Sand Mountain / Lake Guntersville Nonpoint Source Watershed Project: Macroinvertebrate Bioassessment

Ecological Studies Section - Field Operations Division
Alabama Department of Environmental Management

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Macroinvertebrate Bioassessment

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Ecological Studies Section - Field Operations Division

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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, June of 1993, and June of 1994.

On May 20-21, 1995 at the request of the 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 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.

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 (Fig. 1).

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 stations 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 (MACINV) 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 smaller sand deposits than noted in 1994.

It should be noted that the control site for the study was located in the upper 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. 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 1995, as illustrated in Fig. 1 (Table 4) , ranged from “Good” with a score of 90 (Good 71-103) to “Excellent” with a score of 113 (Excellent 104-135). Since no scores varied more than 20 percent from the control or reference station score, all study stations sampled during 1995 were comparable to the control and reference station in terms of the habitat assessment scoring (Plafkin et al.

1989). Further direct comparison utilizing estimated substrate composition (Table 1) indicates that the control station (TCD1) is most similar to TCD3, followed by LSLM1, SLM1, SCD3, SHM3a and SSD3. BYTJ1 (Table 2) is most similar to SSD3, followed by SCD3, SLM1, SHM3a, LSLM1, TCD1 and TCD3.

Field parameters were measured at all stations during the 1992-95 field studies (Table 3). Water temperature, dissolved oxygen, pH, and conductivity values showed little variation between sampling dates. Stream flows (Table 3, Fig. 3) were somewhat higher than in 1994 at BYTJ1, TCD1, TCD3 and similar to 1994 flows at the remaining stations.

A list of macroinvertebrate taxa collected at each station is located in Table 12. 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 1995 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 4 - 6. "Interpretation of Biometrics" - Table 7, 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 (Fig. 4, Table 4). In 1995, total taxa richness ranged from 50 to 58. At the control station (TCD1) 55 taxa were collected and at the reference station (BYTJ1) 58 taxa were collected. As illustrated in Fig. 4, total taxa richness increased or remained the same from 1994 to 1995 for all stations. In general, an increase in taxa richness suggests an increase in water quality. However, natural variation in taxa richness due to changes in annual weather patterns may account for this trend.
- In 1995, the EPT taxa richness (Fig. 5, Table 4), which is the total number of the generally pollution-intolerant Ephemeroptera, Plecoptera and Trichoptera taxa, ranged from 15 to 26. The control station sample had 17 and the reference station

had 21 EPT taxa. Of the 8 stations in the study, station TCD3 had the largest change in the number of EPT taxa (gaining 11 taxa) as compared to the 1994 sample. Stations BYTJ1 and LSLM1 each gained 9 EPT taxa. With the exception of TCD1, which lost 1 taxa, the remaining stations gained less than four EPT taxa. As with the total taxa richness metric, changes in stream flow may partially account for this trend. In addition, some of the EPT taxa that emerge early in the spring may still have been present at the slightly earlier 1995 sampling date.

- The Biotic Index (BI) (Fig. 6, Table 4) 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 1995, this metric ranged from 4.26 to 5.40 with an average of 5.03. The control station BI was 5.40 and the reference site BI was 5.29. All study station biotic indices for 1995 were similar (within 1.0) to the control and reference station (with the exception of LSLM1 - BI = 4.26). It should be noted that BI scores in this report are not comparable with scores from previous reports due to updates of the pollution tolerance values utilized. All historical Sand Mountain BI scores were recalculated to reflect these changes.

  The BI for most stations (except BYTJ1 & LSLM1) did not vary more than 1.0 from the 1994 values. Reference station BYTJ1 appeared to deteriorate based on the biotic index, however this is probably an anomaly in that the remaining metrics all indicate improvement in water quality. Station LSLM1 appeared to improve based on the BI. This is probably an accurate indication based upon little change in stream flow or field parameter values from 1994 to 1995 and the remaining metrics also indicate improvement in water quality.

  Hilsenhoff (1987) established guidelines for evaluating the biotic index in Wisconsin. Utilizing that method of evaluation the study station LSLM1 water quality was 'very good' with 'possible slight pollution' (3.51-4.50) and the remaining stations all had "good" water quality with "some" degree of pollution (4.51-5.50). 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 (Fig. 7, Table 4). 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 1995, with the exception of the study sites TCD3 and LSLM1, 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 (Fig. 8, Table 4) ranged from 22 to 38 percent during the 1995 study. This compares with the ranges of 29 to 39 and 29 to 41 percent Chironomidae taxa in the 1994 and 1993 collections, respectively. In 1995, the control (TCD1) station was 38 percent Chironomidae taxa and the reference (BYTJ1) station sample was 33 percent Chironomidae taxa.

- The percent contribution of the numerically dominant taxon (Fig. 9, Table 4) 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 Fig. 8, all study stations during 1995 had percentages at or below this level (range 12% to 32%). The reference and control sites had the dominant taxon comprising 20 percent and 17 percent of the sample, respectively.

- The ratio of the scraper and filtering collector functional feeding groups (Table 4) collected in the riffle sample reflects the riffle/run community food base and provides insight into the nature of potential disturbance factors. The proportion of the two feeding groups is important because predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source. (Plafkin et al. 1989) The riffle habitat at all stations, with the exception of BYTJ1, has historically been dominated by filtering collectors. The riffle habitat at BYTJ1 is composed predominantly of bedrock which is an excellent substrate for diatoms. Scraper-type organisms increase with increased abundance of diatoms and decrease as filamentous algae and aquatic mosses

increase. However filamentous algae and aquatic mosses do provide good attachment sites for filtering collectors, and the organic enrichment often responsible for overabundance of filamentous algae provides FPOM (fine particulate organic matter) utilized by the filterers. (ADEM 1992)

- The relative abundance of the shredder functional feeding group (Table 4) indicates potential impairment to the CPOM (course particulate organic matter) based community when compared to the reference community which should have an abundance and diversity of shredders representative of the particular area under study (Plafkin et al. 1989). Only stations TCD3 and LSLM1 had a much smaller percentage of the community composed of shredders than the reference or control stations. Shredders are sensitive to riparian zone impacts and toxicants, such as pesticides and herbicides, that are readily adsorbed to organic matter (Plafkin et al. 1989).

- The relative composition 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 (Table 8). This indicates that the dominant food source is located within the water column, in the form of algae and suspended solids.

Station Comparison Metrics

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

- The Sorenson's Community Similarity Index (CSI) (Figs. 10, 11; Tables 5, 6) 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. CSI values greater than or equal to 0.4 indicate that the stations being compared are similar. CSI values at all study stations in 1995 were greater than 0.4 when compared to the control or reference station.

- The Community Similarity Index, QSI-Taxa (Figs. 12, 13; Tables 5, 6) compares two communities in terms of presence or absence, as well as relative abundance, of the individual taxa. For the 1995 study, as compared to the control, the study stations ranged from 43 to 58 percent similar (in 1994 the percentage range was 20 - 37). Stations SSD3, SHM3a and SCD3 had the highest similarity ($\geq$ 57%). When the reference site was utilized for comparison, the similarity index ranged from 25

to 38 percent similar (in 1994 the percentage range was 12 - 23 percent). Station LSLM1 and TCD3 had the lowest percent similarities to the reference, of 25 percent and 27 percent, respectively. The remaining stations were all greater than 30 percent similar. 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. This value is used as a benchmark for the upper end of similarity expectations for the same stream. Values for unrelated streams such as the Sand Mountain stations could be expected to be considerably lower than 70 percent.

- 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 (Figs. 14, 15; Tables 5, 6, 8). When compared to the control, the 1995 study stations ranged from 77 to 84 percent similar as to the relative composition of the feeding types. As compared to the reference station, the study stations ranged from 52 to 72 percent similar. The control station was 52 percent similar. Quality assurance work by Ecological Studies Section personnel on an unrelated stream indicated 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. This value is used as a benchmark for the upper end of similarity expectations for the same stream. Values for unrelated streams such as the Sand Mountain stations could be expected to be considerably lower than 80 percent.

  Table 8 compares the communities collected at the same station during different years by using the QSI-FFG. This illustrates the stability from year-to-year in the function of the community collected at each site. Utilizing the 80 percent value described above (which may be somewhat higher than you would expect between years), only stations SHM3a and SSD3 were consistently similar ($\geq$80%) between sampling years. LSLM1 and BYTJ1 were consistently less than 80 percent similar.

- Shackleford's Indicator Assemblage Index (IAI) (Figs. 16, 17; Tables 5, 6) 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 or reference stations.

- The Biological Condition Category, advocated by EPA (Plafkin et al. 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 (Table 10) based on the percent comparability to a reference/control station metric or on a preassigned range (Table 9). 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. It should be noted that due to the recalculation of BI scores in this report (see above), Biological Condition scores and categories may be different than those from previous reports. All scores and categories listed in this report are based upon the recalculated BI values.

  Using the Biological Condition Scoring Criteria with the 1995 data, station LSLM1 continued to be "slightly impaired", as compared to the reference (Table 11). Stations TCD1 and SLM1 were elevated to the "non-impaired" category as compared to the reference. Station SHM3a improved scores into the "borderline slightly impaired" category (one point from the "non-impaired" category). Stations TCD3, SCD3, and SSD3 fell into the "borderline slightly impaired" category, as compared to the reference.

SUMMARY AND CONCLUSIONS

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

On May 20-21, 1995 at the request of the Nonpoint Source Section of the Water Division, Ecological Studies Section personnel from Field Operations Division completed in-stream multi-habitat bioassessments utilizing aquatic macroinvertebrates of selected Sand Mountain stations. 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 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.

The Sand Mountain watershed is located in the Tennessee River Basin, Interior Plateau Ecoregion, and occupies parts of Dekalb, Etowah, Jackson and Marshall counties in northeast Alabama. This study focused on seven streams (eight stations) including the reference stream: Shoal Creek (SLM1), Little Shoal Creek (LSLM1), Scarham Creek (SCD3), Short Creek (SHM3a), South Sauty Creek (SSD3), Town Creek (TCD1-control, TCD3), and Bryant Creek (BYTJ1-reference).

Analysis of the macroinvertebrate data collected during the 1995 in-stream bioassessment of selected streams within the Sand Mountain watershed indicated that the study stations were all similar (no difference in Biological Condition Category) 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. Field parameters measured during the study indicated little change in water quality from the 1992, 1993, or 1994 study.

The biological metrics used to analyze the data indicate that the macroinvertebrate communities of SLM1 and TCD1 showed improvement from 1994 - 1995. The ecoregional reference site, BYTJ1, showed some improvement in biotic quality over the 1994 study as indicated by the majority of the metrics. Using the Biological Condition Scoring Criteria with the 1995 data, all sites were found to be "non-impaired" as compared to the control station TCD1. Station LSLM1 continued to be "slightly impaired", when compared to the reference station. Three stations (TCD3, SCD3, and SSD3) fell into a borderline "slightly impaired" category as compared to the reference. Station SHM3a improved scores into the borderline "slightly impaired category". The metrics for all other stations generally showed an increase in the quality of the biological community, however, no change in the Biological Condition Category since the 1994 report was indicated.

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TABLES

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FIGURES

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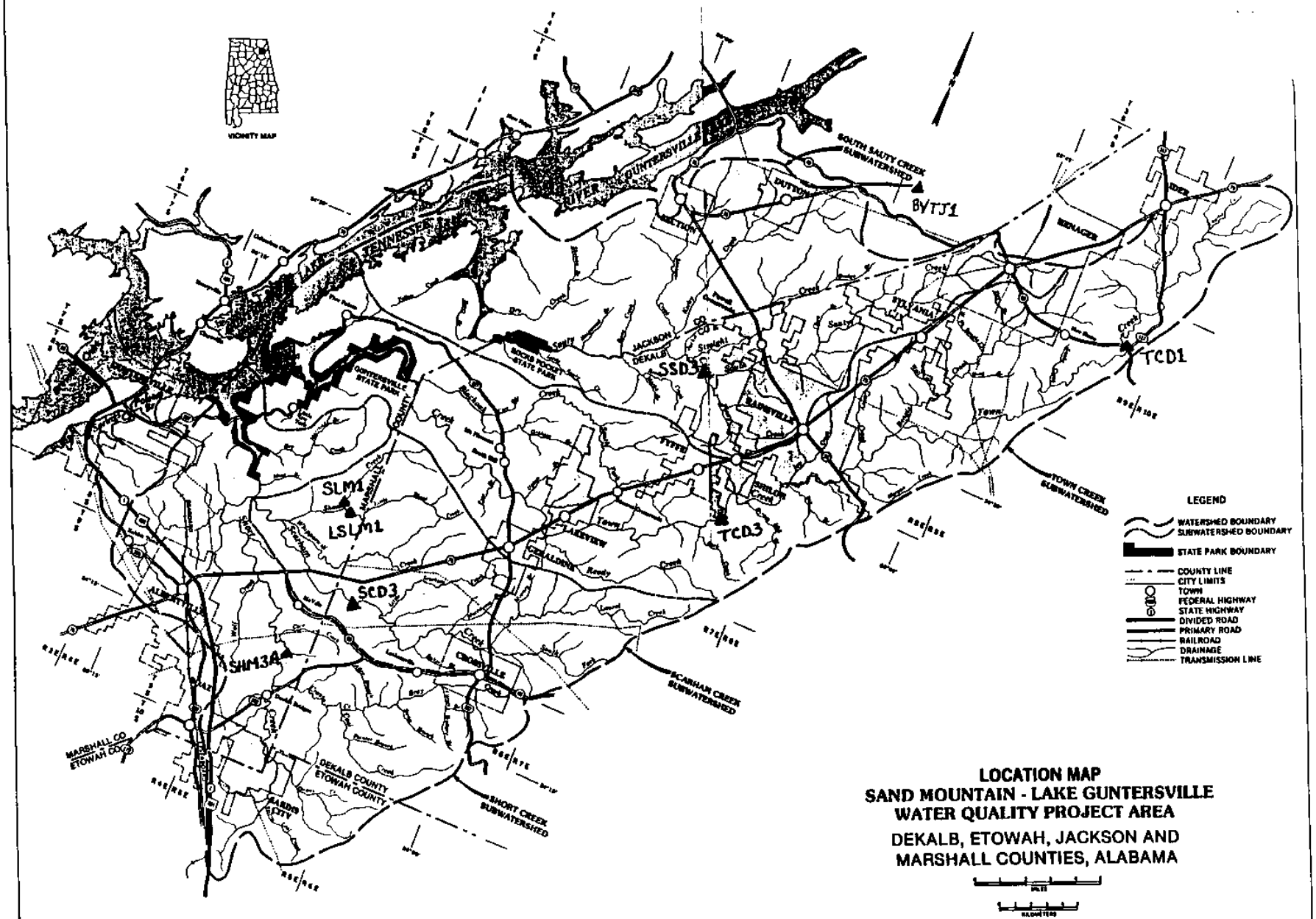

LOCATION MAP
SAND MOUNTAIN - LAKE GUNTERSVILLE
WATER QUALITY PROJECT AREA

DEKALB, ETOWAH, JACKSON AND
MARSHALL COUNTIES, ALABAMA

SOURCE
BASE MAP COMPILED FROM LATEST
AVAILABLE COUNTY GENERAL HIGHWAY MAPS
TRANSVERSE MERCATOR PROJECTION

USDA-SCS NATIONAL CARTOGRAPHIC CENTER, FT. WORTH, TX -1987

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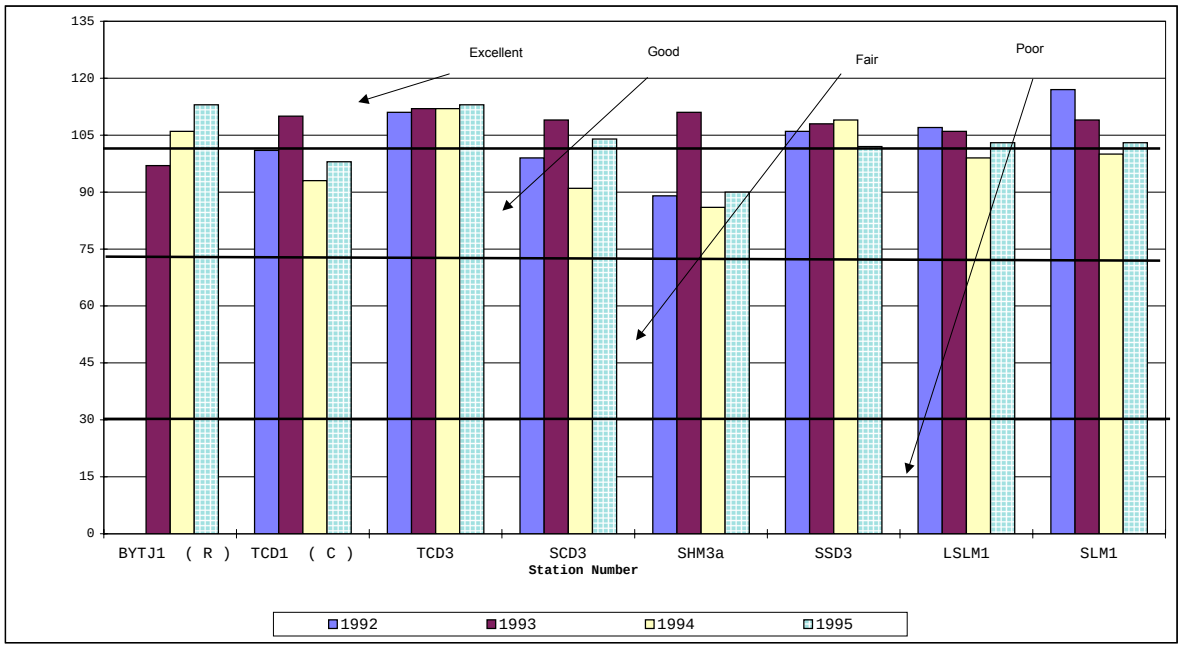

Fig. 2. Habitat assessment of Sand Mountain bioassessment stations. Habitat quality categories of excellent, good, fair, and poor are illustrated.

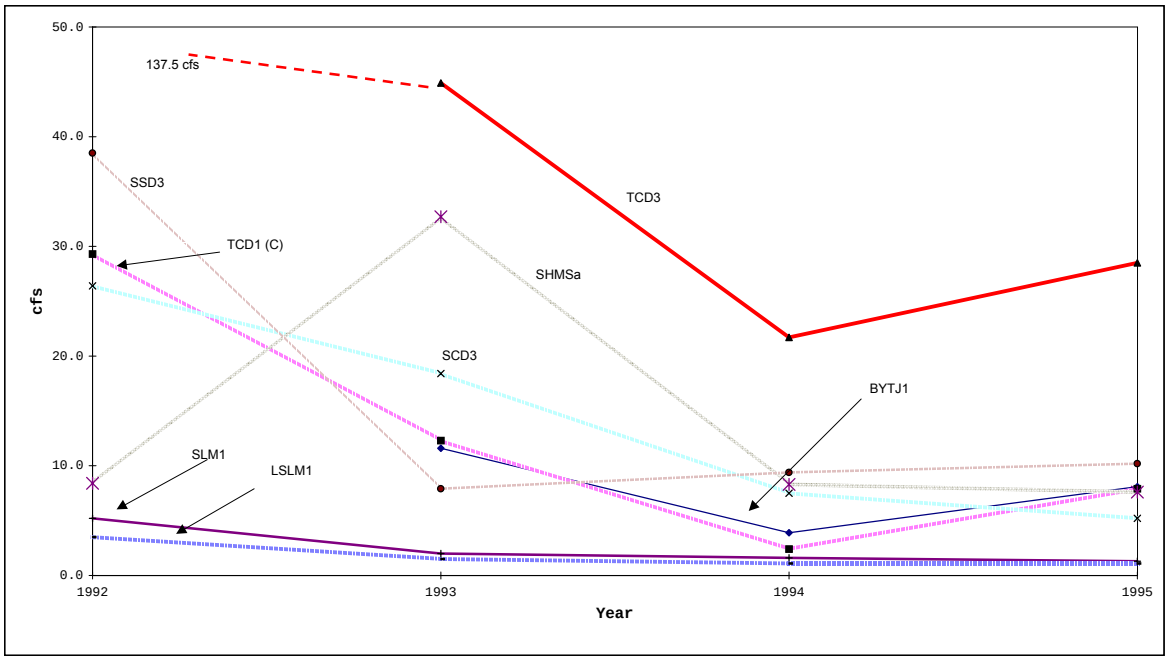

Fig. 3. Stream flow measurements at Sand Mountain stations during annual bioassessments from 1992 to 1995.

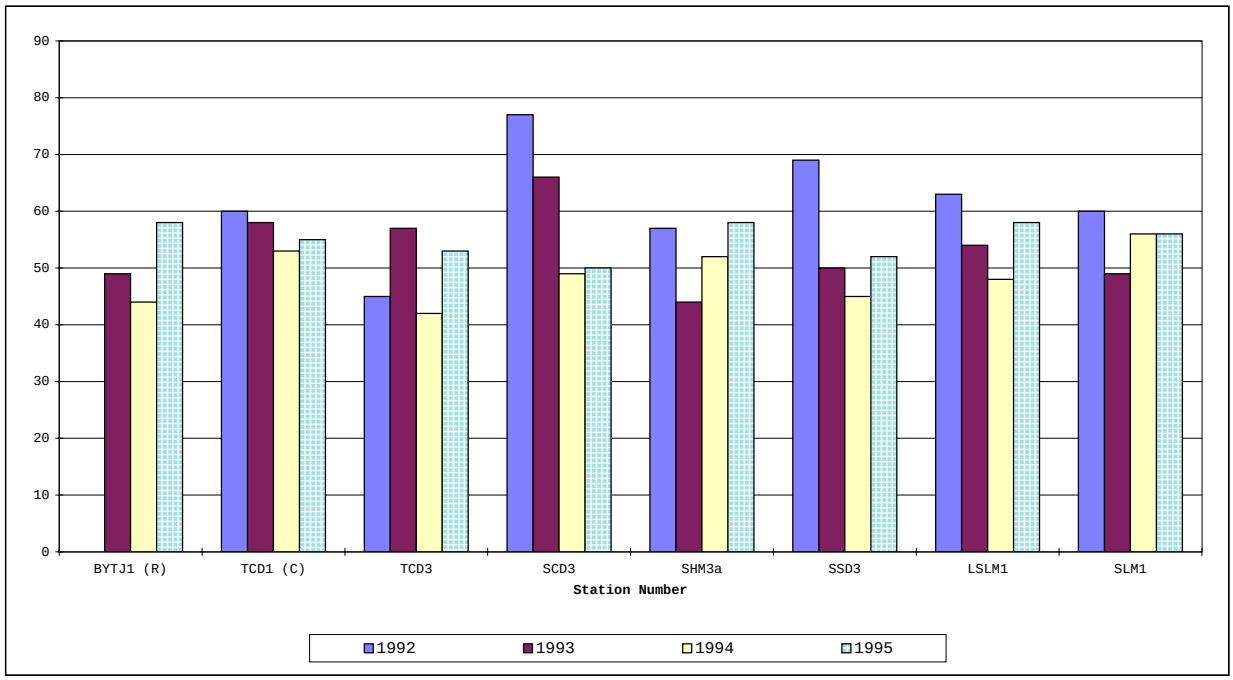

Fig. 4. Total taxa richness from bioassessments completed (1992-1995) at Sand Mountain NPS stations and control (C) and ecoregional reference (R) sites.

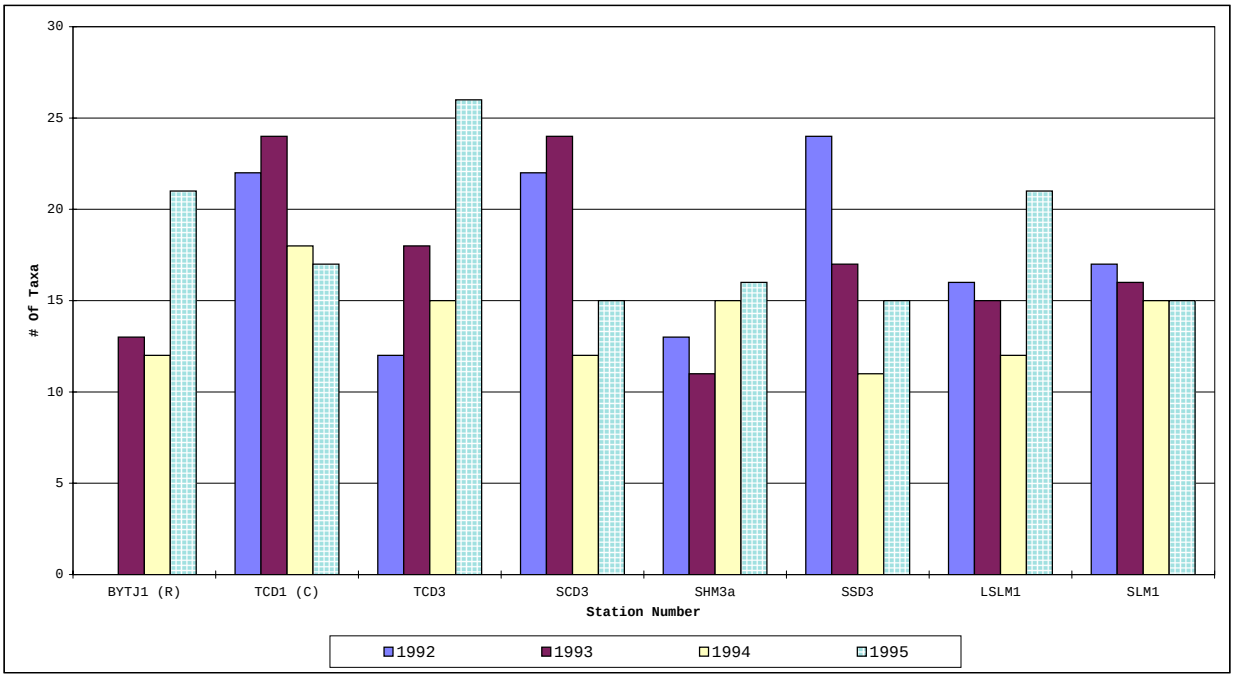

Fig. 5. EPT taxa richness from bioassessments completed (1992-1995) at Sand Mountain NPS stations and control (C) and ecoregional reference (R) sites.

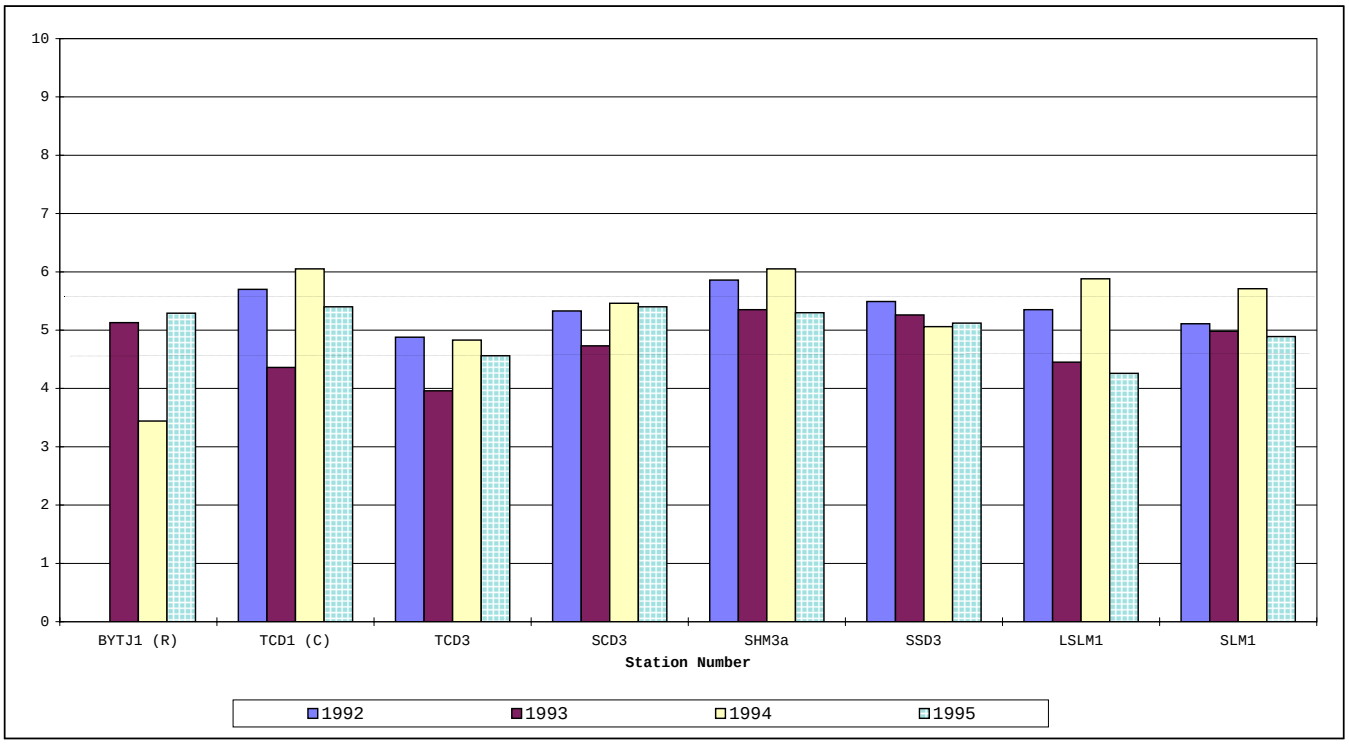

Fig.6. Biotic Indices (BI) from bioassessments completed (1992-1995) at Sand Mountain NPS stations and control (C) and ecoregional reference (R) sites. Dotted Lines indicate a range of 1.0 where most BI values fall.

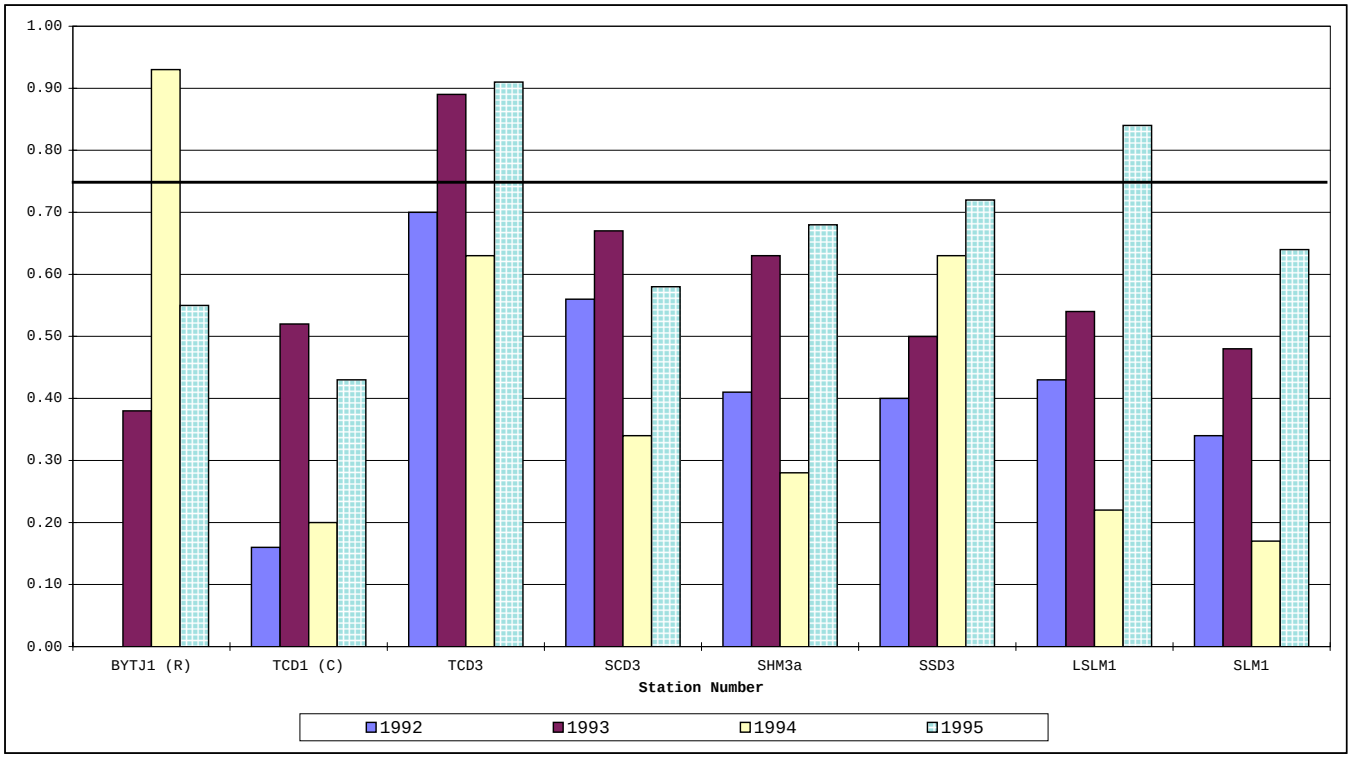

Fig. 7. EPT/ (EPT + Chironomidae) metric from bioassessments completed (1992-1995) at Sand Mountain NPS stations and control (C) and ecoregional reference (R) sites. Heavy line indicates optimum value (0.75).

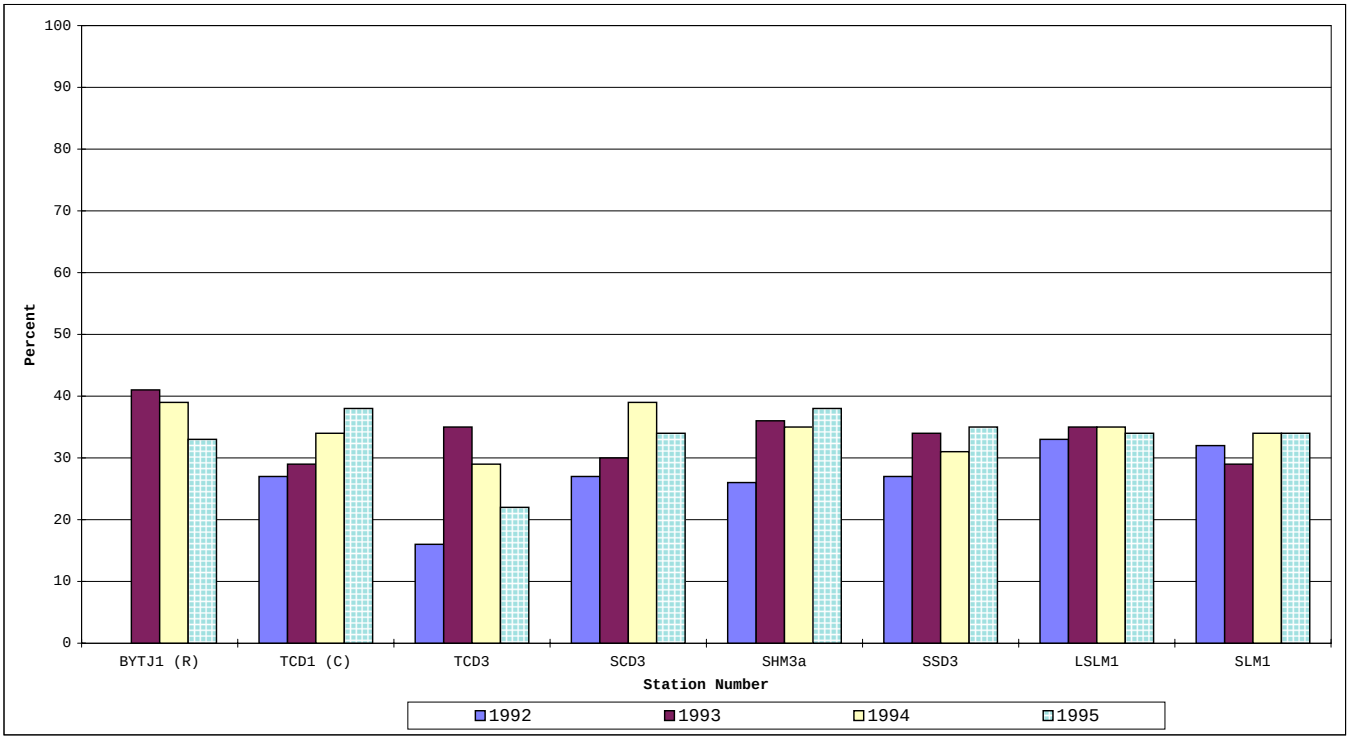

Fig. 8. Percent of total taxa richness attributable to the generally pollution tolerant Chironomidae taxa from bioassessments completed (1992-1995) at Sand Mountain NPS stations and control (C) and ecoregional reference (R) sites.

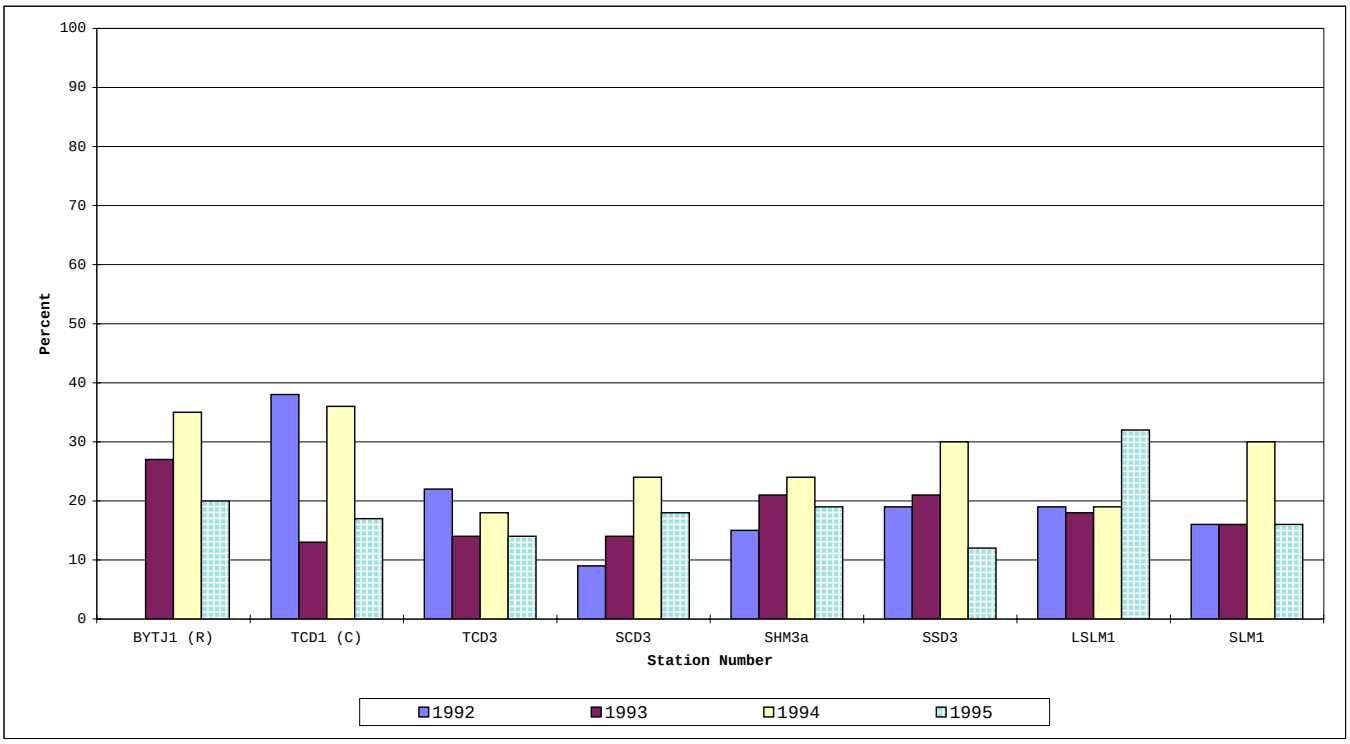

Fig.9. Percent of total organisms collected attributable to the dominant taxon from bioassessments completed (1992-1995) at Sand Mountain NPS stations and control (C) and ecoregional reference (R) sites.

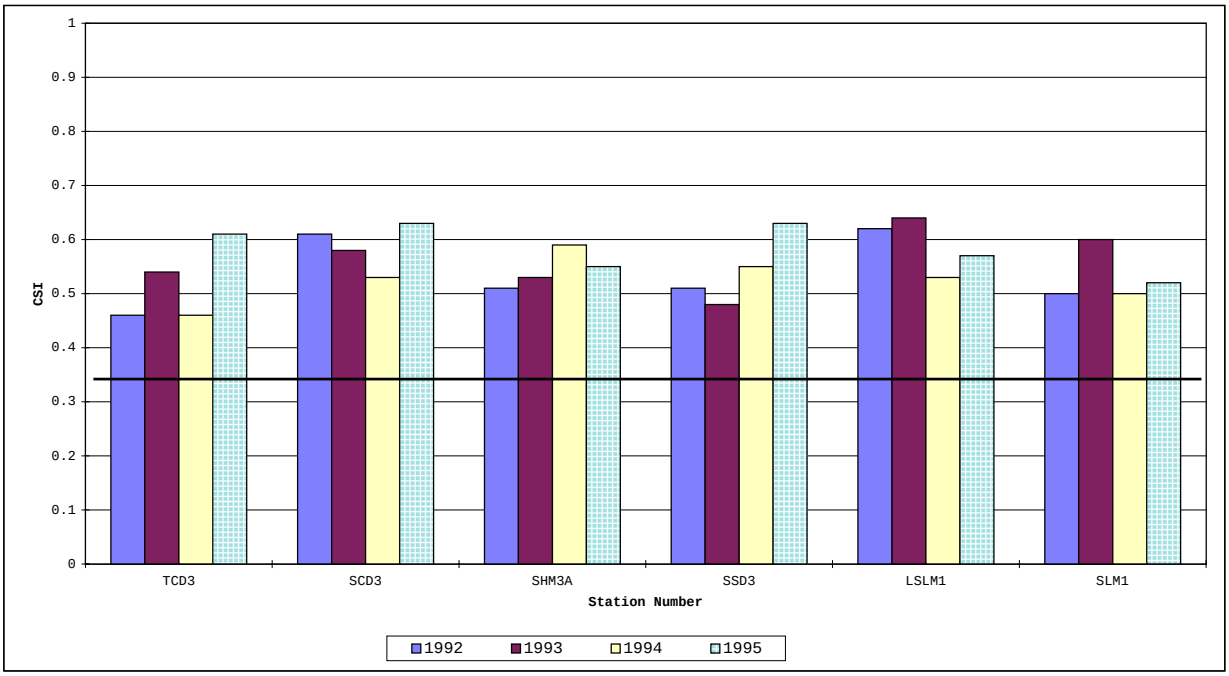

Fig. 10. Sorenson's Community similarity Index (CSI) utilizing the control station TCD1 from bioassessments completed (1992-1995) at Sand Mountain NPS stations and control (C) and ecoregional reference (R) sites. Values greater than 0.4 indicate similarity.

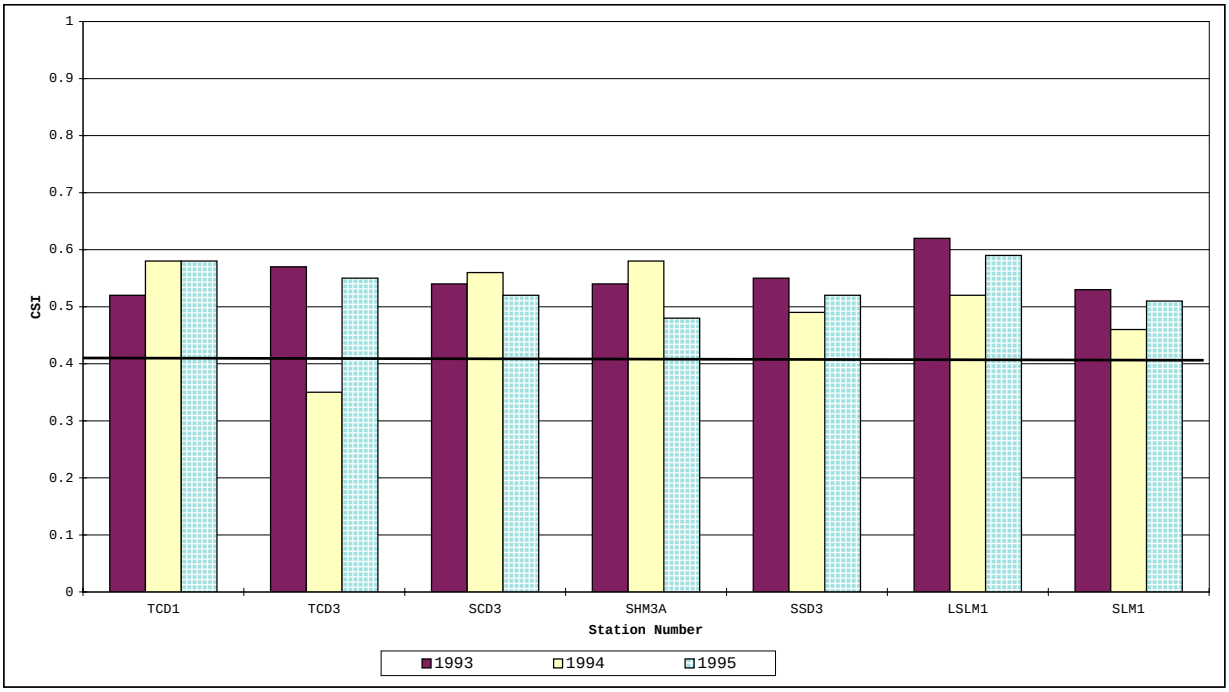

Fig. 11. Sorenson's Community similarity Index (CSI) utilizing the ecoregional reference station BYTJ1 from bioassessments completed (1993-1995) at Sand Mountain NPS stations and control (C) and ecoregional reference (R) sites. Values greater than 0.4 indicate similarity.

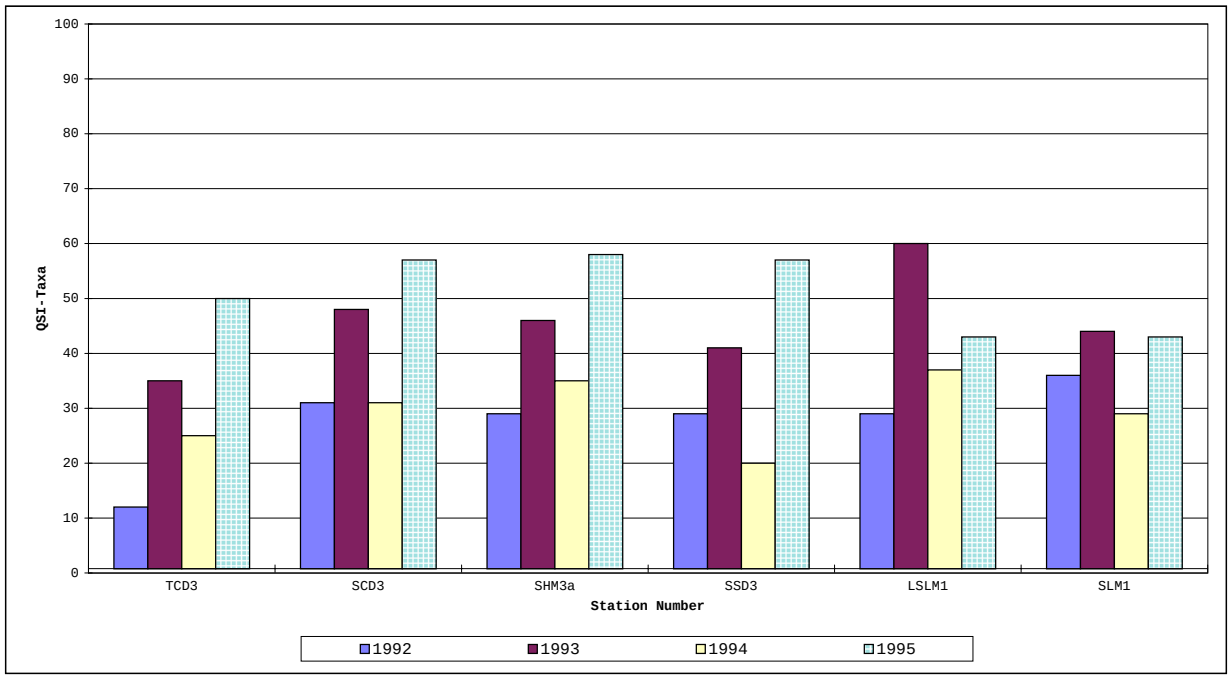

Fig. 12. Community Similarity Index for Taxa (QSI-Taxa) utilizing the control station TCD1 from bioassessments completed (1992-1995) at Sand Mountain NPS stations.

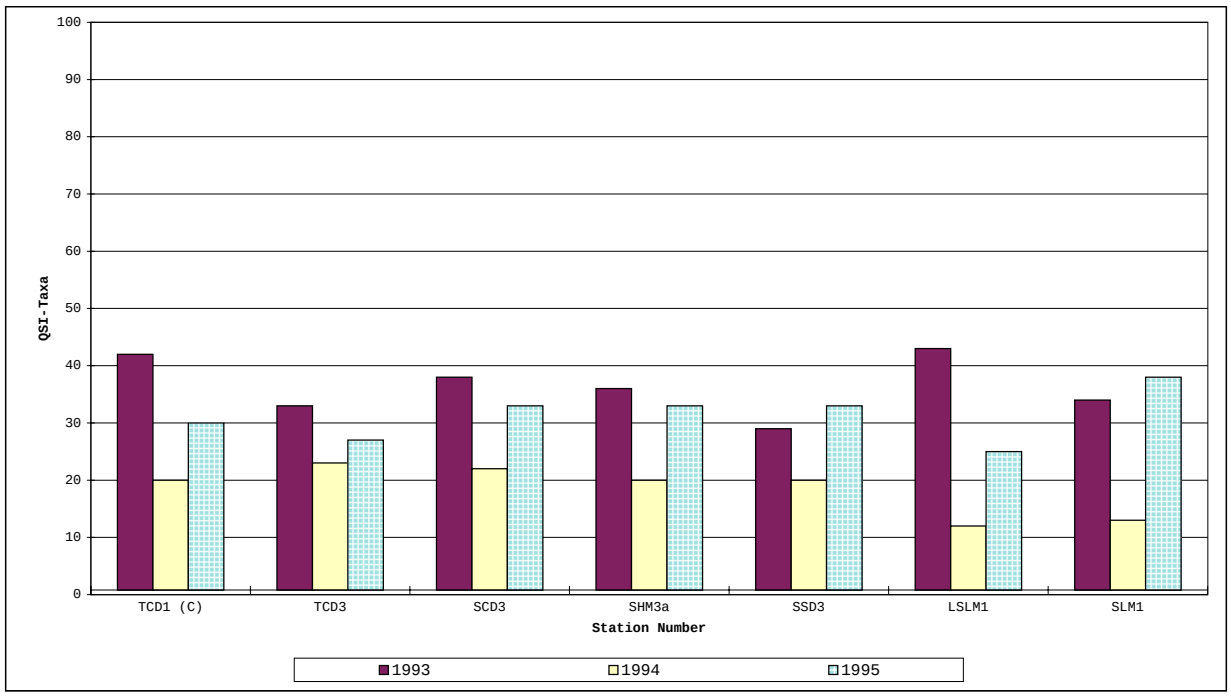

Fig. 13. Community Similarity Index for Taxa (QSI-Taxa) utilizing the ecoregional reference station BYTJ1 from bioassessments completed (1993-1995) at Sand Mountain NPS stations.

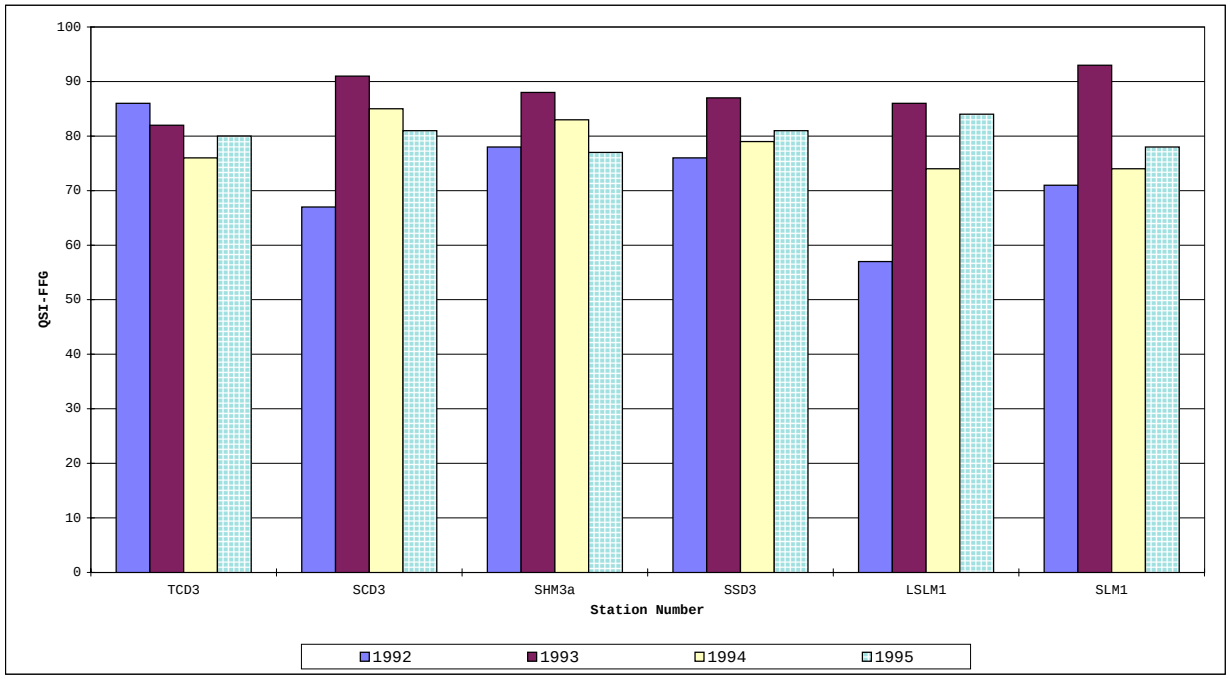

Fig. 14. Community Similarity Index for functional feeding groups (QSI-FFG) utilizing the control station TCD1 from bioassessments completed (1992-1995) at Sand Mountain NPS stations.

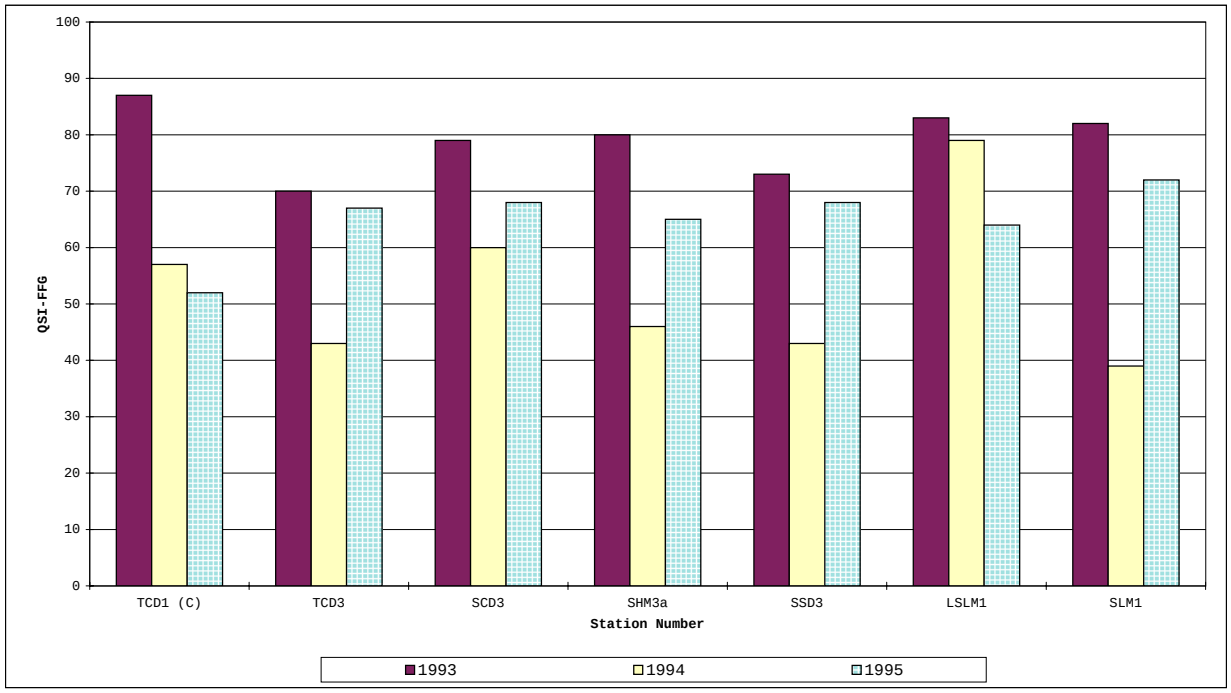

Fig. 15. Community Similarity Index for functional feeding groups (QSI-FFG) utilizing the ecoregional reference station BYTJ1 from bioassessments completed (1993-1995) at Sand Mountain NPS stations.

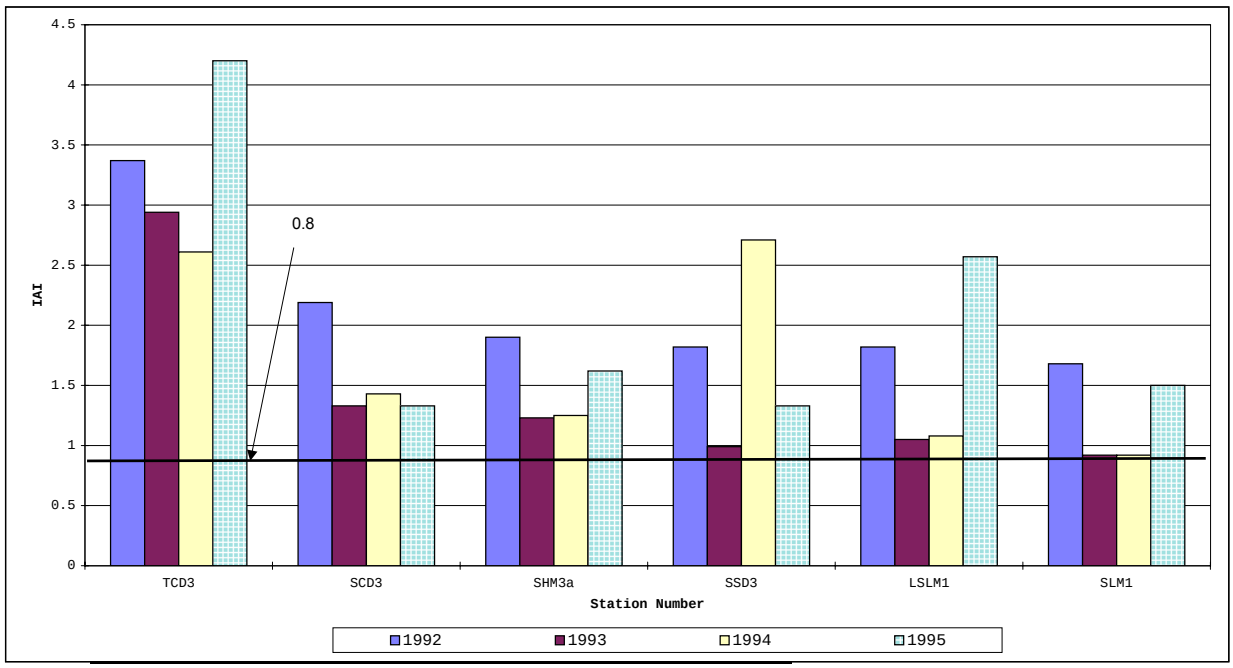

Fig. 16. Indicator Assemblage Index (IAI) utilizing the control station TCD1 from bioassessments completed (1992-1995) at Sand Mountain NPS stations. A value of 0.8 or greater indicates no impairment.

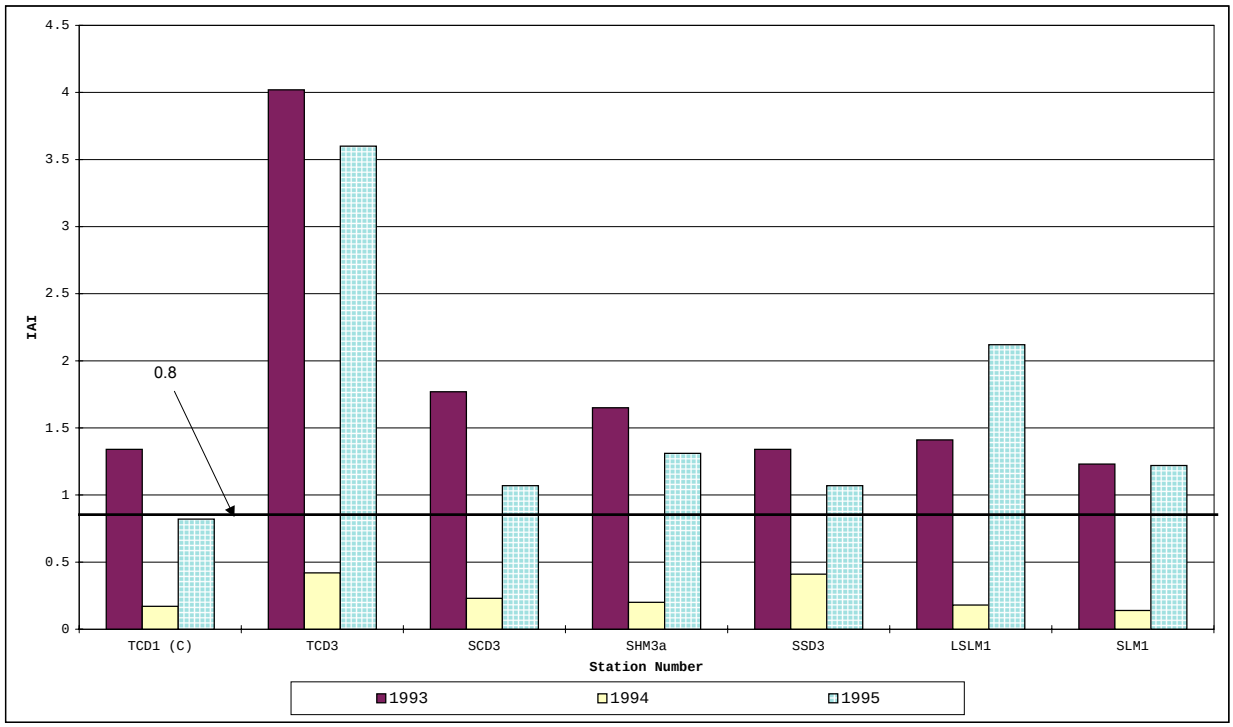

Fig. 17. Indicator Assemblage Index (IAI) utilizing the ecoregional reference station BYTJ1 from bioassessments completed (1993-1995) at Sand Mountain NPS stations. A value of 0.8 or greater indicates no impairment.

Table 1. Percent comparability of core habitat assessment parameters and substrate composition between ecoregional reference station (BYTJ1) and study stations in the Sand Mountain Watershed Project (1995).

	Habitat Assessment Categories			
Core Parameters	Excellent	Good	Fair	Poor
Bottom Substrate Available Cover	20-16	15-11	10-6	5-0
Stream Flow Category	20-16	15-11	10-6	5-0
Run/Bend Pool/Riffle Ratio	15-12	11-8	7-4	3-0
Bank Stability	10-9	8-6	5-3	2-0
Bank Vegetative Stability	10-9	8-6	5-3	2-0
Stream Side Cover	10-9	8-6	5-3	2-0
Core Parameter Total	**85-71**	**65-48**	**42-25**	**19-0**

	REFERENCE STATION	*STUDY STATIONS*						
	BYTJ1	LSLM1	SCD3	SHM3a	SLM1	SSD3	TCD1	TCD3
Habitat Assessment Total	113	103	104	90	103	102	98	112
Bottom substrate available cover	19	18.5	18	17.5	19	17	17	18.5
Stream Flow Category	16.5	7	16	15	6	13.5	16.5	18.5
Run/Bend Pool/Riffle Ratio	12.5	14.5	12	12	15	14	12	12.5
Bank stability	9	8.5	7.5	5.5	7.5	8.5	6	7.5
Bank vegetative stability	9	9	7.5	7.5	7.5	8.5	7	8.5
Streamside cover	8	8	8	8	8	8	8	8
Total of core parameters	74	66	69	66	63	70	67	74
PERCENT COMPARABILITY		**88**	**97**	**96**	**87**	**96**	**95**	**97**
% Substrate Composition	**BYTJ1**	LSLM1	SCD3	SHM3a	SLM1	SSD3	TCD1	TCD3
Bedrock	59	2	30	20	15	35	0	0
Boulder	10	40	30	30	40	20	30	35
Cobble	7	25	5	3	20	5	30	45
Gravel	10	15	7	2	9	15	5	3
Sand	5	5	20	30	5	15	12	10
Silt	5	10	4	10	8	7	20	5
Clay	1	0	0	0	0	0	0	0
Stick/Wood	2	2	2	2	2	2	2	1
CPOM	1	1	2	3	1	1	1	1
TOTAL	100	100	100	100	100	100	100	100
PERCENT COMPARABILITY		**42**	**64**	**48**	**54**	**73**	**35**	**32**
Water Chemistry Parameters	**BYTJ1**	LSLM1	SCD3	SHM3a	SLM1	SSD3	TCD1	TCD3
pH	6.9	6.9	7.1	7.0	8.1	7.4	6.5	7.2
Conductivity	58	72	77	79	77	161	54	74
D.O.	7.7	8.2	8.2	7.7	7.0	8.1	8.4	8.9
Turbidity	2.8	1.8	0.8	1.8	1.6	1.7	3.3	5.2
Water Temperature	18	20	20	19	20	21.5	16	22
Habitats Sampled*	**BYTJ1**	**LSLM1**	**SCD3**	**SHM3a**	**SLM1**	**SSD3**	**TCD1**	**TCD3**
Riffle	X	X	X	X	X	X	X	X
Rootbank	O	O	O	O	O	O	O	O
Rock/Log	X	X	X	X	X	X	X	X
CPOM	X	X	X	X	X	X	X	X
Sand	X	X	X	X	X	X	X	X
Macrophytes	-	-	O	-	-	O	-	O

Habitats Sampled* X=Sampled and used in taxa list and metrics calculations
0=Sampled but not included in taxa list and metrics calculations
(-) =habitat not present at site

Table 2. Percent comparability of core habitat assessment parameters and substrate composition between control station (TCD1) and study stations in the Sand Mountain Watershed Project (1995)

	Habitat Assessment Categories			
Parameters	Excellent	Good	Fair	Poor
Bottom Substrate Available Cover	20-16	15-11	10-6	5-0
Stream Flow Category	20-16	15-11	10-6	5-0
Run/Bend Pool/Riffle Ratio	15-12	11-8	7-4	3-0
Bank Stability	10-9	8-6	5-3	2-0
Bank Vegetative Stability	10-9	8-6	5-3	2-0
Stream Side Cover	10-9	8-6	5-3	2-0
Total	**85-71**	**65-48**	**42-25**	**19-0**

	CONTROL STATION	*STUDY STATIONS*					
	TCD1	LSLM1	SCD3	SHM3a	SLM1	SSD3	TCD3
Habitat Assessment Total	98	103	104	90	103	102	112
Bottom substrate available cover	17	18.5	18	17.5	19	17	18.5
Stream Flow Category	16.5	7	16	15	6	13.5	18.5
Run/Bend Pool/Riffle Ratio	12	14.5	12	12	15	14	12.5
Bank stability	6	8.5	7.5	5.5	7.5	8.5	7.5
Bank vegetative stability	7	9	7.5	7.5	7.5	8.5	8.5
Streamside cover	8	8	8	8	8	8	8
Total of Core Parameters	66.5	65.5	69	65.5	63	69.5	73.5
PERCENT COMPARABILITY		**86**	**97**	**97**	**85**	**93**	**97**
% Substrate Composition	**TCD1**	LSLM1	SCD3	SHM3a	SLM1	SSD3	TCD3
Bedrock	0	2	30	20	15	35	0
Boulder	30	40	30	30	40	20	35
Cobble	30	25	5	3	20	5	45
Gravel	5	15	7	2	9	15	3
Sand	12	5	20	30	5	15	10
Silt	20	10	4	10	8	7	5
Clay	0	0	0	0	0	0	0
Stick/Wood	2	2	2	2	2	2	1
CPOM	1	1	2	3	1	1	1
TOTAL	100	100	100	100	100	100	100
PERCENT COMPARABILITY		**78**	**59**	**60**	**71**	**52**	**80**
Water Chemistry Parameters	**TCD1**	LSLM1	SCD3	SHM3a	SLM1	SSD3	TCD3
pH	6.5	6.9	7.1	7	8.1	7.4	7.2
Conductivity	54	72	77	79	77	161	74
D.O.	8.4	8.2	8.2	7.7	7	8.1	8.9
Turbidity	3.3	1.8	0.8	1.8	1.6	1.7	5.2
Water Temperature	16	20	20	19	20	21.5	22
Habitats Sampled*	**TCD1**	LSLM1	SCD3	SHM3a	SLM1	SSD3	TCD3
Riffle	X	X	X	X	X	X	X
Rootbank	O	O	O	O	O	O	O
Rock/Log	X	X	X	X	X	X	X
CPOM	X	X	X	X	X	X	X
Sand	X	X	X	X	X	X	X
Macrophytes	-	-	O	-	-	O	O

Habitats Sampled* X=Sampled and used in taxa list and metrics calculations
0=Sampled but not included in taxa list and metrics calculations
(-) =habitat not present at site

Table 3. Field parameter data summary (1992 - 1995) for Sand Mountain Watershed Project study stations and ecoregional reference site (R) and control (C) stations.

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	+	+	+	+	+	+
(R)	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
	5/23/95	18	7.7	6.9	2.8	58	8.1
TCD1	6/17/92	18.5	8.6	6.7	4.5	57	29.3
(C)	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
	5/23/95	16	8.4	6.5	3.3	54	7.9
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
	5/22/95	22	8.9	7.2	5.2	74	28.5
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
	5/22/95	21.5	8.1	7.4	1.7	161	10.2
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
	5/22/95	20	8.2	7.1	0.8	77	5.2
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
	5/31/95	19	7.7	7.0	1.8	79	7.6
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
	5/22/95*	20/20	8.1/8.5	7.0/7.1	1.6/1.6	77/77	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
	5/22/95	20	8.2	6.9	1.8	72	1.3

+ no samples collected
* duplicate field parameters

Table 4. Summary of single station biometrics for Sand Mountain NPS Watershed Study: 1992 - 1995. (Ecoregional reference (R) and control (C))

Station	Sampling Year	Habitat Assessment	Total Taxa Richness	EPT Taxa Richness	Biotic Index	EPT/ (EPT+Chiro.)*	Percent Chiro.* Taxa	Scr /(Scr + Filt.Col) (Riffle only)	Shredders/ Total (CPOM only)	Percent Dominant taxa
BYTJ1	1992	----	----	----	----	----	----			----
(R)	1993	97	49	13	5.13	0.38	41	0.04	0.00	27
	1994	106	44	12	3.44	0.93	39	0.79	0.01	35
	1995	113	58	21	5.29	0.55	33	0.82	0.20	20
TCD1	1992	101	60	22	5.70	0.16	27	0.03	0.14	38
(C)	1993	110	58	24	4.36	0.52	29	0.15	0.32	13
	1994	93	53	18	6.05	0.20	34	0.35	0.22	36
	1995	98	55	17	5.40	0.43	38	0.03	0.26	17
TCD3	1992	111	45	12	4.88	0.69	16	0.04	0.13	22
	1993	112	57	18	3.96	0.89	35	0.37	0.16	14
	1994	111	42	15	4.83	0.63	29	0.23	0.37	18
	1995	113	54	26	4.56	0.91	22	0.08	0.05	14
SCD3	1992	99	77	22	5.33	0.56	27	0.33	0.03	9
	1993	109	66	24	4.73	0.67	30	0.15	0.49	14
	1994	91	49	12	5.46	0.34	39	0.29	0.18	24
	1995	104	50	15	5.40	0.58	34	0.12	0.40	18
SHM3a	1992	89	57	13	5.86	0.41	26	0.05	0.02	15
	1993	111	44	11	5.35	0.63	36	0.18	0.18	21
	1994	86	52	15	6.05	0.28	35	0.09	0.44	24
	1995	90	58	16	5.30	0.68	38	0.09	0.19	19
SSD3	1992	106	69	24	5.49	0.40	27	0.27	0.31	19
	1993	108	50	17	5.26	0.50	34	0.56	0.24	21
	1994	109	45	11	5.06	0.63	31	0.25	0.34	30
	1995	102	52	15	5.12	0.72	35	0.09	0.14	12
LSLM1	1992	107	63	16	5.35	0.43	33	0.24	0.02	19
	1993	106	54	15	4.45	0.54	35	0.04	0.12	18
	1994	100	48	12	5.88	0.22	35	0.14	0.05	19
	1995	103	58	21	4.26	0.84	34	0.07	0.04	32
SLM1	1992	117	60	17	5.11	0.34	32	0.17	0.16	16
	1993	109	49	16	4.98	0.48	29	0.15	0.17	16
	1994	100	56	15	5.71	0.17	34	0.07	0.47	30
	1995	103	56	15	4.89	0.64	34	0.19	0.28	16

*Chiro. = Chironomidae
Filt. Col = Filtering Collector
Scr. = Scraper
Note: metrics based upon the common habitats of Riffle, Rock/log, Sand and CPOM.

Table 5. Summary of comparison biometrics utilizing the ecoregional reference station BYTJ1 for the Sand Mountain NPS Watershed Project (1993 -1995).

Station	Sampling Year	Indicator Assemblage Index	Sorenson's CSI	Community Loss Index	QSI-Taxa	QSI-FFG
TCD1	1993	1.34	0.52	0.63	42	87
	1994	0.17	0.58	0.30	20	57
	1995	0.82	0.58	0.45	30	52
TCD3	1993	4.02	0.57	0.61	33	70
	1994	0.42	0.35	0.69	23	43
	1995	3.60	0.55	0.50	27	67
SCD3	1993	1.77	0.54	0.50	38	79
	1994	0.23	0.56	0.36	22	60
	1995	1.07	0.52	0.60	33	68
SHM3a	1993	1.65	0.54	0.97	36	80
	1994	0.20	0.58	0.30	20	46
	1995	1.31	0.48	0.51	33	65
SSD3	1993	1.34	0.55	0.75	29	73
	1994	0.41	0.49	0.48	20	43
	1995	1.07	0.52	0.61	33	68
LSLM1	1993	1.41	0.62	0.61	43	83
	1994	0.18	0.52	0.41	12	79
	1995	2.12	0.59	0.41	25	64
SLM1	1993	1.23	0.53	0.83	34	82
	1994	0.14	0.46	0.37	13	39
	1995	1.22	0.51	0.51	38	72

Table 6. Summary of comparison biometrics utilizing the control station TCD1 for the Sand Mountain NPS Watershed Project (1992 -1995).

Station	Sampling Year	I.A.I.	Sorenson's CSI	Community Loss Index	QSI-Taxa	QSI-FFG
TCD3	1992	3.37	0.46	0.90	12	86
	1993	2.94	0.54	0.47	35	82
	1994	2.61	0.46	0.73	25	76
	1995	4.20	0.61	0.40	50	80
SCD3	1992	2.19	0.61	0.27	31	67
	1993	1.33	0.58	0.33	48	91
	1994	1.43	0.53	0.53	31	85
	1995	1.33	0.63	0.44	57	81
SHM3a	1992	1.90	0.51	0.60	29	78
	1993	1.23	0.53	0.70	46	88
	1994	1.25	0.59	0.42	35	83
	1995	1.62	0.55	0.41	58	77
SSD3	1992	1.82	0.51	0.38	29	76
	1993	0.99	0.48	0.65	41	87
	1994	2.71	0.55	0.57	20	79
	1995	1.33	0.63	0.42	57	81
LSLM1	1992	1.82	0.62	0.42	29	57
	1993	1.05	0.64	0.40	60	86
	1994	1.08	0.53	0.54	37	74
	1995	2.57	0.57	0.39	43	84
SLM1	1992	1.68	0.50	0.49	36	71
	1993	0.92	0.60	0.53	44	93
	1994	0.92	0.50	0.46	29	74
	1995	1.50	0.52	0.46	43	78

Table 7. Generalized interpretation of commonly used biometrics for macroinvertebrate bioassessments.

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 backgroun station for similar stream siz 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

Table 8. Functional feeding group composition for each year and comparison between years (QSI-FFG) at Sand Mountain Watershed Project stations.

SHM3a	*Percent Contribution of Feeding Type*									
	Year									
FEEDING TYPE	1992	1993	1994	1995	92 *vs* 93	92 *vs* 94	92 *vs* 95	93 *vs* 94	93 *vs* 95	94 *vs* 95
SCRAPER	18	8	7	4	8	7	4	7	4	4
SHREDDER	4	18	19	11	4	4	4	18	11	11
F/C	40	42	38	42	40	38	40	38	42	38
C/G	24	21	19	31	21	19	24	19	21	19
PRED	11	8	16	10	8	11	10	8	8	10
M/P	0	0	0	1	0	0	0	0	0	0
OTHERS	2	3	1	2	2	1	2	1	2	1
QSI-FFG					**84**	**80**	**84**	**91**	**88**	**82**

SLM1	*Percent Contribution of Feeding Type*									
	Year									
FEEDING TYPE	1992	1993	1994	1995	92 *vs* 93	92 *vs* 94	92 *vs* 95	93 *vs* 94	93 *vs* 95	94 *vs* 95
SCRAPER	11	6	3	11	6	3	11	3	6	3
SHREDDER	11	19	32	11	11	11	11	19	11	11
F/C	30	39	32	42	30	30	30	32	39	32
C/G	31	25	23	25	25	23	25	23	25	23
PRED	16	10	9	10	10	9	10	9	10	9
M/P	1	0	0	0	0	0	0	0	0	0
OTHERS	1	2	0	0	1	0	0	0	0	0
QSI-FFG					**82**	**76**	**87**	**87**	**91**	**79**

LSLM1	*Percent Contribution of Feeding Type*									
	Year									
FEEDING TYPE	1992	1993	1994	1995	92 *vs* 93	92 *vs* 94	92 *vs* 95	93 *vs* 94	93 *vs* 95	94 *vs* 95
SCRAPER	16	2	4	5	2	4	5	2	2	4
SHREDDER	6	19	4	6	6	4	6	4	6	4
F/C	36	38	20	56	36	20	36	20	38	20
C/G	18	31	54	25	18	18	18	31	25	25
PRED	17	6	18	7	6	17	7	6	6	7
M/P	0	3	0	0	0	0	0	0	0	0
OTHERS	8	1	0	1	1	0	1	0	1	0
QSI-FFG					**68**	**63**	**73**	**64**	**78**	**60**

SSD3	*Percent Contribution of Feeding Type*									
	Year									
FEEDING TYPE	1992	1993	1994	1995	92 *vs* 93	92 *vs* 94	92 *vs* 95	93 *vs* 94	93 *vs* 95	94 *vs* 95
SCRAPER	8	16	15	5	8	8	5	15	5	5
SHREDDER	21	17	15	8	17	15	8	15	8	8
F/C	41	36	41	41	36	41	41	36	36	41
C/G	18	20	17	31	18	17	18	17	20	17
PRED	9	8	12	12	8	9	9	8	8	12
M/P	1	0	0	0	0	0	0	0	0	0
OTHERS	3	3	0	3	3	0	3	0	3	0
QSI-FFG					**89**	**90**	**83**	**91**	**80**	**83**

Table 8, cont.

SCD3	*Percent Contribution of Feeding Type*									
	Year									
FEEDING TYPE	1992	1993	1994	1995	92 *vs* 93	92 *vs* 94	92 *vs* 95	93 *vs* 94	93 *vs* 95	94 *vs* 95
SCRAPER	19	10	13	9	10	13	9	10	9	9
SHREDDER	5	19	12	18	5	5	5	12	18	12
F/C	36	36	30	38	36	30	36	30	36	30
C/G	17	21	29	26	17	17	17	21	21	26
PRED	12	12	16	7	12	12	7	12	7	7
M/P	0	0	0	0	0	0	0	0	0	0
OTHERS	11	2	1	1	2	1	1	1	1	1
QSI-FFG					**83**	**78**	**76**	**85**	**93**	**85**

TCD3	*Percent Contribution of Feeding Type*									
	Year									
FEEDING TYPE	1992	1993	1994	1995	92 *vs* 93	92 *vs* 94	92 *vs* 95	93 *vs* 94	93 *vs* 95	94 *vs* 95
SCRAPER	5	20	15	8	5	5	5	15	8	8
SHREDDER	6	13	19	2	6	6	2	13	2	2
F/C	49	31	38	53	31	38	49	31	31	38
C/G	25	21	15	25	21	15	25	15	21	15
PRED	9	9	13	10	9	9	9	9	9	10
M/P	0	0	0	1	0	0	0	0	0	0
OTHERS	6	6	1	1	6	1	1	1	1	1
QSI-FFG					**77**	**73**	**92**	**84**	**72**	**73**

TCD1 (C)	*Percent Contribution of Feeding Type*									
	Year									
FEEDING TYPE	1992	1993	1994	1995	92 *vs* 93	92 *vs* 94	92 *vs* 95	93 *vs* 94	93 *vs* 95	94 *vs* 95
SCRAPER	3	6	4	4	3	3	3	4	4	4
SHREDDER	4	15	7	22	4	4	4	7	15	7
F/C	62	36	39	53	36	39	53	36	36	39
C/G	18	28	30	16	18	18	16	28	16	16
PRED	12	15	19	5	12	12	5	15	5	5
M/P	0	0	0	0	0	0	0	0	0	0
OTHERS	1	0	1	0	0	1	0	0	0	0
QSI-FFG					**73**	**77**	**81**	**89**	**76**	**70**

BYTJ1 (R)	*Percent Contribution of Feeding Type*									
	Year									
FEEDING TYPE	1992*	1993	1994	1995	92 *vs* 93	92 *vs* 94	92 *vs* 95	93 *vs* 94	93 *vs* 95	94 *vs* 95
SCRAPER	-----	2	10	30	-----	-----	-----	2	2	10
SHREDDER	-----	6	1	4	-----	-----	-----	1	4	1
F/C	-----	46	3	23	-----	-----	-----	3	23	3
C/G	-----	30	57	24	-----	-----	-----	30	24	24
PRED	-----	15	28	19	-----	-----	-----	15	15	19
M/P	-----	0	0	0	-----	-----	-----	0	0	0
OTHERS	-----	1	2	1	-----	-----	-----	1	1	1
QSI-FFG								**52**	**68**	**58**

* No collection in 1992

Table 9. Biological Condition Scoring Critera (BCSC) and interpretation.

Metric		Score			
		6	4	2	1
Taxa Richness	(a)	>80%	60-80%	40-60%	<40%
Biotic Index	(b)	>85%	70-85%	50-70%	<50%
Scr/(Scr+F/C)	(a,c)	>50%	35-50%	20-35%	<20%
EPT/(EPT+Chiro.)	(a)	>75%	50-75%	25-50%	<25%
% Contr. Dom. Taxa	(d)	<20%	20-30%	30-40%	>40%
EPT Index	(a)	>90%	80-90%	70-80%	<70%
Community Loss Index	(e)	<0.5	0.5-1.5	1.5-4.0	>4.0
Shredders/Total	(a,c)	>50%	35-50%	20-35%	<20%

*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) Determination of F. G. is independent of taxonomic grouping

(d) Scoring criteria evaluate actual % contribution, not % comparability to the reference station.

(e) Range of values obtained. A comparison to the reference station is incorporated in these indices

BIOASSESSMENT		
% Comparison to Reference Score	**Biological Condition Category**	**Attributes**
>81%	**Non-impaired**	Comparable to best situation within ecoregion. Balanced trophic structure Optimum community structure for stream size and habitat
81-52%	**Slightly impaired**	Community structure less than expected Composition lower than expected due to loss of intolerant taxa % contribution of tolerant forms increases
51-19%	**Moderately impaired**	Fewer taxa due to loss of most intolerant forms Reduction in EPT index
<19%	**Severely impaired**	Few taxa present

Table 10. Biological Condition Scoring (BCSC) for 1995 Sand Mountain bioassessment stations utilizing either control station TCD1 or ecoregional reference station BYTJ1.

Metric	Study Station **SCD3**	Control Station **TCD-1**	Study Station Value	Study Station Score	Control Station Value	Control Station Score
Taxa Richness	50	55	91	6	100	6
Biotic Index	5.40	5.4	100	6	100	6
Scr/(Scr+F/C)	0.12	0.03	400	6	100	6
EPT/(EPT+Chiro.)	0.58	0.43	135	6	100	6
% Contr. Dom. Taxa	18	17	18	6	17	6
EPT Index	15	17	88	4	100	6
Community Loss Index	0.44		0.4	6	100	6
Shredders/Total	0.40	0.26	154	6	100	6
				46		48
	SCD3	**Nonimpaired**		S.S./R.S x100 =		**96**

Metric	Study Station **TCD3**	Control Station **TCD-1**	Study Station Value	Study Station Score	Control Station Value	Control Station Score
Taxa Richness	54	55	98	6	100	6
Biotic Index	4.56	5.4	118	6	100	6
Scr/(Scr+F/C)	0.08	0.03	267	6	100	6
EPT/(EPT+Chiro.)	0.91	0.43	212	6	100	6
% Contr. Dom. Taxa	14	17	14	6	17	6
EPT Index	26	17	153	6	100	6
Community Loss Index	0.40		0.4	6	100	6
Shredders/Total	0.05	0.26	19	1	100	6
				43		48
	TCD3	**Nonimpaired**		S.S./R.S x100 =		**90**

Metric	Study Station **LSLM1**	Control Station **TCD-1**	Study Station Value	Study Station Score	Control Station Value	Control Station Score
Taxa Richness	58	55	105	6	100	6
Biotic Index	4.26	5.4	127	6	100	6
Scr/(Scr+F/C)	0.07	0.03	233	6	100	6
EPT/(EPT+Chiro.)	0.84	0.43	195	6	100	6
% Contr. Dom. Taxa	32	17	32	2	17	6
EPT Index	21	17	124	6	100	6
Community Loss Index	0.39		0.4	6	100	6
Shredders/Total	0.04	0.26	15	1	100	6
				39		48
	LSLM1	**Nonimpaired**		S.S./R.S x100 =		**81**

Metric	Study Station **SLM1**	Control Station **TCD-1**	Study Station Value	Study Station Score	Control Station Value	Control Station Score
Taxa Richness	56	55	102	6	100	6
Biotic Index	4.89	5.4	110	6	100	6
Scr/(Scr+F/C)	0.19	0.03	633	6	100	6
EPT/(EPT+Chiro.)	0.64	0.43	149	6	100	6
% Contr. Dom. Taxa	16	17	16	6	17	6
EPT Index	15	17	88	4	100	6
Community Loss Index	0.46		0.5	6	100	6
Shredders/Total	0.28	0.26	108	6	100	6
				46		48
	SLM1	**Nonimpaired**		S.S./R.S x100 =		**96**

Metric	Study Station **SSD3**	Control Station **TCD-1**	Study Station Value	Study Station Score	Control Station Value	Control Station Score
Taxa Richness	52	55	95	6	100	6
Biotic Index	5.12	5.4	105	6	100	6
Scr/(Scr+F/C)	0.09	0.03	300	6	100	6
EPT/(EPT+Chiro.)	0.72	0.43	167	6	100	6
% Contr. Dom. Taxa	12	17	12	6	17	6
EPT Index	15	17	88	4	100	6
Community Loss Index	0.42		0.4	6	100	6
Shredders/Total	0.14	0.26	54	6	100	6
				46		48
	SSD3	**Nonimpaired**		S.S./R.S x100 =		**96**

Metric	Study Station **SHM3a**	Control Station **TCD-1**	Study Station Value	Study Station Score	Control Station Value	Control Station Score
Taxa Richness	58	55	105	6	100	6
Biotic Index	5.30	5.4	102	6	100	6
Scr/(Scr+F/C)	0.09	0.03	300	6	100	6
EPT/(EPT+Chiro.)	0.68	0.43	158	6	100	6
% Contr. Dom. Taxa	19	17	19	6	17	6
EPT Index	16	17	94	6	100	6
Community Loss Index	0.41		0.4	6	100	6
Shredders/Total	0.19	0.26	73	6	100	6
				48		48
	SHM3a	**Nonimpaired**		S.S./R.S x100 =		**100**

Table 10, cont. Biological Condition Scoring (BCSC*) for 1995 Sand Mountain bioassessmentstations utilizing either control station TCD1 or ecoregional reference station BYTJ1.

Metric	Study Station SHM3a	Reference Station BYTJ1	Study Station Value	Study Station Score	Reference Station Value	Reference Station Score
Taxa Richness	58	58	100	6	100	6
Biotic Index	5.30	5.29	100	6	100	6
Scr/(Scr+F/C)	0.09	0.82	11	1	100	6
EPT/(EPT+Chiro.)	0.68	0.55	124	6	100	6
% Contr. Dom. Taxa	19	20	19	6	20	4
EPT Index	16	21	76	2	100	6
Community Loss Index	0.51		0.5	4	100	6
Shredders/Total	0.19	0.2	95	6	100	6
				37		46
	SHM3a	**Slightly impaired**		S.S./R.S x100 =		**80**

Metric	Study Station SSD3	Reference Station BYTJ1	Study Station Value	Study Station Score	Reference Station Value	Reference Station Score
Taxa Richness	52	58	90	6	100	6
Biotic Index	5.12	5.29	103	6	100	6
Scr/(Scr+F/C)	0.09	0.82	11	1	100	6
EPT/(EPT+Chiro.)	0.72	0.55	131	6	100	6
% Contr. Dom. Taxa	12	20	12	6	20	4
EPT Index	15	21	71	2	100	6
Community Loss Index	0.61		0.6	4	100	6
Shredders/Total	0.14	0.2	70	6	100	6
				37		46
	SSD3	**Slightly impaired**		S.S./R.S x100 =		**80**

Metric	Study Station SLM1	Reference Station BYTJ1	Study Station Value	Study Station Score	Reference Station Value	Reference Station Score
Taxa Richness	56	58	97	6	100	6
Biotic Index	4.89	5.29	108	6	100	6
Scr/(Scr+F/C)	0.19	0.82	23	2	100	6
EPT/(EPT+Chiro.)	0.64	0.55	116	6	100	6
% Contr. Dom. Taxa	16	20	16	6	20	4
EPT Index	15	21	71	2	100	6
Community Loss Index	0.51		0.5	4	100	6
Shredders/Total	0.28	0.2	140	6	100	6
				38		46
	SLM1	**Nonimpaired**		S.S./R.S x100 =		**83**

Metric	Study Station LSLM1	Reference Station BYTJ1	Study Station Value	Study Station Score	Reference Station Value	Reference Station Score
Taxa Richness	58	58	100	6	100	6
Biotic Index	4.26	5.29	124	6	100	6
Scr/(Scr+F/C)	0.07	0.82	9	1	100	6
EPT/(EPT+Chiro.)	0.84	0.55	153	6	100	6
% Contr. Dom. Taxa	32	20	32	2	20	4
EPT Index	21	21	100	6	100	6
Community Loss Index	0.41		0.4	6	100	6
Shredders/Total	0.04	0.2	20	2	100	6
				35		46
	LSLM1	**Slightly impaired**		S.S./R.S x100 =		**76**

Metric	Study Station TCD3	Reference Station BYTJ1	Study Station Value	Study Station Score	Reference Station Value	Reference Station Score
Taxa Richness	54	58	93	6	100	6
Biotic Index	4.56	5.29	116	6	100	6
Scr/(Scr+F/C)	0.08	0.82	10	1	100	6
EPT/(EPT+Chiro.)	0.91	0.55	165	6	100	6
% Contr. Dom. Taxa	14	20	14	6	20	4
EPT Index	26	21	124	6	100	6
Community Loss Index	0.50		0.5	4	100	6
Shredders/Total	0.05	0.2	25	2	100	6
				37		46
	TCD3	**Slightly impaired**		S.S./R.S x100 =		**80**

Metric	Study Station SCD3	Reference Station BYTJ1	Study Station Value	Study Station Score	Reference Station Value	Reference Station Score
Taxa Richness	50	58	86	6	100	6
Biotic Index	5.40	5.29	98	6	100	6
Scr/(Scr+F/C)	0.12	0.82	15	1	100	6
EPT/(EPT+Chiro.)	0.58	0.55	105	6	100	6
% Contr. Dom. Taxa	18	20	18	6	20	4
EPT Index	15	21	71	2	100	6
Community Loss Index	0.60		0.6	4	100	6
Shredders/Total	0.40	0.2	200	6	100	6
				37		46
	SCD3	**Slightly impaired**		S.S./R.S x100 =		**80**

Metric	Study Station TCD-1	Reference Station BYTJ1	Study Station Value	Study Station Score	Reference Station Value	Reference Station Score
Taxa Richness	55	58	95	6	100	6
Biotic Index	5.4	5.29	98	6	100	6
Scr/(Scr+F/C)	0.03	0.82	4	1	100	6
EPT/(EPT+Chiro.)	0.43	0.55	78	6	100	6
% Contr. Dom. Taxa	17	20	17	6	20	4
EPT Index	17	21	81	4	100	6
Community Loss Index	0.45		0.5	6	100	6
Shredders/Total	0.26	0.2	130	6	100	6
				41		46
	TCD-1	**Nonimpaired**		S.S./R.S x100 =		**89**

Table 11. Biological Scoring Condition Category based on comparison to either control station (TCD1) or reference station (BYTJ1) for 1992 to 1995.

Station	Year	Compared to			
		Control (c)		Reference	
		Score	Category	Score	Category
TCD1 (c)	1993	------	------	100	Non-Impaired
TCD1 (c)	1994	------	------	75	**Slightly Impaired**
TCD1 (c)	1995	------	------	89	Non-Impaired
TCD3	1992	84	Non-Impaired	------	------
TCD3	1993	88	Non-Impaired	100	Non-Impaired
TCD3	1994	95	Non-Impaired	86	Non-Impaired
TCD3	1995	90	Non-Impaired	80	**Borderline Slightly Impaired**
SCD3	1992	100	Non-Impaired	------	------
SCD3	1993	100	Non-Impaired	100	Non-Impaired
SCD3	1994	89	Non-Impaired	82	Non-Impaired
SCD3	1995	96	Non-Impaired	80	**Borderline Slightly Impaired**
SHM3a	1992	82	Non-Impaired	------	------
SHM3a	1993	73	**Slightly Impaired**	91	Non-Impaired
SHM3a	1994	91	Non-Impaired	75	**Slightly Impaired**
SHM3a	1995	100	Non-Impaired	80	**Borderline Slightly Impaired**
SSD3	1992	100	Non-Impaired	------	------
SSD3	1993	79	**Slightly Impaired**	96	Non-Impaired
SSD3	1994	82	Non-Impaired	82	Non-Impaired
SSD3	1995	96	Non-Impaired	80	**Borderline Slightly Impaired**
LSLM1	1992	89	Non-Impaired	------	------
LSLM1	1993	77	**Slightly Impaired**	100	Non-Impaired
LSLM1	1994	80	**Borderline Slightly Impaired**	77	**Slightly Impaired**
LSLM1	1995	81	Non-Impaired	76	**Slightly Impaired**
SLM1	1992	100	Non-Impaired	------	------
SLM1	1993	85	Non-Impaired	100	Non-Impaired
SLM1	1994	91	Non-Impaired	73	**Slightly Impaired**
SLM1	1995	96	Non-Impaired	83	Non-Impaired

Table 12. Taxa list for Sand Mountain Bioassessment stations (1992 - 1995).

MACROINVERTEBRATE	BYTJ 1 95-05-23	TCD 1 95-05-23	TCD 3 95-05-22	SCD 3 95-05-22	SHM 3 a 95-05-22	SSD 3 95-05-22	LSLM 1 95-05-22	SLM 1 95-05-22
ANNELIDA								
OLIGOCHAETA	11	3	13	49	90	45	8	4
ARTHROPODA								
CRUSTACEA								
DECAPODA	2		12		6			
INSECTA								
COLEOPTERA								
Dryopidae								
Helichus	15							
Elmidae								
Ancyronyx	1	9	3	25	47	15	18	
Dubiraphia	17	15	4		4	1	6	1
Macronychus		2	65	63	2	139		
Microcylloepus		1	31		24	6		
Optioservus					12			
Oulimnius		24						
Promoresia	1	132	26	48			75	
Stenelmis					12		12	6
Hydrophilidae								
Sperchopsis				2			19	
Hydrophilidae undet. dif						1		
Psephenidae								
Psephenus								6
Staphylinidae								
Staphylinidae undet. dif								2
COLEOPTERA undet. dif						6		
DIPTERA								
Ceratopogonidae								
Atrichopogon						1		
Bezzia	2	4				1		3
Chironomidae								
Chironominae								
Chironomini								
Chironomus				4		13		
Cryptochironomus		18	2	8	16	4	21	4
Cryptotendipes							4	7
Demicryptochironomus		4						
Dicrotendipes					11			

Table 12. Taxa list for Sand Mountain Bioassessment stations (1992 - 1995).

MACROINVERTEBRATE	BYTJ 1 95-05-23	TCD 1 95-05-23	TCD 3 95-05-22	SCD 3 95-05-22	SHM 3 a 95-05-22	SSD 3 95-05-22	LSLM 1 95-05-22	SLM 1 95-05-22
Microtendipes	10	12				6		15
Nilothauma				4			2	
Omnisus	19							
Paracladopelma					1	4		
Paratendipes						4		4
Phaenopsectra		137		50	2		3	
Polypedilum	45	809	14	616	575	131	55	121
Saetheria					2			
Stenochironomus					11			
Stictochironomus						9	10	
Tribelos	13	37				34	1	11
Chironomini undet.		6	1		1	1	1	3
Tanytarsini								
Cladotanytarsus	10				2		14	
Rheotanytarsus	60	366	67	194	326	73	30	33
Tanytarsus	124	97		40	54	39	22	48
Stempellinella								6
Tanytarsini undet.					12		2	
Orthocladinae								
Brillia		202	3	14	24	11	18	5
Cardiocladius		24						
Corynoneura					12	15		2
Cricotopus		27						
Cricotopus/Orthocladius	4	24	12	21	47			1
Eukiefferiella		24						
Nanocladius		3	1	4				
Parakiefferiella								4
Parametriocnemus	3	24		26	36	15	17	25
Rheocricotopus	24	90	8	62	225	82	1	8
Rheosmittia					39			
Symposiocladius	3						1	1
Synorthocladius	18			27	19		3	1
Thienemanniella	15	42	4	44	55			
Tvetnia	12	84	2	14		17	3	
Xylotopus					11			1
Orthocladinae undet. dif							13	
Orthocladinae undet.		6		14				
Tanypodinae								

Table 12. Taxa list for Sand Mountain Bioassessment stations (1992 - 1995).

MACROINVERTEBRATE	BYTJ 1 95-05-23	TCD 1 95-05-23	TCD 3 95-05-22	SCD 3 95-05-22	SHM 3 a 95-05-22	SSD 3 95-05-22	LSLM 1 95-05-22	SLM 1 95-05-22
Ablabesmyia	37	16	1	4		4	3	
Labrundinia	8		2					
Natarsia	18	14			12			
Nilotanypus					11			
Procladius	78					4	4	
Thienemannimyia Grp	30	48	3	27	103	5	21	32
Tanypodinae undet.		12						
Chironomidae undet.								1
Empididae								
Hemerdromia			7	23	107		1	1
Simulidae	57	822	273	50	408	41	1	59
Tipulidae								
Antocha				23	23			20
Pilaria						11		
Tipula	1	2		2	12	19	6	
EPHEMEROPTERA								
Baetidae								
Acentrella		40	144	31	67	97	24	2
Acerpenna	50		36				12	2
Baetis	47	70	62	487	804	174	114	184
Cloeon	2		2					
Heterocloeon			25			15	6	
Paracloeodes			26				7	2
Pseudocloeon			36	1		5		
Baetidae undet.	67	2	49	15	410	11	2	
Ephemerellidae								
Attenella	9				4			
Danella		5		2	1			
Drunella		1	1		4			
Ephemerella	2	84		3			72	6
Eurylophella	6	12	2			5		
Serratella			1					
Ephemerellidae undet.		36	1				7	
Ephemeridae								
Hexagenia	1						2	
Heptageniidae								
Epeorus						10		
Heptagenia	18	15	14	1				

Table 12. Taxa list for Sand Mountain Bioassessment stations (1992 - 1995).

MACROINVERTEBRATE	BYTJ 1 95-05-23	TCD 1 95-05-23	TCD 3 95-05-22	SCD 3 95-05-22	SHM 3 a 95-05-22	SSD 3 95-05-22	LSLM 1 95-05-22	SLM 1 95-05-22
Stenacron	67		2				6	
Stenonema	276	31	73	182	189	46	48	72
Heptageniidae undet.	9	12	10	12			3	1
Leptophlebiidae								
Habrophlebiodes							1	
Paraleptophlebia	6							
Oligoneuridae								
Isonychia	6	12	28	24			6	
Tricorythidae								
Tricorythodes			11					
HEMIPTERA								
Gerridae								
Trepobates						3	1	6
Veliidae								
Microvelia							6	
Rhagovelia	1				12		18	27
LEPIDOPTERA								
LEPIDOPTERA undet.					2			
MEGALOPTERA								
Corydalidae								
Corydalus			3			6		
Nigronia	24			41	12		1	14
Sialidae								
Sialis		1						
ODONATA								
Aeshnidae								
Boyeria	23	13	8	1	14	2	4	14
Calopterygidae								
Calopteryx							1	1
Hetaerina			24		28			
Coenagrionidae								
Argia				1				1
Chromagrion								1
Coenagrionidae undet.					12			
Cordulegastridae								
Cordulegaster	2							
Gomphidae								
Dromogomphus	11	3						4

Table 12. Taxa list for Sand Mountain Bioassessment stations (1992 - 1995).

MACROINVERTEBRATE	BYTJ 1 95-05-23	TCD 1 95-05-23	TCD 3 95-05-22	SCD 3 95-05-22	SHM 3 a 95-05-22	SSD 3 95-05-22	LSLM 1 95-05-22	SLM 1 95-05-22
Hagenius			3					
Gomphus				1	14	7		
Stylurus				1	1			
Gomphidae undet.			4	1			1	
Macromiidae								
Didymops	1							
Macromia		1		1				3
PLECOPTERA								
Nemouridae								
Amphinemura			1			6	18	
Perlidae								
Perlesta	14	19	128	136	211	188	17	2
Perlodidae								
Isoperla	4	49	2		12	10	21	
TRICHOPTERA								
Brachycentridae								
Brachycentrus				12	26			
Micrasema	1		12		12			
Glossosomatidae								
Glossosoma		12				18	8	3
Hydropsychidae								
Ceratopsyche	2	67	81			11	31	121
Cheumatopsyche	7	210	134	243	477	242	22	5
Hydropsyche	32	838	275	468	1116	255	550	118
Hydropsychidae undet.	9	78	28			46	159	20
Hydroptilidae								
Hydroptila			12	2	43			
Hydroptilidae undet. dif							3	2
Leptoceridae								
Mystacides					3			2
Nectopsyche				4				
Oecetis	2		4					
Triaenodes							4	
Limnephilidae								
Pycnopsyche			1					
Molannidae								
Molanna								3
Philopotamidae								

Table 12. Taxa list for Sand Mountain Bioassessment stations (1992 - 1995).

MACROINVERTEBRATE	BYTJ 1 95-05-23	TCD 1 95-05-23	TCD 3 95-05-22	SCD 3 95-05-22	SHM 3 a 95-05-22	SSD 3 95-05-22	LSLM 1 95-05-22	SLM 1 95-05-22
Chimarra		37	79		16	43	134	37
Dolophilodes					16			
Philopotamidae undet.				25				
Polycentropodidae								
Cernotina	1							
Polycentropus	2			1				
Psychomyiidae								
Lype		5						
TRICHOPTERA undet.			1					
MOLLUSCA								
GASTROPODA								
LIMNOPHILA								
Ancylidae								
Ferrissia			1					
Laevapex								27
Physidae								
Physella				2	12	13		
Planorbidae								
Helisoma	1			75				3
Menetus	23							3
MESOGASTROPODA								
Hydrobiidae								
Hydrobiidae undet. dif			1					
PELECYPODA								
HETERODONTA								
Corbiculidae								
Corbicula		29	62	249	44	97	2	17
Sphaeriidae								
Sphaerium	6							
NEMATODA		1						
PLATYHELMINTHES								
TURBELLARIA								
TRICLADIDA								
Planariidae						3	6	
MISCELLANEOUS								
Collembola		1						