Biological Assessment and Habitat Characterization of Reference Streams for the Central Great Plains Ecoregion of Oklahoma
FY 1993 104 (b)(3)

Oklahoma Conservation Commission
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INTRODUCTION

The purpose of this study was to determine the reference conditions for fish, benthic macroinvertebrates, and habitat for streams in the Central Great Plains ecoregion. Sparse information on optimum biological conditions exists for this ecoregion.

The introduction to this report will discuss the following aspects of the study:

A. **Background,** and
B. Study Design.

Background

This study was funded by a grant from Region VI Environmental Protection Agency (EPA) awarded to the Oklahoma Conservation Commission (OCC). The OCC has extensive experience in the analysis of biological communities for the determination of stream quality. In the past these efforts have been concentrated in the Illinois and Little River Basins and the Muddy Boggy System in south central Oklahoma. This project is intended to apply the OCC's experience towards broadening the application of biological assessment in the state.

Due to the complex nature of nonpoint source pollution, chemical analysis of streams is often inadequate to determine water quality effects, especially when non-toxic compounds are the primary source of impairment or when there is a complex variety of chemical components. The analysis of biological communities has proven to be an effective method of assessing stream quality particularly when nonpoint source pollution causes the majority of water quality degradation. Oklahoma is largely a rural state, thus the majority of impaired streams are affected primarily by nonpoint rather than point source pollution.

The Central Great Plains ecoregion covers approximately one-third of western Oklahoma (**Figure 1**). This is an area of intensive agricultural activity, and most streams in this ecoregion are impacted by sedimentation, riparian destruction, and other impairments associated with agricultural activity. The goal of this study was to provide quantitative descriptions of habitat and fish and benthic communities for small streams with relatively unimpaired conditions. These descriptions can then be used for determining impairment at other sites in the region.

Study Design

The following strategy was used to determine reference conditions for streams from the expansive Central Great Plains ecoregion:

1. SOLICITATION OF NOMINATIONS,
2. SELECTION OF CANDIDATES,
3. CANDIDATE STREAM ANALYSIS, and

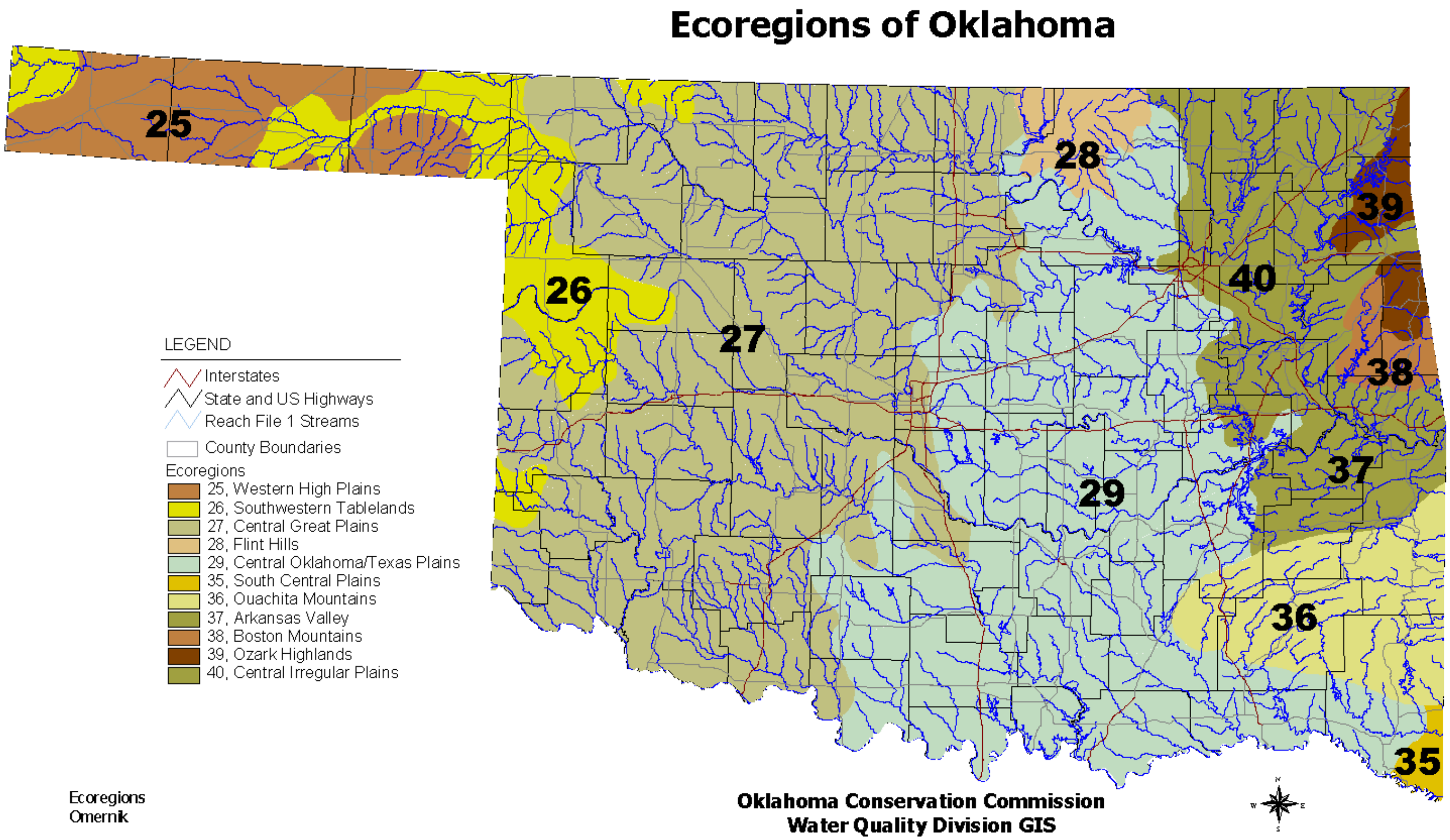


Figure 1. Location of Central Great Plains Ecoregion

4. DETERMINATION OF REFERENCE CONDITIONS.

A brief explanation of each of these is presented below.

SOLICITATION OF NOMINATION

Nominations for reference quality streams were solicited from the OCC District Offices. There are eighty-nine districts in the state, forty-one of which are located within the Central Great Plains ecoregion. Each district was asked to nominate the best two "good" streams and one "bad" stream within their district. This method was utilized because of these offices' familiarity with land and water use in their districts. The list of streams collected from the OCC Districts was then used to select candidate streams. The criteria used in selecting streams are seen in Appendix A.

SELECTION OF CANDIDATES

A list of 68 nominees was compiled. Habitat assessment surveys were conducted on 48 nominees that met the specified qualifications. This information was used to select candidate streams for collection of additional habitat information and biological data.

CANDIDATE STREAM ANALYSIS

Fish and benthic macroinvertebrate community data were collected following the EPA Rapid Bioassessment Protocol III. Habitat data was collected using field sheets developed by the OCC and the Oklahoma Water Resources Board.

DETERMINATION OF REFERENCE CONDITIONS

The following parameters were calculated for the corresponding dimension of the reference streams:

a. <u>Fish</u>: Index of Biotic Integrity (IBI)
b. <u>Benthic Macroinvertebrates</u>: Taxa richness, Modified Hilsenhoff Biotic Index (HBI) score, ratio of scrapers and filtering collection functional feeding groups, ratio of EPT and Chironomidae abundance, percent contribution of dominant taxa, ratio of shredder functional feeding group, and Shannon-Weiner diversity index.
c. <u>Habitat:</u> A complete habitat assessment was completed for each reference stream.

Each of these parameters is discussed in more detail below.

<u>IBI</u>

The IBI was used to measure the condition of fish communities in the candidate streams. The IBI is designed to assess fish communities based on taxonomic and trophic composition and the abundance and condition of fish. The index is composed of 13 metrics which assess these different perspectives of the fish community. Eleven of these metrics were found to be appropriate for assessing the fish communities of streams in the CGP. Each of these is discussed below.

Metric 1: Total number of fish species- High numbers of fish species are associated with good water quality and habitat conditions; therefore, the number of species is expected to decrease as a result of stream quality degradation. Available habitat and the number of species will increase with increasing stream size. Thus, when using this metric it is necessary to account for these changes using determined relationships between the number of species and stream size for reference streams.

Metric 2.- Number and identity of sensitive benthic species- Sensitive benthic species were used instead of darter species due to the lack of darter species in this ecoregion. This metric measures the presence of sensitive benthic species and is useful in determining degradation associated with sedimentation and associated destruction of the gravel and bedrock habitat on which these organisms depend. The organisms considered sensitive benthic species are *Phenacobius, Campostoma, Etheostoma, and Percina*. Scoring of this metric is also dependent on the species richness/waterbody size relationship.

Metric 3: Number and identity of sunfish species- This metric is based on sunfish species dependence on the presence of non-degraded pools and instream cover. In smaller streams, the number of sunfish will be dependent on stream size. Any *Centrarchid* organism is considered a sunfish.

Metric 4: Number and identity of minnow species- Because sucker species are rare in this ecoregion, minnow species-Cyprinid species (except *Cyprinus carpio*) were substituted for this metric. These species generally dominate the biomass of streams. Minnows are generally sensitive to both habitat and water quality degradation.

Metric 5: Number and identity of intolerant species- This metric uses the presence of species which have been determined to be restricted to only the highest quality streams. A list of these organisms is available from the EPA Rapid Bioassessment Protocols. The absence of such species may result from various chemical and/or physical impacts on water quality. This metric is useful for differentiating between high and moderate quality streams.

Metric 6: Proportion of individuals as very tolerant species- Green sunfish, black bullhead, mosquitofish, and red shiner are generally dominant in disturbed Midwestern streams and are therefore useful in distinguishing between low and moderate quality streams.

Metric 7: Proportion of individuals as omnivorous- The percent of omnivorous will generally increase as habitat deteriorates. A list of these organisms is available from the EPA Rapid Bioassessment Protocols.

Metric 8: Proportion of individuals as insectivorous cyprinids- These species are associated with streams which support the abundant and diverse populations of invertebrates found in higher quality streams. A list of these organisms is available from the EPA Rapid Bioassessment Protocols. This metric assesses streams of moderate quality.

Metric 9: Proportion of individuals as top carnivores- The top carnivores are those which, as adults feed on other fish. crayfish or other vertebrates. This metric is useful for streams of high to moderate quality.

Metric IO: Number of individuals in sample- This metric is expressed as catch per unit effort and is dependent on consistent technique. The scoring of this metric is also dependent on stream size. This metric is most useful in streams which have experienced some significant form of chemical degradation.

Benthic macroinvertebrates

Analysis of the conditions of benthic macroinvertebrate populations was based on seven parameters described in the E.P.A. Rapid Bioassessment Protocol manual. A brief description of the significance of the parameters and how they are calculated is given below.

Metric 1. Taxa Richness – Variety of taxa reflects the general health of the community as species richness increases with increasing water quality, habitat diversity, and/or suitability. The total taxa is determined based on the total number of taxa collected at a site. This method of species richness calculation requires a sufficient number of individuals are collected to minimize changes in species number with increases in total number of individuals.

Metric 2. Modified Hilsenhoff Biotic Index (HBI)- This metric describes the tolerance of populations to organic pollution. The score is ranked from 0 to 10, where species with a tolerance of 10 are the most tolerant. Therefore, scores generally increase with decreases in water quality. Scores are calculated using the following formula.

$$HBI = \text{sum } x_i \, t_i \, / \, n$$

where: x_i= number of individuals within a species, t_i= tolerance value of a species, and n= total number of organisms in a sample.

The tolerance values may be obtained from the EPA Rapid Bioassesment Protocols manual.

Metric 3. Ratio of Scraper and Filtering Collector Functional Feeding Group – This metric partially describes the riffle/run community foodbase and provides insight into the nature of potential disturbance factors. Indicates periphyton community composition and availability of Fine Particulate Organic Material (FPOM) associated with organic enrichment. Predominance of a particular feeding type may indicate an unbalanced community responding to an overabundance of a particular food source. Scrapers increase with increased abundance of diatoms and decrease as filamentous algae and aquatic mosses increase. Filtering Collectors use filamentous algae and mosses as habitat and the organic enrichment often responsible for filamentous algae generally provides the FPOM utilized by the filterers.

Metric 4. Ratio of EPT and Chironomidae Abundance- These four groups of insects, Ephemeroptera, Plecoptera, Trichoptera, and Chironomidae should be found in approximate balance in streams. As pollution increase, the sensitive EPT decrease in numbers, and the generally pollution tolerant Chironomidae increase in numbers. This metric is calculated by dividing the sum of EPT organisms by the sum of EPT organisms plus the sum of Chironomid organisms.

Metric 5. Percent Contribution of Dominant Taxa- This metric is a measure of how balanced the community is. A well-balanced community that is not stressed by pollution should not have any single taxon of invertebrate composing a large percentage of the total sample. This number rises as pollution increases. This metric is calculated by dividing the number of organisms in the taxon of highest occurrence by the total number of organisms collected.

Metric 6. EPT Index- The sensitive orders Ephemeroptera, Plecoptera, and Tricoptera will generally be less represented in polluted streams that in unimpaired ones. This metric is the sum of all EPT taxa collected.

Metric 7. Ratio of Shredder Functional Feeding Group and Total Number of Individuals Collected- Abundance of Shredder Functional Group relative to other groups allows evaluation of potential impairment as indicated by the Course Particulate Organic Material (CPOM)-based Shredder community. Shredders are particularly sensitive to riparian zone impacts and are good indicators of toxic effects when toxicants absorbed to the CPOM affect either the microbial community colonizing the CPOM or the shredders directly.

Metric 8. Shannon-Weaver Diversity Index- The term diversity has two main components: species richness, and equitability, which refers to the evenness with which individuals are distributed numerically among taxa. This metric expresses diversity in terms of heterogeneity by combining these two components. The metric is calculated using the following formula:

$$H' = -\sum \mathrm{p_i} \log_2 \mathrm{p_i}$$

Where p_i = the proportion, or frequency, of the i^{th} species. This metric should increase with increasing diversity, and hence water quality.

<u>Habitat</u>

The habitat assessments were conducted to determine the ability of the physical characteristics of the stream to support biological communities. This habitat assessment is a more quantitative measure of habitat assessment than that of the habitat assessment survey used in the selection of candidate streams; however, the parameters measured are nearly identical. Scores were given to each stream based on habitat assessment surveys. The criteria for scoring included: depth, width, instream substrate, habitat type, percent area of instream cover, flow measurements, riparian stability, shading, and channel sinuosity. A habitat survey assigns one estimated value to each criteria. Habitat assessments involve multiple measurements of stream and riparian characteristics. The parameters can be grouped into primary, secondary. and tertiary categories-these categories and their corresponding parameters are listed below.

Primary: *Substrate and instream cover*- This category includes instream cover, pool bottom substrate, pool variability, canopy cover shading, rocky runs or riffles, and flow.

Secondary: *Channel morphology*- This category includes channel alteration. and pool/riffle or run/bend ratios.

Tertiary: *Riparian and bank structure*- This category includes bank stability, bank vegetation, and streamside cover.

METHODS

The methods for each of the four phases involved in this study are discussed below. They will be presented in the following sequence:

- **A. Solicitation of nominations,**
- **B. Selection of candidates,**
- **C. Candidate stream analysis,** and
- **D. Determination of reference conditions.**

Solicitation of Nominations

To facilitate selection of small perennial streams from such a large area, OCC Conservation Districts were asked to make reference stream nominations.

A Conservation District generally includes the area of one county although in large counties the area may be divided into more than one district. The role of these districts is to provide information on methods of conserving soil and water resources. In this role, district employees become intimately familiar with local resource management practices.

The forty-one districts located within the Central Great Plains ecoregion were asked to select the two streams of highest quality, and one of lowest quality within their district based on qualifiers developed by the OCC staff. The nominations were to consist of the following characteristics:

- small, medium, or large perennial streams,
- no channelization,
- good riparian areas,
- intact pools, and
- riffle if possible.

Each of the nominated streams was then evaluated for reference quality using the method described in the following subsection.

Selection of Candidate Streams

Site visits were conducted for each stream that met the qualifications established in the nomination process. Three processes were used to evaluate the suitability of nominated streams-these were:

1. INITIAL EVALUATION,
2. SITE SURVEY, and
3. HABITAT ASSESSMENT SURVEY.

The methods used in applying these processes are listed below.

INITIAL EVALUATION

Previous studies conducted by the OCC provided biological and chemical data on some of the nominated streams. When information already existed for nominee streams, this information was applied towards determining suitability of nominee streams. If sufficient historical data was not available to determine suitability of a stream, a site visit was conducted for the stream.

SITE SURVEY

To further evaluate whether the nominated stream met the qualifications established in the letter sent to the districts, site surveys were conducted. Surveys involved investigation for the presence of riparian areas and absence of channelization. These surveys were conducted at the site locations recommended by the districts and at other local access points. If a stream displayed severe impact from riparian disturbance or channelization, it was not considered for candidacy. Habitat assessment surveys were conducted for all streams that met this qualification.

HABITAT ASSESSMENT SURVEY

Habitat assessment surveys were completed at specific locations on suitable candidate streams. The length of stream surveyed was proportional to the width of the stream (where length surveyed= 400*average width of stream). Scores were given to each stream based on habitat assessment surveys. The criteria for scoring included: depth, width, instream substrate, habitat type, percent area of instream cover, flow measurements, riparian stability, shading, and channel sinuosity.

The habitat assessment survey used by the OCC was adapted from EPA, "Rapid Bioassessment Protocols for use in Streams and Rivers", 1989. The field sheets used by the OCC are included in Appendix A. A description of the parameters listed on this field sheet is available in the Standard Operating Procedure (SOP) for the Stream Habitat Assessment included in Appendix B. Comparison between the SOP's for habitat assessment survey and habitat assessment reveals that the survey does not record as much information as a habitat assessment.

Habitat Assessment Survey scores were calculated for these streams and the top 20 streams were chosen as Candidate streams.

Candidate Stream Analysis

The candidate streams selected within the Central Great Plains Ecoregion received a complete biological assessment. This assessment included analysis of the following parameters:

1. FISH,
2. BENTHIC MACROINVERTEBRATES, and

3. HABITAT

Methods involved in the analysis of each of these parameters are discussed below.

FISH

Fish collections were conducted in accordance with OCC Standard Operating Procedures Sampling Procedures used by the OCC for Fish Collection in Streams. A copy of the SOP is located in Appendix C. This document is based on the EPA Rapid Bioassessment Protocol III and other supporting documents. Procedures included a 400m collection using both a seine and electro-fishing technique. Collected organisms were identified to species. When possible, organisms were identified in the field. Organisms not identified in the field were preserved in 10% formalin and identified in the lab by an experienced taxonomist.

BENTHIC MACROINVERTEBRATES

Benthics were collected in accordance with the following OCC Standard Operating Procedures: (1) Collection of Benthic Macroinvertebrates from Rocky Riffles, (2) Collection of Macroinvertebrates from Streamside Vegetation, and (3) Collection of Macroinvertebrates from Woody Debris. These standard operating procedures, included in Appendix D, are based on the EPA "Rapid Bioassessment Protocols for Use in Streams and Rivers", 1989 . Benthics were collected from three habitat types-- riffles, streamside vegetation, and woody debris. These habitats were only collected when present in rapid currents. Some streams in the Central Great Plains did not have sufficient conditions to represent all three habitat types. In such cases, only those habitats which existed in sufficient condition to support the definition of the habitat were sampled.

The collected organisms were separated from debris, and subsamples were selected to represent the total sample. A professional macroinvertebrate taxonomist then enumerated and identified the organisms to genus level, where possible.

HABITAT

The habitat assessments were completed in accordance with the OCC Standard Operation Procedure-- Stream Habitat Assessment. A copy of this SOP is located in Appendix B. This document was adopted from the EPA Rapid Protocol Assessment by OCC staff. These assessments include evaluation of instream and riparian conditions. Habitat assessments were conducted on a 400 m stretch of each stream. Measurements were recorded every 20 m.

Determination of Reference Condition

The determination of reference conditions involved the use of simple statistics to determine representative conditions for the streams assessed. The mean and population standard deviation (a) were calculated for each parameter. Points lying outside the range of 2*a were considered discordant data. This process was repeated after each discordant data point was rejected to most accurately approximate the true population mean.

Once the true population and a mean had been calculated for a parameter, the percent error and the 90 % confidence limit were calculated where applicable. These results were used to determine the biological reference conditions for streams in the Central Great Plains ecoregion.

RESULTS

The first step in determining the reference conditions for the Central Great Plains Ecoregion was the selection of reference streams. **Table 1**. shows the streams selected as reference quality. The table also shows summer baseflows and habitat assessment survey scores.

Table 1. Selected Reference Streams.

Stream Name/Legal Description	County	Survey Score	Flow (cfs)
Skeleton Cr. / w2 22N 6W	Garfield	46	2.16[b]
Sand Cr. / s18 22N 7W	Garfield	74	2.48[b]
West Cache Cr. / w6 2S 12W	Cotton	112	14.54
East Roaring Cr. / 36 5N 6W [a]	Grady	NA	1.07[b]
East Bitter Cr. / n32 8N 5W	Grady	125	0.39
Lone Cr. / n26 17N 18W	Dewey	108	0.86
Trail Cr. / s7 17N 15W	Dewey	89	0.87
Griever Cr. / e9 22N 15W	Major	110	0.55
Bear Cr. / ne swl7 14N 13W	Custer	119	1.68
Whirlwind Cr. / w33 15N 13W [a]	Blaine	NA	2.72[b]
Deer Cr. / s4 6N 24W	Greer	89	1.23
Station Cr. / sl8 6N 23W	Greer	85	0.52
Little Beaver Cr. / sl9 1N 8W	Stephens	89	14.33
unnamed tributary to Jimmy Cr./ ne n29 4N 13W	Comanche	150	0.43
Trail Cr. / s2 9N 2OW	Washita	84	0.87
Little Washita R. / e22 5N 1OW	Caddo	73	0.87
unnamed tributary to Canadian R./ w3 12N 11w	Caddo	104	2.01
Tahoe Cr. / e7 5N 11W [a]	Caddo	NA	6.71 [b]

[a]: Habitat surveys were not completed at these streams. These streams were selected based on existing information.
[b] : These flows are winter baseflow conditions

Fish

The results for the fish collection for the reference streams are shown in **Table 2**. The IBI was not calculated for East Roaring Creek because a portion of the sample was lost during collection. These results are represented graphically in **Figure 2**. The raw data is included in Appendix E.

Table 2. Index of Biotic Integrity Results for Fish Collection.

Stream Name	**County**	**Date**	**Metric #**										
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Total**
Skeleton	Garfield	08/12/93	1	1	3	1	1	1	3	5	3	5	24
Sand	Garfield	08/12/93	1	1	3	1	1	1	1	1	3	5	18
West Cache	Cotton	08/10/93	1	1	3	3	1	1	3	3	3	5	24
East Roaring	Grady												
East Bitter	Grady	07/01/93	1	1	3	3	1	3	5	1	1	5	24
Lone	Dewey	09/21/93	1	1	1	3	1	1	1	3	3	5	20
Trail	Dewey	09/21/93	1	1	3	1	1	1	1	1	1	5	16
Griever	Major	09/20/93	1	1	3	1	1	1	1	3	1	5	18
Bear	Blaine	09/15/93	1	1	1	3	1	1	3	3	1	5	20
Whirlwind	Blaine	08/12/93	1	1	1	3	1	1	1	1	1	5	16
Deer	Greer	09/22/93	1	1	1	3	1	1	1	1	1	3	14
Station	Greer	09/22/93	1	1	3	1	1	1	1	1	1	5	16
Little Beaver	Stephens	09/23/93	1	1	1	1	1	1	1	1	1	5	14
Trib. To Jimmy	Comanche	09/23/93	1	3	3	3	1	5	5	1	3	5	30
Trail	Washita	08/19/93	1	1	3	3	1	1	1	1	1	5	18
Little Washita	Caddo	08/18/93	1	1	3	3	1	1	1	3	3	5	22
Trib. To Canadian	Caddo	08/11/93	1	1	3	3	1	1	3	3	3	5	24
Tahoe	Caddo	08/17/93	1	1	3	3	1	3	5	1	1	5	24
										AVERAGE			20.11
										STD. DEV.			4.44

Metric 1: total number of species
Metric 2: # and ID of sensitive benthic species
Metric 3: # and ID of sunfish species
Metric 4: # and ID of minnow species
Metric 5: # and ID of intolerant species
Metric 6: proportion of very tolerant species
Metric 7: proportion of omnivores
Metric 8: proportion of insectivores
Metric 9: proportion of top carnivores
Metric 10: number of individuals in sample

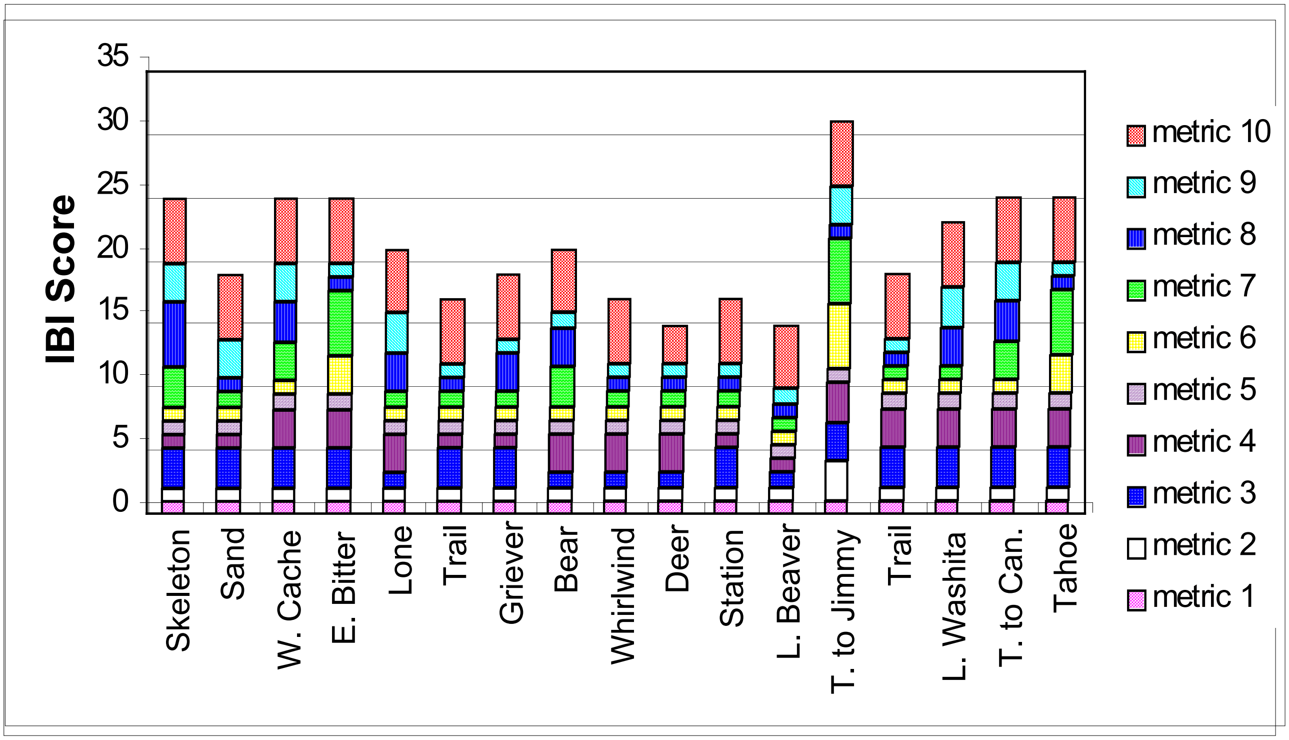


Figure 2. Index of Biological Integrity (IBI) Score Results.

Benthic Macroinvertebrates

The results for the benthos collections are shown in **Tables 3** and **4**. "R" refers to riffle collections, "W" refers to woody debris collections, and "V" refers to vegetative collections. A separate printout for each collection is included in Appendix G. A Wilcoxin Signed Rank Confidence interval was computed for each of the metrics. **Table 5** presents these 95% confidence intervals for winter and summer collections.

Table 3. Summary Analysis of Results for Winter Benthic Macroinvertebrate Collections.

	Taxa Richness			Modified HBI			Scrap. & Filt./Total			EPT/EPT + Chiron.			Dominants/Total			EPT Index			Percent Shredders			Shannon-Weiner		
Habitat Type	R	W	V	R	W	V	R	W	V	R	W	V	R	W	V	R	W	V	R	W	V	R	W	V
Skeleton	15.00	12.00	8.00	5.04	5.58	5.63	0.48	0.43	0.45	0.67	0.31	0.26	0.48	0.44	0.58	3.00	3.00	2.00	0.00	0.00	0.00	2.71	2.48	1.79
Sand	13.00	13.00	15.00	5.40	6.09	6.28	0.48	0.32	0.38	0.46	0.51	0.47	0.37	0.30	0.23	3.00	3.00	3.00	0.00	0.00	0.00	2.31	2.83	3.22
West Cache	20.00	20.00	23.00	5.16	5.42	5.75	0.31	0.29	0.34	0.53	0.40	0.66	0.25	0.21	0.29	5.00	6.00	8.00	0.00	0.00	0.00	3.53	3.60	3.50
East Roaring	12.00	13.00	8.00	5.42	5.44	6.35	0.47	0.46	0.36	0.21	0.31	0.04	0.41	0.32	0.32	1.00	3.00	1.00	0.37	0.00	0.00	2.48	2.68	2.50
East Bitter	20.00	---	19.00	4.36	---	5.09	0.27	---	0.34	0.71	---	0.53	0.19	---	0.19	5.00	---	6.00	18.87	---	11.04	3.53	---	3.59
Lone	12.00	9.00	13.00	6.17	6.00	0.00	0.67	0.47	0.50	0.10	0.12	0.59	0.38	0.78	0.43	2.00	2.00	2.00	0.00	0.00	0.00	1.56	1.33	2.79
Trail-Dewey Co.	9.00	7.00	11.00	6.01	6.04	6.00	0.59	0.51	0.50	0.04	0.03	0.02	0.65	0.87	0.83	2.00	1.00	2.00	0.00	0.00	0.48	1.60	0.88	1.20
Griever	14.00	13.00	12.00	4.95	5.87	4.49	0.61	0.59	0.84	0.52	0.16	0.33	0.29	0.35	0.76	1.00	3.00	2.00	0.00	1.57	0.00	2.90	2.77	1.59
Bear	11.00	14.00	11.00	6.45	6.65	6.82	0.29	0.37	0.30	0.03	0.11	0.09	0.43	0.39	0.44	1.00	5.00	2.00	0.25	0.00	0.00	1.99	2.45	2.16
Whirlwind	---	14.00	12.00	---	6.87	6.97	---	0.34	0.28	---	0.10	0.04	---	0.46	0.48	---	3.00	2.00	---	0.00	0.00	---	2.09	1.84
Deer	13.00	14.00	13.00	4.52	6.31	5.97	0.65	0.49	0.57	0.50	0.04	0.08	0.25	0.42	0.22	2.00	2.00	2.00	0.00	0.00	0.00	3.15	2.70	3.11
Station	11.00	14.00	13.00	5.10	6.07	6.09	0.67	0.48	0.52	0.12	0.11	0.05	0.40	0.39	0.62	1.00	4.00	3.00	0.00	0.49	0.00	2.45	2.61	2.16
Little Beaver	---	12.00	11.00	---	6.14	6.12	---	0.43	0.43	---	0.17	0.04	---	0.53	0.74	---	3.00	4.00	---	0.00	0.27	---	2.38	1.54
Trib. To Jimmy	22.00	---	---	5.57	---	---	0.51	---	---	0.32	---	---	0.23	---	---	4.00	---	---	0.88	---	---	3.70	---	---
Trail-Washita Co.	12.00	21.00	14.00	4.52	5.08	5.07	0.49	0.44	0.51	0.46	0.56	0.57	0.27	0.31	0.35	4.00	7.00	3.00	0.00	1.34	0.00	2.97	3.30	2.76
Little Washita	14.00	13.00	14.00	5.19	5.58	6.10	0.62	0.75	0.65	0.05	0.33	0.33	0.35	0.41	0.34	1.00	3.00	3.00	0.00	0.00	0.88	2.79	2.82	2.97
Trib. To Canadian	15.00	14.00	17.00	6.01	6.12	6.17	0.47	0.47	0.40	0.10	0.12	0.20	0.41	0.41	0.35	2.00	4.00	4.50	0.00	0.08	1.33	2.81	2.64	3.04
Tahoe	13.00	---	17.00	3.68	---	5.94	0.20	---	0.38	0.84	---	0.19	0.24	---	0.42	5.00	---	5.00	0.00	---	0.00	3.12	---	2.98
Average	14.13	13.53	13.59	5.22	5.95	5.58	0.49	0.46	0.46	0.35	0.23	0.26	0.35	0.44	0.45	2.63	3.47	3.21	1.27	0.23	0.82	2.63	2.59	2.51

Table 4. Summary Analysis of Results for Summer Benthic Macroinvertebrate Collections.

	Taxa Richness			Modified HBI			Scrap. & Filt./Total			EPT/EPT + Chiron.			Dominants/Total			EPT Index			Percent Shredders			Shannon-Weiner		
Habitat Type	R	W	V	R	W	V	R	W	V	R	W	V	R	W	V	R	W	V	R	W	V	R	W	V
Skeleton	16.00	18.00	17.00	5.08	2.12	2.35	0.58	0.40	0.39	0.64	0.76	0.75	0.38	0.43	0.30	4.50	5.00	5.50	0.15	0.98	2.80	2.77	3.10	3.24
Sand	14.50	17.00	17.00	5.16	5.38	5.05	0.43	0.31	0.51	0.69	0.61	0.75	0.40	0.33	0.31	6.00	5.00	5.00	0.74	1.48	1.65	2.82	3.28	3.11
West Cache	16.00	16.00	22.00	4.95	5.69	5.51	0.40	0.35	0.26	0.75	0.46	0.55	0.25	0.34	0.28	8.00	6.00	9.00	0.00	0.00	0.38	3.29	3.20	3.57
East Roaring	19.00	21.00	23.00	4.71	4.87	5.71	0.55	0.28	0.36	0.28	0.56	0.45	0.34	0.22	0.21	4.50	7.00	7.50	0.30	0.29	0.00	3.17	3.58	3.83
East Bitter	13.00	19.00	14.50	4.45	5.70	5.97	0.28	0.30	0.31	0.57	0.34	0.53	0.41	0.26	0.19	3.50	4.00	4.00	0.00	1.03	0.00	2.53	3.64	3.28
Lone	16.50	22.00	15.00	4.71	5.72	5.61	0.53	0.38	0.42	0.55	0.40	0.30	0.25	0.20	0.19	4.00	4.00	4.00	0.34	0.00	0.00	3.31	3.88	3.32
Trail-Dewey Co.	12.00	17.00	15.50	4.57	5.31	5.99	0.47	0.45	0.48	0.57	0.47	0.30	0.36	0.35	0.29	3.00	5.00	3.50	0.00	0.00	0.18	2.82	3.15	3.27
Griever	14.00	19.00	13.00	4.61	5.96	5.25	0.68	0.43	0.59	0.56	0.08	0.28	0.47	0.32	0.48	2.00	3.00	2.50	0.00	0.48	0.23	2.59	3.39	2.51
Bear	15.00	16.00	17.00	5.61	5.58	5.34	0.33	0.29	0.41	0.36	0.34	0.55	0.31	0.19	0.26	5.50	4.00	7.00	1.53	3.68	0.90	3.01	3.43	3.23
Whirlwind	10.00	17.00	16.50	4.08	5.86	5.02	0.50	0.40	0.34	0.83	0.24	0.61	0.41	0.24	0.23	3.00	4.00	3.50	0.85	0.38	3.70	2.64	3.23	3.54
Deer	14.00	17.00	14.50	4.76	5.51	5.93	0.53	0.32	0.46	0.58	0.21	0.40	0.28	0.25	0.36	2.50	2.00	2.50	0.00	0.00	0.00	3.19	3.44	2.81
Station	12.00	14.00	10.50	4.78	5.40	6.36	0.74	0.68	0.49	0.29	0.34	0.66	0.56	0.32	0.37	2.50	3.00	1.50	0.00	0.00	0.00	2.25	3.05	2.60
Little Beaver	---	18.00	11.00	---	4.98	5.87	---	0.45	0.32	---	0.53	0.28	---	0.32	0.30	---	3.00	3.50	---	0.00	0.00	---	2.41	2.67
Trib. To Jimmy	17.50	17.00	18.00	5.55	5.83	5.37	0.62	0.70	0.53	0.43	0.12	0.08	0.37	0.37	0.25	2.00	2.00	3.00	2.22	0.75	0.00	2.95	3.14	3.37
Trail-Washita Co.	15.00	---	16.00	4.67	---	4.86	0.60	---	0.53	0.53	---	0.60	0.25	---	0.25	6.00	---	6.00	0.00	---	0.00	3.08	---	3.02
Little Washita	13.00	13.50	18.00	1.63	5.21	5.74	0.58	0.54	0.35	0.48	0.49	0.26	0.40	0.25	0.35	4.50	4.00	2.50	0.52	0.00	0.00	2.67	2.86	3.14
Trib. To Canadian	13.00	16.00	16.50	4.71	5.25	6.08	0.63	0.50	0.56	0.48	0.51	0.42	0.53	0.31	0.31	3.00	5.00	3.50	0.00	0.48	1.15	2.37	3.08	3.23
Tahoe	15.50	---	14.00	4.51	---	4.55	0.43	---	0.11	0.80	---	0.88	0.37	---	0.42	5.50	---	4.00	0.00	---	0.00	3.04	---	2.78
Average	14.47	17.34	16.06	4.62	5.34	5.36	0.52	0.42	0.41	0.55	0.40	0.48	0.37	0.29	0.30	4.12	4.13	4.33	0.39	0.60	0.61	2.85	3.24	3.14

Table 5. 95% Confidence Intervals for Benthic Macroinvertebrates Collections.

Metric Name	Winter						Summer					
	R		W		V		R		W		V	
	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL	LL	UL
Taxa Richness	12.0	16.5	12.0	15.5	11.5	15.5	13.3	15.5	16.3	18.5	14.5	17.3
Modified HBI	4.84	5.61	5.71	6.19	5.41	6.19	4.56	4.96	5.21	5.71	5.18	5.79
Scrap. & Filt./Total	0.40	0.57	0.40	0.51	0.38	0.51	0.46	0.59	0.35	0.50	0.35	0.48
EPT/EPT + Chiron.	0.21	0.50	0.12	0.32	0.12	0.38	0.47	0.64	0.31	0.50	0.37	0.59
Dominants/Total	0.29	0.41	0.35	0.55	0.33	0.55	0.32	0.41	0.26	0.33	0.26	0.34
EPT Index	1.50	3.50	2.50	4.50	2.00	4.00	3.25	5.00	3.50	5.00	3.25	5.25
Ratio of Shredders	0.00	0.44	0.00	0.67	0.00	0.58	0.00	0.74	0.15	0.76	0.00	1.02
Shannon-Weiner	2.31	3.09	2.09	2.85	2.16	2.91	2.68	3.03	3.10	3.42	2.95	3.31

The results for metric 7, ratio of shredders, are shown in **Figures 3** and **4**.

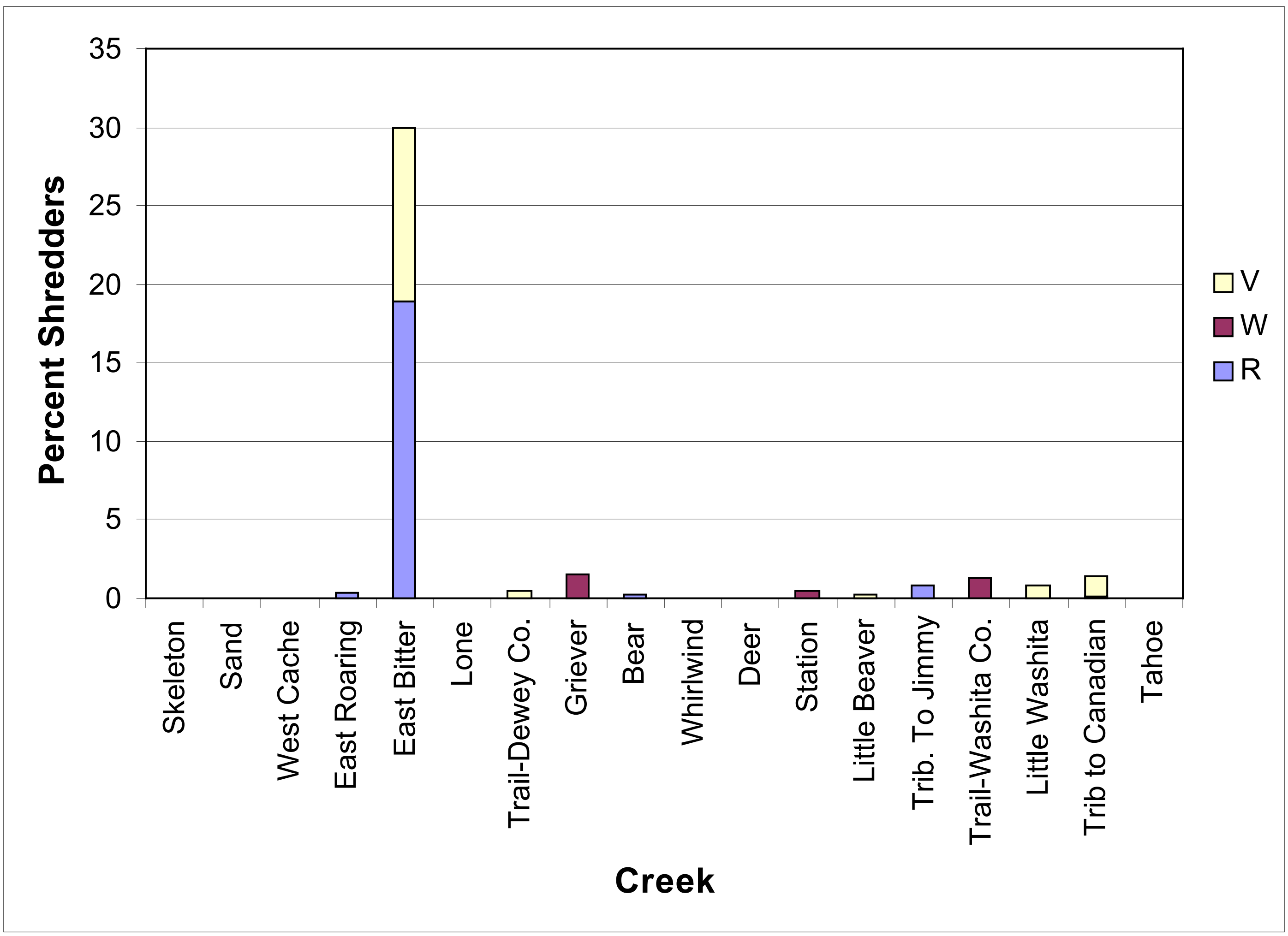
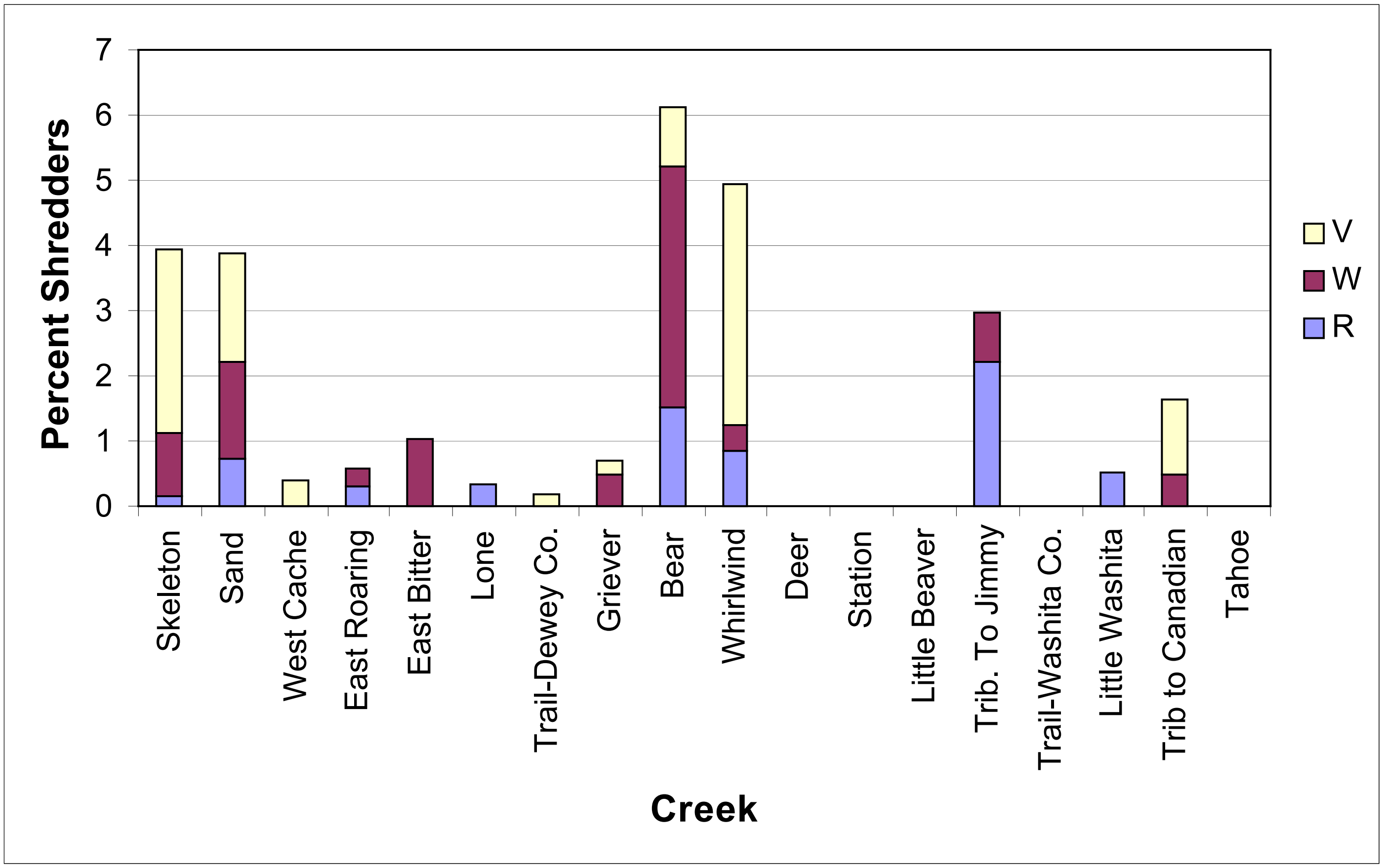


Figure 3. Percent Shredders in Winter Benthic Macroinvertebrate Collections.



HABITAT

Habitat was surveyed during the summers of 1993 and 1994. Results of Habitat collections are seen in **Tables 6** and **7**. **Table 8** further summarizes these results.

Table 6. Habitat Scores for Reference Quality Streams in Central Great Plains Ecoregion.

Stream	Date	Instream Cover	Pool Bottom Substrate	Pool Variability	Canopy Cover Shading	Rocky Runs and Riffles	Flow	Channel Alteration	Channel Sinuosity	Bank Stability	Bank Vegetation Stability	Streamside Cover	Total
Bear Creek	8/25/93	4.60	17.50	0.00	0.00	0.00	8.43	15.00	4.65	10.00	10.00	4.44E-16	70.17
Bear Creek	8/3/94	1.7	17.14	20.00	5.50	0.00	10.65	4.00	4.65	5.09	1.21	2.96	72.90
Deer Creek	8/19/93	4.66	20.00	0.00	0.00	0.00	6.15	15.00	3.15	10.00	10.00	4.44E-16	68.96
Deer Creek	7/21/94	1.95	10.20	2.63	2.75	0.00	4.91	10.00	3.15	5.69	4.73	9.85	55.86
East Roaring Creek	6/29/94	7.63	16.05	5.56	19.10	6.00	3.22	2.63	5.10	2.61	0.00	2.96	70.84
East Bitter Creek	7/1/93	8.31	18.90	20.00	0.00	6.35	1.96	15.00	2.70	10.00	10.00	4.44E-16	93.22
East Bitter Creek	6/29/94	12.4	14.76	7.14	12.92	10.00	5.37	0.00	2.70	2.84	0.00	9.70	77.82
Griever Creek	8/18/93	3.85	5.83	0.00	0.00	20.00	2.75	15.00	3.50	10.00	10.00	4.44E-16	70.94
Griever Creek	8/2/94	6.04	14.04	7.89	14.42	5.00	2.75	10.00	3.50	2.26	0.10	2.96	68.94
Unnamed Trib. to Canadian	7/16/93	3.45	20.00	0.00	0.00	0.00	10.02	15.00	5.10	10.00	10.00	4.44E-16	73.57
Unnamed Trib. to Canadian	7/1/94	2.05	17.13	0.00	19.07	0.00	5.44	0.00	5.10	5.12	1.30	5.50	60.70
Little Beaver	7/13/93	2.95	15.00	10.00	0.00	0.00	18.11	15.00	0.60	10.00	10.00	4.44E-16	81.66
Little Beaver	7/25/94	0.823	19.33	13.96	10.67	0.00	11.62	2.63	0.60	7.31	2.90	6.41	76.26
Little Washita	8/10/93	9.20	10.00	0.00	0.00	12.14	13.18	15.00	2.70	10.00	10.00	4.44E-16	82.22
Little Washita	7/20/94	6.96	16.88	16.67	15.06	10.00	15.72	5.00	2.70	8.47	8.92	3.41	109.77
Lone Creek	8/17/93	8.88	17.38	12.50	0.00	0.00	4.29	15.00	1.20	10.00	10.00	4.44E-16	79.24
Lone Creek	8/3/94	2.81	13.64	6.25	10.22	0.00	4.29	2.63	1.20	2.05	0.00	4.55	47.63
Sand Creek	7/15/93	1.50	13.33	20.00	0.00	10.95	18.91	15.00	1.05	10.00	10.00	4.44E-16	100.75
Sand Creek	8/2/94	2.75	18.07	0.00	5.55	7.00	20.00	1.50	1.05	3.51	0.00	4.78	64.20
Skeleton Creek	7/15/93	4.66	20.00	0.00	0.00	0.00	19.53	15.00	2.70	10.00	10.00	4.44E-16	81.90
Skeleton Creek	8/2/94	7.60	18.54	0.00	0.05	6.00	20.00	5.00	2.70	2.83	0.00	5.00	67.72
Station Creek	8/19/93	5.95	11.67	0.00	0.00	7.64	2.62	15.00	2.70	10.00	10.00	4.44E-16	65.57
Station Creek	7/21/94	1.23	9.97	7.50	0.00	0.00	20.00	2.63	2.70	3.13	0.73	5.00	52.87
Tahoe Creek	8/17/93	12.72	18.75	14.29	0.00	9.71	20.00	15.00	3.00	10.00	10.00	4.44E-16	113.47
Tahoe Creek	7/20/94	15.30	14.43	8.33	18.55	6.00	20.00	0.00	3.00	6.38	5.87	9.67	107.55
Trail Cr (Dewey Cr)	8/17/93	2.96	19.50	0.00	0.00	0.00	4.36	15.00	1.95	10.00	10.00	4.44E-16	63.77
Trail Cr (Dewey Cr)	8/3/94	1.45	17.44	3.85	1.90	0.00	4.36	6.00	1.95	2.82	0.87	5.00	45.63
Trail Cr (Washita Co)	8/16/93	7.58	20.00	0.00	0.00	9.71	3.78	15.00	2.70	10.00	10.00	4.44E-16	78.77
Trail Cr (Washita Co)	7/21/94	5.10	12.10	5.00	13.10	0.00	3.78	15.00	2.70	2.76	0.00	5.95	65.49
Unnamed trib to Jimmy Cr	8/12/93	14.61	15.42	13.22	0.00	13.97	2.15	15.00	3.50	10.00	10.00	4.44E-16	97.87
Unnamed trib to Jimmy Cr	7/20/94	16.80	16.61	15.63	18.30	0.00	2.15	4.00	3.50	8.14	8.22	10.00	103.34
West Cache	7/13/93	13.76	18.33	16.67	0.00	20.00	18.18	15.00	1.95	10.00	10.00	4.44E-16	123.89
West Cache	7/25/94	11.02	18.57	5.56	11.65	0.00	18.17	0.00	1.95	5.35	2.49	10.00	84.75
Whirlwind Creek	8/5/94	0.84	2.5E-08	0.00	15.08	0.00	1.60	0.00	0.90	5.17	2.04	1.06	26.69

Table 7. Habitat Ratings for Reference Quality Streams in Central Great Plains Ecoregion.

Stream	Date	Instream Cover	Pool Bottom Substrate	Pool Variability	Canopy Cover Shading	Rocky Runs and Riffles	Flow	Channel Alteration	Channel Sinuosity	Bank Stability	Bank Vegetation Stability	Streamside Cover
Bear	8/25/93	poor	optimal	poor	poor	poor	fair	optimal	fair	optimal	optimal	poor
Bear	8/3/94	poor	optimal	optimal	poor	poor	adequate	fair	fair	adequate	poor	fair
Deer	8/19/93	poor	optimal	poor	poor	poor	fair	optimal	fair	optimal	optimal	poor
Deer	7/21/94	poor	adequate	poor	poor	poor	poor	adequate	fair	adequate	fair	optimal
East Roaring	6/29/94	fair	optimal	fair	optimal	fair	poor	poor	fair	fair	poor	fair
East Bitter	7/1/93	fair	optimal	optimal	poor	fair	poor	optimal	poor	optimal	optimal	poor
East Bitter	6/29/94	adequate	adequate	fair	adequate	fair	fair	poor	poor	fair	poor	optimal
Griever	8/18/93	poor	fair	poor	poor	optimal	poor	optimal	fair	optimal	optimal	poor
Griever	8/2/94	fair	adequate	fair	adequate	poor	poor	adequate	fair	fair	poor	fair
Trib. to Canadian	7/16/93	poor	optimal	poor	poor	poor	adequate	optimal	fair	optimal	optimal	poor
Trib. to Canadian	7/1/94	poor	optimal	poor	optimal	poor	fair	poor	fair	adequate	poor	adequate
Little Beaver	7/13/93	poor	optimal	fair	poor	poor	optimal	optimal	poor	optimal	optimal	poor
Little Beaver	7/25/94	poor	optimal	adequate	adequate	poor	adequate	poor	poor	adequate	poor	adequate
Little Washita	8/10/93	fair	adequate	poor	poor	adequate	adequate	optimal	poor	optimal	optimal	poor
Little Washita	7/20/94	fair	optimal	optimal	optimal	fair	optimal	fair	poor	optimal	optimal	fair
Lone	8/17/93	fair	optimal	fair	poor	poor	poor	optimal	poor	optimal	optimal	poor
Lone	8/3/94	poor	adequate	fair	adequate	poor	poor	poor	poor	fair	poor	fair
Sand	7/15/93	poor	adequate	optimal	poor	adequate	optimal	optimal	poor	optimal	optimal	poor
Sand	8/2/94	poor	optimal	poor	poor	fair	optimal	poor	poor	fair	poor	fair
Skeleton	7/15/93	poor	optimal	poor	poor	poor	optimal	optimal	poor	optimal	optimal	poor
Skeleton	8/2/94	fair	optimal	poor	poor	fair	optimal	fair	poor	fair	poor	adequate
Station	8/19/93	fair	adequate	poor	poor	fair	poor	optimal	poor	optimal	optimal	poor
Station	7/21/94	poor	fair	fair	poor	poor	optimal	poor	poor	fair	poor	adequate
Tahoe	8/17/93	adequate	optimal	fair	poor	fair	optimal	optimal	fair	optimal	optimal	poor
Tahoe	7/20/94	optimal	adequate	fair	optimal	fair	optimal	poor	fair	adequate	fair	optimal
Trail (Dewey Co)	8/17/93	poor	optimal	poor	poor	poor	poor	optimal	poor	optimal	optimal	poor
Trail (Dewey Co)	8/3/94	poor	optimal	poor	poor	poor	poor	fair	poor	fair	poor	adequate
Trail (Washita Co)	8/16/93	fair	optimal	poor	poor	fair	poor	optimal	poor	optimal	optimal	poor
Trail (Washita Co)	7/21/94	fair	adequate	poor	adequate	poor	poor	optimal	poor	fair	poor	adequate
trib to Jimmy Cr	8/12/93	adequate	optimal	adequate	poor	adequate	poor	optimal	fair	optimal	optimal	poor
trib to Jimmy Cr	7/20/94	optimal	optimal	optimal	optimal	poor	poor	fair	fair	optimal	optimal	optimal
West Cache	7/13/93	adequate	optimal	optimal	poor	optimal	optimal	optimal	poor	optimal	optimal	poor
West Cache	7/25/94	adequate	optimal	fair	adequate	poor	optimal	poor	poor	adequate	poor	optimal
Whirlwind Creek	8/5/94	poor	poor	poor	optimal	poor	poor	poor	poor	adequate	poor	poor

Table 8. Summary Statistics of Habitat Scores for Central Great Plains Ecoregion.

	Instream Cover	Pool Bottom Substrate	Pool Variability	Canopy Cover Shading	Rocky Runs and Riffles	Flow	Channel Alteration	Channel Sinuosity	Bank Stability	Bank Vegetation Stability	Streamside Cover	Total
minimum	0.83	0.00	0.00	0.00	0.00	1.60	0.00	0.60	2.05	0.00	0.00	26.69
25% quartile	2.77	13.74	0.00	0.00	0.00	3.78	2.63	1.95	3.90	0.95	0.00	65.51
median	4.88	17.00	5.56	0.03	0.00	5.79	12.50	2.70	8.30	8.57	2.01	73.23
75% quartile	8.73	18.56	13.04	12.60	9.19	18.15	15.00	3.41	10.00	10.00	5.00	84.12
maximum	16.80	20.00	20.00	19.10	20.00	20.00	15.00	5.10	10.00	10.00	10.00	123.89
mean	6.30	15.49	6.84	5.70	4.72	9.66	9.15	2.71	7.10	5.86	3.08	76.62
std	4.61	4.43	7.02	7.24	5.97	7.11	6.34	1.26	3.14	4.47	3.59	20.79

DISCUSSION

Fish

The results of the Index of Biotic Integrity for the fish collections in the Central Great Plains is discussed below. The mean value of the IBI was 20.11 and only one stream scored greater than two standard deviations from the mean (Tributary to Jimmy Creek). This stream is located in the Wichita Mountains and therefore maintains different characteristics than other streams in the ecoregion. Fourteen streams (Skeleton, Sand, West Cache, East Bitter, Lone, Trail Cr (Dewey Co.), Griever, Bear, Whirlwind, Station, Trail (Washita Co.), Little Washita River, the unnamed tributary to the Canadian River, and Tahoe) had IBI scores of 16 which were less than one standard deviation from the average IBI.

Metrics 1, and 5 showed no variation between streams. All streams scored the lowest possible score for metrics 1 and 5 and no stream scored above a 3 for metrics 2 - 4. This may be explained by the benthic conditions of Central Great Plains streams. Stream substrate is particularly relevant for metrics 1- 5. The substrate of these streams is largely composed of sand, silt, and clay which, relative to gravel, cobble and boulder substrates, offer fewer habitat options for fish and limit instream shelter. Despite the relative prevalence of the gravel and cobble substrate in the unnamed tributary to Jimmy Cr., West Cache Cr., and Tahoe Cr., these creeks also scored the lowest score for metrics 1and 2 and scored threes (middle scores) on metrics 3 – 5. The low scores for these metrics may also be the result of very low summer base flows which dominate this region.

The low scores for the proportion of omnivores-metric 7 indicates there was high number of omnivores. When compared with the scores for metric 8 and 9-proportions of insectivores and top carnivores, respectively-it may be concluded that omnivores dominate in this ecoregion. The results of metrics 8 and 9 are discussed further later in the text.

High numbers of individuals were found in all streams resulting in the highest scoring at all streams in the ecoregion (with the exception of Deer Creek, which scored a 3) for metric 10. In addition to the ability of these streams to support high numbers of fish, this result could also be accounted for by hydrologic conditions, habitat availability and/or ecological relations. The efficiency of fish collection may have benefited from hydrologic conditions of very low base flows which confine fish to pools during the summer months and limit their ability to avoid being collected. The substrate conditions discussed previously may also have contributed to the efficiency of collection since available habitat may concentrate fish in the limited habitat areas. The high number of individuals may also have resulted from the lack of predator pressure on small fish in the region.

Metrics 2, 3, 4, 6,7, 8, 9, and 10 showed variation between the streams. No stream scored above a 3 for metrics 2 – 4 and 9, indicating streams of this ecoregion generally lack sensitive species, have high numbers of tolerant species, and generally have low numbers of top carnivores as they are dominated by omnivores. Only one stream scored above a 3 for metrics 6 and 8 (unnamed tributary to Jimmy Creek and Skeleton Creek, respectively) indicating that these streams had either a low proportion of tolerant species (Tributary to Jimmy Creek) or a high proportion of insectivores (Skeleton Creek). All streams received the lowest score for the number of intolerant species. All but the unnamed tributary to Jimmy Creek and East Bitter Creek received the lowest possible score for metric 6. Such results indicate that the few fish assigned intermediate or high tolerances exist in the Central Great Plains.

Benthic Macroinvertebrates

Taxa richness: The mean values for the taxa richness metric were 14.13 for riffle, 13.53 for woody debris, and 13.59 for vegetation in the winter collection, and 14.47 (riffles), 17.34 (woody debris), and 16.06 (vegetation) in the summer. Values fell within the 95% confidence intervals for all habitat-type collections (riffle, woody debris, and vegetation) for Sand Creek (summer and winter), Griever Creek (winter), Whirlwind Creek (winter), Deer Creek (summer and winter), Trail Creek- Washita Co. (summer), Little Washita River (winter), and Tahoe Creek (summer). Values were outside the confidence intervals for all habitat types collected in West Cache Creek (summer and winter), East Roaring Creek (summer), East Bitter Creek (winter), Trail Creek- Dewey Co.(winter), Station Creek (summer), Tributary to Jimmy Creek (winter), and Little Washita River (summer). This suggests Sand Creek and Deer Creek are most representative of the area with respect to Taxa Richness and West Cache Creek was least representative of the Central Great Plains Region with respect to taxa richness. Confidence intervals overlapped for summer and winter collections in riffles and vegetation, but not in woody debris. This suggests taxa richness does not vary seasonally in riffles or vegetation, but is higher in summer in woody debris.

HBI:
The mean scores for the winter and summer collections were 5.22 (riffle), 5.95 (woody), 5.58 (vegetation) and 4.62 (riffle), 5.34 (woody), 5.36 (vegetation), respectively. These values represent high quality macroinvertebrate populations. Values were within the 95% confidence interval for all habitat types collected on West Cache Creek (summer), Griever Creek (winter), Bear Creek (summer), Station Creek (winter), Little Beaver Creek (winter), and tributary to Jimmy Creek (winter). Values were outside the 95% confidence limits for all habitat types collected on Skeleton Creek (summer), East Roaring Creek (summer), Bear Creek (winter), Whirlwind Creek (summer and winter), Little Beaver Creek (summer), Trail Creek - Washita Co. (winter), and Tahoe Creek (winter). These results suggest Whirlwind Creek was least representative of the Central Great Plains Ecoregion with respect to HBI index.

There was no significant difference between the winter and summer HBI. This indicates that the population's ability to tolerate organic pollution changes little throughout the year. The winter population was found to have a slightly higher tolerance than the summer collection. This is likely the result of changes in land use in this agriculturally dominated area. Instream cattle density is usually higher in the winter months during the production of winter wheat.

Ratio of Scraper and Filtering Collector Functional Feeding Group:
Mean winter values for this metric were 0.49, 0.46 and 0.46 for riffle, woody debris, and vegetation collections, respectively. Mean summer values were 0.52 (riffle), 0.42 (woody debris), and 0.41(vegetation). These low values suggest a fairly balanced community where no one feeding type predominates. Values were within 95% confidence itervals at all habitat-types collected on Skeleton Creek (winter and summer), Lone Creek (summer), Trail Creek – Dewey Co. (summer), Little Beaver Creek (winter), Tributary to Jimmy Creek (winter), Trail Creek -Washita Co.(winter), and Tributary to the South Canadian River (winter). Values were outside the 95% confidence interval on all habitat types collected at Sand Creek (summer) West Cache Creek (winter), East Bitter Creek (summer and winter), Griever Creek (winter), Bear Creek (winter), Whirlwind Creek (winter), Station Creek (summer), Tributary to Jimmy Creek (summer), Trail Creek – Washita Co. (summer), Little Washita River (winter), and Tahoe Creek (summer). This suggests Skeleton Creek was most representative to the area with respect to ratio of scrapers and filterers and East Bitter Creek was least representative. Confidence intervals overlapped between winter and summer collections for all three habitat-types collected, suggesting no seasonal differences in this metric. Confidence intervals of different habitat types overlapped within collection season suggesting no difference between habitat type.

Ratio of EPT and Chironomidae Abundance:
Mean values were 0.35, 0.23, and 0.26 for winter collections in riffles, woody debris, and vegetation, respectively. Mean values were 0.41, 0.55, 0.40 for summer collections in riffles, woody debris, and vegetation, respectively. Values were within 95% confidence limits for all habitat types collected on East Bitter Creek (summer) and Tributary to Jimmy Creek (winter). Values were outside 95% confidence limits for all habitat types collected at Sand Creek (summer), West Cache Creek (winter), East Bitter Creek (winter), Trail Creek – Dewey Co. (winter), Bear Creek (winter), Whirlwind Creek (summer and winter), Station Creek (winter), Little Beaver Creek (summer), Tributary to Jimmy Creek (summer), and Tahoe Creek (winter). This suggests Whirlwind Creek was least representative of Central Great Plains conditions with respect to this metric. Confidence limits barely overlapped, suggesting summer collection metrics had a slightly more balanced ratio than winter collections.

Percent Contribution of Dominant Taxa:

Average winter collection values were 0.35, 0.44, and 0.45 for riffle, woody debris, and vegetation habitats. Average summer collection values were 0.37, 0.29, and 0.30 for riffle, woody debris, and vegetation habitats. This indicated dominant taxa comprised approximately 30-40% of the total sample collected, suggesting communities may be impacted by some factor leading to fairly unbalanced domiance of one taxa over others. Values fell within the 95% confidence limits for all habitat types collected for Sand Creek (summer), Whirlwind Creek (winter), Little Beaver Creek (summer), Little Washita River (winter), and Tributary to South Candadian River (winter). Values fell outside the 95% confidence limits for all habitat types collected for West Cache Creek (winter), East

Bitter Creek (winter), Lone Creek (summer), Trail Creek – Dewey Co. (winter), Deer Creek (summer), Tributary to Jimmy Creek (winter), and Trail Creek – Washita Co. (summer). Summer and winter confidence intervals overlapped for riffle and vegetation collections, suggesting little seasonal influence on this metric in these collections. However, summer and winter confidence intervals did not overlap for woody debris collections, suggesting possible seasonal influences on percent contribution of dominant taxa in woody debris.

EPT Index:

Mean values for this metric ranged from 2.6 – 3.5 for winter collections and 4.1 to 4.3 for summer collections. These ranges were fairly low, indicating fairly low numbers of Ephemeroptera, Plecoptera, and Trichoptera taxa which suggests moderately impaired water quality. Values were within 95% confidence intervals on all habitat types collected for Skeleton Creek (winter), Sand Creek (winter), East Bitter Creek (summer), Lone Creek (summer), Whirlwind Creek (winter), Station Creek (winter), and Little Beaver Creek (winter). Values were outside confidence intervals on all habitat types collected for West Cache Creek (summer and winter), East Bitter Creek (winter), Griever Creek (summer), Deer Creek (summer), Station Creek (summer), Tributary to Jimmy Creek (summer and winter), and Tahoe Creek (winter). This suggests West Cache and Tributary to Jimmy Creek were not typical of Central Great Plains Ecoregion Reference Streams for the EPT index metric. Summer and Winter Confidence intervals overlapped, suggesting little seasonal variation in this metric.

Ratio of Shredder Functional Feeding Group:

Mean values ranged from 0.2 – 1.3 for winter collections and 0.4 – 0.6 for summer collections indicating low numbers of shredder feeding group which suggests potential riparian zone impacts or toxic affects. This metric was one of the least variable metrics collected. Values were within the 95% confidence limits for all habitat types collected for Skeleton Creek (winter), Sand Creek (winter), West Cache Creek (winter), East Roaring Creek (winter and summer), Lone Creek (winter), Trail Creek – Dewey Co. (winter), Bear Creek (winter), Deer Creek (winter), Station Creek (winter), Little Beaver Creek (winter), Trail Creek – Washita Co. (summer), and Tahoe Creek (winter and summer). Values were outside confidence limits at East Bitter Creek (winter) and Tributary to Jimmy Creek (winter) for all habitats collected. Confidence intervals overlapped between seasons suggesting little seasonal influence on the ratio of shredders in the populations collected.

Shannon-Weiner Diversity Index:

Mean values ranged from 2.5 –2.6 for winter collections and 2.9 – 3.2 for summer collections. Values were within 95% confidence limits for all habitats collected at Skeleton, Sand, and Trail (Dewey Co.) Creeks for summer collections and at East Roaring and Station Creeks for winter collections. Values were outside 95% confidence limits for all habitat-types collected for West Cache Creek (winter), East Roaring Creek (summer), East Bitter Creek (winter), Lone Creek (summer), Trail Creek-Dewey Co. (winter), Deer Creek, (summer), Station Creek (summer), Little Beaver Creek (summer), Tributary to Jimmy Creek (winter), and Tahoe Creek (summer and winter). Summer and winter confidence intervals overlapped for riffle collections but not for woody debris or vegetation collections. This suggested seasonal differences for woody debris and vegetation collections, but not for riffle habitats.

HABITAT

Habitat ratings were variable among metrics in the Central Great Plains Ecoregion. The majority of streams were rated poor for instream cover, pool variability, canopy cover shading, rocky runs and riffles, channel sinuosity, and streamside cover. These ratings might be expected given soil types and lower abundance of trees in the ecoregion. The majority of streams rated optimal for pool bottom substrate, channel alteration, and bank stability. Ratings were evenly split between optimal (11 of 34) and poor (15 of 34) for flow and between optimal (18 of 34) and poor (14 of 34) for bank vegetation stability. Total scores for collections on Bear, Griever, Little Beaver, Skeleton, and Trail (Washita) Creeks were within the quartile range, suggesting these creeks were most representative of habitat for the Central Great Plains Ecoregion. Total scores for Sand, Tahoe, Trail (Dewey), Unnamed Tributary to Jimmy, West Cache, and Whirlwind creeks were outside the quartile range, suggestings these creeks were the poorest representatives of habitat scores for the ecoregion.

CONCLUSIONS

The effectiveness of the metrics selected for establishing the reference conditions in the Central Great Plains varied. The results of this study establish reference conditions for streams located in the ecoregion; however, care should be taken to apply the results of this study appropriately. Furthermore, conclusions may be drawn about the effectiveness of the different metrics and actions which should be taken to improve the applicability of these metrics in the Central Great Plains. The following subsections describe appropriate conclusions for each of the parameters evaluated in this study.

Fish

The Index of Biotic Integrity results of this study provide a valuable assessment of reference conditions for the ecoregion. Additional data will be valuable for assessing the accuracy of these results.

The criteria used to calculate the IBI for this ecoregion differ from those which should be used in another region. It is important to customize the IBI to better characterize the fish communities of various ecoregions.

Benthic Macroinvertebrates

The metrics used to assesses the macroinvertebrate reference conditions should be applied only with consideration of the effectiveness on the metric in evaluating ecoregion conditions.

The results of this study indicate that there was significant relationship between streams to assign a HBI value as reference. The results of the species richness evaluation provided a useful target for Central Great Plains streams. Additional data will be valuable for increasing the dependability of the calculated reference condition. Further data collection may decrease the variance found in these two collections.

Habitat

The habitat results of this study provide a good baseline of reference conditions in the ecoregion. These can be a valuable tool to compare against habitat metrics in other streams in the region for purposes of assessing habitat degradation.

APPENDIX A

APPENDIX B

STANDARD OPERATING PROCEDURE

Habitat documentation for Macroinvertebrate Collections

Macroinvertebrate collections made for purposes of stream assessment are made from the community which requires or prefers flowing water. Reasons why this community is sampled rather than various lentic communities include:

1. The flowing water community is routinely exposed to the average water quality of the stream.

2. The metrics designed to analyze the macroinvertebrate community of streams was designed for the flowing water community. There is no evidence that they work when applied to lentic communities.

3. The database of pollution tolerance of macroinvertebrates found in Oklahoma is much larger for lotic communities.

Lotic communities in streams require a substrate of some type of attach to. The most common substrates of this type which are encountered are rocky riffles, streamside rootmasses, and woody debris. Where possible, a rocky riffle should be sampled, but if it is not present, or is of dubious quality, or rocky riffles cannot be found in all streams of a given ecoregion, both of the other two alternate habitats should be sampled. At present, it appears that the streamside rootmasses are superior to woody debris but until that is definitely established, both should be sampled. SOP's are available for the sampling methodology of all three habitats.

Samples should be preserved in ethanol for subsampling and i. & e., in the lab. In no case should the mason jar be filled more than 3/4 full of loose sample. There should always be enough room in the jar to have at least 3 cm of free ethanol over the sample.

Regardless of the habitat sampled, a macroinvertebrate habitat assessment form must be filled out at each collection site. If one or two of the three sample types are not collected, write "not collected" above the habitat type. A copy of the form and instructions for filling it out follow.

Bottle should be labeled on the lid using a fine tip sharpie pen following the example given. A small sheet of paper (approx 2" x 2") should be filled out with the same information in <u>pencil</u> and placed in the jar.

date collected
stream name
legal description
county
type of sample (i.e. riffle, woody or vegetation)

Instructions for completing Macroinvertebrate Habitat Form

1. **Name of stream on USGS 7-1/2 minute map.** If the county map, soil map, or other map has a different name, the USGS 7-1/2' map takes precedence. If a stream is unnamed on the USGS map, but named on another map, use that name, but write the name of the map in parentheses beside the stream name.

2. **Water Body number.** If the stream has site letters assigned to it, use the site designation of the start point also.

3. **Legal description of the portion of the stream assessed** to the nearest 1/4 section.

4. **Date the assessment is done.**

5. **Time.** Time of day the assessment and collection was started.

6. **Stream Condition.** This refers to the height of the stream above base flow for the season you are sampling. The normal baseflow waterline is usually evidenced by the line of well developed periphyton on the substrate. If the stream is within 1 cm of this line, write "b.f." in this space. If the stream is 1-5 cm above this line, write "SE" in this space. If the stream is up more than five cm, don't collect a sample.

7. **Name(s) of Collector(s).**

8A. **Embeddedness.** This quantifies the amount of silt, clay and sand which has been **DEPOSITED IN RIFFLES.** If there is no fine material surrounding the cobble and gravel of riffles, and there is at least some free space under the rocks, that is 0 percent embedded. If the free space under the rocks is filled but the sides are untouched, count that as 5 percent embedded. As the level of fines rises up the cobble sides, estimate the percentage of the total height of the cobbles that is covered. This is your embeddedness estimate. You can often see this line quite distinctly if you lift the rocks out of the water.

8B. **Substrate.** This is an estimate of the substrate of the riffle <u>where you are collecting invertebrates</u>. The total of all substrate components should add up to 100%.

silt & clay refers to loose silt & clay particles
sand refers to particles 0.1 to 2mm is size
gravel is 2mm to 50mm
cobble is 50mm to 250mm
boulders are > 250mm
bedrock is rock that is attached to the earth's crust. If a rock can be moved by any means, it's not bedrock.
Hardpan clay is clay which is firm to hard, not highly erosive, and provides stable habitat.

8C. **Velocity-typical maximum.** This is an estimate of the average velocity of the habitat sampled in the fastest part. In a riffle this would be the thalweg. For streamside vegetation it would be on the outside (streamside) edge of the rootmass, and for woody debris, it would be the average velocity of the water passing over the sides of the wood. This velocity can be estimated using a floating object and a watch. The categories follow: low =.2 to .5 ft/sec, medium =.5 to 1.0 ft/sec, high = >1.0 ft/sec.

8D. **Periphyton- non cladophora, check one line.**

Sparse _____	{sparse. rocks, bedrock, limbs, trash, etc., are free of attached algae or have only a thin film of greenish or brownish algae that cannot be measured by holding a ruler perpendicular to the surface of the submerged object.
Moderate ____	{moderate. Submerged surfaces have a slight fuzzy or blanketed appearance. The thickness of the attached algae doesn't exceed 5mm.
Abundant ____	{heavy. Submerged surfaces have a definite fuzzy or blanketed (covered with gelatinous mat) appearance. Thickness of attached growths exceed 5mm.

8E. **Cladophora** refers to the aereal percent of the substrate sampled which is covered with cladophora. Check one line.

Absent	_____	0%
Sparse	_____	> 0% but < 5%
Moderate	_____	5% to 25%
Abundant	_____	> 25%

8F. **Aquatic Moss** refers to the aereal percent of the substrate sampled which is covered with aquatic moss. Check one line.

Absent	_____	0%
Sparse	_____	> 0% but < 5%
Moderate	_____	5% to 25%
Abundant	_____	> 25%

8G. **CPOM in sample** refers to the % of sample composed of partially or well rotted plant material not counting the substrate being sampled. i.e. if you are sampling roots, don't count the roots in the sample as part of the CPOM. This should mostly be composed of leaf material. Do not count freshly fallen leaves which have not started to rot. Check one line.

Absent _____ 0%

Sparse _____ > 0% but < 5%

Moderate _____ 5% to 25%

Abundant _____ > 25%

8H. **Substrate roughness** refers to the roughness of rocks in riffles. Check one line.

_____ low = a rock which when scraped with a pocket knife or spatula resulting in removal of >75% of visible periphyton.

_____ moderate = a rock which when scraped with a pocket knife or spatula resulting in removal of 25% - 75% of visible periphyton.

_____ high = a rock which when scraped with a pocket knife or spatula resulting in removal of < 25% of visible periphyton.

If you can easily assign the riffle to one of these categories by a visual estimate of the roughness no scraping is necessary. If you are not sure, pick up a typical rock and scrape it with a pocket knife or spatula to help you in your estimate.

8I. **% of sample collected in jar.** Usually you will be able to put all of the sample you collect from any one habitat in a one quart mason jar. If you can't fit everything in the jar without overfilling the jar (see page 1 of this SOP), mix the sample until all the components (algae, leaves, twigs, rocks, sand, etc.) appear to be uniformly mixed and discard enough of it so that the remainder will fit in the jar without overpacking the jar. Write down the % of sample you estimate that you have placed in the jar.

9A. **Presence** refers to the amount of suitable streamside vegetation or woody debris habitat present in the stream. Check one line.

_____ Occasional indicates that you must walk more than 50 meters to get a good 3 minute sample.
_____ Common indicates that you must walk 10 to 50 meters to get your sample.
_____ Abundant indicates that a good sample can be collected in less than 10 meters of stream.

9B. **Type** refers to the type of streamside vegetation sampled. Check all lines where that type of vegetation makes up at least 1/4 of the total habitat sampled.

_____ grass-like leaves. Leaves of aquatic or semi aquatic grasses & sedges which have been hanging in the water long enough to develop a periphyton and/or slime coat.

_____ fine roots. Root masses where most of the roots are <2mm in diameter.

_____ coarse roots. Root masses where most of the roots are >2mm but <6mm in diameter.

9C. **Velocity-typical maximum** - See instructions under 8C.

9D. **CPOM (non root) in sample** - See instructions in 8G.

9E. **Periphyton-non cladophora** - See instructions in 8C.

9F. **Cladophora** - See instructions in 8E.

9G. **% of sample collected in jar** - See instructions in 8I.

10A. **Presence** - See instruction in 9A.

10B. **State of Decay** refers to the state of decay of the woody debris sampled. Check all lines where debris of this type makes up at least 1/4 of the habitat you sampled. All of these categories may or may not have bark on them.

These categories are determined by firmly pressing your thumbnail into the wood (not bark) of the debris sampled perpendicular to the grain. The depth of the indentation, if any, that remains when your thumbnail is removed is measured to determine the state of decay.

_____ low - indentation is 0 to 0.5 mm deep
_____ moderate - indentation is 0.5 to 2 mm deep
_____ high - indentation is > 2 mm deep

10C. **Size** refers to the average diameter of the woody debris sampled. Check all lines where that size class makes up at least 1/4 of the habitat sampled.

_____ small - .6 to 2.0 cm
_____ medium - 2.0 to 7.5 cm
_____ large - > 7.5 cm

10D. Velocity-typical maximum - See instructions under 8C.

10E. CPOM (non woody) in sample - See instructions under 8G.

10F. Periphyton-non cladophora - See instructions under 8C.

10G. Cladophora - See instructions under 8E.

10H. % of sample in jar - See instructions under 8I.

Macroinvertebrate Habitat Assessment

1. Stream ________ 2. WB # ________ 3. Legal _________4. Date ________ 5. Time ________ 6. Stream Condition
7. Name(s) of Collector(s)

Riffle

8A. embeddedness _______

8B. Substrate
__ silt & clay
__ sand
__ gravel
__ cobble
__ boulder
__ bedrock
__ hard pan clay

8C. Velocity typical maximum
__ low
__ medium
__ high

8D. Periphyton-non cladophora
__ sparse
__ moderate
__ abundant

8E. Cladophora
__ absent
__ sparse
__ moderate
__ abundant

Streamside vegetation

9A. Presence
___ Occasional
___ Common
___ Abundant

9B. Type
__ grass like leaves
__ fine roots
__ coarse roots

9C. Velocity typical-maximum
__ low
__ medium
__ high

9D. CPOM (non root) in sample
__ absent
__ sparse
__ moderate
__ abundant

9E. Periphyton-non chadophora
__ sparse
__ moderte
__ abundant

Woody Debris

10A. Presence
___ Occasional
___ Common
___ Abundant

10B. State of Decay
__ low
__ moderate
__ high

10C. Size
__ small
__ medium
__ large

10D. Velocity typical-maximum
__ low
__ medium
__ high

10E. CPOM (non woody) in sample
__ absent
__ sparse
__ moderate

8F. Aquatic Moss
__ absent
__ sparse
__ moderate
__ abundant

8G. CPOM in sample
__ absent
__ sparse
__ moderate
__ abundant

8H. Substrate Roughness
__ low
__ moderate
__ high

8I. % of Sample Collected
__ in jar

9F. Cladophora
__ absent
__ sparse
__ moderate
__ abundant

9G. % of Sample Collected
__ in jar

__ abundant

10F. Periphyton-non cladophora
__ sparse
__ moderate
__ abundant

10G. Cladophora
__ absent
__ sparse
__ moderate
__ abundant

10H. % of Sample Collected

__ in jar

APPENDIX C

STANDARD OPERATING PROCEDURE

Sampling Procedures used by the Oklahoma Conservation Commission for Fish Collection in Streams

Variations of habitat, types of fish, and water chemistry dictate the use of different collection techniques both within and among streams. For purposes of conducting a statewide assessment which allows for the comparison of one stream to another, we use a combination of seines and a backpack shocker in every stream. The width and length of the seine being used will vary according to the stream width and the depth of pools. All seines used are 1/4" mesh.

Specific techniques for, and relative advantages of seining and electrofishing vary considerably according to stream type, and conductivity and are discussed in detail in Fisheries Techniques (edited by L.A. Nielsen and D.L. Johnson and published by the American Fisheries Society 1983).

The following procedure is used by the Oklahoma Conservation Commission to collect fish in streams.

A. Training Procedures

1. If you have not already done so, read the chapters in Fisheries Techniques which deal with streams, seines, and electroshockers.

2. Do not collect fish without the supervision of or the permission of Dan Butler or John Hassell.

B. Field Collection Methods

1. Distance of stream to be sampled. Streams should be sampled for a distance of 30 or more times their average width, taking whatever time is necessary until the team leader feels that additional sampling will not significantly affect the results of the survey.

2. Collection Procedures

a. Seining. A stream should be seined before it is shocked since fish that utilize cover in the stream will generally not leave the area when disturbed. These fish are most efficiently collected by shocking and will still be there when electroshocking commences. OCC utilizes 4 and 6 foot seines in 10, 20, and 30 foot lengths. Seine height is dictated by water depth, and length is determined by width of the water being sampled. If possible the seine should be 15-25% longer than the width of the waterbody being sampled and about 25% higher than the depth of the water. This will allow the center of the net to form a bag behind the operators where the fish are more likely to stay in the net.

The seine should be pulled through the water. Since fish tend to orient towards to current, the direction of the seine haul should generally be towards (in the same direction of) the current.

The lead line should be kept on the bottom, and in front of the float line.

If there are many obstructions on the bottom, the lead line will become caught or bounce, and most fish will escape underneath the bottom of the net. If this happens use a smaller net that allows you to avoid obstructions or go to electroshocking.

The brailes of the net should be used to disturb the area under any undercut banks or beds of macrophytes near the edge, in order to scare fish hiding under cover out towards the middle of the net.

Under ideal conditions the net should be pulled through the water in the manner described above for about 10 meters and dragged out of the water on a gradually sloping pre-selected beach. The person pulling the seine on the side of the stream opposite the beach should swing ahead of the other person so that the seine is pulled out on the beach stretched over the same distance it was stretched in the stream.

If the stream doesn't have gradually sloping banks, the dip method should be used. This method consists of sweeping around and through the area to be sampled, keeping a wide bag and moving the lead line as much under the undercut bank as possible. Use the brailes to probe repeatedly as far as possible into the undercut area working towards each other until the brailes overlap. The seine should then be swiftly stretched and lifted vertically from the water. An alternative method of retrieving fish under these conditions is to slowly turn the brailes to wind the net up once they have overlapped to form an enclosure. This may wind up the fish with the net and allow them to be lifted out of the water with the rolled up net.

b. <u>Electroshocking</u>. The electroshocker used at the OCC is a Coffelt CPS backpack shocker powered by a 300 ma 120V Honda generator.

<u>BEFORE OPERATING OR ASSISTING</u> with the shocker, **<u>READ</u>** and **<u>UNDERSTAND</u>** the manuals for the generator and the shocker. Starting procedures, <u>safety</u> <u>procedures</u> and troubleshooting are well documented in these manuals and are not spelled out here. The manuals can be obtained from our equipment file in the main office.

The shocker consists of a trailing stainless steel cable electrode and either a ring or diamond electrode mounted on the end of a fiberglass pole. Under most conditions, both the ring and diamond electrodes can be used at the same time. In waters of extremely low conductivity (<40Fs). The ring should be used. In waters of high conductivity (>500Fs) only the diamond should be used. In very deep water where the ring seems to be ineffective the diamond electrode may offer better results.

The shocking team <u>must</u> consist of at least two people. One will carry and operate the shocker while the other(s) will net stunned fish.

The shocker is most useful where a seine cannot be used effectively in areas such as brushpiles, rootwads and cobble substrates. The forward electrode should be gradually passed back and forth over and in these areas as the team walks upstream. As fish are stunned, they will usually roll over and become more visible, allowing the netters to see and capture them.

In very dense brush or root cover, fish often sense the presence of the team before they are close enough to be stunned and then retreat so deeply into cover that it is impossible to net them when they are stunned. It is often better in situations such as these to insert the electrode into the brush before it is turned on, give the fish a minute or so to get used to the new situation and then turn the current on. Many fish will be much closer to the edge of brushpile when they are stunned in this manner.

c. Fish collected by seining and electroshocking should be kept in separate jars and labeled as to what method was used to capture them. This will help make our methods more comparable to those people who just use one method or the other.

C. Preservation and Field I.D.

In general all fish should be placed in 10% formalin immediately after capture and returned to the lab at OCCHD for identification. There are a few exceptions made for large (>100 gms) fish which can be positively identified in the field. If all team members agree on the identification of such a fish, it can be returned to the water far enough away that recapture is unlikely. All large fish released must be photographed on slide film. This includes fish such as gars, all types of carpsuckers, black bass, any white bass in water where yellow bass or striped/white hybrids may be found, all buffalo, all redhorse, and any other unusual fish. **Please note,** the golden and black redhorse cannot be told apart without counting lateral line scales and pelvic rays. Unless you record that data on field form, you must either bring the fish into the lab, or record it as Moxostoma sp. Similar notes must be taken when releasing other fish that can be difficult to tell apart in the field such as the river and shorthead redhorses or any of the buffalos. It is important that you take photos and label them such that we will know which pictures go with what fish 5 or 7 years from now. The photos are data, and should be labeled as to the ID of the fish in the picture, the date, the stream name, county, and legal location of the site. One copy should be kept in your files, and one should be forwarded to the data manager.

Fish much larger than 3 to 4 Kg should be sliced open along the lower rib when preserved in order to allow the formalin to penetrate the body cavity fast enough to prevent decay. A slit through the ribs is preferred to a belly slit to facilitate counting belly scales in the lab.

Formalin is a carcinogen and can also cause permanent damage to mucous membranes and eyes. Care must be taken when placing fish in formalin so that the fish does not flop around and splash formalin onto people near the jar. The fish should be put into the jar with the lid tilted open away from the operator so that the lid shields the face and body of the operator. Flood any skin exposed to formalin with plenty of water as soon as possible. If it gets in your eyes, flood the eyes with water immediately and go to the doctor immediately after that.

D. Sample Identification

Write date, stream name, number of bottles composing sample, and legal location on a piece of 100% cotton rag paper with pencil and put it into every jar of fish from each site. Write the same information on the front of each jar using a wax pencil or an indelible marking pen.

E. Field Data

At all sites where fish are collected, a stream habitat evaluation must be performed. It does not have to be done on the same day as the fish are collected, but should be done before major floods change the habitat. A fish collection data sheet must always be filled out at the time of the collection. All lines on the form must be filled out.

F. Safety

1. Primary responsiblity for safety while electroshocking rests with the fish team leader. All crew memebers should receive training in First Aid and CPR. Electro-fishing units have a high voltage output and may deliver dangereous electrical shock. While electrofishing, avoid contact with water unless sufficiently insulated againest electric shock. Use chest waders with non-slip soles and water-tight rubber (or electrian's) gloves that cover to the elbow. If they become wet inside, **stop fishing until thoroughly dry. Avoid contact with anode at all times. <u>At no time while electrofishing should a crewmember reach into the water for any reason.</u>** The electrofishing equipment provided is equipped with a 45 degree tilt switch which interrupts the current. Do not make any modifications to the electrofishing unit which would make it impossible to turn off the electricity.

2. General safety guidelines should be observed. If waders or gloves develop leaks, leave the water immediately. Avoid operating electrofishing equipment near people, pets or livestock. Discontinue any activity in streams during thunderstorms or heavy rain. Rest if crew becomes fatigued.

3. Gasoline is extremely volatile and flammable. Its vapors readily ignite on contact with heat, spark or flame. Never attempt to refill the generator while it is running. **<u>Always allow the generator to cool before refilling.</u>** Keep gasoline out of direct sunlight to reduce volatilization and vapor release. Always wear gloves and safety glasses when handling gasoline. Keep gasoline only in approved containers.

4. Decision to use electrofishing equipment will depend on size of site, flow, conductivity and turbidity. If conductivity is below 10 uS or if flow is too high, site too deep or water is too turbid to assure safe footing or locate stunned fish, crew may consider use of seine only or determine that site is "Unsampleable". <u>THIS IS A SAFETY DECISION.</u>

5. **Failure to observe safety procedures will result in disciplinary actions including probation and dismissal.**

FISH COLLECTION; FIELD SHEET

WB Name______________________ **Date**_________________ **Time**_________________

WB#__________________________ **Crew leader**_____________________ **crew members** _____________________________
Legal______________________ __________________________________

County_____________________ **%cld.cv.**_______ **str.cond.**____________
DO-riffle_______ **cond.**_________ **water temp**_____ **wind;dir/vel**_______ **pool,top**______
pool,btm______ **pH**_________ **Turb.**__________ **air temp.**_____________

Seining time (min)________ **comments**_________________________________

Shocking time (sec)_________ **comments**_______________________________

FISH IDENTIFIED & RELEASED IN FIELD

SPECIES	COUNT	COMMENTS
1		
2		
3		
4		
5		
6		
7		
8		

OTHER COMMENTS

EQUIPMENT CHECKLIST - FISH COLLECTION

Clothing

Rubber Gloves (as many pairs as the shocking crew consists of)
Waders (as many pairs as the shocking crew consists of, although everyone is responsible for their own waders.)
Goggles (for use mixing formalin)

Documentation

Fish Field Forms
Information for forms including; WB#, lat/long of site, legal location other things as necessary
Waterproof paper for labels inside jar
Pencils
Sharpy pen for labeling jar
Extra white paper for use as a background for fish pictures
Clip board
Camera
Two rolls slide film
Tape measure to record lengths of released fish if desired

Chemicals

Gasoline/oil mix for generator
Extra two stroke oil
Concentrated formaldehyde (37%)

Shocker

Electrode
Backpack
Generator with spare plug, plug wrench, and screwdriver
Shocker unit (green box)

Nets

4 10 , 6 30 , and 4 30 seines and any other seines that are preferred by the crew leader. All seines should be 3 mesh
Dip Net to collect shocked fish with

Containers

Wide mouth 1 gallon jars, 4 per site
1 or 2 liter graduated cylinder for mixing 10% formalin (3.7% formaldehyde)
Whirlpacs for putting special fish in

Instruments

DO meter Alkalinity test kit turbidity meter
pH meter
Conductivity meter See the checklist for instruments for further needs

APPENDIX D

STANDARD OPERATING PROCEDURE

Collection of Benthic Macroinvertebrates from Rocky Riffles

I. Suitable Substrates - A riffle is defined as any sudden downward change in the level of the streambed on such that the surface of the water becomes disrupted by small waves. For this collection method the substrate of the riffle must be composed of gravel, or cobble from 1" to 12" in the longest dimension. Riffles with substrates of bedrock or tight clay are not suitable.

II. Method of collecting the sample - Support a 1 m^2 Kicknet composed of a double layer of fiberglass window screen or a net of number 30 mesh in such a way that any organisms dislodged from the substrate will be carried into it by the current. The bottom of the net should be tight against the bottom of the stream and the current must be sufficient to insure that dense organisms such as small molluscs will be carried into the net from the sampling area.

Vigorously agitate the substrate of a 1 m^2 area of the bed of the riffle immediately upstream of the riffle until all rocks and sediment to a depth of at least five inches have been thoroughly scraped against each other and the organisms living between and upon the rocks have been dislodged and carried into the net by the current. Continue agitation until it can be seen that the area being sampled is producing no new detritus, organisms, or fine sediment.

At this point you rinse leaves, sticks and other large debris caught in the net in the current so that organisms on them are carried into the net. When the volume of the sample is reduced enough that three such samples will fill a 1 quart mason jar three fourths full or less, remove all of the material from the net and place it in the mason jar.

III. Where to sample the riffle - Three 1 m^2 areas of the riffle must be sampled. They can be square, rectangular or trapezoidal so long as each area equals 1 m^2 in area. One should be in the fastest part of the riffle where the largest rocks and the smallest amount of interstitial sediment will generally be found. The second should be in the slowest part of the riffle, often near the edge of the stream where the smallest rocks and the greatest amount of interstitial sediment will be found. The third sample should be in an area intermediate between the first two.

IV. Processing of the Sample - The sample should be processed (subsampled and picked) according to the EPA RBP's with the following modification:

- Record the number of grids required to obtain 100+ organisms.
- Use OCC SOP **Subsampling and Picking Macroinvertebrates from Field Collected Samples Procedure**.

STANDARD OPERATING PROCEDURE

Collection of Macroinvertebrates from streamside vegetation

I. Suitable substrates - Any streamside vegetation which offers fine structure for invertebrates to dwell within or upon is suitable. The vegetation being sampled must be in the current so that it offers suitable habitat for organisms which collect drifting particles or which need flowing water for other reasons. This habitat will often be found along the undercut banks of runs and bends where the fine roots of grasses, sedges, and trees, such as willow and sycamore, hang in the water.

II. Method of collecting the sample - This type of sample should be collected with a dip net made of #30 size mesh material. The net should be placed around or immediately downstream of the vegetation being sampled. The organisms can be dislodged from the roots either be vigorously shaking the net around the roots or by shaking the roots with your hand while the roots and your hand are inside the net.

III. Where to sample - Sampling should continue for 3 minutes of actual shaking of roots. Do not count the time while you are walking between areas you sample.

IV. Processing of the samples - The sample should be processed according to the EPA RBP's with the following modification:

- Record the number of grids required to obtain 100+ organisms.
- Use OCC SOP **Subsampling and Picking Macroinvertebrates from Field Collected Samples Procedure**.

STANDARD OPERATING PROCEDURE

Collection of Macroinvertebrates from Woody Debris

I. Suitable substrates - Any dead wood with or without bark in the stream is suitable as long as it is in current fast enough to offer suitable habitat for organisms which collect drifting particles or which need flowing water for other reasons. The final sample should consist of organisms collected from an even mixture of wood of all sizes and in all stages of decay.

II. This type of sample should be collected with a dip net made of #30 size mesh material. The net should be placed around or immediately downstream of the debris being sampled. The organisms can be dislodged from the debris either by vigorously shaking the net around the woody debris or by shaking the debris with your hand while the debris and your hand are inside the net. Large logs which are too big to shake should be brushed or rubbed vigorously by hand while the net is held immediately downstream.

III. Where to sample - Sample for total of three minutes counting only the time that debris is actually being agitated. Include as many types of debris in the sample as possible. These types often include wood which is very rotten and spongy with bark, wood which is fairly soled which has loose and rotten bark, and wood that is solid with firmly attached bark. They should range in size from 1/4" to about 8" in diameter.

IV. Processing the sample - The sample should be processed according to the EPA RBP's with the following modification:

- Record the number of grids required to obtain 100+ organisms.
- Use OCC SOP **Subsampling and Picking Macroinvertebrates from Field Collected Samples Procedure**.

STANDARD OPERATING PROCEDURE

Subsampling and Picking Macroinvertebrates From Field Collected Samples

The waterbody assessment procedure utilized by OCC requires that a random sample of macroinvertebrates be collected, identified and enumerated, from a portion of the waterbody being assessed. In order to make this test cost effective it is not possible to identify more than about 150 organisms from each site. This SOP describes the procedure we use to subsample a field collected sample which may contain 200-10,000 organisms.

1. The sample will be brought in from the field in a 1 quart mason jar preserved with 70% ethanol. Mason jar lids have a sealing compound which is not particularly resilient so it is important that you don't damage the lids when opening or resealing the jar. **IF YOU BEND THE LID, IT CAN'T BE REUSED AND YOU MUST PUT A NEW ONE ON**. Keep a fresh supply of lids handy in case this happens. If you use a new lid, label it exactly the same as the one that was there. Use a white label with a soft #2 pencil. (Ink or sharpie pens run in ethanol and become illegible.) Fill out the lab notebook at this point with today's date, date sample was collected, name of stream, county where sample was collected, legal location where sample was collected and what type of sample was collected.

2. **POUR THE ETHANOL OUT OF THE JAR**, without shaking or disturbing the contents, through a sieve made of #30 or finer screen. Save the ethanol to preserve the unused portion of the sample.

3. **SPREAD THE CONTENTS OF THE JAR INTO A BAKING DISH WHICH IS DIVIDED INTO 28 PORTIONS OF EQUAL AREA.** It is easiest to draw the dividing lines if a rectangler dish is used which is divided into four rows of seven blocks each. The size and shape are not important so long as they are all equal to each other in area. Most people find it easiest to see small organisms on a white background. The easiest way to get a white pan whose lines don't rub off or dissolve in ethanol is to use a clear glass pan, draw lines on the bottom of it with a sharpie pen, number each square 1-28, and glue or tape a sheet of white paper over the outside bottom of the pan. If you wrote the numbers in mirror writing on the bottom, they will be legible when you look down from the top.

4. **REMOVE ALL LARGE OR WHOLE LEAVES AND LARGE PIECES OF WOOD AND BARK BEING VERY CAREFUL TO PICK ALL MACROINVERTEBRATES OFF OF THEM.** Return the macroinvertebrates to the dish, and throw the leaves and bark away. At this point, the material remaining in the dish should consist of a mixture of sand, fine gravel, small organic detritus, pieces of leaf < 1-2 cm wide, fine roots, algae and macroinvertebrates.

5. **SPREAD THE REMAINING MASS INTO AN EVEN SHEET ABOUT 2-5mm THICK.** Both leaves and gravel should be as uniformly distributed over the bottom of the dish as possible.

6. **DIVIDE THE TRAY INTO FOUR EQUAL PORTIONS** by separating the sample into top and bottom halves and then into right and left halves. When you are done, the four portions should appear as equal as possible in terms of the amount of leave present, amount of fine gravel present, amount of algae present, etc. If they don't, rearrange things until you are satisfied that any one of the quarters selected will be as equal as possible to the other three.

7. **PICK ONE QUARTER** by flipping a coin to select either the top half or the bottom half, and then flipping the coin again to select either the right or left side of the first half selected. If the sample is not to dense, that is, the fourth you selected does not totally cover 1/4 of the bottom of the tray, you can stop here. If no glass is visible through the sample you will need to divide the remaining portion into half and select the half you will use by flipping the coin again. The purpose of this subsampling is to thin the sample down enough that you will only be picking a thin layer of debris. The inverts will be much easier to see that way.

8. **FILL THE TRAY ABOUT 1 TO 2 CM DEEP WITH WATER.** If the water is run in very slowly out of a tap, you can take this opportunity to rinse off some of the remaining leaves and discard them. This will make the sample even easier to pick.

9. **PLACE THE TRAY ON THE TABLE WHERE YOU WILL WORK AND DISTRIBUTE THE CONTENTS EVENLY OVER THE BOTTOM.** You should take care that all materials in the tray are evenly distributed, especially the gravel and leaves.

10. While you are waiting for the water to stop moving **ESTIMATE THE COMPOSITION OF THE SAMPLE** (exclusive of inverts) according to the following list: silt and clay, sand, fine gravel (<2mm), course gravel (>2mm), woody debris (twigs, bark, roots, etc.), whole leaves, rotted pieces of leaves, filamentous algae, and unidentifiable organic material. **YOU MUST ALSO RECORD THE FRACTION OF THE SAMPLE THAT REMAINS IN THE TRAY.** i.e. 1/2, 1/4, or 1/8

11. **SELECT AT LEAST 6 OF THE 28 SQUARES USING EITHER A RANDOM NUMBER GENERATOR OR A RANDOM NUMBER TABLE.** The random number generators that are on most pocket calculators will give a three digit number and it may have a decimal in front of it. For our purpose, we will use only the last two numbers. Starting with the first random # you generate, record all numbers between 1 and 28 until you have 6 numbers. These will be the numbers of the squares you pick the invertebrates from. Your lab notebook should then look like this:

TODAY'S DATE	11-18-93
Sample date, stream name, county, legal description, sample type	7-16-93, Griever Creek, Major County, E9 2N 11W, riffle kick
Sample description - sand gravel, algae, etc.	40% fine gravel, 5% course gravel, 10% filamentous algae, 5% woody debris, 30% well rotted leaves, 10% whole leaves
Amount of sample picked	1/4 of sample picked
Square ________ organisms	Square 2 5 23 17 9 28 organisms

12. If the organisms are floating in the water and moving, you will need to **CONFINE THEM TO THE SQUARES YOU HAVE PICKED.** Place rectangles or squares constructed of clear plastic that are the same or greater height as the water in each square you have selected. This will keep the organisms from drifting out of the squares as you move leaves or disturb the water. If a large leaf goes under the wall from one square to another you can facilitate the job of picking by slicing it in half by running an exacto knife along the wall. The same can be done for twigs, roots, and masses of algae.

13. Examine the edges of the square you are picking to see if any invertebrates are trapped under the wall. If there are any there, **PLACE THEM IN THE SQUARE IN WHICH THEIR HEAD IS ALREADY LYING.**

14. **PICK ALL THE INVERTEBRATES OUT OF THE FIRST SQUARE SELECTED.** Keeping track of the number picked, place the organisms picked in a scintillation vial that is filled up to the neck with 70-100% ethanol. If any large organisms are picked such as crayfish or hellgrammites, place them in a separate vial. If you aren't sure something is an organism, place it in the vial but don't count it as part of the total.

15. When you are sure all of the organisms are picked out of the square, **RECORD THE NUMBER THAT WERE PICKED** in that square under the number of that square in the lab book.

16. **REPEAT STEPS 15 AND 15 UNTIL YOU HAVE PICKED AT LEAST 100 ORGANISMS.** Remember that once you have started a square, you must pick all of the invertebrates out of that square. You will typically end up with 100-130 organisms in the vial. If you end up with much more than this, you have not subdivided your sample enough and should be more careful in the future.

17. **LABEL THE VIAL(S)** using a fine point sharpie pen. The top and side of the vial should look like the one in the following drawing keeping in mind that if there were only one vial for this sample it would say 1 of 1. If there were three vials, they would all say 1 of 3, etc.

18. **PLACE CLEAR TAPE OVER THE LABEL** on the side of the bottle to protect it from spilled alcohol which will dissolve the ink.

APPENDIX E

APPENDIX F

APPENDIX G