993 1994

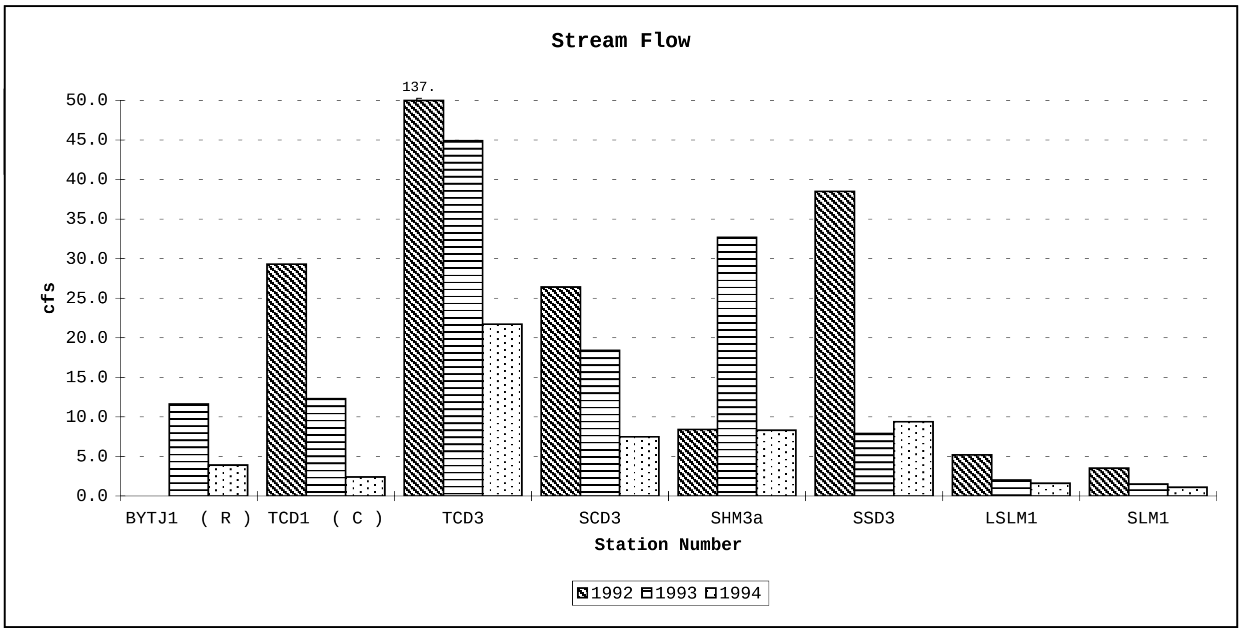
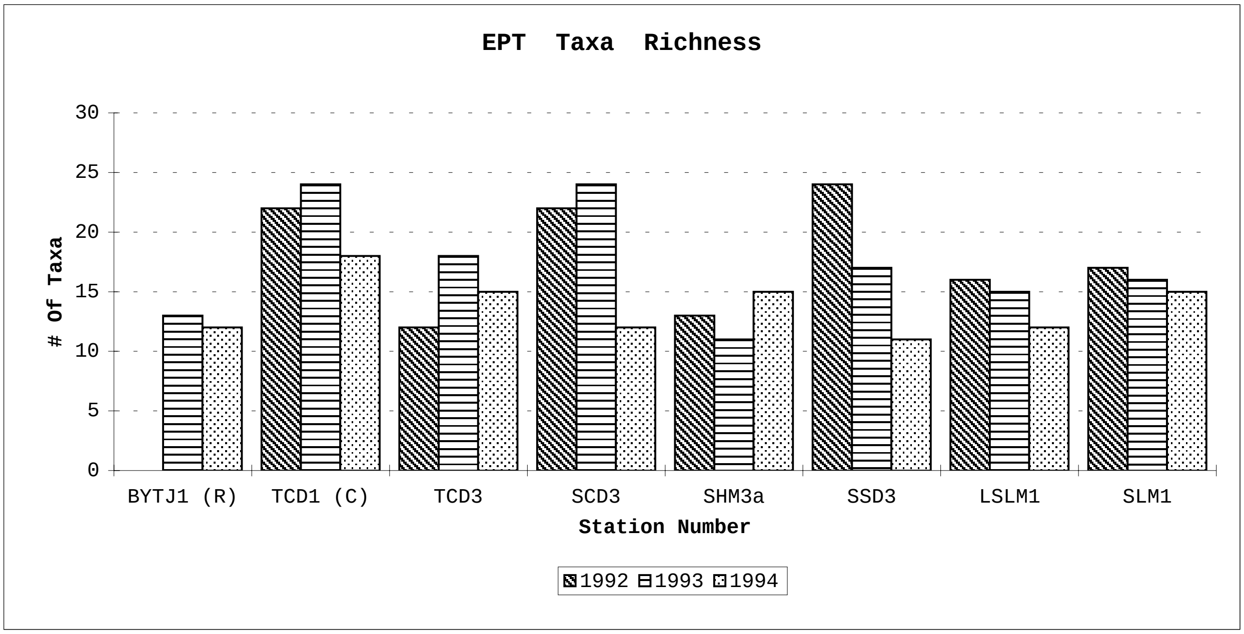

Stream Flow
137.
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
cfs
BYTJ1 (R)
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992 1993 1994

FIGURE 2


EPT Taxa Richness
30
25
20
15
10
5
0
Of Taxa
BYTJ1 (R)
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992
1993
1994

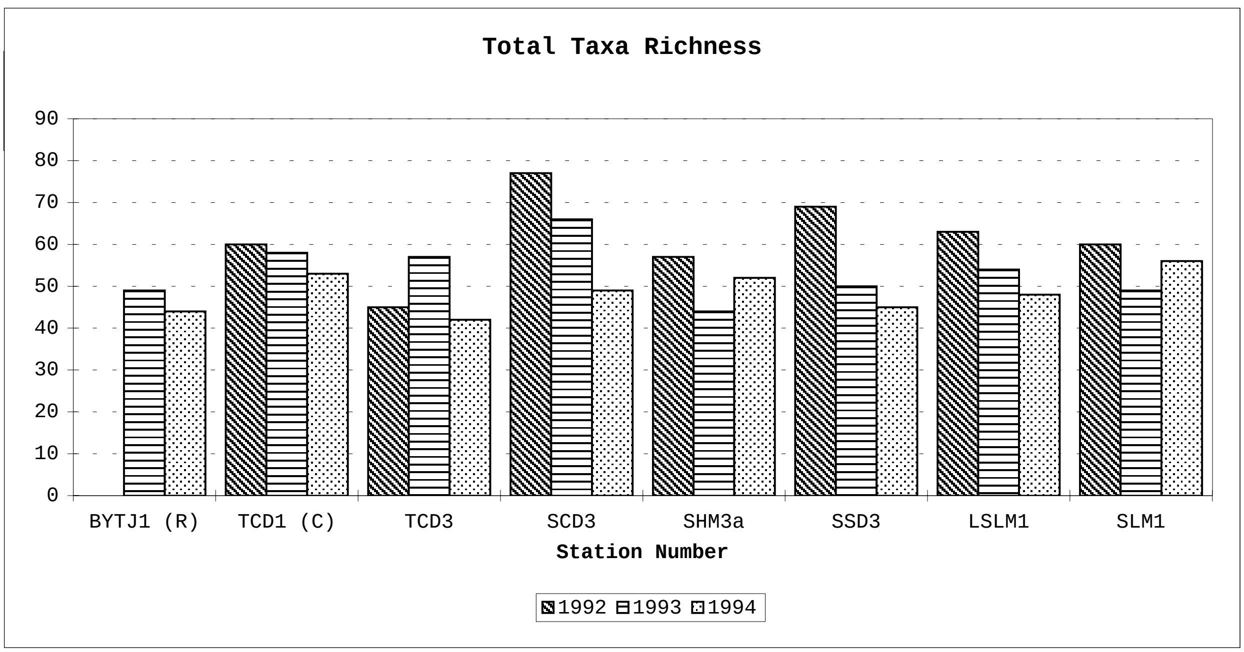
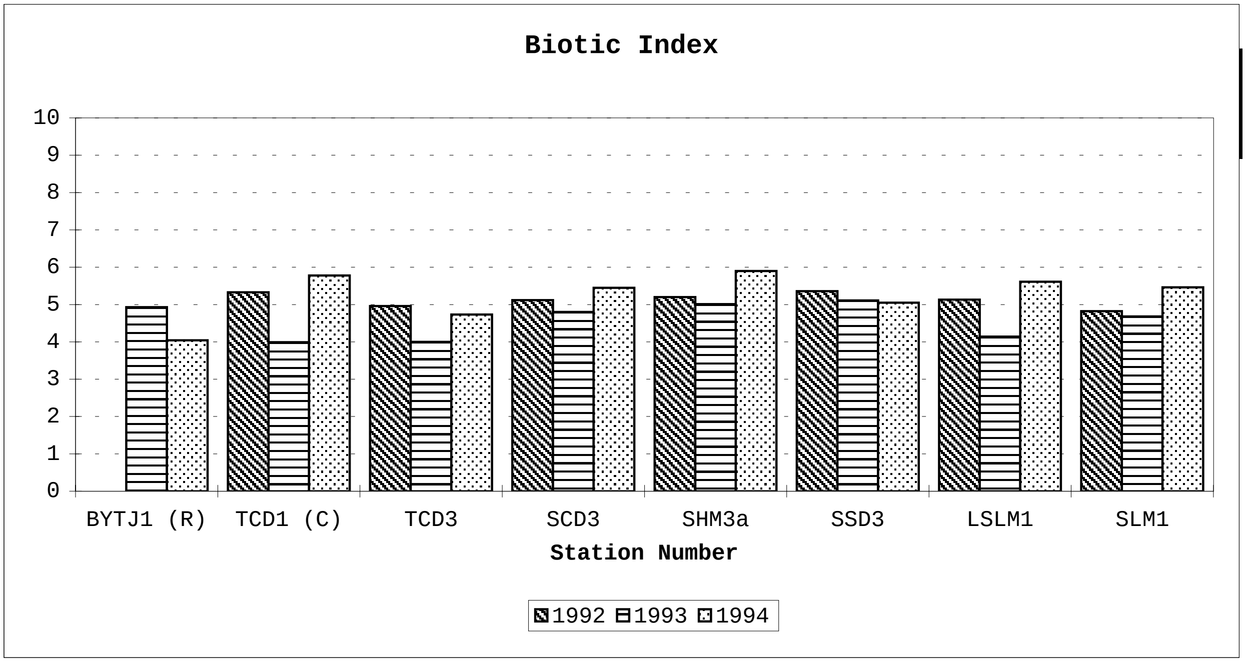

Total Taxa Richness
90
80
70
60
50
40
30
20
10
0
BYTJ1 (R)
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992
1993
1994

FIGURE 3


Biotic Index
10
9
8
7
6
5
4
3
2
1
0
BYTJ1 (R)
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992
1993
1994

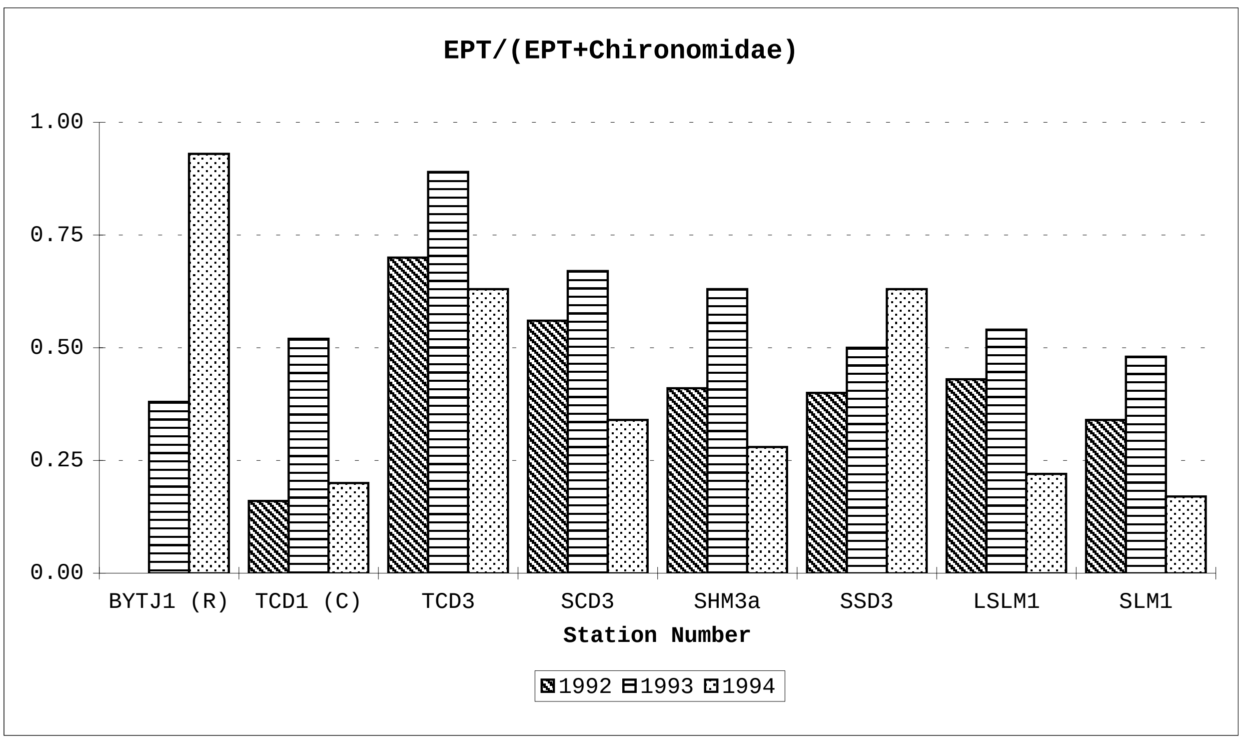
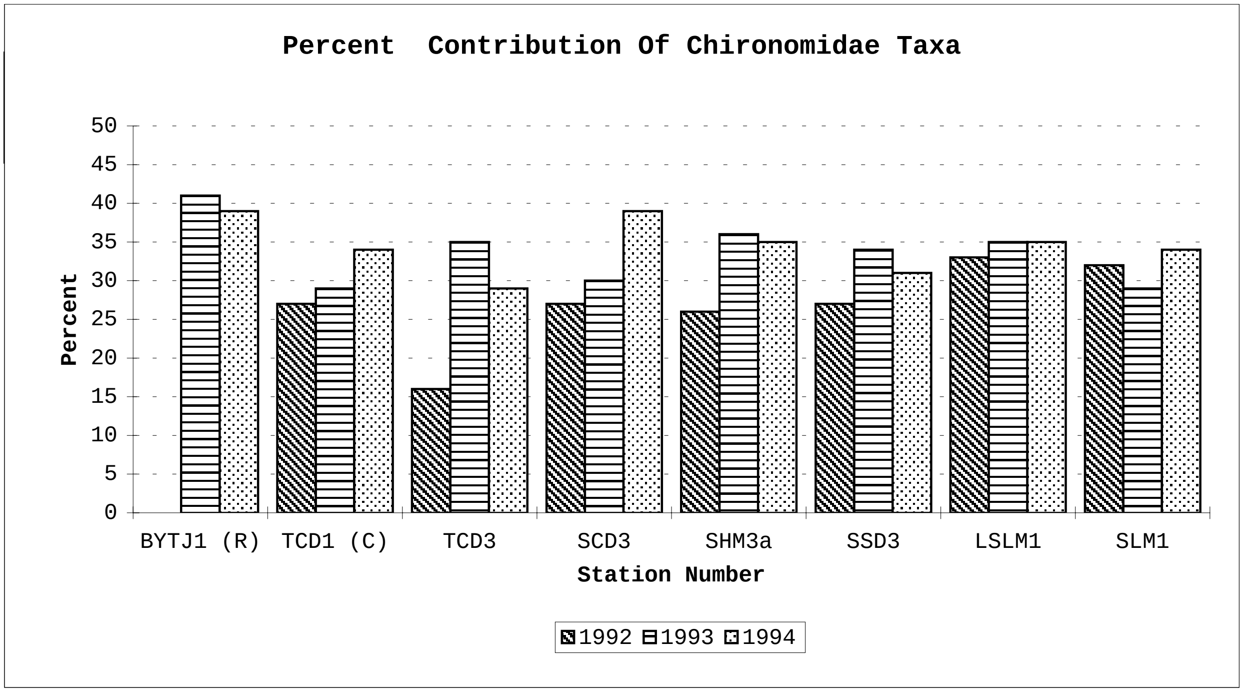

EPT/(EPT+Chironomidae)
1.00
0.75
0.50
0.25
0.00
BYTJ1 (R)
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992
1993
1994

FIGURE 4


Percent Contribution Of Chironomidae Taxa
50
45
40
35
30
25
20
15
10
5
0
Percent
BYTJ1 (R)
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992
1993
1994

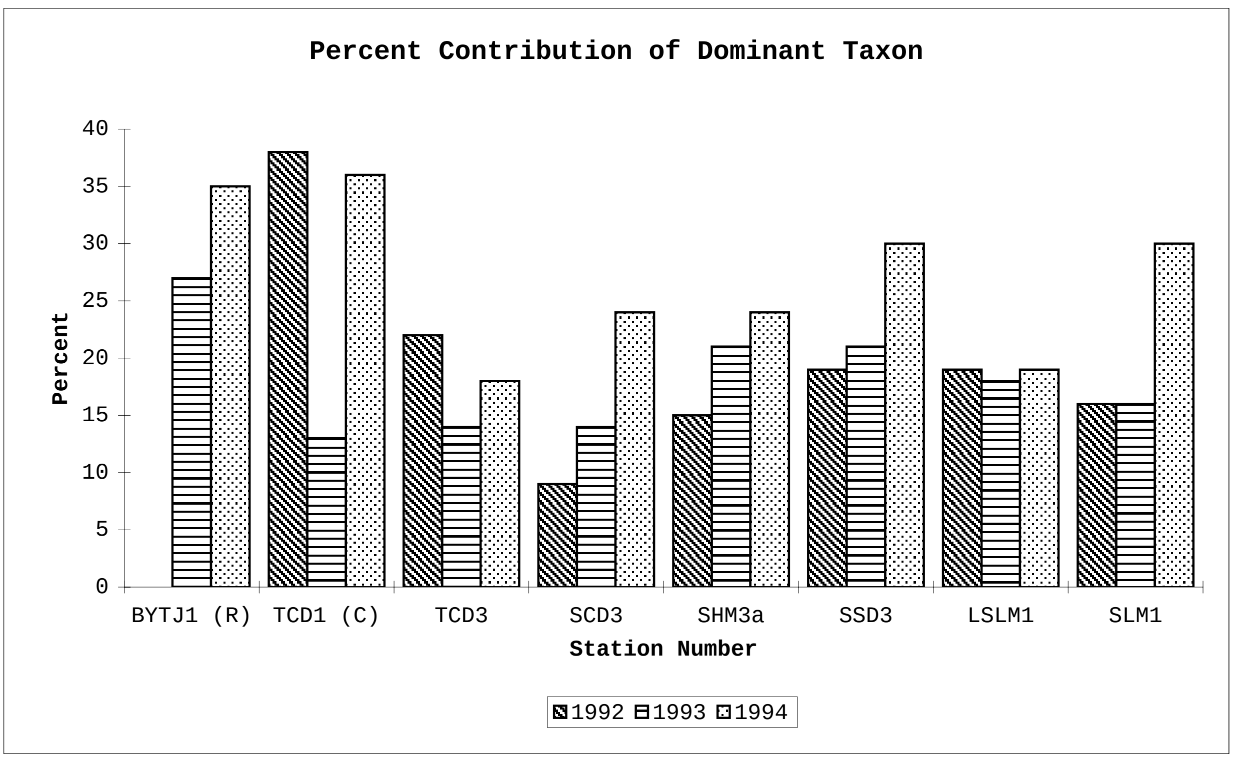
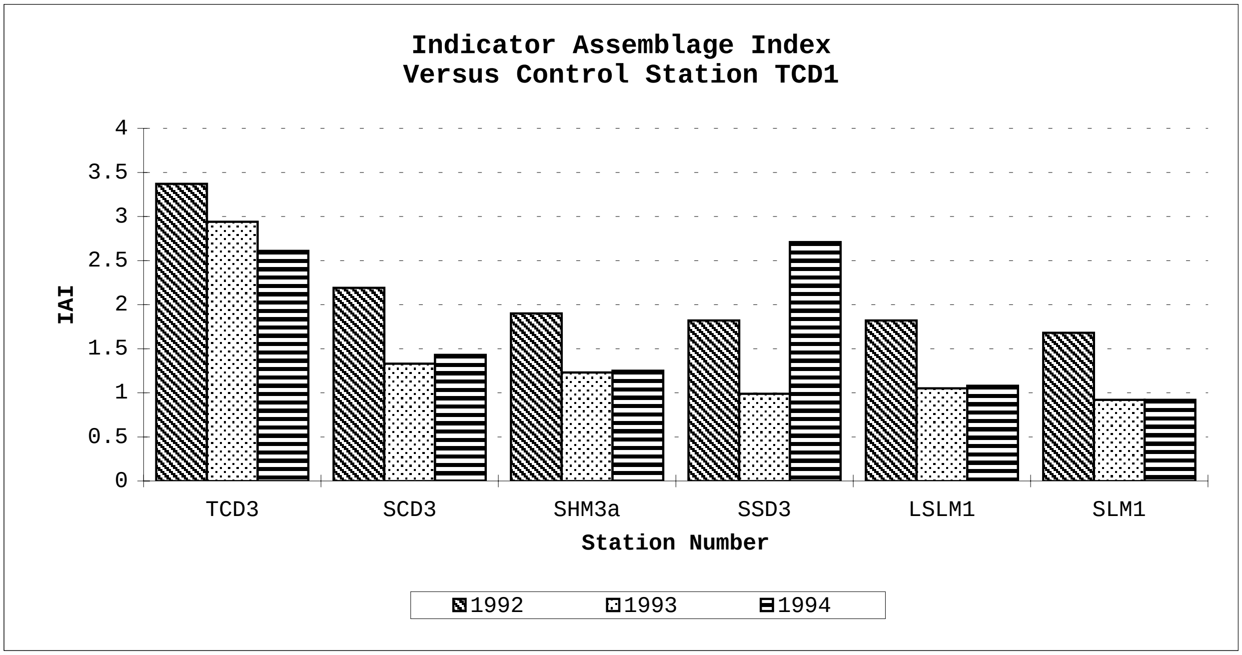
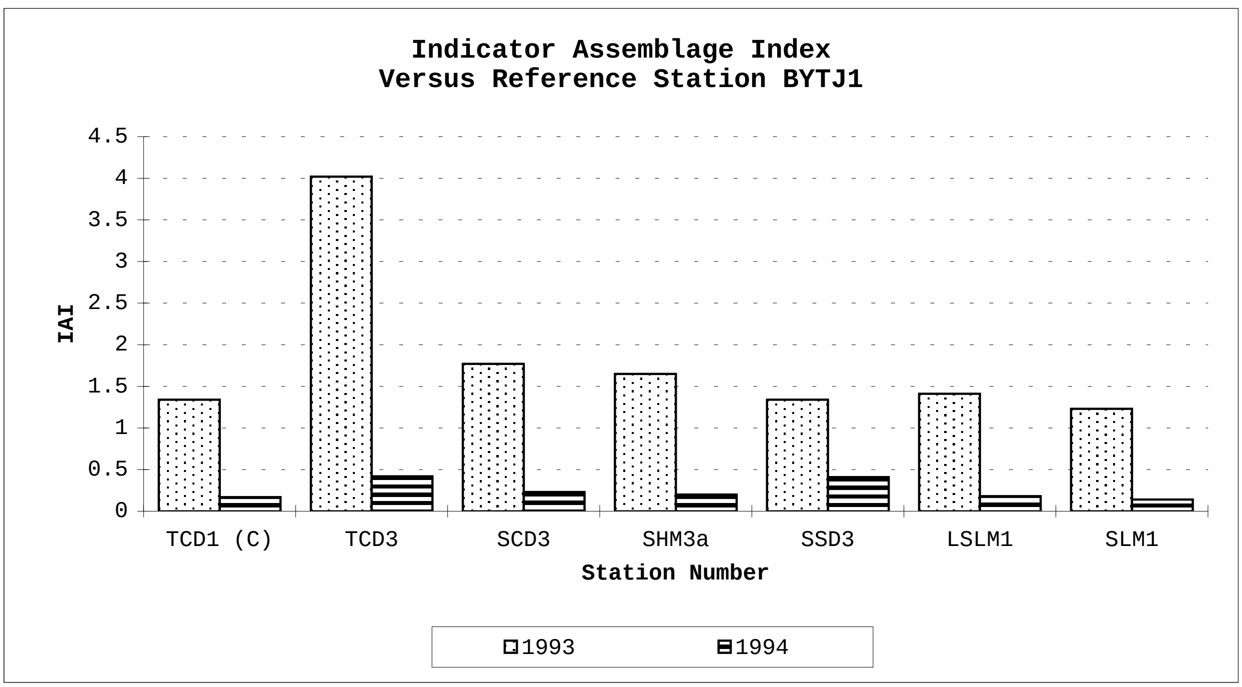

Percent Contribution of Dominant Taxon
40
35
30
25
20
15
10
5
0
Percent
BYTJ1 (R)
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992
1993
1994

FIGURE 5

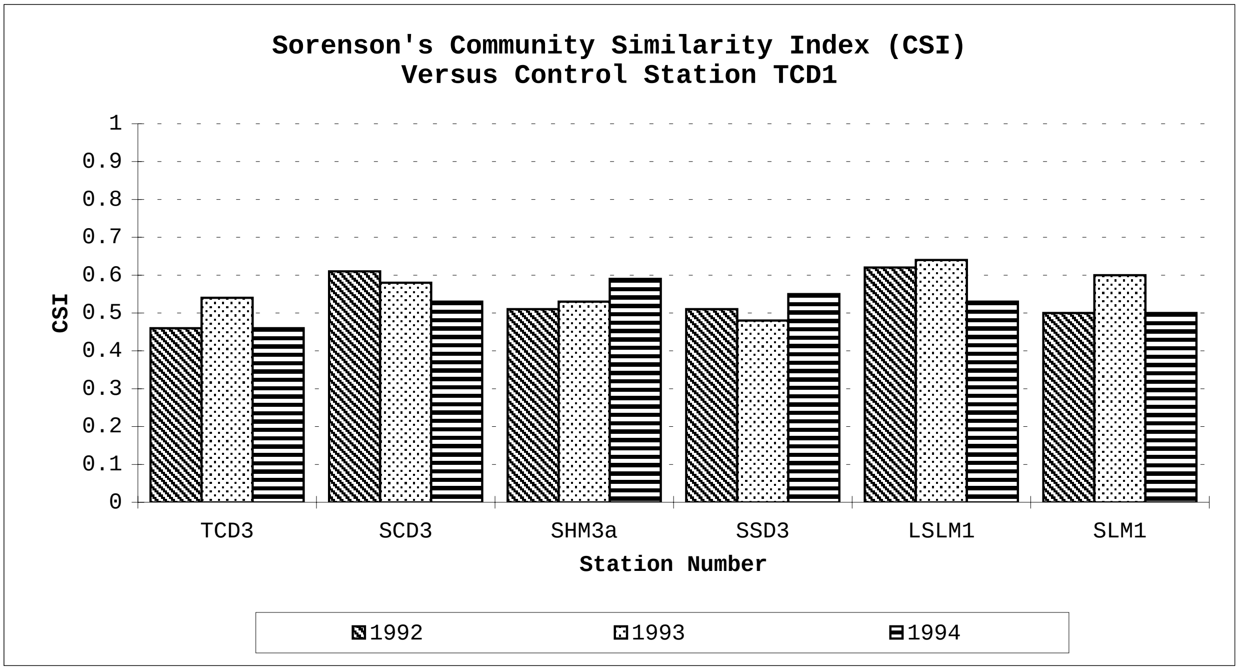


Indicator Assemblage Index
Versus Control Station TCD1
IAI
4
3.5
3
2.5
2
1.5
1
0.5
0
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992
1993
1994

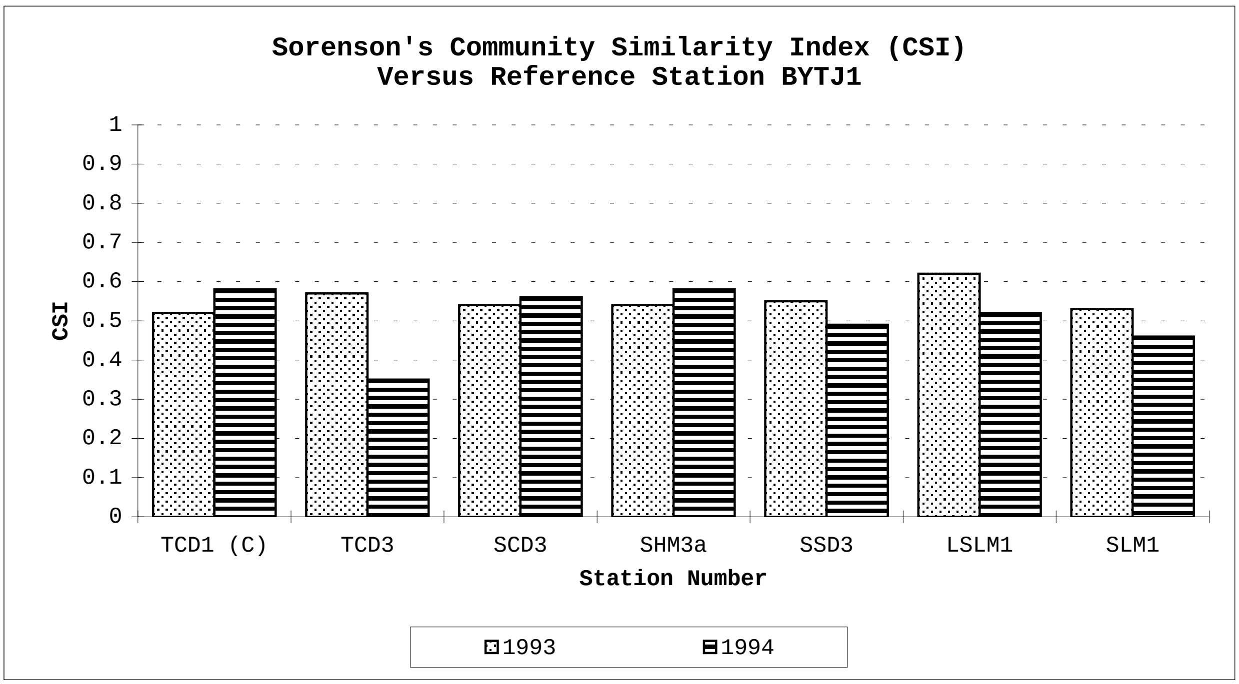


Indicator Assemblage Index
Versus Reference Station BYTJ1
IAI
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1993
1994

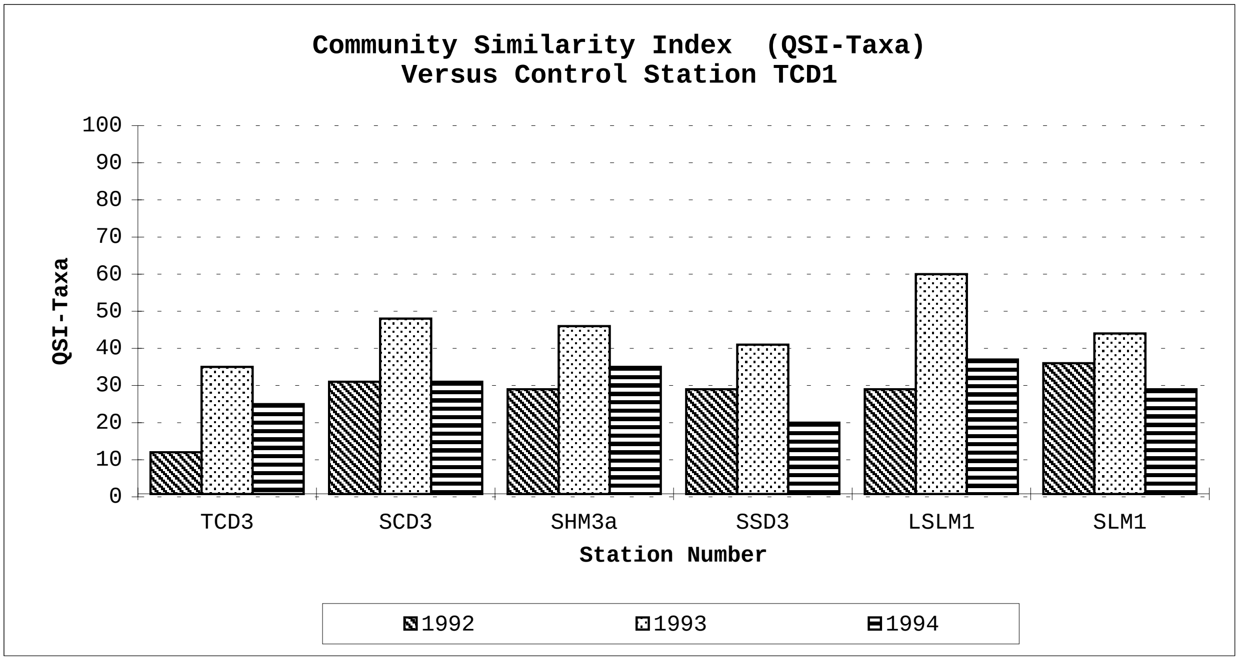
FIGURE 6



Sorenson's Community Similarity Index (CSI)
Versus Control Station TCD1
CSI
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992
1993
1994



Sorenson's Community Similarity Index (CSI)
Versus Reference Station BYTJ1
CSI
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1993
1994


Community Similarity Index (QSI-Taxa)
Versus Control Station TCD1
QSI-Taxa
100
90
80
70
60
50
40
30
20
10
0
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992
1993
1994

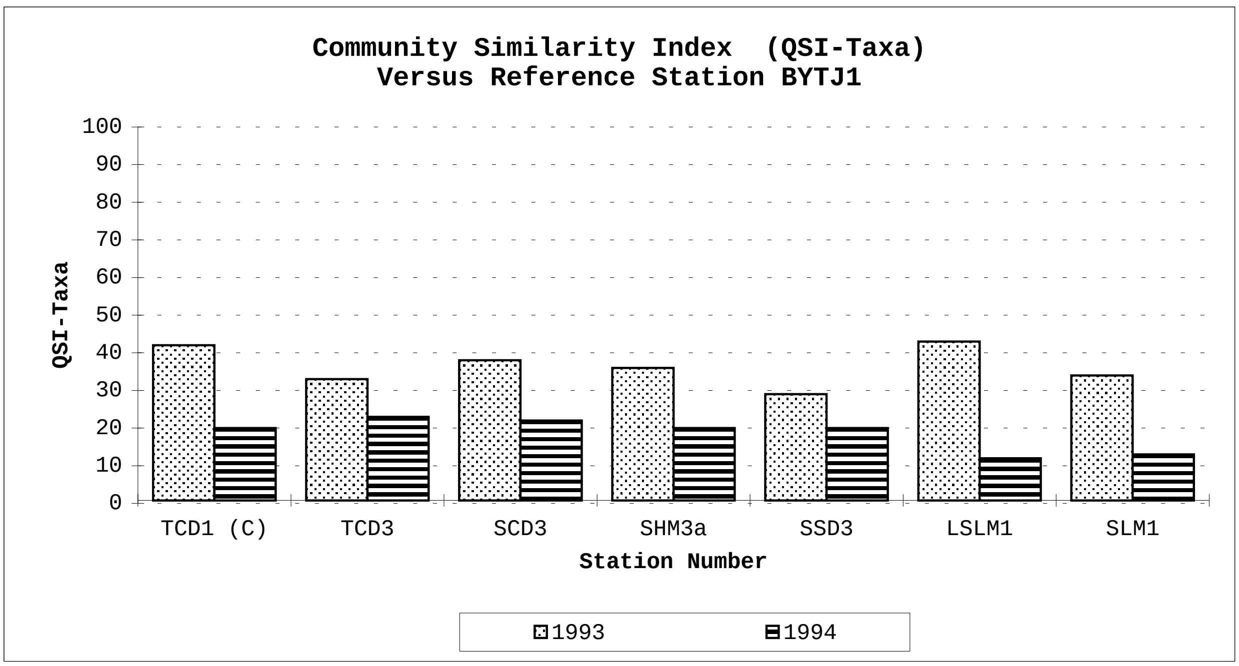
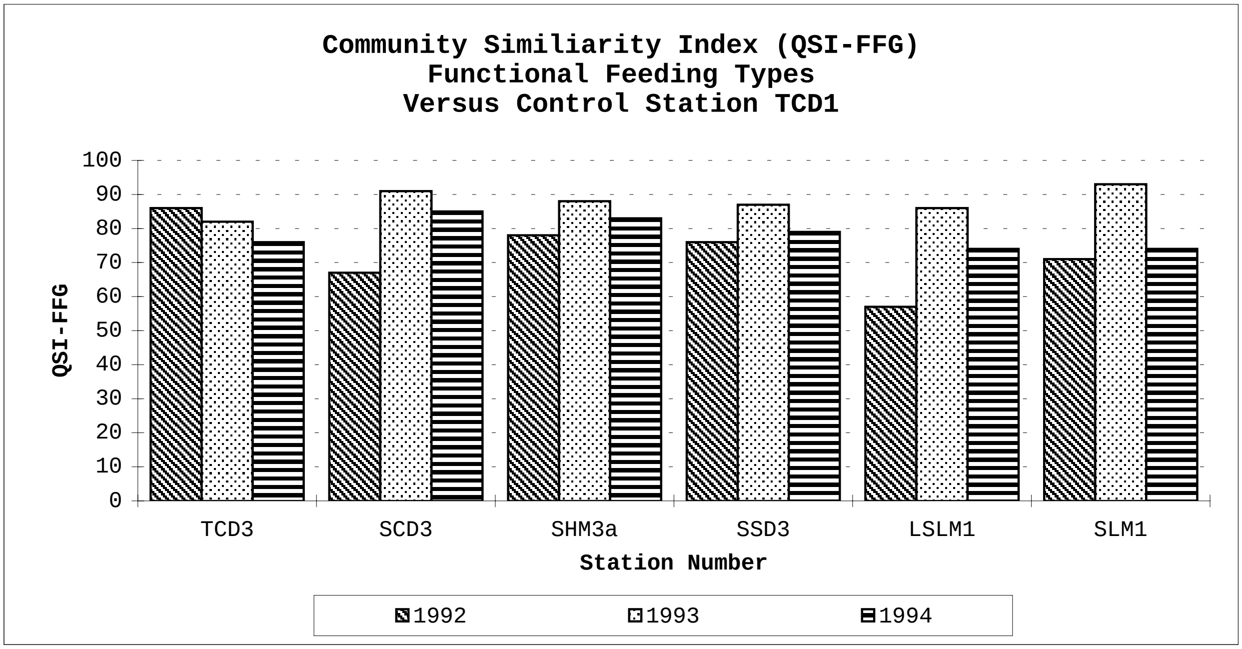
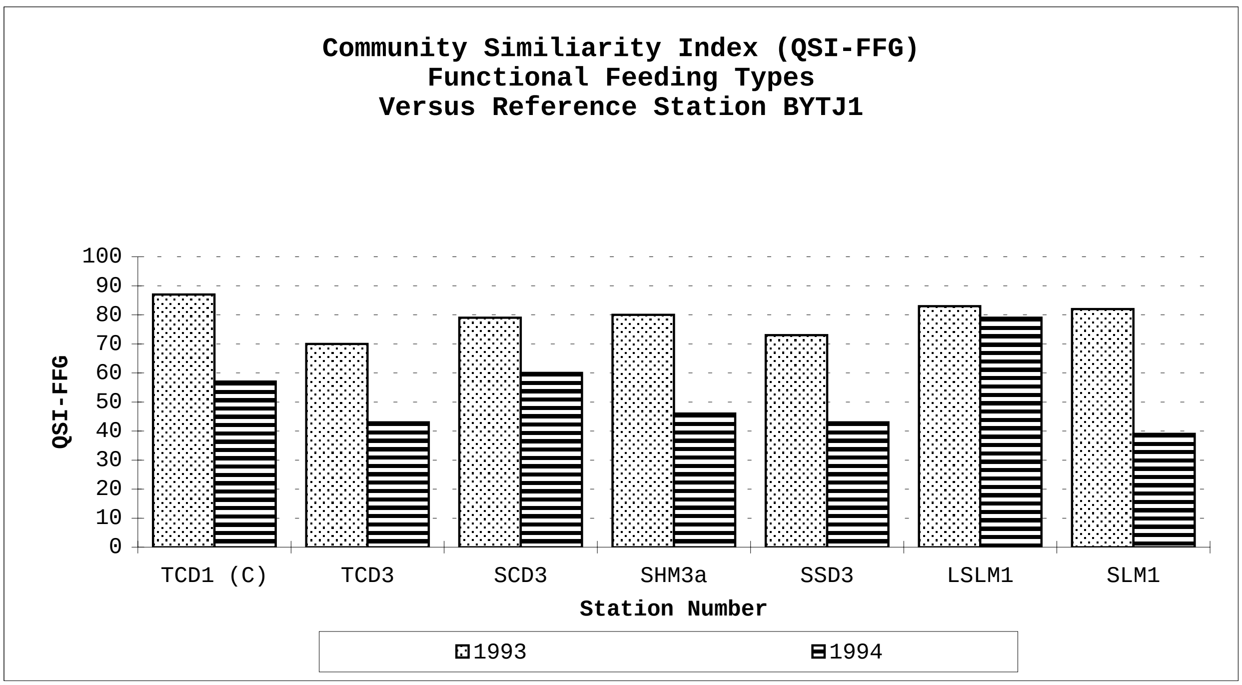

Community Similarity Index (QSI-Taxa)
Versus Reference Station BYTJ1
QSI-Taxa
100
90
80
70
60
50
40
30
20
10
0
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1993
1994

FIGURE 8



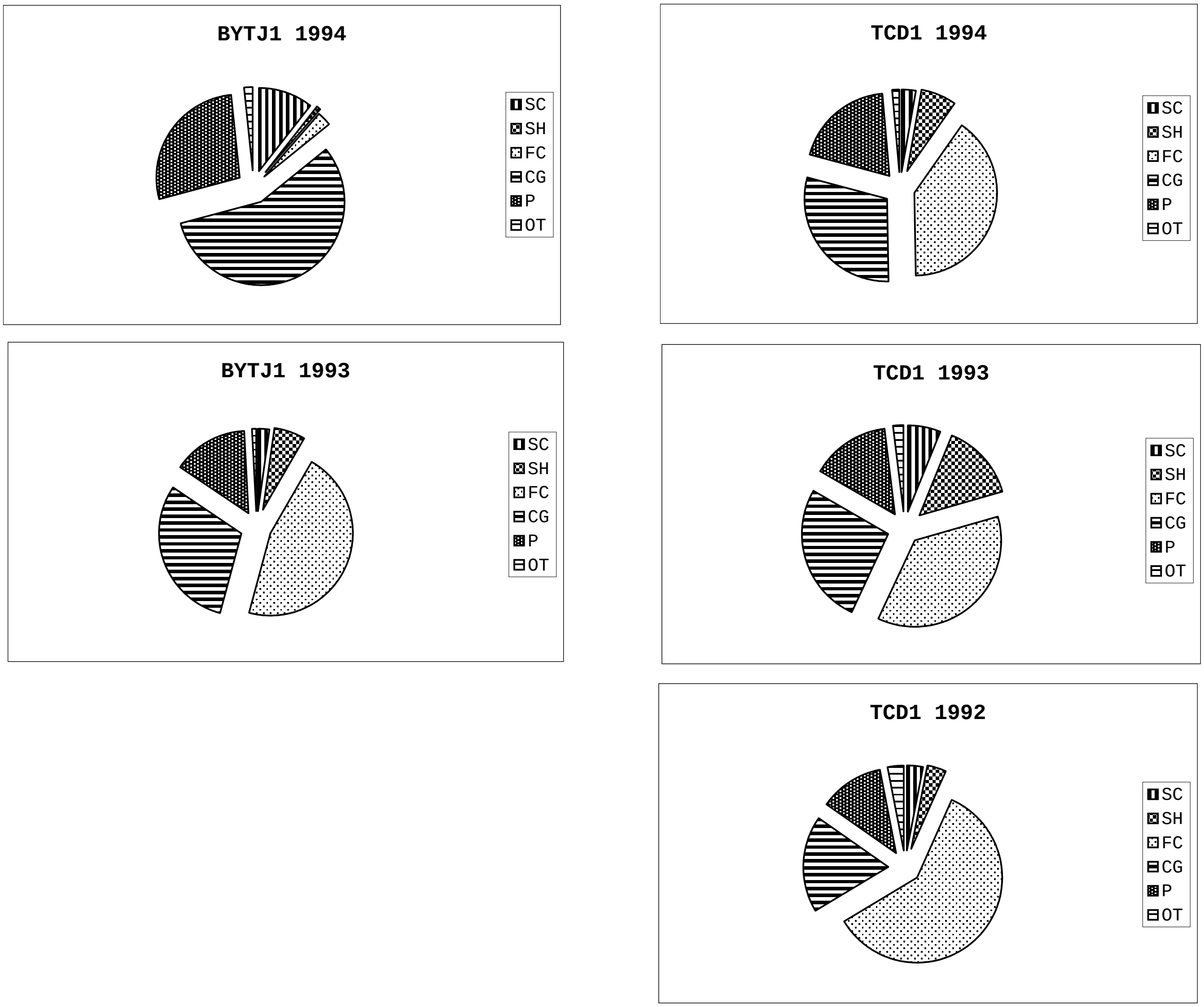
Community Similiarity Index (QSI-FFG)
Functional Feeding Types
Versus Control Station TCD1
QSI-FFG
100
90
80
70
60
50
40
30
20
10
0
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1992
1993
1994



Community Similiarity Index (QSI-FFG)
Functional Feeding Types
Versus Reference Station BYTJ1
QSI-FFG
100
90
80
70
60
50
40
30
20
10
0
TCD1 (C)
TCD3
SCD3
SHM3a
SSD3
LSLM1
SLM1
Station Number
1993
1994

FIGURE 9

FUNCTIONAL FEEDING GROUP COMPOSITION

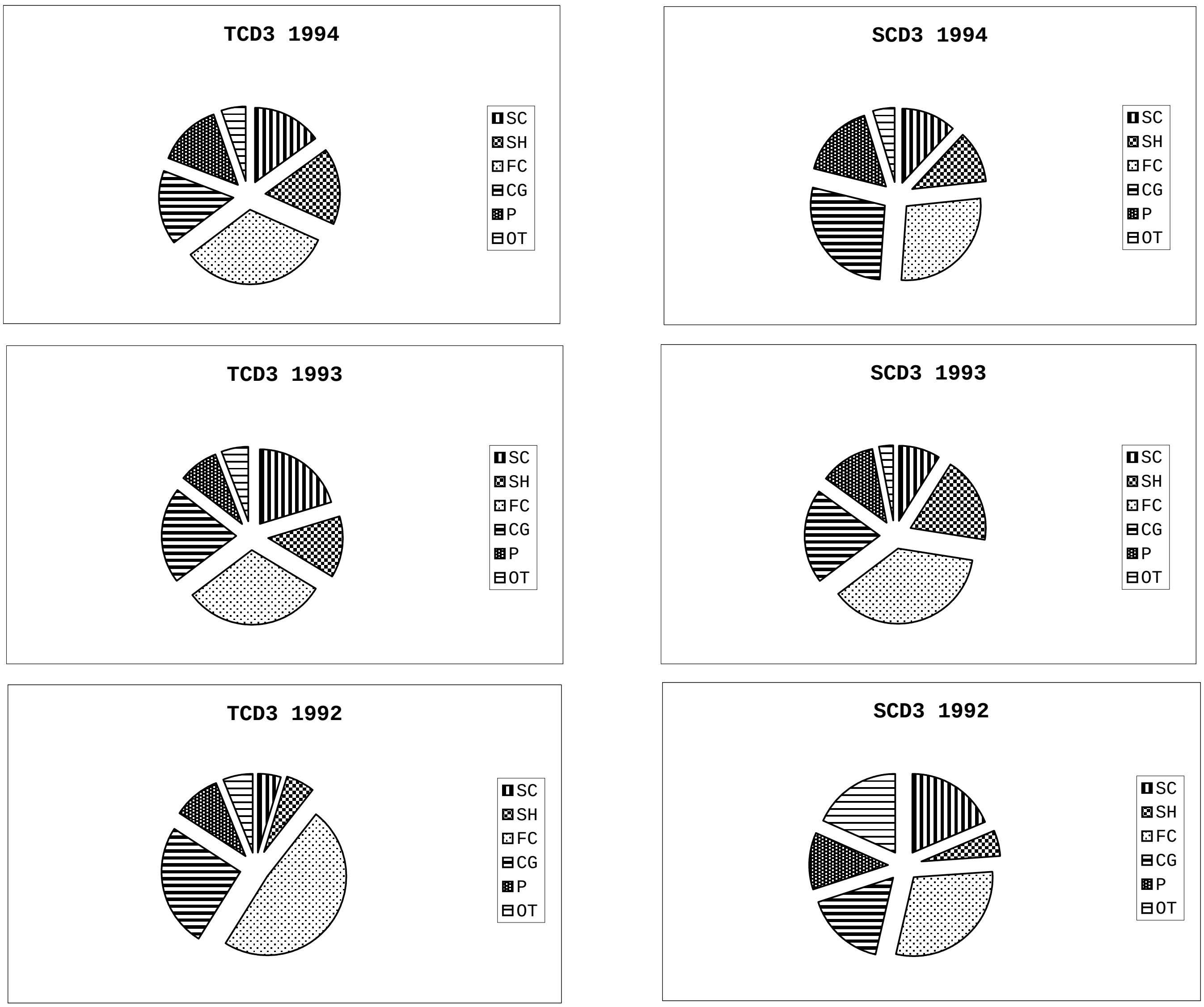


FEEDING TYPES

SC	SCRAPERS	FC	FILTERING COLLECTORS	P	PREDATORS
SH	SHREDDERS	CG	COLLECTOR GATHERERS	OT	OTHERS

FIGURE 10

FUNCTIONAL FEEDING GROUP COMPOSITION

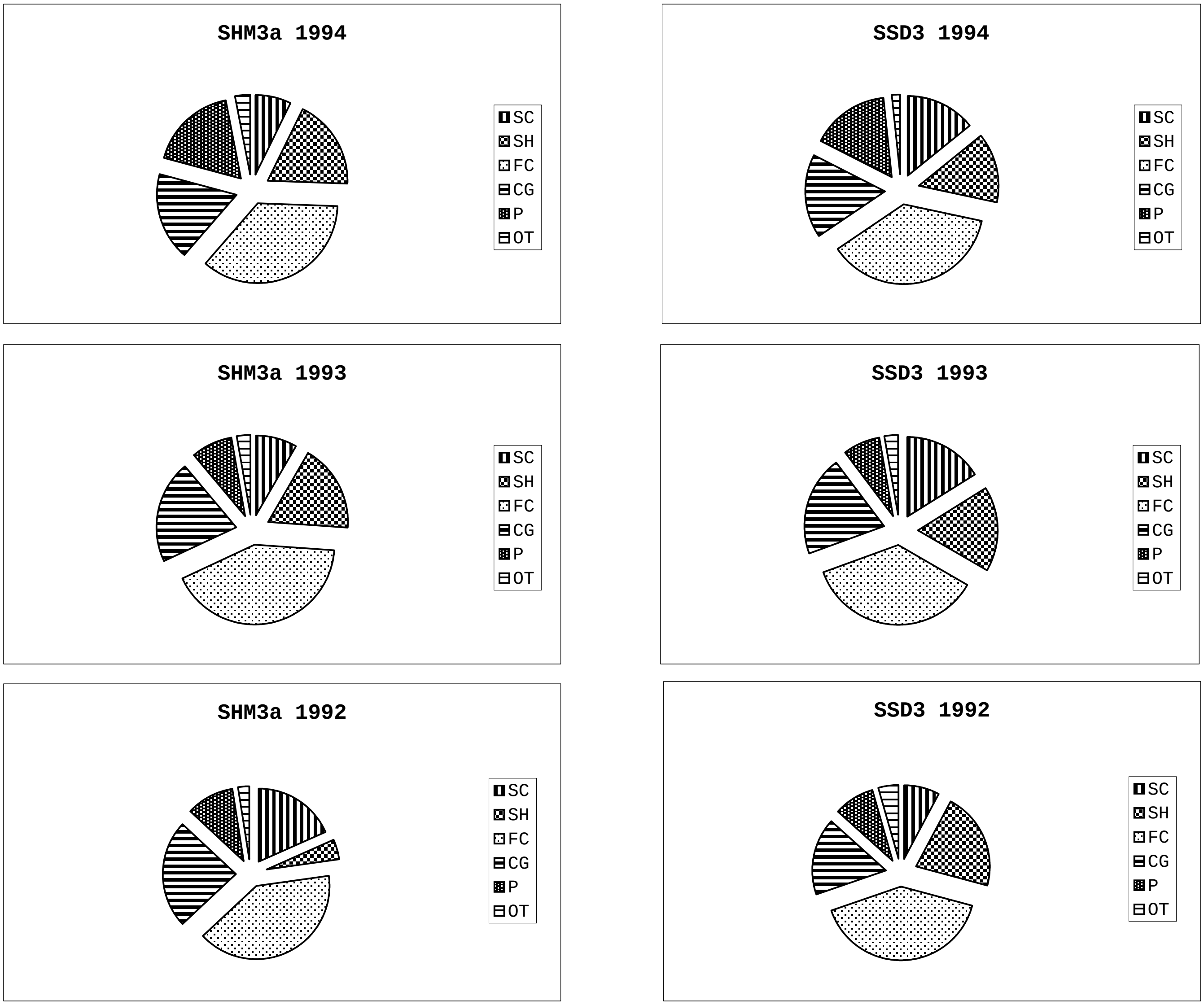


FEEDING TYPES

SC	SCRAPERS	FC	FILTERING COLLECTORS	P	PREDATORS
SH	SHREDDERS	CG	COLLECTOR GATHERERS	OT	OTHERS

FIGURE 11

FUNCTIONAL FEEDING GROUP COMPOSITION

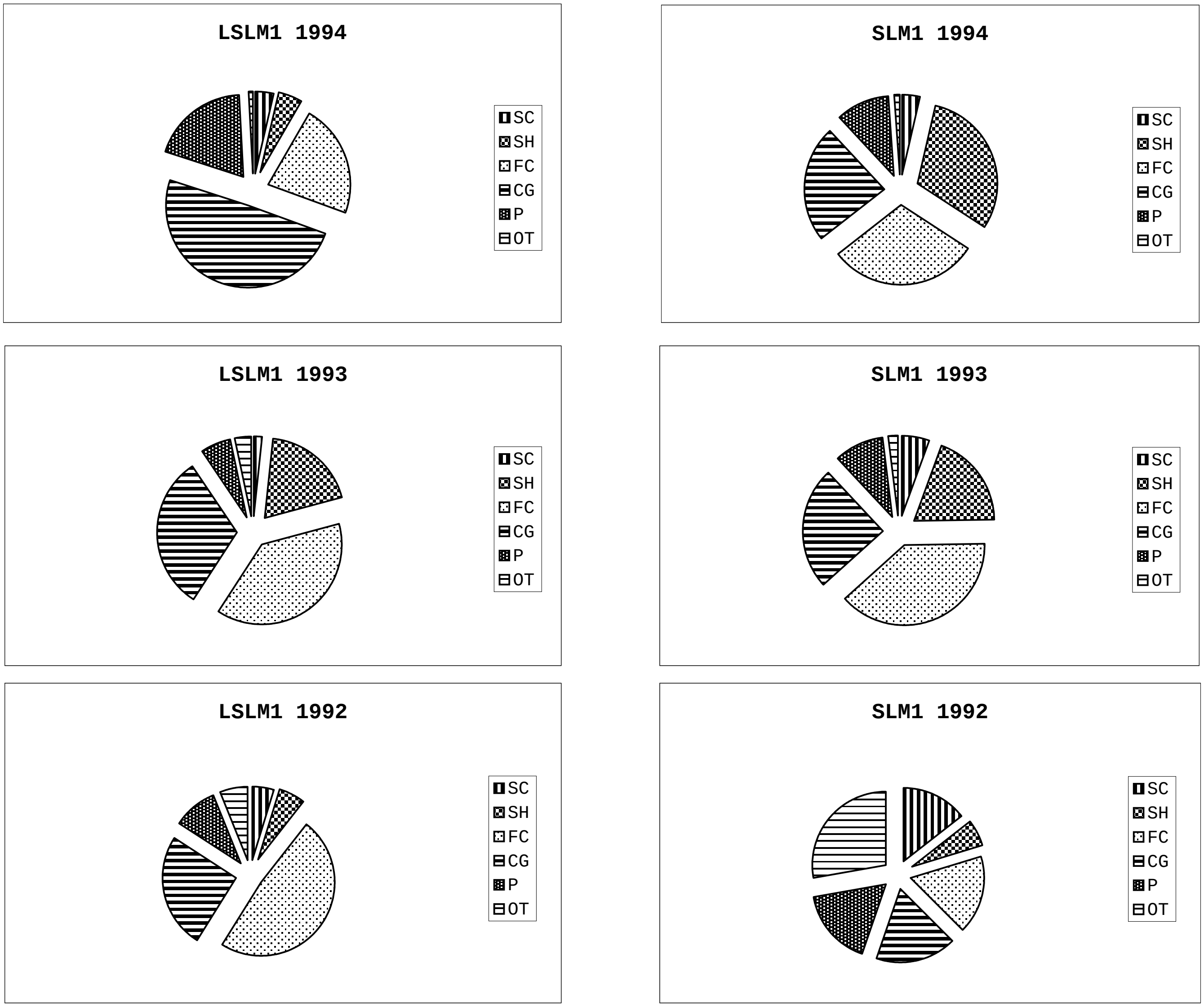


FEEDING TYPES

SC	SCRAPERS	FC	FILTERING COLLECTORS	P	PREDATORS
SH	SHREDDERS	CG	COLLECTOR GATHERERS	OT	OTHERS

FIGURE 12

FUNCTIONAL FEEDING GROUP COMPOSITION



FEEDING TYPES

SC	SCRAPERS	FC	FILTERING COLLECTORS	P	PREDATORS
SH	SHREDDERS	CG	COLLECTOR GATHERERS	OT	OTHERS

FIGURE 13

SCORING FOR BIOLOGICAL CONDITION CATEGORY

1994

STATION	**BYTJ1 (ref)**		**TCD1(Control)**		**TCD3**		**SCD3**		**SHM3a**		**SSD3**		**LSLM1**		**SLM1**	
METRIC	% SIMILARITY TO REFERENCE	SCORE	% SIMILARITY TO REFERENCE	SCORE	% SIMILARITY TO REFERENCE	SCORE	% SIMILARITY TO REFERENCE	SCORE	% SIMILARITY TO REFERENCE	SCORE	% SIMILARITY TO REFERENCE	SCORE	% SIMILARITY TO REFERENCE	SCORE	% SIMILARITY TO REFERENCE	SCORE
TAXA RICHNESS	100	6	100	6	95	6	100	6	100	6	100	6	100	6	100	6
BIOTIC INDEX	100	6	70	2	85	4	74	4	68	2	80	4	72	4	74	4
SCR/(SCR/F/C)	100	6	44	4	29	2	37	4	11	1	32	2	18	1	9	1
EPT/(EPT+CHIRONOMIDAE)	100	6	22	1	68	4	37	2	30	2	68	4	24	1	18	1
% CONTRIBUTION DOMINANT TAXON	35	2	36	2	18	6	24	4	24	4	30	4	19	6	30	4
EPT TAXA RICHNESS	100	6	100	6	100	6	100	6	100	6	92	6	100	6	100	6
COMMUNITY LOSS INDEX	100	6	0.3	6	0.7	4	0.4	6	0.3	6	0.5	6	0.41	6	0.4	6
SHREDDERS/TOTAL	100	6	100	6	100	6	100	6	100	6	100	6	100	6	100	6
TOTAL SCORE		44		33		38		38		33		38		36		34
SIMILARITY OF TOTAL SCORE		100%		75%		86%		86%		75%		86%		82%		77%
CONDITION CATEGORY			**SL. IMPAIRED**		NON-IMPAIRED		NON-IMPAIRED		**SL. IMPAIRED**		NON-IMPAIRED		**SL. IMPAIRED**		**SL. IMPAIRED**	

1994

STATION	**TCD1**		**TCD3**		**SCD3**		**SHM3a**		**SSD3**		**LSLM1**		**SLM1**	
METRIC	% SIMILARITY TO CONTROL	SCORE	% SIMILARITY TO CONTROL	SCORE	% SIMILARITY TO CONTROL	SCORE	% SIMILARITY TO CONTROL	SCORE	% SIMILARITY TO CONTROL	SCORE	% SIMILARITY TO CONTROL	SCORE	% SIMILARITY TO CONTROL	SCORE
TAXA RICHNESS	100	6	79	4	92	6	98	6	85	6	91	6	100	6
BIOTIC INDEX	100	6	100	6	100	6	98	6	100	6	100	6	100	6
SCR/(SCR/F/C)	100	6	66	6	83	6	26	2	71	6	40	4	20	2
EPT/(EPT+CHIRONOMIDAE)	100	6	100	6	100	6	100	6	100	6	100	6	85	6
% CONTRIBUTION DOMINANT TAXON	36	2	18	6	24	4	24	4	30	4	19	6	30	4
EPT TAXA RICHNESS	100	6	83	4	67	1	83	4	61	1	67	1	83	4
COMMUNITY LOSS INDEX	100	6	0.7	4	0.5	4	0.4	6	0.6	4	0.5	4	0.5	6
SHREDDERS/TOTAL	100	6	100	6	82	6	100	6	100	6	23	2	100	6
TOTAL SCORE		44		42		39		40		39		35		40
SIMILARITY OF TOTAL SCORE		100%		95%		89%		91%		89%		80%		91%
CONDITION CATEGORY			NON-IMPAIRED		NON-IMPAIRED		NON-IMPAIRED		NON-IMPAIRED		**SL.IMPAIRED**		NON-IMPAIRED	

FIGURE 14

BIOLOGICAL CONDITION SCORING CRITERIA*

Metric		Score 6	4	2	1
Taxa Richness	(a)	>80%	60-80%	40-60%	<40%
Biotic Index	(b)	>85%	70-85%	50-70%	<50%
EPT/(EPT+Chiro.)	(a)	>75%	50-75%	25-50%	<25%
% Contr. Dom. Taxa	(c)	<20%	20-30%	30-40%	>40%
EPT Index	(a)	>90%	80-90%	70-80%	<70%

*From Plafkin (1989)
(a) Score is ratio of study site to reference site X 100
(b) Score is a ratio of reference site to study site X 100
(c) Scoring criteria evaluate actual % contribution, not % comparability to the reference station.

BIOASSESSMENT

% Comparison to Reference Score	Biological Condition Category	Attributes
>82%	**Nonimpaired**	Comparable to best situation within ecoregion. Balanced trophic structure Optimum community structure for stream size and habitat
82-52%	**Slightly impaired**	Community structure less than expected Composition lower than expected due to loss of intolerant spp % contribution of tolerant forms increases
51-19%	**Moderately impaired**	Fewer species due to loss of most intolerant forms Reduction in EPT index
<19%	**Severely impaired**	Few species present

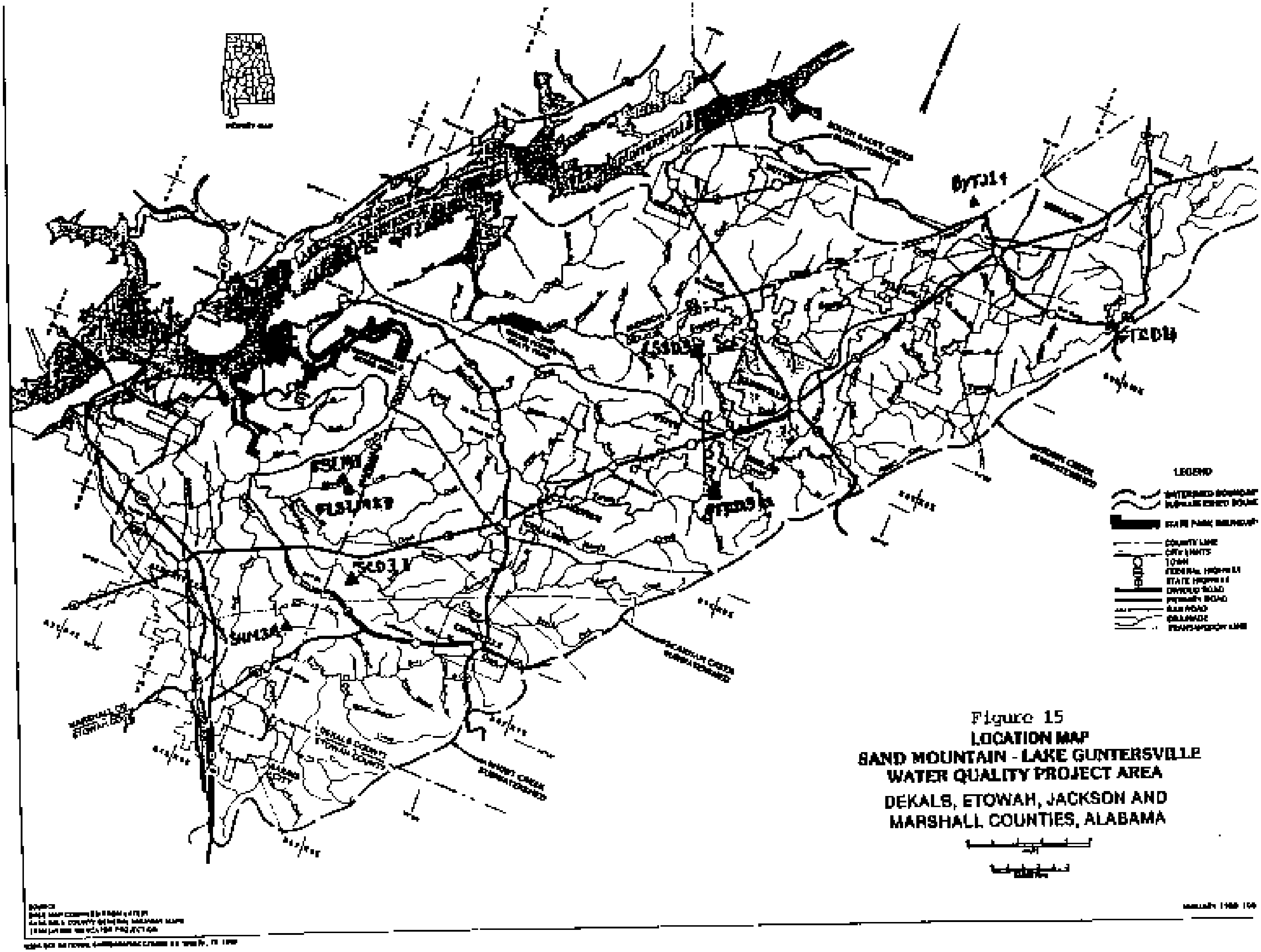


Figure 15
LOCATION MAP
SAND MOUNTAIN - LAKE GUNTERSVILLE WATER QUALITY PROJECT AREA

DEKALB, ETOWAH, JACKSON AND MARSHALL COUNTIES, ALABAMA

Table 1 Sand Mountain Watershed Project Field Parameter Data Summary							
Station Number	Date mm/dd/yy	H20 Temp C	Dissolved Oxygen mg/l	pH s.u.	Turbidity ntu	Conductivity umhos @25c	Flow cfs
BYTJ1	1992	+	+	+	+	+	+
	6/2/93	16	8.5	6.9	3.8	60	11.6
	6/1/94	17	7.8	6.9	2.2	65	3.9
TCD1	6/17/92	18.5	8.6	6.7	4.5	57	29.3
	6/2/93	16	8.6	6.7	4.5	48	12.3
	6/1/94	17.5	8.0	6.9	2.4	58	2.4
TCD3	6/16/92	20.5	8.6	6.9	6.6	71	137.5
	6/2/93	16	7.8	6.9	2.9	60	44.9
	6/1/94	17	7.5	7.0	2.8	89	21.7
SSD3	6/16/92	22	9.1	7.4	3.7	95	38.5
	6/2/93	16	8.7	7.1	1.3	109	7.9
	6/1/94	17	8.2	7.1	2.2	118	9.4
SCD3	6/17/92	20.5	8.3	7.1	3.5	82	26.4
	6/1/93	19	8.5	7.4	1.6	73	18.4
	5/31/94	18	8.4	7.2	2.3	81	7.5
SHM3a	6/18/93	20	6.2	6.9	3.8	83	8.4
	6/1/93	17	7.2	7.0	18	83	32.7
	5/31/94	17	7.3	7.2	2.2	77	8.3
SLM1	6/17/92	21	7.8	7.1	5.1	70	3.5
	6/1/93	19	8.0	7.3	2.1	68	1.5
	5/31/94*	17/17	7.8/7.9	7.2/7.2	2.7/2.3	89/83	1.1
LSLM1	6/17/92	19	8.2	6.8	5.7	68	5.2
	6/1/93	19	8.1	7.1	1.2	68	2.0
	5/31/94	17	8.1	6.9	4.2	65	1.6

+ no samples collected
* duplicate field parameters

TABLE 2
TAXA LIST
Sand Mountain Watershed Study 1994
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	BYTJ 1 94-06-01	YCD 1 94-06-01	YCD 3 94-06-01	SCD 3 94-05-31	SHS 3 a 94-05-31	SSD 3 94-06-01	LSLN 1 94-05-31
ANNELIDA							
OLIGOCHAETA	31	30	13	19	23	1	2
ARTHROPODA							
CRUSTACEA							
AMPHIPODA							
Talitridae							
Hyalella	6						
INSECTA							
COLEOPTERA							
Curculionidae							
Lixus	1	1			4		
Dryopidae							
Helichus	14	5				2	
Dytiscidae							
Hydroporus		1			4		
Dytiscidae UNID dif						1	
Elmidae							
Ancyronyx	1	11	5	17	1	1	1
Dubiraphia	7	7		6	5		3
Macronychus		2	50	11		77	
Microcylloepus			34			1	
Promoresia		25	38			6	79
Stenelmis		4				1	6
Haliplidae							
Peltodytes					5	1	
Hydrophilidae							
Enochrus					4		
Helophorus							1
Hydrochus						1	
Sperchopsis					8		
Hydrophilidae UNID dif			1				

TABLE 2
TAXA LIST
Sand Mountain Watershed Study 1994
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	BYTJ 1 94-06-01	TCO 1 94-06-01	TCO 3 94-06-01	SCO 3 94-05-31	SHM 3 a 94-05-31	SSD 3 94-06-01	LSLM 1 94-05-31
COLEOPTERA UNID dif					1		
DIPTERA							
Ceratopogonidae							
Atrichopogon						6	
Bezzia	2				5		2
Palpomyia					4		
Ceratopogonidae UNID dif				6			
CHIRONOMIDAE							
Chironominae							
Chironomini							
Chironomus	1	36			33		225
Cryptochironomus		20					
Dicrotendipes	6	159		39	99	5	32
Endochironomus				46			
Microtendipes	1			5			124
Paracladopelma					10		10
Paralauterborniella		20					
Paratendipes							121
Phaenopsectra				123	47		47
Polypedilum	9	132	264	188	352	167	65
Stenochironomus	6			5		2	
Stictochironomus		40	1	11	8		
Tribelos	7			24	8		405
Chironomini UNID				2	4	1	3
Tanytarsini							
Cladotanytarsus	3		4		12	1	10
Rheotanytarsus			9			5	
Stempellinella		22					

TABLE 2
TAXA LIST
Sand Mountain Watershed Study 1994
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	BYTJ 1 94-06-01	TCD 1 94-06-01	TCD 3 94-06-01	SCD 5 94-05-31	SJIH 3 A 94-05-31	SSD 5 94-06-01	LSLH 1 94-05-31
Tanytarsus	9	771		101	243	6	241
Tanytarsini UNID						1	7
Orthocladiinae							
Brillia			52	24		52	16
Cardiocladius		4	7	114	36		
Corynoneura	1					7	
Cricotopus				94	62	27	
Cricotopus/Orthocladius	1	12	3	135	35	5	
Parametriocnemus	23	153	72	172	6	15	86
Rheocricotopus	12	4	29	54	61		
Stilocladius			1				
Symposiocladius		3					
Thienemanniella				24			
Tvetenia	13	4	16	217	76	75	16
Orthocladiinae UNID				6		1	1
Tanypodinae							
Ablabesmyia	4	31	2		9		16
Labrundinia		2					
Natarsia	1						
Procladius	21	132		5	14	1	11
Tanypus							119
Thienemannimyia Grp	6	54		15	18	7	1
Tanypodinae UNID	1						
CHIRONOMIDAE UNID			1	6		1	2
Empididae							
Chelifera		1					

95/01/18 10:59:09
PROGRAM ID: PRTMULTE

TABLE 2
TAXA LIST
Sand Mountain Watershed Study 1994
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	BYTJ 1 94-06-01	TCD 1 94-06-01	TCD 3 94-06-01	SCD 3 94-05-31	SHM 3 a 94-05-31	SSD 3 94-06-07	LSLK 1 94-05-31
Hemerodromia			6	4		1	
Simuliidae	36	60	322	738	564	503	10
Tabanidae							
Tabanus							4
Tipulidae							
Antocha		4				12	
Tipula	6	1					
EPHEMEROPTERA							
Baetidae							
Baetis	292	67	6	8	14	28	19
Centroptilum				1	5		
Cloeon					43		2
Heterocloeon			12				
Pseudocloeon		39	87	126	59	227	6
Baetidae UNID			13	60	8	32	28
Ephemerellidae							
Attenella	656	49		3	10	2	1
Danella	18	10		24	1		
Ephemerella		23				11	114
Eurylophella			6	48			
Serratella		4					6
Ephemerellidae UNID dif		4					
Ephemerellidae UNID							12
Ephemeridae							
Hexagenia	1						
Heptageniidae							
Epeorus	6				6		
Heptagenia			10				

TABLE 2
TAXA LIST
Sand Mountain Watershed Study 1994
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	BYTJ 1 94-06-01	TCD 1 94-06-01	TCD 3 94-06-01	SCD 3 94-05-31	SHM 3 a 94-05-31	SSO 3 94-06-01	LSLM 1 94-05-31
Stenonema	181	34	94	71	16	21	12
Heptageniidae UNID			52	7		3	
Leptophlebiidae							
Habrophlebiodes					8		
Paraleptophlebia	19	4					
Leptophlebiidae UNID							2
Oligoneuridae							
Isonychia			4	6		12	
Tricorythidae							
Tricorythodes			4				
HEMIPTERA							
Gerridae							
Rheumatobates	1						
Trepobates	1						
HEMIPTERA UNID dif							1
LEPIDOPTERA							
Pyralidae							
Acentria						1	
MEGALOPTERA							
Corydalidae							
Chauliodes							1
Corydalus			13				
Nigronia				15			
Sialidae							
Sialis	15	5		2	5		2
ODONATA							
Aeshnidae							
Boyeria	13	4	6	34		11	7
Calopterygidae							
Hetaerina						1	
Corduliidae							
Helocordulia							1

TABLE 2
TAXA LIST
Sand Mountain Watershed Study 1994
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	BYTJ 1 94-06-01	TCD 1 94-06-01	YCD 3 94-06-01	SCD 3 94-05-31	SHM 3 a 94-05-31	SSD 3 94-06-01	LSLN 1 94-05-31
Gomphidae							
Hagenius			6	2	4		
Progomphus					1		1
Macromiidae							
Didymops							1
Macromia	1			4			
PLECOPTERA							
Leuctridae							
Leuctra	1	7					
Nemouridae							
Amphinemura		1	13		14		
Perlidae							
Acroneuria		5					
Attaneuria		1					
Neoperla					6		
Perlesta	414	34	134	234	231	155	37
Perlodidae							
Isoperla	42	128	55	70	10	12	165
Perlodidae UNID dif			1				
Perlodidae UNID						6	
TRICHOPTERA							
Brachycentridae							
Brachycentrus			7				
Glossosomatidae							
Glossosoma							2
Hydropsychidae							
Ceratopsyche							1
Cheumatopsyche		15	42	26	12	2	
Hydropsyche			250	22		136	25
Hydropsychidae UNID			12	6		9	18

TABLE 2
TAXA LIST
Sand Mountain Watershed Study 1994
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	BYTJ 1 94-06-01	TCD 1 94-06-01	TCD 3 94-06-01	SCD 3 94-05-31	SHM 3 a 94-05-31	SSD 3 94-06-01	LSLH 1 94-05-31
Leptoceridae							
Oecetis					1		
Limnephilidae							
Neophylax	1						
Pycnopsyche		1					
Polycentropodidae							
Polycentropus		1				2	
Rhyacophilidae							
Rhyacophila	1						
MOLLUSCA							
GASTROPODA							
LIMNOPHILA							
Ancylidae							
Ferrissia			1	1	1		4
Physidae							
Physella		1			9		1
Planorbidae							
Helisoma	2			10	53	4	
Planorbella			1	57			
PELECYPODA							
HETERODONTA							
Corbiculidae							
Corbicula		1	12	6	97	21	6
Sphaeriidae *							
Sphaeriidae UNID dif *				2			
MISCELLANEOUS							
Planaria			1	1		2	

TABLE 3
TAXA LIST
Sand Mountain Watershed Study 1994
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	SLM 1 94-05-31
ANNELIDA	
OLIGOCHAETA	12
ARTHROPODA	
INSECTA	
COLEOPTERA	
Elmidae	
Dubiraphia	2
Stenelmis	2
Hydrophilidae	
Sperchopsis	1
Psephenidae	
Psephenus	4
DIPTERA	
Ceratopogonidae	
Atrichopogon	3
CHIRONOMIDAE	
Chironominae	
Chironomini	
Cryptochironomus	6
Microtendipes	76
Paratendipes	7
Polypedilum	730
Stenochironomus	7
Tribelos	35
Chironomini UNID	1
Tanytarsini	
Cladotanytarsus	11
Rheotanytarsus	72
Tanytarsus	49
Orthocladinae	
Brillia	58
Cardiocladius	61

TABLE 3
TAXA LIST
Sand Mountain Watershed Study 1994
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	SLM 1 94-05-31
Corynoneura	14
Cricotopus/Orthocladius	50
Nanocladius	14
Parametriocnemus	282
Rheocricotopus	14
Tvetnia	43
Xylotopus	7
Tanypodinae	
Thienemannimyia Grp	64
Empididae	
Chelifera	2
Hemerdromia	1
Simuliidae	423
Tipulidae	
Antocha	4
Limonia	6
EPHEMEROPTERA	
Baetidae	
Baetis	42
Pseudocloeon	24
Baetidae UNID	10
Ephemerellidae	
Ephemerella	1
Heptageniidae	
Stenonema	35
Heptageniidae UNID	3
Leptophlebiidae	
Habrophlebiodes	6
Leptophlebiidae UNID	6

TABLE 3
TAXA LIST
Sand Mountain Watershed Study 1994
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	SLM 1 94-05-31
HEMIPTERA	
Veliidae	
Microvelia	6
Rhagovelia	1
MEGALOPTERA	
Corydalidae	
Nigronia	10
Sialidae	
Sialis	1
ODONATA	
Aeshnidae	
Boyeria	6
Calopterygidae	
Calopteryx	1
Gomphidae	
Gomphidae UNID	1
PLECOPTERA	
Nemouridae	
Amphinemura	2
Perlidae	
Perlesta	18
Perlodidae	
Isoperla	23
Malirekus	6
TRICHOPTERA	
Hydropsychidae	
Cheumatopsyche	7
Hydropsyche	99
Hydropsychidae UNID	23
Leptoceridae	
Oecetis	1
Philopotamidae	
Chimarra	10

TABLE 3
TAXA LIST
Sand Mountain Watershed Study 1994
MACROINVERTEBRATE DATA

MACROINVERTEBRATE	SLH 1 94-05-31
Polycentropodidae	
Polycentropus	2
Rhyacophilidae	
Rhyacophila	1
MOLLUSCA	
GASTROPODA	
LIMNOPHILA	
Planorbidae	
Helisoma	5
Planorbella	4
PELECYPODA	
HETERODONTA	
Corbiculidae	
Corbicula	12
Sphaeriidae *	
Sphaerium *	7
Sphaeriidae UNID dif *	6

TABLE 4a
Biometrics
Sand Mountain Watershed Study 1995

Station	Sampling Year	Habitat Assessment	Total Taxa Richness	EPT Taxa Richness	Biotic Index	EPT/ EPT+Chiro.*	Percent Chiro.* Taxa	Percent Dominant taxa
BYTJ1	1992	----	----	----	----	----	----	----
	1993	97	49	13	4.93	0.38	41	27
	1994	106	44	12	4.04	0.93	39	35
TCD1	1992	101	60	22	5.33	0.16	27	38
	1993	110	58	24	3.99	0.52	29	13
	1994	93	53	18	5.78	0.20	34	36
TCD3	1992	111	45	12	4.96	0.70	16	22
	1993	112	57	18	4.00	0.89	35	14
	1994	111	42	15	4.73	0.63	29	18
SCD3	1992	99	77	22	5.12	0.56	27	9
	1993	109	66	24	4.80	0.67	30	14
	1994	91	49	12	5.45	0.34	39	24
SHM3a	1992	89	57	13	5.20	0.41	26	15
	1993	111	44	11	5.01	0.63	36	21
	1994	86	52	15	5.90	0.28	35	24
SSD3	1992	106	69	24	5.36	0.40	27	19
	1993	108	50	17	5.11	0.50	34	21
	1994	109	45	11	5.05	0.63	31	30
LSLM1	1992	107	63	16	5.13	0.43	33	19
	1993	106	54	15	4.14	0.54	35	18
	1994	100	48	12	5.61	0.22	35	19
SLM1	1992	117	60	17	4.82	0.34	32	16
	1993	109	49	16	4.68	0.48	29	16
	1994	100	56	15	5.46	0.17	34	30

*Chiro. = Chironomidae

TABLE 4b
Comparison Biometrics versus Reference Station BYTJ1
Sand Mountain Watershed Study 1994

Station	Sampling Year	I.A.I.	Sorenson's CSI	QSI-Taxa	QSI-FFG
TCD1	1994	0.17	0.58	20	57
	1993	1.34	0.52	42	87
TCD3	1994	0.42	0.35	23	43
	1993	4.02	0.57	33	70
SCD3	1994	0.23	0.56	22	60
	1993	1.77	0.54	38	79
SHM3a	1994	0.20	0.58	20	46
	1993	1.65	0.54	36	80
SSD3	1994	0.41	0.49	20	43
	1993	1.34	0.55	29	73
LSLM1	1994	0.18	0.52	12	79
	1993	1.41	0.62	43	83
SLM1	1994	0.14	0.46	13	39
	1993	1.23	0.53	34	82

TABLE 4c
Comparison Biometrics versus Control Station TCD1
Sand Mountain Watershed Study 1994

Station	Sampling Year	I.A.I.	Sorenson's CSI	QSI-Taxa	QSI-FFG
TCD3	1994	2.61	0.46	25	76
	1993	2.94	0.54	35	82
	1992	3.37	0.46	12	86
SCD3	1994	1.43	0.53	31	85
	1993	1.33	0.58	48	91
	1992	2.19	0.61	31	67
SHM3a	1994	1.25	0.59	35	83
	1993	1.23	0.53	46	88
	1992	1.90	0.51	29	78
SSD3	1994	2.71	0.55	20	79
	1993	0.99	0.48	41	87
	1992	1.82	0.51	29	76
LSLM1	1994	1.08	0.53	37	74
	1993	1.05	0.64	60	86
	1992	1.82	0.62	29	57
SLM1	1994	0.92	0.50	29	74
	1993	0.92	0.60	44	93
	1992	1.68	0.50	36	71

TABLE 5
BIOMETRIC INTERPRETATION TABLE

METRIC	RANGE	INTERPRETATION
Habitat Assessment	104-135 71-103 35-70 0-34	Excellent Good Fair Poor
Total Taxa Richness EPT Taxa Richness		Generally Increases with Increasing Water Quality
Biotic Index % Contribution of Dominant Taxon % Chironomidae Taxa		Generally Increases With Decreasing Water Quality
% Contribution of Functional Feeding Types %Shredders %Scrapers %Predators %Collector Gatherers %Collector Filterers %Macrophyte Piercers %Others		Percentages and Composition Should be similar to background station for similar stream sizes and habitat composition
EPT / EPT + Chironomidae		Generally increasing water Quality as approaches 1.0
SIMILARITY INDICES		
Indicator Assemblage Index (IAI) Sorenson's Community Index (CSI)		Increasing Similarity as Approaches 1.0
Community Similarity Index for Functional Feeding Groups (QSI-FFG) Community Similarity Index for Taxa (QSI- Taxa)		Generally Increases with Increasing Similarity