BIOLOGICAL METRIC DEVELOPMENT FOR THE ASSESSMENT OF NONPOINT POLLUTION IN THE SNAKE RIVER ECOREGION OF SOUTHERN IDAHO

1990-1991

Final Report

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IDAHO

SNAKE RIVER ECOREGION

FINAL REPORT

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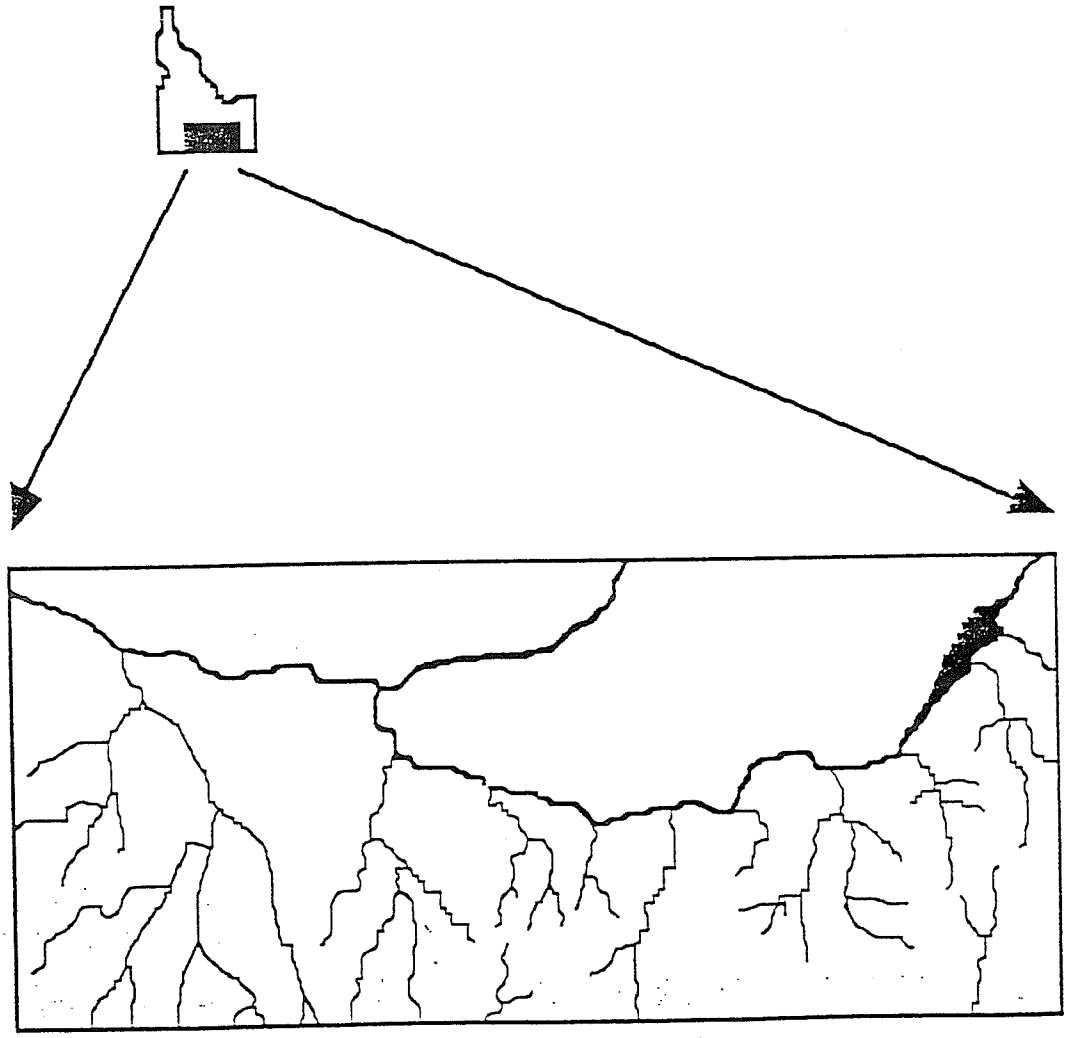

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INTRODUCTION

The Clean Water Act directs the U.S. Environmental Protection Agency to develop programs that will evaluate, restore, and maintain the chemical, physical, and biological integrity of the Nation's waters (USEPA 1990). For some time, evaluation of water quality has focused on the chemical criteria and single-factor toxicity tests. However, this approach has been inadequate for assessing all types of surface water pollution problems. Efforts currently are underway to improve the assessment procedure by incorporating in situ environmental conditions and more-complete evaluation of environmental conditions. To meet the objectives of the Water Quality Act and to comply with statutory requirements under Sections 303 and 304, States are to adopt narrative biological criteria in State standards by 1993. Adoption of numeric criteria is to follow later.

To provide direction for this effort, the EPA has developed a set of Rapid Bioassessment Protocols (RBP)(USEPA 1990) for the collection and utilization of biological data. A key step in developing values for supporting narrative (and creating numeric) biological criteria is to establish reference conditions. These define the least disturbed (unimpaired) characteristics and serve as the point of comparison for determining attainment or non-attainment, refining use designations, evaluating effectiveness of current programs, and detecting and characterizing previously unknown impairments. Integration of biological criteria into surface water management involves evaluation of impacted waters with comparable habitat characteristics using the same procedures as those used to establish the criteria. Resulting data are compared with reference conditions to determine extent of impairment.

Because of differences in environmental conditions, the structure and function of biological communities are expected to vary both at the levels of geographic region and habitat type.

Therefore, in an area as large and diverse as Idaho, biological responses (criteria) may be expected to vary from one location to another. Subdivision of the state into ecoregions recognizes this spatial diversity while allowing large areas of a similar type to be classified and examined together. An ecoregion is a relatively homogeneous area having similar geology, hydrology, land-use, and other ecologically relevant factors. There are nine ecoregions in Idaho but only about half of those cover sufficient area to be of concern. The Snake River Basin ecoregion, which covers most of the southern part of the state, is perhaps the most important of these because of its size and the substantial and varied uses to which the land is put.

The purpose of this project was to develop and test a biological assessment program for representative streams in the Snake River Basin ecoregion of southern Idaho. A habitat analysis component was included to provide an independent measure of environmental conditions. The overall goals of the project were to (1) determine the ecological conditions found in a series of relatively undisturbed (reference) stream habitats in the ecoregion, (2) use this information to examine a variety of measures (metrics) of biological integrity and determine their applicability to conditions found in the Snake River Basin ecoregion, and (3) demonstrate the utility of the ecological assessment approach by comparing conditions in environmentally impacted streams with those in the reference streams. The reference streams were further partitioned to cover the three major lotic habitat types in the region: (1) upland (high gradient), (2) lowland (low gradient), and (3) spring brook. The validation sites were anthropogenically perturbed locations representative of the major land use practice in the area: livestock grazing. Special effort was made to select designated "stream segments of concern" where ever possible (Clark 1990, Dunn 1990).

METHODS

Selection of Study Sites

Study sites were selected from candidate streams by reviewing existing literature concerning site conditions, discussions with agency personnel (United States Forest Service, Idaho Fish and Game, Bureau of Land Management, and Idaho Division of Environmental Quality) and private landowners, and field reconnaissance. Stream types analyzed included upland, lowland, spring, and impacted lowland sites on small 2-4th order streams (Strahler 1957). Upland sites were characterized as having greater slopes, more turbulent flow, and being higher in elevation than lowland sites (Table 1). The impacted sites were representative of lowland areas perturbed primarily by livestock grazing, and served for metric validation. Upland, lowland, and spring sites were selected to provide baseline data on "pristine" (best available) lotic habitats in each class, and to test the applicability of published metrics among habitat types of similar quality in the Snake River ecoregion. Of 54 sites examined during late April and May 1990, habitat assessment was conducted on 34 sites that appeared suitable after on-site inspection (Table 2). Of these 34 sites, 22 eventually were selected for rapid-bioassessment field sampling and analysis during June through August 1990 (Figure 1). These included a minimum of 5 sites from each of the four stream types.

Field reconnaissance provided an important avenue for the final selection of study sites from candidate streams. A two-page habitat assessment data sheet was used during field reconnaissance (Table 3). The first page provided for detailed information on physical and chemical characteristics (e.g. stream slope, elevation, land-use, vegetative characteristics, discharge (Platts et al. 1983), riparian conditions, substrate measures, water temperature, pH, specific conductance, alkalinity, and turbidity) for a site; and the second page allowed for the tally

Table 1. Summary habitat measurements recorded for each study site in the Snake River Basin Ecoregion for 1990.

STATION	TYPE	DATE COLLECTED	RATIO CHANNEL AREA (H/L)	MEAN WIDTH (m)	AREA SHOCKED (m-2)	RIPARIAN % COVER	AFDM (g/cm2)	CHL a (ug/cm2)	Q (m3/s)	TEMP (C)	SPEC. COND. (umhos)	ALKALINITY (mg/L) (CaCO3)	TOTAL HARDNESS (mg/L CaCO3)	pH	SUBST CV	SUBST AVG	SLOPE	% POOL	% RIFFLE	% RUN	BOM AFDM
3rd Fork	UP	07/17/90	0.28	5.4	189	50	0.001	0.009	0.12	9.0	78	68	90	7.6	0.94	20.8	2	6	22	72	
4th Fork	UP	07/17/90	0.25	4.5	157	60	0.000	0.053	0.07	9.0	36	52	52					1	24	75	
Buck	UP	06/20/90	0.33	3.5	88	50	0.001	3.520	0.03	15.2	137	105	121		0.74	10.5	9	30	35	35	1.71
Cottonwood	UP	06/14/90	0.22	2.9	145	30	0.000	0.176	0.10	14.3	59	35	40	7.9	1.28	15.7	1	10	27	63	8.12
Green	UP	06/14/90	0.38	2.8	280	65	0.000	0.221	0.12	10.0	22	10	42	7.3	0.66	28.4	12	4	82	14	5.46
Stinson	UP	06/14/90	0.25	2.2	66	80	0.000	0.329	0.10	13.6	27	14	40		0.76	6.4	9	11	47	42	2.35
Trapper	UP	06/15/90	0.48	3.7	130	1	0.001	1.022	0.36	16.7	151	109	139	8.0	0.66	5.5	2	4	24	72	2.37
Devil's Corral	SP	07/18/90	0.78	1.3	119	75	0.002	4.180	0.04	14.7	555	188	279	7.0	2.71	5.2	1	1	0	99	6.35
Dove	SP	08/30/90	0.36	1.9	57	50	0.001	3.496	0.07	12.0	29	7	12	7.3	1.59	6.2	2	0	0	100	3.05
Salmon Falls	SP	06/19/90	0.56	4.3	279	10	0.003	11.799	0.46	12.0	128	93	104	7.2	3.14	6.0	1	75	0	25	0.41
Sand Springs	SP	08/25/90	0.49	4.5	225	35	0.002	3.780	2.11	16.5	303	145	168	8.2	1.87	4.6	1	0	0	100	2.86
Vineyard	SP	07/18/90	0.83	7.8	273	1	0.002	2.247	0.36	15.5	500	205	270	7.6	1.86	22.0	2	2	13	85	2.93
Big Jack's	LO	08/25/90	0.52	4.4	110	50	0.002	6.376	0.15	18.0	125	67	60	8.9	0.61	18.2	1	19	7	74	
Cottonwood	LO	08/26/90	0.31	2.7	40	100	0.001	2.075	0.04	16.0	210	41	44	7.9	1.94	17.2	0.8	7	13	80	3.43
Lake Fork	LO	06/13/90	0.58	1.3	39	0	0.000	0.975	0.05	10.2	234	229	246	8.3	0.59	1.9	0.8	14	0	86	0.78
Little Jack	LO	07/21/90	0.21	3.3	99	65	0.001	1.212	0.05	18.8	125	57	50	7.9	0.89	8.4	0.8	3	9	89	5.63
Station	LO	06/13/90	0.25	4.5	293	0	0.029	27.377	0.14	10.2	281	248	294	8.0	0.99	1.3	1	2	2	96	1.10
Big Jack's	IM	06/19/90	0.42	5.8	319	5	0.002	8.445	0.16	18.0	153	66	57	6.4	1.46	17.5	1	8	4	88	1.20
Cassia	IM	06/18/90	0.36	6.7	402	7	0.002	4.163	0.45	13.5	115	81	106	8.3	0.94	5.2	0.5	20	36	44	2.13
Duncan	IM	06/19/90	0.25	2.2	77	30	0.002	3.609	0.01	14.1	100	56	46	7.1	1.54	13.7		5	0	95	18.39
Low Trapper	IM	06/21/90	0.34	6.6	198	25	0.010	7.202	0.34	14.5	151	119	161	8.5	1.25	8.3	1	3	21	76	1.49
Marys	IM	07/20/90	0.27	4.9	245	2	0.002	3.048	0.06	15.7	75	54	78	7.3	0.79	16.9	1	8	3	89	
Sheep	IM	06/20/90	0.33	6.6	198	3	0.004	2.835	0.59	14.7	72	57	68	7.9	0.81	10.6	2	7	20	73	1.96
Shoshone	IM	06/19/90	0.26	8.3	208	0	0.000	0.468	0.69	16.0	92	63	82	7.1	0.82	8.7	1	13	9	78	2.52

Note. 4th Fork and Duncan Creeks used in fish quantitative analysis only.

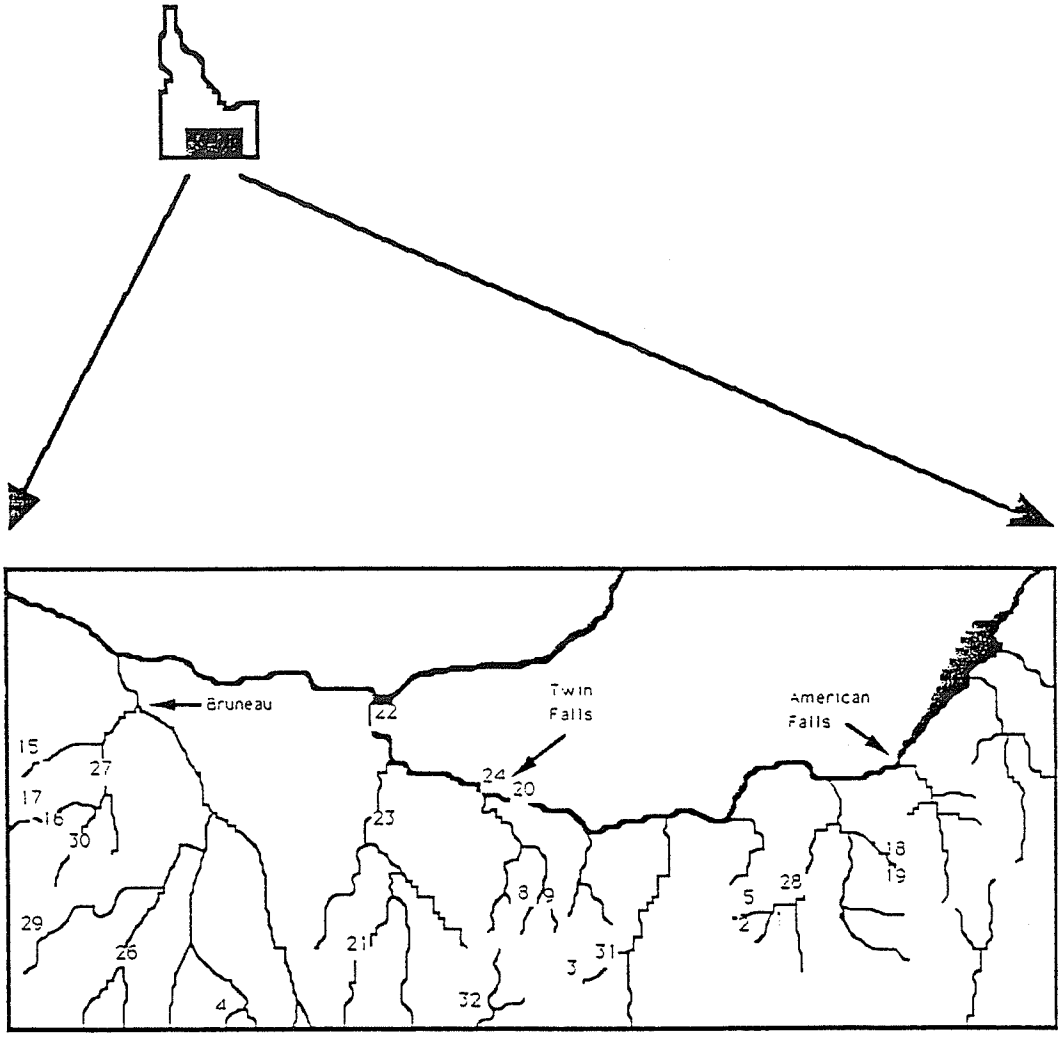


Figure 1. General locations of study streams for the Snake River Ecoregion bioassessment. Here, 1=Green Creek, 2=Stinson Creek, 3=Upper Trapper Creek, 4=Buck Creek, 5=Cottonwood Creek, 8=3rd Fork Rock Creek, 9=4th Fork Rock Creek, 15=Little Jack's Creek, 16=Upper Big Jack's Creek, 17=Cottonwood Creek, 18=Lake Fork Creek, 19=Station Fork Creek, 20=Vineyard Creek, 21=Dove Creek, 22=Sand Springs Creek, 23=Salmon Falls Creek, 24=Devil's Corral Creek, 26=Sheep Creek, 27=Lower Big Jack's Creek, 28=Cassia Creek, 29=Mary's Creek, 30=Duncan Creek, 31=Lower Trapper Creek, and 32=Shoshone Creek.

Table 2. Specific locations of Snake River Ecoregion study sites examined by field reconnaissance.

STREAM	7.5 TOPOGRAPHIC	LONGITUDE	LATITUDE	TOWNSHIP	RANGE	SECTION	ELEVATION	WIDTH
Green	Elba	113°43'	42°15'	T14S	R24E	11	1772	2.8
Stinson	Cache Peak	113°40'	42°15'	T13S	R24E	33	1848	2.2
Trapper	Severe Springs	114°08'	42°10'	T15S	R20E	10	1612	3.7
Buck	Dish Pan	115°25'	42°00'	T16S	R09E	28	1590	3.5
Cottonwood	O'connor Ridge	113°40'	42°15'	T13S	R24E	23	1500	2.9
Goose (Upper)	Timber Butte	114°15'	42°05'	T15S	R19E	31	1848	5.1
Six Mile	Strevell	113°10'	42°07'	T15S	R28E	16	1757	1.2
Rock (3rd Fork)	Grandview Peak	114°15'	42°15'	T13S	R19E	32	1575	5.4
Rock (4th Fork)	Grandview Peak	114°15'	42°15'	T13S	R19E	32	1575	4.5
Big Cottonwood	Buckhorn Canyon	114°05'	42°15'	T13S	R21E	30	1515	4.6
Ef Jarbridge	Murphy Hot Springs	115°20'	42°00'	T16S	R09E	25	1590	16.0
Trout	Mahogany Butte	114°10'	42°05'	T16S	R19E	12	1818	1.5
Eight Mile	Sandrock Canyon	113°10'	42°10'	T15S	R28E	4	1757	0.8
Cold	Blue Hill	113°55'	42°07'	T15S	R22E	21	1727	1.6
Little Jack's	Bighorse Basin Gap	116°00'	42°35'	T08S	R03E	16	1072	3.3
Lake Fork	Sublett	113°02'	42°20'	T12S	R29E	34	1634	1.1
Station Fork	Sublett	113°00'	42°20'	T13S	R29E	1	1636	4.5
Cottonwood	Hill Pasture	116°05'	42°32'	T10S	R03E	27	1455	2.7
Big Jack's (Upper)	Hill Pasture	116°02'	42°35'	T10S	R04E	18	1333	6.1
Vinyard	Kimberly	114°20'	42°35'	T10S	R18E	4	1067	7.8
Salmon Falls	Roseworth Ne	114°50'	42°25'	T11S	R14E	19	1136	4.2
Devil's Corral	Kimberly	114°20'	42°35'	T09S	R18E	32	1030	1.3
Sand Springs	Thousand Springs	114°50'	42°37'	T08S	R14E	17	939	9.5
Dove	Taylor Canyon	114°55'	42°05'	T15S	R13E	26	2012	1.7
Sheep	Triguero Lake	115°45'	42°15'	T14S	R06E	15	1467	6.6
Big Jack's (Lower)	Wickahoney Cross	116°00'	42°35'	T10S	R04E	4	1242	4.4
Cache	O'connor Ridge	113°30'	42°15'	T13S	R25E	22	1500	6.7
Mary's	Buckhorn	115°55'	42°10'	T14S	R04E	27	1730	4.9
Duncan	Hill Pasture	116°00'	42°34'	T10S	R04E	19	1364	4.8
Shoshone	Magic Hot Springs	114°30'	42°02'	T16S	R16E	24	1636	8.3
Deep	Buhl	114°50'	42°35'	T10S	R14E	8	1121	6.0
Goose (Lower)	Blue Hill	113°55'	42°05'	T15S	R22E	31	1467	8.2
Trapper (Lower0	Severe Springs	114°03'	42°10'	T15S	R21E	6	1539	6.6
Billingsley	Tuttle	114°50'	42°50'	T07S	R14E	19	909	5.2

Table 3. Example of habitat assessment field data sheet. Habitat parameters as defined by Plafkin et al. (1989).

IDAHO ECOREGION - HABITAT ASSESSMENT FIELD DATA SHEET

ECOREGION:_____
STREAM/TYPE:_____
DATE:_____
RECORDER:_____

GENERAL PHYSICAL CHARACTERISTICS
STREAM ORDER:
STREAM SLOPE:
SITE ELEVATION:
DISCHARGE:

LAND-USE
ADJACENT TO STREAM:
WATERSHED:

IN-STREAM VEGETATION:
RIPARIAN VEGETATION:
WATERSHED VEGETATION:

BANK EROSION PRESENT:
NPS POLLUTION EVIDENT:

STREAM WIDTH:_____,_____,_____,_____,_____

DEPTH: (1)____,____,____,____,____,____,____,____,____,____
(2)____,____,____,____,____,____,____,____,____,____
(3)____,____,____,____,____,____,____,____,____,____
(4)____,____,____,____,____,____,____,____,____,____
(5)____,____,____,____,____,____,____,____,____,____

VELOCITY:____,____,____,____,____,____,____,____,____,____
PROP #,TIME:_____,_____
PERCENT CANOPY COVER:
RIPARIAN ZONE WIDTH: rt bk____,____,____ lft bk____,____,____
PREDOMINANT SUBSTRATE:a-axis____,____,____ b-axis____,____,____

WATER QUALITY
TEMPERATURE:
ALKALINITY:
pH:
CONDUCTIVITY:
TURBIDITY:

WEATHER CONDITIONS:
PHOTOGRAPH NUMBER:
COMMENTS
ACCESSIBILITY:
LOCATION:
OWNERSHIP:

Table 3 (cont.)

IDAHO ECOREGION - HABITAT ASSESSMENT FIELD DATA SHEET

ECOREGION: _____

STREAM/TYPE: _____ SCORE _____

DATE: _____

RECORDER: _____

HABITAT PARAMETER	RANKING	COMMENTS
1. SUBSTRATE/COVER		
2. EMBEDDEDNESS		
3. FLOW/VELOCITY		
4. CHANNEL ALTERATION		
5. SCOUR/DEPOSITION		
6. POOL/RIFFLE		
7. BANK STABILITY		
8. VEGETATIVE STABILITY		
9. STREAMSIDE COVER		

RANKINGS:

PARAMETER	EXCELLENT	GOOD	FAIR	POOR
1-3	16-20	11-15	6-10	0-5
4-6	12-15	8-11	4-7	0-3
7-9	9-10	6-8	3-5	0-2

of a habitat score based upon the ranking of 9 categories. Riparian width was measured by pacing the width of the riparian zone at the 5 transects (30 m equidistant) where stream widths and depths were recorded. The habitat scoring page was derived from Plafkin et al. (1989). The habitat score for a site provided the data upon which the biological metrics were initially tested. In addition, photographs were taken of the stream site and surrounding riparian/watershed conditions.

On-site field reconnaissance and habitat assessment generally required about 5 person-hours per stream once the site was reached. Initial logistic planning in the laboratory using 1:100,000-scale planimetric maps made field reconnaissance more efficient. This procedure was emphasized due to the remote nature and travel distance of field sites in Southern Idaho from the base of operations. However, some sites were first examined on an impromptu basis while en route to a scheduled site. A minimum of 5 sites were selected from each of the 4 stream types. It is recommended that field crews also complete a habitat assessment field sheet at the time of sampling to take into account changes in habitat conditions since time of field reconnaissance.

Field Sampling of Fish and Benthic Macroinvertebrates

Qualitative sampling was completed at 24 selected sites, with additional quantitative samples collected at 5 of these sites. Generally, field sampling for macroinvertebrates and fish required 10 person-hours (5 crew members for 2 hours) per site to complete, but only 2 sites typically were completed in one day due to the remote locations of sites. Qualitative sampling followed protocols III and V of the Rapid Bioassessment Protocols recommended by the US Environmental Protection Agency (Plafkin et al. 1989). No separate "leaf pack" (coarse particulate organic matter/shredder) samples were collected due to a paucity of this

material in the streams at the time of sampling. The rarity of leaf packs during a significant portion of the ice-free period indicates that this metric may be of little value in this ecoregion except in mid to late autumn.

Benthic macroinvertebrates were qualitatively collected from riffle/run habitats using a metal-framed net (1 mm mesh, 30cm high x 60cm wide x 100 cm long) affixed to a "D"-style scoop shovel handle. A 3-minute sample was proportioned between riffle and run habitats after an initial assessment of the relative proportions of riffle, run, and pool habitat in a 150-meter length of stream. The material in the net was stored in labeled Whirl-pac(tm) bags and preserved with 10% formalin.

In addition, 3 quantitative benthic organic samples (BOM) were collected at riffle/run locations upstream of the qualitative sample at each site using a modified Hess net (250 um mesh)(Waters and Knapp 1961). Quantitative sampling followed the methodology described in Platts et al. (1983). Two additional BOM samples were collected at 5 sites. At these 5 sites all 5 BOM samples were used to quantify the benthic macroinvertebrates and to compare with results from the qualitative benthic samples.

In the laboratory, a 300-count sample of macroinvertebrates was systematically handpicked from each qualitative sample for metric analysis, except 4th Fork and Duncan Creeks. The BOM samples from the 5 quantitative sites had all macroinvertebrates removed for metric analysis, with the remaining material used for organic matter determination. All benthic macroinvertebrates from qualitative subsamples and quantitative samples were identified to lowest feasible taxonomic unit (usually species level) and enumerated. The 3 BOM samples from the remaining sites were used only for organic matter determination. Organic matter was determined by drying an entire sample, with only large macroinvertebrates removed, at 60 °C for 48-72 hours, weighing, ashing at 550 °C for 2 hours, rehydrating, redrying for 24 hours,

and reweighing. The difference in dry weights is the quantity of organic matter (as AFDM) for that sample. Specimens of all macroinvertebrate taxa collected were retained for voucher collections and housed at the Stream Ecology Center of Idaho State University; selected voucher specimens also were deposited with the Idaho Department of Health and Welfare, Bureau of Laboratories; and the Orma J. Smith Museum of Natural History, College of Idaho, Caldwell, Idaho.

Five periphyton samples also were collected at each site to further quantify the resource base. These were collected by scraping a known area from the surface of a stone and collecting the material onto a Whatman GF/F glass fiber filter (see Robinson and Minshall 1986). Upon filtering, the material was kept frozen until analysis in the laboratory for chlorophyll a and ash-free-dry-mass (AFDM). Initially, samples were ground in reagent-grade acetone using a Brinkmann tissue homogenizer (Model PT 10/35). Chlorophyll a was extracted in reagent-grade acetone and quantified using a Gilford Model 2600 spectrophotometer (APHA 1989). The AFDM of each sample was determined as described above for BOM using the material from chlorophyll a analysis.

Fish were collected using a Cofelt Model #2010 backpack electrofisher (110 or 220 AC voltage) downstream from the benthic macroinvertebrate sample section. All 24 qualitative sites had at least one pass made with the electrofisher along a maximum 100 m reach of stream encompassing a minimum of 2 riffles/runs and 2 pools, or a minimum of 100 fish collected. Blocknets were installed below and above each section prior to electrofishing. Three passes were completed at 5 sites for a quantitative estimate of fish abundance (Zippin 3-step method; Platts et al. 1983). The fish from each pass were identified, counted, weighed, and noted for any external anomalies. A specimen of each species was retained for reference and for verification of field identifications, and all remaining captured fish released. The voucher specimens were deposited in the Orma J. Smith Museum

of Natural History, College of Idaho, Caldwell, Idaho.

Data Analysis

Analysis of biotic metrics: Qualitative fish and macroinvertebrate samples were analyzed initially using metrics from Plafkin et al. (1989). These metrics for macroinvertebrates were Taxa Richness, Hilsenhoff Biotic Index, Ratio of Scrapers/Filterers, Ratio of EPT/Chironomidae Abundances, % Dominant Taxa, EPT Index, and Ratio of Shredders/Total Abundances. Criteria scores were modified, as recommended by Plafkin et al. (1989), to reflect the Snake River Ecoregion and study objectives. Values for criteria scores were determined using recommendations in Plafkin et al. (1989) and based on the relative distribution of scores for each metric. For example, metric values were transformed into relative values based on the highest value observed, then scores (i.e. 1, 3, or 5) determined based on these relative values as shown in Table 6. The HBI used an assumed scale from 0-10 (Hilsenhoff 1988), with tolerance values found in Plafkin et al. (1989). Future tolerance values for macroinvertebrates will be derived from Wisseman (1990). Metric criteria scores were summed for each site and initially regressed against habitat assessment scores. Additional linear regressions were run on these metrics against individual habitat measures (see Table 1). Multiple forward-stepwise regression was used to determine relationships between habitat variables and biotic metrics.

Biotic metrics for fish included: Number of native species; Number of sculpin; Dace; Young of year (YOY) trout; Number of cyprinid and trout species; Number of trout species; Number of intolerant species; % tolerant species (redside shiner); % omnivores (shiner, dace, YOY trout); % insectivores (sculpin; YOY trout); % adult trout; Total abundance; % hybrids/introduced; % anomalies; Condition Index of trout. Fish Condition Index was

calculated as: (weight in grams)/(total length^3)*(10^5). No subsequent additions or deletions from this list of fish metrics were made. The modified scoring criteria for the fish metrics are in Table 4 and were based on values found in Plafkin et al. (1989). Metric criteria scores were summed for each site and regressed against habitat assessment scores. Fish metric scores were further assessed using simple linear regression against additional habitat parameters. Multiple forward-stepwise regression was used to determine relationships between habitat variables and particular metrics.

Comparison Among Sites: Among-site-comparisons were conducted for biotic metrics (macroinvertebrates and fish) and habitat measures. Results were expressed as means ± 1 standard deviation. Cluster analysis was used to determine similarity among sites (Statsoft CSS, 1988). This analysis used among-site eigenvalues to cluster similar sites by Euclidean distance.

Quantitative vs. Qualitative Sampling: Five sites were used in the quantitative/qualitative comparison of macroinvertebrate metrics. Mean metric scores derived from the quantitative macroinvertebrate samples were used to test metric scores derived from the qualitative samples. Linear regressions were completed on quantitative biotic metric scores against qualitative biotic metric scores for each macroinvertebrate metric. In addition, a linear regression was completed for the summed quantitative metric scores against habitat assessment scores.

Fish abundance was quantified at 7 sites using the Zippin 3-pass method. Analyses consisted of regressing 1st-pass abundance against the estimated total abundance for a site. Further, the relative abundance of fish species was compared among passes for a site.

Modifications to Metrics and Habitat Assessment Score: We attempted to provide a better fit of macroinvertebrate biotic

Table 4. (a) List of fish species collected, trophic status, and tolerance category from streams in the Snake River ecoregion. (b) Adjusted IBI metrics used for fish data of the Snake River ecoregion.

A. Species List of Fish Collected, Trophic Status, Tolerance Category.

COMMON NAME	SPECIES	TROPHIC STATUS	TOLERANCE CATEGORY
Rainbow Trout	Oncorhynchus mykiss	insectivore	intolerant
Brown Trout	Salmo trutta	insectivore	intolerant
Brook Trout	Salvelinus fontinalis	insectivore	intolerant
Cutthroat Trout	Oncorhynchus clarki	insectivore	intolerant
Redside Shiner	Richardsonius balteatus	omnivore	tolerant
Mountain Sucker	Catostomus platyrhynchus	omnivore	tolerant
Bluehead Sucker	Catostomus discobolus	omnivore	tolerant
Mottled Sculpin	Cottus bairdi	insectivore	intolerant
Torrent Sculpin	Cottus rhotheus	insectivore	intolerant
Speckled Dace	Rhinichthys osculus	omnivore	tolerant
Longnose Dace	Rhinichthys cataractae	omnivore	tolerant
Chiselmouth	Acrocheilus alutaceus	omnivore	tolerant
Smallmouth Bass	Micropterus dolomieui	insectivore	tolerant

B. Adjusted IBI Fish Metrics and Associated Scores

1. Number of native species	(1=1, 1-3=3, >3=5)
2. Number of sculpin, dace, YOY trout	(<10=1, 10-20=3, >20=5)
3. Number of cyprinid and trout species	(1=1, 1-3=3, >3=5)
4. Number of trout species	(0=1, 1=3, >2=5)
5. Number of intolerant species	(0=1, 1=3, >2=5)
6. % tolerant species (shiner, dace, sucker)	(>25=1, 10-25=3, <10=5)
7. % omnivores (shiner, dace, YOY trout)	(>45=1, 20-45=3, <20=5)
8. % insectivores (sculpin, Adult trout)	(<20=1, 20-45=3, >45=5)
9. % adult trout	(<1=1, 1-5=3, >5=5)
10. Total abundance	(<33=1, 33-67=3, >67=5)
11. % hybrids/introduced	(>1=1, 0-1=3, 0=5)
12. % anomalies	(>5=1, 1-5=3, <1=5)
13. Condition Index	(<0.9=1, 0.9-1.0=3, >1.0=5)

metrics to the derived habitat assessment score by incorporating additional indices as described in Platts et al. (1983) and Fisher (1989). Additional metrics included: Chandler Biotic Index (CBS)(Chandler 1970), Biotic Condition Index (BCI)(Winget and Magnum 1979, Platts et al. 1983), Simpsons Index, % Shredders, % Collector-Gatherers, % Scrapers, % Predators, % Filterers, and % Miners (Fisher 1989). These indices were included with initial metrics, the relative data transformed [arcsine(X)], and the data regressed against the habitat assessment score using multiple forward-stepwise linear regression. Single correlation coefficients were used to test the significance of each variable found important in the multiple regression. Of the 16 metrics tested, 7 metrics consistently proved to be significantly correlated to the habitat assessment score: CBS, BCI, % Scrapers, %Filterers, S/F Ratio, EPT Index, and HBI. We selected five metrics from these seven due to redundancy of particular indices, namely among CBS, BCI, and HBI. The BCI and HBI were eliminated from the selected metrics due to the higher significance level of the CBS to the habitat score, and the ease of calculating the CBS. However, the HBI will be used in the future incorporating Wisseman' (1990) tolerance values to facilitate standardization. The combined criteria scores from these selected metrics were then linearly regressed against the habitat assessment score.

The habitat assessment score also was modified by running a multiple forward-stepwise regression of each of the five biotic metrics against all additional habitat measures recorded (Table 1) using transformed data [(arcsine(x)] and with intercorrelated habitat variables eliminated (e.g., alkalinity and total hardness) from the analyses (Zar 1984). These analyses indicated that measures of bankfull channel area to baseflow channel area (H/L ratio), average substrate size, and % riffle were important determinants of the selected biotic metrics. These habitat measures were incorporated into the habitat assessment score with channel area ranked from 0-15 and substrate size and % riffle

ranked from 0-20. The modified habitat assessment score was then linearly regressed against the modified macroinvertebrate metric score.

RESULTS

Habitat and Biotic Metric Scores: Habitat assessment scores ranged from 68 (Cold Creek) to 130 for upland sites, from 92-129 for lowland sites, from 72-123 for spring sites, and from 57-105 for impacted sites (Table 5). Maximum score possible was 130. We also determined habitat assessment scores using revised criteria developed by Barbour and Stribling (1990). The regression of initial habitat assessment scores and the revised habitat assessment scores (from Barbour and Stribling 1990) was high (r^2=0.86)(Figure 2), and thus similar results were found when habitat scores or revised habitat scores were regressed against macroinvertebrate metric scores. Consequently, original habitat assessment scores were used for data analysis.

In attempting to provide a better fit of macroinvertebrate metrics to respective habitat assessment scores we analyzed metric scores derived by respective stream type and regressed these values to macroinvertebrate metrics derived for the complete data set. Again, a strong positive regression resulted (r^2=0.56)(Figure 3), and consequently the regression of stream type biotic metric scores against habitat assessment scores was essentially unchanged (r^2=0.02). Macroinvertebrate metric scores and values used for analysis can be found in Table 6. Additional habitat measures made at each site are given in Table 1.

Metric Scores vs. Habitat Scores

Macroinvertebrates: The unmodified macroinvertebrate metric score provided a poor regression against habitat assessment score

Table 5. Summary of Habitat Assessment Field Data Scores. Categories from Plafkin et al. (1989).

STREAM	TYPE	SUBSTRATE COVER	EMBEDDEDNESS	FLOW TYPES	CHANNEL ALTERATION	BOTTOM DEPOSITION	POOL/RIFFLE RATIO	BANK STABILITY	VEGETATIVE STABILITY	STREAMSIDE COVER	TOTAL
Green	Up	20	20	15	15	15	15	10	10	10	130
Stinson	Up	20	20	18	15	15	13	10	10	9	130
Trapper	Up	19	20	19	20	11	13	10	10	8	130
Buck	Up	20	18	20	15	14	14	10	10	8	129
Cottonwood	Up	18	18	18	15	15	14	10	10	10	128
Goose (Upper)	Up	20	20	19	15	12	12	8	10	9	125
Six Mile	Up	18	19	15	15	15	13	10	10	9	124
Rock (3rd Fork)	Up	18	18	18	15	14	14	8	9	9	123
Rock (4th Fork)	Up	19	19	19	12	12	12	9	9	9	117
Big Cottonwood	Up	18	19	17	11	11	12	8	9	8	113
EF Jarbridge	Up	20	20	18	11	10	14	4	7	7	111
Trout	Up	16	20	8	10	10	6	7	7	8	92
Eight Mile	Up	18	19	8	5	13	4	5	8	7	87
Cold	Up	16	13	11	5	6	6	0	7	4	68
Little Jack's	Lo	18	20	16	15	15	15	10	10	10	129
Upper Big Jack's	Lo	20	14	18	15	11	15	10	10	10	123
Cottonwood	Lo	18	10	14	15	15	10	10	10	10	112
Lake Fork	Lo	15	18	10	15	14	11	9	10	5	108
Station Fork	Lo	15	18	10	11	9	10	5	8	6	92
Vineyard	Sp	17	18	15	15	15	13	10	10	10	123
Dove	Sp	12	16	10	14	14	9	10	10	10	105
Sand Springs	Sp	15	11	10	15	15	5	10	10	10	101
Salmon Falls	Sp	15	7	11	15	15	6	10	10	9	98
Devils Corral	Sp	10	0	1	15	15	2	10	10	9	72
Billingsley	Im/Lo	10	16	13	15	15	10	10	10	6	105
Sheep	Im/Lo	17	17	19	7	9	12	1	8	9	99
Lower Big Jack's	Im/Lo	10	11	15	11	11	13	7	10	5	93
Cassia	Im/Lo	15	11	17	6	6	13	7	9	8	92
Mary's	Im/Lo	13	11	17	6	6	13	1	8	7	82
Duncan	Im/Lo	16	16	7	12	6	8	1	8	6	80
Lower Trapper	Im/Lo	13	1	18	1	9	8	3	9	4	66
Shoshone	Im/Lo	8	3	8	10	10	6	4	10	4	63
Deep	Im/Lo	4	11	6	12	3	3	9	9	5	62
Goose (Lower)	Im/Lo	6	11	6	5	5	5	5	9	5	57

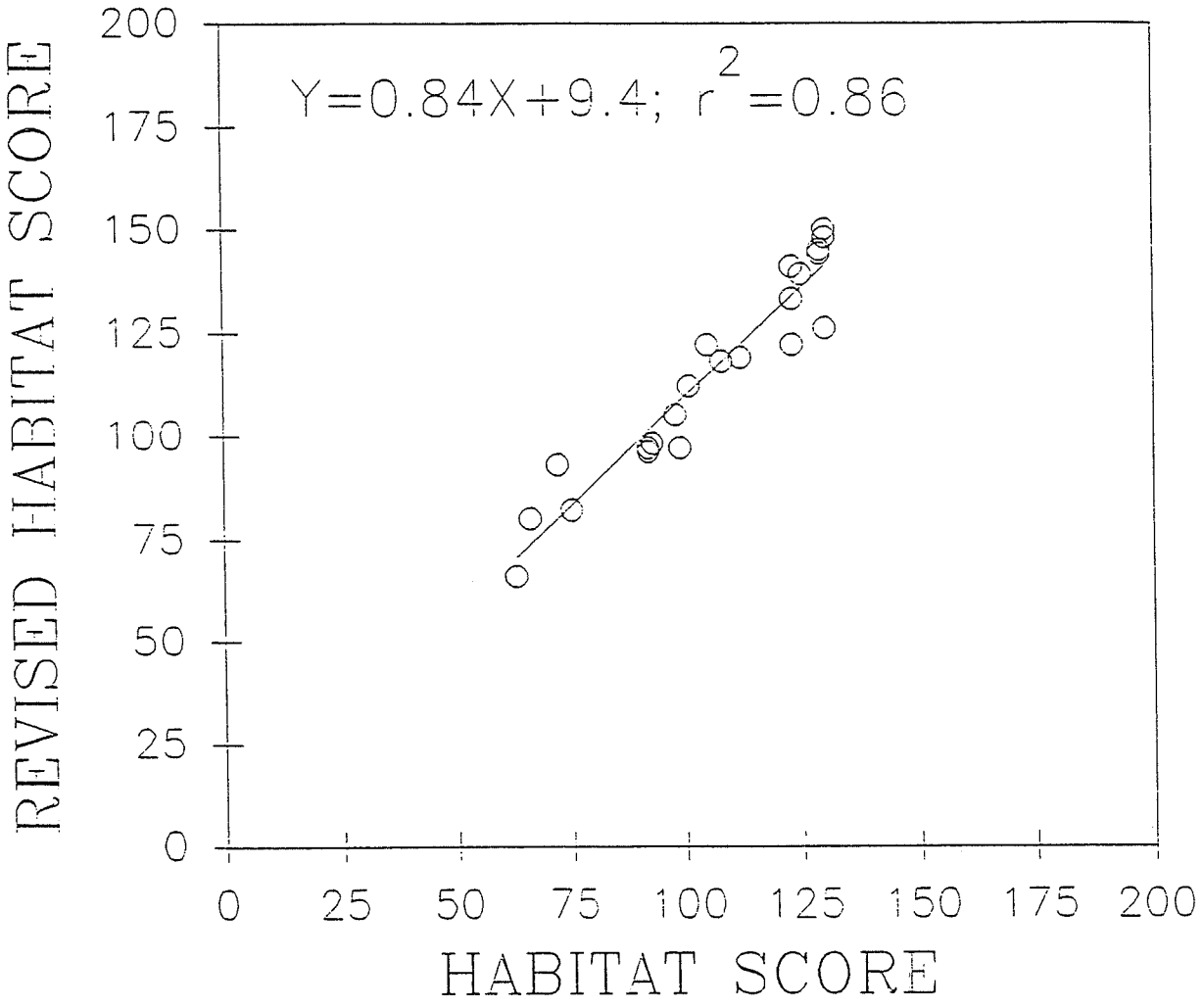


Figure 2. Regression of habitat assessment score (from Plafkin et al. 1989) against the revised habitat assessment score (from Barbour and Stribling 1990).

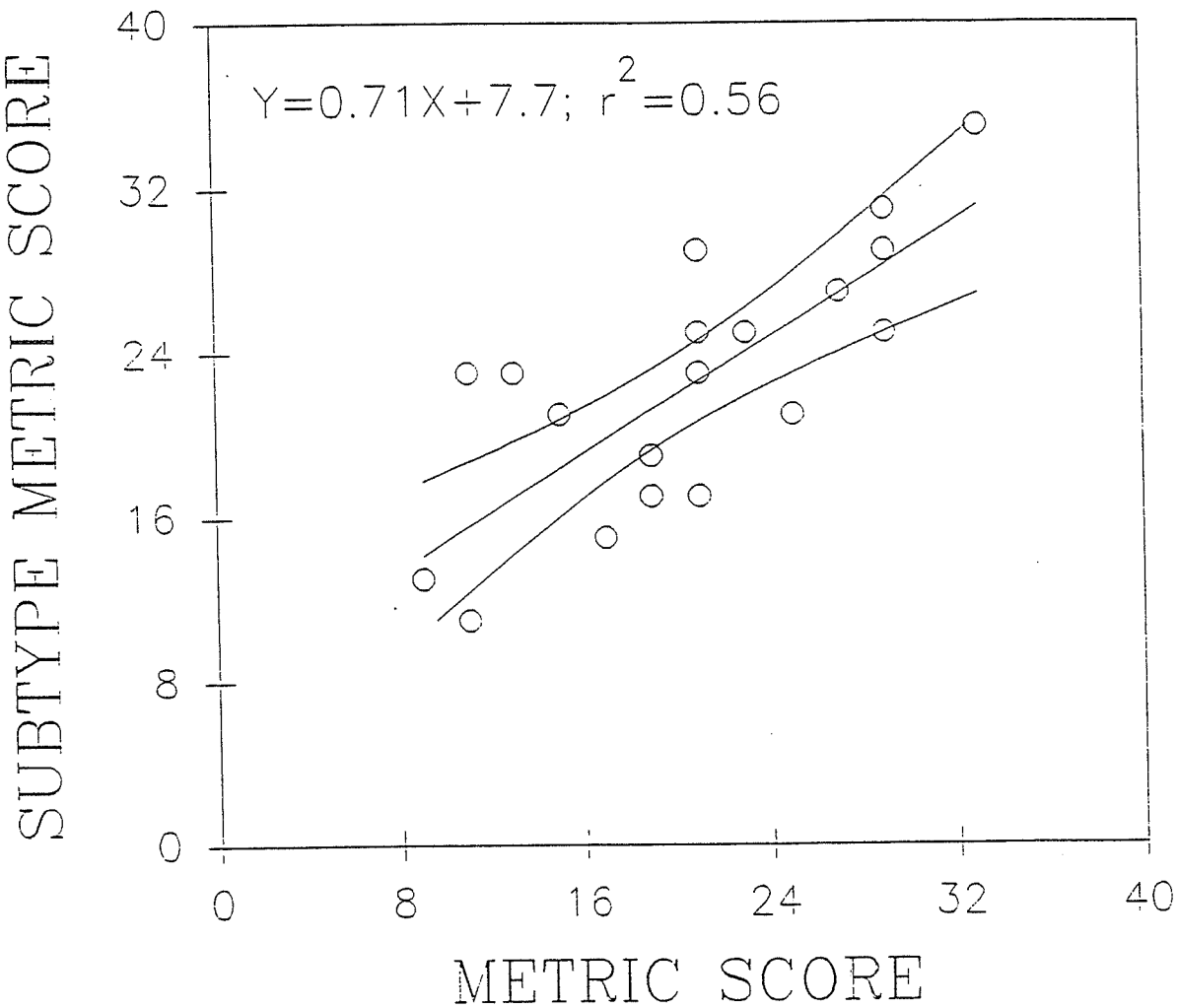


Figure 3. Regresssion of metric score against metric score by stream subtype. Bar bounded by 95% confidence limits. Metrics are for macroinvertebrates.

Table 6. Absolute and relative values for macroinvertebrate metrics by site with respective score.

Station		QUAL RICH	% RICH	SCORE	S/F RATIO	% S/F	SCORE	EPT/C RATIO	% EPT/C	SCORE	% DOM	% %DOM	SCORE	EPT INDEX	% EPT	SCORE	SHR/TOT	% SH/TOT	SCORE	HBI INDEX	% HBI	SCORE	TOTAL SCORE	HABITAT SCORE
3rd Fork	UP	19	56	3	0.40	2	1	1.51	5	1	0.42	48	3	10	48	5	0.052	40	3	4.29	72	5	21	123
Buck	UP	21	62	3	6.25	25	5	11.38	35	5	0.22	25	5	10	48	5	0.013	10	1	4.19	71	5	29	129
Cottonwood	UP	24	71	3	25.00	100	5	1.31	4	1	0.36	41	3	16	76	5	0.060	46	3	4.76	80	3	23	125
Green	UP	34	100	5	3.12	12	5	7.64	24	5	0.20	23	5	21	100	5	0.033	25	3	4.21	71	5	33	130
Stinson	UP	13	38	1	0.04	0	1	3.50	11	3	0.87	100	1	7	33	3	0.003	2	1	5.85	99	1	11	130
Trapper	UP	23	68	3	3.85	15	5	32.33	100	5	0.42	48	3	10	48	5	0.033	25	3	4.12	70	5	29	130
Devil's Corral	SP	20	59	3	0.57	2	1	1.04	3	1	0.58	67	1	7	33	3	0.030	23	1	5.85	99	1	11	72
Dove	SP	15	44	1	1.89	8	3	1.46	5	1	0.50	57	1	3	14	1	0.011	8	1	4.52	76	5	13	105
Salmon Falls	SP	23	68	3	0.30	1	1	4.69	15	3	0.44	51	1	4	19	1	0.010	8	1	4.75	80	3	13	98
Sand Springs	SP	17	50	3	1.89	8	3	0.69	2	1	0.35	40	3	5	24	1	0.033	25	3	5.51	93	1	15	101
Vineyard	SP	10	29	1	20.00	80	5	0.09	0	1	0.72	83	1	2	10	1	0.000	0	1	5.66	96	1	11	123
Big Jack (up)	LO	32	94	5	1.25	5	3	0.36	1	1	0.39	45	3	9	43	5	0.020	15	1	5.34	90	1	19	123
Cottonwood low	LO	28	82	5	12.50	50	5	1.67	5	1	0.28	32	3	12	57	5	0.130	100	5	4.07	69	5	29	112
Lake Fork	LO	22	65	3	0.67	3	1	2.04	6	1	0.18	21	5	7	33	3	0.003	2	1	5.21	88	3	17	108
Little Jack	LO	22	65	3	0.67	3	1	2.04	6	1	0.18	21	5	7	33	3	0.003	2	1	5.21	88	3	17	129
Station	LO	19	56	3	1.47	6	3	25.50	79	5	0.28	32	3	7	33	3	0.093	72	5	5.05	85	3	25	92
Big Jack Low	IM	23	68	3	0.75	3	1	2.81	9	1	0.20	23	5	9	43	5	0.000	0	1	4.54	77	5	21	93
Cassia	IM	21	62	3	1.16	5	3	0.95	3	1	0.26	30	5	9	43	5	0.003	2	1	5.01	85	3	21	92
Low Trapper	IM	20	59	3	1.20	5	3	11.92	37	5	0.26	30	5	8	38	3	0.060	46	3	4.65	79	5	27	66
Marys	IM	25	74	3	0.92	4	3	0.94	3	1	0.36	41	3	11	52	5	0.003	2	1	5.28	89	3	19	75
Sheep	IM	18	53	3	0.17	1	1	0.53	2	1	0.45	52	1	6	29	1	0.000	0	1	5.92	100	1	9	99
Shoshone	IM	25	74	3	0.46	2	1	4.00	12	3	0.11	13	5	8	38	3	0.057	44	3	4.84	82	3	21	63

METRIC SCORE DETERMINATION: Score is based on relative value of individual metric.

SCORE	as % RICHNESS	as % S/F Ratio	as % EPT/C	as % %DOM	as % EPT	as % SHR/TOT	as % % HBI
5	>80	>10	>20	<30	>40	>50	<80
3	50-80	5-10	10-20	30-50	30-40	25-50	80-90
1	<50	<5	<10	>50	<30	<25	>90

(r^2=0.019; Figure 4), although habitat assessment scores adequately indicated impacted sites. When individual biotic metrics were regressed against habitat assessment scores the S/F Ratio had the highest regression coefficient (r^2=0.13), and Species Richness and EPT/C Ratio the lowest (r^2=0.0009 and 0.0025; respectively)(Figure 5). The remaining biotic metrics had regression coefficients ranging from 0.04 (HBI Index) to 0.06 (EPT Index).

We next ran a correlation matrix of the macroinvertebrate metrics as dependent variables against the additional habitat measurements and the habitat assessment scores as independent variables (Table 7). In general, a measure of water chemistry (e.g. alkalinity, specific conductance, or total hardness) displayed strong negative associations with Species Richness, % Dominant, and EPT Index; and a strong positive association with the HBI. For Species Richness, relatively high correlation coefficients were found for % riparian cover (r=0.33), substrate size (r=0.37), slope (r=0.41), % riffle (r=0.44), and % run (r=-0.50). For S/F Ratio, relatively high correlation coefficients were found for only habitat type (r=0.30), and % pool (r=0.36).

For EPT/C Ratio, relatively high values were found for chlorophyll AFDM (r=0.56), chlorophyll a (r=0.45), and substrate size (r=-0.31)(Table 7). For % Dominant, high values were found for channel area (H/L) (r=0.62), and the CV of substrate size (r=0.48). For EPT Index, high correlation coefficients were found for channel area (H/L) (r=-0.41), % riparian cover (r=0.31), CV of substrate size (r=-0.39), substrate size (r=0.55), slope (r=0.62), % riffle (r=0.76), and % run (r=-0.51). For Shredder/Total Ratio, high values were found for channel area (H/L) (r=-0.36), % riparian cover (r=0.40), and chlorophyll AFDM (r=0.40). And for HBI Index, high correlation coefficients were found for measures of habitat type (r=0.31), channel area (H/L) (r=0.41), slope (r=-0.31), % riffle (r=-0.40), and % run (r=0.37)(Table 7).

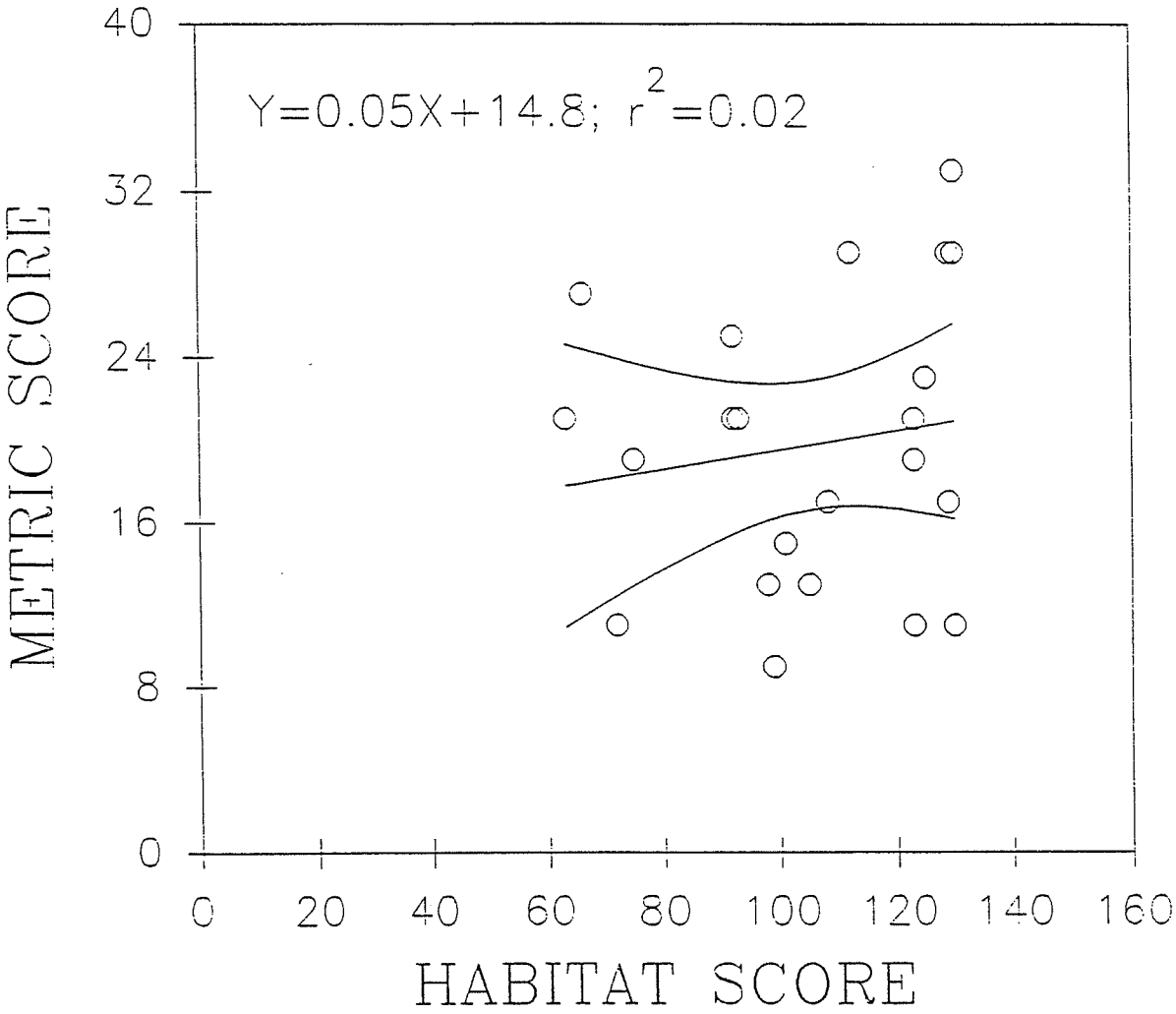


Figure 4. Regression of habitat assessment score against the macroinvertebratemetric score. Regression line bounded by 95% confidence limits.

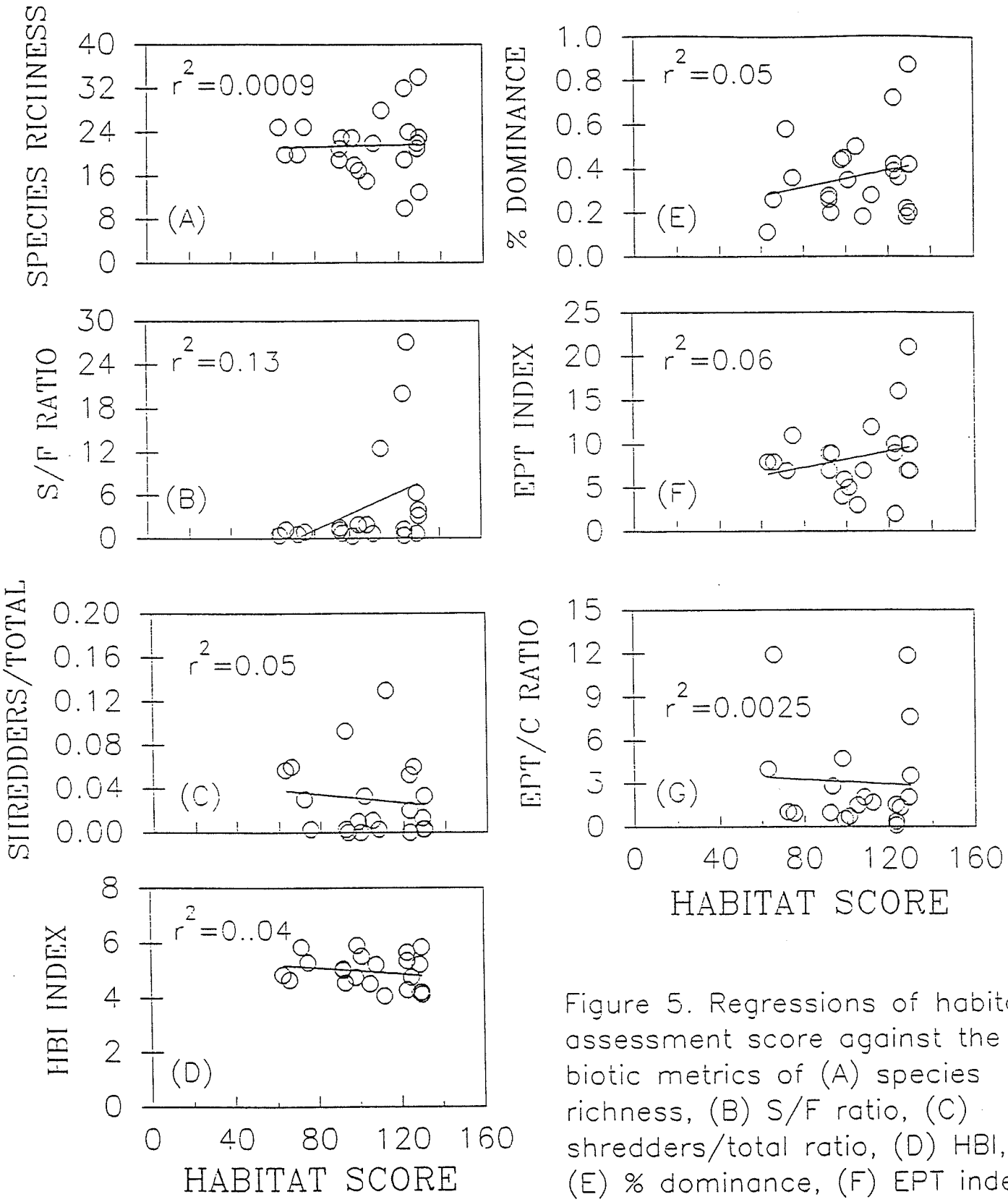


Figure 5. Regressions of habitat assessment score against the biotic metrics of (A) species richness, (B) S/F ratio, (C) shredders/total ratio, (D) HBI, (E) % dominance, (F) EPT index, and (G) EPT/C ratio.

Table 7. Correlation matrix (r-values) of macroinvertebrate metrics against physical habitat measurements. *=significant at p=0.10.

PARAMETER	RICHNESS	S/F RATIO	EPT/C RATIO	% DOMINANT	EPT INDEX	SHREDDER/TOTAL	HBI INDEX
STREAM TYPE	-0.08	-0.38*	-0.26	-0.31	-0.32	-0.03	0.33
CHANNEL AREA (H/L)	-0.27	0.11	-0.11	0.73*	-0.33	-0.28	0.45*
% RIPARIAN COVER	0.35	0.09	-0.24	-0.03	0.31	0.58*	-0.23
CHLOROPHYLL (AFDM)	-0.17	-0.12	0.43*	-0.08	-0.13	0.32	0.05
CHLOROPHYLL a	-0.14	-0.18	0.37*	-0.06	-0.21	0.24	0.03
DISCHARGE	-0.22	-0.11	-0.08	0.02	-0.22	-0.05	0.25
TEMPERATURE	0.03	0.01	-0.05	-0.11	-0.21	-0.12	0.15
CONDUCTIVITY	-0.37*	0.07	-0.05	0.57*	-0.35	0.02	0.52*
ALKALINITY	-0.41*	-0.07	0.31	0.17	-0.38	0.05	0.32
HARDNESS	-0.41*	-0.04	0.28	0.32	-0.34	0.05	0.38*
pH	0.17	0.01	0.07	-0.07	-0.07	0.09	0.12
HABITAT SCORE	0.21	0.37	0.15	0.11	0.31	-0.04	-0.28
CV SUBSTRATE SIZE	-0.22	0.04	-0.21	0.44*	-0.33	0.06	0.13
AVG SUBSTRATE SIZE	0.61*	0.25	-0.24	0.06	0.71*	0.05	-0.22
SLOPE	0.58*	-0.02	0.09	-0.21	0.75*	-0.08	-0.31
% POOL	0.07	-0.11	-0.07	0.01	-0.16	-0.17	-0.14
% RIFFLE	0.64*	0.11	0.11	-0.24	0.87*	0.01	-0.32
% RUN	-0.51*	-0.13	-0.08	0.26	-0.54*	0.06	0.38*
BOM	0.18	0.67*	-0.21	0.12	0.45*	0.15	0.03

CV=Coefficient of Variation; AVG=Average; BOM=Benthic Organic Matter.

Table 8 shows the results of multiple regression analysis for the dependent variables of habitat assessment score and the original macroinvertebrate metrics against the independent variables of physical habitat measures after intercorrelated independent variables were removed (Zar 1984). The habitat assessment score was included as an independent variable for multiple regression against biotic metrics. In general, the results indicate the importance of including water temperature and some measure of water chemistry, e.g. pH, conductivity, into the habitat assessment score (Table 8). Further, water chemistry measures were important for the biotic metrics of Species Richness, S/F Ratio, and the HBI. In addition, some measure of food resources was more important for a particular biotic metric than some other measure. For example, chlorophyll a was ranked first for the metric EPT/C Ratio. This is important because EPT taxa feed primarily on an algal resource and detritus derived from this resource. Further, the % riparian cover ranked high for the metric of Shredder/Total Ratio. This is important because shredders feed primarily on allochthonous resources. Finally, measures of habitat quality ranked high for the biotic metrics of S/F Ratio, % Dominant, and EPT Index (Table 8). These data provided information on important habitat measures to include in assessing habitats.

Fish: The fish data were analyzed by regressing IBI metric score, fish abundance (#/unit shock time), mean fish condition, and % occurrence of intolerant taxa against habitat assessment scores and various measures of water quality. Table 9 provides a summary for the biotic values used. The fish IBI score showed a relatively strong positive relationship with the habitat assessment score (r^2=0.34)(Figure 6). Fish abundance displayed a weak negative or no relationship to the parameters of interest (Figures 7 and 8). For example, negative regressions were found for the habitat assessment score (r^2=-0.16), specific conductance (r^2=-0.08), and discharge (r^2=-0.07); and no relationship for fish IBI score (r^2=0.0004), and temperature (r^2=0.0009). Fish

Table 8. Results of multiple stepwise regression for dependent variables of habitat score and individual macroinvertebrate metrics against independent variables derived from physical habitat measurements listed in correlation matrix table. Beta represents the regression coefficient (a constant)(Zar 1984).

DEPENDENT VARIABLE: Habitat Score F=83.7; df=10, 10; P=0.000

INDEPENDENT VARIABLES	BETA	R-SQUARE	SIGNIFICANCE
pH	.999	.961	.00128
STREAM TYPE	-.400	.978	.0045
AVG SUBSTRATE	.112	.984	.182
TEMPERATURE	.263	.985	.254
DISCHARGE	-.036	.986	.481
CONDUCTIVITY	-.017	.987	.839
% RIPARIAN COVER	.001	.988	.991
CV SUBSTRATE SIZE	-.098	.988	.504
% POOL	.055	.988	.534
% RUN	.093	.988	.662

DEPENDENT VARIABLE: Species Richness F=63.7; df=11, 9; p=0.000

INDEPENDENT VARIABLES	BETA	R-SQUARE	SIGNIFICANCE
pH	.529	.941	.171
SLOPE	.228	.954	.016
CONDUCTIVITY	.096	.960	.511
TEMPERATURE	.547	.966	.028
% POOL	.284	.971	.029
DISCHARGE	-.054	.975	.325
CHANNEL AREA (H/L)	-.160	.978	.440
% RIPARIAN COVER	.165	.979	.051
CV SUBSTRATE SIZE	-.326	.984	.069
HABITAT SCORE	-.314	.986	.201
% RUN	.213	.987	.431

DEPENDENT VARIABLE: S/F Ratio F=2.35; df=9, 11; p=0.0915

INDEPENDENT VARIABLES	BETA	R-SQUARE	SIGNIFICANCE
STREAM TYPE	.807	.525	.172
% POOL	.604	.594	.109
CHLOROPHYLL a	-.254	.603	.348
TEMPERATURE	-1.026	.607	.364
% RUN	1.201	.629	.318
SLOPE	.255	.644	.436
DISCHARGE	.113	.651	.621
CHANNEL AREA (H/L)	-.196	.655	.714
pH	-.404	.658	.767

Table 8. (cont.)

DEPENDENT VARIABLE: EPT/C Ratio	F=3.96; df=10, 10; p=0.0202		
INDEPENDENT VARIABLES	BETA	R-SQUARE	SIGNIFICANCE
CHLOROPHYLL a	.668	.386	.011
% RIFFLE	.769	.478	.029
AVG SUBSTRATE	-.772	.523	.054
HABITAT SCORE	-.470	.584	.557
CV SUBSTRATE SIZE	-.365	.616	.332
STREAM SIZE	-1.431	.635	.019
TEMPERATURE	2.084	.730	.064
% RIPARIAN COVER	-.357	.747	.178
DISCHARGE	-.254	.772	.236
% RUN	.765	.798	.280

DEPENDENT VARIABLE: % Dominant	F=20.72; df=9, 11; p=0.000012		
INDEPENDENT VARIABLES	BETA	R-SQUARE	SIGNIFICANCE
CHANNEL AREA (H/L)	.678	.891	.091
HABITAT SCORE	.500	.910	.071
CV SUBSTRATE SIZE	.580	.919	.049
% POOL	-.257	.925	.092
% RIPARIAN COVER	-.159	.930	.264
STREAM TYPE	-.145	.934	.350
DISCHARGE	-.072	.936	.456
CONDUCTIVITY	-.283	.940	.297
SLOPE	-.107	.944	.356

DEPENDENT VARIABLE: EPT Index	F=32.9; df=6, 14; p=0.0000		
INDEPENDENT VARIABLES	BETA	R-SQUARE	SIGNIFICANCE
HABITAT SCORE	.023	.814	.945
% RIFFLE	.412	.899	.001
TEMPERATURE	.389	.913	.291
DISCHARGE	-.120	.922	.197
CHANNEL AREA (H/L)	-.247	.928	.195
pH	.532	.934	.305

Table 8. (cont.)

DEPENDENT VARIABLE: Shredder/Total F=6.99; df=6, 14; p=0.0013

INDEPENDENT VARIABLES	BETA	R-SQUARE	SIGNIFICANCE
pH	1.587	.471	.029
% RIPARIAN COVER	.319	.552	.151
CHLOROPHYLL a	.204	.619	.303
CHANNEL AREA (H/L)	-1.515	.677	.019
CONDUCTIVITY	.664	.730	.086
STREAM TYPE	-.397	.750	.314

DEPENDENT VARIABLE: HBI Index F=118.6; df=12, 8; p=0.0000

INDEPENDENT VARIABLES	BETA	R-SQUARE	SIGNIFICANCE
pH	.514	.985	.047
CONDUCTIVITY	.123	.989	.316
STREAM TYPE	.101	.991	.287
CHANNEL AREA (H/L)	-.061	.992	.728
% RUN	.280	.992	.186
SLOPE	.087	.993	.168
% POOL	.081	.993	.368
CHLOROPHYLL a	-.043	.994	.397
% RIPARIAN COVER	-.045	.994	.445
CV SUBSTRATE SIZE	.017	.994	.882
TEMPERATURE	.025	.994	.884
DISCHARGE	.005	.994	.897

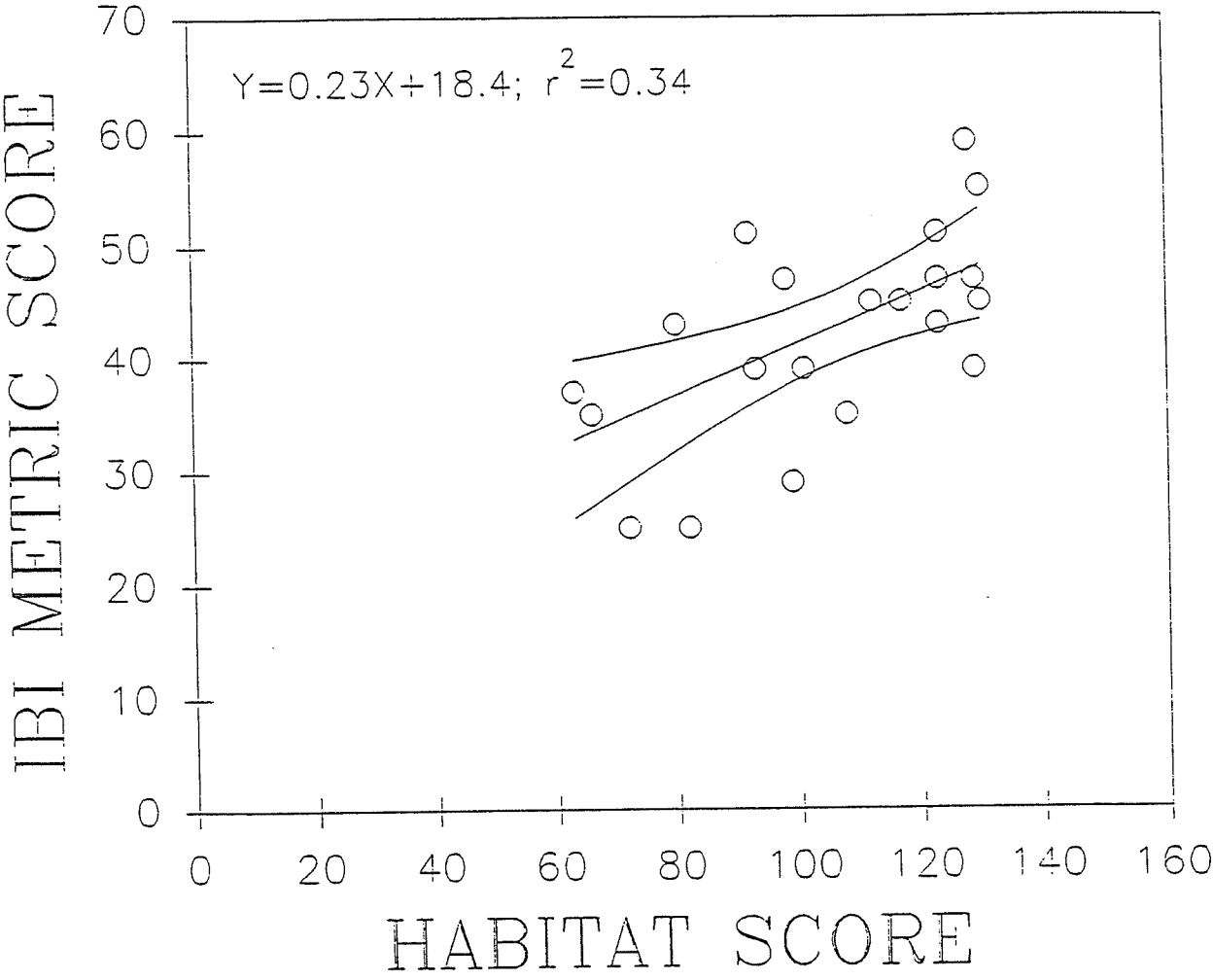


Figure 6. Regression of Habitat Assessment Score against Fish IBI metric score.

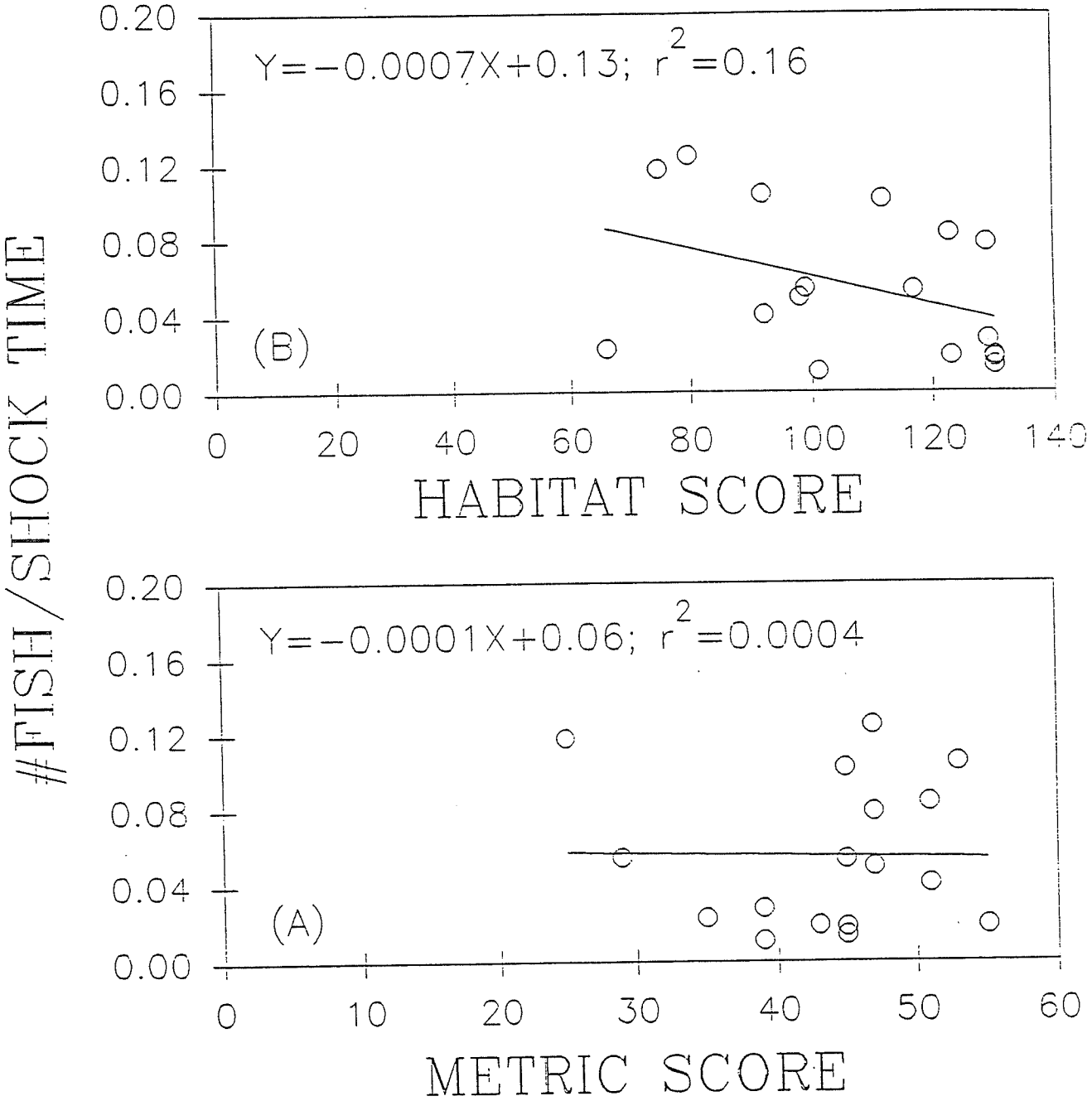


Figure 7. Regression of (A) fish IBI metric score, and (B) habitat assessment score against fish abundance expressed in terms of shock time.

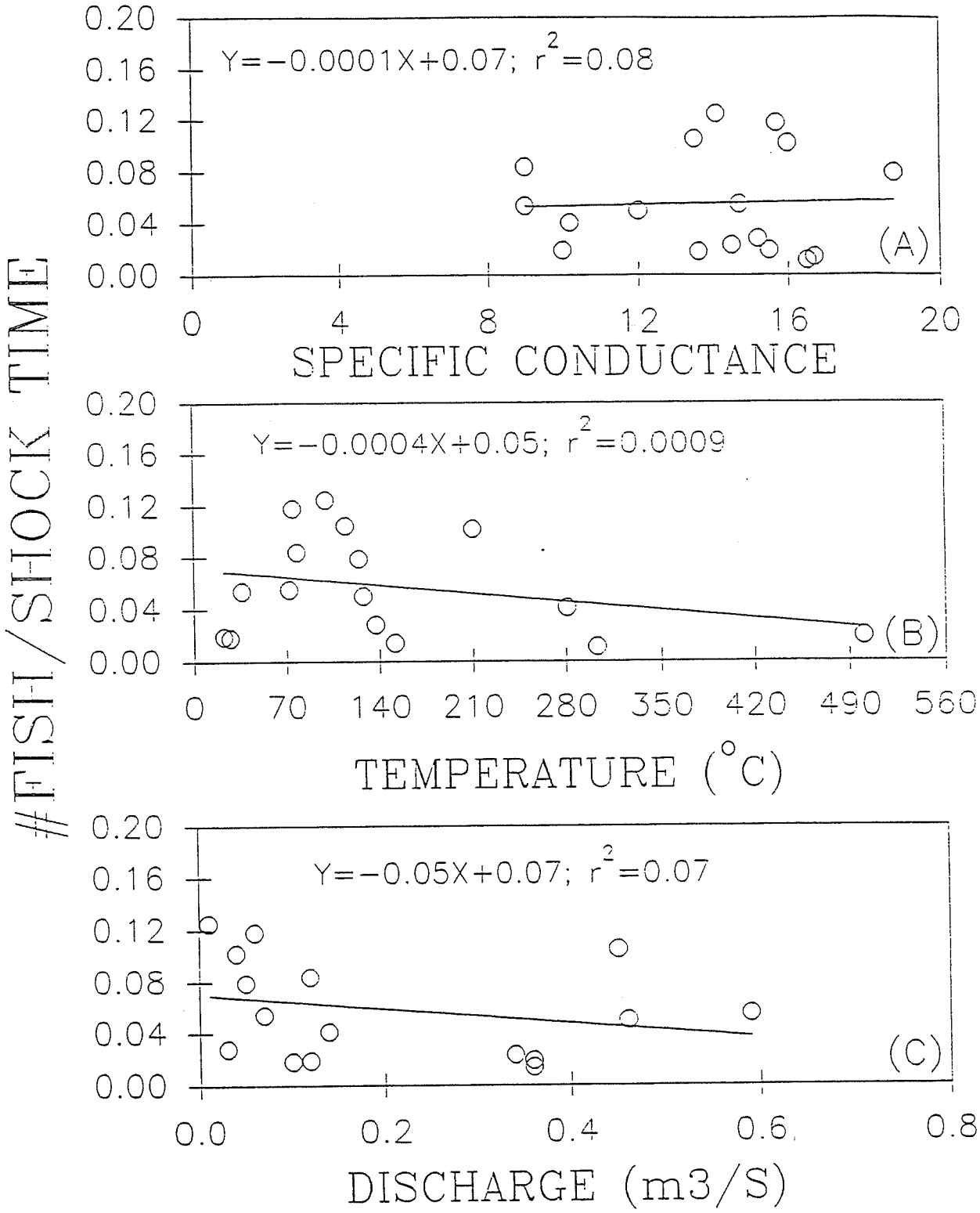


Figure 8. Regressions of (A) specific conductance, (B) temperature, (C) discharge against fish abundance expressed as per shock time.

Table 9. Summary of Habitat Score, IBI Fish Metric Score, fish condition index, and fish relative abundance by habitat type.

Station	Type	Habitat Score	IBI Score	Condition Index (N)	Abundance (#/unit time)
3rd Fork	UP	123	51	0.97(16)	0.08
4th Fo	UP	117	45	0.97(13)	0.05
Buck	UP	129	39	0.88 (7)	0.03
Cottonwood	UP	125	59	0.97(12)	
Green	UP	130	55	1.08(11)	0.02
Stinson	UP	130	45	1.07 (8)	0.02
Trapper	UP	130	45	1.00(14)	0.01
Devil's Corral	SP	72	25	NA	
Dove	SP	105	*	NA	
Salmon Falls	SP	98	47	1.05 (1)	0.05
Sand Springs	SP	101	39	0.71 (1)	0.01
Vineyard	SP	123	43	0.97 (6)	0.02
Big Jack (up)	LO	123	47	0.86 (3)	0.25
Cottonwood low	LO	112	45	0.86 (9)	0.10
Lake Fork	LO	108	35	0.85 (1)	
Little Jack	LO	129	47	0.73 (4)	0.08
Station	LO	92	51	0.95(14)	0.04
Big Jack Low	IM	93	39	0.78 (7)	
Cassia	IM	92	53	1.02 (1)	0.11
Duncan	IM	80	43	0.81(11)	0.13
Low Trapper	IM	66	35	1.05 (2)	0.02
Marys	IM	75	25	NA	0.12
Sheep	IM	99	29	NA	0.06
Shoshone	IM	63	37	NA	0.30

Note: Maximum value for Habitat Score = 130, maximum value for Fish IBI Score = 65, condition index derived from trout only. * No fish present.

condition displayed little relation to habitat assessment score (r^2=0.006), negative regressions with specific conductance (r^2=-0.08) and temperature (r^2=-0.35), and a positive regression with fish IBI metric score (r^2=0.14)(Figure 9). The % occurrence of intolerant taxa showed the strongest positive relationship with habitat assessment score (r^2=0.41), fish IBI metric score (r^2=0.37), specific conductance (r^2=0.04), and a negative relationship with temperature (r^2=-0.09)(Figure 10). These relationships also can be seen in the presence and absence of fish taxa by habitat type (Table 10). For example, tolerant species such as redside shiners, dace, and suckers appear, while cutthroat and brook trout disappear from the more impacted lowland sites.

A correlation matrix of the IBI metric score, fish abundance, and fish condition as dependent variables and physical habitat measures as independent variables indicate high correlation coefficients for channel area (H/L) (r=-0.40), specific conductance (r=-0.34), substrate size (r=0.37), and % riffle (r=0.30) for the fish IBI metrics (Table 11). For fish abundance high correlation coefficients were found for habitat type (r=-0.31), discharge (r=-0.32), temperature (r=-0.56), specific conductance (r=-0.32), slope (r=0.39), % riffle (r=0.59), and % run (r=-0.66). For fish condition high correlations were indicated against habitat type (r=-0.47), temperature (r=0.42), substrate size (r=0.32), and slope (r=-0.35)(Table 11).

Multiple forward-stepwise regression analysis was performed on the dependent variables of fish IBI metrics, fish abundance, and fish condition against the physical habitat measures. In general, the independent variables of pH, specific conductance, % riparian cover, and % riffle appeared important for the dependent fish variables (Table 12). For the dependent variable of fish IBI metrics the independent variable pH proved most important followed by habitat characteristics of average substrate size and channel area (H/L). For the dependent variable of fish abundance

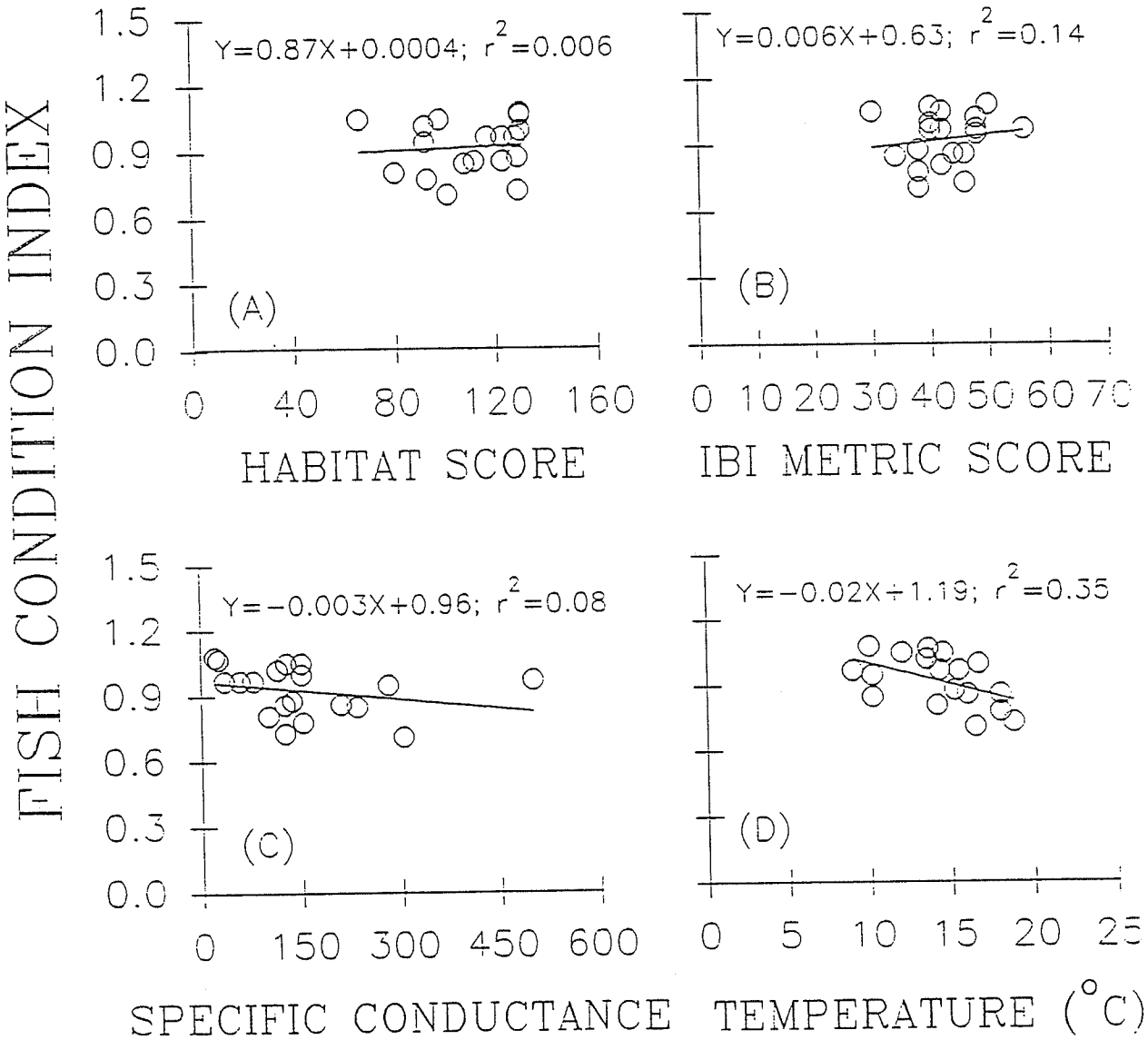


Figure 9. Regressions of (A) habitat assessment score, (B) IBI metric score, (C) specific conductance, and (D) temperature against fish condition index.

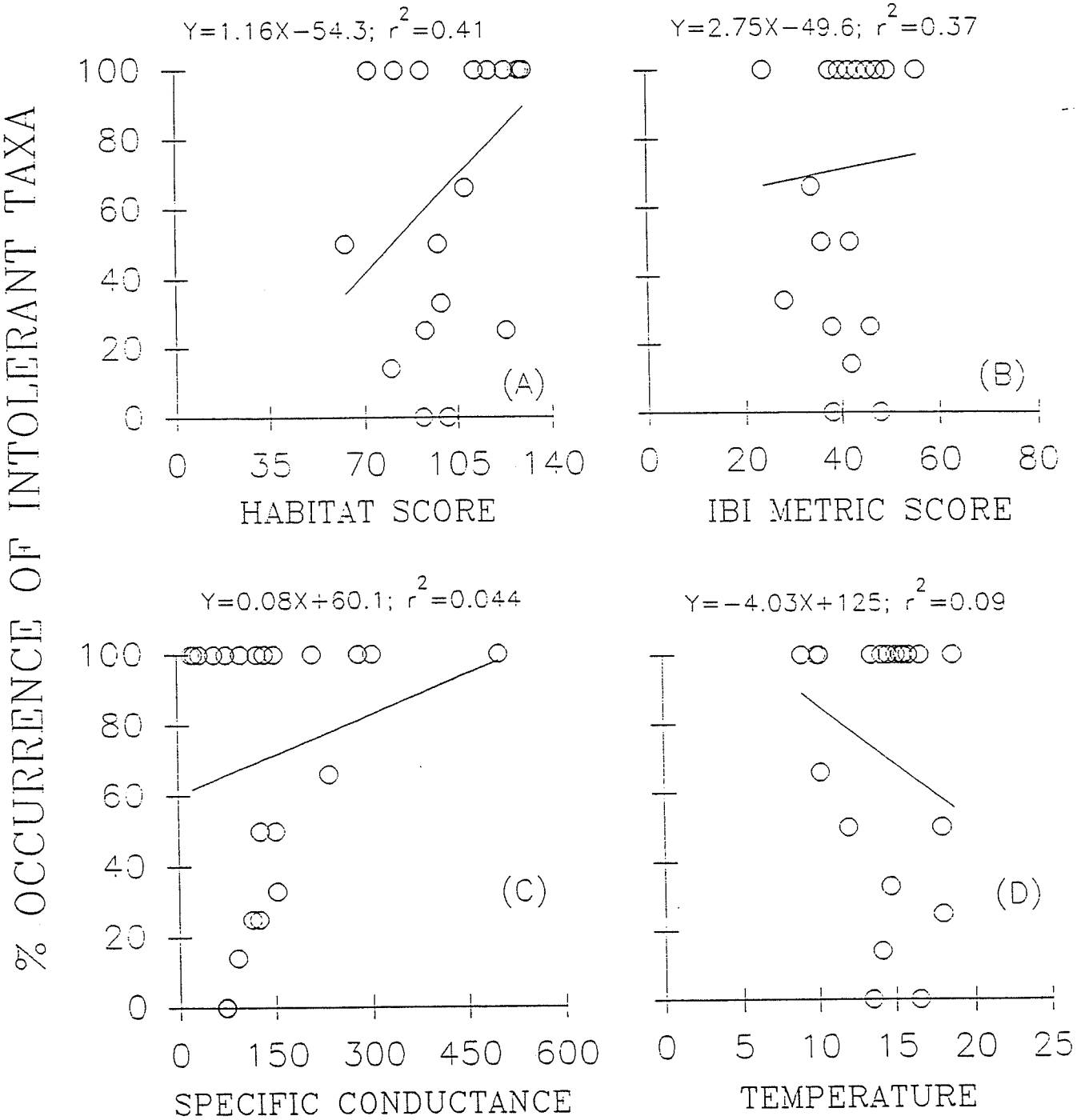


Figure 10. Regressions of (A) habitat assessment score, (B) fish IBI metric score, (C) specific conductance, and (D) temperature against the % occurrence of intolerant fish taxa.

Table 10. List of fish species and number captured in one pass of electrofisher at Snake River Basin ecoregion study sites.

STREAM	TYPE	STREAM NUMBER	DATE COLLECTED	Rainbow Trout	Brook Trout	Cutthroat Trout	Brown Trout	Mottled Sculpin	Torrent Sculpin	Redside Shiner	Mountain Sucker	Bluehead Sucker	Speckled Dace	Longnose Dace	Chiselmouth	Smallmouth Bass
Green	Up	1	900614	1	10											
Stinson	Up	2	900614		8											
Trapper	Up	3	900615	12				1								
Buck	Up	4	900620	7												
Cottonwood	Up	5	900614	13	10	1		9								
Rock (3rd Fork)	Up	8	900717	42												
Vineyard	Sp	20	900718	6												
Dove	Sp	21	900830													
Sand Springs	Sp	22	900825	1				1								
Salmon Falls	Sp	23	900619	1				1		21						2
Devils Corral	Sp	24	900718							5	5					
Little Jack's	Lo	15	900721	10				11								
Big Jack's (Upper)	Lo	16	900825	3						55	12			42		
Cottonwood	Lo	17	900826	9												
Lake Fork	Lo	18	900613	2					2	5						
Station Fork	Lo	19	900613	9			4	6	5							
Sheep	Im	26	900620							19			19			
Big Jack's (Lower)	Im	27	900619	5						17	35		34			
Cassia	Im	28	900618	1				47		11				2		
Marys	Im	29	900720							24				5		
Duncan	Im	30	900815	17										4		
Trapper (Lower)	Im	31	900621	2												
Shoshone	Im	32	900619					2		31		20	3		2	1

Table 11. Correlation matrix (r-value) of fish IBI metrics, fish abundance, and fish condition index against physical habitat measurements. *=significant at p=0.10.

PARAMETER	IBI METRICS	ABUNDANCE	CONDITION
STREAM TYPE	-0.297	-0.307	-0.465*
CHANNEL AREA (H/L)	-0.396*	-0.012	-0.051
% RIPARIAN COVER	0.219	-0.085	0.044
CHLOROPHYLL a	0.009	0.025	0.098
DISCHARGE	-0.228	-0.322	-0.237
TEMPERATURE	-0.194	-0.555*	0.419*
CONDUCTIVITY	-0.342	-0.318	-0.196
pH	-0.069	0.043	-0.126
AVG SUBSTRATE SIZE	0.365*	0.116	0.319
SLOPE	0.052	0.386*	-0.346
% POOL	-0.025	0.246	0.058
% RIFFLE	0.303	0.588*	-0.275
% RUN	-0.232	-0.661*	0.187

Table 12. Results of multiple stepwise regression for dependent variables of fish IBI metrics, fish abundance, and fish condition index against independent variables derived from physical habitat measurements listed in correlation matrix table. Beta represents the regression coefficient (a constant)(Zar 1984).

DEPENDENT VARIABLE: Fish IBI Metrics F=95.6; df=9, 8; p=0.0000

INDEPENDENT VARIABLES	BETA	R-SQUARE	SIGNIFICANCE
pH	1.178	.972	.00026
AVG SUBSTRATE	.278	.980	.018
CHANNEL AREA (H/L)	-.431	.983	.045
% RIPARIAN COVER	-.106	.985	.221
% POOL	.106	.988	.097
CONDUCTIVITY	.133	.989	.288
STREAM TYPE	-.112	.990	.271
SLOPE	-.081	.990	.426
% RIFFLE	.078	.991	.527

DEPENDENT VARIABLE: Fish Abundance F=6.68; df=10, 7; p=0.0097

INDEPENDENT VARIABLES	BETA	R-SQUARE	SIGNIFICANCE
STREAM TYPE	.612	.608	.141
AVG SUBSTRATE	.902	.667	.009
CONDUCTIVITY	-.877	.737	.024
% RIFFLE	-.784	.855	.072
TEMPERATURE	1.039	.884	.175
% RIPARIAN COVER	-.195	.889	.440
CHLOROPHYLL a	.122	.894	.554
SLOPE	.112	.900	.754
% POOL	-.114	.902	.575
% RUN	-.290	.905	.667

DEPENDENT VARIABLE: Fish Condition F=287.9; df=6, 11; p=0.000

INDEPENDENT VARIABLES	BETA	R-SQUARE	SIGNIFICANCE
pH	1.084	.981	.00001
% RUN	-.186	.988	.108
% RIPARIAN COVER	-.079	.989	.084
AVG SUBSTRATE	.082	.992	.131
CHLOROPHYLL a	.047	.993	.196
% RIFFLE	.067	.997	.270

measures of stream type, average substrate size, specific conductance, and % riffle were important. The independent variables of pH, % run, and % riparian were important determinants for the dependent variable of fish condition (Table 12). These data provided additional insights into important variables to include in assessing aquatic habitats.

Habitat and Biotic Metric Scores among Different Stream Types

Habitat Scores: The impacted lowland sites displayed the lowest habitat scores among stream types averaging a total score less than 90 (Figure 11). Spring sites also displayed low habitat scores, usually less than 100, although appearing relatively pristine. Both upland and lowland sites received average habitat assessment scores greater than 100, although scores for upland sites were highest (>120)(Figure 11). These data suggest that either habitat scoring was biased towards heterogeneous habitat types, or that spring sites were not as pristine as upland and lowland sites (unlikely). Spring sites may display low habitat values due to the homogeneous physical characteristics of such habitats. However, these characteristics may be offset by other outstanding features of springs (e.g., high water quality, optimal year round temperatures, habitat stability, etc.) in terms of suitability for fish and other aquatic life. The fact that impacted lowland sites scored lower than pristine lowland sites further suggests that the index is sensitive to habitat heterogeneity.

A cluster analysis of sites using habitat measures alone generally grouped stream types together (Figure 12). These groupings tended to follow habitat conditions observed in the field. Spring sites were mixed among other types except that Devil's Corral Creek and Vineyard Creek grouped together. Sand Springs Creek, a spring site, and Cottonwood Creek, a lowland site, did not group with any other site. Salmon Falls Creek,

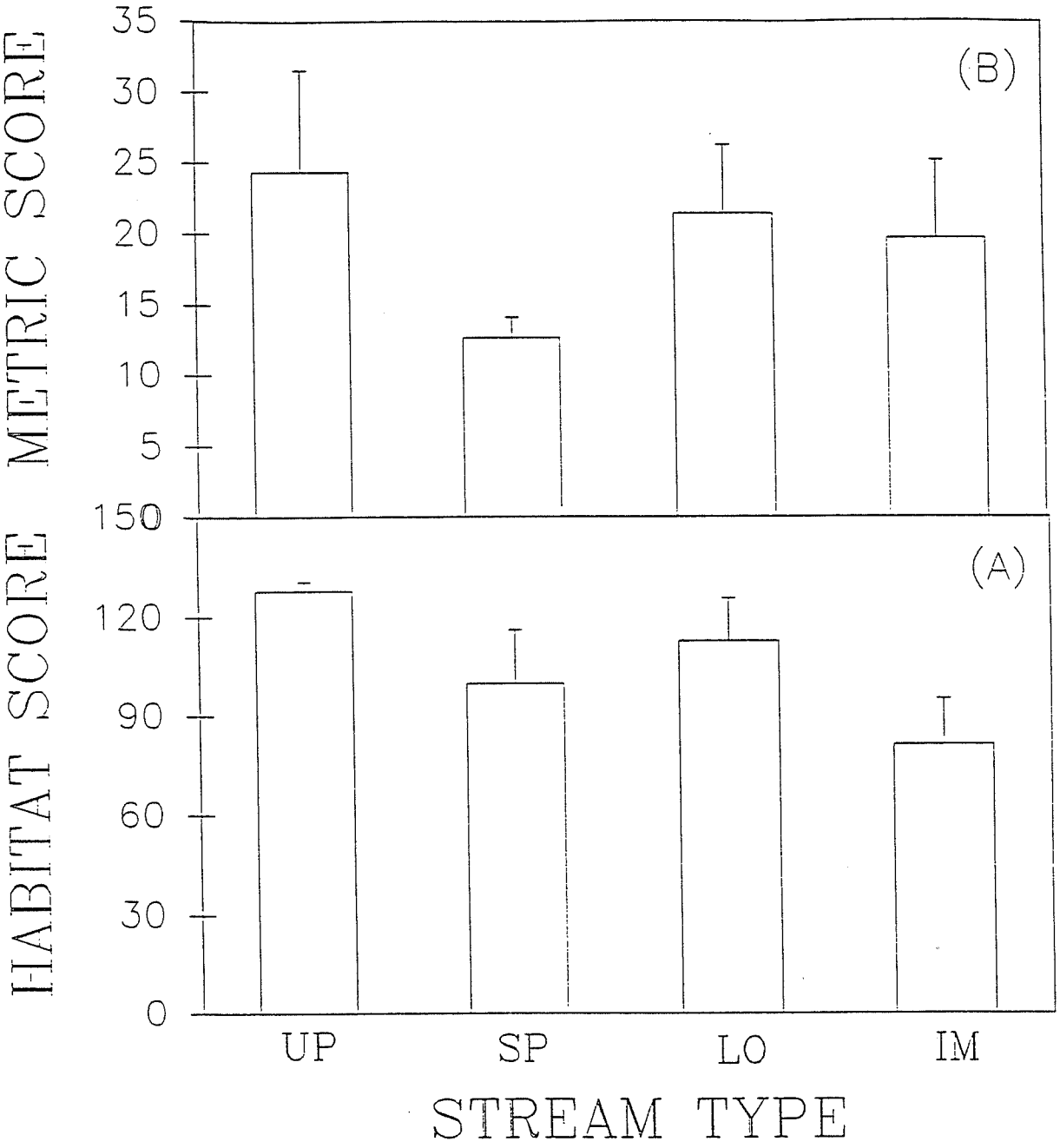


Figure 11. Bar graph of (A) habitat assessment score; and (B) macroinvertebrate metric score by stream type. Bars represent mean score +1 SD. Sample size is UP=7, SP=5, LO=5, IM=7.

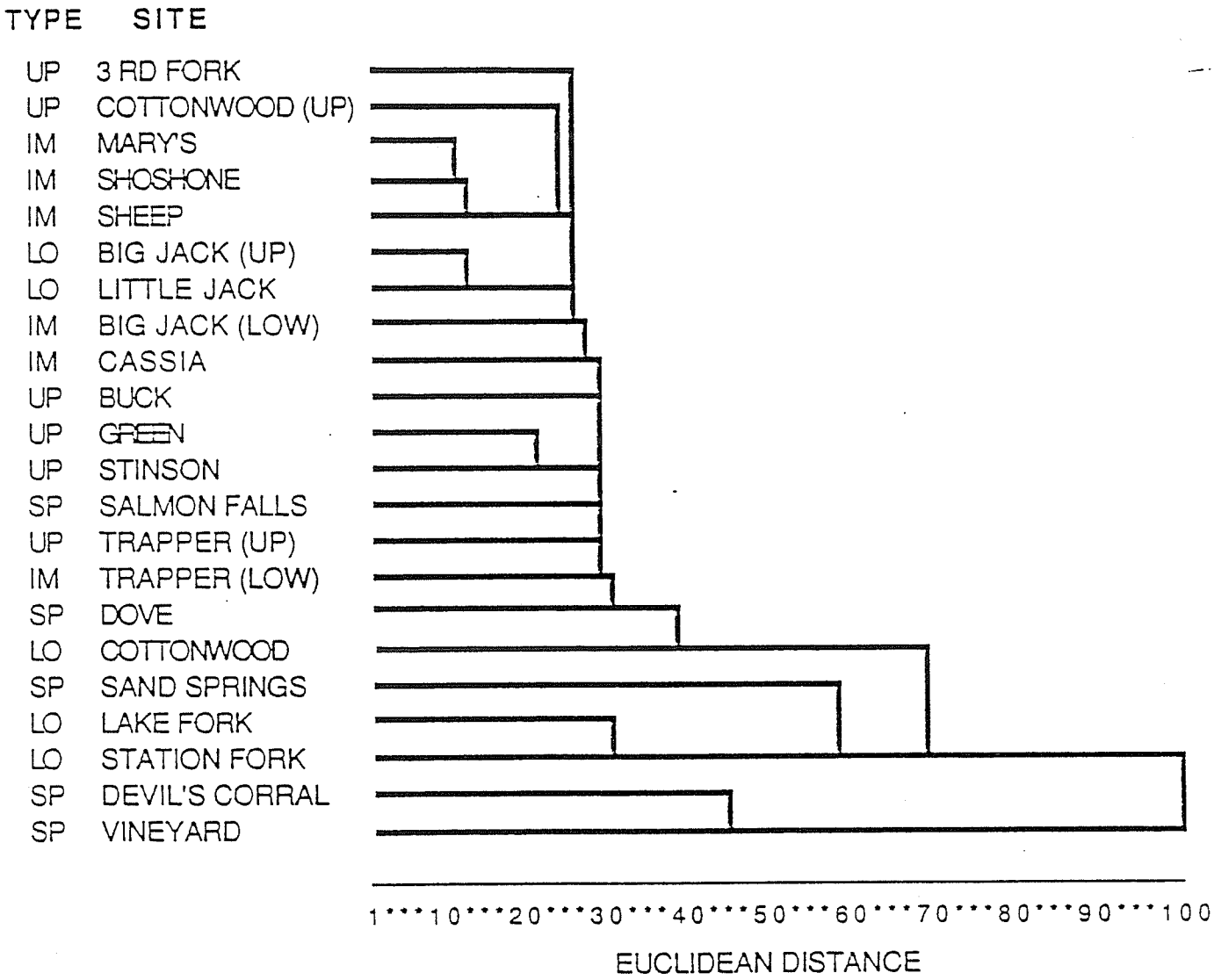


Figure 12. Cluster analysis of streams in the Snake River Ecoregion based on habitat measures.

classed as a spring site because it has been fed almost continually and extensively by groundwater for the past 80 years, actually grouped with the upland sites. Mary's, Shoshone, and Sheep Creeks, all impacted sites, grouped together (Figure 12).

Macroinvertebrate metrics and stream types: Spring sites had a lower average biotic metric score than all other stream types (Figure 11). No significant difference in mean biotic metric score was observed among upland, lowland, and impacted sites (ANOVA, $p=0.05$), although upland sites tended to have a higher mean metric score than other stream types. Species Richness was lowest in spring streams, and similar among other stream types (Figure 13). The S/F Ratio was lowest in impacted lowland sites, reflecting the low abundance of scrapers in these sites. The EPT Index was greatest for upland sites and lowest for spring sites. EPT Index values were essentially the same for lowland and impacted sites (Figure 13). The EPT/C Ratio scores were lowest in spring and impacted sites, and were similar in upland and lowland sites. The % Dominance scores were greatest for upland and spring sites, whereas lowland and impacted sites had lower but similar values. The Shredder/Total Ratio was not significantly different among stream types ($p=0.05$), although somewhat higher values were found in lowland streams. The HBI Index score was lowest for upland sites and similar among other stream types, although spring sites had the highest HBI Index scores (Figure 13).

A cluster analysis of sites using habitat assessment scores and biotic metric scores clumped stream types less distinctly than using habitat measures alone, although groupings of stream sites appeared more distinct (Figure 12 vs. Figure 14). For example, Stinson Creek, an upland site, was grouped closely with other upland sites using habitat measures but was isolated from other sites using biotic metric scores and habitat measures. Stinson Creek had a predominance of filterers (Simuliidae: blackflies) at the time of sampling. However, other upland sites

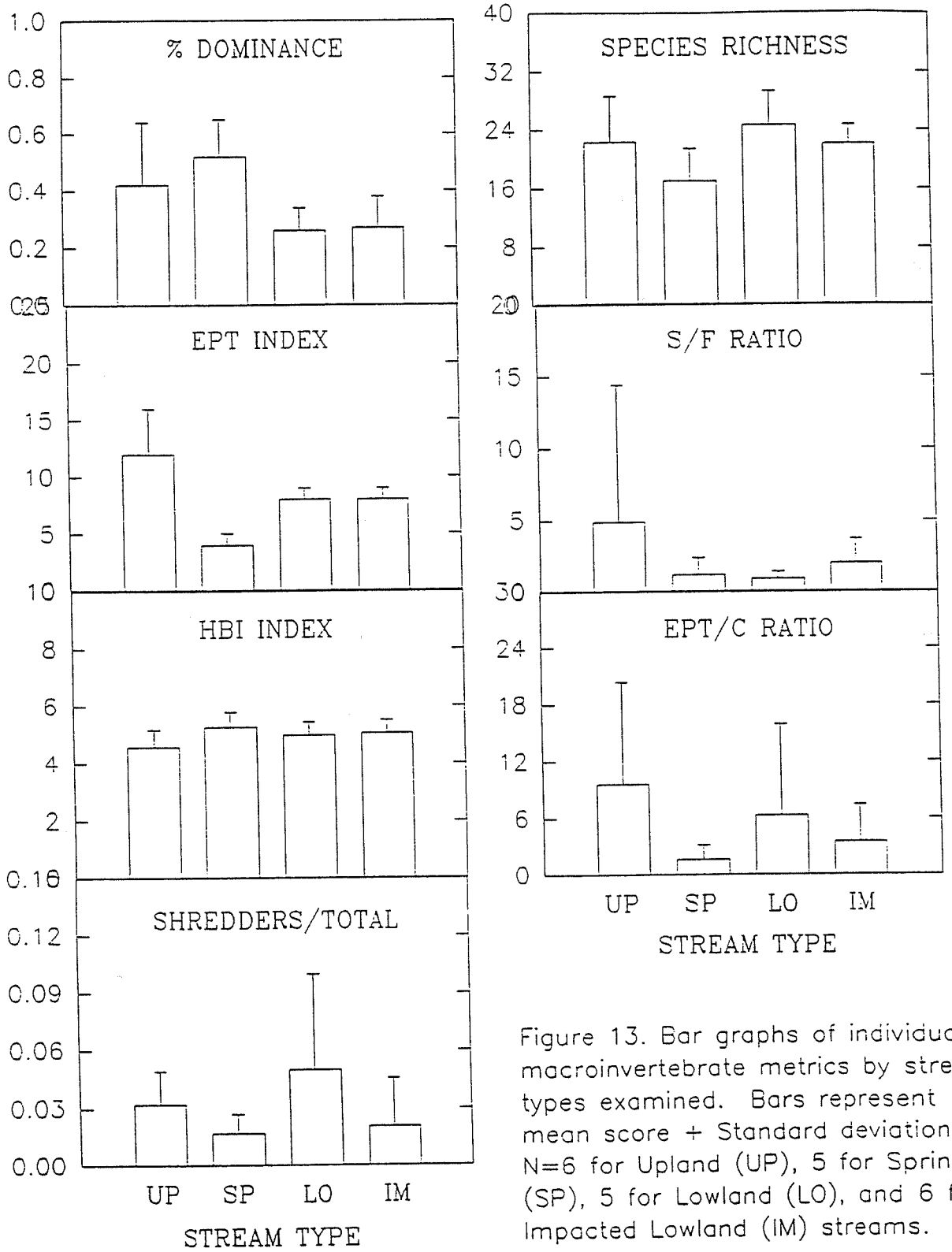


Figure 13. Bar graphs of individual macroinvertebrate metrics by stream types examined. Bars represent mean score + Standard deviation. N=6 for Upland (UP), 5 for Springs (SP), 5 for Lowland (LO), and 6 for Impacted Lowland (IM) streams.

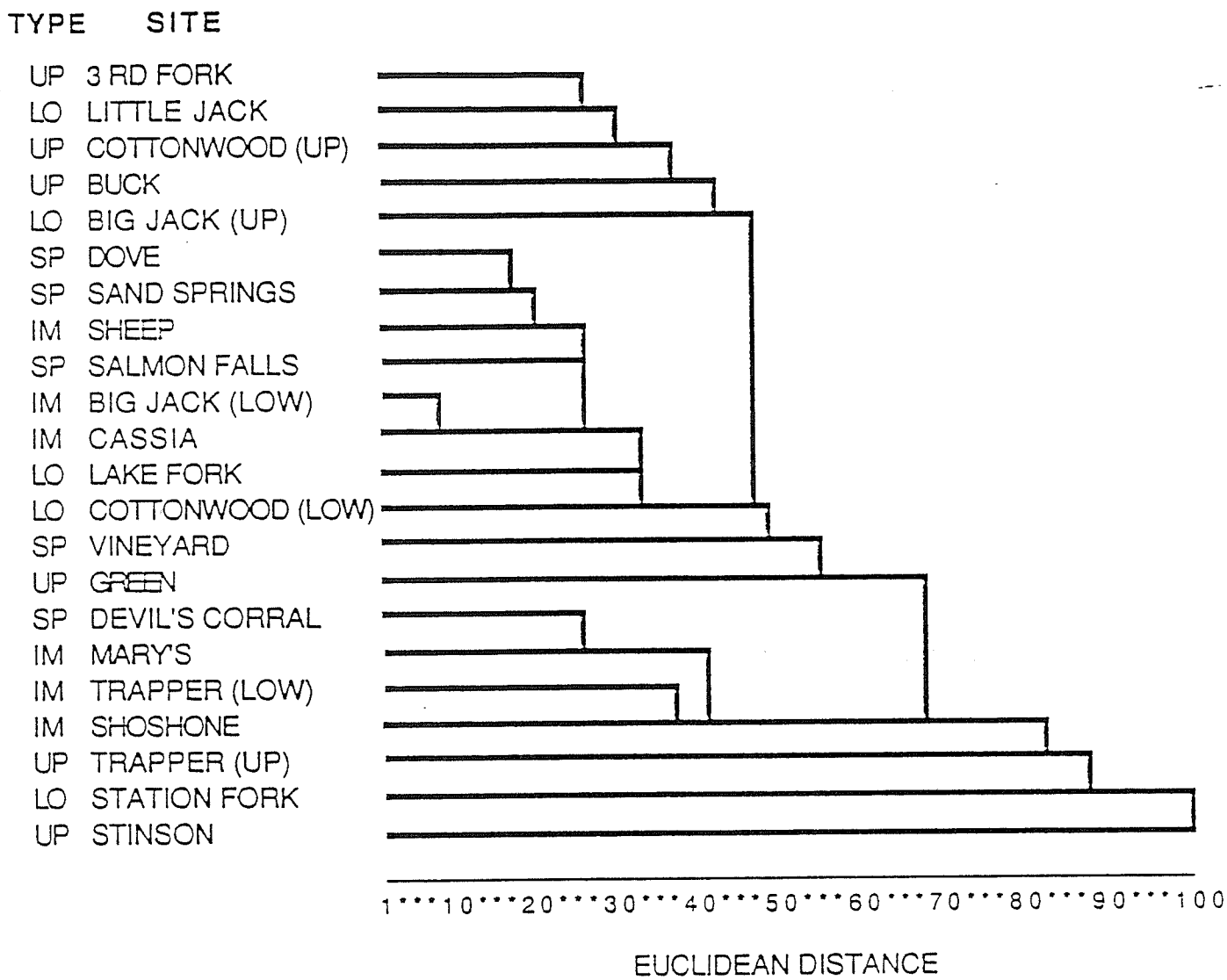


Figure14. Cluster analysis of streams in the Snake River Ecoregion based on habitat score and macroinvertebrate metrics.

grouped fairly well using the biotic metrics, except Green Creek (Figure 14). In addition, spring sites tended to group together except Devil's Corral which grouped with impacted stream types. Lowland sites appeared to group with all other stream types. For example, the adjacent Station Fork Creek and Lake Fork Creek grouped together using habitat measures but were placed into separate groups using biotic metrics. Sheep Creek, an impacted site, grouped with spring sites.

Fish metrics and stream types: Fish metric score, fish condition, fish abundance, and % occurrence were compared across stream types. The fish IBI metric score was similar between upland and lowland sites and higher than spring and impacted sites (Figure 15). Spring sites had the lowest fish metric score among stream types. Fish condition index displayed trends similar to the fish IBI metric being higher in upland and lowland sites than in spring and impacted sites. Fish abundance, expressed as per unit shock time, was substantially greater in lowland and impacted sites than in spring and upland sites, although tolerant taxa comprised the majority of fishes present (see below). Spring sites exhibited the lowest values of fish abundance (Figure 15). These data suggest similar fish abundance in lowland and impacted sites, but better fish condition in lowland sites than in impacted lowland sites.

Upland sites had fish assemblages comprised entirely of intolerant species such as trout and sculpin (Figure 16, also see Table 10). Lowland sites showed a small increase in the percent occurrence of tolerant fish taxa (around 20%), while spring streams tended towards an even occurrence of tolerant and intolerant species (around 55% for each). Impacted sites displayed a high percentage of sites with tolerant (about 55%) and intolerant (about 85%) fish taxa occurring (Figure 16).

Cluster analysis using the variables of habitat assessment score, fish metric score, fish abundance, and fish condition

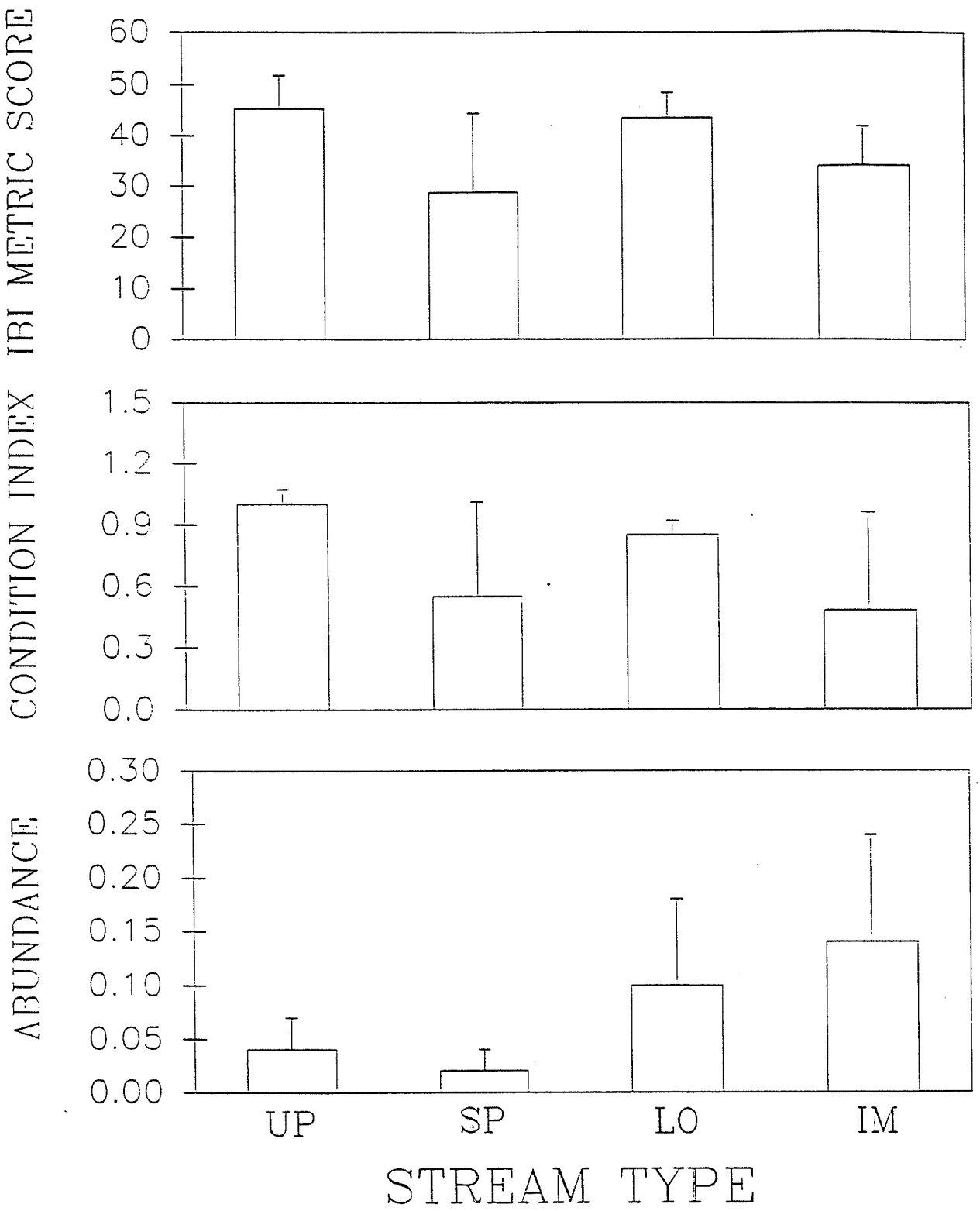


Figure 15. Bar graph of fish abundance (#/shock time), fish condition index, and fish IBI metric score by stream type studied. Bars represent mean +1SD. Sample size is UP=7, SP=5, :LO=5, IM=7.

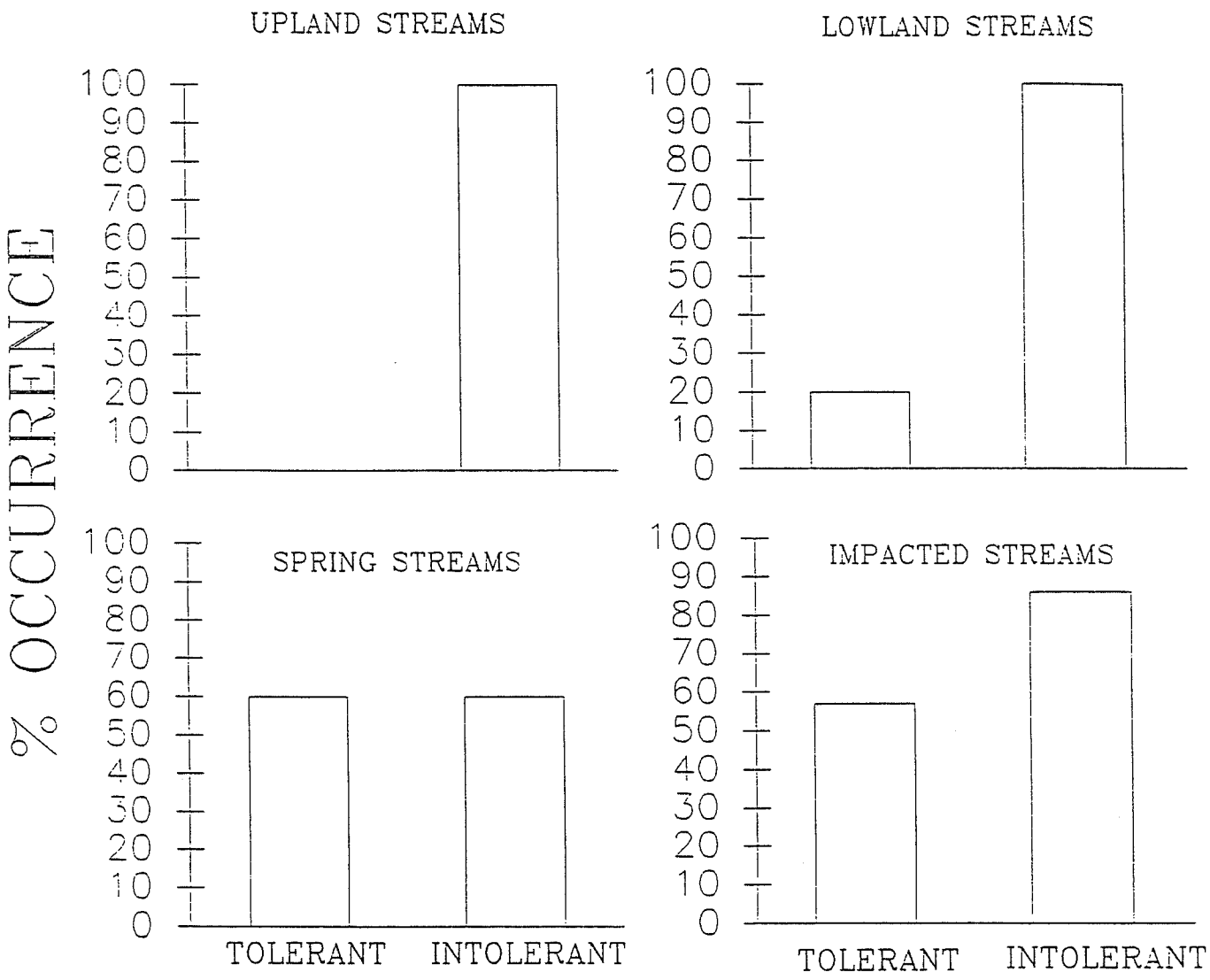


Figure 16. The percent occurrence of tolerant and intolerant fish taxa present in the four stream types studied. For example, 100% of the upland streams had intolerant taxa present, but 0% of the upland sites had tolerant taxa present.

provided distinct clusters by stream types (Figure 17). Only one impacted site could be included in this analysis due to the lack of data for a particular variable, usually fish condition which was estimated from trout (see Table 9). This impacted site, however, constituted a single group. Spring sites tended to cluster into subgroups, for example Dove Creek and Devil's Corral Creek grouped together, while Sand Springs Creek and Salmon Falls Creek clustered into a separate group. Vineyard Creek, a spring site, clustered more closely to lowland sites than to other spring sites (Figure 17). Cottonwood Creek, a lowland site, clustered with the upland Green Creek site. However, upland sites and lowland sites tended to cluster into distinct groups. These data support the conclusion that the measured biotic variables adequately assessed the general health of the fishery in streams that differ in habitat quality.

QUALITATIVE VERSUS QUANTITATIVE ANALYSIS

Quantitative samples were collected for macroinvertebrates from 2 upland (Buck and Green Creeks), 1 impacted (Shoshone Creek), 1 lowland (Little Jack's Creek), and 1 spring site (Sand Springs Creek) using a modified Hess sampler. Quantitative fish collections, using the 3-pass method, were analyzed from 7 study sites. These sites included 3rd Fork Rock Creek, 4th Fork Rock Creek, Little Jack's Creek, Upper and Lower Big Jack's Creek, Duncan Creek, and Mary's Creek.

Macroinvertebrates: Biotic metric scores were regressed from the qualitative and quantitative data and revealed a poor positive relationship between scores (r^2=0.22)(Figure 18). Differences between qualitative and quantitative metric scores ranged from zero for Green Creek, an upland site, to as high as 12 for the lowland Little Jack's Creek site. We next ran regressions between the individual biotic metrics (qualitative versus quantitative) expecting strong positive regression coefficients. Positive relationships were found for Species Richness (r^2=0.25),

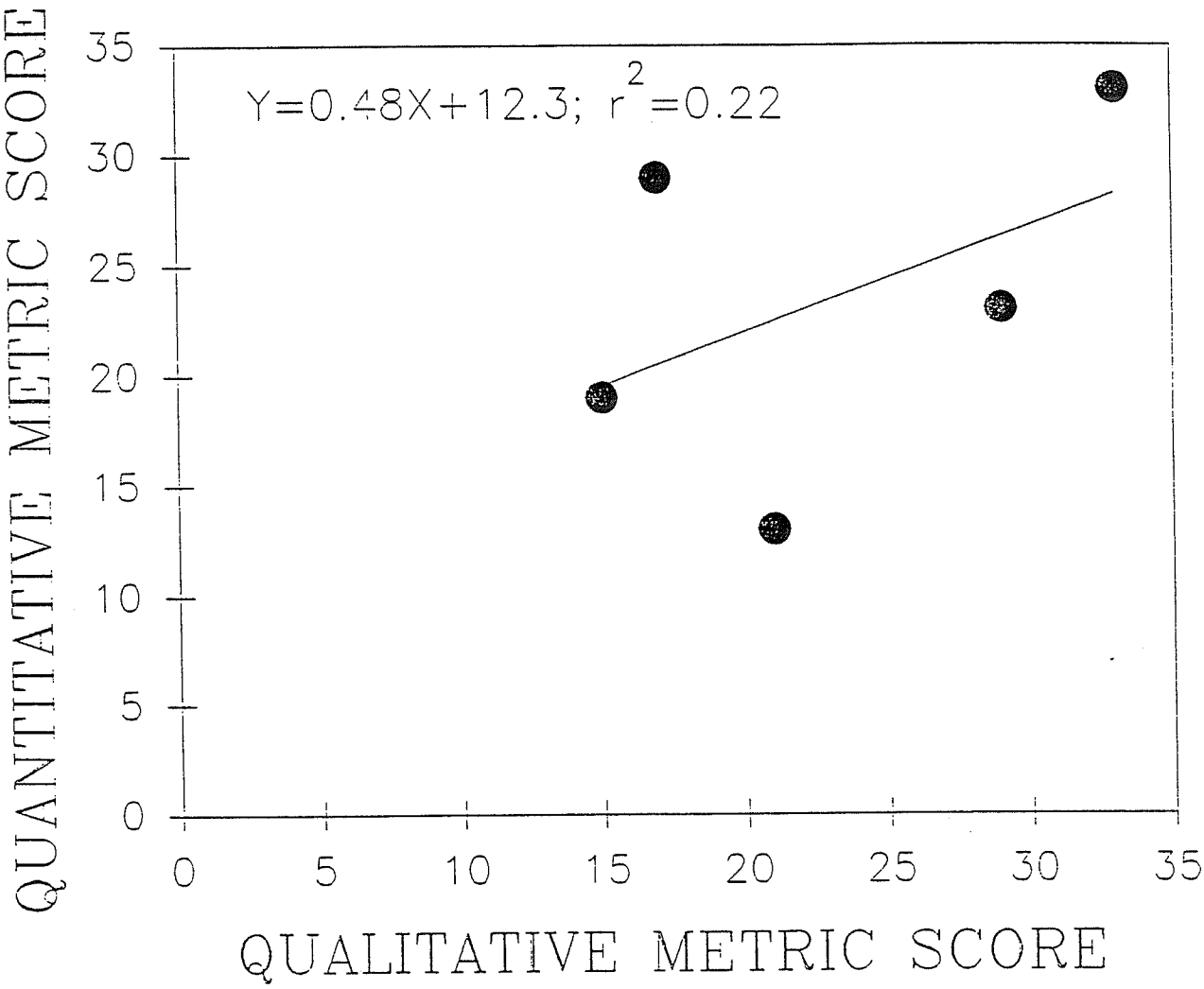


Figure 18. Regression of metric score derived from qualitative samples against metric score derived from quantitative samples collected from the same stream.

% Dominant (r^2=0.14), EPT Index (r^2=0.71), and the HBI (r^2=0.28)(Figure 19). No relationship was found for S/F Ratio (r^2=0.01) and Shredder/Total Ratio (r^2=0.0004)(Figure 19). The EPT/C Ratio actually displayed a negative relationship (r^2=-0.20) between the qualitative and quantitative data. When we regressed biotic metric scores derived from the quantitative samples against the habitat assessment scores for these sites a strong positive relationship was observed (r^2=0.77, N=5)(Figure 20). Recall that the regression of biotic metric scores derived from qualitative sampling against the habitat assessment score resulted in no relationship (r^2=0.02, N=22)(Figure 4) and a poor fit for the same five sites used for quantitative analyses (r^2=0.16)(Figure 20). These results suggest a need to modify the methods by replacing the qualitative sampling of macroinvertebrates with a quantitative sampling approach, or at least by stratifying the qualitative collection procedure to include only riffle habitats.

Fish: We regressed fish abundance in one pass to fish abundance for 3 passes and found a positive relationship (r^2=0.41) with a sample size of 7 sites. By removing the outlier (Little Jack's Creek)(Zar 1984) this relationship became much stronger (r^2=0.96)(Figure 21). The relative abundance of fish in the first pass ranged from 9% for the outlier site to 85% for Mary's Creek, and without the outlier these values ranged from 37% to 85%, although the lower first pass catches were primarily from sites with higher absolute abundances (Table 13). The relative abundance of fish taxa among passes were similar. These data suggest that in the Snake River Ecoregion a single pass is sufficient for determining fish IBI metric scores, although three passes should still be used for estimating fish standing stocks.

MODIFICATION OF BIOTIC METRICS AND HABITAT ASSESSMENT SCORE

The macroinvertebrate metrics were modified to include the

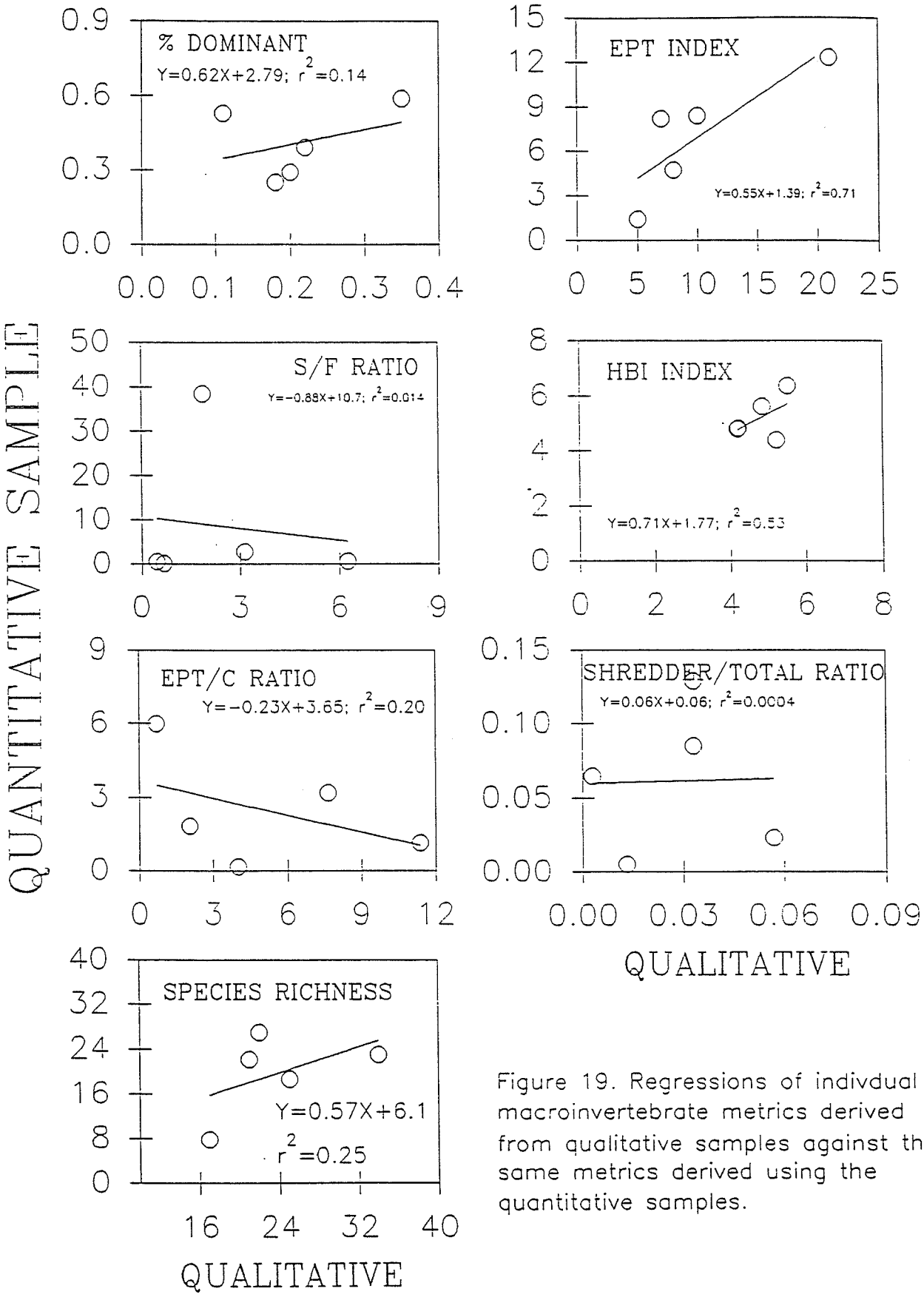


Figure 19. Regressions of indivdual macroinvertebrate metrics derived from qualitative samples against the same metrics derived using the quantitative samples.

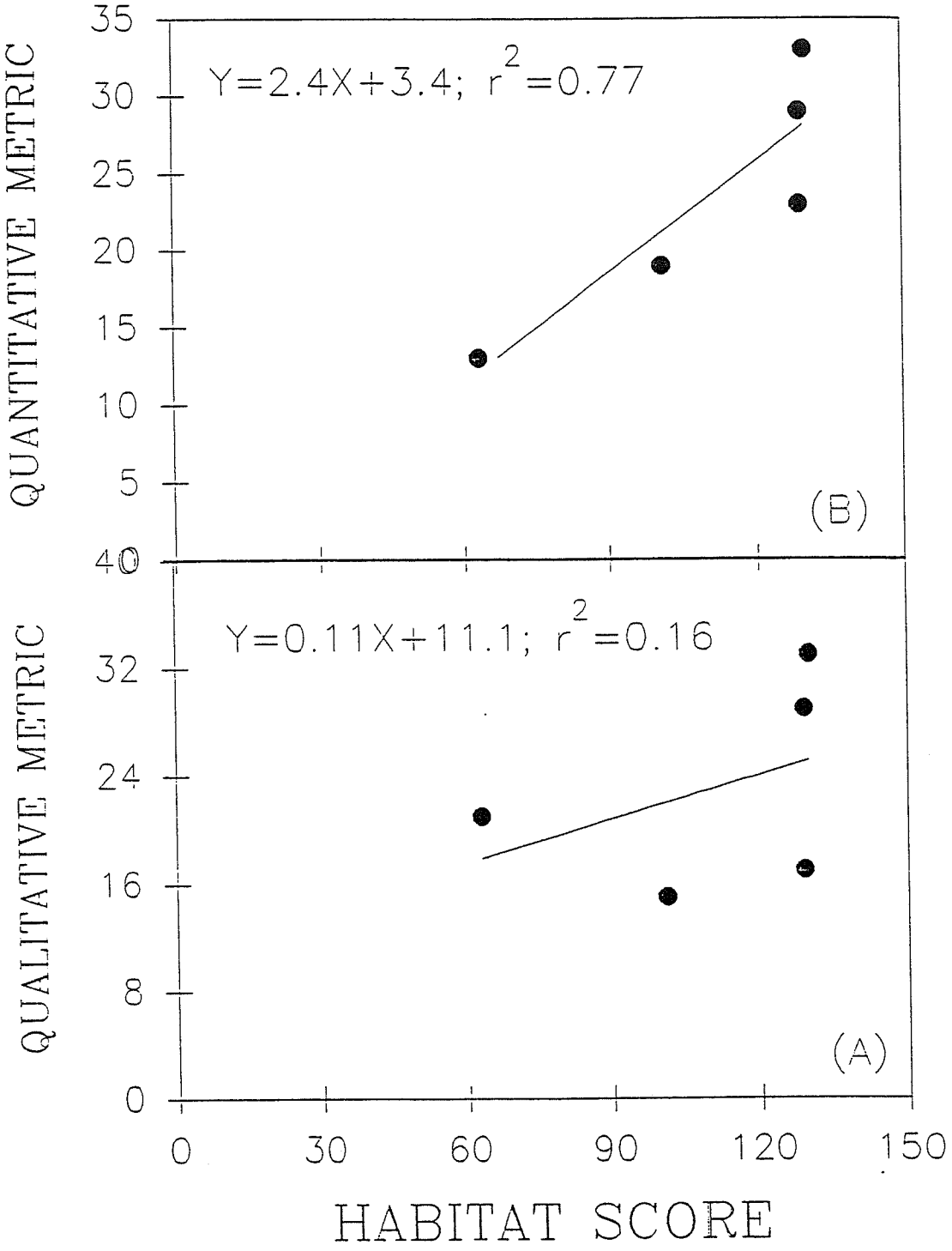


Figure 20. Regression of habitat assessment score against biotic metric derived from qualitative samples (A), or derived from quantitative samples B). Regressions bounded by 95% Confidence Limits.

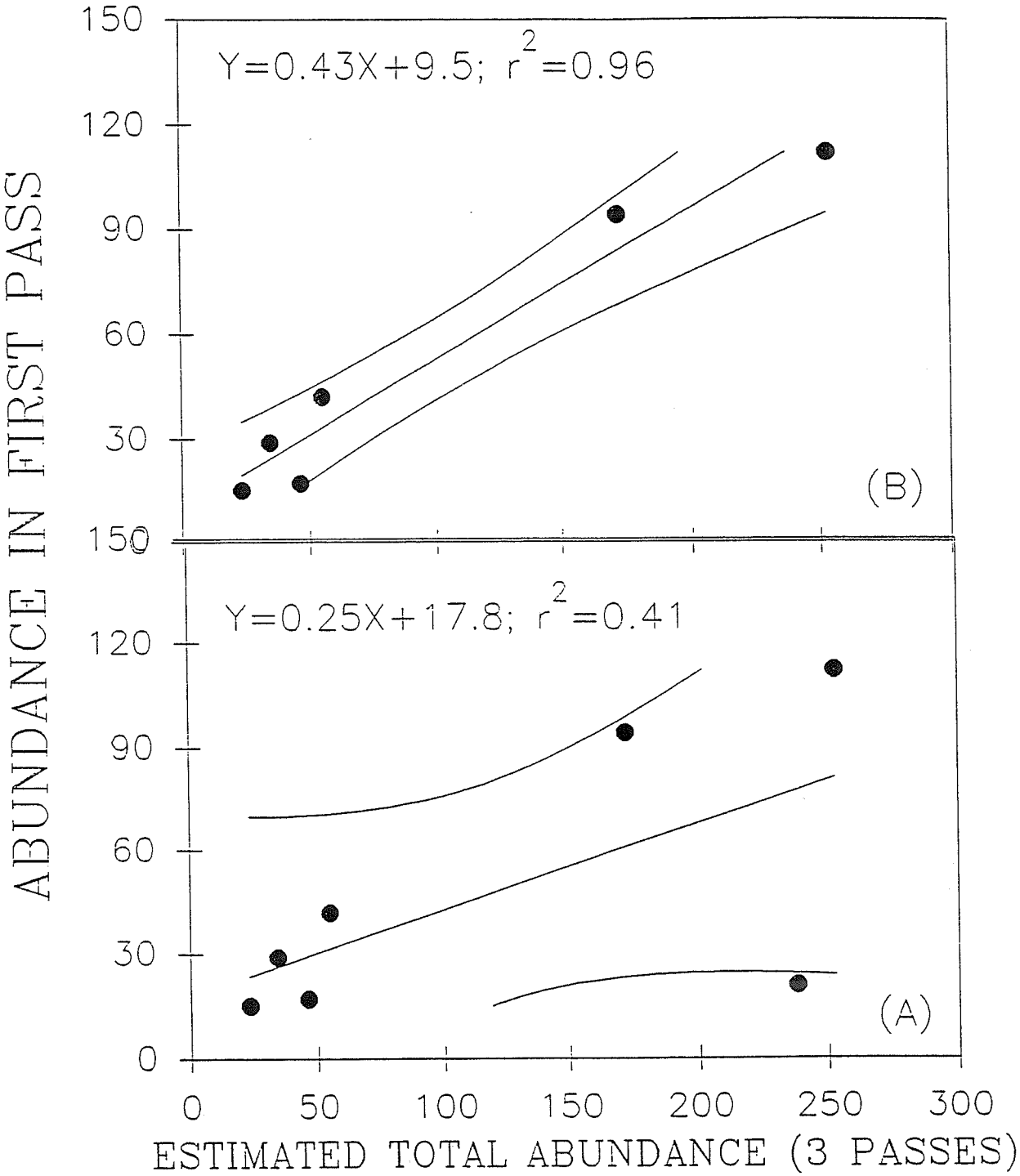


Figure 21. Regression of estimated fish abundance against fish abundance collected in one pass. (A) All samples included; (B) regression with outlier removed. Bars bounded by 95% confidence limits.

Table 13. Comparison of fish abundances collected in each of 3 passes with electrofisher at seven study sites.

STREAM	Little Jack						3rd Fork						Big Jack (Up)						4th Fork					
PASS	P1		P2		P3		P1		P2		P3		P1		P2		P3		P1		P2		P3	
	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL
Rainbow Trout	10	48	8	35	0	0	42	100	10	100	2	100	3	3	1	1	2	9	15	100	6	100	1	100
Mottled Sculpin	11	52	15	65	17	100							12	11	11	13	6	27						
Mountain Sucker													55	49	25	30	1	4						
Redside Shiner													42	38	47	56	13	59						
Longnose Dace																								
Totals	21		23		17		42		10		2		112		84		22		15		6		1	
Estimated N	238						55						253						23					
Pass 1 %	9						76						44						65					

STREAM	Mary's						Big Jack (Lo)						Duncan					
PASS	P1		P2		P3		P1		P2		P3		P1		P2		P3	
	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL	ABS	REL
Rainbow Trout							5	5	2	5	1	5	17	100	10	100	7	100
Mottled Sculpin							69	73	30	75	14	67						
Mountain Sucker							17	18	8	20	6	28						
Redside Shiner	24	83	5	100	0	0												
Longnose Dace	5	17	0	0	0	0												
Totals	29		5		0		94		40		21		17		10		7	
Estimated N	34						172						46					
Pass 1 %	85						55						37					

NOTE: ABS=absolute value, REL=relative value, P1=pass 1, P2=pass 2, P3=pass 3.

Chandler Biotic Score, % Scrapers, % Filterers, S/F Ratio, and the EPT Index based on results from the multiple stepwise regression and simple linear regression (Tables 14, 15) and provided a maximum summed criteria score of 25 (Table 16). A simple linear regression of the modified metric score to the initial habitat assessment score provided a significant positive relationship (r^2=0.61; p=0.003)(Figure 22). Recall that the unmodified macroinvertebrate metric score provided a poor fit (r^2=0.02)(Figure 4).

The habitat assessment score was modified to include the variables of channel area (H/L ratio), average substrate size, and the % riffle. This modification extended the range of possible summed habitat scores. Previously, habitat assessment scores ranged from about 60-130, whereas the modified habitat assessment score ranged from about 80-180 thus increasing the range of estimated values by 30 units. The regression of the modified habitat assessment score against the modified biotic metric score increased from r^2=0.61 to r^2=0.68 with the p-value becoming more significant. Thus, although the relationship was improved somewhat by modifying the habitat assessment score, <u>a greater gain in improvement was seen by modifying the biotic metric categories alone.</u>

We attempted further modification of the "original" macroinvertebrate metrics by deriving criteria scores using 95% and 99% confidence limits (CL) about the mean. Metric values within the 95% CL received a score of 5, within 99% CL received a score of 3, and outside the 99% CL received a score of 1 (Table 17). Data were analyzed with and without spring sites. The results indicated a poor relationship of the macroinvertebrate metric score against the habitat assessment score (r^2=0.0005) when spring sites were included (Figure 23). By removing spring sites the relationship failed to improve (r^2=0.0007). Tables 18 and 19 campare the various macroinvertebrate metrics used and their respective scores.

Table 14. Results of multiple stepwise regression for dependent variable of Habitat Assessment Score and all biotic metrics as independent variables.

DEPENDENT VARIABLE: Habitat Assessment Score F=47.8; DF=10, 11; p=0.000

INDEPENDENT VARIABLES	*BETA	R-SQUARE	SIGNIFICANCE
CBS	0.643	0.941	0.037
% DOMINANT	0.325	0.966	0.096
% SCRAPERS	0.213	0.967	0.092
EPT INDEX	-0.347	0.969	0.134
SPECIES RICHNESS	0.355	0.972	0.174
%FILTERERS	-0.011	0.974	0.927
SHREDDERS/TOTAL RATIO	-0.081	0.975	0.272
% SHREDDERS	0.059	0.976	0.473
% MINERS	0.065	0.977	0.499
HBI	-0.177	0.977	0.601

*Beta represents the regression coefficient (a constant)(Zar 1984).

Table 15. Results of simple linear regressions of biotic metrics against the Habitat Assessment Score. N=21.

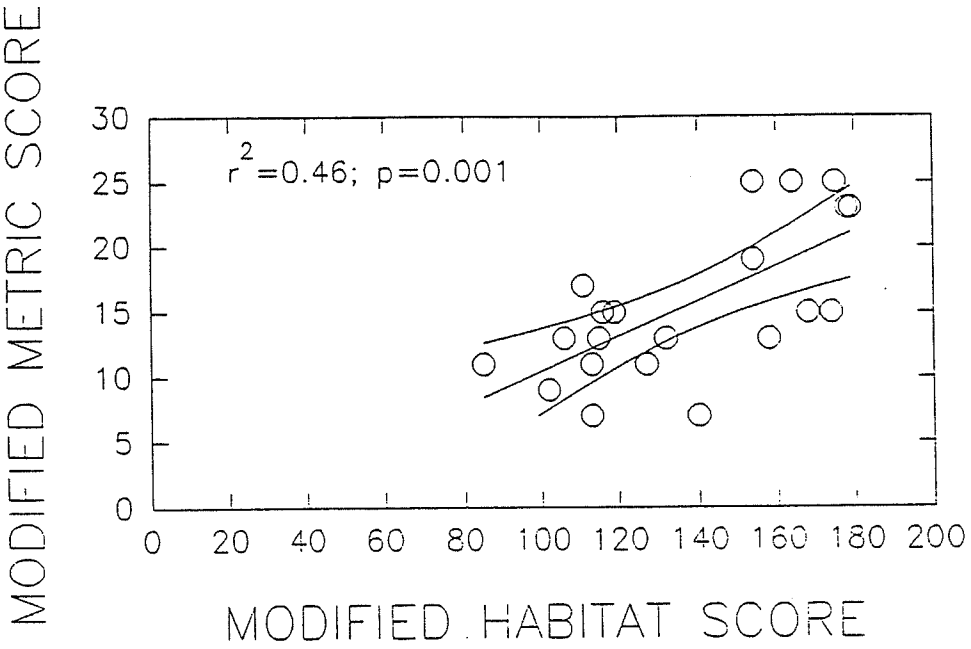
BIOTIC METRIC	REGRESSION (r)	P-VALUE	SLOPE	INTERCEPT (transformed)
CBS	0.36	0.114	0.004	0.587
BCI	0.39	0.073	0.004	0.437
SIMPSON'S	0.08	0.726	0.001	0.207
% PREDATORS	-0.05	0.838	-0.001	0.282
% GATHERERS	-0.11	0.623	-0.002	0.623
% SCRAPERS	0.31	0.184	0.005	-0.136
% SHREDDERS	0.19	0.417	0.003	-0.069
% FILTERERS	-0.41	0.067	-0.002	0.408
% MINERS	0.15	0.513	0.002	0.125
SPECIES RICHNESS	0.21	0.351	0.006	0.464
S/F RATIO	0.37	0.099	0.002	-0.468
EPT/C RATIO	0.15	0.513	0.003	-0.066
% DOMINANCE	0.11	0.648	0.001	0.311
EPT INDEX	0.31	0.173	0.004	0.004
SHREDDER/TOTAL RATIO	-0.04	0.849	-0.001	0.348
HBI	-0.28	0.214	-0.002	-0.145

Table 16. Absolute and relative values for modified macroinvertebrate metrics by site with respective condition score.

SITE LOCATION	CBS	CBS as %	score	% SCRAPER	%SCRAPER as %	score	% FILTERER	% FILTERER as %	score	S/F RATIO	S/F as %	score	EPT INDEX	EPT as %	score	total score	HABITAT SCORE
Up BUCK	52.5	85	5	46.2	90	5	7.2	8	5	6.3	23	5	10	48	5	25	129
Up GREEN	61.3	99	5	51.2	100	5	16.3	18	3	3.1	12	5	21	100	5	23	130
Up 3RD FORK	54.8	89	5	8.1	16	1	18.3	20	3	0.4	1	1	10	48	5	15	123
Up TRAPPER	53.6	87	5	25.7	50	5	6.8	7	5	3.8	14	5	10	48	5	25	130
Up COTTONWOOD	61.8	100	5	30.2	59	5	11.2	12	3	27.0	100	5	16	76	5	23	125
Sp SAND SPRINGS	41.7	67	1	15.2	30	3	8.1	9	5	1.9	7	3	5	24	1	13	101
Sp DOVE	43.7	71	1	5.3	10	1	2.8	3	5	1.9	7	3	3	14	1	11	105
Sp DEVIL'S CORRAL	44.9	73	1	3.3	6	1	5.8	6	5	0.6	2	1	7	33	3	11	72
Sp VINEYARD	34.5	56	1	6.1	12	1	0	0	5	20.0	74	5	2	10	1	13	123
Sp SALMON FALLS	38.2	62	1	4.5	9	1	14.8	16	3	0.3	1	1	4	19	1	7	98
Lo LITTLE JACK	58.6	95	5	9.9	19	1	6.5	7	5	0.7	2	1	7	33	3	15	129
Lo STATION	52.7	85	5	37.2	73	5	25.3	27	1	1.5	5	3	7	33	3	17	92
Lo LAKE FORK	46.3	75	3	16.2	32	3	24.3	26	1	0.7	2	1	7	33	3	11	108
Lo COTTONWOOD	53.6	87	5	29.5	58	5	2.5	3	5	12.5	46	5	12	57	5	25	112
Lo BIG JACK	53.2	86	5	5.2	10	1	4.1	4	5	1.3	5	3	9	43	5	19	123
Im MARY'S	52.6	85	5	13.4	26	1	14.4	16	3	0.9	3	1	11	52	5	15	75
Im CASSIA	46.3	75	3	13.5	26	1	11.5	12	3	1.2	4	1	9	43	5	13	92
Im SHEEP	46.2	75	3	8.4	16	1	48.4	52	1	0.2	1	1	6	29	1	7	99
Im TRAPPER	51.9	84	3	28.9	56	5	24.9	27	1	1.2	4	1	8	38	3	13	66
Im SHOSHONE	48.9	79	3	13.4	26	1	29.1	31	1	0.5	2	1	8	38	3	9	63
Im BIG JACK'S	58.1	94	5	15.4	30	3	20.6	22	1	0.7	3	1	9	43	5	15	93

METRIC SCORE DETERMINATION

IBI SCORE	as % CBS	as % SCRAPER	as % FILTERER	as % S/F	as % EPT
5	>85	>50	<10	>10	>40
3	75-85	30-50	10-20	5-10	30-40
1	<75	<30	>20	<5	<30



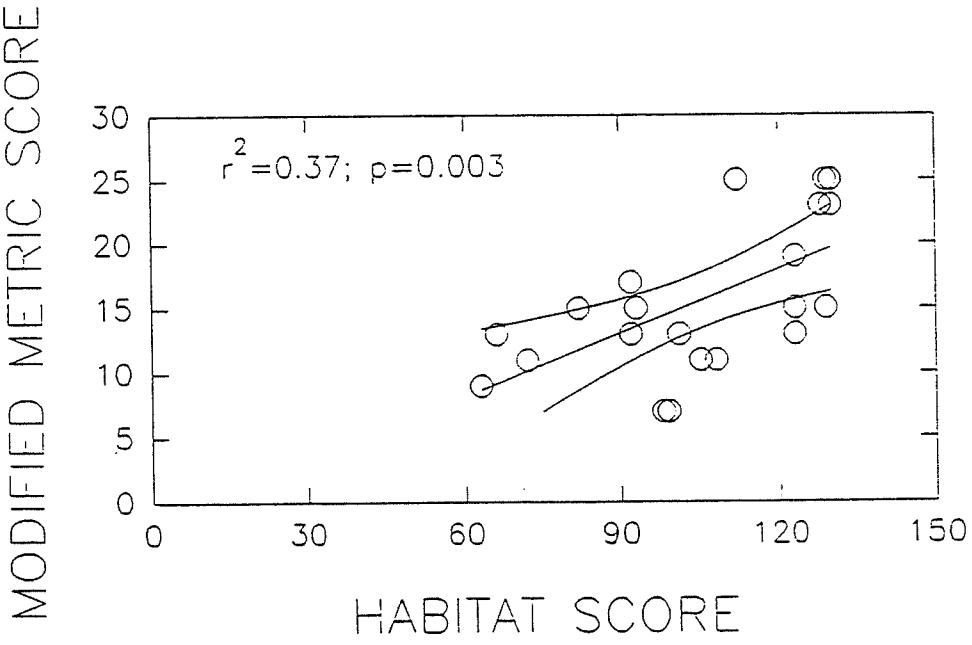


Figure 22. Regression of modified metric score against habitat assessment score and modified habitat assessment score. Regression line bounded by 95% confidence limits.

Table 17. Absolute values for macroinvertebrate metrics by site with respective score based on confidence limits (95, 99%)

Station		QUAL RICH	SCORE	S/F RATIO	SCORE	EPT/C RATIO	SCORE	% DOM	SCORE	EPT INDEX	SCORE	SHR/TOT	SCORE	HBI INDEX	SCORE	TOTAL SCORE	HABITAT SCORE
3rd Fork	UP	19	3	0.40	3	1.51	3	0.42	5	10	5	0.052	5	4.29	5	29	123
Buck	UP	21	5	6.25	5	11.38	5	0.22	5	10	5	0.013	5	4.19	5	35	129
Cottonwood	UP	24	5	25.00	5	1.31	3	0.36	5	16	5	0.060	5	4.76	5	33	125
Green	UP	34	5	3.12	5	7.64	5	0.20	5	21	5	0.033	5	4.21	5	35	130
Stinson	UP	13	1	0.04	1	3.50	5	0.87	1	7	5	0.003	1	5.85	1	15	130
Trapper	UP	23	5	3.85	5	32.33	5	0.42	5	10	5	0.033	5	4.12	5	35	130
Devil's Corral	SP	20	5	0.57	3	1.04	3	0.58	1	7	5	0.030	5	5.85	1	23	72
Dove	SP	15	1	1.89	5	1.46	3	0.50	1	3	1	0.011	3	4.52	5	19	105
Salmon Falls	SP	23	5	0.30	3	4.69	5	0.44	5	4	1	0.010	1	4.75	5	25	98
Sand Springs	SP	17	1	1.89	5	0.69	1	0.35	5	5	1	0.033	5	5.51	1	19	101
Vineyard	SP	10	1	20.00	5	0.09	1	0.72	1	2	1	0.000	1	5.66	1	11	123
Big Jack (up)	LO	32	5	1.25	5	0.36	1	0.39	5	9	5	0.020	5	5.34	1	27	123
Cottonwood low	LO	28	5	12.50	5	1.67	3	0.28	5	12	5	0.130	5	4.07	5	33	112
Lake Fork	LO	22	5	0.67	3	2.04	5	0.18	5	7	5	0.003	1	5.21	3	27	108
Little Jack	LO	22	5	0.67	3	2.04	5	0.18	5	7	5	0.003	1	5.21	3	27	129
Station	LO	19	3	1.47	5	25.50	5	0.28	5	7	5	0.093	5	5.05	5	33	92
Big Jack Low	IM	23	5	0.75	3	2.81	5	0.20	5	9	5	0.000	1	4.54	5	29	93
Cassia	IM	21	5	1.16	5	0.95	3	0.26	5	9	5	0.003	1	5.01	5	29	92
Low Trapper	IM	20	5	1.20	5	11.92	5	0.26	5	8	5	0.060	5	4.65	5	35	66
Marys	IM	25	5	0.92	3	0.94	3	0.36	5	11	5	0.003	1	5.28	1	23	75
Sheep	IM	18	1	0.17	1	0.53	1	0.45	3	6	1	0.000	1	5.92	1	9	99
Shoshone	IM	25	5	0.46	3	4.00	5	0.11	5	8	5	0.057	5	4.84	5	33	63
MEAN SCORE		21.5		3.8423		5.3818		0.365		8.545		0.02955		4.9468			

METRIC SCORE DETERMINATION: Score is based on 95% confidence limits (5), and 99% CL (3) about the mean score.

SCORE	RICHNESS	S/F Ratio	EPT/C	%DOM	EPT	SHR/TOT	% HBI
5	>19.3	>1.12	>1.98	<0.44	>6.8	>0.015	<5.18
3	>18.6	>0.26	>0.90	<0.46	>6.3	>0.011	<5.26
1	<18.6	<0.26	<0.90	>0.46	<6.3	<0.011	>5.26

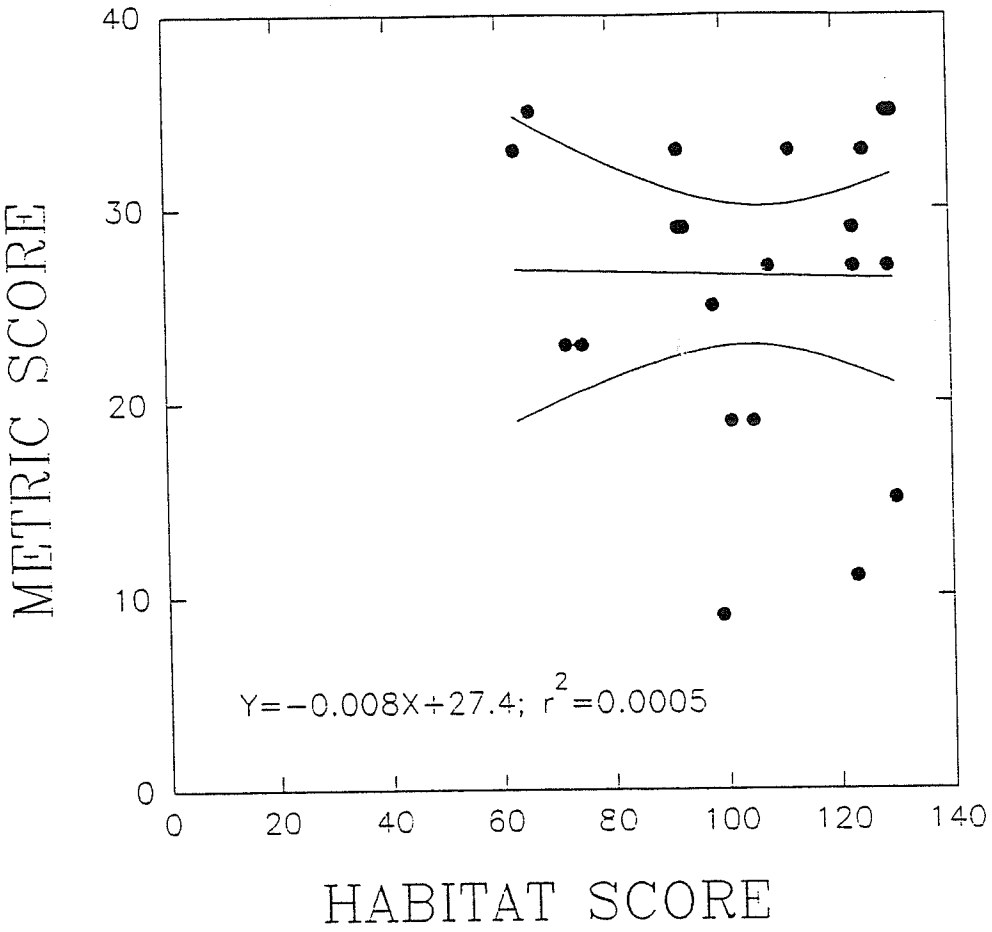


Figure 23. Regression scattergram of habitat assessment score against macroinvertebrate metric score derived from using 95% and 99% confidence limits about the mean score of individual biotic metics. Regression line bounded by 95% confidence limits.

ble 18. Absolute values for all macroinvertebrate metrics with respective criteria score, fish IBI score, and habitat assessment score by site.

E LOCATION	CBS	SCORE	% SCRAPER	SCORE	% FILTERER	SCORE	S/F RATIO	SCORE	EPT INDEX	SCORE	SPECIES RICHNESS	SCORE	EPT/C RATIO	SCORE	% DOM	SCORE	SHR/TOT	SCORE	HBI INDEX	SCORE	FISH IBI SCORE	HABITAT ASSESSMENT SCORE
BUCK	52.5	5	46.2	5	7.2	5	6.3	5	10	5	21	3	11.38	5	0.22	5	0.013	1	4.19	5	39	129
GREEN	61.3	5	51.2	5	16.3	3	3.1	5	21	5	34	5	7.64	5	0.20	5	0.033	3	4.21	5	55	130
3RD FORK	54.8	5	8.1	1	18.3	3	0.4	1	10	5	19	3	1.51	1	0.42	3	0.052	3	4.29	5	51	123
TRAPPER	53.6	5	25.7	5	6.8	5	3.8	5	10	5	23	3	32.33	5	0.42	3	0.033	3	4.12	5	45	130
COTTONWOOD	61.8	5	30.2	5	11.2	3	27.0	5	16	5	24	3	1.31	1	0.36	3	0.060	3	4.76	3	59	125
SAND SPRINGS	41.7	1	15.2	3	8.1	5	1.9	3	5	1	17	3	0.69	1	0.35	3	0.033	3	5.51	1	39	101
DOVE	43.7	1	5.3	1	2.8	5	1.9	3	3	1	15	1	1.46	1	0.50	1	0.011	1	4.52	5	NA	105
DEVIL'S CORRAL	44.9	1	3.3	1	5.8	5	0.6	1	7	3	20	3	1.04	1	0.58	1	0.030	1	5.85	1	25	72
VINEYARD	34.5	1	6.1	1	0	5	20.0	5	2	1	10	1	0.09	1	0.72	1	0.000	1	5.66	1	43	123
SALMON FALLS	38.2	1	4.5	1	14.8	3	0.3	1	4	1	23	3	4.69	3	0.44	1	0.010	1	4.75	3	47	98
LITTLE JACK	58.6	5	9.9	1	6.5	5	0.7	1	7	3	22	3	2.04	1	0.18	5	0.003	3	5.21	3	47	129
STATION	52.7	5	37.2	5	25.3	1	1.5	3	7	3	19	3	25.50	5	0.28	3	0.093	3	5.05	3	51	92
LAKE FORK	46.3	3	16.2	3	24.3	1	0.7	1	7	3	22	3	2.04	1	0.18	5	0.003	3	5.21	3	35	108
COTTONWOOD	53.6	5	29.5	5	2.5	5	12.5	5	12	5	28	5	1.67	1	0.28	3	0.130	5	4.07	5	45	112
BIG JACK	53.2	5	5.2	1	4.1	5	1.3	3	9	5	32	5	0.36	1	0.39	3	0.020	1	5.34	1	47	123
MARY'S	52.6	5	13.4	1	14.4	3	0.9	1	11	5	25	3	0.94	1	0.36	3	0.003	3	5.28	3	25	75
CASSIA	46.3	3	13.5	1	11.5	3	1.2	1	9	5	21	3	0.95	1	0.26	5	0.003	3	5.01	3	53	92
SHEEP	46.2	3	8.4	1	48.4	1	0.2	1	6	1	18	1	0.53	1	0.45	1	0.000	1	5.92	1	29	99
TRAPPER	51.9	3	28.9	5	24.9	1	1.2	1	8	3	20	3	11.92	5	0.26	5	0.060	5	4.65	5	35	66
SHOSHONE	48.9	3	13.4	1	29.1	1	0.5	1	8	3	25	1	4.00	3	0.11	5	0.057	3	4.84	3	37	63
BIG JACK'S	58.1	5	15.4	3	20.6	1	0.7	1	9	5	23	1	2.81	1	0.20	5	0.000	5	4.54	5	39	93

TRIC SCORE DETERMINATION: Score based on relative value of individual metric to high score of that metric.

METRIC SCORE	as % CBS	as % SCRAPER	as % FILTERER	as % S/F	as % EPT	as % RICH	as % EPT/C	as % %DOM	as % SHR/TOT	as % % HBI
5	>85	>50	<10	>10	>40	>80	>20	<30	>50	<80
3	75-85	30-50	10-20	5-10	30-40	50-80	10-20	30-50	25-50	80-90
1	<75	<30	>20	<5	<30	<50	<10	>50	<25	>90

Table 19. Summary of unmodified and modified macroinvertebrate metric scores, fish IBI score, and habitat assessment scores.

SITE LOCATION	MACROINVERTEBRATE METRIC SCORE UNMODIFIED max=35	MODIFIED max=25	FISH IBI SCORE max=60	HABITAT ASSESSMENT SCORE max=130
Up BUCK	29	25	39	129
Up GREEN	33	23	55	130
Up 3RD FORK	21	15	51	123
Up TRAPPER	29	25	45	130
Up COTTONWOOD	23	23	59	125
Sp SAND SPRINGS	15	13	39	101
Sp DOVE	13	11	NA	105
Sp DEVIL'S CORRAL	11	11	25	72
Sp VINEYARD	11	13	43	123
Sp SALMON FALLS	13	7	47	98
Lo LITTLE JACK	17	15	47	129
Lo STATION	25	17	51	92
Lo LAKE FORK	17	11	35	108
Lo COTTONWOOD	29	25	45	112
Lo BIG JACK	19	19	47	123
Im MARY'S	19	15	25	75
Im CASSIA	21	13	53	92
Im SHEEP	9	7	29	99
Im TRAPPER	27	13	35	66
Im SHOSHONE	21	9	37	63
Im BIG JACK'S	21	15	39	93

DISCUSSION and CONCLUSIONS

Rapid bioassessment has become an important component in the upgrading of water quality monitoring programs because of its incorporation of direct measures of the health of stream macroinvertebrate and fish assemblages (Karr 1991). Rapid bioassessment protocols are currently in use by numerous state agencies with results strongly favoring their continued use (see references in Plafkin et al. 1989, Hughes et al. 1990). Rapid bioassessment protocols currently are being applied towards ecoregions, of which nine ecoregions are present in Idaho alone.

The importance and usefulness of baseline monitoring data for resource managers cannot be overstated (Hughes et al. 1990, Karr 1991). The use of a rapid bioassessment allows for the efficient and effective collection of data in a regionally standardized and economical fashion. The standardization of stream benthic and fish data collection allows for more effective transfer of information among resource agencies, besides providing for baseline data of stream assemblages under the "best" case (pristine) scenario. We found that the rapid bioassessment protocols are viable for use in Idaho but that some modifications in the macroinvertebrate metrics are necessary for application at the ecoregion level. Similar conclusions were reached by Fisher (1989) for streams in northern and central Idaho.

The habitat assessment score derived from Plafkin et al. (1989) provided a good fit against the index of biotic integrity (IBI)(Karr et al. 1986) for fish, although the Snake River Ecoregion has a paucity of fish species (most sites had fewer than 5 species; Table 10). For example, upland pristine sites typically contained only 1-2 trout species and one sculpin species. However, as stated in Plafkin et al. (1989), the metrics for fish must be modified to account for regional differences. We found, as did Fisher (1989), additional modifications are unnecessary for the fish metrics as the habitat

assessment score adequately assessed fish habitat for the streams studied. The habitat assessment score is designed towards streams with good riparian vegetation, instream cover, and heterogeneous habitats which reflect good fish habitat, and consequently does not accurately assess quality habitat of springs.

A poor fit was found between the habitat assessment score and the biotic metric criteria score for macroinvertebrates. Fisher (1989) also found a poor relationship between these two scores. A much better fit was realized upon modifying the biological metrics to reflect conditions in the Snake River Ecoregion (Figure 22). Additional metrics were selected from Fisher (1989) and Platts et al. (1983), with selected metrics including the Chandler Biotic Index, % Filterers, % Scrapers, the S/F Ratio, and the EPT Index. These five metrics seem to better reflect the inorganic pollution (primarily sedimentation) that occurs in the Intermountain West, while the metrics of Plafkin et al. (1989) tend to primarily reflect changes in organic pollution. We suggest that macroinvertebrate metrics be modified in similar fashion as the IBI fish metrics; that is to develop metrics for specific regions, as done in the present study, to take into account the natural regional variation observed for lotic systems (Hughes et al. 1990). We also believe that it is preferable to examine the responses of individual metrics rather than focusing on the total metric score. The latter, through its averaging effect, often obscures important differences among streams.

The habitat assessment score separated lowland sites from impacted lowland sites, however pristine spring sites also received low habitat assessment scores because of the relatively homogeneous nature of spring habitats. No relationship was observed for stream size in the present study, although streams were selected with similar baseflow. Fisher (1989) found, for a broader range of stream sizes, that conditions change with stream size. We feel the habitat assessment score clearly was designed

towards mid-sized (3rd - 4th order), pristine, montane, trout streams. Future studies incorporating rapid bioassessment should at least be stratified between between springs and other streams. Its important to note, however, that the biotic metric score did distinguish the rather depauperate macroinvertebrate communities found in springs, although this result reflects the relatively homogeneous habitat of spring brooks rather than some form of pollution.

Our analysis indicates that incorporation of measures of substratum size and heterogeneity, food resources, and water chemistry do not significantly enchance the habitat assessment procedure, at least for the five macroinvertebrate metrics we used. However, the results from the step-wise regression suggests the inclusion of H/L area, mean substratum size, and percent riffle seems warranted and the possibility of incorporating a measure of annual or seasonal temperature variation and annual temperature maxima should be explored.

The present method of qualitative sampling of macroinvertebrates may be the cause for the poor relationship between macroinvertebrate metric scores and habitat assessment scores. We believe the present qualitative sampling procedure incorporates a greater number of different habitats, greater sample area, and greater probability of encountering possible refugia than an habitat-specific sampling method thereby minimizing the importance and hypothesized differences for some metrics (e.g. species richness). We found that macroinvertebrate metric scores derived from quantitative samples provided a significant regression against the habitat score with a sample size of only 5 (Figure 18). Quantitative samples were collected using a modified Hess sampler in riffle sections of study sites. These data suggest that either qualitative samples should be stratified to sample a single habitat type (riffle), or that an habitat-specific quantitative sampling approach be adopted. In addition, a single pass of the electrofisher was adequate for IBI

calculation, although we recommend the placement of blocknets at both ends of the study reach. Fish escapes were observed when blocknets were not in place, especially in low gradient systems where the stream was essentially "run" habitat. Further, a single-pass sample may not be sufficient for determining absolute fish densities, especially where large numbers of fish are encountered.

In summary, we believe that the modified rapid bioassessment protocols developed here show great promise for an improved impact-monitoring system for Idaho. Macroinvertebrate metrics need to take into account the natural variation observed at the ecoregional level and the differences in land use practices (i.e. differences in types of impacts). Modifications also are necessary to discriminate among homogeneous habitats, such as springs, and more heterogeneous stream habitats. Stratification in the analysis of these two habitats appears necessary and ultimately the development of two different assessment procedures may result. Lastly, restriction of macroinvertebrate sampling to a single habitat type (riffle) seems to provide a better relationship between habitat assessment scores and the macroinvertebrate metrics. However, the poor fit of both the unmodified and modified macroinvertebrate metric scores to the habitat assessment score clearly underlines the conclusion of Hughes et al. (1990) that more research is necessary before a regional framework is established.

We recommend that the Idaho Rapid Bioassessment Protocols be tested against a wider range of conditions within the Snake River Ecoregion, including more severely impacted sites, and further modified, if necessary. Once the robustness of the Idaho Rapid Bioassessment Score (IRBS) has been determined for a single ecoregion and validated against an independent data set, it will be important to extend the procedure to other ecoregions in the state and to determine if conditions differ markedly among them. Basically, it must be determined whether a single IRBS system is

applicable to the entire state or whether separate indices must be developed for each ecoregion, type of disturbance, etc. A separate scoring procedure probably also eventually should be developed for springs but with the assumptions that springs, because of their greater constancy, are more likely to be similar among ecoregions than are runoff-dominated streams. Eventually the extent of within-stream variation, temporal and/or seasonal variation, and responses in larger (>3rd order) stream sizes also will need to be determined for more precise monitoring and enhanced data interpretation. Presently our findings are strictly applicable only to summer baseflow conditions in 1st-3rd order streams and the responses in other seasons and stream sizes is uncertain.

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ppendix 1. Species list of macroinvertebrates collected with counts of individual taxa from qualitative benthic samples using about a 300 count subsample.

ITE LOCATION	Im	Sp	Im	Sp	Up	Up	Im	Im	Im	Im	Im	Up	Lo	Sp	Up	Up	Lo	Lo	Up	Lo	Lo	Sp	Sp
TATION #	29	24	30	23	4	1	28	26	31	32	27	8	15	20	3	2	19	18	5	17	16	22	21
ATE	900720	900718	900815	900619	900620	900614	900618	900620	900621	900619	900619	900717	900721	900718	900615	900614	900613	900613	900614	900826	900825	900825	900830
EP #	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.
REDATORS																							
arabidae												1	1							1			1
llloperla																1	3	1	1	4			
therix variagata									5						2								
eloneuria							5						5							4			
alineuria				3				2	7			1								1			
eratopogonidae											3												
laasenia											1						4				1		
ecapoda					1			1							1					1			
icronota																							
ytiscidae	10						2	2															
mpididae					8						5						1	20			6		
lesperoperla pacifica													4	6	4		18	15		1	10	14	13
lexatoma			63	11	1		3	12	2		6	1							1				
lydracarina	1														2				3				
imnophila				3			2		6														
lematoda			1		2															10	2		
Oreodytes											9								1				
Skwala	1				1		2	18				2									2		
Ryacophila hyalinata																					1		
Tipulidae																		2	4				140
Calopteryx			2				14				1						1	7					
Turbellaria											2												
Yugus																							
Naucoridae								15													11		
Cascadoperla				9				3	28		5									3	7		
Ophiogomphus	1												1										
Coenagrionidae	2										8												
Sialis											3										4		
Amphiagrion										5													
Argia		6									1										1	2	
Hirudinidae	1																						
Corixidae	2																						
GATHERERS																							
Ameletus velox							1																
Amiocentrus					4						4	8	16		2		3	2			5		
Antocha				1																			
Dixa		1								19										6	2		
Dubiraphia															166	6	5	31	33				
Rhizelmis	4		5	31	91			60	44					4							1	5	
Hemerodromia		2		1					5	33													
Ephemerella									6										2				
Ephemerella aurivilli																							
Ephemerella grandis							1	5				122		2									
Heterlimnius																							

ppendix 1 (cont.)

ITE LOCATION	Im	Sp	Im	Sp	Up	Up	Im	Im	Im	Im	Im	Up	Lo	Sp	Up	Up	Lo	Lo	Up	Lo	Lo	Sp	Sp
TATION #	29	24	30	23	4	1	28	26	31	32	27	8	15	20	3	2	19	18	5	17	16	22	2
ATE	900720	900718	900815	900619	900620	900614	900618	900620	900621	900619	900619	900717	900721	900718	900615	900614	900613	900613	900614	900826	900825	900825	90083
EP #	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.
ATHERERS																							
lyallela azteca	10	169		5						6				36	8	1	18	64				64	
renitis	1																						
epidostoma		5	3																				
eptophlebia	1										35									40	62		
ptioservus											14	1	7										
araleptophlebia			42											4									
ericoma																							
olycentropus			1																	2			
yacophila acropedes						6																	
erratella tibialis						9																	
aitzevia				2																			
ricorythodes	11			127				2	1	9	24	2	5								19	21	
onielmis			1			13				21			44										
tenelmis	2												20										
oselyana	3														1								
aenis	20																						
SCRAPERS																							
Baetis bicaudatus														10	56	3							1
Baetis intermed	23	5	7		57	22	16	15	78	34							89	12	40	65	2		
Baetis tricaudatus				13							6	10											
Cinygmula			5			59													20	1			
Drunella coloradensis																			6				
Drunella doddsi						6																	
Drunella flavilinea						20										3							
Epeorus iron																			8				
Epeorus longimanus					59	35	1													7	4		
Epeorus albertae										3	27		3										
Ephemerella inermis							16		1						12	3	27	41	10				
Gastropoda																		2					
Glossosoma						3	1				6	11	21							15	1	2	
Heptageniidae		1						3	1		5				4	2		1					
Hydroptila	13	2	64					6					1	10						7		43	
Helicopsyche	3						1			1			1		4						4		
Neophylax						3													2				
Blephariceridae																					2		
Pyralidae																					2		
Rhithrogena						3																	
Caudatella heterocaudata					12							1											
Psephenidae									3		5		1										
SHREDDERS																							
Capnia						3														1	1	1	
Limnephilidae		5				2	1			3		5							12			6	
Micrasema					3	3									3								
Psychoglypha																	22	1					
Pteronarcys californica									18			7			4								
Zapada cinctipe	1		5			1						3							2				
Zapada oregonesis		4											25			1				41			

Appendix 1 (cont.)

SITE LOCATION	Im	Sp	Im	Sp	Up	Up	Im	Im	Im	Im	Im	Up	Lo	Sp	Up	Up	Lo	Lo	Up	Lo	Lo	Sp	Sp
STATION #	29	24	30	23	4	1	28	26	31	32	27	8	15	20	3	2	19	18	5	17	16	22	21
DATE	900720	900718	900815	900619	900620	900614	900618	900620	900621	900619	900619	900717	900721	900718	900615	900614	900613	900613	900614	900826	900825	900825	900830
REP #	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.	QUAL.
SHREDDERS																							
Paracapnia						1								24		3				4		5	3
Grensia										14													
Dicosmoecus																							
Chyranda				3													6						
Amphineumura																							
FILTERERS																							
Arctopsyche	37	1				1										8	1	5	51	2		4	
Brachycentrus					1	3	10		60											4		4	
Hydropsyche				22	2		16	1	2	31	59	34	8							21	4	4	
Ostracoda		5	32	1					3	2			9		6		32	22					
Parapsyche elis						3																	
Pisidium		6		8	1					24		16			2		34	5	4	2		1	4
Simulium		1		6	3	41	4	136	4	6					4		8		1	2			
Prosimulium					13											286		6					
Physa	5	1	5	6				1		11													20
Gyraulus										8												3	
MINERS																							
Chironomidae	110	22	38	35	18	25	84	79	14	32	58	47	57	243	3	4	6	57	104	93	113	105	1
Oligochaeta	29	6	3	3		1	12	3	3	11	7	2	9	13	1		30	6		10	9	3	7
OTHERS																							
Gerridae																				1			
Eubranchiopoda	1																						
Hymenoptera							3	1	1	1													
Diptera						2															1	3	
Homoptera																							

Appendix 2. List of candidate streams used for the Snake River Plain Ecoregion Study.

Stream	TYPE	SSOC	RNA	IF&G	BLM	USFS
Green	Up			X		
Stinson	Up					
Trapper	Up					X
Buck	Up					
Cottonwood	Up			X		
Connor	Up			X		X
Goose (upper)	Up			X	X	X
Six Mile	Up					
Rock (3rd Fk)	Up					
Rock (4th Fk)	Up					X
Rock (5th Fk)	Up					X
Big Cottonwood	Up		PO	X		X
EF Jarbridge	Up		PO/LI			
Trout	Up			X		
Eight Mile	Up					
Cold	Up			X	X	
Little Jack's	Lo	X				
Big Jack's (Up)	Lo	X	PO			
Cottonwood	Lo					
Lake Fork	Lo					X
Station Fork	Lo					X
Salmon Falls	Lo					
Box Canyon	Sp					
Branbury	Sp					
Vinyard	Sp		PO/PR			
Dove	Sp					
Sand Springs	Sp					
Salmon Falls	Sp	X	LI/PR		X	
Devils Corral	Sp					
Billingsley	Sp	X				
Silver	Sp	X				
Billingsley	Im/Sp					
Sheep	Im/Lo	X				
Big Jack's (Lo)	Im/Lo	X	PO			
Cassia (Lower)	Im/Lo	X			X	X
Mary's	Im/Lo	X				
Duncan	Im/Lo					
Trapper(Lower)	Im/Lo					X
Shoshone	Im/Lo	X				
Shoshone (Mid)	Im/Lo	X				
Salmon Falls	Im/Lo	X				
Deep	Im/Lo	X				
Goose (Lower)	Im/Lo					
Bruneau	Im/Lo					
Yahoo	Im/Lo					