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Distribution of Fishes and Changes in Biotic Integrity in the New River, Tennessee

R. Brian Evans
University of Tennessee - Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by R. Brian Evans entitled "Distribution of Fishes and Changes in Biotic Integrity in the New River, Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Animal Science.

David A. Etnier, Major Professor

We have read this thesis and recommend its acceptance:

Dewey Bunting, Richard Strange

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Associate Vice Chancellor and
Dean of The Graduate School

DISTRIBUTION OF FISHES AND CHANGES IN BIOTIC INTEGRITY IN THE NEW RIVER, TENNESSEE

A Thesis Presented for the Master of Science Degree
The University of Tennesse, Knoxville

R. Brian Evans

May 1998

Dedication

To my Grandmother, for her love and encouragement and for sharing in my childhood explorations of streams.

Acknowledgments

Completion of this thesis was accomplished with the assistance of several people to whom I am grateful. I thank my major professor, Dave Etnier, for suggesting this study, providing encouragement and direction, and exhibiting confidence in me during my research. For their editing and constructive critique of this thesis, I thank the other members of my graduate committee, Dewey Bunting and Richard Strange.

Many people helped me complete my field work. I am particularly grateful to Bo Baxter, Barry Hart, and Chris Paxton for accompanying me on almost every collecting trip. Their knowledge of the aquatic fauna of the Big South Fork system, since of humor, and friendship made my research a very enjoyable experience. I appreciate the time and effort spent by several other individuals who helped collect fishes: Steve Fraley, Barron Moody, Chris Skelton, Shea Eskew, Shea Gaither, Denny Smith, and Brad Tarbert (UT); Tammy Mendelson (Duke); and Liz Etnier. I thank Steve Bakaletz (BSFNR), who in addition to helping collect fishes, coordinated access to portions of the New River within National Park and private land boundaries. Three people from the Tennessee Wildlife Resources Agency, Rick Bivens, Bart Carter, and Carl Williams , graciously provided their expertise and equipment to complete the large river sample. I also thank Dave McKinney (TWRA) for orchestrating the funding that supported this research. Lastly, I thank my wife, Kim, for being patient and supportive while I pursued my interests.

Abstract

Electrofishing samples of fishes were obtained from forty-two localities in the New River system, Tennessee during summer and fall 1996. Eight of forty-two species collected represent new records from the New River: *Notropis telescopus*, *Moxostoma macrolepidotum breviceps*, *M. carinatum*, *Lepomis auritus*, *L. gulosus*, *L. microlophus*, *Etheostoma cinereum*, and *Stizostedion vitreum*. Temporal changes in the distribution of fishes were detected by comparing historical collection records with fish samples from 1996. Older records were also employed in the compilation of a modified index of biotic integrity (IBI) that was used to assess changes in fish assemblage health during the past twenty years. Positive changes in the distribution of fishes and the IBI indicate that water quality and fish assemblages have improved in the New River over the past two decades, subsequent to federal legislation that required decreased input of sediment and mine drainage into the Big South Fork of the Cumberland River system.

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1. Introduction

This thesis reports the results of an ichthyofaunal survey conducted during the summer and fall of 1996 in streams throughout the New River basin, Tennessee. After completion of the survey, the present distribution of fishes was compared with historical records to determine spatial and temporal variation in fish community composition that coincided with changes in watershed land use, primarily surface coal mining. Research presented herein was undertaken because the ichthyofauna of the area has been poorly studied over the previous twenty years, probably because the region was believed to be too degraded to posses healthy communities or interesting taxa. Compared to other river systems in Tennessee, few collection records from the New River were available. Improved land use activities initiated by federal legislation were anticipated to have had positive effects on the integrity of fish communities. The law that established the Big South Fork National River and Recreation Area (BSFNRA) (Public Law 93-251, 1974), in reference to downstream portions of the New River and most of the Big South Fork River, directed state and federal agencies in Tennessee to "...enhance the environment and conserve and develop natural resources, and to minimize siltation and acid mine drainage." Additional improvements in water quality were expected to have occurred as a result of the Clean Water Act (1972) and the Surface Mining Act (1977). The discovery of *Etheostoma cinereum,* a threatened species in Tennessee, in the New River (Rakes and Shute, 1994 pers. com.) indicated that fish populations were probably improving, providing the final impetus for doing a comprehensive ichthyofaunal survey.

2. Study Area

Located in the Cumberland Mountains of northeast Tennessee, the New River flows 55 miles from its headwaters to its confluence with the Clear Fork River (Figure 1). It has a drainage area of 382^2 miles. 63.5 % of which occupies Scott County, followed by 17.6 % and 16.8 % in Campbell and Anderson Counties, respectively. The remaining 2.1 % consists of small headwater streams located in northeastern Morgan County (Tung, 1975). Starting in Anderson County, the river flows northeast into the southwest corner of Campbell County where it turns and follows a northwesterly course into Scott County. The confluence of New and Clear Fork rivers form the head of the Big South Fork of the Cumberland River that travels northward into Kentucky approximately 50 miles until it reaches Lake Cumberland, an impoundment on the Cumberland River. The entire Big South Fork of the Cumberland River and lower portions of the New and Clear Fork rivers are bounded by the BSFNRA.

The New River is located in the northeast corner of the Cumberland Plateau, one of Tennessee's six major physiographic provinces. To account for regional variation in faunal patterns and to better predict these patterns, the U.S. EPA in conjunction with the Tennessee Department of Environment and Conservation has developed a classification system that more precisely defines biomes in Tennessee than do physiographic provinces. Under this scheme the state is divided into 25 ecoregions, defined as areas of relative homogeneity in ecological systems and their components (Griffith et al., 1997). Factors used to classify ecoregions are soil characteristics, vegetation type, climate, geology, and physiography. The New River Basin lies in the Cumberland Mountain ecoregion and on

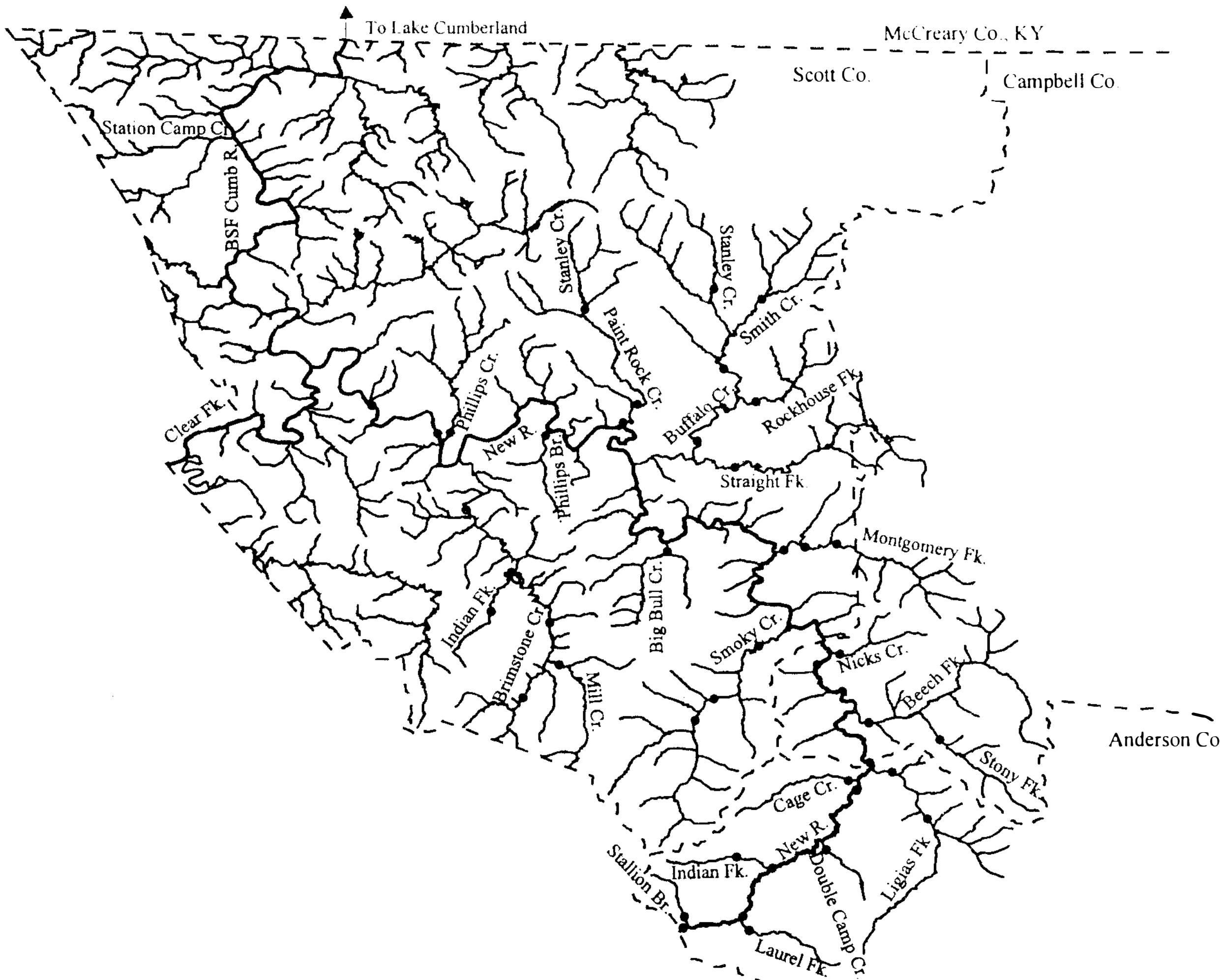


Figure 1 Map of New River system including portions of the Big South Fork of the Cumberland River system. Closed circles represent localities sampled in 1996.

a coarser scale is included with the Central Appalachian ecoregion that stretches from northern Tennessee to central Pennsylvania. Soils of the Cumberland Mountains and New River watershed are classified as well drained, loamy, and acidic with low fertility. Forests are composed of white oak, chestnut oak, and black oak with northern red oakforests on north slopes. Pennsylvanian age shales followed in order of predominance by sandstones, siltstones, and coal comprise its geology. The topography of this ecoregion is described by its steep mountain slopes, having narrow crests, elevations ranging from 1200 to 3500 feet, and relief ranging from 1800 to 2000 feet. Mean winter low temperature is 21 degrees and mean summer high temperature is 85 degrees. Average annual rainfall ranges from 50 to 55 inches.

Much of the New River watershed, contains either abandoned underground mines or surface mines. In the early 1940s a shift to surface mining, presently the exclusive coal extraction method, occurred (Tung, 1975). Since the early 1980s active mining has been reduced in the watershed (C. Walker, OSM, pers. com.)

3. History of Water Quality

Historically, the New River has been adversely affected by coal mine drainage. The primary deleterious form of mine pollution entering its streams has shifted from acute acid pulses to chronic siltation. During a survey of the chemical characteristics of New River in August 1938, Shoup (1940) determined that the main stem was affected by acid mine drainage for at least twenty miles from its headwaters at Fork Mountain downstream to Buffalo Creek near the town of Norma (Figure 1). Five pH measurements taken at sites between Fork Mountain and the Big South Fork confluence ranged from 5.2 to 7.0. All these values are high enough to support fish survival, but two tributaries had lethal pH of 4.1 and 4.4. Measurements taken at Norma on different weeks ranged from 4.6 to 6.8 indicating that acidic drainage was pulsing into the main stem from degraded tributaries. The lower section of Buffalo Creek and its major tributary, Straight Fork, had satisfactory water quality when chemical conditions were initially monitored in 1938, but in the following year both became degraded with a heavy deposit of sludge, and acidity that dropped pH from 7.1 to 5.0. Several tributaries including Beech Fork, Brimstone Creek, Smoky Fork, Ligias Fork, Paint Rock Creek, and Indian Fork were not found to be affected by acid mine drainage at the time of Shoup's survey.

Shaft mining commenced in the river basin in the early 1900s followed by a shift to surface mining, begun in the 1940s (Tung, 1975). Although some acid drainage still seeps into New River streams from abandoned shaft mines, the change to surface mining has altered the nature of water chemistry in most of the river system. In many cases surface mine drainage has increased alkalinity in streams. The source of this alkalinity,

primarily sulfate compounds in the form of calcium and magnesium complexes (Branson et al., 1984), is disturbed overburden (Talak, 1977; Tolbert, 1978), the material removed from coal seams and deposited on mountain slopes that subsequently leaches into streams during rainfall. Dissipation in the frequency of acid drainage pulses in New River streams is indicated by measurements taken at twenty-four sites at various times between 1975 and 1978 (Minear and Tschantz, 1976; Brazinski, 1979). Monitoring during these periods revealed that acidity levels in only two streams, Straight Fork and Montgomery Fork (Figure 1), were harmful to fish.

Since it has been established that acid mine drainage is a minor form of pollution currently deleterious to aquatic communities in New River, other factors must be responsible for observed declines in communities of aquatic organisms. Previous research (Talak, 1977; Tolbert, 1978; Vaughan, 1979; Tolbert and Vaughan, 1980) indicates that siltation is the major form of mine pollution currently affecting the New River system fauna. One study, although it did not occur in the New River watershed, (Branson and Batch, 1972, 1974; Branson et. al. 1984) is particularly relevant because it was undertaken in a region having very similar geological and ecological characteristics to the New River. Also, it is one of few studies monitoring *long term* effects of surface mining on streams in the central Appalachians, and serves as an account of extreme impacts of surface mining in the New River system. The study commenced in eastern Kentucky just prior to the initiation of surface mining in the watershed of one stream, and just after mining had started in another. Initially, sites were monitored for a period of seventeen months. Fish and benthic macroinvertebrate faunas were resampled at the

same sites five and ten years after the study began. Within one month after strip mining began, both streams incurred drastically higher turbidity levels. Substrata in one of the streams became encrusted with two to six inches of clay that virtually eliminated benthic fauna and vegetation, and peak silt loads were twenty times greater than normal levels. By the end of the first seventeen months of the study, fishes were extirpated from headwaters and forced to move downstream, reproduction of benthic fishes ceased, and benthic food resources were reduced 90 %. Mining, which had continued for four years in one watershed, had completely obliterated one monitoring site with siltation, and fish species richness had decreased at all sampling stations included in the study. Ten years after mining had been halted in one of the watersheds its streams remained silted up to 45 cm deep. While some of the sites in both watersheds exhibited modest increases in fish species richness and recolonizations, none had reached pre-disturbance levels.

In another relevant study, Vaughan (1979) determined that although variation in heavy metals, pH, alkalinity, temperature, and oxygen content occurred in streams in the New River, it did not account for changes in community structure of fishes and diatoms; rather, siltation was responsible for alteration of communities. Tolbert (1978) sampled benthic insects of three disturbed streams and one undisturbed stream in the New River system and found significant reductions in species richness, diversity, and number of individuals in those streams influenced by surface mines. Further, Tolbert determined that streams exhibiting declines in benthic community integrity had greater flow and turbidity. During a study of benthic insect communities involving several small streams in the New River system, Talak (1977) also concluded that sedimentation was responsible

for reducing species richness, altering relative abundance, and decreasing population density.

4. Fish Sampling Methods

From May through October 1996, 42 localities in 25 second to sixth order streams were sampled in the New River basin (Figure 2). Additionally, one large river site was sampled in April 1997. Initially, the sampling goal was to detect all species present at a site. Fish were stunned with a backpack shocker (set at 150 V AC) equipped with a dip net. Dip netters followed the shocker, captured dazed fish, and placed them in a bucket of stream water. At each pool-riffle boundary fish were identified, counted, and those not preserved were released downstream to reduce stress and mortality by decreasing time individuals spent in the bucket. Fishes were released far enough below the sampling area to limit the probability that they would swim back upstream into the sampling area. To reduce variability in sampling effort, a single shocker was used in stream reaches having average widths less than 6 m. Localities with average widths greater than 6 m were sampled with two shockers. All sites included at least one riffle and pool sequence and were further sampled upstream until collectors stopped accumulating species. For a majority of sites in the New River, capture of additional species stopped at stream lengths ranging from 200-300 m. A few of the stream reaches sampled included portions with pools too deep or riffles too torrential to effectively electrofish. In these cases, a 12 X 6 foot seine (3/8 inch mesh) was deployed. The seine was pulled through deep pool habitat several times until collectors determined that there were no new species to be obtained. Very swift riffles were effectively sampled by electrofishing and kicking substrata loose for short (less than 10 meter) reaches downstream towards the seine which was anchored by collectors who stood on the weighted lead line, keeping it in contact with the stream

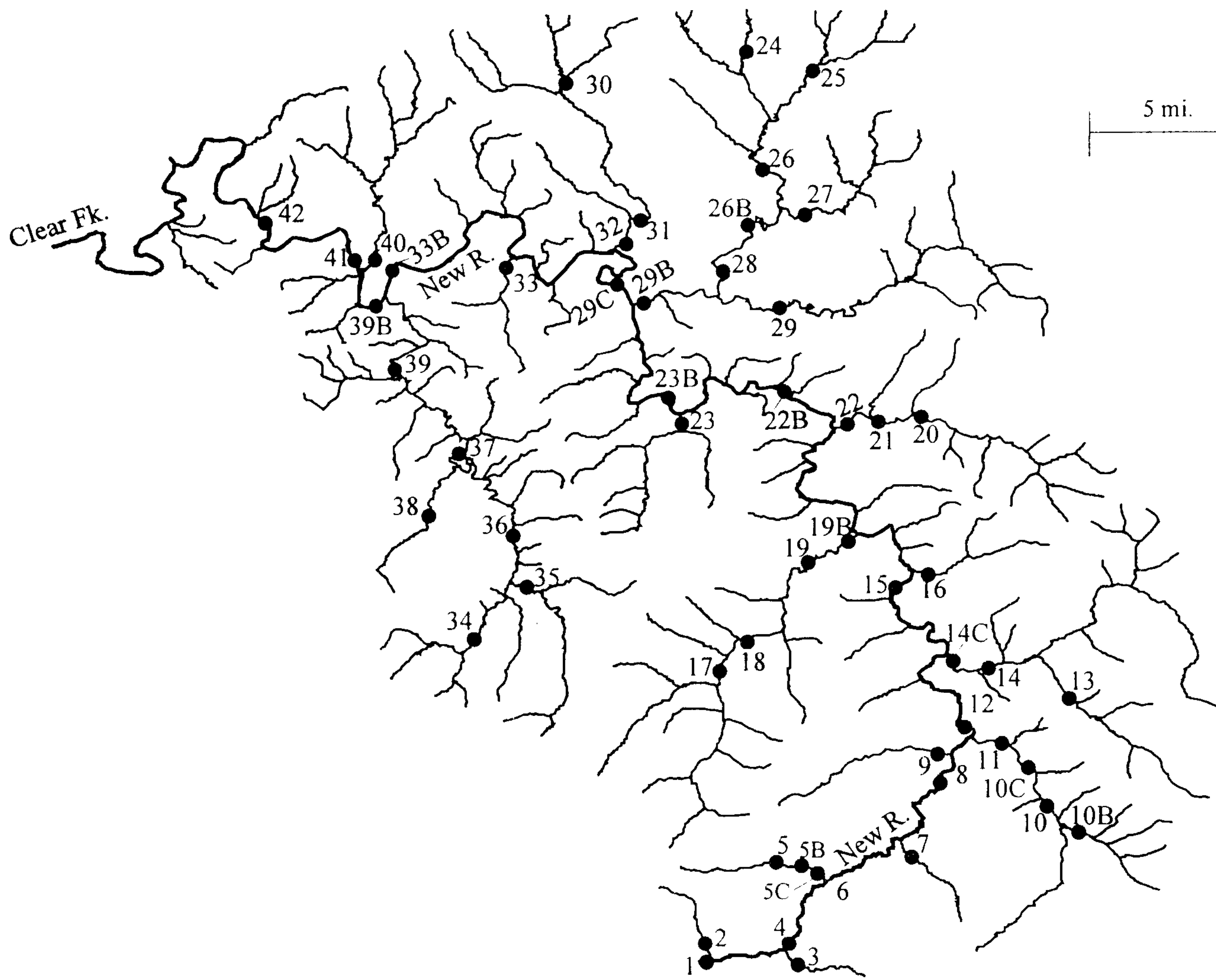


Figure 2. Map of the New River system. Locality numbers followed by letter were sampled prior to 1996. All others were sampled during 1996-97.

bottom while simultaneously holding the net up by grasping either end of the brail. The largest big river sample (site 42, Figure 2) required a variety of collecting techniques in attempt to accurately determine species richness. In addition to all the sampling techniques mentioned above, a boat shocker was used in long deep pools at site 42. Representatives of each species captured from each of the forty-two sites and those taxa that eluded easy field identification were preserved in 10 % formalin, and catalogued in the UT research collection of fishes.

5. Annotated List of Fishes

Spanning the past 115 years, ten ichthyofaunal surveys have been completed in New River streams. Kirsch (1893) completed the first survey in 1891 followed by surveys done by Shoup and Peyton in 1938 (1940, and UMMZ records), Thompson and Kelly (ANSP records) in 1953, Comiskey (1970: Comiskey and Etnier, 1972) during 1968 and 1969, Riddle (1975), Brazinski (1979) during 1977 and 1978, O'Bara and Estes (1984a) in 1982, Bivens and Williams (1990) in 1989, and most recently, the survey completed in 1996 which is reported herein. Prior to the 1996 survey, only Brazinski's included samples from more than a few streams in the New River system. The localities of all ichthyofaunal surveys known to have occurred in the New River system, and the species collected from each site in each of these surveys are listed in Appendices 1 and 2, respectively.

The status of species collected in or believed to inhabit the New River system is described below. The relative abundance of each species based on samples taken at all locations within the entire New River system is listed in Table 1. Substantial differences in species frequency of occurrence among 21 sites sampled both in 1996 and 1977-78 are described in Figure 3. Species richness and abundance of individual species is listed for all sites resampled since 1968 (Appendix 3). Large differences in species relative abundance detected at sites resampled since 1977 probably reflect real temporal changes in species composition at the scale of the whole river system.

Table 1. Number of individuals and species relative abundance (expressed as percent of total individuals collected) in the New River system, 1996-97 and 1977-78 surveys. Number of samples = 44 and 32, 1996-97 and 1977-78 respectively.

	Individuals		% Overall		% Within family	
Cyprinidae	1996 - 97	1977 - 78	1996 - 97	1977 - 78	1996 - 97	1977 - 78
C. anomalum	3832	2281	24.12	29.26	35.32	40.77
C. galactura	267	12	1.68	0.15	2.46	0.21
C. carpio	1	1	0.01	0.01	0.01	0.02
L. chrysocephalus	1790	30	11.27	0.38	16.50	0.54
L. fasciolaris	1172	282	7.38	3.62	10.80	5.04
N. micropogon	24	0	0.15	0.00	0.22	0.00
N. rubellus	1182	257	7.44	3.30	10.89	4.59
N. stramineus	941	1553	5.92	19.92	8.67	27.76
N. volucellus	482	76	3.03	0.97	4.44	1.36
R. atratulus	65	58	0.41	0.74	0.60	1.04
S. atromaculatus	1094	1045	6.89	13.40	10.08	18.68
Total:	10850	5595	68.29	71.77	100.00	100.00
Catostomidae						
C. commersoni	111	90	0.70	1.15	11.76	17.27
H. nigricans	652	399	4.10	5.12	69.07	76.58
M. carinatum	19	0	0.12	0.00	2.01	0.00
M. duquesnei	80	29	0.50	0.37	8.47	5.57
M. erythrurum	67	3	0.42	0.04	7.10	0.58
M. macrolepidotum	15	0	0.09	0.00	1.59	0.00
Total:	944	521	5.94	6.68	100.00	100.00
Ictaluridae						
A. natalis	12	22	0.08	0.28	66.67	66.67
I. punctatus	4	11	0.03	0.14	22.22	33.33
N. exilis	1	0	0.01	0.00	5.56	0.00
P. olivaris	1	0	0.01	0.00	5.56	0.00
Total:	18	33	0.11	0.42	100.00	100.00
Centrarchidae						
A. rupestris	206	50	1.30	0.64	21.66	14.29
L. auritus	1	0	0.01	0.00	0.11	0.00
L. cyanellus	28	0	0.18	0.00	2.94	0.00
L. gulosus	1	0	0.01	0.00	0.11	0.00
L. macrochirus	81	13	0.51	0.17	8.52	3.71
L. megalotis	436	132	2.74	1.69	45.85	37.71
L. microlophus	1	0	0.01	0.00	0.11	0.00
M. dolomieu	138	14	0.87	0.18	14.51	4.00
M. punctulatus	55	140	0.35	1.80	5.78	40.00
M. salmoides	4	1	0.03	0.01	0.42	0.29
Total:	951	350	5.99	4.49	100.00	100.00

Table 1.(continued)

	Individuals		% Overall		% Within family	
	1996 - 97	1977 - 78	1996 - 97	1977 - 78	1996 - 97	1977 - 78
Percidae						
E. baileyi	108	55	0.68	0.71	3.46	4.24
E. blennioides	392	100	2.47	1.28	12.55	7.71
E. caeruleum	1838	853	11.57	10.94	58.83	65.77
E. camurum	442	168	2.78	2.15	14.15	12.95
E. cinereum	68	0	0.43	0.00	2.18	0.00
E. sanguifluum	178	10	1.12	0.13	5.70	0.77
P. caprodes	24	86	0.15	1.10	0.77	6.63
P. maculata	68	25	0.43	0.32	2.18	1.93
S. vitreum	6	0	0.04	0.00	0.19	0.00
Total:	3124	1297	19.66	16.64	100.00	100.00

	1996 - 97	1977 - 1978
Total Individuals	15887	7796

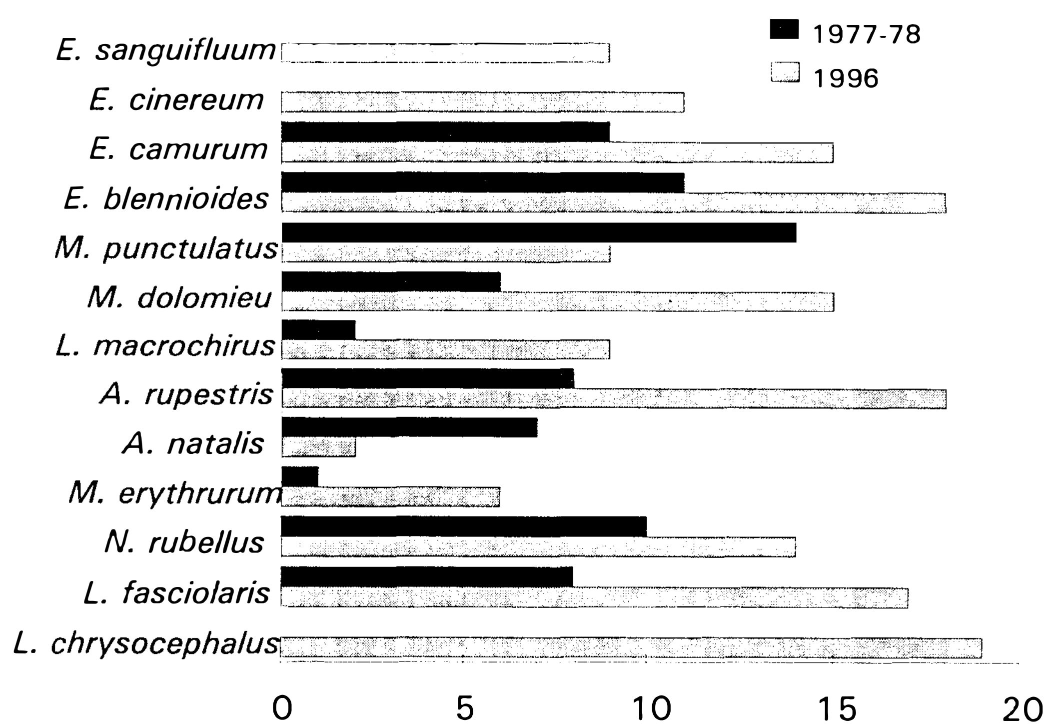


Figure 3. Frequency of occurrence, 21 sites.

Cyprinidae

Campostoma anomalum (Rafinesque), central stoneroller: Collected at 38 of 42 sites and 22 of 24 streams sampled. the central stoneroller was the most widespread species in the New River. A majority of specimens were captured in the high flow interface between pools and riffles. Stoneroller abundance was lowest at sites that appeared to be most degraded and intermediate where water quality seemed unaltered. They were most abundant in streams that appeared to be enriched by either sewage or pasture drainage.

Preliminary samples from ongoing research of stoneroller systematics by D. A. Etnier indicates that a transition from *C. anomalum* to *C. oligolepis* occurs downstream of New River in the proximity of Station Camp Creek (Figure 1), a tributary of the Big South Fork located approximately 14 river miles below the mouth of New River. Only *C. anomalum* were collected from the New River system in 1996. Thus, this river system is believed to be upstream and outside of the range of *C. oligolepis*.

Cyprinella galactura (Cope), whitetail shiner: Found primarily in larger streams, the whitetail shiner was most often collected in deep runs. Quicker and more elusive than other cyprinidae, this species was occasionally observed avoiding the electrofisher, and in some sites its relative abundance was probably underestimated. Except at the most downstream site on the New River, relative abundance of whitetail shiners was low.

Cyprinella spiloptera (Cope), spotfin shiner: This species has not appeared in any collection from the New River system since 1953 (Thompson and Kelly, ANSP record). In addition to currently inhabiting the downstream Big South Fork and adjacent Clear

Fork, it is encountered in lower reaches of the Upper Cumberland River above Cumberland Falls (Baxter, 1997), inhabiting areas equal in size and habitat quality to those sampled in the New River. Thus, it is surprising that this otherwise widespread and tolerant *Cyprinella* has apparently been extirpated from the New River system while the previously sympatric and ecologically similar *C. galactura* has persisted. *Cyprinella galactura* is found throughout much of the Big South Fork system and is usually more abundant than *C. spiloptera,* but *C. spiloptera* was expected to occur more frequently in lower reaches and larger tributaries of the New River. Both species have comparable feeding and reproductive strategies, so it is doubtful that either is more tolerant of environmental perturbations than the other. Whitetail shiners inhabit smaller streams than do spotfin shiners and this habitat size preference may have enabled them to survive in unimpacted refugia while all larger stream habitats were degraded enough to prevent persistence of spotfin shiners. If it is not already a rare inhabitant of lower portions of the New River, it is likely that spotfin shiners will return from neighboring source areas (Clear Fork and Big South Fork) in the near future.

Erymistax dissimilis (Kirtland) streamline chub: With the exception of two records from Little South Fork River (Burr and Warren, 1986), now separated from remaining portions of the Big South Fork system by Lake Cumberland, the streamline chub was not known to occur in the Big South Fork system. On 16 October 1997 two specimens (UT 44.7736) were collected from the Big South Fork at Leatherwood Ford, 70 river miles upstream from Lake Cumberland and 7 river miles downstream from the mouth of the New River. Absence of physical barriers between Leatherwood Ford and

the mouth of the New River, and the close proximity of these two sites, indicates that streamline chubs may be future denizens of or already inhabit the New River system.

Hybopsis amblops (Rafinesque), bigeye chub: In 1953 eight specimens of the bigeye chub were collected; five from Brimstone Creek (ANSP 82730), and three from the New River proper just upstream from Brimstone Creek (ANSP 109551). Since this discovery forty-four years ago there have been nine surveys in six sites in Brimstone Creek, none of which detected bigeye chubs. All other samples from the New River system have failed to yield this species. Scarcity of bigeye chubs in the Big South Fork system is indicated by their presence in only four other collections; one from Kennedy Creek (Kirsch, 1893) two from Rock Creek (O'Bara and Estes, 1984b) and one from Little South Fork (Burr and Warren 1986).

Surprisingly, life history of the bigeye chub has been poorly studied. Most information about its feeding and reproductive requirements is anecdotal, making it difficult to assess its habitat preferences and tolerance to pollution. Smith (1979) and Trautman (1981) have attributed population declines of this species to siltation, but life history and physiological analyses provide conflicting evidence on habitat and substrate requirements. A study based on brain development (Davis and Miller, 1967, cited in Etnier and Starnes, 1993) suggested that bigeye chubs were adapted for feeding in both clear and turbid environments, but Reno (1969; cited in Etnier and Starnes, 1993) concluded that pore size and completeness of the lateralis system implied specialization for inhabiting clear waters. In other river systems east of the Cumberland Plateau, bigeye chubs are most frequently captured over sandy or silty substrates. However, gut contents

of 10 adult and subadult specimens contained macroinvertebrates associated with coarser, cleaner substrates than that of bigeye chub's purported habitat (Etnier and Starnes, 1993). Jenkins and Burkhead (1994) suggest that they were extirpated from the Big Sandy River in Virginia due to coal mine pollution. Perhaps bigeye chubs have become imperiled in some river systems because they use a broad range of benthic habitats daily, but require specific silt free areas, which have been reduced in the New River system, for feeding or reproduction. This species is likely extirpated from the New River, and its persistence in the Big South Fork system is hampered as fragmented populations have become constricted due to episodes of pollution. Additionally, the separation of a once continuous riverine environment by Lake Cumberland probably has resulted in isolation of source populations, thereby restricting recruitment and genetic diversity, further hindering survival of the bigeye chub.

Luxilus chrysocephalus Rafinesque, striped shiner. Striped shiners were common and often abundant throughout tributaries and upper portions of the New River. Most specimens were captured in pools having low to moderate current and were found swimming over a variety of substrate types. Second only to the stoneroller in abundance, the striped shiner appears to have recently invaded the New River, greatly expanding its previously known distribution. Historical collection records reflect the recent proliferation of this species; Prior to 1968 there are no records of striped shiners from the Big South Fork System. In the New River system they were found in two of sixteen, one of thirty, and thirty-four of forty-one sites during 1968-69, 1977-78, and 1996, respectively (Appendix 3). All three striped shiner records prior to 1996 are from Buffalo

Creek and two of its tributaries, Stanley Branch and Smith Creek. In addition to New River collections, Comiskey (1970) sampled fishes from forty-seven other sites in the Big South Fork System. During this survey striped shiners were found at two sites in White Oak Creek, a tributary of Clear Fork. The only stream in which striped shiners were found to be common was Little South Fork, where they were collected from six localities, and were abundant only at the most downstream site.

The striped shiner is an ecologically tolerant species, and regardless of the collecting technique, it was the easiest cyprinid to catch during the 1996 survey. If it was always present in the New River system, presumably it would have been detected in most if not all previous surveys, even during periods of high water quality degradation. As a commonly used bait fish (Etnier and Starnes, 1993), striped shiners were likely introduced to the Big South Fork system by fishermen. The close proximity of lower Little South Fork, the only stream previously known to support a substantial population of striped shiners, to Lake Cumberland and their high relative abundance near the embayment indicates dispersal from the lake as a likely means of establishing populations that have persisted in Little South Fork into the present. Striped shiners may have invaded Clear Fork and the New River via Lake Cumberland. However, their preference for streams smaller than the main channel of the Big South Fork and the hiatus in their distribution between upper and lower tributaries suggests a more likely scenario whereby they were introduced from a bait bucket, possibly into Buffalo Creek and Clear Fork independently, and then spread during the past twenty five years.

Lythrurus fasciolaris (Gilbert), rosefin shiner: The rosefin shiner was the third most abundant species collected, and it was distributed throughout the New River system in all but the smallest headwater streams. Specimens were abundant in gently flowing pools of tributaries to the main river but constituted only a small percentage of fish communities in large stream sites. Rosefin shiners are nest associates (Etnier and Starnes 1993) indicating that they probably require clean gravel for successful spawning. Their increase in frequency of occurrence among resampled sites in 1996 (Figure 1) may be the result of improved substrate quality in New River streams.

The *Lythrurus ardens* complex was recently reevaluated (Dimmick et al., 1996) and it was determined that three taxa previously considered subspecies within the complex, *L. fasciolaris*, *L. ardens*, *and L. matutinus*, are evolutionary species. All three are distinguished by differences in coloration of nuptial males and body shape. Of the three species, *L. fasciolaris* has the most westernly distribution, inhabiting streams of the Ohio Basin and one river system (Black Warrior) in the Mobile Bay basin. The two eastern species inhabit Atlantic drainage rivers in Virginia and North Carolina. *Lythrurus fasciolaris* is further separated from the other two species by having a lower anal fin ray modal count (10 vs. 11) and different allele frequencies at three polymorphic loci.

Nocomis micropogon (Cope), river chub: The river chub was the least abundant native cyprinid in the New River system. Prior to the 1996 survey, river chubs were known from only two localities, both within seven river miles upstream of the Big South Fork River confluence (Comiskey, 1970). Records of this species exist for sites along most of the length of Clear Fork River. Therefore, a similar distribution was expected in

the comparably sized New River. The river chub is noted as abundant in the Cumberland Plateau and Cumberland River drainages (Etnier and Starnes, 1993), thus its paucity in the New River is surprising. It is likely that it was once more common, but was not detected because early collectors only sampled smaller streams. During the past sixty years its abundance has likely decreased as a result of its sensitivity to mine drainage. The most recent records, far upstream from previous ones, indicate reinvasion and proliferation from downstream refugia.

Notropis leuciodus (Cope), Tennessee shiner: Tennessee shiners have not been found in the New River since 1953 (ANSP 83009) when they were collected in Brimstone Creek. They were also found during surveys prior to 1953 (Shoup and Peyton, 1940) in Smoky Creek and the river proper, and at that time probably inhabited other streams in the river system. Noted to be most common in streams at the periphery of the Cumberland Plateau (Etnier and Starnes, 1993), Tennessee shiners appear to be rare throughout remaining portions of this province. Records from Clear Fork, one from Little South Fork (Burr and Warren, 1986), and the old records from New River are the only ones known from the Big South Fork system. Notably, tennessee shiners were last collected as extensive strip mining began in the New River watershed. Possibly, populations will re-invade New River from Clear Fork, but presently they appear to be extirpated, since no specimens have been collected during the past 53 years.

Notropis rubellus micropteryx (Cope), rosyface shiner: The rosyface shiner was collected in exactly half the sites sampled in 1996. Population size of this species has likely increased, as it composed 10.9 % of the cyprinid catch in 1996 - 97, but composed

only 4.6 % of the catch in 1977 - 78. Specimens were most often collected in swift flowing areas of pools over cobble or gravel substrates. They were absent or scarce in smaller stream sites and in upper portions of the river system located upstream from Ligias Fork. They were moderately abundant at other sites except for the Buffalo Creek system, where only 30 were collected (site 28) in just one of the six localities sampled. The rosyface shiner is considered to be the most silt tolerant member of its subgenus, *Hydrophlox,* in Tennessee (Etnier and Starnes, 1993). Nevertheless, it appeared to be less tolerant of silt than other New River cyprinids, (e.g. rosefin shiner and sand shiner) as it was absent or sparse in streams, including Buffalo Creek, that were heavily silted.

Notropis stramineus (Cope), sand shiner. Inhabiting most of the streams in the New River system, the sand shiner was generally abundant in pools, particularly in smaller headwater sites, and was captured over a variety of substrates. Although continuing to be a widely distributed species in the New River system, it was approximately four times less abundant in 1996-97 samples than in 1977-78 samples. Reduction in the abundance of the tolerant sand shiner may be related to increases in the abundance of and interspecific competition with the very tolerant striped shiner. Research on the food habits of both species indicates that there diet overlaps during the summer months (Gillen and Hart, 1980).

Notropis telescopus (Cope), telescope shiner. Previously unreported from the New River system, one 29 mm telescope shiner was collected in Paint Rock Creek. Although not common, telescope shiners have been found in Clear Fork and downstream

in tributaries of the Big South Fork. Since the individual was a young of the year, it was very likely a recruit from an adult population inhabiting Paint Rock Creek.

Notropis volucellus (Cope), mimic shiner: Less widespread than its very similar congener, the sand shiner, the mimic shiner was restricted to large pool habitats in or near the New River proper. This species was much more predominant in downstream samples.

Rhinichthys atratulus (Hermann), blacknose dace. There are relatively few records of blacknose dace from the New River, but it is likely not as rare as collection records indicate. Truly a headwater species, very few collections have been made in the preferred small stream habitat of this species. For example, 1996 samples from third order, downstream portions of Double Camp Creek and a fourth order section of Laurel Fork detected only one specimen per site, but subsequent collections from sites upstream reveal blacknose dace to be very abundant in these creeks (Etnier unpub. report, 1997). During these upstream surveys, 53 and 43 specimens were captured in the two creeks respectively, and blacknose dace ranked second to creek chubs in relative abundance.

Semotilus atromaculatus (Mitchill), creek chub: Creek chubs in the New River are most common in small headwater streams, decreasing in abundance as stream size increases. Individuals were found most often in pools, exhibited no particular substrate preference, and occupied the most degraded streams. The creek chub is certainly the most pollution tolerant fish inhabiting the New River system. Although the decline in abundance of the creek chub may be attributed in part to an increase in striped shiner abundance, its decrease also coincided with increases in other less tolerant minnows.

Shifts in relative abundance among the cyprinids are likely associated with improved water quality in the New River system.

Catostomidae

Carpiodes cyprinus (Lesueur), quillback: In 1977 one quillback was collected from the main stem of New River at site 15, approximately 1 mile upstream from Nicks Creek (Fig 1). This is the only record of the quillback from the entire Big South Fork system, although specimens likely inhabit large river habitats that have rarely been sampled. Existence of quillback in the Big South Fork system is also supported by two collection records from the Cumberland River upstream from Lake Cumberland (Burr and Warren, 1984).

Catostomus commersoni (Lacepede), white sucker: Like the creek chub, the white sucker tended to be a habitat generalist and was more prevalent in degraded sites. Specimens were collected in both small and large streams, in slow or swift flowing areas of pools in just under half (19) of the sites sampled.

Hypentelium nigricans (Lesueur), northern hogsucker: As the most abundant catostomid, and together with the central stoneroller the most widely distributed fish in the New River system, *H. nigricans* was captured in a variety of habitats ranging from slow moving pools to swift riffles. Although it was common, it appeared to exhibit sensitivity to pollution as its abundance was very low at degraded sites.

Moxostoma carinatum (Cope), river redhorse: Collections from the 1996 survey revealed for the first time the presence of the river redhorse in the Big South Fork River

System south of the Kentucky border. It is surprising that this species has not been previously detected in this part of the river system, but it is suspected that its presence has been undetected because it is uncommon, and its big river habitat has rarely been sampled. The individual collected from Buffalo Creek, after first jumping out of the water, was chased approximately 75 m downstream with a backpack electrofisher before it was apprehended. Boat shocking proved to be the most effective method for capturing river redhorses. At the big river locality (site 42), 18 individuals were collected from the boat but none was collected by using seines and backpack shockers in the same vicinity. Failure to previously detect this species in the New River may be a result of its true absence rather than ineffective sampling. It is feasible that river redhorses have recently returned to the New River from downstream as water quality improved.

Moxostoma duquesnei (Lesueur), black redhorse: Usually captured in swift areas of deep pools and runs, black redhorses were not abundant at any site in the New River. Apparently this species is sensitive to disturbance as no individuals were observed in degraded streams. It is likely that relative abundance was slightly underestimated because these often large and powerful fish were observed swimming away from and escaping the electric field before being fully stunned.

Moxostoma erythrurum (Rafinesque), golden redhorse: Like the black redhorse, the golden redhorse was captured in similar habitats, was not abundant. Although they sometimes occurred sympatrically, golden redhorses differed from black redhorses by inhabiting an array of streams ranging in degree of disturbance. They appear to be less sensitive to habitat perturbation than the black redhorse.

Moxostoma macrolepidotum (Lesueur), shorthead redhorse: The 1996 records of the shorthead redhorse are the first for the New River. The shorthead redhorse and river redhorse were found in the same two localities, reflecting their preference for similar large river habitats. Prior failure to detect the shorthead redhorse in the New River probably occurred for the same reasons that the river redhorse was previously undetected (see comments under *Moxostoma carinatum*).

Ictaluridae

Ameirus natalis (Lesueur), yellow bullhead: An uncommon species in the New River, eleven yellow bullheads were collected from five of forty-two localities. All individuals were captured beneath undercut stream banks or submerged root wads in sluggish pools that usually were underlain with clay or silt substrates. The yellow bullhead is native to the eastern United States (Etnier and Starnes, 1993), and is almost certainly native to the New River as indicated by its appearance in most earlier collections. Low numbers of this species have been observed probably because sluggish, low gradient pool habitats are uncommon in much of the river system.

Ictalurus punctatus (Rafinesque), channel catfish: During the 1996 survey four channel catfish were captured by boat shocking in the most downstream locality (site 42) in the New River. This species is certainly more widespread along the main stem of the New River than the 1996 collection indicates, but like the large suckers, channel catfish probably avoided capture by backpack electroshockers. Typically they are denizens of medium to large rivers, areas that were rarely collected during the survey. Persistence of

channel catfish in locations further upstream has been substantiated by Comiskey (1970) and Brazinski (1979) who collected specimens in the main channel in the vacinity of Nicks Creek, over thirty-eight river miles upstream from the river mouth.

Noturus exilis Nelson, slender madtom: In the Big South Fork Cumberland River system, slender madtoms have been found only in two nearby localities in Brimstone Creek. Four individuals were collected in 1953 and one was found during the 1996 survey. The nearest known slender madtom collection locality is on the Eastern Highland Rim in the Stones river, (Etnier and Starnes, 1993), the mouth of which is approximately 310 river miles downstream from the mouth of the Big South Fork (TVA, 1962). Individuals inhabiting Brimstone Creek probably represent a relict population. The hiatus between the Brimstone Creek population and remaining populations, which are distributed throughout the central portion of the Mississippi River basin, is perplexing; Slender madtoms are most abundant in the Ozark region which, like the Cumberland Plateau, is an upland region. Thus, it appears factors other than physiography explain their disjunct distribution in Tennessee. Possibly, the array of impoundments in the Cumberland River system between the eastern Highland Rim and the Big South Fork have isolated eastern populations on the Cumberland Plateau, precipitating a decline in numbers such that populations have been extirpated or are rarely detected. Although the distribution of *N. exilis* is peculiar, its rarity in the New River system may be explained in part as a result of reduced reproductive success caused by siltation and olfactory noise (Etnier and Jenkins, 1980; Morison 1983; Etnier and Starnes 1993), each increased by mine drainage.

Noturus flavus Rafinesque, stonecat: In the New River system the stonecat has been collected only once. The individual was collected 8.8 miles upstream from the river mouth during a muskellunge survey done between 1973 and 1975 (Riddle, 1975, precise collection date not provided). Stonecats are distributed along most of the Big South Fork, and although none was collected in 1996, it is likely that they continue to exist in lower portions of New River.

Pylodictis olivaris (Rafinesque), flathead catfish: Flathead catfish have been collected throughout the Big South Fork and in lower Clear Fork. One juvenile (77 mm SL) was collected in 1997, near river mile 5.5, from a swift bedrock chute interspersed with large boulders. Spending daytime hours under the cover of undercut banks or brush piles and actively seeking prey at night (Etnier and Starnes, 1993), this species has probably always been present in low numbers in large downstream portions of the New River, but had previously avoided detection due to its daily movement patterns and preference for habitats that are difficult to sample.

Centrarchidae

Ambloplites rupestris (Rafinesque), rockbass: The rockbass was the most widely distributed and second most abundant centrarchid captured during the 1996 survey. Specimens were most common in relatively clear streams and tended to be collected more frequently in runs over cobble or boulder substrate. In a survey of Big South Fork streams, O'Bara (1984b) found rockbass to be the most abundant game fish. A comparison of the same sites sampled in both in 1977-78 and 1996 indicates that

populations are expanding within the New River system; during the 1977-78 survey, 50 individuals were collected, constituting 0.64 % of the total fish catch, whereas during the 1996 survey 206 individuals constituting 1.3 % of the total catch were collected. Also, in 1996 rockbass inhabited ten of the sites where they were absent during 1977-78 (Figure 3).

Lepomis auritus (Linnaeus), redbreast sunfish: One specimen was collected in a large pool nearly fifty river miles upstream from the river mouth (site 8) in the upper portion of New River. Redbreast sunfish have not been reported from anywhere in the Big South Fork River system, but have invaded the Cumberland River above Cumberland Falls via transplant by humans (Baxter, 1997), possibly causing declines in native longear sunfish populations. Lake Cumberland is a potential source area for invasion of redbreast sunfish but the individual collected in 1996 was obviously introduced by human transport, indicated by its capture far above the lake. If only one or a few specimens were introduced, it is unlikely that redbreast sunfish will persist in the Big South Fork River system.

Lepomis cyanellus Rafinesque, green sunfish: During the 1996 survey green sunfish were collected in nine of forty-two sites and in a 1953 survey of Brimstone Creek three individuals were collected. These two surveys are the only previous ones yielding green sunfish records, and the comparatively high number of sites from which they were collected in 1996 indicates that their distribution is expanding. All specimens were captured in lower portions of the river system, with the most upstream record coming from Buffalo Creek. The green sunfish is an extremely effective colonizer, possessing a

high tolerance for adverse environmental conditions in part as a consequence of its flexible feeding regime (Lemly, 1985). It is likely that it will increase its distribution and abundance in the future, particularly in depauperate streams that are just beginning to improve from the deleterious effects of coal mine pollution.

Lepomis gulosus (Cuvier), warmouth: One warmouth was collected in Buffalo Creek during the 1996 survey. This is the only record of warmouth in the New River system, but Obara and Estes (1984b) reported collecting it in 1981 from the mouth of North Whiteoak Creek, a tributary to the Big South Fork. They speculated that this record represented a recruit from Lake Cumberland. Lending credence to this recruitment theory is the fact that Lake Cumberland was formed over fifty years ago, providing ample time for warmouth populations to spread upstream over several generations Another possibility is that initial populations were founded by introduction from ponds, sampled by Shoup and Peyton (1940), that used to exist near Clear Fork. Having a total length of 46 mm, the individual from Buffalo Creek was a juvenile, indicating the presence of a nearby adult population. If it was not washed out of a farm pond, its presence coupled with the record from North White Oak Creek implies reproduction, recruitment, and persistence of a species invasive to the Big South Fork system.

Lepomis macrochirus Rafinesque, bluegill: Bluegill were spottily distributed in the New River system and ranked fourth in abundance among centrarchids. As expected, all individuals were captured from slow moving areas of pools usually in association with cover of undercut banks, overhanging vegetation, or submerged woody debris. The presence of specimens in silty areas of streams, including Straight Fork (site 29), the most

degraded stream sampled, indicates that bluegill, which have nesting and flexible diet habits similar to those of the green sunfish, are relatively tolerant of mine drainage.

Lepomis megalotis (Rafinesque), longear sunfish: Detected in almost every survey of New River streams, the widely distributed longear sunfish was frequently taken from pools, often in association with snags and/or undercut stream banks. It continues to be the most abundant centrarchid inhabiting the New River system.

Lepomis microlophus (Guenther), redear sunfish: One individual collected from Phillips Creek (site 40) during the 1996 survey is a new record for the New River system. Another specimen was collected in the Big South Fork system from Clear Fork in 1981 (UT 90.593). These two records represent introductions to the Big South Fork either via recruitment from Lake Cumberland or more likely from farm ponds or bait buckets.

Micropterus dolomieu Lacepede, smallmouth bass: Ranking third in abundance among centrarchids, smallmouth bass were found in 21 of 42 sites sampled in 1996-97, were distributed throughout much of the river system, and were more frequently captured than during previous surveys. During the 1977-78 survey, smallmouth bass were collected in only 7 of 28 sites and were not present in 8 sites where they were collected in 1996 (Figure 3). The increase in the spread of this species can probably be attributed to improvements in water quality. Most individuals were captured in swift flowing areas of pools or in riffles over clean, coarse gravel, cobble, and boulder substrates.

Micropterus punctulatus (Rafinesque), spotted bass: Unlike the smallmouth bass, spotted bass were less abundant, captured primarily in slow moving pools, and occasionally found in degraded streams. Compared to the 1996 survey, over twice as

many individuals (140 vs. 55) were collected during the 1977-78 survey, even though the earlier survey included 11 fewer sites and sampling covered smaller areas. If not an artifact of poor sampling, the decline in spotted bass numbers and occurrence may be related to competition from increasing populations of other predators, particularly rebounding smallmouth bass and rockbass populations.

Micropterus salmoides (Lacepede), largemouth bass: Largemouth bass have been introduced to streams of the Big South Fork system probably by recruitment from Lake Cumberland (O'Bara and Estes, 1984b) and stocking from nearby ponds. Records of largemouth bass from Kirsch (1893), are actually misidentified spotted bass (Comiskey and Etnier, 1972). In the New River system, a total of four individuals was collected from Paint Rock Creek and Buffalo Creek during the 1996 survey. Previously two specimens were reported from Brimstone Creek, one in 1977 and one in 1953. It does not appear that largemouth bass populations are increasing, and they will probably continue to persist as only a small component of Big South Fork system fish communities.

Percidae

Etheostoma baileyi Page and Burr, emerald darter: Listed as a species in need of management by the Tennessee Natural Heritage Program, the emerald darter was found in two-thirds of the streams surveyed during 1996 but was not abundant in any sample. Most specimens were collected in gently flowing areas of pools underlain with cobble substrates. Occasionally individuals were present in moderately silted and degraded habitats, but none was collected in areas that were severely impacted. Although the

distribution of emerald darters has expanded in the New River system, low abundance of this species detected in the 1996 survey suggests that it still warrants "need of management" status in Tennessee.

Etheostoma blennioides newmani Rafinesque, greenside darter: Typically collected from riffles, greenside darters were found in a majority of the sampled sites in 1996. Total and relative abundance of this species was greatest in lower sections of the river system, particularly in Buffalo Creek and Paint Rock Creek . All the sites in these two creeks, except for one in Paint Rock Creek, were moderately to heavily silted and were inhabited by fewer darter species than nearby streams. Greenside darter populations may actually be larger in these creeks because siltation levels exclude more sensitive darters, thereby reducing competition.

Etheostoma caeruleum Storer, rainbow darter: Collected in a variety of habitats, but tending to be most heavily concentrated in riffles, the rainbow darter was the predominant percid and second most abundant of all species collected in the New River system. Its success in the New River can apparently be attributed to its relative tolerance of degradation, indicated by the presence of populations in heavily silted areas. Nevertheless, siltation did appear to have some effect on rainbow darters, as the number of individuals collected at these degraded sites was consistently lower.

Etheostoma camurum Cope, bluebreast darter: Virtually all bluebreast darters were captured in rocky riffles or swift flowing water over bedrock. Their range and abundance has expanded in the New River system. Over twice as many individuals were collected in 1996 than from the same sites in 1977-78. Also, eight sites that did not yield

specimens in the earlier survey were found to be inhabited during the recent survey (Figure 3). Prior to the 1996 survey, the farthest upstream locality was below Ligias Fork at river mile 39, about one mile upstream from Beech Fork. In 1996 the bluebreast darter population was almost continuously distributed in the river proper upstream to the mouth of Laurel Fork at site 4. Known to be restricted to medium and large rivers (Etnier and Starnes, 1993), bluebreast darters were more abundant in larger sites in lower portions of the main river where they were the predominant percid. Rainbow darters followed this longitudinal cline in an opposite direction, decreasing in abundance in larger downstream areas.

Etheostoma cinereum Storer, ashy darter: Prior to 1996 the only record of ashy darters in the New River was from snorkeling observations by Rakes and Shute in 1994, near the town of Cordell, approximately 1 river mile downstream from Big Bull Creek. Although they were not abundant where collected, ashy darters are now widely distributed in the New River system. Specimens were captured in eighteen of the forty-two sites sampled, and nearly 50 river miles above the river mouth, just upstream from the confluence of Cage Creek (Figure 2, site 8). Ashy darters have likely reinvaded from downstream refugia in the Big South Fork where they are known to have always persisted. Most individuals were collected from deeper regions of pools having moderate current and substrate composed of large cobble and boulders.

Certainly electrofishing increases the effectiveness and probability of detecting ashy darters, but this sampling technique was employed at 23 sites during 1977-78 and yielded no specimens. Had individuals been present, they likely would have been

detected. In 1996, specimens were found both times (once during high flow) in Smoky Creek, above the bridge at Hembree. This is one of the most frequently sampled sites in the history of New River fish surveys. Although they were not collected in 1891 during Kirsch's survey of Brimstone creek and a lower section of the river proper, ashy darters probably inhabited those sites at that time. They were probably overlooked because effectively sampling their bouldery habitat effectively with a seine is difficult.

Etheostoma sanguifluum (Cope), bloodfin darter: Found to be much more common than in any previous survey, bloodfin darters have extended their range in the New River system. Presumably, populations persisted throughout large streams in the river system until the onset of stream degradation. Although no specimens were detected during the 1891 survey, they most likely were present but overlooked because their habitat is in the swiftest flowing portions of riffles, which are difficult to sample. Compared to earlier surveys, samples from 1996 show a dramatic increase in the distribution and abundance of bloodfin darters. None were collected previously in the New River until one individual was obtained from river mile 8.8 around 1975 (Riddle, 1975). A total of only 10 individuals was found in two of thirty-one sites sampled during the 1977-78 survey. During 1996, 10 of 21 sites that contained no specimens in 1977-78 were inhabited, yielding 104 individuals. In other sites that were not previously sampled, an additional 74 specimens were captured. Although their abundance increases downstream, there is ample riffle habitat to support bloodfin darters along most of the river proper, and it is anticipated that upstream populations will continue to increase in the future.

Etheostoma stigmaeum stigmaeum (Jordan), speckled darter: Kirsch (1893) reported the presence of the speckled darter in Brimstone Creek. This century old discovery is the only record from the New River system. It is probably valid since the speckled darter is easily distinguished from other darters inhabiting the Big South Fork system by its nuptial coloration (Kirsch sampled during its spawning season) and presence of hourglass shaped dorsal saddles. Further supporting the validity of this old record is the persistence of speckled darters in Station Camp Creek (Etnier and Starnes, 1993) and Puncheon Camp Creek (O'Bara and Estes, 1984b), tributaries to the Big South Fork River near the Kentucky border. Possibly, populations lived in upper portions of the Big South Fork system but became restricted to lower portions of the river due to mining pollution. During the 1996 survey, suitable habitats, silty or sandy pools with fine gravels, were observed in Brimstone Creek and many other streams in the New River system in areas downstream from Buffalo Creek. Speckled darters have probably been extirpated from the New River. Even though existing populations inhabit an area far below the river mouth, present habitat quality does not appear to be a barrier for the return of populations in the future.

Percina caprodes (Rafinesque), logperch: Compared to population levels detected during previous surveys, the logperch was the only darter species that appeared to be less common in 1996. In 1996, 24 individuals were captured, comprising less that 0.75 % of the total darter catch. Yet in 1977-78, 85 specimens, comprising over 6.5 % of the total darter catch were found. Although collecting effort per surface area was greater in the earlier survey, more sites and area were covered during the 1996 survey, so the

disparity in logperch abundance cannot be attributed entirely to differences in sampling regime and probably reflects real temporal differences in populations. Perhaps low numbers detected in 1996 can be attributed to increases in relative abundance of rebounding populations of other darter species coupled with a random decrease in recruitment. Logperch populations should return from this anomalous decline if water quality in the New River is sustained or improves.

Percina maculata (Girard), blackside darter: Usually found in deep pools on a variety of substrates, the blackside darter was common but not abundant. More individuals were captured in the 1996 survey than in others, but their relative abundance within the percidae remained close to 2 % during the past two surveys. Individuals were collected primarily in small to medium streams tributary to New River and were absent from large main channel sites sampled below Nicks Creek.

Percina squamata (Gilbert and Swain), olive darter: Based on the close proximity of Clear Fork River populations, Comiskey (1970) hypothesized that olive darters inhabited lower portions of the New River. The 1997 sample of site 42, starting at river mile 4.6 and proceeding approximately one mile upstream, did not yield any specimens. This site was the only one sampled in New River having deep, high gradient, bedrock and boulder areas described as the preferred habitat of olive darters. Other areas of the lowest ten miles of New River probably have similar patches of habitat. One of the primary goals of the 1997 sample was to locate olive darters by concentrating effort in their preferred habitat, so it is highly likely that none were present in the lower New River site. Although this sample and a few others provide limited evidence about the distributional

history of olive darters in New River, a reasonable conclusion is that they inhabited the main stem before it became degraded, but did not persist afterwards. Presently, suitable habitat exists for olive darters to colonize New River. However, the probability of their return may be reduced because populations from source areas in the Big South Fork system appear to be declining. Collection records from the Big South Fork in 1968 show that olive darters were fairly abundant, as different samples near Leatherwood Ford yielded 14, 17, and 23 specimens, but a visual snorkeling survey in September 1994, which began upstream from the mouth of the New River and continued downstream through the Big South Fork, did not yield any observations of olive darters (J. R. Shute pers. com.). Also, during another snorkeling survey of the Leatherwood Ford site in October 1997, no olive darters were observed (pers. obs.).

Stizostedion vitreum (Mitchill), walleye: Comiskey and Etnier (1972) reported gill netting several adults from the Big South Fork and Riddle (1975) captured five individuals from Clear Fork. The known range of this species is now extended to the proximity of New River mile 5 where six individuals were captured from a deep pool by boat electrofishing. Local fishermen reported catches of walleye in New River, and this species probably always inhabited the main stem but was not previously collected due to the paucity of large river samples. Presently, genetic analyses are being conducted (S. Bakaletz, pers. com.) to determine whether New River populations include recruits that were stocked in Lake Cumberland and/or remnant generations from the original native Cumberland River system stock.

6. **Analysis of Fish Assemblages**

In addition to determining the status and distribution of New River fish species, samples were analyzed to detect spatial and temporal differences in fish assemblages. Changes in water quality resulting from differences in watershed land-use were likely reflected in shifts in fish assemblage structure. These shifts were detected by comparing an index of biotic integrity (IBI) measured for each sample. The null hypothesis was that the IBI would not differ among fish samples. Spatial comparisons were made among sites sampled during the 1996 survey, and temporal comparisons were made between sites sampled both in the 1996 and 1977-78 surveys.

Description and History of the IBI

The index of biotic integrity was first proposed by Karr (1981) as a measurement of anthropogenic effects on stream water quality. Karr and Dudley (1981) defined biotic integrity as "the ability to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity and functional organization comparable to that of natural habitat of the region." The original version of the IBI consisted of 12 variables, termed metrics, that were combined to describe fish community structure (Table 2). Each metric was given a score of 5 if its value was close to that expected for an undisturbed stream. Values that deviated substantially from those of unimpacted reference streams were scored as 3 or 1 depending upon how greatly they differed from ideal criteria. Thus, a stream with fish community structure equivalent to that of an undisturbed counterpart would receive a score of 60, whereas streams with the

absolute poorest water quality would receive a score of 12. Streams where water quality was so poor that no fish were collected were scored as "no fish".

Table 2. Original IBI metrics used to assess fish communities in the Midwest (modified from Karr et al. 1986; Miller et al. 1988) and metrics used for the New River system, Tennessee.

Original Metric	New River, Tennessee Metric
Total number of fish species	Total number of fish species
Number of darter species	Number of darter species
Number of sunfish species	
Number of sucker species	[a]Proportion of individuals as suckers
Number of intolerant species	Number of intolerant species
Proportion of individuals as green sunfish	Proportion of individuals as creek chubs
Proportion of individuals as insectivorous cyprinids	[a]Proportion of individuals as benthic invertivores
Proportion of individuals as top carnivores	Proportion of individuals as rockbass and smallmouth bass
Number of individuals in sample	Catch per unit effort (fish per surface area)
Proportion of individuals as hybrids	Proportion of pioneering species
Proportion of individuals with disease, tumors, fin damage, and skeletal anomalies	Proportion of individuals as generalist feeders

[a] Excluding white suckers

Widespread use of the IBI since it was first proposed is noted by Simon and Lyons (1996) who list twenty-two examples in which it was applied to streams located among several different ecoregions. Virtually all aquatic biologists working outside the midwest have modified IBI metrics to account for natural differences in fish faunal composition resulting from zoogeographic and environmental constraints. Although the IBI has been applied to many streams in the Tennessee River system, primarily by TVA biologists, there are few published reports (Crumby et al. 1990; Bivens et al., 1995) of its use in the Cumberland River system. Only one IBI has been employed in the Cumberland Mountain ecoregion (Bivens et al., 1995) and it was based primarily upon criteria developed for the Tennessee River system. Also, this IBI referred to fish assemblages above Cumberland Falls, a barrier that has resulted in isolation of taxa and differentiation of fish assemblages in the upper Cumberland River system (Starnes and

Etnier, 1986). Therefore, using samples from 1996 and 1977-78 surveys, an IBI was developed specifically for New River fish assemblages.

Modifications of the IBI for the New River

The IBI is based upon the premise that certain taxa or guilds disappear from the community in concert with differing levels of sensitivity to anthropogenic disturbance. Given the preponderance of evidence gathered during previous studies that linked this form of pollution to depressed diversity and richness of benthic assemblages, metrics for New River streams were weighted to reflect effects of siltation. Three of the twelve original metrics were retained, seven were modified (either for this study or previously, during others), and one was deleted (Table 2). The modified metrics, discussed below, have been used effectively in other North American ecoregions.

An IBI could not be generated for all known fish samples from New River streams because sampling technique and effort varied among collectors. Discrepancies in sampling methods between surveys obscures detection of the extent of change in fish assemblages. However, large differences in species richness or species diversity, gleaned from older survey data, serve as coarse indicators of what are likely real temporal shifts in species composition and water quality. Changes in species richness and species diversity are incorporated into the IBI. As particular guilds or sensitive taxa diminish in abundance or become lost from the community, resulting in a more homogeneous assemblage, species diversity decreases. This decrease is accounted for in the IBI by scoring affected percent composition metrics lower. Disturbance effects on species

richness are measured by the three metrics retained from the original IBI: total number of native fish species, darter species, and intolerant species.

The measure of species diversity used in this study was Simpson diversity, which is the probability that two species randomly chosen from a sample of fish will be different. Perhaps because statistical tests for comparing Shannon diversity have been published, it is the measure of diversity most frequently applied to samples from aquatic communities. However, (Washington, 1984) noted that its ecological validity needed further testing. Lande (1996) demonstrated that an unbiased estimator for Shannon diversity does not exist and that this measure may have substantial bias when applied to communities containing a high number of species. Bias in Shannon diversity decreases with sample size, but Simpson diversity was found to be superior for use on community samples of modest size. Even though species diversity is incorporated into the IBI, it was calculated separately for all samples as a means of detecting anomalies in the composition of fish assemblages (Appendix 3). For example, if over 50 % of a sample was composed of creek chubs, diversity would be relatively low as compared to samples with a more even distribution of species abundances.

Declines in water quality due to siltation result in decreased diversity and richness of benthic species. Fishes restricted to a benthic lifestyle are most sensitive to the myriad effects of siltation; visual feeding and reproductive cues can become obstructed by high levels of suspended sediment, and the smothering effects of settled silt can destroy eggs and larvae and reduce abundance and diversity of prey resources. In one of few studies attempting to quantify siltation effects on stream fish assemblages, Berkman and Rabeni

(1987) determined that relative abundance of benthic invertivore and herbivore feeding guilds and the simple lithophilus spawning guild (Muncy et al. 1979, as cited in Berkman and Rabeni, 1987) decreased with increased siltation of streams in northeast Missouri. A subsequent study by Rabeni and Smale (1995) determined that these guild responses were consistent throughout Missouri ecoregions. Additionally, they found that although mean species diversity was uncorrelated with siltation and species richness was weakly correlated with siltation, IBI scores were significantly correlated with silt percentages.

Metrics used to indicate degradation by siltation (number of darter and intolerant species, percent composition of catostomid species, benthic invertivores, and simple lithophilus spawners) incorporate groups of taxa having all or part of their life history tied to benthic habitats. Siltation increases in the habitat to which these functional groups are evolutionarily bound will result in loss of species from the community, either by migration from the disturbance or mortality. All darters, whether inhabiting slow moving pools or swift riffles, spend a majority of their lives in contact with or near the substrate, feeding almost exclusively on benthic invertebrates. Moreover, the subterminal mouth and loss of the swim bladder are adaptations that have restricted members of the genus *Etheostoma* to benthic habitats. Like the darters, suckers have feeding adaptations restricting them to subsistence on benthic prey. Suckers are further susceptible to sedimentation because they are simple lithophilus spawners, depositing their eggs freely on clean, rocky or gravely surfaces, leaving them subject to smothering influxes of silt. White suckers were excluded from the sucker composition metric because they are known to be tolerant of pollution and were present more frequently at sites that were

obviously degraded. Although adult feeding strategies of many minnow species preclude them from a benthic subsistence, some are simple lithophilus spawners, a life history trait that ties their survival to benthic habitats, rendering them sensitive to siltation.

Intolerant species are defined as those first to disappear after the onset disturbance. As suggested by Karr et al. (1986), tolerance levels, food, and reproductive habits of specific taxa (Table 3) were determined by reviewing species accounts in regional ichthyological references (Etnier and Starnes, 1993; Jenkins and Burkhead, 1994) and in Berkman and Rabeni (1987). Food and feeding habits of sand shiners and striped shiners were further evaluated and determined based on Gillen and Hart (1980). Although it is extremely rare in the Big South Fork system, the slender madtom was not designated as intolerant, because its scarcity is probably a result zoogeographic rather than anthropogenic effects.

Table 3. Ecological guilds of fishes known from the New River, TN: I = intolerant, IH = intolerant in headwaters, M = moderately tolerant, T = Tolerant. H = herbivore, BI = benthic insectivore and/or invertivore, NI = necktonic invertivore, GI = Generalist invertivore, GO = generalist omnivore, P = predator. N = nester, C = crevice spawner, SM = simple miscellaneous (broadcast spawn successfully over substrates of varying quality), SL = simple lithophilous (broadcast spawn successfully only over clean gravel), CVPC = cavity nester parental care, CPC = complex parental care, CNPC = complex, no parental care. ? = reproductive behavior has not been completely described in published literature. * = presumed extirpated from New River system.

Species	Tolerance	Trophic	Reproductive
Campostoma anomalum	M	H	N
*Cyprinella spiloptera**	M	NI	C
Cyprinella galactura	M	NI	C
Cyprinus carpio	T	GO	SM
*Hybopsis amblops**	I	BI	?
Luxilus chrysocephalus	T	GO	SM
Lythrurus fasciolaris	M	NI	SL
Nocomis micropogon	M	BI	N
Notemigonus crysoleucas	T	NI	SM
*Notropis leuciodus**	I	NI	SL
Notropis rubellus	IH	NI	SL
Notropis stramineus	M	GI	SM
Notropis telescopus	I	NI	SM
Notropis volucellus	M	NI	SM
Rhinichthys atratulus	M	BI	SM
Semotilus atromaculatus	T	GO	N
Carpiodes cyprinus	M	GO	SL
Catostomus commersoni	T	BI	SM
Hypentelium nigricans	M	BI	SL
Moxostoma carinatum	I	BI	SL
Moxostoma duquesnei	M	BI	SL
Moxostoma erythrurum	T	BI	SL
Moxostoma macrolepidotum	M	BI	SL
Ameiurus natalis	T	GO	CVPC
Ictalurus punctatus	M	GO	CVPC
Noturus exilis	M	BI	CVPC
Noturus flavus	M	BI	CVPC
Pylodictis olivaris	M	P	CVPC
Ambloplites rupestris	M	P	CPC
Lepomis auritus	M	GO	CPC
Lepomis cyanellus	T	GO	CPC
Lepomis gulosus	M	P	CPC
Lepomis macrochirus	T	GO	CPC
Lepomis megalotis	M	GO	CPC
Lepomis microlophis	M	BI	CPC
Micropterus dolomieu	M	P	CPC
Micropterus punctulatus	T	P	CPC
Micropterus salmoides	T	P	CPC

Table 3. (continued)

Species	Tolerance	Trophic	Reproductive
Etheostoma baileyi	I	BI	CNPC
Etheostoma blennioides	M	BI	CNPC
Etheostoma caeruleum	M	BI	CNPC
Etheostoma camurum	I	BI	CNPC
Etheostoma cinereum	I	BI	CNPC
Etheostoma sanguifluum	I	BI	CPC
*Etheostoma stigmaeum**	I	BI	CNPC
Percina caprodes	M	BI	SL
Percina maculata	M	BI	SM
Stizostedion vitreum	M	P	SM

The majority of species determined to be intolerant in the New River are darters. It is likely that some darters that are classified as complex spawners have reproductive strategies rendering them equally as sensitive to siltation as those species in the simple lithophilus guild. The bloodfin darter requires small crevices under flat rocks or slabs for deposition and adhesion of eggs. These small interstices are easily clogged by silt accumulations which, depending on timing, can either smother eggs or reduce potential spawning sites. Another intolerant species, the emerald darter, attaches its eggs to the sides of boulders or cobbles, which are less prone to inundation of sediment, but gaps between these large substrates can become filled with silt if the deposition load is severe. However, emerald darters were deemed intolerant primarily to indicate degradation of pool habitats, and because their distribution has spread relative to a time when the river system was severely degraded. The ashy darter is also a pool species, and although spawning behavior has not been determined in the wild, aquarium observations (Jenkins and Burkhead, 1994) indicated that ashy darters have an egg depositing strategy similar to that of the emerald darter. The complete and long term disappearance of the native ashy darter from the New River system is probably the result of its sensitivity to a form of chemical pollution associated with mine drainage in addition to extreme siltation of pool habitats.

In fourth and higher order streams the river redhorse was determined to be intolerant because, like the ashy darter, it is a native species that disappeared from the river system for a long period of time. Also, its dependence on a diet consisting primarily of bivalve mollusks, which have been extirpated from all but the most downstream

portions of the New River proper (personal obs.), greatly jeopardizes chances for its survival or persistence. During the 1996 survey a few live specimens of the asiatic clam, *Corbicula fluminea,* were found in the main stem of the river from Buffalo Creek downstream to the river mouth, but this exotic mollusk was not abundant at any site, and it is unlikely that population levels are presently high enough to support a large population of river redhorses. In smaller, lower order streams, the rosyface shiner was classified as intolerant because it is one of only two extant simple lithophilus minnows inhabiting the New River, and it was not abundant or was absent at sites that appeared degraded. Rosyface shiners were not determined to be intolerant in larger streams, as they often ranked very high in relative abundance at these sites regardless of observed habitat quality.

Some guilds and taxa are expected to increase corresponding with decreases in sensitive groups. High relative abundance (measured as proportion of total individuals in a sample) of three groups inhabiting New River streams: creek chubs, generalist feeders, and pioneering species, comprised metrics that served as negative indicators of biotic integrity. Creek chubs were always present and often were the most abundant species in New River streams observed to be heavily impacted by mine drainage. Leonard and Orth (1986) developed an IBI for streams in the Appalachian Plateau ecoregion of eastern West Virginia that are affected in part by coal mine drainage, and selected the creek chub as an indicator of disturbance because it is known to be a common inhabitant of small to medium streams and is tolerant of a broad array of pollutants. Selection of this metric

was verified when they found that proportions of creek chubs in communities consistently increased with corresponding increases in a cultural pollution index.

Unlike benthic invertivores, generalist feeders, which feed upon a wide range of food resources and successfully consume either allochthonus or autochthonus items, (Schlosser, 1982), are most tolerant of siltation. The generalist feeder guild, used in the West Virginia IBI by Leonard and Orth (1986), more consistently includes those species tolerant of disturbance than the omnivore feeding guild used in the original IBI. Omnivorous species feed on a variety of food types, but diet breadth does not indicate whether they can successfully shift feeding effort to a different source or location. For example, an omnivorous fish may be capable of consuming necktonic invertebrates, surface insects, and fishes but may be incapable of exploiting food resources inhabiting the substrate.

Non-indigenous species are considered pioneering species, a metric that has been applied to Ohio fish communities (Ohio EPA, 1988; Gatz and Harig 1993). As discussed in the annotated list of fishes, the striped shiner and green sunfish are recent invaders of New River and Big South Fork system streams, but the former is the only commonly occurring pioneering species. Schlosser (1987), who studied fish assemblages of a warmwater stream in Illinois, concluded that striped shiners were excellent colonizers due to their "rapid maturity, prolonged breeding seasons, high reproductive rates and strong dispersal capability of young." Proficiency of striped shiners as colonizers suggests that they are apt to be one of the first species to reinvade a degraded site. Thus, a high

proportion of striped shiners in a New River fish assemblage indicates that the area they inhabit has been either recently disturbed and/or is presently degraded.

Absence of striped shiners during previous surveys lowers recent IBI scores relative to those calculated from older samples. That is, there were virtually no pioneering species known to inhabit the New River prior to the 1996 survey, so this metric will almost always score high for 1977-78 samples. However, the pioneering species metric was retained in the IBI analysis because it increases information about the structure and integrity of existing New River fish assemblages, adding a finer degree of resolution to the measurement of water quality. Further, this metric will serve as a baseline measure of biotic integrity because striped shiners are likely to persist in the New River. Future decreases in their predominance at a site should indicate improvements in habitat quality.

Species richness of native sunfish (genus *Lepomis*), one of the original IBI metrics, was not used in the New River IBI. The longear sunfish is the only sunfish species definitely native to the river system. Wide-spread introductions of bluegill in streams throughout North America (Etnier and Starnes, 1993) and its scarcity in historical collections make it impossible to determine with certainty the origin of this species in the Big South Fork River system. All other sunfish species collected during the 1996 survey are derived from unnatural introductions. The number of sunfish metric has been used to assess degradation of pool habitats (Karr et al., 1986), but it provides little information about the impact of siltation on fish assemblages, because sunfish have feeding and reproductive life styles that render them insensitive to its effects. Consuming benthic and

terrestrial invertebrates as well as small fishes, sunfish are not restricted to feeding on specific types of prey. If benthic food resources become limited, they can survive exclusively on a diet of allochthonus and necktonic resources. Reproduction involves construction of nests by males that subsequently enhance survival of eggs by guarding the nest from predators and keeping it free from smothering loads of silt with the fanning action of their caudal fins.

Percent of the community as rockbass and smallmouth bass was used as a partial substitute for the original IBI sunfish metric because each of these predatory centrarchids inhabits pools. High relative abundance of these two species is expected to be an indicator of a healthy fish assemblage because they are linked to abundance of prey species that are dependent on water quality. The increase in the New River population of rockbass, which are primarily benthic feeders of macroinvertebrates, crustacea, and fishes (Etnier and Starnes, 1993), may be attributable to improved substrate quality resulting from decreases in siltation that have enabled recolonization of benthic prey resources. In addition to occurring more frequently in areas having clean substrates, smallmouth bass were suspected to be useful indicators of water quality based upon research by Yoder and Rankin (1995), who, using a large data base of Ohio stream fish collections (n = 4113), determined that smallmouth bass relative frequency and occurrence increased markedly as the IBI rose in quality from poor to good.

Another original IBI metric, proportion of individuals as hybrids, was excluded from the New River fish community analysis. Other researchers have substituted proportion of deformed or diseased individuals for this metric. Neither the original nor

the substituted metric was used because very few hybrids were observed in fish samples and captured specimens were not scrutinized or noted for diseases and deformities prior to their release. Also, hybrids of small species (minnows and darters) are not always easily identifiable in the field. Just 13 of 15,900 and 1 of 7,797 specimens were identified as hybrids from 1996 and 1977-78 samples respectively.

Development of Metric Scoring Criteria

Originally, IBI metrics were established relative to values obtained from fish assemblages in undisturbed sites. The extent of degradation in New River streams has been so great that, other than 115 year old seining samples from two sites (Kirsch, 1893), all streams previously sampled were probably disturbed or rebounding from degradation. Since all metrics were derived from sites in varying states of disturbance, IBI scores do not reflect a pristine Cumberland Mountain ecoregion stream. However, they do enable comparison of sites within the New River system.

Fausch et al. (1984) constructed scatter plots of stream order and drainage size versus number of species. Using these plots, a maximum species richness line estimated to bound 95 % of sites was constructed to generate expected species richness for stream size classes. A very similar method was employed in the development of the New River IBI. Scoring criteria for all metrics were derived by plotting histograms of metric values ordered from highest to lowest. These values were measured from sites surveyed during 1977-78 and 1996 where 100 or more individuals were collected. Each histogram was divided into thirds, and metrics in the top third of the distribution were scored as 5, those

in the lower third were scored as 1, and those in the middle third were scored as 3 (Appendix 4). In the case of ties, when equal values straddled both sides of the 33 % boundary, that point was moved up to the next break in the distribution. For example, the distribution of darter species richness for fourth and fifth order streams includes six equal values of 4 that straddle the 33 % boundary (Appendix 4). In this case the boundary was shifted upward, resulting in all fourth and fifth order sites containing 4 or fewer darter species (lower 40^{th} percentile) receiving score of 1. For continuous data (percent composition metrics), values at the 33^{rd} percentile break could be equal to, nearly equal to, or significantly different than the next highest value. If the difference between the 33^{rd} percentile value and the next highest value was less than 1 %, the boundary was shifted up to the next substantial break in the distribution, arbitrarily determined to have a value at least 1% greater than the value at the 33^{rd} percentile boundary. Metric scoring criteria derived from the histogram analysis are listed in Table 4.

For second and third order streams, scoring criteria for the number of sensitive species metric was established using a different protocol. In smaller streams of the New River system only two intolerant species, the rosyface shiner and emerald darter, were expected to be persistent inhabitants, while the other three intolerant species, bluebreast darter, ashy darter, and bloodfin darter, preferred larger streams and were probably transient inhabitants of smaller tributaries. Thus, presence of two (or more, if transient species were present) intolerant species in small stream sites indicated favorable water quality and resulted in a metric score of 5.

Table 4. IBI Metric Scoring Criteria

	2nd & 3rd Order			4th & 5th Order		
Number	1	3	5	1	3	5
Native Species	≤ 8	9 – 12	≥ 13	≤ 14	15 – 17	≥ 18
Darter Species	≤ 1	2 – 3	≥ 4	≤ 4	5 – 6	≥ 7
Intolerant species	0	1	≥ 2	≤ 1	2	≥ 3
Percent						
Benthic Invertivores	≤ 8.5	between	≥ 21.8	≤ 20.7	between	≥ 36.6
Generalist Feeders	≥ 61.7	between	≤ 26.4	≥ 33.5	between	≤ 18.5
Suckers	≤ 2.4	between	≥ 4.4	≤ 3.1	between	≥ 8.2
Creek Chubs	≥ 30.5	between	≤ 9.3	≥ 18.0	between	≤ 2.2
Smallmouth Bass & Rockbass	≤ 0.8	between	≥ 4.1	≤ 1.2	between	≥ 3.3
Pioneering sp.	≥ 17.6	between	≤ 5.1	≥ 17.6	between	≤ 5.1
Simple spawners	≤ 3.8	between	≥ 14.2	≤ 13.5	between	≥ 23.3
CPUE (Fish/100 m^2)						
1977 & 1978	≤ 28.7	between	≥ 101.3	≤ 25.7	between	≥ 42.4
1996	≤ 8.8	between	≥ 39.3	≤ 10.2	between	≥ 22.1

Even in undisturbed streams, assemblage composition varies naturally with stream size. Stream discharge is correlated with food availability, habitat space, juvenile recruitment, and ease of colonization, which all affect the composition of fish assemblages (Horwitz, 1978; Matthews and Styron, 1981; Ross et al. 1985; Schlosser 1982; Schlosser 1985; Schlosser 1987; Schlosser and Ebel, 1989; Angermeier and Schlosser, 1989; Poff and Allan 1995). These effects are magnified in small streams due to their lower volume. Thus, in low order streams in the New River system species richness, darter species richness, and large predator abundance was expected to be lower, and abundance of generalist feeders higher in small streams compared to larger streams. Metrics were adjusted to reflect natural variation in assemblage composition among stream size classes by grouping and analyzing separately metric distributions for second and third order streams together and fourth and fifth order streams. The metric, proportion of the assemblage as creek chubs, was excluded from IBI calculations for all

fifth order streams because creek chub relative abundance in these large streams is naturally low. This metric was also excluded from biotic integrity assessment in fourth order sites in the main stem of the New River because these sites were more comparable in size and species composition to fifth order streams than they were to tributary fourth order sites. Only three samples from sixth order sites surveyed during either 1996-97 or 1977-78 were available for analysis of fish assemblages. Since the number of these large-river site samples was small, they were excluded from the process of determining metric criteria. Metrics developed for fourth and fifth order streams were applied to sixth order sites as a best estimate of fish community health in large-river sites. IBI scores were also estimated for sites sampled during 1968-1969 by scoring the unknown CPUE metric as 5. This enabled comparison of IBI scores over a 27 year period among some sites.

Relationship Between Sampling and the IBI

Reliability of IBI scores is dependent upon the accuracy of two categories of metrics, species richness and relative abundance measures, which are both related to sampling effort and species-area relationships. The effort necessary to reliably measure relative abundance is less than that required for determining true species richness at a sampling locality. Several recent studies indicate that sampling effort, described either by reach length, volume, surface area, or number of electrofishing passes, required to accurately estimate species relative abundance does not vary much among North American ecoregions. A study of fish sampling in three different ecoregions of Virginia (Angermeier and Smogor, 1995) determined that a stream reach length 15-20 times the average stream width was required to accurately detect relative abundance. For small

streams in southern Wisconsin, Simonson and Lyons (1995) determined that, without deploying block nets, a single tow barge electrofishing pass through a length of stream approximately 35 times the mean stream width adequately assessed species richness, abundance, and assemblage structure. The number of species detected by multiple pass methods in these small Wisconsin streams and first through fourth order streams in the South Carolina Coastal Plain (Paller, 1995) differed little from the number detected by single pass methods. Another study completed in South Carolina (Paller et al., 1996) concluded that precision of the IBI was good when one electrofishing pass was performed in stream reaches of at least 150 m.

Conclusions based on the study of Virginia streams suggested that sampling reaches less than 10 mean widths long is inadequate for comparison of community attributes. All samples from the 1996 survey met and or exceeded this minimum reach length, which was necessary for estimating species relative abundance. Four samples from sites 8, 12, 15, and 39 failed to meet this minimum criterion during the 1977-78 survey (Appendix 5). Caution must be applied when comparing IBI scores temporally (Table 5) among samples from these four sites. The lack of change in IBI score detected at the New River near the Ligias Fork confluence (site 12) is probably valid. If sampling effort had been greater during 1977, the gap in species richness and diversity between the two samples would have probably narrowed and slightly inflated the IBI score from 1977, but it is unlikely that the score would have increased significantly. Notably, the length of site 8, New River above Cage Creek, was 9.6 times the average stream width, which is very close to the minimum stream reach criterion. Additionally, the dramatic difference

Table 5. Individual, mean, and median IBI, metric, and diversity scores. Fourth and fifth order sites sites sampled both in 1996 and 1977-78.

Fourth Order Sites

	CPUE		Native		Darter		Intolerant		Lithophilus		Generalist		Invertivore		Suckers		Sm. & Rck		Cr. Chubs		Pioneering	
Site	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977
11f	28.6	55.4	14	12	6.0	5.0	4.0	1.0	12.5	10.1	24.4	27.6	20.1	34.2	5.6	3.8	0.0	0.5	0.0	3.8	15.0	0.0
11s	10.2	46.8	16	13	5.0	4.0	3.0	2.0	15.1	7.7	34.1	15.6	26.9	34.4	1.2	1.9	2.4	0.0	1.2	0.7	14.2	0.0
14	12.1	16.6	18	14	5.0	4.0	3.0	2.0	32.0	12.2	3.6	20.4	27.7	58.0	8.6	8.8	2.5	0.0	0.4	2.2	19.1	0.0
31	46.1	59.9	21	16	7.0	6.0	3.0	2.0	28.0	8.2	30.7	28.3	16.6	27.1	5.3	3.6	1.8	1.7	3.3	7.0	5.1	0.0
35	12.4	368.1	14	13	4.0	4.0	1.0	0.0	11.8	9.6	28.2	72.1	57.4	17.8	8.2	0.3	2.6	1.2	5.1	19.5	0.0	0.0
Mean	21.9	109.4	16.6	13.6	5.4	4.6	2.8	1.4	19.9	9.6	24.2	32.8	29.7	34.3	5.8	3.7	1.9	0.7	2.0	6.6	10.7	0.0
Med.	12.4	55.4	16.0	13.0	5.0	4.0	3.0	2.0	15.1	9.6	28.2	27.6	26.9	34.2	5.6	3.6	2.4	0.5	1.2	3.8	14.2	0.0

Fifth Order Sites

8	8.0	23.6	19	12	8.0	5.0	4.0	1.0	14.6	10.5	18.5	27.2	31.6	36.6	1.0	7.9	3.7	1.0	0.0	0.0	5.0	0.0
12	13.4	24.6	17	14	7.0	5.0	4.0	2.0	17.3	13.3	21.0	15.6	25.8	53.8	2.3	6.4	1.1	0.0	0.0	0.6	8.2	0.0
15	3.7	8.7	19	19	7.0	6.0	3.0	2.0	16.6	25.6	24.3	33.5	33.2	37.9	2.7	15.8	3.9	1.5	0.0	0.0	6.9	0.0
17f	42.9	25.7	19	15	7.0	5.0	4.0	2.0	12.7	13.5	14.8	18.0	67.0	42.1	10.0	2.3	2.5	2.2	0.5	1.7	3.0	0.0
39	9.5	34.1	18	20	7.0	6.0	3.0	2.0	26.7	54.4	45.3	22.2	15.7	15.8	9.7	7.6	0.4	1.2	0.8	1.8	28.4	0.3
Mean	15.5	23.3	18.4	16.0	7.2	5.4	3.6	1.8	17.6	23.5	24.8	23.3	34.7	37.2	5.1	8.0	2.3	1.2	0.3	0.8	10.3	0.1
Med.	9.5	24.6	19.0	15.0	7.0	5.0	4.0	2.0	16.6	13.5	21.0	22.2	31.6	37.9	2.7	7.6	2.5	1.2	0.0	0.6	6.9	0.0

	IBI		Diversity	
Site	1996	1977	1996	1977
11f	31	27	0.73	0.77
11s	35	29	0.85	0.68
*14	43	31	0.86	0.72
*31	43	35	0.84	0.79
*35	31	19	0.81	0.67
Mean	36.6	28.2	0.82	0.73
Med.	35.0	29.0	0.84	0.72

	IBI		Diversity	
Site	1996	1977	1996	1977
*8	38	24	0.86	0.83
12	30	28	0.84	0.75
15	34	36	0.88	0.91
*17f	42	32	0.71	0.80
19	40	40	0.89	0.91
39	30	34	0.87	0.86
Mean	35.7	32.3	0.84	0.84
Med.	36.0	33.0	0.87	0.86

* Significant positive increase in IBI.

Fourth and Fifth Order Sites Combined

	Native		Darter		Intolerant		Lithophilus		Generalist		Invertivore		Suckers		Sm. & Rck		Pioneering		Diversity	
	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977	1996	1977
Mean	17.5	14.8	6.3	5.0	3.2	1.6	18.7	16.5	24.5	28.1	32.2	35.8	5.5	5.8	2.1	0.9	10.5	0.0	0.82	0.77
Med.	18.0	14.0	7.0	5.0	3.0	2.0	15.9	11.3	24.4	24.7	27.3	35.5	5.4	5.1	2.5	1.1	7.6	0.0	0.84	0.78

in IBI scores between the two samples taken at site 8 is reflected in the large difference in species richness. Assuming species richness at site 8 was actually close to the mean species richness of 15 measured at other large stream sites that met the reach length criterion in 1977-78, this site still did not contain a comparable number of species and has improved in terms of assemblage composition. The small difference in IBI detected at New River above Nicks Creek (site 15) is also likely a good estimate. The large discrepancy between the two surveys in proportions of suckers and channel catfish indicates that gill nets, although the localities were not specified, were probably employed at this site in 1977. Although failing to meet the minimum length criterion, a fairly long reach of 116 m was sampled at site 15 in 1977, and it is unlikely that significant differences in species richness or proportions would have been detected with greater sampling effort. Although the four point decrease in IBI measured at lower Brimstone Creek (site 39) may not be statistically significant (discussed below), real declines probably have occurred there. Since sampling effort was much less in the earlier survey, but similar numbers of species were caught, it is likely that integral components of the resident assemblage were incompletely sampled, causing the IBI score from 1977 to be underestimated.

Except for southern Wisconsin streams, the preceding studies on relationships between sampling effort and assemblage characteristics indicated that the sampling effort needed to adequately estimate true species richness is highly variable within ecoregions. Detecting all species present in an assemblage required that reaches as long as 158 mean stream widths be sampled. This was an unrealistically high amount of effort for the study

described herein. During the 1996 survey, these species-sample area size relationships were accounted for partially by incorporating a large number of riffle-pool sequences in stream samples, and by sampling additional habitat units until accumulation of new species ceased. Further compensating for difficulties in assessing true species richness was the method of assigning a single metric score to a range of richness values, thereby reducing the effect on metric scores of finding one or two rare species that had lower probabilities of detection. Unfortunately, sampling effort by area during the 1977-78 survey was considerably lower, in most cases incorporating less than half the stream length sampled in 1996. However, approximating species richness within the reach sampled (but not the assemblage) was probably adequate during the earlier survey because three electofishing passes were used.

Increases in species richness were expected to have occurred in New River streams since 1978, but the magnitude of changes in species number was difficult to assess because sampling effort differed between surveys. Nevertheless, the 1977-78 survey provided the best available database from which to compare fish assemblage components, including species richness, in the New River system. Therefore, except for CPUE, metrics from this earlier survey were grouped with 1996 metrics in the histogram analysis. Separating and analyzing richness distributions independently would have skewed IBI scoring criteria relative to only one survey period and reduced the ability to compare changes in assemblages over time. In addition to reducing the effect of detection of rare species within a survey period, assigning a single score to a range of richness values diminished the effect of differences in sampling effort on IBI scores

between survey periods. Also, metric scoring criteria were calibrated in reference to the best known measurements of assemblage integrity, regardless of the time sampling was undertaken.

IBI Scores and Evaluation of New River Streams

Confidence intervals were assigned to IBI scores to determine whether differences in samples were significant. Using repeated samples from an Illinois stream, the standard deviation of IBI scores was determined to be approximately ±4 (Angermeier and Karr 1986; Karr et al. 1987). Employing a resampling algorithm to derive replicate samples from sites in Ohio streams, Fore et al. (1994) determined that samples containing fewer than 400 individuals were more likely to have 90 % IBI confidence intervals greater than 6 and ranging as high as 12. Many of the fish samples taken in 1996 and most samples from 1977-78 yielded relatively low numbers of individuals, so confidence intervals of 12 were assigned to IBI scores calculated from samples containing fewer than 350 individuals. Confidence intervals of 8 and 6 were assigned to samples consisting of 350-399 individuals and 400 or more fish, respectively. If half of the sum of the confidence intervals of two IBI scores was less than the difference in IBI between the pair, that difference was considered significant.

The biotic integrity of fish assemblages in the New River system appears to have improved, indicated by a general trend of higher IBI scores in sites that were sampled both in 1996 and 1977-78 (Table 5). One second order site, the headwaters of New River at Fork Mountain (site 1), and one third order site, Cage Creek (site 9), were sampled

during both survey periods (Appendix 3). Five fourth order and six fifth order sites were also resampled in 1996. Fourth order and fifth order sites were compared together but also were compared separately, because total possible IBI scores (50 vs. 55) and expected percent of creek chubs differed for these two stream size classes. Grouping fourth and fifth order sites increased the sample size from 5 to 11 and enabled more robust estimates of mean and median values of metrics not expected to vary with stream size class. Site 8, which is in a fourth order section of the New River proper, and based on its size more properly classified with fifth order sites, was grouped with other sites of that magnitude. The IBI score at both resampled third order sites (Appendix 6) was much greater in 1996: 31 versus 23 at site 1 and 49 versus 37 at site 9. Mean temporal differences in IBI scores among fourth and fifth order streams were not as dramatic, but recent samples averaged about six points higher than earlier ones. Moreover, except for lower Brimstone Creek, resampled sites consistently had higher IBI scores in 1996. Three of five pairs of samples from fourth order sites and two of six pairs of fifth order sites had significant positive increases in IBI. Overall, biotic integrity at seven of twelve sites resampled in 1996 had significantly improved since the 1977-78 survey.

A review of individual metrics also reveals improvement in fish assemblages over the past twenty years. The number of native, darter, and intolerant species was greater in 9 of the 11 fourth and fifth order sites that were resampled (Table 5). Differences between these species richness metrics were greatest in fifth order sites. Percent composition metrics that differed substantially between surveys were lithophilus spawners, invertivores, suckers, smallmouth and rockbass, and pioneering species. In

1996 samples the median percentage of simple lithophilus spawners was approximately 5 % and 3 % higher in fourth order and fifth order streams, respectively. The median proportion of benthic invertivores was unexpectedly lower in fourth and fifth order streams in 1996. This reduction may have been due to the addition of the pioneering striped shiner that was present in all sites resampled in 1996 but absent in all those sites in 1977-78. Since they utilize different habitat and prey resources, it is unlikely that striped shiners reduced abundance of benthic invertivores through direct competition, although they may have exerted a small negative impact on juvenile recruitment as they are known to consume fry and eggs. (Gillen and Hart, 1980; Angermeier, 1985; Jenkins and Burkhead, 1994). Also unexpected were the lower median proportions of suckers collected from resampled sites in the New River proper during 1996. This discrepancy in sucker composition is likely an artifact of differences in sampling efficiency, as these elusive fish were captured by multiple electrofishing passes used at all sites and gill nets that were deployed at some of the larger sites during the 1977 survey. The proportion of suckers collected from New River tributaries was very similar for both surveys, and although 1996 samples indicated otherwise, this likely was the case for the main stem too. The mean proportion of smallmouth and rockbass was low in 1996 samples but had doubled in comparison to 1977-78 samples. The large increase in frequency of occurrence of these two species also indicated improvement of fish assemblages between surveys (Figure 3).

IBI scores were classified into one of six qualitative categories (Table 6). Although biotic integrity in just over half (21/41) the sites sampled in 1996 was classified as poor or very poor, temporal improvement is discernible. Qualitatively, 18 of 28 sites resampled in 1996 moved up at least one classification level (Table 7). Five of these sites (Appendix 3) previously contained too few fish to calculate reliable IBI scores: Montgomery Fork sites 20, 21, and 22 (sampled twice in 1977-78 survey), New River site 6, and Double Camp Creek site 7. All three sites in Montgomery Fork were virtually devoid of fish in 1977-78, but in 1996 they all contained viable fish assemblages composed of 13 to 16 species. The 1977 sample from New River site 6 contained 89 individuals and 10 species, and had species diversity of 0.74. In contrast, the 1996 sample from site 6 included 214 individuals and 15 species, and had species diversity of 0.89. Also, the proportion of benthic invertivores was 15 % higher in 1996. Sampling of Double Camp Creek in 1969 yielded only 4 species and 36 individuals, composed predominately of the highly tolerant creek chub. In 1996 480 individuals and 14 species were collected at this same locality, and biotic integrity was classified as fair. New River site 4 has also improved dramatically from a state of severe degradation. The extremely low species diversity of 0.23 detected in 1969 was due to predominance of the generalist feeding sand shiner, which composed 90 % of the 105 individuals collected. Furthermore, other than three stonerollers, there were no benthic species inhabiting the site. Species diversity measured at site 4 in 1996 had improved to 0.68, and although biotic integrity was rated as poor, 34.5 % of the fish assemblage was composed of benthic invertivores. The preponderance of sites that were impacted severely enough to

dramatically reduce species richness and abundance in the late 1960s and 1970s, coupled with the scarcity of such sites in 1996, indicates strongly that biotic integrity and viability of fish assemblages has improved over time in the New River system.

Table 6. IBI score range and qualitative classification.

5^{th} order streams IBI	2^{nd}, 3^{rd}, and 4^{th} order streams IBI	Classification
44-50	49-55	Excellent
37-43	41-48	Good
30-36	33-40	Fair
23-29	25-32	Poor
≤ 22	≤ 24	Very Poor

Table 7. Qualitative ranking and classification based on IBI scores of streams sampled in the New River System.

Classification														
Very Poor			Poor			Fair			Good			Excellent		
Site	Stream	Year	Site	Stream	Year	Site	Stream	Year(s)	Site	Stream	Year(s)	Site	Stream	Year
1	New River	77	1	New River	96	7	Double Camp Cr.	96	8	New River	96	9	Cage Cr.	96
2	Stallion Br.	69	2	Stallion Br.	96	9	Cage Cr.	77	13	Stony Fork	96	17	Smoky Cr.	96F
3	Laurel Fk.	96	4	New River	96	11	Ligias Fork	96S	14	Beech Fk.	96	42	New River	97
4	New River	69	6	New River	96	12	New River	96	19	Smoky Cr.	77, 96			
5C	Indian Fk.	77	8	New River	77	13	Stony Fork	69	35	Paint Rock Cr.	96			
20	Montgomery Fk.	96	10B	Graves Gap Br.	77	15	New River	77, 96	40	Phillips Cr.	96			
22	Montgomery Fk.	96	10	Ligias Fork	96	17	Smoky Creek	69, 77, 96S	41	New River	96			
26	Buffalo Cr.	96	11	Ligias Fork	77F	18	Smoky Creek	96						
27	Rockhouse Fk.	96	11	Ligias Fork	78S	22B	New River	77						
30	Stanley Cr.	96	11	Ligias Fork	96F	26	Buffalo Cr.	69						
34	Brimstone Cr.	96	12	New River	77	31	Paint Rock Cr.	77						
35	Mill Cr.	77	14	Beech Fk.	77	32	Paint Rock Cr.	96						
			16	Nicks Creek	96	33	Phillips Br.	96						
			21	Montgomery Fk.	96	36	Brimstone Cr.	96						
			23	Big Bull Cr.	96	38	Brimstone Cr.	96						
			24	Stanley Cr.	96	39	Brimstone Cr.	77, 96						
			25	Smith Cr.	96									
			26B	Buffalo Cr.	77									
			28	Buffalo Cr.	96									
			33B	New River	68									
			35	Mill Cr.	96									
			37	Indian Fk.	96									
			39	Brimstone Cr.	68									
			41	New River	77									

F = fall and S = summer, for sites sampled twice in one year.
Sites 11 and 17 were sampled during bank-full flows in June 1996 that likely resulted in underestimation of IBI.

Detection of sites having good or excellent biotic integrity were reported almost exclusively in 1996 (Table 7), further indicating that integrity of New River fish communities has improved over time. Smoky Creek and Beech Fork, ranked highest in IBI among major tributary systems of the New River. Beech Fork was noted by Shoup (1940) and O'Bara and Estes (1984a) to be one of the only healthy streams in the New River system. In 1977 however, Beech Fork site 14 received an IBI score of 31. Scoring 12 points higher in 1996, Beech Fork habitat was observed to be exceptional. Compared to other streams in the river system siltation was minimal. The riparian zone on the south side of the stream consisted of old, established hardwoods, while the north side was occupied by a narrow strip of homes interspersed with woodlands. Relative to other sites in the New River system, an inordinate number of mayfly larvae, including at least several hundred individuals of *Isonychia,* was collected with the fishes. Stony Fork (site 13), a third order tributary of Beech Fork that also had a good biotic integrity rating, matched downstream areas in terms of substrate and riparian quality. Having a higher gradient than other sites in the river system, it was the only area sampled that contained a greater proportion of riffle habitat than pool habitat. Other than the main stem locality 42, the fish assemblage at the Stony Fork site had the highest proportion of smallmouth bass in the river system.

The observed habitat quality of Smoky Creek did not appear to match that of Beech Fork, but the quality of its fish communities did. Siltation at the two uppermost sites was moderate and pool and riffle habitats were evenly proportioned. About 90 % of the area at the most downstream site sampled consisted of a long pool with cobble, silt,

and bedrock substrates. The remaining 10 % was occupied by a cobble and gravel riffle. Site 19 on lower Smoky Creek was the only site that rated as good during a previous survey. Nevertheless, all sites in Smoky Creek contained signs of mine drainage, primarily "yellow boy" and coal particles. The gravel road paralleling sections of the creek was frequently traversed by coal trucks, indicating active mining in the watershed. Although not confirmed, it seems likely that existing mining operations have implemented practices that mitigate the impact of drainage received by Smoky Creek. Fish assemblages at the two upstream sites on Smoky Creek (17 and 18) have improved since 1977-78, particularly in total abundance, species richness, and presence of sensitive species (Appendix 3).

The improvement in biotic integrity within Cage Creek (site 9) since 1977 is also exceptional. The disparity between biotic integrity measured most recently at Cage Creek and the 1977 sample may in part be the result of differences in sampling effort; a 45 m and 116 m reach were sampled in the earlier and recent survey, respectively. In 1989 Bivens and Williams (TWRA) sampled a reach approximately 100 m long in the same Cage Creek locality and collected only 89 individuals, including just one darter species and very few benthic species (Appendix 3). Their sample, which encompassed an appropriate length of stream, yet revealed a stressed fish assemblage, indicates that the 1977 IBI score is not an unreasonable estimate. If the 1989 sample was accurate, the return of a healthy fish assemblage to Cage Creek probably occurred within the past seven years. The quality of habitat at Cage Creek corresponded with the 1996 IBI score.

Substrate consisted primarily of cobble and boulder, siltation was minimal, and the creek was heavily canopied and bordered on both sides by forest.

Two streams sampled in 1977 and resampled in 1996, Indian Fork (tributary of New River) and Straight Fork, continued to lack fish communities. The extent of degradation at these two sites was obvious. The water and substrate in Indian Fork was rusty orange, characteristic of iron precipitate that is indicative of acid-mine drainage. At other sites in the New River system several benthic invertebrates representing most neuropteroid orders and several families were coincidentally taken in fish samples. In addition to 8 creek chubs, two insect species which seem to predominate other mine impacted streams of the Cumberland Plateau (Pers. Obs.), the stonefly nymph, *Acroneuria carolinensis* and cranefly maggot, *Tipula* cf. *abdominalis*, were the only macroinvertebrates present in Indian Fork. A few highly tolerant green sunfish and creek chubs as well as one emaciated greenside darter were collected in Straight Fork. It is surprising that any fish were found in Straight Fork, as the water had the color and appearance of that in a swimming pool, the substrate was denuded of periphyton, and a brief search for invertebrates failed to yield a single specimen.

The only major tributary stream system of the New River having all sections in a state of poor or very poor biotic integrity is Buffalo Creek. Stanley Creek (site 24) and Smith Creek (site 25), headwater tributaries of Buffalo Creek, had improved since 1969, when population levels were low and species richness was lower (Appendix 3). However, habitat quality was poor, as both streams were bordered by open pasture on one side and both had riffles inundated with silt. Notably, the nearly ubiquitous hog sucker

was absent from Smith Creek and was very low in abundance in Stanley Creek, while the pollution tolerant white sucker was abundant in Smith Creek and was present in Stanley Creek. Farther downstream biotic integrity at Buffalo Creek site 26 had declined from fair to very poor since 1969. In contrast to the 1969 fish sample from this site, the 1996 sample was composed of a high number of invasive species and generalist feeders. Site 26 was bordered on both sides by pasture, was lined by few trees, and contained very little riffle habitat or hard substrates. Appearing to have been previously channelized, the stream cut through steep, eroding banks. Another stream in the Buffalo Creek system classified as very poor, Rockhouse Fork (incidentally, devoid of rocky substrates), garnered an IBI score of 13, almost the lowest possible measure of biotic integrity. It did contain an ample amount of riparian vegetation, but like site 26, was heavily silted and lacked riffle habitats. Apparently, Rockhouse Fork was severely degraded as long ago as 1938 when only three species were collected (Appendix 2). Straight Fork of Buffalo Creek, discussed above, was not suitable for habitation of fish. During 1996, the most downstream sample in Buffalo Creek occurred at site 28, which has improved since 1969 (Appendix 3). Although this improvement is encouraging, biotic integrity at this site was rated as poor, and at the time of sampling the water was turbid and appeared to have been enriched, possibly by pastures located upstream. Stonerollers which consisted of 72 % of the sample at site 28 and resulted in the low diversity measure of 0.48, apparently thrive there as a result of algal growth enhanced by this enrichment.

Integrity of fish assemblages in the next major tributary downstream from Buffalo Creek, Paint Rock Creek, varied significantly between its headwaters and mouth. Site 30,

Stanley Creek, was extremely silty and was receiving flow from a 5 cm diameter pipe that was carrying what appeared to be chemically treated sewage. The impact of this sediment and chemical pollution was reflected in the sampled fish assemblage, which was composed predominately of creek chubs, striped shiners, and other generalist feeders. The yellow bullhead collected at this site had skin lesions and was blind. Virtually all fish in the sample had nematode cysts ("black spot") which were most profuse on the darters. The remaining two sites downstream from Stanley Creek had markedly better water quality and fish assemblages. Site 31, which was relatively depauperate in 1968, exhibited signs of recovery by 1977 and showed further improvement by 1996 (Appendix 3). Site 32, located downstream from site 31, had a slightly lower IBI score primarily because the extremely high proportion of simple lithophilus rosyface shiners and rosefin shiners outweighed remaining composition metrics. A few signs of mine drainage were observed in the Paint Rock Creek system, but it does not appear to be adversely affecting its fish communities. Point source pollution and low substrate variety and quality probably account for differences in the IBI between upstream and downstream portions of the creek.

Because there have been only two sites sampled historically in Brimstone Creek, determination of creek system-wide changes in biotic integrity was not possible. The two sites that were resampled in 1996, 35 and 39, both appeared to have been adversely affected by siltation. Mill Creek (site 35), which has improved in IBI classification from very poor to poor since 1977, was extremely turbid. An investigation upstream, revealed the source of this turbidity was deforestation close to the stream bank and lumber-hauling

roads that cut through small tributaries. Much of the siltation in lower Brimstone Creek (site 39) probably originates from pastures that intermittently abut and drain the western side of substantial portions of the lower 3/4 of the creek. On the eastern side of site 39 the riparian zone ranged in depth from approximately 10 m to 30 m and was vegetated by a mix of young hardwoods and weeds that paralleled a road. The opposite side of the creek consisted of an expansive open pasture that was at least 100 m wide and was longer than the 299 m sample reach it bordered. Upstream, site 38, which had a higher IBI score and contained more species than site 39, was sampled just above the end of a pasture, was surrounded by hardwoods that canopied much of the stream, and contained more riffle habitat than site 39. Other sites not previously sampled in the creek system ranked poor or fair in biotic integrity. Although the biotic integrity in Brimstone Creek has been compromised by siltation, it remains one of the most speciose tributaries of the New River.

At a few sites in the New River system, Laurel Fork (site 3), Nicks Creek (site 16) and Upper Brimstone Creek (site 34), the IBI likely underestimated conditions of fish assemblages or failed to reflect observed habitat quality. In the first two sites, estimates probably failed because stream order did not depict the size of the stream watershed. Laurel Fork, although exhibiting some signs of mine drainage, was very comparable to Double Camp Creek in size and habitat, and if it had been classified as a third order stream, would have scored in the poor to fair integrity range. Nicks creek, which had an average width of only 5 m, also more closely resembled the size of third order New River streams. It is probably more properly classified as having fair or good biotic integrity

based on the habitat quality and the high number of species, including sensitive taxa, found there. Signs of mine drainage were not visible in Nicks Creek and the substrate was composed cobble, gravel, and many slab-rocks. In addition to Brimstone Creek, Nicks Creek had the most suitable habitat for slender madtoms in the New River system. Unlike sites 3 and 16, Brimstone Creek site 34 was similar in size to other fourth order sites. It is surprising that it scored so poorly in biotic integrity, because habitat quality appeared to be excellent relative to other sites sampled in remaining segments of the creek system; siltation was minimal, there were a variety of substrate types, and the riparian zone was well buffered with hardwoods. Perhaps, IBI accurately assessed the status of the fish assemblage at this site but did not reflect habitat quality because pollution impacts downstream acted as a barrier, prohibiting immigration of sensitive species.

From the headwaters of the main stem of the New River downstream, there was a general increasing trend in IBI. Biotic integrity improved substantially at sites downstream from the confluence of Indian Fork. Notably, all sites in the river system from Indian Fork upstream exhibited obvious signs of mine drainage. Signs of this type of pollution were appreciably greater than observed in other streams below Indian Fork except for Montgomery Fork which also had low IBI scores. Except for site 12 at the Ligias Fork confluence, IBI measured at main stem sites downstream from Double Camp Creek was in the fair to excellent range with the lower-most sites scoring highest. A broad range of IBI scores was obtained for sites in both eastern and western tributaries of

the New River, as one side did not appear different than the other in terms of fish assemblage health and composition.

7. Conclusions and Future Considerations

Development and use of a modified IBI was effective in determining the effects of anthropogenic impacts on streams in the Cumberland Mountain ecoregion. Slight modification of New River IBI criteria could serve as a tool for future community analyses conducted in the Big South Fork system. Extrapolating even further from this study, this IBI could be adjusted for natural faunal differences within the portion of the Cumberland River system draining the Cumberland Plateau, and thus be applied on a larger scale. The distribution of Cumberland Plateau fishes is fairly well described, but additional information is needed to acquire better estimates of the integrity of fish communities in the New River or elsewhere. It would be beneficial to use pilot samples to first predict the relationship between sampling effort and IBI metrics, particularly those that measure species richness. Coupling fish samples with benthic macroinvertebrate samples would assess a larger component of the stream fauna. Since fish and insects differ in sensitivity to different types of disturbance, sampling them together might enable detection of specific types of pollution. Measurement and description of types of watershed land-use would also enable quantitative assessment of its effects on IBI.

Increases in IBI, species richness and diversity, the spread of intolerant species, and the return of once extirpated species, serve as overwhelming evidence that the New River has improved during the past twenty years. Because the 1996 survey included a larger number of sites and included samples from virtually all third order or greater tributary systems of the New River, it provided the most reliable indication of the status of fish communities in the whole river system. Mining impact is still visible in much of

the watershed. Except for Montgomery Fork and the headwaters from Indian Fork upstream, mine pollution appears to be in the form of sedimentation, a legacy of pre-reclamation practices. Other sources of sediment observed were logging in the upper Brimstone Creek watershed, pastures in the Brimstone and Buffalo creek watersheds, and roads that exist throughout the river drainage. Viable, healthy fish assemblages now inhabit some areas of the New River. They should become more common in the future as long as mining operations and reclamation efforts are sufficient in preventing deleterious inputs of wastes into the river system.

LITERATURE CITED

Literature Cited

Angermeier, P. L. 1985. Spatio-temporal patterns of foraging success for in an Illinois stream. American Midland Naturalist 114:342-359.

Angermeier, P. L. and J. R. Karr. 1986. Applying an index of biotic integrity based on stream fish communities: considerations in sampling and interpretation. North American Journal of Fisheries Management 6:418-429.

Angermeier, P. L. and I. J. Schlosser. 1989. Species-area relationships for stream fishes. Ecology 70:1450-1462.

Angermeier, P. L. and R. A. Smogor. 1995. Estimating number of species and relative abundances in stream-fish communities: effects of sampling effort and discontinuous spatial distributions. Canadian Journal of Fisheries and Aquatic Science 52:936-949.

Baxter, J. T. 1997. Fish fauna of the Upper Cumberland River Drainage, Tennessee. M.S. Thesis, The University of Tennessee, Knoxville 101 p.

Berkman, H. E. and C. F. Rabeni. 1987. Effect of siltation on stream fish communities. Environmental Biology of Fishes 18:285-294.

Bivens, R. D., and C. E. Williams. 1990. 1989 Region IV Stream Fishery Data Collection Report. Tennessee Wildlife Resources Agency, 271 p.

Bivens, R. D., B. Carter, and C. E. Williams. 1995. Annual Stream Fisher Data Collection Report Region IV 1994. Tennessee Wildlife Resources Agency, 182 p.

Branson, B. A., and D. L. Batch. 1972. Effects of strip mining on small-stream fishes in east-central Kentucky. Proceedings of the Biological Society of Washington 84:507-518.

Branson, B. A., and D. L. Batch. 1974. Additional observations of the effects of strip mining on small-stream fishes in east-central Kentucky. Transactions of the Kentucky Academy of Science 35:81-83.

Branson, B. A., D. L. Batch, and W. R. Curtis. 1984. Small-stream recovery following surface mining in east-central Kentucky. Transactions of the Kentucky Academy of Science 45:55-72.

Brazinski, M. J. 1979. Fish populations of the New River: a system receiving acid coal mine drainage. M.S. Thesis, Tennessee Technological University, 68 p.

Burr, B. M., and M. L. Warren, Jr. 1986. A distributional atlas of Kentucky fishes. Kentucky Nature Preserves Commission Scientific and Technical Series 4, 398 p.

Comiskey, C. E. 1970. The Fishes of the Big South Fork of the Cumberland River System. M.S. Thesis, The University of Tennessee, Knoxville 91 p.

Comiskey, C. E. and D. A. Etnier. 1972. Fishes of the Big South Fork of the Cumberland River. Journal of the Tennessee Academy of Science 27:140-145.

Crumby, W. D., M. A. Webb, F. J. Bulow, and H. J. Cathey. 1990. Changes in biotic integrity of a river in north-central Tennessee. Transactions of the American. Fisheries Society 119:885-893.

Davis, J. R. and R. J. Miller. 1967. Brain patterns in minnows of the genus *Hybopsis* in relation to feeding habits and habitat. Copeia 1967:1-39.

Dimmick, W. W., K. L. Fiorino, and B. M. Burr. 1996. Reevaluation of the *Lythrurus ardens* (Cypriniformes: Cyprinidae) complex with recognition of three evolutionary species. Copeia 1996:813-823.

Etnier, D. A. 1997. A survey of fishes and benthic macroinvertebrates from Laurel Fork and Double Camp Creek, Anderson County, Tennessee. Unpublished report, 13 p.

Etnier, D. A. and R. E. Jenkins. 1980. *Noturus stanauli*, a new madtom catfish (Ictaluridae) from the Clinch and Duck rivers, Tennessee. Bulletin Alabama Museum of Natural History 55:17-22

Etnier, D. A. and W. C. Starnes. 1993. The Fishes of Tennessee University of Tennessee Press, Knoxville, 681 p.

Fausch, K. D., J. R. Karr, and P. R. Yant. 1984. Regional application of an index of biotic integrity based on stream fish communities. Transactions of the American Fisheries Society 113:39-55.

Fausch, K. D., J. Lyons, J. R. Karr, and P. L. Angermeier. 1990. Fish communities as indicators of environmental degradation. American Fisheries Society, Symposium 8:123-144.

Fore, L. S., J. R. Karr and L. L. Conquest. 1993. Statistical properties of an index of biological integrity used to evaluate water resources. Canadian Journal of Fisheries and Aquatic Science 51:1077-1087.

Gatz, J. A. and A. L. Harig. 1993. Decline in the index of biotic integrity of Delaware Run, Ohio, over 50 years. Ohio Journal of Science 93:95-100.

Gillen, A. L. and T. Hart. 1980. Feeding interrelationships between the sand and the striped shiner. Ohio Journal of Science, 80:71-78.

Griffith, G. E., J. M. Omernik, and S. H. Azevedo. 1997. Ecoregions of Tennessee. U.S. Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Corvallis, Oregon, EPA/600/9-97/022, 51 p.

Horwitz, R. J. 1978. Temporal variability patterns and distributional patterns of stream fishes. Ecological Monographs 48:307-321.

Jenkins, R. E., and N. M. Burkhead. 1994. Freshwater fishes of Virginia. American Fisheries Society, Bethesda, Maryland, 1080 p.

Kirsch, P. H. 1893. Notes on a collection of fishes from the southern tributaries of the Cumberland River in Kentucky and Tennessee. Bulletin. of the U.S. Fish Commission 11:257-268.

Karr, J. R., 1981. Assessment of biotic integrity using fish communities. Fisheries 6:21-27.

Karr, J. R., and D. R. Dudley. 1981. Ecological perspective on water quality goals. Environmental Management 5:55-68.

Karr, J. R., K. D. Fausch, P. L. Angermeier, P. R. Yant, and I. J. Schlosser, 1986. Assessing biological integrity in running waters: A method and its rationale. Illinois Natural History Survey Special Publication 5, 28 p.

Karr, J. R., P. R. Yant, K. D. Fausch, and I. J. Schlosser. 1987. Spatial and temporal variability of the index of biotic integrity in three midwestern streams. Transactions of the American Fisheries Society 116:1-11.

Lande, R. 1996. Statistics and partitioning of species diversity, and similarity among multiple communities. Oikos 76:5-13.

Lemly, A. D. 1985. Suppression of native fish populations by green sunfish (*Lepomis cyanellus*) in first order streams of Piedmont North Carolina (USA). Transactions of the American Fisheries Society 114:705-712.

Leonard, P. M. and D. J. Orth, 1986. Application and testing of an index of biotic integrity in small, coolwater streams. Transactions American Fisheries Society 115:401-414.

Matthews, W. J. and J. T. Styron Jr. 1981. Tolerance of headwater vs. mainstream fishes for abrupt physicochemical changes. American Midland Naturalist 105:149-158.

Miller, D. L., P. M. Leonard, R. M. Hughes, J. R. Karr, P. B. Moyle, L. H. Schrader, B. A. Thompson, R. A. Daniels, K. D. Fausch, G. A. Fitzhugh, J. Gammon, D. B. Halliwell, P. L. Angermeier, and D. Orth. 1988. Regional applications of an index of biotic integrity for use in water resource management. Fisheries 16:28-35.

Minear, R. A. and B. A. Tschantz. 1976. The effect of coal surface mining on the water quality of mountain drainage basin streams. Water Pollution Control Federation Journal 48:2549-2569.

Morison, R. 1983. The acute sublethal effects of the pesticides Carbaryl and Malathion on partial ethograms of the yellow bullhead (*Ictalurus natalis*, Lesueur). Ph.D. Dissertation., The University of Tennessee, Knoxville, 118 p.

Muncy, R. J., G. J. Atchinson, R. V. Bulkley, B. W. Menzel, L. G. Perry and R. W. Summerfelt, 1979. Effects of suspended solids and sediment on reproduction and early life of warmwater fishes. EPA-600/3-79-0. Corvallis Environmental Research Laboratory, Corvallis, Oregon.

O'Bara, C. J. and R. D. Estes, 1984a. A survey of fish communities of streams in coal surface mining areas of the Cumberland Plateau, Tennessee. Southeastern Fishes Council Proceedings, p. 9-12.

O'Bara, C. J. and R. D. Estes, 1984b. Recent collections of fishes from the Big South Fork of the Cumberland River system, Tennessee and Kentucky. Southeastern Fishes Council Proceedings, p. 12-16.

Ohio EPA. 1988. Biological criteria for the protection of aquatic life. Ohio Environmental Protection Agency, Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

Paller, M. H. 1995. Relationships among number of fish species sampled, reach length surveyed, and sampling effort in South Carolina coastal plain streams. Transactions of the American Fisheries Society 15:110-120.

Paller, M. H., M. J. M. Reichert, and J. M. Dean, 1996. Use of fish communities to assess environmental impacts in South Carolina coastal plain streams. Transactions of the American Fisheries Society 125:633-644.

Poff, N. L., and J. D. Allan. 1995. Functional organization of stream fish assemblages in relation to hydrological variability. Ecology 76:606-627.

Rabeni, C. F. and M. A. Smale. 1995. Effects of siltation on stream fishes and the potential mitigating role of the buffering riparian zone. Hydrobiologia 303:211-219.

Rankin, T. R. and C. R. Yoder. 1990. The nature of sampling variability in the index on biotic integrity (IBI) in Ohio streams. Proceedings of the midwest pollution control biologists meeting, p. 9-18.

Reno, H. W. 1969. Cephalic lateral-line systems of the cyprinid genus *Hybopsis*. Copeia 1969:736-773.

Riddle, J. W. 1975. Status of the native muskellunge, *Esox masquinongy ohioensis*, of the Cumberland Plateau, Tennessee. M.S. Thesis, Tennessee Technological University, 70 p.

Ross, S. T., W. J. Matthews, and A. A. Echelle. 1985. Persistence of stream fish assemblages: effects of environmental change. American Naturalist 126:24-40.

Schlosser, I. J. 1982. Fish community structure and function along two habitat gradients in a headwater stream. Ecological Monographs 52:395-414.

Schlosser, I. J. 1985. Flow regime, juvenile abundance, and the assemblage structure of stream fishes. Ecology 66:1484-1490.

Schlosser, I. J. 1987. A conceptual framework for fish communities in small warmwater streams. *In* Community and Evolutionary Ecology of North American Stream Fishes. Matthews and Heins eds. University of Oklahoma Press, Norman and London, p. 17-24.

Schlosser, I. J. 1990. Environmental variation , life history attributes and community structure in stream fishes: implications for environmental management and assessment. Environmental Management 14:621-628.

Schlosser, I. J. and K. K. Ebel. 1989. Effects of flow regime and cyprinid predation on a headwater stream. Ecological Monographs, 59:41-57.

Shoup, C. S. Biological and chemical characteristics of the drainage of the Big South fork of the Cumberland River in Tennessee. Journal of the Tennessee Academy of Science 15:76-105.

Shoup, C. S. and H. H. Peyton. 1940. Collections from the drainage of the Big South Fork of the Cumberland River in Tennessee. Journal of the Tennessee Academy of Science 15:106-116.

Simon, T. P. and J. L. Lyons. 1996. Application of the index of biotic integrity to evaluate water resource integrity in freshwater ecosystems. *In* Biological Assessment and Criteria. Tools for Water Resource Planning and Decision Making. W. S. Davis and T. P. Simon, eds. Lewis Publishers, Boca Raton, Florida, p. 245-262.

Simonson, T. D. and J. L. Lyons. 1995. Comparison of catch per effort and removal procedures for sampling stream fish assemblages. North American Journal of Fisheries Management 15:419-427.

Smith, P. W. 1979. The Fishes of Illinois. University of Illinois Press, Urbana, 314 p.

Starnes, W. C. and D. A. Etnier. 1986. Drainage evolution and fish biogeography of the Tennessee and Cumberland rivers drainage realm. *In* The Zoogeography of North American Freshwater Fishes. C. H. Hocutt and E. O. Wiley, eds. Wiley Interscience, New York, p. 325-361.

Talak, T. A. 1977. The recovery of stream benthic insect communities following coal strip mining in the Cumberland Mountains of Tennessee. M.S. Thesis, The University of Tennessee, Knoxville, 82 p.

Taylor, W. R. 1969. A revision of the catfish Genus *Noturus* Rafinesque with an analysis of higher groups in the Ictaluridae. U.S. National Museum Bulletin, 282:1-315.

Tennessee Valley Authority 1962. Division of water control planning hydraulic data branch report 0-5829-R-1. Drainage areas for streams in the Tennessee and Cumberland River Basins, p. 73 - 89.

Trautman, M. B. 1981. The Fishes of Ohio. 2nd. Ed., Ohio State University Press, Columbus, 782 p.

Tolbert, V. R. 1978. Effects of strip mining related disturbance on the benthic insect communities of selected streams in the New River Basin of East Tennessee. Ph.D. dissertation, The University of Tennessee, Knoxville, 104 p.

Tolbert, V. R. and Vaughan 1980. Stripmining as it relates benthic insect communities and their recovery. West Virginia Academy of Science p. 168-181.

Tung, H. S. 1975. Impacts of contour coal mining on stream flow, a case study of the New River watershed, Tennessee. M.S. Thesis, The University of Tennessee, Knoxville, 138 p.

Vaughan, G. L. 1979. Effects of stripmining on fish and diatoms in streams of the New River drainage basin. Journal of the Tennessee Academy of Science 54:110-114.

Washington, H. G. 1984. Diversity, biotic and similarity indices, a review with special relevance to aquatic ecosystems. Water Research 18:653-694.

Winger, P. V. 1977. Fish and benthic populations of the New River, Tennessee. U.S. Army Corps of Engineers, Nashville, Tennessee, p. 190-202.

Yoder, C. O. and E. T. Rankin 1995. Biological criteria program development and implementation in Ohio. *In* Biological Assessment and Criteria. Tools for Water Resource Planning and Decision Making. W. S. Davis and T. P. Simon eds. Lewis Publishers, Boca Raton Florida, p. 109-144.

APPENDICES

APPENDIX 1

Appendix 1. List of localities sampled in the New River system, Tennessee. Localities are listed under the same number if the maximum distance between sampled areas is less than 250 m. Numbers preceded by * refer to sample sites greater than 250 m apart, but considered to have been resampled in 1996. Locality descriptions of sites sampled in 1996 or 1997 refer to the point from which sampling proceeded upstream. Collections are by Kirsch, 1891; Kuhne, 1938; Shoup, 1939; Thompson and Kelly, 1953; Comiskey 1968-1969; Brazinski, 1977-1978; O'Bara, 1980; Bivens and Williams, 1989; Evans 1996 and 1997. Site numbers correspond to localities plotted in Figure 2 and collections listed in Appendix 2.

1. New River at Hwy. 116 bridge, Fork Mountain, Anderson Co., TN. 3 August 1938, Fall 1977 and 4 May 1996.

1B. Headwaters of New River, 1 mile west of Fork Mountain, opposite old prison, Morgan Co., TN 16 August 1938.

2. Stallion Branch above Hwy. 116 bridge, Anderson Co., TN. 6 September 1969 and 22 May 1996.

3. Laurel Fork, upstream of bridge on gravel road opposite and parallel to Hwy. 116, ca. 100 m upstream from New River confluence, Anderson Co., TN. 24 May 1996.

4. New River below the confluence of Laurel Fork, Anderson Co., TN. September 1969 and 22 May 1996.

5. Indian Fork, at bridge ca. 1 road mile west of Hwy. 116, Anderson Co., TN. Summer 1978 and 27 April 1996.

5B. Indian Fork, 0.8 Km upstream from Hwy. 116 Bridge, Anderson Co., TN. Summer, 1978.

5C: Indian Fork, above Hwy. 116 Bridge, Anderson Co., TN. 15 August 1938, Fall 1977, Summer 1978, and 17 October 1989.

6. New River, at Indian Fork confluence adjacent to Hwy. 116 , Anderson Co., TN. 27 April 1996 and Fall 1977

7. Double Camp Creek, 338 m above RR trestle, Anderson Co., TN. 6 September 1969 and 4 May 1996

*8 New River, 0.5 km upstream from the confluence of Cage Creek, just downstream from the Free Communion Baptist Church, Anderson Co., TN. Fall 1977.
New River, immediately upstream from Cages Creek confluence, Anderson Co , TN. 12 July 1996

9. Cages Creek above Hwy. 116 Bridge, Anderson Co., TN. 15 August 1938, Fall 1977, 17 October 1989, and 22 May 1996.

10. Ligias Fork above Carroll Branch near Hwy. 116, Anderson Co., TN 6 September 1969, Summer 1978, and 27 April 1996.

10B. Graves Gap Branch, tributary to Ligias Fork, ca. 7 road km east of Hwy. 116 bridge crossing New River. Summer, 1978.

10C. Ligias Fork, 0.5 mi. below right fork. 9 August 1938

Appendix 1. (continued)

11. Ligias Fork, ca. 1 road mile above New River confluence, opposite Grave Hill Baptist church, Hwy. 116, Anderson Co., TN. 6 September 1969, Fall 1977, Summer 1978, 11 June 1996, and 17 October 1996.

12. New River, ca. 300 ft. upstream from Ligias Fork confluence. 4 December 1989. New River, below Hwy. 116 bridge and Ligias Fork confluence, Anderson Co., TN. Fall 1977 and 12 July 1996.

13. Stony Fork, tributary to Beech Fork, 0.5 road mi. above Beech Fork confluence, Campbell Co., TN 7 September 1969 and 30 May 1996.

*14. Beech Fork, 1.5 km upstream from the bridge at the mouth of Beech Fork. Fall 1997. Beech Fork, ca. 0.5 road miles southeast of Shea, adjacent to Stony Fork Rd., Campbell Co., TN 24 May 1996. and Fall 1977

14B. Beech Fork at Shea, 3 August 1938 and Fall 1980.

15. New River, at Nicks Creek Confluence, Campbell Co., TN. 7 September 1969. New River, 1 road mile upstream from Nicks Creek, along New River Rd., Campbell Co., TN. Fall 1977 and 12 July 1996.

16. Nicks Creek upstream of RR trestle off Nicks Creek Rd., Campbell Co., TN. 17 July 1996.

17 Smoky Creek, above bridge on Smoky Creek Rd., Hembree, Scott Co., TN. 7 September 1969, Summer 1978, Fall 1980, 30 May 1996 and 17 October 1996.

18. Smoky Creek, ca. 4 road miles southwest of bridge crossing New River at Smoky Junction, Scott Co., TN. Summer 1978 and 10 July 1996.

19. Smoky Creek, off private dirt road, ca. 1.5 road miles southwest of bridge crossing New River at Smoky Junction, Scott Co., TN. , Fall 1977, Summer 1978 and 10 July 1996

19B Smoky Creek, 200 yd's. above junction with New River at Smoky Junction, 5 August 1938

20. Montgomery Fork, ca. 1.75 road miles east of Norma Rd. intersection, above first ford that crosses Montgomery Fork. Summer 1978 and 9 July 1996.

21. Montgomery Fork at Roach Creek confluence, ca. 0 7 road miles east of bridge on Norma Rd. 9 July 1996 and Summer 1978.

22. Montgomery Fork, below bridge on Norma Rd., Scott Co., TN. Fall 1977, Summer 1978, and 10 July 1996

22B. New River, at ford west of Norma, Scott Co., TN., 5 September 1939 and Fall 1977.

23. Big Bull Creek, at ford off Bull Creek Rd., ca. 0.5 road mi above New River confluence, Scott Co., TN 13 June 1996

23B New River at Cordell. 19 August 1938.

Appendix 1. (continued)

24. Stanley Creek, tributary to Buffalo Creek, upstream of bridge on Stanley creek Rd., Scott Co., TN 19 September 1969 (precise locality not described) and 19 July 1996.

25. Smith Creek, tributary to Buffalo Creek, at bridge 0.5 road miles northeast of New Salem, Scott Co., TN. 27 July 1969 and 9 July 1996.

26. Buffalo Creek, upstream of bridge on Sugar Grove Rd., ca. 1.5 road miles north of Rockhouse Fork, Scott Co., TN. 27 July 1969 and 12 July 1996.

26B. Buffalo Creek, 2.6 km upstream from Hwy. 63. Fall 1977.

27. Rockhouse Fork, upstream of Sugar Grove Rd., Scott Co., TN. 11 August 1938 (precise locality not described) and 19 July 1996.

28. Buffalo Creek, at Hwy. 63 bridge, Scott Co., 11 October 1968 and 15 August 1996.

29. Straight Fork, above Norma Rd. 10 August 1938, Fall 1977 and 19 July 1996.

29B. Buffalo creek, at ford 0.7 km east of Winona. 19 August 1938 Fall 1977.

29C. New River, below the mouth of Buffalo Creek, at bridge west of Winona, Scott Co. TN. Fall 1977.

30. Stanley Creek, tributary to Paint Rock Creek, at bridge east of Almy, Scott Co., TN. 8 August 1996

31. Paint Rock Creek, 100 m above Hwy. 63 bridge, Scott Co., TN. 11 August 1938, 11 October 1968, Fall 1977, and 15 August 1996.

32 Paint Rock Creek upstream from New River confluence, Scott Co., TN. 13 Oct. 1996.

33 Phillips Branch, 20 m upstream from New River confluence, ca. 0.25 road miles west of River Rd bridge that crosses New River 1.5 miles south of Huntsville, Scott Co., TN. 17 Oct. 1996.

33B. New River, 1 mile east of the town of New River, Scott Co., TN, 11 October 1968.

33C. New River, 0.25 miles east of the town of New River, Scott Co., TN. 26 September 1953

34. Brimstone Creek, ca. 0.75 road mi. and west of Indian Creek, Scott Co., TN. 8 August 1996.

35. Mill Creek, tributary to Brimstone Creek, upstream of bridge on Brimstone Rd. Scott Co., TN. Fall 1997 and 8 August 1996.

36. Brimstone Creek, ca. 0.75 road miles south of Slick Rock, Scott Co., TN. 13 October 1996.

37. Indian Fork, tributary to Brimstone Creek, ca. 1.5 road miles south of Wolf Creek Rd. bridge, Scott Co., TN. 22 September 1996

38. Brimstone Creek, at Wolf Creek Rd. bridge, Scott Co., TN. 22 Sept. 1996

Appendix 1. (continued)

39. Brimstone Creek, at Brimstone Rd. bridge, west of Lone Mountain Rd. intersection, Scott Co., TN. 26 September 1953, 11 October 1968, Fall 1977, and 22 September 1996.

40. Phillips Creek, an eastern tributary of the New River, at bridge on road north of U.S. 27, Scott Co., TN. 13 June 1996.

41. New River downstream of Hwy. 27 bridge, Scott Co., TN. 18 August 1938, 5 September 1939, 26 September 1953, Fall 1977, and 15 August 1996.

42. New River, at Silcott Ford, 4.2 road miles west of U.S. 27 at Helenwood, 11 April 1997.

APPENDIX 2

Appendix 2. Summary of fish collections from the New River system, Tennessee. Site numbers correspond to localities listed in Appendix 1 and plotted in Figure 2.

Site	1B	1	1	1	2	2	3	4	4	5	5	5B	5C	5C	5C	6	6
Year	1938	1938	1977	1996	1969	1996	1996	1969	1996	1978	1996	1978	1938	1977	1978	1977	1996
Species																	
Campostoma anomalum	X	X	X	X	X	X	X	X	X				X	X	X	X	X
Cyprinella galactura									X								X
Cyprinella spiloptera																	
Cyprinus carpio																	
Hybopsis amblops																	
Luxilus chrysocephalus				X		X	X		X								X
L. chrysocephalus X C. anomalum																	
Lythrurus fasciolaris	X	X						X	X				X	X	X		X
Nocomis micropogon																	
Notemigonus crysoleucas																	
Notropis leuciodus																	
Notropis rubellus																	X
L. chrysocephalus X N. rubellus																	
Notropis stramineus	X	X	X	X	X		X	X	X				X	X	X	X	X
Notropis telescopus																	
Notropis volucellus																	
Rhinichthys atratulus			X	X	X	X	X	X									
Semotilus atromaculatus	X	X	X	X	X	X	X	X	X		X		X	X	X		
L. chrysocephalus X S. atromaculatus																	
Carpiodes cyprinus																	
Catostomus commersoni			X			X	X							X	X		
Hypentelium nigricans	X		X	X		X	X		X					X		X	X
Moxostoma carinatum																	
Moxostoma duquesnei																	
Moxostoma erythrurum				X													
Moxostoma macrolepidotum																	
Ameiurus natalis														X	X	X	
Ictalurus punctatus																	
Noturus exilis																	
Pylodictis olivaris																	

Appendix 2. (continued)

Site	7	7	8	8	9	9	9	9	10B	10	10	10	10C
Year	1969	1996	1977	1996	1938	1977	1989	1996	1978	1969	1977	1996	1938
Species													
Campostoma anomalum	X	X	X	X	X	X	X	X	X	X	X	X	
Cyprinella galactura			X	X			X			X			X
Cyprinella spiloptera													
Cyprinus carpio													
Hybopsis amblops													
Luxilus chrysocephalus		X		X				X				X	
L. chrysocephalus X C. anomalum													
Lythrurus fasciolaris		X		X	X	X	X	X	X	X			X
Nocomis micropogon													
Notemigonus crysoleucas													
Notropis leuciodus													
Notropis rubellus			X	X		X	X	X					
L. chrysocephalus X N. rubellus													
Notropis stramineus	X	X	X	X		X	X		X	X		X	X
Notropis telescopus													
Notropis volucellus				X									
Rhinichthys atratulus		X					X	X				X	
Semotilus atromaculatus	X	X			X	X	X	X	X	X		X	
L. chrysocephalus X S. atromaculatus													
Carpiodes cyprinus													
Catostomus commersoni	X	X										X	
Hypentelium nigricans		X	X	X		X	X	X	X	X	X	X	
Moxostoma carinatum													
Moxostoma duquesnei													
Moxostoma erythrurum		X											
Moxostoma macrolepidotum													
Ameiurus natalis						X					X		
Ictalurus punctatus													
Noturus exilis													
Pylodictis olivaris													

Appendix 2. (continued)

Site	11	11	11	11	11	12	12	12	13	13	14	14	14B	14B	15	15	15
Year	1969	1977	1978	1996	1996	1977	1989	1996	1969	1996	1977	1996	1938	1980	1969	1977	1996
Species																	
Campostoma anomalum		X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Cyprinella galactura	X			X	X	X	X	X		X	X	X	X	X		X	X
Cyprinella spiloptera																	
Cyprinus carpio																	
Hybopsis amblops																	
Luxilus chrysocephalus				X	X			X		X		X					X
L. chrysocephalus X C. anomalum																	
Lythrurus fasciolaris	X			X	X	X	X	X				X	X	X			
Nocomis micropogon																	X
Notemigonus crysoleucas																	
Notropis leuciodus																	
Notropis rubellus	X	X	X	X	X	X	X	X		X	X	X		X	X	X	X
L. chrysocephalus X N. rubellus					X			X									X
Notropis stramineus	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X
Notropis telescopus																	
Notropis volucellus		X						X							X	X	X
Rhinichthys atratulus							X			X							
Semotilus atromaculatus		X	X	X		X			X		X	X					
L. chrysocephalus X S. atromaculatus																	
Carpiodes cyprinus																X	
Catostomus commersoni									X			X				X	
Hypentelium nigricans	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Moxostoma carinatum																	
Moxostoma duquesnei	X	X			X	X				X		X	X			X	X
Moxostoma erythrurum										X		X	X	X			
Moxostoma macrolepidotum																	
Ameiurus natalis			X	X							X						
Ictalurus punctatus															X	X	
Noturus exilis																	
Pylodictis olivaris																	

Appendix 2. (continued)

Site	16	17	17	17	17	17	18	18	19	19	19	19B	20	20	21	21
Year	1996	1969	1978	1980	1996	1996	1978	1996	1977	1978	1996	1938	1978	1996	1978	1996
Species																
Campostoma anomalum	X	X	X	X	X	X	X	X	X	X	X			X	X	X
Cyprinella galactura	X											X				
Cyprinella spiloptera																
Cyprinus carpio																
Hybopsis amblops																
Luxilus chrysocephalus	X				X	X		X			X			X		X
L. chrysocephalus X C. anomalum						X										
Lythrurus fasciolaris		X			X	X						X	X		X	X
Nocomis micropogon								X			X			X		
Notemigonus crysoleucas																
Notropis leuciodus												X				
Notropis rubellus	X		X	X			X		X	X	X	X				X
L. chrysocephalus X N. rubellus																
Notropis stramineus		X	X	X	X	X	X	X	X	X	X	X	X	X		X
Notropis telescopus																
Notropis volucellus									X							
Rhinichthys atratulus	X															
Semotilus atromaculatus		X	X	X	X	X			X		X		X	X	X	X
L. chrysocephalus X S. atromaculatus														X		
Carpiodes cyprinus																
Catostomus commersoni					X	X			X		X			X		X
Hypentelium nigricans	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Moxostoma carinatum																
Moxostoma duquesnei		X			X	X		X	X	X	X					
Moxostoma erythrurum		X		X		X										X
Moxostoma macrolepidotum																
Ameiurus natalis			X				X		X		X					
Ictalurus punctatus										X						
Noturus exilis																
Pylodictis olivaris																

Appendix 2. (continued)

Site	22	22B	22B	23	23B	24	24	25	25	26	26	26B	27	27	28	28
Year	1996	1939	1977	1996	1938	1969	1996	1969	1996	1969	1996	1977	1938	1996	1968	1996
Species																
Campostoma anomalum	X		X	X		X	X	X	X	X	X	X	X	X	X	X
Cyprinella galactura																X
Cyprinella spiloptera		X			X											
Cyprinus carpio																
Hybopsis amblops																
Luxilus chrysocephalus	X			X		X	X	X	X		X	X		X		X
L. chrysocephalus X C. anomalum																
Lythrurus fasciolaris	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
Nocomis micropogon																
Notemigonus crysoleucas																
Notropis leuciodus																
Notropis rubellus	X	X	X													X
L. chrysocephalus X N. rubellus																
Notropis stramineus	X	X		X		X	X	X	X	X	X	X		X	X	X
Notropis telescopus																
Notropis volucellus		X	X								X					X
Rhinichthys atratulus																
Semotilus atromaculatus	X			X		X	X	X	X	X	X	X	X	X	X	X
L. chrysocephalus X S. atromaculatus																
Carpiodes cyprinus																
Catostomus commersoni				X			X		X		X	X		X		
Hypentelium nigricans	X		X	X		X		X	X	X	X	X		X	X	X
Moxostoma carinatum																X
Moxostoma duquesnei			X	X								X			X	
Moxostoma erythrurum		X					X					X			X	
Moxostoma macrolepidotum																X
Ameiurus natalis			X								X					X
Ictalurus punctatus																
Noturus exilis																
Pylodictis olivaris																

Appendix 2. (continued)

Site	29	29	29	29B	29B	29C	30	31	31	31	31	32	33	33B	33C	34
Year	1938	1977	1996	1938	1977	1977	1996	1938	1968	1977	1996	1996	1996	1968	1953	1996
Species																
Campostoma anomalum				X	X	X	X	X	X	X	X	X	X	X	X	X
Cyprinella galactura					X	X		X				X	X	X		
Cyprinella spiloptera				X												
Cyprinus carpio						X										
Hybopsis amblops															X	
Luxilus chrysocephalus							X				X	X	X			
L. chrysocephalus X C. anomalum																
Lythrurus fasciolaris	X			X	X	X	X	X	X	X	X	X	X	X	X	X
Nocomis micropogon												X	X	X		
Notemigonus crysoleucas																
Notropis leuciodus																
Notropis rubellus				X	X	X					X	X	X	X		
L. chrysocephalus X N. rubellus											X					
Notropis stramineus				X	X	X	X		X	X	X	X	X	X		X
Notropis telescopus											X					
Notropis volucellus				X				X				X		X		
Rhinichthys atratulus																
Semotilus atromaculatus			X	X	X		X			X	X		X	X	X	X
L. chrysocephalus X S. atromaculatus									X							
Carpiodes cyprinus																
Catostomus commersoni					X		X			X	X		X			X
Hypentelium nigricans				X	X	X	X	X	X	X	X	X	X	X		X
Moxostoma carinatum																
Moxostoma duquesnei										X						
Moxostoma erythrurum				X							X	X				
Moxostoma macrolepidotum																
Ameiurus natalis							X									
Ictalurus punctatus																
Noturus exilis																
Pylodictis olivaris																

Appendix 2. (continued)

Site	35	35	36	37	38	39	39	39	39	40	41	41	41	41	41	42
Year	1977	1996	1996	1996	1996	1953	1968	1977	1996	1996	1938	1939	1953	1977	1996	1996
Species																
Campostoma anomalum	X	X	X	X	X	X	X	X	X	X			X	X	X	X
Cyprinella galactura								X	X	X					X	X
Cyprinella spiloptera						X					X	X				
Cyprinus carpio																X
Hybopsis amblops																
Luxilus chrysocephalus					X				X	X						
L. chrysocephalus X C. anomalum																
Lythrurus fasciolaris	X	X	X		X		X	X	X	X	X	X		X	X	X
Nocomis micropogon							X			X					X	X
Notemigonus crysoleucas								X								
Notropis leuciodus						X										
Notropis rubellus					X	X		X	X	X		X			X	X
L. chrysocephalus X N. rubellus																
Notropis stramineus	X	X	X		X	X	X	X	X	X		X	X			X
Notropis telescopus																
Notropis volucellus	X					X		X	X	X	X	X			X	X
Rhinichthys atratulus																
Semotilus atromaculatus	X	X	X	X	X	X	X	X	X	X						
L. chrysocephalus X S. atromaculatus																
Carpiodes cyprinus																
Catostomus commersoni	X		X					X								
Hypentelium nigricans	X	X	X	X	X	X	X	X	X	X				X	X	X
Moxostoma carinatum																X
Moxostoma duquesnei			X		X	X	X	X						X	X	X
Moxostoma erythrurum		X	X				X					X		X		X
Moxostoma macrolepidotum																X
Ameiurus natalis																
Ictalurus punctatus														X		X
Noturus exilis					X	X										
Pylodictis olivaris																X

Appendix 2. (continued)

Site	1B	1	1	1	2	2	3	4	4	5	5	5B	5C	5C	5C	6	6
Year	1938	1938	1977	1996	1969	1996	1996	1969	1996	1978	1996	1978	1938	1977	1978	1977	1996
Species																	
Ambloplites rupestris							X		X								X
Lepomis auritus																	
Lepomis cyanellus																	
Lepomis gulosus																	
Lepomis macrochirus																	X
L. cyanellus X L. macrochirus																	
Lepomis microlophus																	
Lepomis megalotis																X	X
L. macrochirus X L. megalotis																	
Micropterus dolomieu			X	X		X			X								X
Micropterus punctulatus			X											X	X	X	
Micropterus salmoides																	
Etheostoma baileyi							X		X							X	
Etheostoma blenniodes				X			X		X								X
Etheostoma caeruleum			X	X	X	X	X		X					X	X	X	X
Etheostoma camurum									X								X
Etheostoma cinereum																	
Etheostoma sanguifluum																	
Etheostoma stigmaeum																	
Percina caprodes																	
Percina maculata																X	X
Stizostedion vitreum																	
Species Richness	5	4	9	10	5	8	11	5	13	0	1	0	4	9	8	10	15

Appendix 2. (continued)

Site	7	7	8	8	9	9	9	9	10B	10	10	10	10C
Year	1969	1996	1977	1996	1938	1977	1989	1996	1978	1969	1977	1996	1938
Species													
Ambloplites rupestris		X		X				X				X	X
Lepomis auritus				X									
Lepomis cyanellus													
Lepomis gulosus													
Lepomis macrochirus													
L. cyanellus X L. macrochirus													
Lepomis microlophus													
Lepomis megalotis			X	X				X					
L. macrochirus X L. megalotis													
Micropterus dolomieu			X	X				X	X		X	X	
Micropterus punctulatus		X	X	X									
Micropterus salmoides													
Etheostoma baileyi		X	X	X				X				X	
Etheostoma blenniodes		X	X	X				X				X	
Etheostoma caeruleum		X	X	X		X	X	X	X	X		X	
Etheostoma camurum				X				X					
Etheostoma cinereum				X									
Etheostoma sanguifluum				X				X					
Etheostoma stigmaeum													
Percina caprodes			X	X					X				
Percina maculata			X	X	X			X					
Stizostedion vitreum													
Species Richness	4	14	12	21	4	8	9	16	8	7	4	11	4

Appendix 2. (continued)

Site	11	11	11	11	11	12	12	12	13	13	14	14	14B	14B	15	15	15
Year	1969	1977	1978	1996	1996	1977	1989	1996	1969	1996	1977	1996	1938	1980	1969	1977	1996
Species																	
Ambloplites rupestris				X			X	X		X		X	X			X	X
Lepomis auritus																	
Lepomis cyanellus																	
Lepomis gulosus																	
Lepomis macrochirus														X			
L. cyanellus X L. macrochirus																	
Lepomis microlophus																	
Lepomis megalotis	X	X		X	X		X	X			X	X	X			X	X
L. macrochirus X L. megalotis																	
Micropterus dolomieu	X		X	X			X	X		X		X					X
Micropterus punctulatus		X				X					X						
Micropterus salmoides																	
Etheostoma baileyi	X	X	X	X	X	X		X			X					X	
Etheostoma blenniodes	X	X	X	X	X	X	X	X	X	X		X		X	X	X	X
Etheostoma caeruleum	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X
Etheostoma camurum				X	X	X	X	X			X	X		X	X	X	X
Etheostoma cinereum					X			X				X					X
Etheostoma sanguifluum				X	X			X				X					X
Etheostoma stigmaeum																	
Percina caprodes	X	X	X			X		X			X				X	X	X
Percina maculata	X						X		X					X	X	X	X
Stizostedion vitreum																	
Species Richness	13	13	11	17	15	14	14	18	8	12	14	19	7	12	10	19	20

Appendix 2. (continued)

Site	16	17	17	17	17	17	18	18	19	19	19	19B	20	20	21	21	22
Year	1996	1969	1978	1980	1996	1996	1978	1996	1977	1978	1996	1938	1978	1996	1978	1996	1996
Species																	
Ambloplites rupestris	X	X	X		X	X		X	X		X			X	X	X	X
Lepomis auritus																	
Lepomis cyanellus																	
Lepomis gulosus																	
Lepomis macrochirus						X		X			X			X			
L. cyanellus X L. macrochirus																	
Lepomis microlophus																	
Lepomis megalotis	X	X	X	X	X	X		X	X	X	X				X		X
L. macrochirus X L. megalotis																	
Micropterus dolomieu			X		X	X	X	X			X					X	
Micropterus punctulatus			X	X			X	X	X	X	X			X	X	X	
Micropterus salmoides																	
Etheostoma baileyi	X	X	X	X	X	X		X	X	X	X					X	X
Etheostoma blenniodes	X	X	X	X	X	X	X	X	X		X					X	X
Etheostoma caeruleum	X	X	X	X	X	X	X	X	X	X	X		X	X		X	X
Etheostoma camurum	X		X			X	X	X	X	X	X					X	X
Etheostoma cinereum	X				X	X											
Etheostoma sanguifluum	X							X			X						
Etheostoma stigmaeum								X			X						
Percina caprodes		X	X	X		X	X	X	X		X						
Percina maculata	X	X		X		X			X		X		X				
Stizostedion vitreum																	
Species Richness	16	14	15	13	14	20	11	18	18	11	23	5	6	11	7	16	13

Appendix 2. (continued)

Site	22B	22B	23	23B	24	24	25	25	26	26	26B	27	27	28	28
Year	1939	1977	1996	1938	1969	1996	1969	1996	1969	1996	1977	1938	1996	1968	1996
Species															
Ambloplites rupestris		X	X					X	X		X			X	X
Lepomis auritus															
Lepomis cyanellus										X			X		X
Lepomis gulosus										X					
Lepomis macrochirus										X			X		X
L. cyanellus X L. macrochirus										X					
Lepomis microlophus															
Lepomis megalotis	X	X	X	X		X	X	X	X	X	X		X	X	X
L. macrochirus X L. megalotis															
Micropterus dolomieu															X
Micropterus punctulatus		X							X	X	X				X
Micropterus salmoides										X					
Etheostoma baileyi			X			X		X	X				X		X
Etheostoma blenniodes	X	X	X			X	X	X	X	X	X		X		X
Etheostoma caeruleum		X	X		X	X	X	X	X	X	X		X	X	X
Etheostoma camurum		X	X												
Etheostoma cinereum			X												
Etheostoma sanguifluum		X													
Etheostoma stigmaeum															
Percina caprodes	X	X							X	X	X				
Percina maculata	X		X			X		X			X		X		X
Stizostedion vitreum															
Species Richness	10	15	16	3	7	11	10	13	14	18	15	3	14	10	16

Appendix 2. (continued)

Site	29	29	29	28B	28B	29C	30	31	31	31	31	32	33	33B	33C	34
Year	1938	1977	1996	1938	1977	1977	1996	1938	1968	1977	1996	1996	1996	1968	1953	1996
Species																
Ambloplites rupestris										X	X					X
Lepomis auritus																
Lepomis cyanellus			X								X	X				
Lepomis gulosus																
Lepomis macrochirus			X			X				X	X		X			
L. cyanellus X L. macrochirus																
Lepomis microlophus																
Lepomis megalotis				X		X	X			X	X	X	X	X	X	X
L. macrochirus X L. megalotis																
Micropterus dolomieu																X
Micropterus punctulatus					X	X	X				X		X	X		X
Micropterus salmoides							X				X					
Etheostoma baileyi										X	X	X	X			X
Etheostoma blenniodes	X		X				X		X	X	X	X	X	X		X
Etheostoma caeruleum						X	X		X	X	X	X	X	X		X
Etheostoma camurum						X				X	X	X	X			
Etheostoma cinereum											X	X	X			
Etheostoma sanguifluum						X						X				
Etheostoma stigmaeum																
Percina caprodes										X	X					
Percina maculata						X				X	X		X	X		X
Stizostedion vitreum																
Species Richness	2	0	4	10	9	14	12	5	9	16	22	18	19	14	5	15

Appendix 2. (continued)

Site	35	35	36	37	38	39	39	39	39	40	41	41	41	41	41	42
Year	1977	1996	1996	1996	1996	1953	1968	1977	1996	1996	1938	1939	1953	1977	1996	1996
Species																
Ambloplites rupestris	X	X	X		X	X		X	X	X			X	X	X	X
Lepomis auritus																
Lepomis cyanellus			X			X				X						X
Lepomis gulosus																
Lepomis macrochirus		X					X			X			X	X	X	X
L. cyanellus X L. macrochirus																
Lepomis microlophus										X						
Lepomis megalotis	X	X	X		X		X	X	X		X	X	X	X	X	X
L. macrochirus X L. megalotis														X		
Micropterus dolomieu		X			X	X									X	X
Micropterus punctulatus				X	X		X	X	X	X				X	X	X
Micropterus salmoides													X	X		
Etheostoma baileyi		X	X		X			X	X		X					X
Etheostoma blenniodes	X	X	X	X	X		X	X	X	X		X		X	X	X
Etheostoma caeruleum	X	X	X	X	X	X	X	X	X	X			X	X	X	X
Etheostoma camurum			X		X			X	X	X				X	X	X
Etheostoma cinereum					X				X	X					X	X
Etheostoma sanguifluum					X					X					X	X
Etheostoma stigmaeum																
Percina caprodes			X		X		X	X	X			X				
Percina maculata	X	X	X		X	X	X	X	X	X	X	X	X		X	
Stizostedion vitreum																X
Species Richness	13	14	17	6	21	15	15	20	19	21	6	10	8	14	19	28

APPENDIX 3

Appendix 3. Number of each species, species richness, IBI score, and metric value summary for sites sampled in the New River system, 1968 through 1997. IBI not calculated for samples that yielded < 100 individuals.
* = estimated value

Site 1: New River

Species	1996	1977
Campostoma anomalum	350	606
Luxilus chrysocephalus	214	0
Notropis stramineus	0	33
Rhinichthys atratulus	15	58
Semotilus atromaculatus	80	463
Catostomus commersoni	13	53
Hypentelium nigricans	27	16
Moxostoma erythrurum	2	0
Micropterus dolomieu	1	2
Micropterus punctulatus	0	1
Etheostoma blennioides	8	0
Etheostoma caeruleum	153	64
Total	863	1296
Species Richness	10	9
Species Diversity	0.73	0.65

Metric	Score 1996	Score 1977	Value 1996	Value 1977
CPUE	5	5	49.6	209.3
Number				
Native species	3	3	9	9
Darter species	3	1	2	1
Intolerant species	1	1	0	0
Percent				
Simple & lithophilus	1	1	3.3	1.2
Generalist Feeder	3	3	37.3	46.8
Benthic invertivore	5	1	21.8	6.2
Suckers	3	1	3.4	1.2
Smallmouth & Rockbass	1	1	0.1	0.2
Semotilus	5	1	9.3	35.7
Pioneering sp.	1	5	24.8	0.0
IBI	31	23		

Appendix 3. (continued)

Site 2: Stallion Branch

Species	1996	1969
Campostoma anomalum	116	3
Luxilus chrysocephalus	119	0
Notropis stramineus	0	17
Rhinichthys atratulus	13	13
Semotilus atromaculatus	68	16
Catostomus commersoni	3	0
Hypentelium nigricans	10	0
Micropterus dolomieu	1	0
Etheostoma caeruleum	94	63
Total	424	112
Species Diversity	8	5
Species Diversity	0.77	0.63

Metric	Score 1996	Score 1969	Value 1996	Value 1969
CPUE	5	5	58.9	NA
Number				
Native species	1	1	7	5
Darter species	1	1	1	1
Intolerant species	1	1	0	0
Percent				
Simple & lithophilus	1	1	2.4	0.0
Generalist Feeder	3	3	47.2	41.1
Benthic invertivore	5	5	24.5	56.3
Suckers	1	1	2.4	0.0
Smallmouth & Rockbass	1	1	0.2	0.0
Semotilus	3	3	16.0	14.3
Pioneering sp.	1	5	28.1	0.0
IBI	23	27		

Site 3: Laurel Fork
24 May 1996

Species	1996
Campostoma anomalum	98
Luxilus chrysocephalus	33
Notropis stramineus	3
Rhinichthys atratulus	1
Semotilus atromaculatus	47
Catostomus commersoni	4
Hypentelium nigricans	9
Ambloplites rupestris	2
Etheostoma baileyi	1
Etheostoma blennioides	4
Etheostoma caeruleum	35
Total	237
Species Richness	11
Species Diversity	0.75

Appendix 3. (continued)

Site 3, continued

Metric	Score	Value
CPUE	1	13.5
Number		
Native species	1	10
Darter species	1	3
Intolerant species	1	1
Percent		
Simple & lithophilus	1	3.8
Generalist Feeder	1	37.1
Benthic invertivore	1	20.7
Suckers	1	1.7
Smallmouth & Rockbass	1	0.8
Semotilus	1	19.8
Pioneering sp.	3	13.9
IBI	13	

Site 4: New River

Species	1996	1969
Campostoma anomalum	160	3
Cyprinella galactura	1	0
Luxilus chrysocephalus	24	0
Lythrurus fasciolaris	13	8
Notropis stramineus	4	105
Rhinichthys atratulus	0	2
Semotilus atromaculatus	1	2
Hypentelium nigricans	22	0
Ambloplites rupestris	5	0
Micropterus dolomieu	3	0
Etheostoma baileyi	1	0
Etheostoma blennioides	5	0
Etheostoma caeruleum	79	0
Etheostoma camurum	4	0
Total	322	120
Species Richness	13	5
Species Diversity	0.68	0.23

Appendix 3. (continued)

Site 4, continued

Metric	Score 1996	Score 1969	Value 1996	Value 1969
CPUE	3	5	14.3	NA
Number				
Native species	1	1	12	5
Darter species	1	1	4	0
Intolerant species	3	1	2	0
Percent				
Simple spawner	1	1	6.8	0.0
Generalist Feeder	5	1	9.0	90.9
Benthic invertivore	3	1	34.5	4.2
Suckers	3	1	6.8	0.0
Smallmouth & Rockbass	3	1	2.5	0.0
Semotilus	0	0	0.3	1.7
Pioneering sp.	3	5	7.5	0.0
IBI	26	18		

Site 5: Indian Fork

Species	1996	1978
Semotilus atromaculatus	8	0
Species Richness	1	0

Site 5B: Indian Fork
Summer, 1978.

No fish were present

Site 5C: Indian Fork

Species	1977	1978	1989
Campostoma anomalum	14	1	32
Luxilus chrysocephalus	0	0	3
Lythrurus fasciolaris	12	2	2
Notropis stramineus	51	21	9
Notropis rubellus	0	0	1
Semotilus atromaculatus	76	53	16
Catostomus commersoni	2	5	0
Hypentelium nigricans	3	0	1
Ameiurus natalis	4	3	0
Micropterus punctulatus	1	1	0
Etheostoma caeruleum	6	2	7
Total	169	88	71
Species Richness	9	8	8
Species Diversity	0.70	0.58	0.82

Appendix 3. (continued)

Site 5C, continued

Metric	Score 1977	Score 1978	Score 1989	Value 1977	Value 1978	Value 1989
CPUE	3			41.9	62.8	*45.1
Number						
Native species	3			9	8	4.2
Darter species	1			1	1	2.8
Intolerant species	1			0	0	12.7
Percent						
% Simple & lithophilus	3			8.9	7.1	1.4
% Generalist Feeder	1			77.5	87.5	22.5
% Benthic invertivore	3			13.6	3.4	0.0
% Suckers	1			1.8	0.0	1.4
% Smallmouth & Rockbass	1			0.0	0.0	0.0
% Semotilus	1			45.0	60.2	0.0
% Pioneering sp.	5			0.0	0.0	9.9
IBI	23	NA	NA			

Site 6: New River

Species	1996	1977
Campostoma anomalum	38	18
Cyprinella galactura	9	0
Luxilus chrysocephalus	29	0
Lythrurus fasciolaris	5	0
Notropis rubellus	2	0
Notropis stramineus	4	13
Hypentelium nigricans	25	38
Ameiurus natalis	0	2
Ambloplites rupestris	10	0
Lepomis macrochirus	2	0
Lepomis megalotis	21	2
Micropterus dolomieu	6	0
Micropterus punctulatus	0	2
Etheostoma baileyi	0	2
Etheostoma blennioides	4	0
Etheostoma caeruleum	38	11
Etheostoma camurum	19	0
Percina maculata	2	1
Total	214	89
Species Richness	15	10
Species Diversity	0.89	0.75

Appendix 3. (continued)

Site 6, continued

Metric	Score 1996	Score 1977	Value 1996	Value 1977
CPUE	1		8.2	11.6
Number				
Native species	1		14	10
Darter species	1		4	3
Intolerant species	1		1	1
Percent				
Simple & lithophilus	3		15.0	42.7
Generalist Feeder	3		26.2	19.1
Benthic invertivore	5		41.1	27.4
Suckers	5		11.7	42.7
Smallmouth & Rockbass	5		7.5	0.0
Semotilus	0		0	0
Pioneering sp.	3		13.6	0.0
IBI	28	NA		

Site 7: Double Camp Creek

Species	1996	1969
Campostoma anomalum	164	6
Luxilus chrysocephalus	138	0
Lythrurus fasciolaris	1	0
Notropis stramineus	20	4
Rhinichthys atratulus	1	0
Semotilus atromaculatus	66	24
Catostomus commersoni	12	2
Hypentelium nigricans	22	0
Moxostoma erythrurum	8	0
Ambloplites rupestris	2	0
Micropterus punctulatus	1	0
Etheostoma baileyi	5	0
Etheostoma blennioides	14	0
Etheostoma caeruleum	26	0
Total	480	36
Species Richness	14	4
Species Diversity	0.77	0.53

Appendix 3. (continued)

Site 7, continued

Metric	Score 1996	Score 1969	Value 1996	Value 1969
CPUE	3		26.9	NA
Number				
Native species	5		13	4
Darter species	3		3	0
Intolerant species	3		1	0
Percent				
Simple & lithophilus	3		6.5	0
Generalist Feeder	3		49.4	66.7
Benthic invertivore	3		15.6	16.7
Suckers	5		6.3	0
Smallmouth & Rockbass	1		0.4	0
Semotilus	3		13.8	66.7
Pioneering sp.	1		28.8	0
IBI	33	NA		

Site 8: New River

Species	1996	1977
Campostoma anomalum	121	45
Cyprinella galactura	2	1
Luxilus chrysocephalus	19	0
Lythrurus fasciolaris	10	0
Notropis rubellus	39	5
Notropis stramineus	9	47
Notropis volucellus	21	0
Hypentelium nigricans	4	15
Ambloplites rupestris	9	0
Lepomis auritus	1	0
Lepomis megalotis	21	5
Micropterus dolomieu	5	2
Micropterus punctulatus	1	1
Etheostoma baileyi	11	5
Etheostoma blennioides	16	1
Etheostoma caeruleum	34	38
Etheostoma camurum	38	0
Etheostoma cinereum	2	0
Etheostoma sanguifluum	13	0
Percina caprodes	3	20
Percina maculata	4	6
Total	383	191
Species Richness	21	12
Species Diversity	0.86	0.83

Appendix 3. (continued)

site 8, continued

Metric	Score 1996	Score 1977	Value 1996	Value 1997
CPUE	1	1	8.0	23.6
Number				
Native species	5	1	19	12
Darter species	5	3	8	5
Intolerant species	5	1	4	1
Percent				
Simple & lithophilus	3	1	14.6	10.5
Generalist Feeder	5	3	18.5	27.2
Benthic invertivore	3	5	31.6	36.6
Suckers	1	3	1.0	7.9
Smallmouth Bass & Rockbass	5	1	3.7	1.0
Creek Chub	0	0	0	0
Pioneering sp.	5	5	5.0	0.0
IBI	38	24		

Site 9: Cage Creek

Species	1996	1989	1977
Campostoma anomalum	45	44	60
Cyprinella galactura	0	1	0
Luxilus chrysocephalus	44	0	0
Lythrurus fasciolaris	3	1	3
Notropis rubellus	23	1	18
Notropis stramineus	0	2	19
Rhinichthys atratulus	1	3	0
Semotilus atromaculatus	20	8	3
Hypentelium nigricans	11	1	1
Ameirus natalis	0	0	2
Ambloplites rupestris	1	0	0
Lepomis megalotis	1	0	0
Micropterus dolomieu	3	0	0
Etheostoma baileyi	2	0	0
Etheostoma blennioides	6	0	0
Etheostoma caeruleum	69	28	49
Etheostoma camurum	18	0	0
Etheostoma sanguifluum	2	0	0
Percina maculata	1	0	0
Total	250	89	155
Species Richness	16	9	8
Species Diversity	0.84	0.65	0.73

Appendix 3. (continued)

Site 9, continued

Metric	Score 1996	Score 1989	Score 1977	Value 1996	Value 1989	Value 1977
CPUE	5		5	39.3	*16.2	101.3
Number						
Native species	5		1	15	9	8
Darter species	5		1	6	1	1
Intolerant species	5		3	4	0	1
Percent						
Simple & lithophilus	5		5	14.8	3.4	14.2
Generalist Feeder	5		5	26.4	14.6	15.5
Benthic invertivore	5		5	43.6	32.6	32.3
Suckers	5		1	4.4	1.1	0.65
Smallmouth Bass & Rockbass	3		1	1.6	0	0
Creek Chub	5		5	8	9.0	1.9
Pioneering sp.	1		5	17.6	0	0
IBI	49	NA	37			

Site 10B: Graves Gap Branch, tributary to Ligias Fork.

Species	1978
Campostoma anomalum	82
Lythrurus fasciolaris	1
Notropis stramineus	13
Semotilus atromaculatus	6
Hypentelium nigricans	5
Micropterus dolomieu	1
Etheostoma caeruleum	2
Percina caprodes	2
Total	112
Species Richness	8
Species Diversity	0.45

Metric	Score	Value
CPUE	1	28.7
Number		
Native species	1	8
Darter species	3	2
Intolerant species	1	0
Percent		
Simple & lithophilus	3	7.1
Generalist Feeder	5	17.0
Benthic invertivore	1	8.0
Suckers	5	4.5
Smallmouth Bass & Rockbass	1	0.8
Creek Chub	5	5.3
Pioneering sp.	5	0
IBI	31	

Appendix 3. (continued)

Site 10: Ligias Fork

Species	1996	1977	1969
Campostoma anomalum	138	11	3
Cyprinella galactura	0	0	1
Luxilus chrysocephalus	230	0	0
Lythrurus fasciolaris	0	0	4
Notropis stramineus	5	0	62
Rhinichthys atratulus	2	0	0
Semotilus atromaculatus	24	0	1
Hypentelium nigricans	23	5	1
Ameiurus natalis	0	1	0
Ambloplites rupestris	4	0	0
Micropterus dolomieu	5	1	0
Etheostoma baileyi	1	0	0
Etheostoma blennioides	6	0	0
Etheostoma caeruleum	76	0	25
Total	514	18	97
Species Richness	11	4	7
Species Diversity	0.70	0.58	0.53

Metric	Score			Value		
	1996	1978	1969	1996	1978	1969
CPUE	5		5	32.1	4.6	NA
Number						
Native species	1		1	10	4	7
Darter species	1		1	3	0	1
Intolerant species	1		1	1	0	1
Percent						
Simple & lithophilus	1		1	4.5	27.8	5.2
Generalist Feeder	3		1	50.4	5.6	64.9
Benthic invertivore	1		5	20.6	27.8	26.8
Suckers	3		1	4.7	0	1.0
Smallmouth Bass & Rockbass	5		1	4.5	27.8	1.0
Creek Chub	5		1	1.8	5.6	0.0
Pioneering sp.	1		5	44.7	0	0.0
IBI	27	NA	23			

Appendix 3. (continued)

Site 11: Ligias Fork

Species	1996 S	1996 F	1977 F	1978 S	1969
Campostoma anomalum	75	214	208	123	0
Cyprinella galactura	6	5	0	0	4
Luxilus chrysocephalus	47	67	0	0	0
Lythrurus fasciolaris	1	3	0	0	2
Notropis rubellus	39	23	6	15	3
N. rubellus X L. chrysocephalus	0	3	0	0	0
Notropis stramineus	11	26	62	86	93
Notropis volucellus	0	0	1	0	0
Semotilus atromaculatus	4	0	3	14	0
Hypentelium nigricans	4	24	7	14	1
Moxostoma duquesnei	0	1	1	0	1
Amieurus natalis	1	0	0	1	0
Ambloplites rupestris	1	0	0	0	0
Lepomis megalotis	50	16	1	0	1
Micropterus dolomieu	7	0	0	2	1
Micropterus punctulatus	0	0	1	0	0
Etheostoma baileyi	1	3	15	14	7
Etheostoma blennioides	2	7	1	4	1
Etheostoma caeruleum	71	13	105	85	26
Etheostoma camurum	10	35	0	0	0
Etheostoma cinereum	0	1	0	0	0
Etheostoma sanquifluum	1	6	0	0	0
Percina caprodes	0	0	19	8	1
Percina maculata	0	0	0	0	1
Total:	331	447	430	366	142
Species Richness	17	14	13	12	13
Species Diversity	0.85	0.73	0.68	0.77	0.54

Appendix 3. (continued)

Site 11, continued.

Metric	Score					Value				
	1996 S	1996 F	1977 F	1978 S	1969	1996 S	1996 F	1977 F	1978 S	1969
CPUE	3	5	5	5	5	10.2	28.6	46.8	55.4	NA
Number										
Native Species	3	1	1	1	1	16	14	13	12	13
Darter species	3	3	1	3	1	5	6	4	5	4
Intolerant species	5	5	3	1	1	3.0	4.0	1.0	2.0	1
Percent										
Simple spawners	3	1	1	1	1	15.1	12.5	7.7	10.1	8.5
Generalist Feeder	1	3	5	3	1	34.1	24.4	15.6	27.6	66.2
Benthic invertivore	3	1	3	3	3	26.9	20.1	34.4	34.2	26.8
Catostomidae	1	3	1	3	1	1.2	5.6	1.9	3.8	1.4
Smallmouth & Rockbass	5	1	1	1	3	2.4	0.0	0.0	0.5	0.7
Semotilus	5	5	5	3	5	1.2	0.0	0.7	3.8	0.0
Pioneering sp.	3	3	5	5	5	14.2	15.0	0.0	0.0	0.0
IBI:	35	31	31	29	27					

Appendix 3. (continued)

Site 12: New River

Species	1996	1977
Campostoma anomalum	121	42
Cyprinella galactura	10	1
Luxilus chrysocephalus	29	0
L. chrysocephalus X Notropis rubellu	1	0
Lythrurus fasciolaris	17	3
Notropis rubellus	35	5
Notropis stramineus	15	26
Notropis volucellus	25	0
Semotilus atromaculatus	0	1
Hypentelium nigricans	8	10
Moxostoma duquesnei	0	1
Ambloplites rupestris	2	0
Lepomis megalotis	5	0
Micropterus dolomieu	2	0
Micropterus punctulatus	0	1
Etheostoma baileyi	4	2
Etheostoma blennioides	8	4
Etheostoma caeruleum	26	70
Etheostoma camurum	26	3
Etheostoma cinereum	1	0
Etheostoma sanguifluum	17	0
Percina caprodes	1	4
Total	353	173
Species Richness	18	14

Metric	Score 1996	Score 1977	Value 1996	Value 1977
CPUE	3	1	13.4	24.6
Number				
Native species	3	1	17	14
Darter species	5	3	7	5
Intolerant species	5	3	4	2
Percent				
Simple & lithophilus	3	1	17.3	13.3
Generalist Feeder	3	5	21.0	15.6
Benthic invertivore	3	5	25.8	53.8
Suckers	1	3	2.3	6.4
Smallmouth Bass & Rockbass	1	1	1.1	0.0
Creek Chub	0	0	0.0	0.6
Pioneering sp.	3	5	8.2	0.0
IBI	30	28		

Appendix 3. (continued)

Site 13: Stony Fork

Species	1996	1969
Campostoma anomalum	40	9
Cyprinella galactura	13	0
Luxilus chrysocephalus	39	0
Notropis rubellus	1	0
Notropis stramineus	0	81
Semotilus atromaculatus	0	5
Rhinichthys atratulus	1	0
Catostomus commersoni	0	1
Hypentelium nigricans	24	2
Moxostoma duquesnei	1	0
Moxostoma erythrurum	2	0
Ambloplites rupestris	2	0
Micropterus dolomieu	16	0
Etheostoma blennioides	2	2
Etheostoma caeruleum	25	17
Percina maculata	0	4
Total	166	121
Species Richness	12	8
Species Diversity	0.84	0.75

Metric	Score		Value	
	1996	1969	1996	1969
CPUE	1	5	8.8	NA
Number				
Native species	3	1	11	8
Darter species	3	3	2	3
Intolerant species	3	1	1	0
Percent				
Simple & lithophilus	5	1	15.3	2.5
Generalist Feeder	5	1	24.1	73.6
Benthic invertivore	5	3	32.5	19.0
Suckers	5	3	16.3	2.5
Smallmouth Bass & Rockbass	5	1	10.8	0.0
Creek Chub	5	5	0.0	4.1
Pioneering sp.	1	5	23.5	0.0
IBI	41	29		

Appendix 3. (continued)

Site 14: Beech Fork

Species	1996	1977
Campostoma anomalum	43	26
Cyprinella galactura	23	2
Luxilus chrysocephalus	53	0
Lythrurus fasciolaris	3	0
Notropis rubellus	62	5
Notropis stramineus	6	26
Semotilus atromaculatus	1	4
Catostomus commersoni	1	0
Hypentelium nigricans	15	16
Moxostoma duquesnei	3	0
Moxostoma erythrurum	6	0
Amieurus natalis	0	1
Ambloplites rupestris	6	0
Lepomis megalotis	2	6
Micropterus dolomieu	1	0
Micropterus punctulatus	0	2
Etheostoma baileyi	0	4
Etheostoma blennioides	4	0
Etheostoma caeruleum	33	86
Etheostoma camurum	10	2
Etheostoma cinereum	1	0
Etheostoma sanquifluum	5	0
Percina caprodes	0	1
Total	278	181
Species Richness	19	14
Species Diversity	0.86	0.72

Metric	Score 1996	Score 1977	Value 1996	Value 1977
CPUE	3	1	12.1	16.6
Number				
Native species	5	1	18	14
Darter species	3	1	5	4
Intolerant species	5	3	3	2
Percent				
Simple & lithophilus	5	1	32.0	12.2
Generalist Feeder	5	3	3.6	20.4
Benthic invertivore	3	5	27.7	58.0
Suckers	5	5	8.6	8.8
Smallmouth Bass & Rockbass	3	1	2.5	0.0
Creek Chub	5	5	0.4	2.2
Pioneering sp.	1	5	19.1	0.0
IBI	43	31		

Appendix 3. (continued)

Site 15: New River

Species	1996	1977	1969
Campostoma anomalum	61	12	4
Cyprinella galactura	4	4	0
Luxilus chrysocephalus	18	0	0
L. chrysocephalus X Notropis rubellu	1	0	0
Nocomis micropogon	1	0	0
Notropis rubellus	34	12	2
Notropis stramineus	15	19	0
Notropis volucellus	16	18	1
Carpiodes cyprinus	0	1	0
Catostomus commersoni	0	1	0
Hypentelium nigricans	6	30	1
Moxostoma duquesnei	1	1	0
Ictalurus punctatus	0	8	11
Ambloplites rupestris	7	3	0
Lepomis megalotis	12	21	0
Micropterus dolomieu	3	0	0
Micropterus punctulatus	1	27	0
Etheostoma baileyi	0	1	0
Etheostoma blennioides	7	2	1
Etheostoma caeruleum	7	10	17
Etheostoma camurum	44	23	8
Etheostoma cinereum	2	0	0
Etheostoma sanguifluum	16	0	0
Percina caprodes	2	9	4
Percina maculata	1	1	2
Total	259	203	51
Species Richness	20	19	10
Species Diversity	0.88	0.91	0.82

Metric	Score			Value		
	1996	1977	1969	1996	1977	1969
CPUE	1	1		3.7	8.7	NA
<u>Number</u>						
Native species	5	5		19	19	10
Darter species	5	3		7	6	5
Intolerant species	5	3		3	2	1
<u>Percent</u>						
Simple & lithophilus	3	5		16.6	25.6	13.7
Generalist Feeder	3	1		24.3	33.5	23.5
Benthic invertivore	3	5		33.2	37.9	64.7
Suckers	1	5		2.7	15.8	2.0
Smallmouth Bass & Rockbass	5	3		3.9	1.5	0.0
Creek Chub	0	0		0.0	0.0	0.0
Pioneering sp.	3	5		6.9	0.0	0.0
IBI	34	36	*NA			

Appendix 3. (continued)

Site 16: Nicks Creek

Species	1996
Campostoma anomalum	19
Cyprinella galactura	1
Luxilus chrysocephalus	29
Notropis rubellus	22
Rhinichthys atratulus	31
Semotilus atromaculatus	56
Hypentelium nigricans	5
Ambloplites rupestris	4
Lepomis megalotis	7
Etheostoma baileyi	2
Etheostoma blennioides	1
Etheostoma caeruleum	59
Etheostoma camurum	5
Etheostoma cinereum	1
Etheostoma sanguifluum	2
Percina maculata	6
Total	250
Species Richness	16
Species Diversity	0.85

Metric	Score	Value
CPUE	5	25.0
Number		
Native species	3	15
Darter species	5	7
Intolerant species	5	4
Percent		
Simple & lithophilus	1	10.8
Generalist Feeder	1	49.2
Benthic invertivore	3	32.4
Suckers	1	2.0
Smallmouth Bass & Rockbass	3	1.6
Creek Chub	1	22.4
Pioneering sp.	3	11.6
IBI	31	

Site 17: Smoky Creek

Species	*1996 S	1996 F	1978	1969
Campostoma anomalum	9	133	61	16
Luxilus chrysocephalus	18	26	0	0
C. anomalum X L. chrysocepahlus	0	2	0	0
Lythrurus fasciolaris	52	23	0	7
Notropis rubellus	0	0	4	0
Notropis stramineus	3	89	26	150
Semotilus atromaculatus	4	4	3	2
Catostomus commersoni	2	1	0	0
Hypentelium nigricans	6	83	15	4
Moxostoma duquesnei	1	3	0	0
Moxostoma erythrurum	0	1	0	3
Ameiurus natalis	0	0	2	0
Ambloplites rupestris	5	14	1	1
Lepomis macrochirus	0	3	0	0
Lepomis megalotis	4	6	1	5
Micropterus dolomieu	3	8	3	0
Micropterus punctulatus	0	0	6	1
Etheostoma baileyi	0	21	2	10
Etheostoma blennioides	4	13	8	6
Etheostoma caeruleum	23	436	40	90
Etheostoma camurum	0	2	1	0
Etheostoma cinereum	2	4	0	0
Percina caprodes	0	1	5	3
Percina maculata	0	3	0	5
Total:	136	876	178	303
Species Richness	14	20	15	14
Simpson Diversity	0.80	0.71	0.80	0.66

Appendix 3. (continued)
Site 17, continued.

Metric	Score				Value			
	*1996S	1996F	1978	1969	1996S	1996F	1978	1969
CPUE	1	5	3	5	4.1	42.9	25.7	NA
Number								
Native species	1	5	3	3	14	19	15	14
Darter species	1	5	3	3	3	7	5	5
Intolerant species	3	5	3	1	2	4	2	1
Percent								
Simple spawners	5	1	1	5	43.4	12.7	13.5	52.8
Generalist Feeder	3	5	5	1	22.8	14.8	18.0	51.8
Benthic invertivore	5	5	5	5	64.0	67.0	42.1	41.3
Catostomidae	3	5	1	1	5.1	10.0	2.3	2.3
Smallmouth Bass & Rockbass	5	5	3	1	5.9	2.5	2.2	0.3
Creek Chub	0	0	0	0	2.9	0.5	1.7	0.7
Pioneering sp.	3	5	5	5	13.2	3.0	0.0	0.0
IBI	30	46	32	30				

* Diversity, richness, and IBI underestimated in June 1996 due to uneffective sampling at high flow

Site 18: Smoky Creek

Species	1996	1978
Campostoma anomalum	152	26
Luxilus chrysocephalus	35	0
Lythrurus fasciolaris	54	0
Notropis rubellus	0	2
Notropis stramineus	53	9
Hypentelium nigricans	24	3
Moxostoma duquesnei	2	0
Ameiurus natalis	0	2
Ambloplites rupestris	7	0
Lepomis macrochirus	4	0
Lepomis megalotis	2	0
Micropterus dolomieu	5	3
Micropterus punctulatus	2	4
Etheostoma baileyi	7	0
Etheostoma blennioides	11	2
Etheostoma caeruleum	52	17
Etheostoma camurum	14	5
Etheostoma cinereum	4	0
Etheostoma sanguifluum	18	0
Percina caprodes	1	1
Total	447	74
Species Richness	18	11
Species Diversity	0.83	0.81

Metric	Score 1996	Score 1978	Value 1996	Value 1978
CPUE	3		19.7	22.5
Number				
Native species	3		17	11
Darter species	5		7	4
Intolerant species	5		4	1
Percent				
Simple & lithophilus	3		18.1	8.1
Generalist Feeder	3		21.0	14.9
Benthic invertivore	3		29.8	37.8
Suckers	3		5.8	4.1
Smallmouth Bass & Rockbass	3		2.7	4.1
Creek Chub	0		0	0
Pioneering sp.	3		7.8	0.0
IBI	34	NA		

Appendix 3. (continued)

Site 19: Smoky Creek

Species	1996	1978	1977
Campostoma anomalum	61	13	41
Luxilus chrysocephalus	53	0	0
Lythrurus fasciolaris	4	0	0
Notropis rubellus	18	2	37
Notropis stramineus	17	2	50
Notropis volucellus	0	0	18
Semotilus atromaculatus	1	0	9
Catostomus commersoni	1	0	2
Hypentelium nigricans	59	4	26
Moxostoma duquesnei	1	1	10
Ameiurus natalis	3	0	3
Ictalurus punctatus	0	1	0
Ambloplites rupestris	8	0	5
Lepomis macrochirus	8	0	0
Lepomis megalotis	51	1	11
Micropterus dolomieu	8	0	0
Micropterus punctulatus	8	1	18
Etheostoma baileyi	3	2	5
Etheostoma blennioides	3	0	11
Etheostoma caeruleum	17	17	44
Etheostoma camurum	6	3	14
Etheostoma cinereum	13	0	0
Etheostoma sanguifluum	3	0	0
Percina caprodes	7	0	7
Percina maculata	6	0	7
Total	359	47	318
Species Richness	23	11	18
Species Diversity	0.89	0.91	0.79

Metric	Score 1996	Score 1978	Score 1977	Value 1996	Value 1978	Value 1977
CPUE	3		3	11.9	5.1	32.5
<u>Number</u>						
Native species	5		5	22	11	18
Darter species	5		3	8	3	6
Intolerant species	5		3	4	2	2
<u>Percent</u>						
Simple & lithophilus	5		5	24.8	14.9	25.8
Generalist Feeder	1		3	37.3	8.5	29.2
Benthic invertivore	3		5	32.9	48.9	39.0
Suckers	5		5	17.0	10.6	11.9
Smallmouth Bass & Rockbass	5		3	4.5	0.0	1.6
Creek Chub	0		0	0.3	0.0	2.8
Pioneering sp.	3		5	14.8	0.0	0.0
IBI	40	NA	40			

Appendix 3. (continued)

Site 20: Montgomery Fork

Species	1996	1978
Campostoma anomalum	38	0
Luxilus chrysocephalus	15	0
L. chrysocephalus X Semotilus atrom	1	0
Lythrurus fasciolaris	45	1
Notropis stramineus	4	12
Semotilus atromaculatus	56	9
Catostomus commersoni	2	0
Hypentelium nigricans	14	1
Ambloplites rupestris	4	0
Lepomis macrochirus	1	0
Micropterus punctulatus	1	0
Etheostoma caeruleum	14	1
Percina maculata	0	1
Total	195	25
Species Richness	11	6
Species Diversity	0.81	0.66

	Score		Value	
Metric	1996	1978	1996	1978
CPUE	1		6.6	3.8
Number				
Native species	1		10	6
Darter species	1		1	2
Intolerant species	1		0	0
Percent				
Simple & lithophilus	5		30.3	4.0
Generalist Feeder	1		40.5	84.0
Benthic invertivore	1		14.4	12.0
Suckers	3		7.2	4.0
Smallmouth Bass & Rockbass	3		2.1	0.0
Creek Chub	1		28.7	36.0
Pioneering sp.	3		7.7	0.0
IBI	21	NA		

Appendix 3. (continued)

Site 21: Montgomery Fork

Species	1996	1978
Campostoma anomalum	22	1
Luxilus chrysocephalus	10	0
Lythrurus fasciolaris	6	1
Notropis rubellus	4	0
Notropis stramineus	11	0
Semotilus atromaculatus	22	1
Catostomus commersoni	1	0
Hypentelium nigricans	9	1
Moxostoma erythrurum	1	0
Ambloplites rupestris	1	1
Lepomis megalotis	0	3
Micropterus dolomieu	1	0
Micropterus punctulatus	1	1
Etheostoma baileyi	3	0
Etheostoma blennioides	4	0
Etheostoma caeruleum	25	0
Etheostoma camurum	1	0
Total	122	9
Species Richness	16	7
Species Diversity	0.87	NA

Metric	Score 1996	Score 1978	Value 1996	Value 1978
CPUE	1		3.7	1.2
Number				
Native species	3		15	7
Darter species	1		4.0	0.0
Intolerant species	3		2	0
Percent				
Simple & lithophilus	3		16.4	22.2
Generalist Feeder	1		36.1	44.4
Benthic invertivore	3		35.2	8.2
Suckers	5		8.2	11.1
Smallmouth Bass & Rockbass	3		1.6	11.1
Creek Chub	1		18.0	11.1
Pioneering sp.	3		8.2	0.0
IBI	27	NA		

Appendix 3. (continued)

Site 22: Montgomery Fork

Species	1996	1977	1978
Campostoma anomalum	11	0	0
Luxilus chrysocephalus	14	0	0
Lythrurus fasciolaris	18	0	0
Notropis rubellus	2	0	0
Notropis stramineus	6	0	0
Semotilus atromaculatus	42	0	0
Hypentelium nigricans	1	1	0
Ambloplites rupestris	4	0	0
Lepomis megalotis	3	0	2
Micropterus punctulatus	0	0	2
Etheostma baileyi	1	0	0
Etheostoma blennioides	2	0	0
Etheostoma caeruleum	14	2	0
Etheostoma camurum	2	0	0
Total	120	3	4
Species Richness	13	2	2
Species diversity	0.82	NA	NA

Metric	Score	Value
CPUE	1	6.3
Number		
Native species	1	12
Darter species	1	4
Intolerant species	3	2
Percent		
Simple & lithophilus	3	17.5
Generalist Feeder	1	54.2
Benthic invertivore	1	16.7
Suckers	1	0.8
Smallmouth Bass & Rockbass	5	3.3
Creek Chub	1	35.0
Pioneering sp.	1	15.0
IBI	19	

Appendix 3. (continued)

Site 22B: New River

Species	1977
Campostoma anomalum	18
Lythrurus fasciolaris	6
Notropis rubellus	13
Notropis volucellus	1
Hypentelium nigricans	1
Moxostoma duquesnei	4
Ameiurus natalis	1
Ambloplites rupestris	1
Lepomis megalotis	8
Micropterus punctulatus	11
Etheostoma blennioides	1
Etheostoma caeruleum	20
Etheostoma camurum	43
Etheostoma sanguifluum	9
Percina caprodes	1
Total	138
Species Richness	15
Species Diversity	0.85

Metric	Score	Value
CPUE	1	1.7
<u>Number</u>		
Native species	3	15
Darter species	3	5
Intolerant species	3	2
<u>Percent</u>		
Simple & lithophilus	3	18.1
Generalist Feeder	5	6.5
Benthic invertivore	5	57.2
Suckers	3	3.6
Smallmouth Bass & Rockbass	1	0.7
Creek Chub	0	0.0
Pioneering sp.	5	0.0
IBI	32	

Appendix 3. (continued)

Site 23: Big Bull Creek

Species	1996
Campostoma anomalum	9
Luxilus chrysocephalus	74
Lythrurus fasciolaris	46
Notropis stramineus	2
Semotilus atromaculatus	13
Catostomus commersoni	3
Hypentelium nigricans	2
Moxostoma duquesnei	3
Ambloplites rupestris	5
Lepomis megalotis	1
Etheostoma baileyi	1
Etheostoma blennioides	7
Etheostoma camurum	5
Etheostoma caeruleum	3
Etheostoma cinereum	1
Percina maculata	1
Total	176
Species Richness	16
Species Diversity	0.75

Metric	Score	Value
CPUE	3	19.4
Number		
Native species	3	15
Darter species	3	6
Intolerant species	5	3
Percent		
Simple & lithophilus	5	29.0
Generalist Feeder	1	52.8
Benthic invertivore	1	13.1
Suckers	1	2.8
Smallmouth Bass & Rockbass	3	2.8
Creek Chub	3	7.4
Pioneering sp.	1	42.0
IBI	29	

Appendix 3. (continued)

Site 24: Stanley Creek, tributary to Buffalo Cr.

Species	1996	1969
Campostoma anomalum	96	3
Luxilus chrysocephalus	7	2
Lythrurus fasciolaris	0	20
Notropis stramineus	153	2
Semotilus atromaculatus	38	11
Catostomus commersoni	3	0
Hypentelium nigricans	0	1
Moxostoma erythrurum	2	0
Lepomis megalotis	4	0
Etheostoma baileyi	1	0
Etheostoma blennioides	4	0
Etheostoma caeruleum	20	9
Percina maculata	1	0
Total	329	48
Species Richness	11	7
Species Diversity	0.68	0.75

	Score		Value	
Metric	1996	1969	1996	1969
CPUE	3		30.9	NA
Number				
Native species	3		10	6
Darter species	5		4	1
Intolerant species	1		1	0
Percent				
Simple & lithophilus	1		0.6	43.8
Generalist Feeder	1		62.3	27.1
Benthic invertivore	1		8.5	25.0
Suckers	3		1.5	2.1
Smallmouth Bass & Rockbass	1		0.0	0.0
Creek Chub	3		11.6	22.9
Pioneering sp.	5		2.1	4.2
IBI	27	NA		

Appendix 3. (continued)

Site 25: Smith Creek

Species	1996	1969
Campostoma anomalum	26	7
Luxilus chrysocephalus	82	5
Lythrurus fasciolaris	7	10
Notropis stramineus	31	17
Semotilus atromaculatus	30	6
Catostomus commersoni	29	0
Hypentelium nigricans	3	2
Moxostoma erythrurum	0	0
Ambloplites rupestris	11	0
Lepomis megalotis	8	1
Etheostoma baileyi	1	0
Etheostoma blennioides	2	2
Etheostoma caeruleum	35	16
Percina maculata	1	0
Total	266	66
Species Richness	13	10
Species Diversity	0.84	0.84

	Score		Value	
Metric	1996	1969	1996	1969
CPUE	3		23.6	NA
Number				
Native species	3		12	9
Darter species	5		4	4
Intolerant species	3		1.0	1.0
Percent				
Simple & lithophilus	1		3.8	18.2
Generalist Feeder	1		67.7	43.9
Benthic invertivore	3		15.8	27.3
Suckers	1		1.1	3.0
Smallmouth Bass & Rockbass	5		4.1	0.0
Creek Chub	3		11.3	9.1
Pioneering sp.	1		30.8	7.6
IBI	29	NA		

Appendix 3. (continued)

Site 26: Buffalo Creek

Species	1996	1969
Campostoma anomalum	13	5
Luxilus chrysocephalus	32	0
Lythrurus fasciolaris	78	20
Notropis stramineus	4	21
Notropis volucellus	2	0
Semotilus atromaculatus	1	1
Catostomus commersoni	1	0
Hypentelium nigricans	1	2
Ameiurus natalis	4	0
Ambloplites rupestris	0	6
Lepomis cyanellus	10	0
L. cyanellus X Lepomis macrochirus	1	0
Lepomis gulosus	1	0
Lepomis macrochirus	5	0
Lepomis megalotis	6	7
Micropterus punctulatus	1	1
Micropterus salmoides	2	0
Etheostoma baileyi	0	1
Etheostoma blennioides	4	34
Etheostoma caeruleum	6	38
Percina caprodes	1	2
Percina maculata	0	1
Total	173	139
Species Richness	18	14
Species Diversity	0.75	0.89

Metric	Score 1996	Score 1969	Value 1996	Value 1969
CPUE	1	5	8.7	NA
Number				
Native species	3	1	15	14
Darter species	1	3	3	5
Intolerant species	1	1	0	1
Percent				
Simple & lithophilus	5	3	46.2	16.5
Generalist Feeder	1	3	38.7	20.9
Benthic invertivore	1	5	6.9	56.1
Suckers	1	1	0.6	1.4
Smallmouth Bass & Rockbass	1	5	0.0	4.3
Creek Chub	5	5	0.6	0.7
Pioneering sp.	1	5	26.0	0
IBI	21	37		

Appendix 3. (continued)

Site 26B: Buffalo Creek

Species	1977
Campostoma anomalum	243
Luxilus chrysocephalus	30
Lythrurus fasciolaris	6
Notropis stramineus	4
Semotilus atromaculatus	10
Catostomus commersoni	2
Hypentelium nigricans	74
Moxostoma duquesnei	4
Moxostoma erythrurum	2
Ambloplites rupestris	2
Lepomis megalotis	10
Micropterus punctulatus	10
Etheostoma blennioides	12
Etheostoma caeruleum	49
Percina caprodes	2
Percina maculata	1
Total	461
Species Richness	15
Species Diversity	0.68

Metric	Score	Value
CPUE	5	42.4
Number		
Native species	3	15
Darter species	1	4
Intolerant species	1	0
Percent		
Simple & lithophilus	3	19.1
Generalist Feeder	5	12.1
Benthic invertivore	3	31.2
Suckers	5	17.4
Smallmouth Bass & Rockbass	1	0.4
Creek Chub	0	2.2
Pioneering sp.	3	6.5
IBI	30	

Appendix 3. (continued)

Site 27: Rockhouse Fork

Species	1996
Campostoma anomalum	13
Luxilus chrysocephalus	94
Lythrurus fasciolaris	28
Notropis stramineus	5
Semotilus atromaculatus	70
Catostomus commersoni	1
Hypentelium nigricans	6
Lepomis cyanellus	4
Lepomis macrochirus	25
Lepomis megalotis	8
Etheostoma baileyi	1
Etheostoma blennioides	4
Etheostoma caeruleum	36
Percina maculata	12
Total	307
Species Richness	14
Species Diversity	0.82

Metric	Score	Value
CPUE	3	11.5
Number		
Native species	1	12
Darter species	1	4
Intolerant species	1	1
Percent		
Simple & lithophilus	1	11.1
Generalist Feeder	1	67.4
Benthic invertivore	1	19.2
Suckers	1	2.0
Smallmouth Bass & Rockbass	1	0
Creek Chub	1	22.8
Pioneering sp.	1	38.8
IBI	13	

Appendix 3. (continued)

Site 28: Buffalo Creek

Species	1996	1968
Campostoma anomalum	502	1
Cyprinella galactura	2	0
Luxilus chrysocephalus	2	0
Lythrurus fasciolaris	36	2
Notropis rubellus	30	0
Notropis stramineus	16	2
Notropis volucellus	27	0
Semotilus atromaculatus	1	1
Hypentelium nigricans	20	1
Moxostoma carinatum	1	0
Moxostoma duquesnei	0	2
Moxostoma erythrurum	0	1
Moxostoma macrolepidotum	1	0
Ameiurus natalis	3	0
Ambloplites rupestris	5	2
Lepomis cyanellus	4	0
Lepomis macrochirus	4	0
Lepomis megalotis	14	2
Micropterus dolomieu	1	0
Micropterus punctulatus	2	0
Etheostoma baileyi	3	0
Etheostoma blennioides	16	0
Etheostoma caeruleum	14	2
Percina maculata	1	0
Total	705	16
Species Richness	22	10
Species Diversity	0.48	NA

Metric	Metric	Value
CPUE	5	41.1
<u>Number</u>		
Native species	5	20
Darter species	1	4
Intolerant species	3	2
<u>Percent</u>		
Simple & lithophilus	1	12.5
Generalist Feeder	5	10.1
Benthic invertivore	1	7.5
Suckers	1	3.1
Smallmouth Bass & Rockbass	1	1.0
Creek Chub	0	0.1
Pioneering sp.	5	0.9
IBI	28	

Appendix 3. (continued)

Site 29: Straight Fork

Species	1996	1977
Semotilus atromaculatus	7	0
Lepomis cyanellus	3	0
Etheostoma blennioides	1	0
Lepomis macrochirus	1	0
Total	12	0
Species Richness	4	0

Site 29B: Buffalo creek

Species	1977
Campostoma anomalum	1
Cyprinella galactura	1
Lythrurus fasciolaris	6
Notropis rubellus	1
Notropis stramineus	2
Semotilus atromaculatus	2
Catostomus commersoni	3
Hypentelium nigricans	1
Micropterus punctulatus	18
Total	35
Species Richness	9
Species diversity	0.71

Site 29C: New River

Species	1977
Campostoma anomalum	11
Cyprinella galactura	1
Cyprinus carpio	1
Lythrurus fasciolaris	6
Notropis rubellus	34
Notropis stramineus	14
Hypentelium nigricans	3
Lepomis macrochirus	1
Lepomis megalatois	5
Micropterus punctulatus	3
Etheostoma caeruleum	7
Etheostoma camurum	3
Etheostoma sanguifluum	1
Percina maculata	4
Total	94
Species Richness	14
Species Diversity	0.82

Appendix 3. (continued)

Site 30: Stanley Creek, tributary to Paint Rock Creek

Species	1996
Campostoma anomalum	24
Luxilus chrysocephalus	42
Lythrurus fasciolaris	5
Notropis stramineus	20
Semotilus atromaculatus	65
Catostomus commersoni	4
Hypentelium nigricans	5
Ameiurus natalis	1
Lepomis megalotis	22
Micropterus punctulatus	1
Micropterus salmoides	1
Etheostoma blennioides	11
Etheostoma caeruleum	12
Total	213
Species Richness	13
Species Diversity	0.83

Metric	Score	Value
CPUE	3	*32.3
Number		
Native species	3	12
Darter species	3	2
Intolerant species	1	0
Percent		
Simple & lithophilus	1	2.3
Generalist Feeder	1	72.3
Benthic invertivore	3	13.1
Suckers	3	2.3
Smallmouth Bass & Rockbass	1	0.0
Creek Chub	1	30.5
Pioneering sp.	1	19.7
IBI	21	

Appendix 3. (continued)

Site 31: Paint Rock Creek

Species	1996	1977	1968
Campostoma anomalum	259	249	1
Luxilus chrysocephalus	43	0	0
L. chrysocephalus X L. fasciolaris	1	0	0
Lythrurus fasciolaris	181	28	13
Notropis rubellus	4	0	0
Notropis stramineus	129	115	2
Notropis telescopus	1	0	0
Semotilus atromaculatus	29	45	4
Catostomus commersoni	16	1	0
Hypentelium nigricans	45	21	3
Moxostoma duquesnei	0	2	0
Moxostoma erythrurum	1	0	0
Ambloplites rupestris	9	11	0
Lepomis cyanellus	1	0	0
Lepomis macrochirus	9	1	0
Lepomis megalotis	41	21	0
Micropterus punctulatus	7	0	0
Micropterus salmoides	1	0	0
Etheostoma baileyi	5	1	0
Etheostoma blennioides	32	47	2
Etheostoma caeruleum	45	89	21
Etheostoma camurum	6	13	0
Etheostoma cinereum	1	0	0
Percina caprodes	1	1	0
Percina maculata	9	1	0
Total	876	646	46
Species Richness	22	16	9
Species Diversity	0.84	0.79	0.71

Metric	Score 1996	Score 1977	Score 1968	Value 1996	Value 1977	Value 1968
CPUE	5	5		46.1	59.9	NA
Number						
Native species	5	3		21	16	9
Darter species	5	3		7	6	2
Intolerant species	5	3		3	2	0
Percent						
Simple & lithophilus	5	1		28.0	8.2	34.8
Generalist Feeder	3	3		30.7	28.3	13
Benthic invertivore	1	3		16.6	27.1	50
Suckers	3	3		5.3	3.6	6.5
Smallmouth Bass & Rockbass	1	3		1.0	1.7	0
Creek Chub	5	3		3.3	7.0	8.7
Pioneering sp.	5	5		5.1	0.0	0.0
IBI	43	35	NA			

Appendix 3. (continued)

Site 32: Paint Rock Creek

Species	1996
Campostoma anomalum	7
Cyprinella galactura	1
Luxilus chrysocephalus	9
Lythrurus fasciolaris	172
Nocomis micropogon	4
Notropis rubellus	293
Notropis stramineus	43
Notropis volucellus	16
Hypentelium nigricans	10
Moxostoma erythrurum	1
Lepomis cyanellus	1
Lepomis megalotis	10
Etheostoma baileyi	6
Etheostoma blennioides	14
Etheostoma caeruleum	10
Etheostoma camurum	2
Etheostoma cinereum	6
Etheostoma sanguifluum	5
Total	605
Species Richness	18
Species Diversity	0.68

Metric	Score	Value
CPUE	5	45.9
Number		
Native species	3	17
Darter species	3	6.0
Intolerant species	5	4
Percent		
Simple & lithophilus	5	78.8
Generalist Feeder	5	13.7
Benthic invertivore	1	8.9
Suckers	1	1.8
Smallmouth Bass & Rockbass	1	0
Creek Chub	5	0
Pioneering sp.	5	3.1
IBI	39	

Appendix 3. (continued)

Site 33: Phillips Branch

Species	1996
Campostoma anomalum	10
Cyprinella galactura	18
Luxilus chrysocephalus	19
Lythrurus fasciolaris	58
Nocomis micropogon	6
Notropis rubellus	136
Notropis stramineus	48
Semotilus atromaculatus	52
Hypentelium nigricans	6
Catostomus commersoni	1
Lepomis macrochirus	1
Lepomis megalotis	3
Micropterus punctulatus	1
Etheostoma baileyi	1
Etheostoma blennioides	1
Etheostoma caeruleum	14
Etheostoma camurum	2
Etheostoma cinereum	5
Percina maculata	3
Total	385
Species Richness	19
Species Diversity	0.81

Metric	Score	Value
CPUE	5	64.0
Number		
Native species	5	18
Darter species	5	6.0
Intolerant species	5	4
Percent		
Simple & lithophilus	5	56.6
Generalist Feeder	3	31.9
Benthic invertivore	1	6.0
Suckers	1	1.6
Smallmouth Bass & Rockbass	1	0.0
Creek Chub	3	13.5
Pioneering sp.	5	4.9
IBI	39	

Appendix 3. (continued)

Site 33B: New River

Species	1968
Campostoma anomalum	3
Cyprinella galactura	1
Lythrurus fasciolaris	166
Nocomis micropogon	1
Notropis rubellus	14
Notropis stramineus	2
Notropis volucellus	15
Semotilus atromaculatus	1
Hypentelium nigricans	1
Lepomis megalotis	12
Micropterus punctulatus	4
Etheostoma blennioides	3
Etheostoma caeruleum	10
Percina maculata	3
Total	236
Species Richness	14
Species Diversity	0.49

Metric	Score	Value
CPUE	5	NA
Number		
Native species	1	14
Darter species	1	3
Intolerant species	1	0
Percent		
Simple & lithophilus	5	76.7
Generalist Feeder	5	5.9
Benthic invertivore	1	7.6
Suckers	1	0.4
Smallmouth Bass & Rockbass	1	0.0
Creek Chub	0	0.0
Pioneering sp.	5	0.0
IBI	26	

Appendix 3. (continued)

Site 34: Brimstone Creek

Species	1996
Campostoma anomalum	30
Lythrurus fasciolaris	194
Notropis stramineus	50
Semotilus atromaculatus	179
Catostomus commersoni	3
Hypentelium nigricans	11
Moxostoma sp.	2
Ambloplites rupestris	8
Lepomis megalotis	4
Micropterus dolomieu	1
Micropterus punctulatus	3
Etheostoma baileyi	5
Etheostoma blennioides	16
Etheostoma caeruleum	24
Percina maculata	1
Total	531
Species Richness	15
Species Diversity	0.74

Metric	Score	Value
CPUE	3	20.5
Number		
Native species	3	15
Darter species	1	4
Intolerant species	1	1
Percent		
Simple & lithophilus	5	39.0
Generalist Feeder	1	44.4
Benthic invertivore	1	11.1
Suckers	1	2.4
Smallmouth Bass & Rockbass	3	1.7
Creek Chub	1	33.7
Pioneering sp.	5	0
IBI	25	

Appendix 3. (continued)

Site 35: Mill Creek

Species	1996	1977
Campostoma anomalum	73	304
Lythrurus fasciolaris	7	148
Notropis stramineus	32	878
Notropis volucellus	0	23
Semotilus atromaculatus	10	339
Catostomus commersoni	0	12
Hypentelium nigricans	15	6
Moxostoma erythrurum	1	0
Ambloplites rupestris	2	20
Lepomis macrochirus	1	0
Lepomis megalotis	12	1
Micropterus dolomieu	3	0
Etheostoma baileyi	6	0
Etheostoma blennioides	16	1
Etheostoma caeruleum	14	4
Percina maculata	3	1
Total	195	1737
Species Richness	14	13
Species Diversity	0.81	0.67

	Score		Value	
Metric	1996	1977	1996	1977
CPUE	3	5	12.4	368.1
Number				
Native species	1	1	14	13
Darter species	1	1	4	4
Intolerant species	1	0	1	0
Percent				
Simple & lithophilus	1	1	11.8	9.6
Generalist Feeder	3	1	28.2	72.1
Benthic invertivore	1	1	20	0.3
Suckers	5	1	8.2	0.3
Smallmouth Bass & Rockbass	3	1	2.6	1.2
Creek Chub	5	1	5.1	19.5
Pioneering sp.	5	5	0.0	0.0
IBI	31	19		

Appendix 3. (continued)

Site 36: Brimstone Creek

Species	1996
Campostoma anomalum	86
Lythrurus fasciolaris	57
Notropis stramineus	22
Semotilus atromaculatus	8
Catostomus commersoni	1
Hypentelium nigricans	18
Moxostoma duquesnei	2
Moxostoma erythrurum	1
Ambloplites rupestris	4
Lepomis cyanellus	1
Lepomis megalotis	11
Etheostoma baileyi	1
Etheostoma blennioides	32
Etheostoma caeruleum	92
Etheostoma camurum	1
Percina caprodes	2
Percina maculata	4
Total	343
Species Richness	17

Metric	Score	Value
CPUE	3	11.7
Number		
Native species	3	17
Darter species	3	6
Intolerant species	3	2
Percent		
Simple & lithophilus	5	23.3
Generalist Feeder	5	12.5
Benthic invertivore	5	44.6
Suckers	3	6.1
Smallmouth Bass & Rockbass	1	1.2
Creek Chub	0	2.3
Pioneering sp.	5	0.3
IBI	36	
Species Richness	17	
Species Diversity	0.82	

Site 37: Indian Fork, tributary to Brimstone Creek.

Species	1996
Campostoma anomalum	26
Semotilus atromaculatus	79
Hypentelium nigricans	7
Micropterus punctulatus	1
Etheostoma blennioides	3
Etheostoma caeruleum	12
Total	128
Species Richness	6
Species Diversity	0.57

Appendix 3. (continued)

Site 37, continued

Metric	Score	Value
CPUE	3	27.0
Number		
Native species	1	6
Darter species	3	2
Intolerant species	1	0
Percent		
Simple & lithophilus	3	5.5
Generalist Feeder	1	61.7
Benthic invertivore	3	11.7
Suckers	5	5.5
Smallmouth Bass & Rockbass	1	0
Creek Chub	1	61.7
Pioneering sp.	5	0
IBI	27	

Site 38: Brimstone Creek

Species	1996
Campostoma anomalum	270
Luxilus chrysocephalus	15
Notropis rubellus	3
Notropis stramineus	32
Lythrurus fasciolaris	10
Semotilus atromaculatus	3
Hypentelium nigricans	14
Moxostoma duquesnei	1
Noturus exilis	1
Ambloplites rupestris	4
Lepomis megalotis	21
Micropterus dolomieu	1
Micropterus punctulatus	3
Etheostoma baileyi	6
Etheostoma blennioides	23
Etheostoma caeruleum	63
Etheostoma camurum	15
Etheostoma cinereum	1
Etheostoma sanguifluum	2
Percina caprodes	3
Percina maculata	6
Total	497
Species Richness	21
Species Diversity	0.68

Appendix 3. (continued)

Site 38, continued

Metric	Score	Value
CPUE	3	11.9
Number		
Native species	5	20
Darter species	5	8
Intolerant species	5	5
Percent		
Simple & lithophilus	1	6.0
Generalist Feeder	5	14.5
Benthic invertivore	3	27.0
Suckers	1	3.0
Smallmouth Bass & Rockbass	1	1.0
Creek Chub	0	0.6
Pioneering sp.	5	3.0
IBI	34	

Site 39: Brimstone Creek

Species	1996	1977	1968
Campostoma anomalum	27	8	11
Cyprinella galactura	2	2	0
Luxilus chrysocephalus	67	0	0
Lythrurus fasciolaris	18	50	7
Nocomis micropogon	0	0	1
Notemigonus crysoleucas	0	1	0
Notropis rubellus	20	98	0
Notropis stramineus	4	25	18
Notropis volucellus	8	15	0
Semotilus atromaculatus	2	6	11
Catostomus commersoni	0	2	0
Hypentelium nigricans	23	24	4
Moxostoma duquesnei	0	1	1
Moxostoma erythrurum	0	0	8
Ambloplites rupestris	1	4	0
Lepomis macrochirus	0	0	1
Lepomis megalotis	26	24	1
Micropterus punctulatus	1	17	7
Etheostoma baileyi	3	2	0
Etheostoma blennioides	8	3	6
Etheostoma caeruleum	9	32	65
Etheostoma camurum	8	3	0
Etheostoma cinereum	6	0	0
Percina caprodes	2	6	7
Percina maculata	1	6	22
Total	236	329	170
Species Richness	19	20	15
Species Diversity	0.87	0.86	0.84

Site 39, continued

Metric	Score 1996	Score 1977	Score 1968	Value 1996	Value 1977	Value 1968
CPUE	1	3	5	9.5	34.1	NA
Number						
Native species	5	5	3	18	20	15
Darter species	5	3	1	7	6	4
Intolerant species	3	3	1	3	2	0
Percent						
Simple & lithophilus	5	5	1	26.7	54.4	11.2
Generalist Feeder	1	3	3	45.3	22.2	17.6
Benthic invertivore	3	3	5	25.4	23.4	58.8
Suckers	5	3	1	9.7	7.6	2.9
Smallmouth Bass & Rockbass	1	1	1	0.4	1.2	0.0
Creek Chub	0	0	0	0.8	1.8	6.5
Pioneering sp.	1	5	5	28.4	0.3	0.0
IBI	30	34	26			

Site 40: Phillips Creek

Species	1996
Campostoma anomalum	91
Cyprinella galactura	49
Luxilus chrysocephalus	1
Lythrurus fasciolaris	5
Nocomis micropogon	1
Notropis rubellus	142
Notropis stramineus	10
Noropis volucellus	1
Semotilus atromaculatus	1
Hypentelium nigricans	7
Ambloplites rupestris	2
Lepomis cyanellus	1
Lepomis macrochirus	10
Lepomis microlophus	1
Micropterus punctulatus	1
Etheostoma blennioides	3
Etheostoma camurum	4
Etheostoma caeruleum	2
Etheostoma cinereum	7
Etheostoma sanguifluum	2
Percina maculata	1
Total	342
Species Richness	21
Species Diversity	0.74

Site 40, continued

Metric	Score	Value
CPUE	5	22.1
Number		
Native species	5	18
Darter species	3	6
Intolerant species	5	3
Percent		
Simple & lithophilus	5	43.6
Generalist Feeder	5	7.0
Benthic invertivore	1	6.7
Suckers	1	2.0
Smallmouth Bass & Rockbass	1	0.6
Creek Chub	5	0.0
Pioneering sp.	5	0.3
IBI	41	

Site 41: New River

Species	1996	1977
Campostoma anomalum	31	57
Cyprinella galactura	19	0
Lythrurus fasciolaris	4	3
Nocomis micropogon	9	0
Notropis rubellus	46	0
Notropis volucellus	25	0
Hypentelium nigricans	5	8
Moxostoma duquesnei	1	4
Moxostoma erythrurum	0	1
Ictalurus punctatus	0	1
Ambloplites rupestris	5	2
Lepomis macrochirus	2	10
L. macrochirus X Lepomis megalotis	0	1
Lepomis megalotis	5	10
Micropterus dolomieu	1	0
Micropterus punctulatus	1	12
Micropterus salmoides	0	1
Etheostoma blennioides	15	3
Etheostoma caeruleum	2	2
Etheostoma camurum	27	55
Etheostoma cinereum	3	0
Etheostoma sanguifluum	23	0
Percina maculata	1	0
Total species	225	170
Species Richness	19	14
Species Diversity	0.89	0.77

Appendix 3. (continued)

Site 41, continued

Metric	Score 1996	Score 1977	Value 1996	Value 1977
CPUE	1	1	3.0	1.8
Number				
Native species	5	1	19	14
Darter species	3	1	6	3
Intolerant species	5	1	3	1
Percent				
Simple & lithophilus	5	1	31.6	7.6
Generalist Feeder	5	5	14.2	12.9
Benthic invertivore	5	5	38.2	42.9
Suckers	1	5	2.7	7.6
Smallmouth Bass & Rockbass	3	1	2.7	1.2
Creek Chub	0	0	0	0
Pioneering sp.	5	5	0	0
IBI	38	26		

Site 42: New River

Species	1997
Campostoma anomalum	10
Cyprinella galactura	102
Cyprinus carpio	1
Lythrurus fasciolaris	8
Nocomis micropogon	3
Notropis rubellus	204
Notropis stramineus	39
Notropis volucellus	341
Hypentelium nigricans	19
Moxostoma carinatum	18
Moxostoma duquesnei	60
Moxostoma erythrurum	41
Moxostoma macrolepidotum	14
Ictalurus punctatus	4
Pylodictis olivaris	1
Ambloplites rupestris	52
Lepomis cyanellus	3
Lepomis macrochirus	5
Lepomis megalotis	39
Micropterus dolomieu	53
Micropterus punctulatus	18
Etheostoma baileyi	2
Etheostoma blennioides	49
Etheostoma caeruleum	6
Etheostoma camurum	138
Etheostoma cinereum	7
Etheostoma sanguifluum	63
Stizostedion vitreum	6
Total	1306
Species Richness	28
Species Diversity	0.88

Site 42, continued.

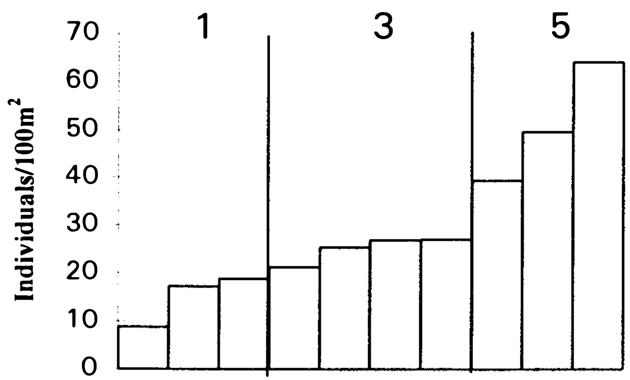
Metric	Score	Value
CPUE	5	NA
Number		
Native species	5	26
Darter species	3	6
Intolerant species	5	5
Percent		
Simple & lithophilus	5	27.9
Generalist Feeder	5	7.0
Benthic invertivore	5	76.9
Suckers	5	11.6
Smallmouth Bass & Rockbass	5	10.0
Pioneering sp.	5	0.3
IBI	48	

APPENDIX 4

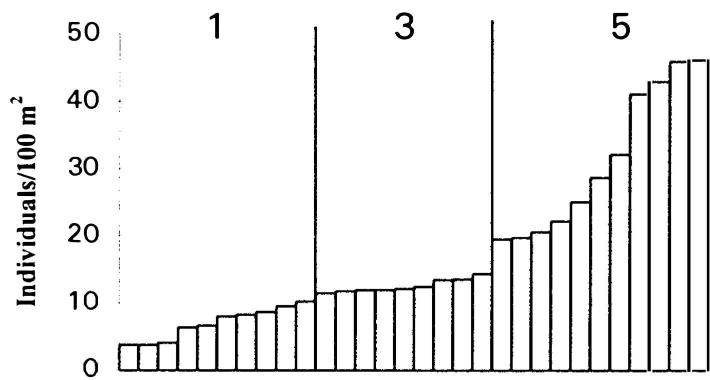
Appendix 4. Distribution and scoring of metric values. Number of sites (N) = 14 2nd and 3rd order streams and 42 4th and 5th order streams. Sample size smaller for CPUE, % creek chub, and % pioneering species.

2nd and 3rd Order Streams | 4th and 5th Order Streams

CPUE 1996 (Single Pass)

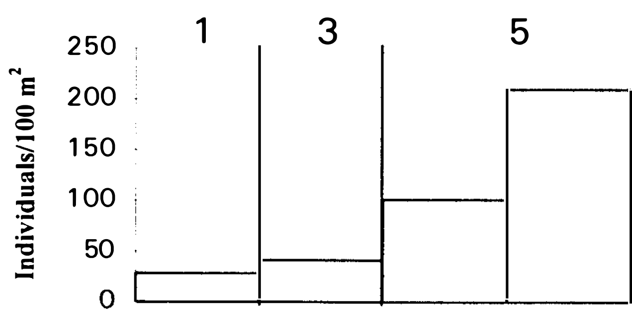


N = 10

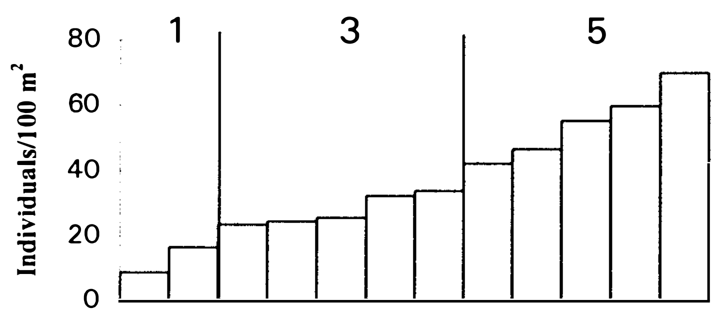


N = 30

CPUE 1977-78 (3 Pass)

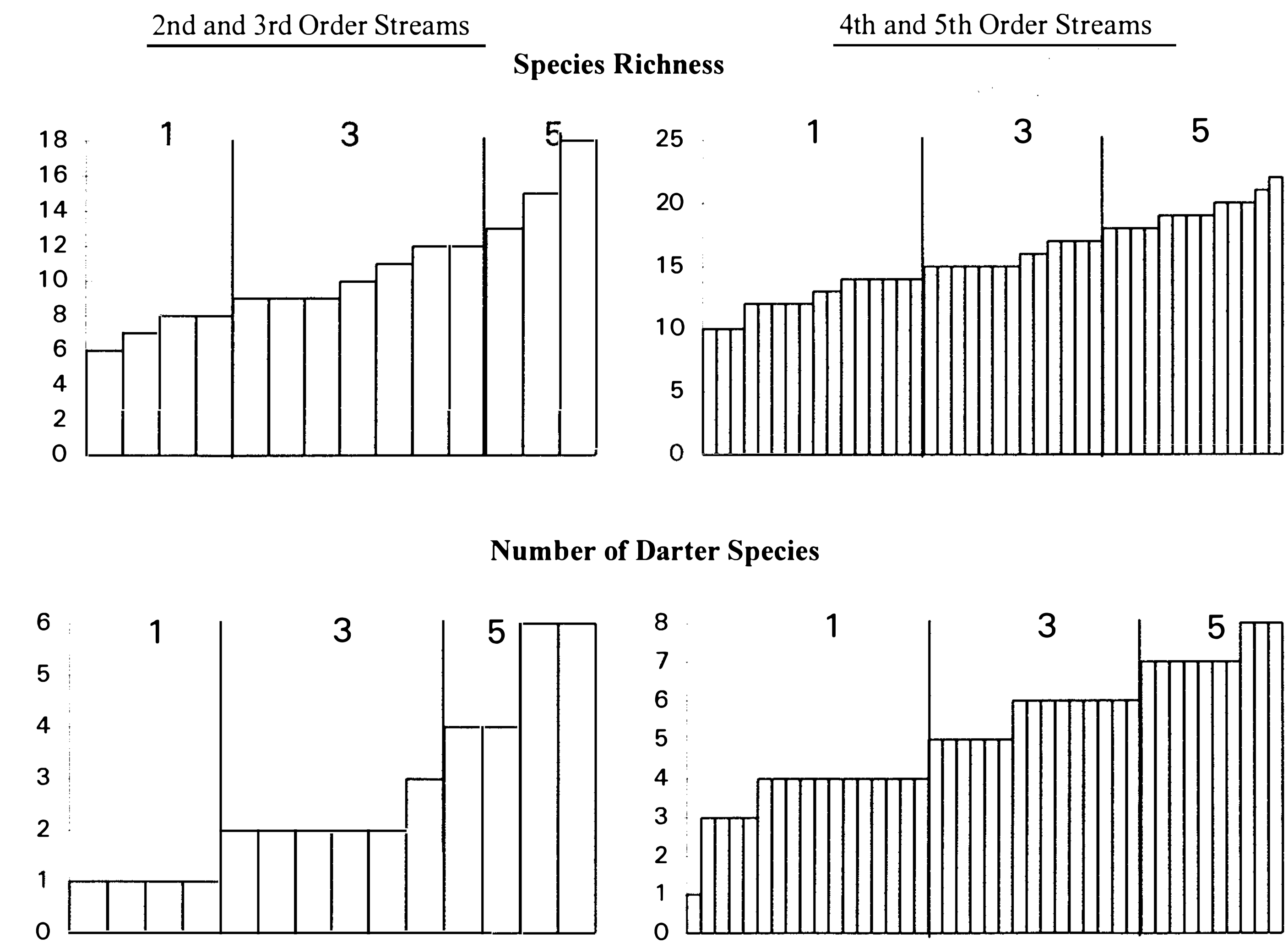


N = 4



N = 12

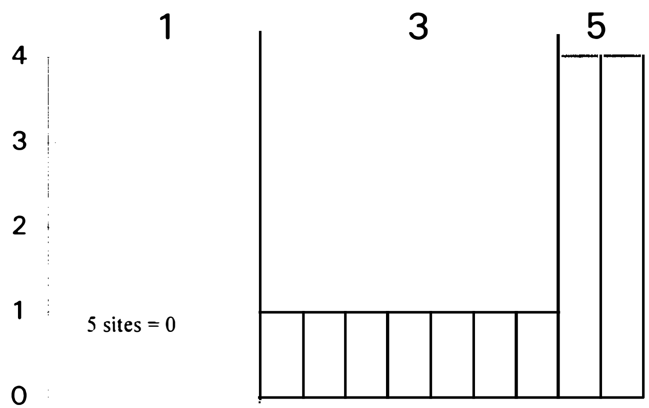
Appendix 4. (continued)

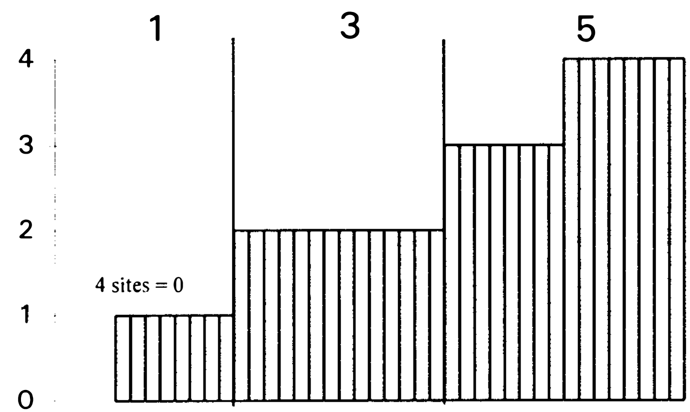


Appendix 4. (continued)

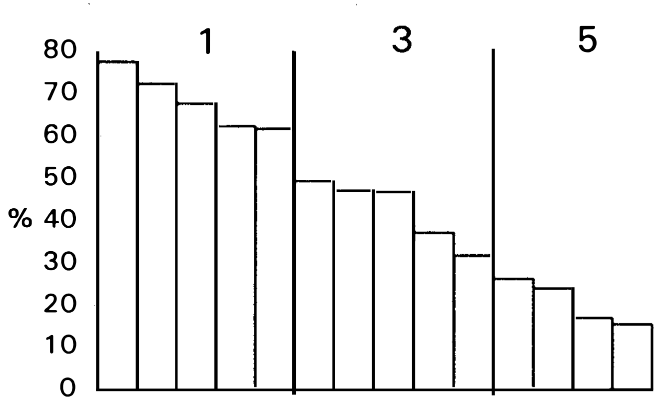
2nd and 3rd Order Streams | 4th and 5th Order Streams

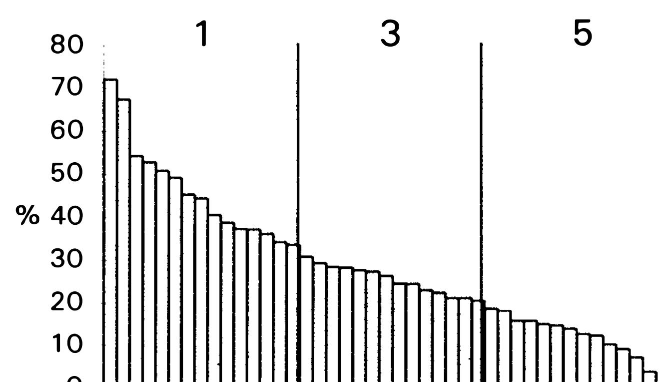
Number of Sensitive Species





Generalist Feeders



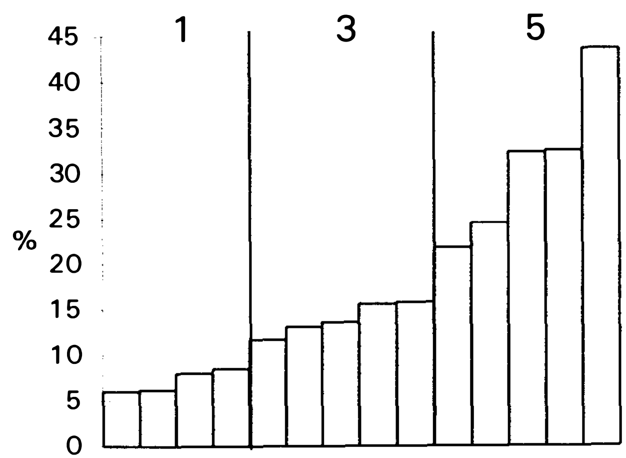


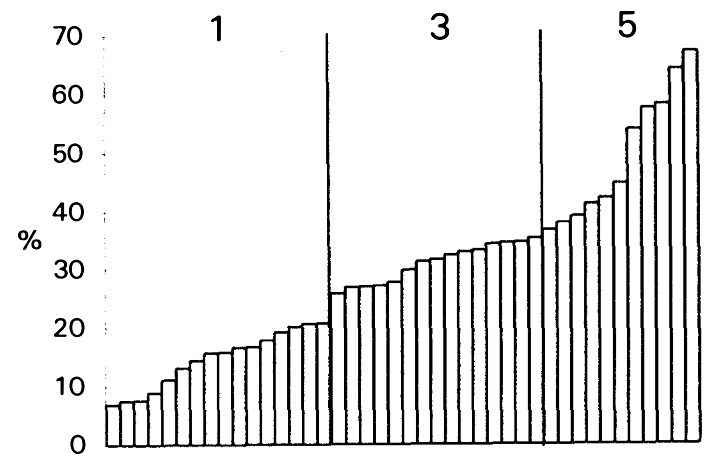
Appendix 4. (continued)

2nd and 3rd Order Streams

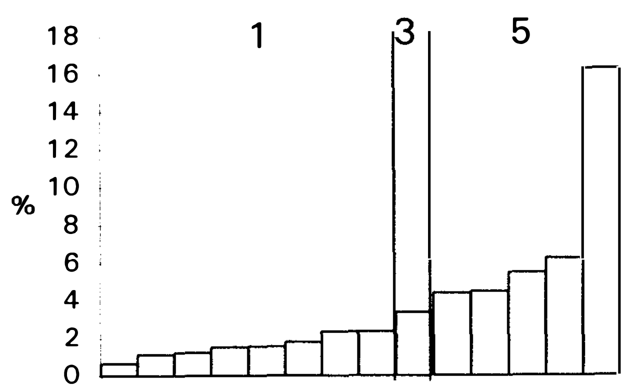
4th and 5th Order Streams

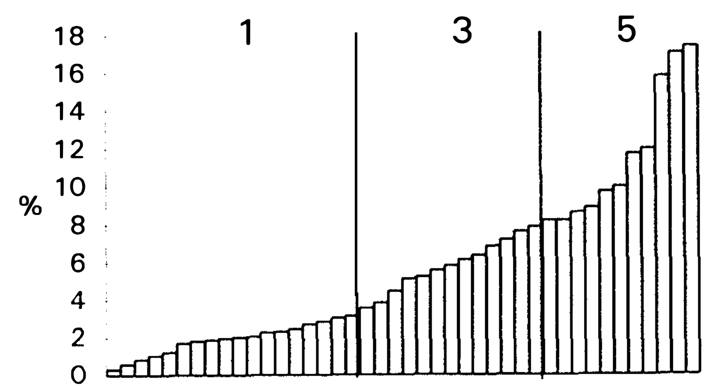
Benthic Invertivores





Suckers

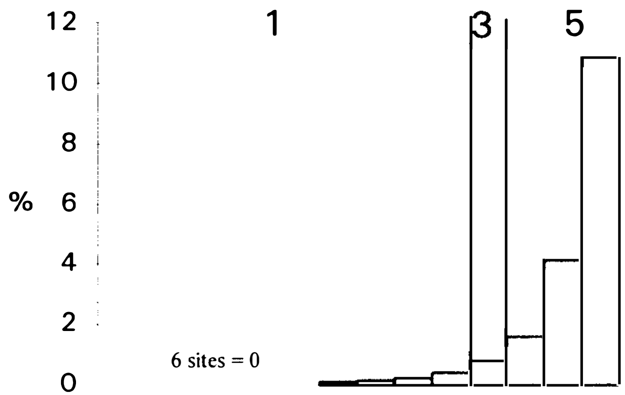


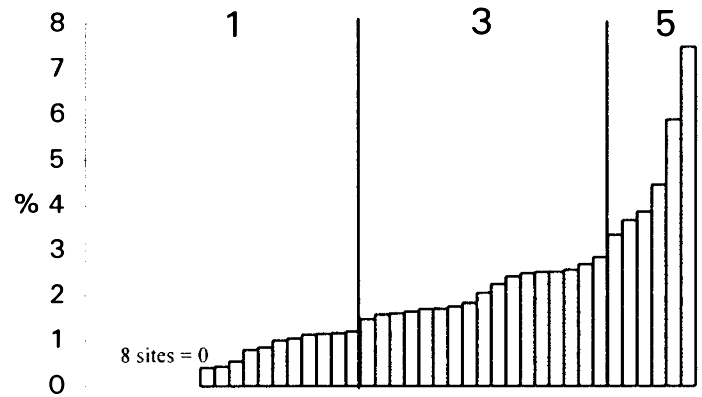


Appendix 4. (continued)

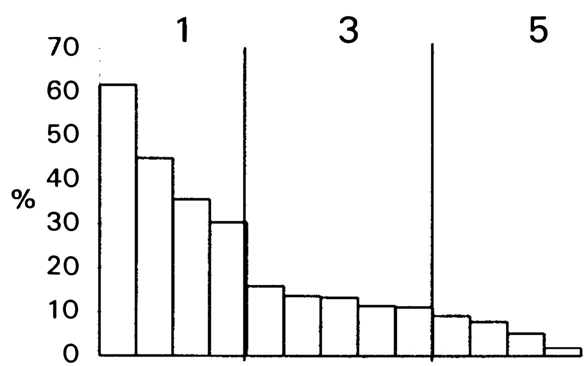
2nd and 3rd Order Streams 4th and 5th Order Streams

Rockbass & Smallmouth bass



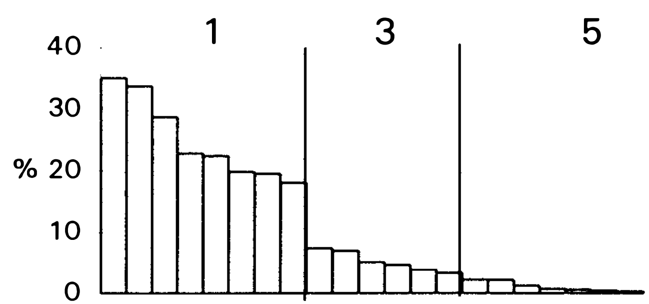


Creek Chubs



N = 14

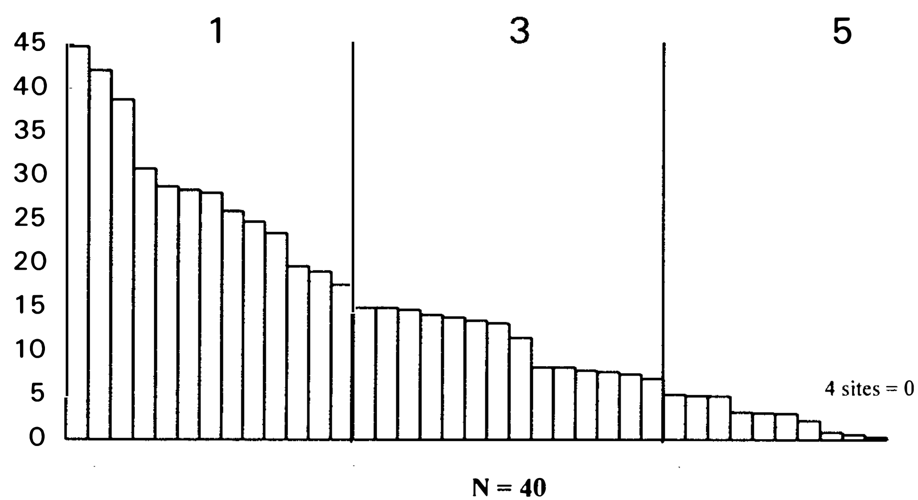
4th Order sites exclusive of main channel



N = 23

Appendix 4. (continued)

Pioneering species, 1996 (excludes 6th order streams)



APPENDIX 5

Appendix 5. Site size components (in meters) for streams sampled 1977-78 and 1996. Sixth order streams excluded.

1996

Site	Order	Mean Width	Length	Area (m^2)	Length/ Width
1	3	8.7	200.0	1740.0	23.0
2	2	3.0	120.0	720.0	40.0
7	3	6.1	293.0	1786.1	48.0
9	3	5.5	116.0	636.4	21.1
13	3	10.3	183.0	1883.7	17.8
24	2	5.3	183.0	1066.0	34.5
25	3	5.9	120.0	1125.2	20.2
30	3	5.5	110.0	660.0	20.0
33	3	3.0	193.0	601.5	63.7
37	3	3.2	148.0	473.6	46.3
Mean	NA	5.7	166.6	1069.3	33.5
Med.	NA	5.5	165.5	893.0	28.8

Third order, 1977 - 78

Site	Mean Width	Length	Area (m^2)	Length/ Width
1	7.1	87.2	619.1	12.3
5C	6.0	67.2	403.2	11.2
9	3.4	45.0	153.0	13.2
10B	6.0	65.0	390.0	10.8
Mean	5.6	66.1	391.3	11.9
Med.	6.0	66.1	396.6	11.7

Fourth order, 1996

Site	Mean Width	Length	Area (m^2)	Length/ Width
3	10.0	185.0	1757.0	18.5
4	9.5	236.8	2249.9	24.9
5	13.0	200.0	2600.0	15.4
8	16.8	286.0	4811.9	17.0
10	8.0	200.0	1600.0	25.0
11f	6.2	252.3	1561.5	40.8
11s	10.7	302.0	3230.9	28.2
14	8.9	258.0	2300.2	28.9
16	5.0	200.0	1000.0	40.0
20	8.9	333.0	2971.8	37.3
21	10.9	299.0	3267.7	27.4
22	8.3	229.0	1905.5	27.5
23	8.2	110.0	905.3	13.4
26	10.0	200.0	1087.8	20.0
27	7.6	354.0	2680.3	46.8
31	9.5	200.0	1900.0	21.1
32	8.6	153.0	1318.9	17.7
34	8.0	325.0	2586.5	40.8
35	6.5	242.0	1573.0	37.2
40	6.9	260.0	1545.8	37.7
Mean	9.1	241.3	2142.7	28.3
Med.	8.8	239.4	1902.8	27.4

Fourth order, 1977 - 78

Site	Mean Width	Length	Area (m^2)	Length/ Width
8	9.2	88.0	809.6	9.6
11s	8.2	112.0	918.4	13.7
11f	6.2	106.5	660.3	17.2
14	10.3	106.0	1091.8	10.3
26B	9.8	111.0	1087.8	11.3
31	9.8	110.0	1078.0	11.2
35	3.9	121.0	471.9	31.0
Mean	8.2	107.8	874.0	14.9
Median	9.2	110.0	918.4	11.3

Appendix 5. (Continued)

Fifth order, 1996

Site	Mean Width	Length	Area (m^2)	Length/ Width
12	9.6	274.0	2633.5	28.5
15	25.8	269.0	6940.2	10.4
17f	6.7	306.1	2036.9	46.0
17s	10.8	308.0	3340.0	28.4
18	8.9	254.0	2271.9	28.4
19	11.0	274.0	3020.5	24.9
28	11.8	145.5	1716.9	12.3
36	12.0	243.5	2924.4	20.3
38	10.8	387.0	4160.3	36.0
39	8.3	299.0	2481.7	36.0
Mean	11.6	276.0	3152.6	27.1
Med.	10.8	274.0	2779.0	28.4

Fifth order, 1977 - 78

Site	Mean Width	Length	Area (m^2)	Length/ Width
12	8.9	79.0	703.1	8.9
15	20.1	116.0	2331.6	5.8
17	7.7	90.0	693.0	11.7
19	8.9	110.0	913.0	12.4
39	10.5	92.0	966.0	8.8
Mean	11.2	97.4	1121.3	9.5
Med.	8.9	92.0	913.0	8.9

APPENDIX 6

Appendix 6. Individual, mean, and median, IBI, metric and diversity values for all samples consisting of > 100 fish.

2nd and 3rd order streams 1996

		Number of Species			Percent of Assemblage								
		Indicator Taxa			Reprod. Guild	Feeding Guild		Indicator Taxa					
Site	CPUE	Native	Darter	Intolerant	Lithophilus	Generalist	Invertivore	Suckers	Sm. & Rckbs	Cr. Chubs	Pioneering	IBI	Divers.
1	49.6	9	2	0	3.3	37.3	21.8	3.4	0.1	9.3	24.8	31	0.73
2	18.8	7	1	0	2.4	47.2	24.5	2.4	0.2	16.0	28.1	23	0.77
7	26.9	13	3	1	6.5	49.4	15.6	6.3	0.4	13.8	28.8	33	0.77
9	39.3	15	6	4	14.8	26.4	43.6	4.4	1.6	8.0	17.6	49	0.84
13	8.8	11	2	1	15.3	24.1	32.5	16.3	10.8	0.0	23.5	41	0.83
24	17.2	10	4	1	0.6	62.3	8.5	1.5	0.0	11.6	2.1	27	0.68
25	21.2	12	4	1	3.8	67.7	15.8	1.1	4.1	11.3	30.8	29	0.84
30	25.4	12	2	0	2.3	72.3	13.1	2.3	0.0	30.5	19.7	21	0.83
33	64.0	18	6	4	76.7	31.9	6.0	1.6	0.0	13.5	4.9	39	0.81
37	27.0	6	2	0	5.5	61.7	11.7	5.5	0.0	61.7	0.0	27	0.57
Mean	29.8	11.3	3.2	1.2	13.1	48.0	19.3	4.5	1.7	17.6	18.0	32.0	0.77
Median	26.1	11.5	2.5	1.0	4.6	48.3	15.7	2.9	0.2	12.5	21.6	30.0	0.79

Appendix 6. (continued)

4th order streams, 1996

		Number of Species			Percent of Assemblage								
		Indicator Taxa			Reprod. Guild	Feeding Guild		Indicator Taxa					
Site	CPUE	Native	Darter	Intolerant	Lithophilus	Generalist	Invertivore	Suckers	Sm. & Rckbs	Cr. Chubs	Pioneering	IBI	Divers.
3	13.5	10	3.0	1.0	3.8	37.1	20.7	1.7	0.8	19.8	13.9	13	0.75
4	14.3	12	4.0	2.0	6.8	9.0	34.5	6.8	2.5	0.3	7.5	26	0.68
6	8.2	14	4.0	1.0	15.0	26.2	41.1	11.7	7.5	0.0	13.6	28	0.89
8	8.0	19	8.0	4.0	14.6	18.5	31.6	1.0	3.7	0.0	5.0	38	0.86
10	32.1	10	3.0	1.0	4.5	50.8	20.6	4.5	1.8	4.7	44.7	27	0.70
11f	28.6	14	6.0	4.0	12.5	24.4	20.1	5.6	0.0	0.0	15.0	31	0.73
11s	10.2	16	5.0	3.0	15.1	34.1	26.9	1.2	2.4	1.2	14.2	35	0.85
14	12.1	18	5.0	3.0	32.0	3.6	27.7	8.6	2.5	0.4	19.1	43	0.86
16	25.0	15	7.0	4.0	10.8	49.2	32.4	2.0	1.6	22.4	11.6	31	0.85
20	6.6	10	1.0	0.0	30.3	40.5	14.4	7.2	2.1	28.7	7.7	21	0.81
21	3.7	15	4.0	2.0	16.4	36.1	35.2	8.2	1.6	18.0	8.2	27	0.87
22	6.3	12	4.0	2.0	17.5	54.2	16.7	0.8	3.3	35.0	15.0	19	0.82
23	19.4	15	6.0	3.0	29.0	52.8	13.1	2.8	2.8	7.4	42.0	29	0.75
26	8.7	15	3.0	0.0	46.2	38.7	6.9	0.6	0.0	0.6	26.0	21	0.75
27	11.5	12	4.0	1.0	11.1	67.4	19.2	2.0	0.0	22.8	38.8	13	0.82
31	46.1	21	7.0	3.0	28.0	30.7	16.6	5.3	1.8	3.3	5.1	43	0.84
32	45.9	17	6.0	4.0	78.8	13.7	8.9	1.8	0.0	0.0	3.1	39	0.68
34	20.5	15	4.0	1.0	39.0	44.4	11.1	2.4	1.7	33.7	0.0	25	0.74
35	12.4	14	4.0	1.0	11.8	28.2	57.4	8.2	2.6	5.1	0.0	31	0.81
40	22.1	18	6.0	3.0	43.6	7.0	7.6	2.0	0.0	0.3	0.6	41	0.74
Mean	17.8	14.6	4.7	2.2	23.3	33.3	23.1	4.2	1.9	10.2	14.6	29.1	0.79
Median	13.0	15.0	4.0	2.0	15.7	35.1	20.4	2.6	1.8	4.0	12.6	28.5	0.81

Appendix 6. (continued)

5th order streams, 1996

		Number of Species			Percent of Assemblage								
		Indicator Taxa			Reprod. Guild	Feeding Guild		Indicator Taxa					
Site	CPUE	Native	Darter	Intolerant	Lithophilus	Generalist	Invertivore	Suckers	Sm. & Rckbs	Cr. Chubs	Pioneering	IBI	Divers.
12	13.4	17	7.0	4.0	17.3	21.0	25.8	2.3	1.1	0.0	8.2	30	0.84
15	3.7	19	7.0	3.0	16.6	24.3	33.2	2.7	3.9	0.0	6.9	34	0.88
17f	42.9	19	7.0	4.0	12.7	14.8	67.0	10.0	2.5	0.5	3.0	42	0.71
17s	4.1	14	3.0	2.0	43.4	22.8	64.0	5.1	5.9	2.9	13.2	30	0.80
18	19.7	17	7.0	4.0	18.1	21.0	29.8	5.8	2.7	0.0	7.8	34	0.83
19	11.9	22	8.0	4.0	24.8	37.3	32.9	17.0	4.5	0.3	14.8	40	0.89
28	41.1	20	4.0	2.0	12.5	10.1	7.5	3.1	0.9	0.1	0.9	28	0.48
36	11.7	17	6.0	2.0	23.3	12.5	44.6	6.1	1.2	2.3	0.3	36	0.82
38	11.9	20	8.0	3.0	6.0	14.5	27.0	3.0	1.0	0.6	3.0	34	0.68
39	9.5	18	7.0	3.0	26.7	45.3	15.7	9.7	0.4	0.8	28.4	30	0.87
Mean	17.0	18.3	6.4	3.1	20.1	22.4	34.8	6.5	2.4	0.7	8.7	33.8	0.78
Median	11.9	18.5	7.0	3.0	17.7	21.0	31.4	5.5	1.8	0.4	7.4	34.0	0.83

3rd order streams, 1977-78

		Number of Species			Percent of Assemblage								
		Indicator Taxa			Reprod. Guild	Feeding Guild		Indicator Taxa					
Site	CPUE	Native	Darter	Intolerant	Lithophilus	Generalist	Invertivore	Suckers	Sm. & Rckbs	Cr. Chubs	Pioneering	IBI	Divers.
1	209.3	9	1.0	0.0	1.2	46.8	6.2	1.2	0.2	35.7	0.0	23	0.65
5C	41.9	9	1.0	0.0	8.9	77.5	13.6	1.8	0.0	45.0	0.0	23	0.70
9	101.3	8	1.0	1.0	14.2	15.5	32.3	0.6	0.0	1.9	0.0	37	0.73
10B	28.7	8	2.0	0.0	7.1	17.0	8.0	4.5	0.8	5.3	0.0	31	0.45
Mean	95.3	8.5	1.3	0.3	7.9	39.2	15.0	2.0	0.2	22.0	0.0	28.5	0.63
Median	71.6	8.5	1.0	0.0	8.0	31.9	10.8	1.5	0.1	20.5	0.0	27	0.67

Appendix 6. (continued)

4th order streams, 1977 - 78

		Number of Species			Percent of Assemblage								
			Indicator Taxa		Reprod. Guild	Feeding Guild		Indicator Taxa					
Site	CPUE	Native	Darter	Intolerant	Lithophilus	Generalist	Invertivore	Suckers	Sm. & Rckbs	Cr. Chubs	Pioneering	IBI	Divers.
8	23.6	12	5.0	1.0	10.5	27.2	36.6	7.9	1.0	0.0	0.0	24	0.83
11s	46.8	13	4.0	2.0	7.7	15.6	34.4	1.9	0.0	0.7	0.0	29	0.68
11f	55.4	12	5.0	1.0	10.1	27.6	34.2	3.8	0.5	3.8	0.0	27	0.77
14	16.6	14	4.0	2.0	12.2	20.4	58.0	8.8	0.0	2.2	0.0	31	0.72
26B	42.4	15	4.0	0.0	19.1	12.1	31.2	17.4	0.4	2.2	6.5	33	0.68
31	59.9	16	6.0	2.0	8.2	28.3	27.1	3.6	1.7	7.0	0.0	35	0.79
35	368.1	13	4.0	0.0	9.6	72.1	17.8	0.3	1.2	19.5	0.0	19	0.67
Mean	87.5	13.6	4.6	1.1	11.0	29.0	34.2	6.2	0.7	5.1	0.9	28.3	0.73
Median	46.8	13.0	4.0	1.0	10.1	27.2	34.2	3.8	0.5	2.2	0.0	29.0	0.72
	*40.8												

* mean CPUE excluding site 35

1977-78 5th order streams

		Number of Species			Percent of Assemblage								
			Indicator Taxa		Reprod. Guild	Feeding Guild		Indicator Taxa					
Site	CPUE	Native	Darter	Intolerant	Lithophilus	Generalist	Invertivore	Suckers	Sm. & Rckbs	Cr. Chubs	Pioneering	IBI	Divers.
12	24.6	14	5.0	2.0	13.3	15.6	53.8	6.4	0.0	0.6	0.0	28	0.75
15	8.7	19	6.0	2.0	25.6	33.5	37.9	15.8	1.5	0.0	0.0	36	0.91
17	25.7	15	5.0	2.0	13.5	18.0	42.1	2.3	2.2	1.7	0.0	32	0.80
19	32.5	18	6.0	2.0	25.8	29.2	39.0	11.9	1.6	2.8	0.0	40	0.91
39	34.1	20	6.0	2.0	54.4	22.2	15.8	7.6	1.2	1.8	0.3	34	0.86
Mean	25.1	17.2	5.6	2.0	26.5	23.7	37.7	8.8	1.3	1.4	0.1	34.0	0.85
Median	25.7	18.0	6.0	2.0	25.6	22.2	39.0	7.6	1.5	1.7	0.0	34.0	0.86

Appendix 6. (continued)

6th order sites, 1996

		Number of Species			Percent of Assemblage								
		Indicator Taxa			Reprod. Guild	Feeding Guild		Indicator Taxa					
Site	CPUE	Native	Darter	Intolerant	Lithophilus	Generalist	Invertivore	Suckers	Sm. & Rckbs	Cr. Chubs	Pioneering	IBI	Divers.
41	3.0	19	6.0	2.0	31.6	14.2	38.2	2.7	2.7	0.0	0.0	38	0.89
42	NA	26	6	5	26.5	7	76.9	11.6	10	0	0.3	46	0.88

6th order sites, 1977

		Number of Species			Percent of Assemblage								
		Indicator Taxa			Reprod. Guild	Feeding Guild		Indicator Taxa					
Site	CPUE	Native	Darter	Intolerant	Lithophilus	Generalist	Invertivore	Suckers	Sm. & Rckbs	Cr. Chubs	Pioneering	IBI	Divers.
22B	1.7	14	5.0	2.0	18.1	7.2	57.2	3.6	0.7	0.0	0.0	32	0.85
41	1.8	14	3.0	1.0	7.6	12.9	42.9	7.6	1.2	0.0	0.0	26	0.77

VITA

Richard Brian Evans was born in Washington D.C. on 12 December 1966 and he grew up in the Maryland suburbs. In 1991 he received a B.S. in biology from Virginia Tech. Afterwards, he continued to live in Blacksburg, VA while working as a fisheries technician for the U.S. Forest Service Southern Experiment Station. Having the opportunity to survey trout streams throughout the southern Appalachians increased his fascination with the large number of fish species that were often downstream and just beyond reach of his work area. Thus, in 1995 he entered The University of Tennessee's graduate program in zoology where he finally gained the chance to study a diverse fish fauna. He was awarded his M.S. degree in zoology in May 1998.

Mr. Evans married his long time friend and companion, the former Kimberly Sharman, in 1994. The author is a member of the American Society of Ichthyologists and Herpetologist and the American Fisheries Society. He plans to continue living the southeastern U.S., studying and working on the conservation of its native aquatic organisms.