INDEX OF BIOTIC INTEGRITY (IBI) MONITORING

IN THE

UPPER LITTLE TENNESSEE WATERSHED

2002

REPORT TO:	Little Tennessee Watershed Association Watershed Action Team, TVA National Forest Foundation SAMAB
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INTRODUCTION

Beginning in 1990 samples of fish (and in some cases benthic macroinvertebrates) have been carried out using an Index of Biotic Integrity protocol, at a total of (to date) 131 sites in the Little Tennessee River watershed upstream of Fontana Reservoir in Swain and Macon Counties, North Carolina and Rabun County, Georgia (McLarney, 1991 and annual reports since then). In 1992, 8 of these sites were selected as "fixed stations" to be monitored annually. Since then, several other sites have been monitored annually and so become de facto fixed stations. Rationale for selection of the original 8 fixed stations is documented in McLarney (1993). Rationale for 3 additional fixed stations (Little Tennessee River at head of Lake Emory, Rabbit Creek at Rabbit Creek Rd. and Skeenah Creek at North Carolina Welcome Center) is offered in McLarney, 1996b, and for the Little Tennessee River at Wolf Fork station in McLarney, 2000b.

Two stream restoration sites on Sutton Branch, located on the campus of Rabun Gap-Nacoochee School in Rabun Gap, Georgia have been monitored annually since 1998. They were tentatively proposed for fixed station status in McLarney, 2001b, and so treated in the 2001 sampling season (McLarney, in prep. b). They are shown as Fixed Stations 12 and 13 in this report, but maintenance of fixed station status is questioned. One of the original fixed stations (Iotla Creek at Macon County Airport) was abandoned in 1999 (McLarney, 1999, 2000b).

This report covers biomonitoring of 12 of the 13 designated fixed stations, including the two Sutton Branch sites. (We failed to sample the Little Tennessee River at Wolf Fork site in 2002.), plus 26 additional stations monitored during May-August, 2001. IBI scores are here presented for all of these stations but one (Big Creek below Randall Dam, see discussion in text), based on fish samples at each, plus benthic macroinvertebrate samples at 14 sites with watershed drainage areas of less than 4 sq. mi.

Rationale for selection of new sites and replication of old sites (other than fixed stations) is given in the following section. IBI scoring criteria for different types of sites are given in Tables 1-7. Table 8 relates IBI scores to Bioclass Rating, with general characteristics of each Bioclass.

Aspects of the 2002 work not dealing directly with biomonitoring are covered in the annual Executive Summary.

Locations of all stream sites monitored during 2002 are shown in Figure 1.

RATIONALE FOR NON-FIXED STATION SITES

Restoration sites

One of the long-term hopes for this project has been to use it to evaluate the results of various stream restoration efforts. In this we have been less successful than hoped, for a variety of reasons:

The most ambitious and best known restoration sites in our watershed do not attempt what could truly be called “stream restoration”, but rather stream bank stabilization, with riparian zone restoration. These efforts are concentrated on the mainstem of the Little Tennessee River and on some of the larger tributaries (for example, Cartoogechaye Creek at Killian Farm, included in this report). Given that biotic integrity at any site is a function of everything occurring upstream and upslope, it is unreasonable to expect that even the best project focusing on a limited length of streambank and riparian zone will show measurable effects in an IBI sample.

An effort to focus on use of near-bank habitat by fish on stabilized and unstabilized sites (McLarney, 2000b) gave ambiguous results. However, information later obtained during IBI sampling on the Little Tennessee River at Tessentee Farm (McLarney, 2001a) and at the Killian Farm site (this report) suggests some positive effects on the biotic community at stabilized sites.

Smaller streams are more likely to show effects from localized efforts, and over the years we have initiated what we thought would be several long-term efforts to monitor such streams as related to restoration efforts. Two such projects have been abandoned, and a third may be:

Beginning in 1995, and through 2001, two sites on Crawford Branch in downtown Franklin (four sites in 1996) were monitored in the hope that the Town of Franklin would undertake an effort to restore its most conspicuous urban stream to a healthier, more attractive and more nearly natural condition. This effort has been at least temporarily suspended due to lack of any serious interest by the Town in doing anything about Crawford Branch.

What appeared to be a successful restoration effort on Mashburn Branch was documented in McLarney, 2000b. However, subsequently the property was sold and the new owner undid much of the restoration before we could be certain of the long term effect. The damage was documented in McLarney, 2001b; we have no plans to return to Mashburn Branch.

We have followed an ambitious restoration effort on Sutton Branch, located on the campus of Rabun Gap-Nacoochee School, with annual monitoring of two sites beginning with the pre-treatment condition (McLarney, 1999b). In fact these sites were proposed for elevation to fixed station status, and are so treated in McLarney (in prep. b). and in this report. However, it has become clear that the restoration effort is severely compromised by land management issues which may be beyond the control of those individuals carrying out the restoration, and this site may also be abandoned. (See discussion under Fixed Stations 12 and 13 in this report.)

Another stream on the Rabun Gap-Nacoochee School campus, Jerry Branch, has been proposed for restoration. It was previously monitored in 1995 (McLarney, 1996b), and was revisited this year on the chance that the restoration effort may be realized.

Two active small stream restoration sites were monitored this year. Blaine Branch on the Sam Greenwood property is the site of an ambitious DOT mitigation project, which includes restoration of natural meanders. Our "before" sample was not taken until after cattle had been removed from the stream for a full year, but there is every reason to believe that this site will be a successful long term monitoring site.

Rocky Branch on the John Tippett farm was previously monitored in 1995 (McLarney, 1996b), at which time cattle had full access and it was seriously damaged. Cattle were subsequently removed and, although no further restoration measures were undertaken, natural improvement is clearly visible. Accordingly, this site was revisited in 2002.

Sites related to spotfin chub studies

In 1999 and 2000 (McLarney, 2000a), it was discovered that the spotfin chub (*Cyprinella monacha*, federally listed as Threatened) and its common congener the whitetail shiner (*Cyprinella galactura*), both considered to be largely restricted to the Little Tennessee mainstem, were making extensive fall migrations into at least a dozen streams tributary to the river downstream of Lake Emory, including streams on the Needmore Tract, a priority issue for conservationists in the upper Little Tennessee watershed. Reasoning that the ecological health of these streams is important information for agencies seeking to protect the spotfin chub, we have endeavored to provide up-to-date monitoring information on these tributaries. Some of these streams (Brush, Tellico and Burningtown Creeks on the Needmore Tract) have been adequately monitored in recent years in any event (McLarney, 2001b and previous years), but others have not. This provided the rationale for monitoring of Sawmill, Wiggins, Lakey, Bradley and Iotla Creeks during 2002, as well as additional justification for including sites on Rocky Branch (see section above on restoration sites) and Cowee Creek (discussed in the following section).

Sites related to specific issues and/or landowner requests

Cowee Creek is the second largest tributary to the Little Tennessee downstream of Lake Emory and the fourth largest overall, but the watershed has not been heavily monitored. Prior to this year IBI monitoring was limited to one site at West's Mill in the lower reaches, and 3 tributary sites monitored in 1997 (McLarney, 1998b). The West's Mill site would have come up in the course of normal rotation, and also related to the known presence of the spotfin chub (see above) in the fall. However, there was additional incentive to monitor Cowee Creek this year, in the form of a rumored golf course development in the upper watershed. In addition to the West's Mill site, two additional sites were planned, thus bracketing the 3 major tributaries to Cowee Creek (Matlock Creek, Caler Fork and Beasley Creek). A surprising result at the site located between Caler Fork and Beasley Creek led to inclusion of a third site just upstream. (See discussion under the Cowee Creek sites.)

Big Creek in Highlands has been the subject of a great deal of discussion since a 1999 dam opening/sedimentation episode, which occurred just after our first monitoring effort on Big Creek. Big Creek was scheduled for monitoring last year, but the site had to be cancelled due to high water. A follow-up effort was requested by several local residents.

In 1995, we monitored all of the tributaries to the Little Tennessee with watershed areas of 1-4 sq. mi. (30 streams) in an effort to refine IBI criteria for such streams (McLarney, 1996a; in prep. a). Two of these sites were selected for monitoring in 2002 based on visible or suspected negative changes, and one because of suspected improvement. (Two other such streams – Rocky Branch and Jerry Branch, were included for other reasons.)

Norton Branch – West Bank (as distinguished from another Norton Branch, tributary to the Little Tennessee on the East Bank), had been visibly degraded due to beaver dam removal, deforestation of the stream bank and flood plain, and access by cattle. As of 1995, a site on Lamb Creek was perceived to be in the early stages of degradation due to a large and controversial development site in the upper reaches. We returned in 2002 to document the damage.

In 1995 McDowell Branch was perceived to be in a state of recovery from earlier point source pollution. It was revisited in 2002 in the hope of verifying this observation.

In 2001, we monitored a site on Betty Creek at Messer Creek Rd., previously monitored in 1996 (McLarney, 1997a), in response to degradation perceived by the property owner (The Hambidge Center for Creative Arts and Sciences). We in fact documented a significant decline in biotic integrity, and decided to return in 2002 to verify this finding. We decided to also revisit another stream on the Hambidge Center property (Patterson Creek) which had been grossly modified by beaver activity since it was last monitored in 1996 (McLarney, 1997a)

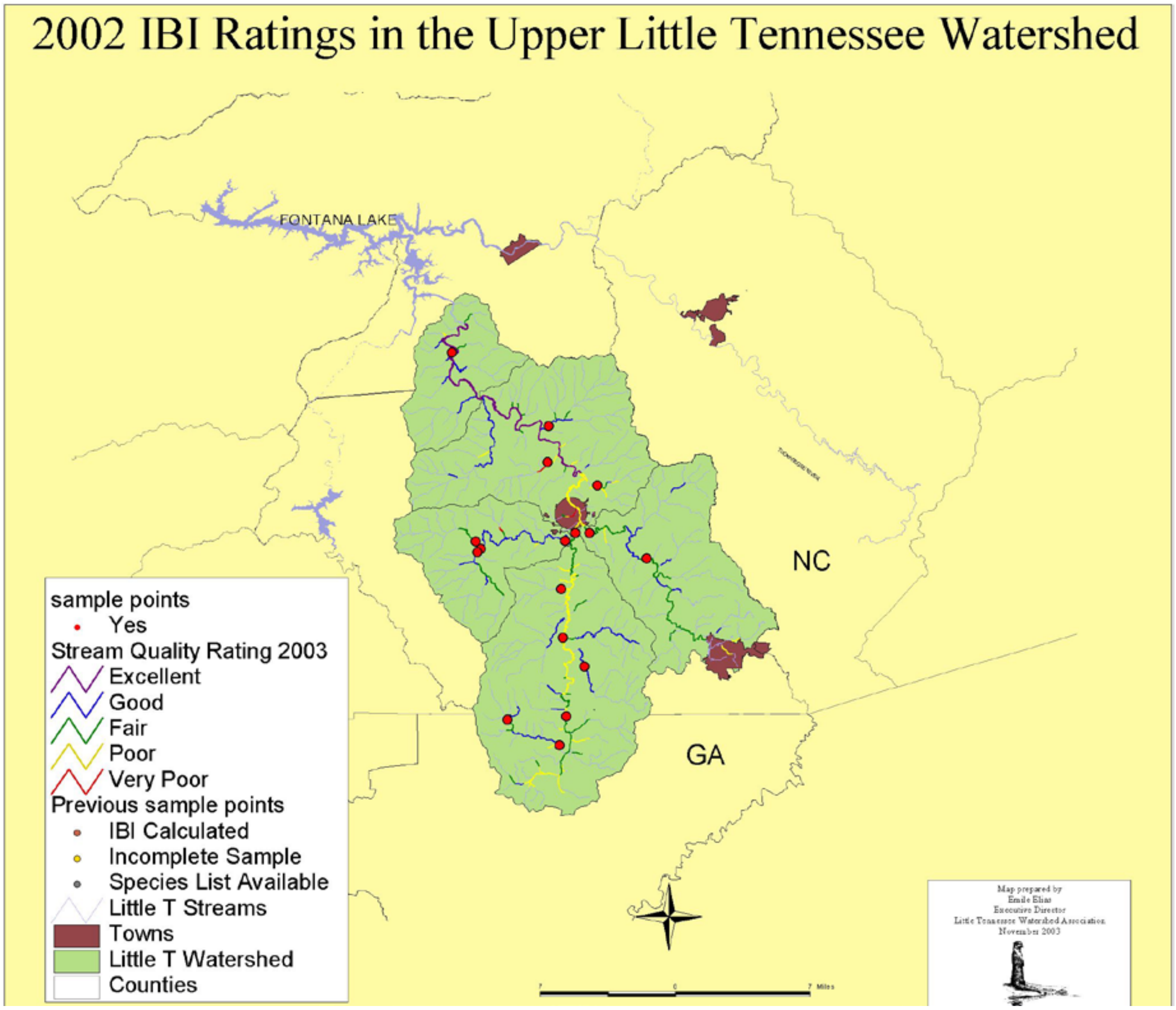
Additional sites

Burningtown Creek is the largest tributary to the Little Tennessee below Lake Emory and the third largest overall. Beginning with monitoring of a site on the lower reaches in 1990 (McLarney, 1991) we have added sites aimed at bracketing the major tributaries (Younce Creek and Left Prong Burningtown). With the addition of a site located just above the confluence of the Left Prong in 2002 we have completed this series.

In 2001 a site on Tessentee Creek at the Land Trust for the Little Tennessee's Tessentee Farm was monitored as part of a biotic inventory effort for the Land Trust. A site on the extreme lower reaches was chosen to maximize species diversity. In the process of sampling it was realized that the condition of Tessentee Creek changes markedly over its length on Tessentee Farm, and that our sample might have understated the biotic integrity of Tessentee Creek on the property as a whole. Accordingly, this year we returned and remonitored the original site, along with another site at the upstream end of the creek on the property.

Locations of all stream sites monitored during 2002 are shown in Figure 1.

Figure 1: Map showing Biomonitoring sites in the Upper Little Tennessee Watershed, 2002.



IBI SCORING CRITERIA

IBI scoring criteria here applied to sites with watershed drainage areas of 4 sq. mi. or more are those proposed by McLarney (1995a), as modified from Saylor and Ahlstedt (1990). These criteria are presented in Tables 1-5, supplemented by Figure 2.

For certain types of stream sites, including those draining less than 4 sq. mi. (14 of which are included in the 2002 samples), an exclusively fish-based IBI is not appropriate. Such streams are thought to be characterized by naturally low fish diversity, such that another assemblage of organisms (benthic macroinvertebrates) must be taken into account in assessing biotic integrity. This was the rationale for development of the Williams (1996) "brook trout" IBI criteria (Table 6) and a modified version of these metrics proposed by this author (McLarney, 1999b, Table 7), both based on combined fish and benthic macroinvertebrate samples.

In our report on 2001 field work (McLarney, in prep. a) the question was raised as to whether monitoring of smaller streams could continue to be justified, given the tremendous lag time between collection and processing of macroinvertebrate samples. With additional funding secured, it is believed that this difficulty has been overcome; at least it has for this report year, with delivery of macroinvertebrate data in time for inclusion in this report. Assuming timely delivery of data continues to be the norm, we will continue work on small streams (and other sites which may have naturally low fish diversity) as appropriate to our larger goals.

Note that no criteria are given for stream sites with watershed areas of 70-150 sq. mi., since there is not enough experience on sites in that size range in the Tennessee Valley to permit establishment of criteria (Saylor and Ahlstedt, 1990). Sites in that size range (one in this report) are scored using criteria from the next smaller or larger size category, according to the judgement of the project director.

Table 8 assigns Bioclass Ratings to the total possible range of IBI scores, from 12 to 60, with general information on the attributes of fish assemblages corresponding to each Bioclass (Karr, et al., 1986).

Table 1. IBI Metric Scoring Criteria for the Upper Little Tennessee River Watershed, Proposed New Revision, for Streams Draining 4-7 square miles

	Metric	Possible Scores		
		1.5	4.5	7.5
1.	Total number of native species	<6	6-10	>10
2.	Number of darter species		deleted	
3.	Number of centrarchid species, other than Micropterus		deleted	
4.	Number of sucker species		deleted	
5.	Number of intolerant species[1]	<2	2	>2
6.	Proportion of individuals as tolerant species[2]	>20%	10 – 20%	<10%
7.	Proportion of individuals as omnivores, generalist feeders, and herbivores	>20%	10 – 20%	<10%
8.	Proportion of individuals as specialized insectivores	<20%	20 – 45%	>45%
9.	Number of species of piscivores		deleted	
10.	Catch rate per unit of effort[3]	<11	11-18	>18
11.	Proportion of individuals as darters and sculpins	<35%	35 – 65%	>65%
12.	Proportion of individuals with disease, tumors, fin damage and other anomalies	>5%	2 – 5%	<2%

1. Replace northern hogsucker with rock bass on list of intolerant species.
2. Add redbreast sunfish and green sunfish to list of tolerant species.
3. If catch rate is less than 3, low scores should be automatically given for Metrics 8, 11 and 12.

Table 2. IBI Metric Scoring Criteria for the Upper Little Tennessee River Watershed, Proposed Revision, for Streams Draining 7-15 square miles.

Metric		Possible Scores		
		1.3	4.0	6.7
1.	Total number of native species	<6	6-10	>10
2.	Number of darter species	0	1-2	>2
3.	Number of centrarchid species, other than Micropterus		deleted	
4.	Number of sucker species		deleted	
5.	Number of intolerant species[1]	<2	2	>2
6.	Proportion of individuals as tolerant species[2]	>20%	10 – 20%	<10%
7.	Proportion of individuals as omnivores, generalist feeders, and herbivores	>20%	10 – 20%	<10%
8.	Proportion of individuals as specialized insectivores	<20%	20 – 45%	>45%
9.	Number of species of piscivores		deleted	
10.	Catch rate per unit of effort[3]	<11	11-18	>18
11.	Proportion of individuals as darters and sculpins	<35%	35 – 65%	>65%
12.	Proportion of individuals with disease, tumors, fin damage and other anomalies	>5%	2 – 5%	<2%

1. Replace northern hogsucker with rock bass on list of intolerant species.
2. Add redbreast sunfish and green sunfish to list of tolerant species.
3. If catch rate is less than 3, low scores should be automatically given for Metrics 8, 11 and 12.

Table 3. IBI Metric Scoring Criteria for the Upper Little Tennessee River Watershed, Proposed Revision, for Streams Draining 15-40 square miles.

Metric		Possible Scores		
		1.3	4.0	6.7
1.	Total number of native species	Varies with drainage (see Figure 2 in Saylor and Ahlstedt, 1990)		
2.	Number of darter species	0	1-2	>2
3.	Number of centrarchid species, other than Micropterus		deleted	
4.	Number of sucker species		deleted	
5.	Number of intolerant species[1]	<2	2	>2
6.	Proportion of individuals as tolerant species[2]	>20%	10 – 20%	<10%
7.	Proportion of individuals as omnivores, generalist feeders, and herbivores	>45%	20 - 45%	<20%
8.	Proportion of individuals as specialized insectivores	<20%	20 – 45%	>45%
9.	Number of species of piscivores		deleted	
10.	Catch rate per unit of effort[3]	<7	7 – 13	>13
11.	Proportion of individuals as darters and sculpins	<35%	35 – 65%	>65%
12.	Proportion of individuals with disease, tumors, fin damage and other anomalies	>5%	2 – 5%	<2%

1. Replace northern hogsucker with rock bass on list of intolerant species.
2. Add redbreast sunfish and green sunfish to list of tolerant species.
3. If catch rate is less than 3, low scores should be automatically given for Metrics 8, 11 and 12.

Table 4. IBI Metric Scoring Criteria for the Upper Little Tennessee River Watershed, Proposed Revision, for Streams Draining 40-70 square miles.

Metric		Possible Scores		
		1.3	3.3	5.5
1.	Total number of native species	Varies with drainage (see Figure 2 in Saylor and Ahlstedt, 1990)		
2.	Number of darter species	0	1	>1
3.	Number of centrarchid species, other than Micropterus		deleted	
4.	Number of sucker species	0	1	>1
5.	Number of intolerant species[1]	<2	2	>2
6.	Proportion of individuals as tolerant species[2]	>20%	10 – 20%	<10%
7.	Proportion of individuals as omnivores, generalist feeders, and herbivores	>30%	15 - 30%	<15%
8.	Proportion of individuals as specialized insectivores	<25%	25 – 50%	>50%
9.	Number of species of piscivores	0		$\geq$1
10.	Catch rate per unit of effort[3]	<7	7 – 13	>13
11.	Proportion of individuals as darters and sculpins	<25%	25 – 50%	>50%
12.	Proportion of individuals with disease, tumors, fin damage and other anomalies	>5%	2 – 5%	<2%

1. Replace northern hogsucker with rock bass on list of intolerant species.
2. Add redbreast sunfish and green sunfish to list of tolerant species.
3. If catch rate is less than 3, low scores should be automatically given for Metrics 8, 11 and 12.

Table 5. IBI Metric Scoring Criteria for the Upper Little Tennessee River Watershed, Proposed Revision, for Streams Draining 150 - 600 square miles.

Metric		Possible Scores 1	3	5
1.	Total number of native species	<10	10-18	>18
2.	Number of darter species	<3	3-4	>4
3.	Number of centrarchid species, other than Micropterus	0	1	>1
4.	Number of sucker species	<2	2 – 4	>4
5.	Number of intolerant species[1]	<2	2 - 3	>3
6.	Proportion of individuals as tolerant species[2]	>20%	10 – 20%	<10%
7.	Proportion of individuals as omnivores, generalist feeders, and herbivores	>30%	15 - 30%	<15%
8.	Proportion of individuals as specialized insectivores	<25%	25 – 50%	>50%
9.	Proportion of individuals as piscivores	<1%	1 – 2%	>2%
10.	Catch rate per unit of effort[3]	<7	7 – 13	>13
11.	Proportion of individuals as darters and sculpins	<10%	10 –25%	>25%
12.	Proportion of individuals with disease, tumors, fin damage and other anomalies	>5%	2 – 5%	<2%

1. Replace northern hogsucker with rock bass on list of intolerant species.
2. Add redbreast sunfish and green sunfish to list of tolerant species.
3. If catch rate is less than 3, low scores should be automatically given for Metrics 8, 11 and 12.

Table 6. IBI Metric Scoring Criteria for Reservoir Lakes in the Blue Ridge.

Metric		Possible Scores		
		1	3	5
1.	Total number of species (excluding exotics)	<8	8 – 15	>15
2.	Mean number of individuals per run*			
	a. Electrofishing	<30	30 – 60	>60
	b. Gill Nets	<30	30 – 60	>60
3.	Number of sunfish species (except Micropterus)	<3	3	>3
4.	Number of benthic invertivore species	<3	3 – 4	>4
5.	Number of intolerant species	<2	2	>2
6.	Percent individuals as tolerants*			
	a. Electrofishing	15	15 – 30	<15
	b. Gill Nets	>20	10 – 20	<10
7.	Number of piscivore species	<3	3 – 5	>5
8.	Percent individuals as omnivores*			
	a. Electrofishing	>10	5 – 10	<5
	b. Gill Nets	>30	15-30	<15
9.	Percent individuals as invertivores*			
	a. Electrofishing	<75	75 – 85	>85
	b. Gill Nets	<3	3 – 7	>7
10.	Percent individuals as single dominant species*			
	a. Electrofishing	>60	40 – 60	<40
	b. Gill Nets	>50	30 – 50	<50
11.	Number of species of lithophilic spawners	<3	3 – 5	>5
12.	Number of exotic species	<2	2 – 5	>5
13.	Percent individuals with disease or anomalies	>5	2 – 5	<2

* For metrics which are split by capture methods (electrofishing or gill net), award half of possible score based on each method.

Multiply score obtained by 0.923 to obtain final IBI score, in order to compensate for 13 metrics.

Table 7a. IBI Metric Scoring Criteria for Stream Sites Draining Less than 10 Square Miles and Located at Elevations of 1800 feet or more in the Tennessee River Drainage Basin. From Williams 1996.

Metric		Possible Scores		
		2	6	10
1.	Total Ephemeroptera taxa	<3	3 – 5	>5
2.	Total EPT taxa	<8	8 – 15	>15
3.	Brook trout presence or absence	Absent	Sympatric	Allopatric
4.	Catch rate (mean number of individual fish per five minute shocking run)	<5	5 – 9	>9[1]
5.	Proportion of individuals with disease, tumors, fin damage and other anomalies	> 5%	5 – 2%	<2%[2]
6.	Proportion of individual fish as tolerant species[3]	>20%	10 – 20%	<10%

1. Score 6 if > 50
2. Score 8 if >0 but <2%.
3. Add redbreast sunfish and green sunfish to list of tolerant species.

Table 7b. Proposed Modified Version of Williams (1996) "Brook Trout" IBI (see Table 7a) for Stream Sites Located at Elevations of 1,700 feet or more in the Upper Tennessee River Watershed.

Metric		Possible Scores		
		1.5	4.5	7.5
1.	Total Ephemeroptera taxa	<3	3 – 5	>5
2.	Total EPT taxa	<8	8 – 15	>15
3.	Brook trout presence or absence	Absent	Sympatric	Allopatric
4.	Catch rate (mean number of individual fish per five minute shocking run)	<5	5 – 9	>9[1]
5.	Proportion of individuals with disease, tumors, fin damage and other anomalies	> 5%	5 – 2%	<2%[2]
6.	Proportion of individual fish as tolerant species[3]	>20%	10 – 20%	<10%
7.	Proportion of individual fish as wild trout (all species)	Absent	0 – 10%	>10%
8.	Proportion of individual fish as omnivores, generalist feeders and herbivores	>20%	20 – 10%	<10%

1. Score 4.5 if > 50
2. Score 6.0 if >0 but <2%.
3. Add redbreast sunfish and green sunfish to list of tolerant species.

Table 8. Biotic Integrity Classes Used in Assessing Fish Communities Along with General Descriptions of their Attributes.

Class	Attributes	IBI Range
Excellent	Comparable to the best situations without influence of man; all regionally expected species for the habitat and stream size, including the most intolerant forms, are present with full array of age and sex classes; balanced trophic structure.	58 – 60
Good	Species richness somewhat below expectation, especially due to loss of most intolerant forms; some species with less than optimal abundance or size distribution; trophic structure shows some signs of stress.	48 – 52
Fair	Signs of additional deterioration include fewer intolerant forms, more skewed trophic structure (e.g., increasing frequency of omnivores); older age classes of top predators may be rare.	39 – 44
Poor	Dominated by omnivores, pollution-tolerant forms, and habitat generalists; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present.	28 – 35
Very Poor	Few fish present, mostly introduced or very tolerant forms; hybrids common; disease, parasites, fin damage and other anomalies regular.	12 – 23
No Fish	Repetitive sampling fails to turn up any fish.	

A NOTE ON THE MACROINVERTEBRATE DATA

Over the years, the level of identification and other aspects of the macroinvertebrate data delivered by TVA and others has varied greatly, making between year comparisons difficult. In general we have concentrated in our reporting on the EPT taxa, partly for this reason but also because this is the information which figures directly into the calculation of small stream IBI's (See Tables 6 and 7).

This year we note that, along with the short turn-around time on our samples, the quality of the data received is the best we have had, including counts for each taxon identified in each of our samples. While our macroinvertebrates samples make no pretense of being quantitative, the numbers supplied do provide a suggestion of the relative abundance of the various taxa encountered.

While neither the taxa counts nor the information on non-EPT forms is germane to calculation of the IBI's we use, we have included it in the tables for each site where macroinvertebrates are sampled, in the belief that it contributes to an understanding of the condition of the sites. In years to come, we would like to consider further application of this information, perhaps through use of a BIBI (Benthic Index of Biotic Integrity) as proposed for our area by Kerans and Karr (1994).

RESULTS AND DISCUSSION

Introduction

Following the format established in McLarney (1995b), in Tables 9 – 56 data are presented for each of the 38 monitoring sites for 2002 and for the previous year of monitoring, if any (plus other years as deemed necessary for interpretation of the data). For new sites, and for any where a significant change in the physical environment was perceived to have occurred, summary data on the physical environment at the site are presented as well (total of 16 sites).

Only common names of fish are used in the tables. For all sites, all species ever taken at that site are listed, whether or not they appeared in any of the samples included in the tables. For a complete list of fish species taken in the upper Little Tennessee watershed, with scientific names, see McLarney (2001b).

Fixed Station 1: Little Tennessee River at Needmore (RM 95.5) (Table 9)

As it has every year since monitoring began in 1990, the Needmore site scored in the GOOD-EXCELLENT range. And as in 2001, the only metrics which scored less than the maximum were Metric 10 (catch rate) and Metric 11 (proportion of individuals as darters and sculpins), but it is notable that record low values were recorded for both of these metrics. However, both may have been affected by some difficulties with the backpack shocker used, which could have caused us to miss fish in some of the riffle habitats.

Even with that caveat, there are some potentially worrisome trends:

All 5 intolerant species (spotfin chub, *Cyprinella monacha*; telescope shiner, *Notropis telescopus*; rock bass, *Ambloplites rupestris*; wounded darter, *Etheostoma vulneratum* and gilt darter, *Percina evides*) declined in absolute numbers and as a proportion of the total catch. The telescope shiner and wounded darter were represented only by small individuals.

The Tuckaseigee darter (*Etheostoma blennioides gutselli*) has never been represented by more than 3 individuals at this site, but was absent for the third consecutive year. As for 5 darter species present, the total catch was extremely low (but see note above about shocker function). Perhaps equally significant, the percentage composition of the species, which had been quite stable for years, continued to fluctuate. Until 2001, the intolerant gilt darter had been the dominant species at Needmore, but in that year its abundance was at an all time low, whether measured as number of individuals or a proportion of the total darter catch. In 2002, number of individuals dropped to a new low (from 26 to 20). Although its percentage in the total darter catch increased from 22.2 to 29.9%, this is still low for a species which has usually outnumbered all other darters combined. The other intolerant darter (wounded darter, *Etheostoma vulneratum*) dropped back to its usual low in numbers and proportional representation. The most striking change, however, was that the banded darter, which accounted for 35.9% of the darter catch last year, dropped back to 10.4%, while the greenfin darter (*Ethostoma chlorobranchium*) recorded a record high of 31 individuals or 46.3% of the darter catch.

The mottled sculpin (*Cottus bairdi*) is more typically a fish of tributary streams in the upper Little Tennessee watershed, and has never been found in large numbers at Needmore. However, 2002 marks the first year in 10 that not a single individual of this species was taken. It is thought that water temperature is the chief factor limiting sculpin numbers in the Little Tennessee mainstem, and this may indicate a trend toward higher temperatures.

Given our doubts about the efficiency of some of the backpack shocker sampling, these tendencies should be treated as no more than possibilities at least until after the 2003 Needmore sample. Based on the 2002 Needmore sample, the Little Tennessee between Lake Emory and Fontana Reservoir continues to merit its renown as the highest quality major river in the Blue Ridge ecoregion.

Table 9. Fixed Station 1 - Little Tennessee River at Needmore (RM 95.5)

Species and Numbers of Fish Taken

Species	Number of individuals 2001	2002
Mountain brook lamprey	1	2
Gizzard shad		
Rainbow trout		
Muskellunge		
Central stoneroller	5	5
Whitetail shiner	72	178
Spotfin chub	13	9
Common carp	1	
Warpaint shiner	68	109
River chub	39	53
Golden shiner		
Tennessee shiner	76	6
Silver shiner		1
Rosyface shiner	106	50
Mirror shiner	50	22
Telescope shiner	31	5
Fatlips minnow	5	2
Creek chub		
Northern hogsucker	9	33
Silver redhorse	1	4
River redhorse	3	3
Black redhorse	1	3
Golden redhorse	2	9
Shorthead redhorse	3	9
Sicklefin redhorse		
Channel catfish	2	1
Stonecat	1	
Flathead catfish	3	
White bass		
Rock bass	47	29
Redbreast sunfish	10	4
Green sunfish	1	
Warmouth		
Bluegill	1	3
Redear sunfish		
Smallmouth bass		12
Largemouth bass		
Black crappie		
White crappie		
Tuckaseigee darter		
Greenfin darter	19	31
Wounded darter	29	6
Banded darter	42	7
Yellow perch		
Tangerine darter	1	3
Gilt darter	26	20
Walleye		1

Species and Numbers of Fish Taken

Species	Number of individuals 2001	2002
Mountain brook lamprey	1	2
Gizzard shad		
Rainbow trout		
Muskellunge		
Central stoneroller	5	5
Whitetail shiner	72	178
Spotfin chub	13	9
Common carp	1	
Warpaint shiner	68	109
River chub	39	53
Golden shiner		
Tennessee shiner	76	6
Silver shiner		1
Rosyface shiner	106	50
Mirror shiner	50	22
Telescope shiner	31	5
Fatlips minnow	5	2
Creek chub		
Northern hogsucker	9	33
Silver redhorse	1	4
River redhorse	3	3
Black redhorse	1	3
Golden redhorse	2	9
Shorthead redhorse	3	9
Sicklefin redhorse		
Channel catfish	2	1
Stonecat	1	
Flathead catfish	3	
White bass		
Rock bass	47	29
Redbreast sunfish	10	4
Green sunfish	1	
Warmouth		
Bluegill	1	3
Redear sunfish		
Smallmouth bass		12
Largemouth bass		
Black crappie		
White crappie		
Tuckaseigee darter		
Greenfin darter	19	31
Wounded darter	29	6
Banded darter	42	7

Yellow perch		
Tangerine darter	1	3
Gilt darter	26	20
Walleye		1
Mottled sculpin	1	
TOTALS	693	620

Metrics and Scores

Metric	2001 Observed value	Score	2002 Observed value	Score
1. No. native species	30	5	29	5
2. No. darter species	5	5	5	5
3. No. sunfish species	4	5	3	5
4. No. sucker species	6	5	6	5
5. No. intolerant species	5	5	5	5
6. % individuals as tolerants	1.7	5	0.6	5
7. % individuals as omnivores & herbivores	6.6	5	8.9	5
8. % individuals as specialized insectivores	77.6	5	72.4	5
9. % individuals as piscivores	10.7	5	6.8	5
10. Catch rate	8.1	3	6.1	3
11. % individuals as darters & sculpins	17.0	3	10.8	3
12. % individuals w. disease or anomalies	0.4	5	0.8	5
TOTALS		56 Excellent		56 Excellent

Fixed Station 2: Little Tennessee River at Head of Lake Emory (RM 118.0) (Table 10)

The best introduction to this site is to repeat what was said about it in last year's report (McLarney, in prep. b):

" Due to a combination of factors including weather, turbidity, short crews at TVA, other demands on the TVA shocker boat and bad planning, we were unable to monitor this site (which scored 38, bioclass rating FAIR in 2000) during the 2001 season. This omission is unfortunate, not only because this station reflects the condition of the Little Tennessee as it enters Lake Emory and the Franklin urban area, but also because of changes which are expected in the years to come. In addition to both accelerating development and concerted efforts to control sedimentation by improving riparian conditions in upstream portions of the watershed, the following changes are foreseen for the immediate area":

- "The Franklin Greenway will pass along the entire length of the sample reach on one side or the other, incorporating a foot bridge. The Greenway has been billed as a conservation project, and to some extent it will be. But it will also exponentially increase human use of the riparian area. In portions which are already being developed further downstream, it has already occasioned some amount of short term damage through removal of vegetation and soil erosion."

- "The new Macon campus of Southwestern Community College will ultimately be located at the juncture of the Little Tennessee River and Cartoogechaye Creek, located just 1 mi. upstream, on what is presently a semi-abandoned farm. Construction and development of the campus will inevitably have some impact on the river."
- "A large convention center facility is already under construction on high ground adjacent to part of the monitoring site. While erosion control measures have been adequate, there are inevitably impacts associated with such a large development."

"All three of the items just cited are no more than fragments of extremely intensive development which is expected to occur around the junction of highways 64 and 441 west of the bridge which crosses the Little Tennessee near the lower end of this site. Plans, some of which will be opposed, include altering highway access and connecting the Whistle Stop Mall area, located on US 441 at Cartoogechaye Creek, with the future SCC campus and the Convention Center on the opposite bank of the river. Ultimately as much as 2 mi. each of the Little Tennessee and Cartoogechaye Creek could be directly impacted."

"There is also a need, independently of projected future development, to attempt to restore the right bank of the river and its riparian zone on and immediately upstream of the monitoring site. This reach (on rented pasture land) and two shorter reaches on lower Cartoogechaye Creek and the left bank of the Little Tennessee just above its mouth constitute one of the most heavily damaged and damaging reaches of stream bank in the entire watershed."

"For all of these reasons the Head of Lake Emory station must be regarded as a priority monitoring site for 2002 and the years to come."

<u>2002 Results and Discussion</u>:

While the IBI score at this site (38, Bioclass FAIR) did not change between 2000 and 2002, there are a number of ongoing and new negative trends which should be mentioned:

- For several years this was the one site in the entire watershed where we could count on taking the olive darter (*Percina squamata*). Almost all of the olive darters taken came from the left bank where a deep run is bordered by rocks placed during partial channelization of the river in construction of the Tallulah Falls Railroad in the early part of the last century. However, not only have we captured no olive darters (nor seen anything which might have been an olive darter escaping in this difficult-to-fish spot) in this habitat since 1998, we have seen no olive darters at all at RM 118 since a single individual was taken in a riffle in the 1999 sample. Somewhat surprisingly, the main species sharing the left bank habitat with the olive darter was the snail bullhead (*Ameiurus brunneus*). In 2002 this species was also absent (though 5 were taken at other parts of the site), and the left bank rocks were populated only by river chubs (*Nocomis micropogon*) and several species of Centrarchids.

- There was a drastic reduction in the proportion of specialized insectivores, to 13.7% of the total catch. (The previous low was 20.2% in 1996.) Particularly notable was the almost total absence of the warpaint shiner (*Luxilus coccogenis*), represented only by 2 individuals taken with the boat shocker.

- Observed values for Metric 2 (no. of darter species) and 5 (no. of intolerant species) were based on the occurrence of a single juvenile gilt darter (*Percina evides*) which, surprisingly, turned up in the boat shocker sample. (If this fish were disallowed, reducing the number of both darter and intolerant species to 1, it would not affect the scoring for either metric.) The gilt darter has been found at this site, always in low numbers, in every monitoring year except 1999.

- There was a huge increase in numbers of the exotic yellowfin shiner (*Notropis lutipinnis*) to 95, tying it with the exotic, tolerant redbreast sunfish (*Lepomis auritus*) for the most abundant fish at the site. The previous high for this species was 25 individuals, in 2000, in which year it was the 7th most abundant species. Most of the individuals taken were small, young fish, suggesting an ongoing invasion. Since we still lack satisfactory criteria for evaluating the yellowfin shiner in terms of tolerance or possible omnivory, the full meaning of this observation remains speculative (as in so many other sites in the watershed above Lake Emory).

- For the first time ever, the mountain brook lamprey (*Ichthyomyzon greeleyi*) was totally absent from the sample at this site.
- Although the value for Metric 12 (% of individuals with disease or anomaly) was within the range normally encountered at this site (3.7%, against a range of 2.9-4.8%) there was a notable diversity of conditions, including blackspot, scoliosis, body fungus, finrot and leeches, affecting 6 species.

One possible positive trend was the high catch per unit effort (22.9 fish per 300 sq. ft. of water surface, against a previous high of 13.4.) However, it must be noted that this was due largely to the boat shocker results, which were in turn boosted by unusually clear water for this generally turbid site.

A single greenfin darter (*Etheostoma chlorobranchium*) – a large, fully colored adult male – was the first individual of this species seen at this site since 1994. All previous occurrences have been juveniles.

Table 10. Fixed Station 2 - Little Tennessee River at Head of Lake Emory (RM 118.0)

Species and numbers of fish taken

Species	Number of individuals taken	
	2000	2002

Mountain brook lamprey	1	
Rainbow trout		
Central stoneroller	11	13
Smoky dace		
Common carp	1	3
Whitetail shiner	68	38
Warpaint shiner	18	2
River chub	27	43
Golden shiner	1	
Tennessee shiner	33	18
Yellowfin shiner	25	95
Silver shiner	3	5
Mirror shiner	4	5
Fatlips minnow	2	1
Creek chub		3
White sucker		
Northern hogsucker	20	31
Black redhorse	60	53
Golden redhorse	72	37
Snail bullhead	10	5
Rock bass	8	14
Redbreast sunfish	92	95
Green sunfish	1	
Warmouth	2	1
Bluegill	15	32
Smallmouth bass	2	1
Largemouth bass	1	6
Black crappie		2
Tuckaseigee darter		
Greenfin darter		1
Yellow perch	4	8
Gilt darter	2	1
Olive darter		
Mottled sculpin	11	7
TOTALS	494	520

Metrics and Scores

Metric	2000		2002	
	Observed value	Score	Observed value	Score
1. No. native species	21	5	21	5
2. No. darter species	1	1	2	1
3. No. sunfish species	5	5	5	5
4. No. sucker species	3	3	3	3
5. No. intolerant species	2	3	2	3
6. % individuals as tolerants	21.1	1	20.4	1

7. % individuals as omnivores & herbivores	7.5	5	12.7	5
8. % individuals as specialized insectivores	26.3	3	13.7	1
9. % individuals as piscivores	2.2	5	3.3	5
10. Catch per unit effort	10.3	3	22.9	5
11. % individuals as darters & sculpins	2.6	1	1.7	1
12. % individuals with disease or anomaly	3.4	3	3.7	3
TOTALS		38		38
		FAIR		FAIR

Fixed Station 3 – Little Tennessee River at North Carolina/Georgia State Line (RM 136.9) (Table 11)

The FAIR Bioclass Rating marks the first time the State Line site has scored this high since 1998, but there is still abundant evidence of pollution. The most outstanding observation from the 2002 fish sample has nothing to do with fish or the IBI directly. We began the 2002 sample early in the morning, at which time the water color was the grayish-green typical of the Little Tennessee in Georgia, and worked until lunch time at a shocker setting of 600 volts. After a lunch break, we noted that the water had turned a reddish color, and it was necessary to take the shocker down to 200 volts to prevent overloading. This demonstrates that the permitted discharge from the Fruit of the Loom plant, located 2.2 mi. upstream, is still a major factor affecting this site. In recent months Fruit of the Loom is said to have cut back production, and this could be the main factor leading to the improvement in IBI score from 31.9 (Bioclass Rating POOR) in 2001 to 40.7 (FAIR) in 2002.

This hypothesis, even if true, must be qualified in at least two ways:

1. So far as we have been able to determine, Fruit of the Loom is operating within their permit parameters. (Their permit does not speak to either color or conductivity.) If this be so, we are not confronting a legal issue.

2. The Little Tennessee River at the State Line is subject to a large number of other stresses, including both point and nonpoint sources originating with industry, municipalities, agriculture and development activities.

Be that as it may, the present situation is unattractive, toxic to plants (see McLarney, 2001 and previous reports re the elimination of riverweed, *Podostemum* below the discharge point), and thus significantly affects the ecosystem. Further, even within all limits of toxicity, it is inherently unhealthy for a stream to undergo such severe and frequent oscillations in any physical or chemical parameter (in this case, apparently mineral content, as suggested by conductivity).

It is also clear that in the years immediately following Fruit of the Loom's acquisition of the former Burlington Industries plant (which remains the source of ca. 95% of total permitted industrial discharges to the entire upper Little Tennessee watershed) the system functioned better, discoloration was not usually apparent, and *Podostemum* was present. Bioclass Rating was FAIR every year but one between 1993 and 1998. Surely maintenance of such conditions is still possible.

Given that Designated Critical Habitat for the Threatened spotfin chub (*Cyprinella monacha*) begins at the North Carolina line, it should be possible to attract constructive attention to the suite of problems compromising water quality and biotic integrity at the state line.

Specific comments related to the 2002 State Line sample follow:

- All expected native species were taken (as was the case in 2000 when State Line received an IBI score of 29.7 and a Bioclass Rating of POOR, tying for the lowest score ever here). There has been a general upward trend in fish diversity since the site was first monitored in 1990.

- The proportion of specialized insectivores (31.7%) was the highest recorded here since 1997. The increase was largely in the shiner component, with record high catches of warpaint shiner (*Luxilus coccogenis*) and whitetail shiner (*Cyprinella galactura*). The whitetail shiner seems to be in the process of populating this site; it was not taken here prior to 1998.

- In addition to the two shiner species just mentioned, record high numbers of the central stoneroller (*Campostoma anomala*) and gilt darter (*Percina evides*) were recorded in 2002.

- 2002 marked the first occurrence of the smallmouth bass (*Micropterus dolomieui*) at this site, although it has been recorded once from the Little Tennessee at Wolf Fork, 6 miles upstream.

- The single riffle at this site, which had nearly disappeared in 2000, continues to recover, but so far physical recovery of the habitat is not reflected in any notable increase in abundance of riffle dwelling fishes.

In general, and the overall positive trend over the last 3 years notwithstanding, the outstanding characteristic of the State Line would appear to be instability. Not only are there multiple stressors affecting the site, but the situation with the Fruit of the Loom discharge must be viewed with concern. While we lack the data to clearly define problems, the recent upturn in biotic integrity is at least coincidental with an apparent drop in the volume of effluent discharged. And this trend is overlain by a longer term trend toward increased conductivity and toxic effects on toxic vegetation. A downward trend in biological health could be initiated by an increase in other stresses acting synergistically with the Fruit of the Loom discharge and/or an improvement in the company's economic condition such that the volume of effluent discharged increased again or a continued downtown in their fortunes causing further decline in the apparent quality of effluent treatment. In terms of the overall health of the Little Tennessee River, including the excellent quality reach downstream of Franklin, North Carolina, the reach of the river in Georgia deserves the highest priority for attention.

Table 11. Fixed Station 3 - Little Tennessee River at North Carolina/Georgia State Line (RM 136.9)

Species and Numbers of fish taken

Species	Number of individuals taken 2001	2002
Mountain brook lamprey	9	2
Rainbow trout	2	
Central stoneroller	66	130
Whitetail shiner	10	29
Warpaint shiner	3	58
River chub	27	44
Golden shiner		
Tennessee shiner	26	28
Yellowfin shiner	42	67
Mirror shiner	8	8
Fatlips minnow	1	3
Longnose dace		
Creek chub		4
White sucker	3	1
Northern hogsucker	2	12
Black redhorse	1	2
Golden redhorse	1	2
Brown bullhead		
Snail bullhead	1	2
Rock bass	7	4
Redbreast sunfish	4	16
Green sunfish		1
Warmouth		
Bluegill	1	2
Smallmouth bass		1
Largemouth bass	1	
Tuckaseigee darter		
Gilt darter	2	14
Mottled sculpin	7	11
TOTALS	224	441

Metrics and Scoring

Metric	2001 Observed value	2001 Score	2002 Observed value	2002 Score
1. No. native species	17	5.5	19	5.5
2. No. darter species	1	3.3	1	3.3
4. No. sucker species	4	5.5	4	5.5

5. No. intolerant species	1	1.1	2	3.3
6. % individuals as tolerants	3.6	5.5	5.4	5.5
7. % individuals as omnivores & herbivores	47.3	1.1	41.5	1.1
8. % individuals as specialized insectivores	22.3	1.1	31.7	3.3
9. No. piscivore species	0	1.1	2	5.5
10. Catch per unit effort	7.0	3.3	9.9	3.3
11. % individuals as darters & sculpins	4.0	1.1	5.7	1.1
12. % individuals w. disease or anomaly	4.0	3.3	2.3	3.3
TOTALS		31.9		40.7
		POOR		FAIR

Fixed Station 4 – Little Tennessee River at Wolf Fork (RM 142.9)

The Wolf Fork fixed station (which received an IBI score of 33.0 and a bioclass rating of POOR in 2001) was not monitored in 2002, owing to the unavailability of the project director on the date scheduled. This site is done annually in conjunction with students from Macon Middle School, as part of Coweeta Hydrologic Laboratory's LTER Project. Its status as a Fixed Station owes to pedagogical convenience, not biological importance. Nevertheless, the apparent decline registered between 2000 and 2001 suggests that this site should be a priority for 2003.

Fixed Station 5 – Rabbit Creek at Rabbit Creek Rd. (former Holly Springs Rd.) (RM 0.8) (Table 12)

The difference between the 2001 and 2002 IBI scores for Rabbit Creek (from 33.3 to 30.6, for a Bioclass Rating of POOR in both cases) may not be significant, but it coincides with:

- record high numbers for two tolerant omnivores, the creek chub (*Semotilus atromaculatus*) and the white sucker (*Catostomus commersoni*), represented respectively by 11 and 10 individuals, as compared to previous highs of 6 and 5. A third tolerant species, the exotic redbreast sunfish (*Lepomis auritus*) also recorded record abundance.

- a significant increase in the proportion of diseases and anomalies (0.3 to 2.3%), involving 6 different pathological conditions in 6 species.

- a dramatic increase in the abundance of the yellowfin shiner (*Notropis lutipinnis*), represented in 2002 by 36 individuals (9.0% of the catch) as compared to the previous year's high of 3 (1.0%). This is typical of the spread of this exotic species, which often seems to follow the sedimentation of rock or gravel substrate. Several of these individuals appeared to be hybrids with the warpaint shiner, *Luxilus coccogenis.*

The Rabbit Creek fixed station scored 36.0 each year from 1994-1996, and 38.7 during 1997-2000. The present decline coincides precisely with removal of beaver ponds, channelization and removal of riparian vegetation along the lower reaches of Rabbit Creek's major tributary, Cat Creek. This activity, which led to a variety of legal actions against a developer (but so far no restoration efforts) resulted in severe sedimentation downstream in Cat Creek and some apparent increase in sediment deposition in Rabbit Creek. The landowner at the monitoring site also reported a large slug of sediment passing through about 2 months prior to the sampling date.

These apparently negative trends are partially counterbalanced by other trends. The large number of redbreast sunfish coincides with the reduction in numbers of the tolerant green sunfish (*Lepomis cyanellus*) Until 2001, green sunfish had appeared in only 3 of 10 samples at this site, and then only as single individuals. However, in 2001 an unanticipated 22 individuals appeared, declining to 3 in 2002.

A record catch of the intolerant rock bass (*Ambloplites rupestris*) (42 individuals) also occurred in 2002, but size distribution was normal as compared to the virtual total dominance of large individuals in 2000, coinciding with the disappearance of one prey species, the blacknose dace (*Rhinichthys atratulus*). The blacknose dace made a modest comeback in 2001, with 2 individuals, and was normally represented (13 individuals) in 2002.

Developing trends in lower Rabbit Creek may continue to reflect a balance between the more or less stable situation in the watershed above Cat Creek (which improved significantly in terms of erosion potential and livestock damage between 1990 and 1994) and ongoing deterioration in Cat Creek, which is already severely stressed by sedimentation, cattle access and possibly other effects associated with an established golf course development. Recovery is retarded by the fact that Cat Creek empties into the forebay of Lake Emory, which reduces the possibility of reestablishment of species (notably the darters) via the Little Tennessee River mainstem.

Table 12. Fixed Station 5 - Rabbit Creek at Rabbit Creek Rd. (formerly Holly Springs Rd.) (RM 0.8)

Species and Numbers of Fish Taken

Species	Number of Individuals Taken	
	2001	2002
Central stoneroller	39	28
Smoky dace		
Whitetail shiner	17	17
Warpaint shiner	39	69
River chub	41	35
Tennessee shiner	14	27
Yellowfin shiner	3	36
Blacknose dace	2	13
Longnose dace	3	1
Creek chub	6	11
White sucker	4	10

Northern hogsucker	32	32
Golden redhorse	3	4
Brown bullhead		
Rock bass	36	42
Redbreast sunfish	16	18
Green sunfish	22	4
Warmouth		
Bluegill	1	6
Largemouth bass		
Mottled sculpin	28	45
TOTALS	297	398

Metrics and Scoring

Metric	2001 Observed value	score	2002 Observed value	score
1. No. native species	15	6.7	15	6.7
2. No. darter species	0	1.3	0	1.3
5. No. intolerant species	1	1.3	1	1.3
6. % individuals as tolerant species	16.2	4.0	10.8	4.0
7. % individuals as omnivores & herbivores	31.0	1.3	25.4	1.3
8. % individuals as specialized insectivores	24.6	4.0	28.6	4.0
10. Catch per unit effort	25.1	6.7	33.2	6.7
11. % individuals as darters & sculpins	9.4	1.3	11.3	1.3
12. % individuals w. disease or anomaly	0.3	6.7	2.3	4.0
TOTALS		33.3 POOR		30.6 POOR

Fixed Station 6 – Cullasaja River at Macon Middle School (RM 0.9) (Table 13)

The 2001 IBI score for the lower Cullasaja River was 38.5, on the boundary line between poor and fair. It was decided, on the basis of doubtful presence of adult piscivorous fish (Metric 10), and in view of the generally poor habitat present at the site, to assign a Bioclass Rating of POOR. However, a modest amount of improvement in the score for 2002 (to 42.9) definitely justifies a Bioclass Rating of FAIR.

In 2002, adults or large juveniles of 3 piscivorous species (rock bass, *Ambloplites rupestris*; largemouth bass, *Micropterus dolomieui* and yellow perch, *Perca flavescens* were present (total of 11 individuals), justifying the high score for Metric 10. (The 2 yellow perch taken constitute the first record for this species in the Cullasaja River watershed, but another individual was subsequently taken at the Peaceful Cove fixed station on the Cullasaja, at RM 8.3. See “Comments on Individual Species”.)

Marked improvement occurred for two metrics: The proportion of individuals as tolerant species (Metric 4) dropped from 12.1 to 4.9%. The only tolerant species present in 2002 was the redbreast sunfish, *Lepomis auritus*. And the proportion of individuals with disease or anomalies (Metric 12) dropped from 6.1 to 2.4%. Both improvements resulted in raising the IBI score.

Other factors suggesting that the improvement may be real are the high total catch of shiners especially the Tennessee shiner (*Notropis leuciodus*), the bluegill (*Lepomis macrochirus*) outnumbering the tolerant redbreast sunfish for the first time, and the continuing decline in numbers of the omnivorous river chub (*Nocomis micropogon*), a trend which has been constant at this site since 1998.

On the other hand, the increase in numbers of the exotic yellowfin shiner (*Notropis lutipinnis*) is not a positive indicator. It is, however, in line with what is occurring on moderately to heavily sedimented sites throughout the watershed above Lake Emory.

This site is characterized by heavy sedimentation and lack of habitat other than that provided by woody debris along the shoreline. Much of this habitat was unavailable at the date of sampling in 2002 (July 11) due to low water. Nevertheless, catch rate was higher than normal, and the size of the sample (409 fish) was the largest ever taken here. Curiously, this coincided with the lowest number of native species (15) and total species (18) ever taken here. The difference was largely made up by "incidental" species, rarely taken at this site. The only expected species missing was the mountain brook lamprey (*Ichthyomyzon greeleyi*) taken every year since 1996.

In 2000, a ca. 6 inch long *Necturus* salamander was captured from a muddy backwater at this site. Although the theoretical range of *Necturus* includes the upper Little Tennessee watershed, it was not previously reported from the watershed. This year we took another *Necturus* of the same size from the same spot.

Table 13. Cullasaja River at Macon Middle School (RM 0.9)

Species and Numbers of Fish Taken

Species	Number of Individuals Taken	
	2001	2002
Mountain brook lamprey	3	
Central stoneroller	2	13
Smoky dace		
Whitetail shiner	41	26
Common carp		
Warpaint shiner	22	82
River chub	18	11
Golden shiner		
Tennessee shiner	35	124
Yellowfin shiner	4	11
Silver shiner		

Mirror shiner	5	20
Telescope shiner		
Fatlips minnow		*
Creek chub	5	
White sucker		
Northern hogsucker	1	12
Golden redhorse	1	2
Black redhorse		
Snail bullhead		
Rock bass	4	7
Redbreast sunfish	19	20
Green sunfish	1	
Warmouth	2	
Bluegill	7	33
Smallmouth bass		**
Largemouth bass	1	2
Tuckaseigee darter		
Greenfin darter	1	
Yellow perch		2
Gilt darter	8	25
Olive darter		
Mottled sculpin	17	19
TOTALS	198	409

* Represented by several young-of-the-year - included in species counts but not in other metrics
** Represented by a single young-of-the-year - included in species counts but not in other metrics

Metrics and Scoring (scored as for sites draining 40-70 sq. mi.)

Metric	2001 Observed value	2001 Score	2002 Observed value	2002 Score
1. No. native species	18	3.3	15	3.3
2. No. darter species	2	3.3	1	3.3
4. No. sucker species	2	5.5	2	5.5
5. No. intolerant species	1	3.3	2	3.3
6. % individuals as tolerants	12.1	3.3	4.9	5.5
7. % individuals as omnivores & herbivores	14.1	5.5	5.9	5.5
8. % individuals as specialized insectivores	57.1	5.5	67.7	5.5
9. No. piscivore species	1	5.5	3	5.5
10. Catch per unit effort	4	1.1	6.8	1.1
11. % individuals as darters & sculpins	13.1	1.1	10.8	1.1
12. % individuals w. disease or anomaly	6.1	1.1	2.4	3.3
TOTALS		38.5 POOR		42.9 FAIR

Fixed Station 7 – Cartoogechaye Creek at Macon County Rec Park (RM 1.0) (Table 14)

Our 2001 report (McLarney, in prep.) commented on the poor quality of sampling at the Rec Park site that year and concluded that "There is a particular need for a high quality monitoring effort at this site in 2002." This was achieved, and the result is not notably different from the previous year, although the Bioclass Rating improved from FAIR to GOOD.

Values for Metrics 7 (% individuals as omnivores and herbivores) and 8 (% individuals as specialized insectivores) were both very near the threshold for assigning the medium (3.3 points) or high (5.5) score. Metric 7, which had an observed value of just below the threshold of 15% in 2001 (14.5%) and so scored high, came out at !5.3 % in 2002, lowering the score. Metric 8 was less equivocal in 2001, with an observed value of 41.8% well below the expected value of 50%, and barely achieved the higher score in 2002, with an observed value of 50.3%. Thus, in their effect on the IBI, the two metrics cancel each other out.

The determining factor in raising the IBI score was Metric 4 (number of sucker species), so that the key was the capture of a single specimen of the tolerant white sucker (*Catostomus commersoni*). The IBI score thus achieved (47.3) falls just below the level requiring a GOOD Bioclass Rating. The GOOD rating was awarded on the basis of being consistent with historic ratings for this site. Note that by capturing or failing to capture just a few more fish, Metrics 4, 7 and 8 could all have been scored differently, with a possible range of IBI scores from 42.9 to 49.5.

This site will be carefully watched in years to come. Following a temporary drop in IBI and Bioclass Rating in 1998 (to 40.7, FAIR) related to an upstream pollution problem which was corrected, Cartoogechaye Creek at the Rec Park has largely recovered, but beginning in 2000, there have been two disturbing trends.

- There has been a large increase in observed values for Metric 12 (% individuals with disease or anomaly). Observed values for this metric over these 3 years have been 14.2, 10.5 and 11.0%, with the increase attributable to severe infestations of blackspot on river chubs (*Nocomis micropogon*) and Tennessee shiners (*Notropis leuciodus*). (This trend has been observed at all upstream sites on Cartoogechaye Creek as well, extending upstream at least to RM 12.)

- Observed values and scores for Metric 11 (% of individuals as darters and sculpins) have dropped over the same period. Prior to 2000, we customarily collected samples over 50% of which were composed of darters and sculpins, but the percentages for 2000-2002 are 41.5, 30.3 and 39.7%, respectively. This may reflect greater sedimentation of riffles at the site.

Other notable observations from the 2002 sample include:

- A decline in numbers of the bluegill (*Lepomis macrochirus*) from a record high of 34 in 2001 to normal levels (5) in 2002. This tends to confirm the suspicion that the 2001 catch was largely composed of pond escapees.

- 2002 marked the first capture of a yellow perch (*Perca flavescens*) in the Cartoogechaye Creek watershed. (See "Comments on Individual Species".)

- In 2002, 6 other species recorded their highest numbers ever at the Rec Park site (whitetail shiner, *Cyprinella galactura*; Tennessee shiner, *Notropis leuciodus*; fatlips minnow, *Phenacobius crassilabrum*; smallmouth bass, *Micropterus dolomieui* and greenfin darter, *Etheostoma chlorobranchium*). The increase by the greenfin darter was particularly impressive, from a previous high of 42 in 1999, to 55 individuals.

- Capture of an olive darter (*Percina squamata*) is always significant. In this instance it was taken from a jumble of broken masonry which had been dumped in the creek – the same site at which we captured an olive darter in 2000.

Table 14. Fixed Station 7 - Cartoogechaye Creek at Macon Count Rec Park (RM 1.0)

Species and numbers of fish taken

Species	Number of individuals taken	
	2001	2002
Mountain brook lamprey	2	2
Rainbow trout		
Brown trout		
Brook trout		
Central stoneroller	18	37
Smoky dace		
Whitetail shiner	22	33
Common carp		
Warpaint shiner	19	32
River chub	32	45
Tennessee shiner	73	101
Yellowfin shiner	26	16
Mirror shiner	5	10
Fatlips minnow	1	7
Blacknose dace		
Creek chub	1	
White sucker		1
Northern hogsucker	5	16
Black redhorse		
Golden redhorse		
Brown bullhead	2	
Snail bullhead		

Rock bass	4	9
Redbreast sunfish	20	18
Green sunfish;		
Warmouth		1
Bluegill	34	5
Smallmouth bass		2
Largemouth bass	1	
Black crappie		
Tuckaseigee darter	1	4
Greenfin darter	20	55
Yellow perch		1
Gilt darter	18	38
Olive darter		1
Mottled sculpin	76	123
TOTALS	380	557

Metrics and Scoring

Metric	2001		2002	
	Observed value	Score	Observed value	Sc
1. No. native species	18	5.5	18	5.5
2. No. darter species	3	5.5	4	5.5
4. No. sucker species	1	3.3	2	5.5
5. No. intolerant species	2	3.3	2	3.3
6. % individuals as tolerants	6.1	5.5	3.4	5.5
7. % individuals as omnivores & herbivores	14.5	5.5	15.3	3.3
8. % individuals as specialized insectivores	41.8	3.3	50.4	5.5
9. No. piscivore species	2	5.5	3	5.5
10. Catch per unit effort	10.1	3.3	11.3	3.3
11. % individuals as darters & sculpins	30.3	3.3	39.7	3.3
12. % individuals w. disease or anomaly	10.5	1.1	11.0	1.1
TOTALS		45.1		47.3
		FAIR		GOO

Fixed Station 8 – Middle Creek at West Middle Creek Rd. (formerly Six Springs Rd.) (RM 2.2) (Table 15)

This remarkably stable site has received a GOOD Bioclass Rating every year since 1992, with a score of 49.5 for the last 4 years and during 8 of the 11 years referred to. Most of the tentative trends which might have positively or negatively influenced the IBI have not panned out.

One clear trend, however, is the decline of the longnose dace (*Rhinichthys cataractae*). The highest number of individuals of this species (22) was recorded in 1990, the first year of sampling, the only year in which Middle Creek did not rate GOOD, and the year in which the total number of fish in the sample (126) was lowest. With one exception, the number of longnose dace taken remained in the teens, until 1999, when it dropped precipitously from 14 the previous year to 2; the numbers recorded each year since then are 2, 1 and 0 in 2002. There is no apparent explanation for this phenomenon, given the lack of apparent change to the site, including an abundance of the high velocity riffles favored by this species.

Table 15. Middle Creek at West Middle Creek Rd. (formerly Six Springs Rd.) (RM 2.2)

Species and numbers of fish taken

Species	Number of individuals taken	
	2001	2002
Rainbow trout	7	3
Brown trout	4	
Central stoneroller	28	32
Smoky dace	21	25
Warpaint shiner	7	18
River chub	28	23
Tennessee shiner	85	58
Yellowfin shiner	18	18
Mirror shiner	3	3
Telescope shiner		
Fatlips minnow	2	5
Blacknose dace	5	2
Longnose dace	1	
Creek chub	13	4
White sucker		
Northern hogsucker	8	7
Rock bass		1
Redbreast sunfish	3	1
Green sunfish	1	1
Tuckaseigee darter	2	1
Greenfin darter	1	
Gilt darter	7	7
Mottled sculpin	476	536
TOTALS	720	745

Metrics and Scoring

Metric	2001

	Observed value	Score	Obs valu	S
1. No. native species	16	6.7	14	6.7
2. No. darter species	3	6.7	2	4.0
5. No. intolerant species	2	4.0	2	4.0
6. % individuals as tolerants	2.4	6.7	0.8	6.7
7. % individuals as omnivores & herbivores	10.3	4.0	8.2	6.7
8. % individuals as specialized insectivores	17.9	1.3	15.7	1.3
10. Catch per unit effort	34.1	6.7	35.3	6.7
11. % individuals as darters & sculpins	67.4	6.7	73.0	6.7
12. % individuals w. disease or anomaly	0.7	6.7	0.0	6.7
TOTALS		49.5 GOOD		49.5 GOO

Fixed Station 9 – Cullasaja River at Peaceful Cove Rd. (RM 8.3) (Table 16)

2002 marks the first time in 11 seasons of monitoring that this site has not received a GOOD Bioclass Rating. However, the change in score may not be significant, depending as it does on a 4.1% increase in the proportion of individuals as omnivores and herbivores (Metric 7). What is perhaps more indicative, or at least more disturbing, is the long term trend in IBI score and two individual metrics.

- During 1991-1997 the range of IBI scores was 49.5 – 53.9, (all GOOD)with a median value of 51.7. During 1998-2002 the range was 45.1- 51.7 (with one FAIR score) and the median was 47.3, on the cusp between FAIR and GOOD.

- During 1991-1997 the proportion of omnivores and herbivores in the sample ranged from 6.6 – 17.2%, with a mean value of 12.7%. During 1998-2002, the range was 10.0 – 32.0%, with a mean of 23.0%. (During the last 3 years, the corresponding numbers are 25.5 – 32.0 % and 28.5%)

- During 1991-1997 the proportion of darters and sculpins in the sample ranged from 66.1 – 79.5%, with a mean value of 70.1%. During 1998-2002, the range was 38.7 – 66.7%, with a mean 48.4%.

At least 4 species appear to show long term trends toward greater frequency in the sample. Most notable is the central stoneroller (*Campostoma anomala*), which recorded a record high catch of 132 individuals in 2002. The list also includes the river chub (*Nocomis micropogon*), the rock bass (*Ambloplites rupestris*) and the whitetail shiner (*Cyprinella galactura*), which was not seen at Peaceful Cove before 1997.

Perhaps more significant is the drop in numbers of darters. Mean numbers of all 4 common darter species at Peaceful Cove were lower during 1998-2002 than during 1991-1997, but the drop was most pronounced for the intolerant wounded darter (*Etheostoma vulneratum*), which has a limited distribution in the Little Tennessee and Cullasaja Rivers. During the earlier period numbers of wounded darters in the sample ranged from 12-25, with a mean of 19.8 individuals. During 1998-2002 the range was 6-9, with a mean of 7.2.

2002 was the second time an olive darter (*Percina squamata*) was taken at this site, and the first record for the yellow perch (*Perca flavescens*). (See “Comments on Individual Species.)

Table 16. Cullasaja River at Peaceful Cove Rd. (RM 8.3)

Species taken and numbers

Species	Numbers of fish taken	
	2001	200
Mountain brook lamprey	4	10
Rainbow trout	(1)*	
Brown trout	(5)*	
Brook trout	(2)*	
Central stoneroller	83	132
Whitetail shiner	7	10
Warpaint shiner	26	44
Golden shiner		
Tennessee shiner	66	75
Mirror shiner	23	8
Fatlips minnow	1	1
Longnose dace	1	
River chub	41	41
Creek chub		
Northern hogsucker	2	8
Black redhorse		
Golden redhorse	2	1
Rock bass	9	14
Redbreast sunfish	1	1
Green sunfish		1
Warmouth		
Bluegill		4
Smallmouth bass		1

Tuckaseigee darter	8	13
Greenfin darter	40	38
Wounded darter	9	6
Banded darter		
Yellow perch		1
Gilt darter	11	6
Olive darter		1
Mottled sculpin	125	157
TOTALS	459	573

* Rainbow and brook trout and at least some of the brown trout were stockers, not included in scoring

Metrics and scoring

Metric	2001		200	
	Observed	Score	Obs	Score
1. No. native species	17	5.5	20	5.5
2. No. darter species	4	5.5	5	5.5
4. No. sucker species	2	5.5	2	5.5
5. No. intolerant species	3	5.5	3	5.5
6. % individuals as tolerants	0.2	5.5	0.4	5.5
7. % individuals as omnivores & herbivores	27.9	3.3	32.	1.1
8. % individuals as specialized insectivores	41.8	3.3	35.	3.3
9. No. piscivore species	1	5.5	3	5.5
10. Catch per unit effort	8.6	3.3	12.	3.3
11. % individuals as darters & sculpins	42.0	3.3	38.	3.3
12. % individuals w. disease or anomaly	11.3	1.1	7.9	1.1
TOTALS		47.3		45.1
		GOOD		FAIR

Fixed Station 10 – Wayah Creek at Crawford Rd. (RM 0.6) (Table 17)

In 2002, Wayah Creek showed an apparent recovery from an all time low IBI score of 38.7 (Bioclass Rating FAIR) in 2001. The 2002 score (46.8) falls between the obligate Fair and Good scoring ranges, but we have decided to retain the FAIR bioclass rating because it is the more conservative course to retain the previous rating. (Wayah Creek has not rated GOOD since 1997) and because on 2 previous occasions when it scored 46.8 (1990 and 1999) the FAIR rating was assigned.

In late 2001 the Wayah Valley was connected to the Franklin municipal Waste Water Treatment Plant, eliminating the need for a package treatment plant at the LBJ Job Corps Center, located 1.7 mi. upstream of the fixed station. In past years there have been frequent complaints of malfunctions and reported fish kills related to the Job Corps plant, and it has been suggested that this is the reason for the absence or extreme rarity of several expected fish species from a site with much better than average physical habitat quality. There may eventually be tradeoffs related to induced development of the Wayah Valley, with attendant new stresses on the creek, but in the short run at least, we hope to see positive changes.

In terms of species diversity these changes may have begun to occur a few years ago, as the quality of management of the Job Corps plant reportedly improved. The Tennessee shiner (*Notropis leuciodus*) had not been seen at the site since a single individual was taken in the first sample in 1990, but has been present (albeit in very small numbers) in 2001 and 2002. The warpaint shiner (*Luxilus coccogenis*) was not known from the site prior to 1997, began to occur sporadically in 1997-1999, and has been present in fair (and increasing) numbers since 2000. However, we still await the return of the intolerant gilt darter (*Percina evides*), common just 0.6 mi. downstream in Cartoogechaye Creek.

A concurrent change which will not be seen positively by all is the abrupt decline in numbers and size of brown trout (*Salmo trutta*). From 1996-2001 samples included 6-17 brown trout, with some of them trophy size. Size began to decline around 2000, and in 2002 the entire catch consisted of 2 juveniles.

The unusually healthy brown trout population was probably related to the hyper-abundance of the mottled sculpin (*Cottus bairdi*), which may in turn have been related to nutrient enrichment by the treatment plant. The number of sculpins in the sample (431) was the lowest since 1990 (when the entire sample was small). Taken as a percentage of the total catch, sculpins are still strongly dominant, but 2001 and 2002 saw the two lowest proportions of sculpin numbers to total fish catch - 60.6 and 71.7%, as compared to 73.3 – 87.8% in previous years (mean 80.6%) in 7 previous years.

2002 saw the highest number of native fish species ever recorded at this site – 15, including the first record of the black redhorse, *Moxostoma duquesni*.

It is still too early to say whether the biotic integrity of lower Wayah Creek is improving, or if our data simply reflect oscillation within a normal range in a moderately unstable assemblage of fishes.

Table 17. Wayah Creek at Crawford Rd. (RM 0.8)

Species and numbers taken

Species	Number of individuals taken	
	2001	2002

Mountain brook lamprey	1	10
Rainbow trout	2	1
Brown trout	16	2
Central stoneroller	97	41
Smoky dace	27	13
Warpaint shiner	9	14
River chub	26	15
Tennessee shiner	1	2
Mirror shiner	13	3
Blacknose dace	68	31
Longnose dace	21	23
Creek chub		1
Northern hogsucker	3	1
Black redhorse		1
Golden redhorse		
Rock bass	1	2
Redbreast sunfish		
Tuckaseigee darter	2	3
Greenfin darter	9	8
Mottled sculpin	455	431
TOTAL	751	602

Metrics and scoring

Metric	2001		200 Obs	
	Observed value	Score	valu	S
1. No. native species	14	6.7	15	6.7
2. No. darter species	2	4.0	2	4.0
5. No. intolerant species	2	4.0	2	4.0
6. % individuals as tolerants	0.0	6.7	0.1	6.7
7. % individuals as omnivores & herbivores	25.6	1.3	16.3	4.0
8. % individuals as specialized insectivores	10.9	1.3	11.0	1.3
10. Catch per unit effort	35.6	6.7	24.1	6.7
11. % individuals as darters & sculpins	62.5	4.0	73.5	6.7
12. % individuals w. disease or anomaly	3.5	4.0	1.3	6.7
TOTALS		38.7 FAIR		46.8 FAI

Fixed Station 11 – Skeenah Creek at North Carolina Welcome Center (RM 0.5) (Table 18)

This site is normally done as part of the North Carolina Center for the Advancement of Teaching's "Natural Rhythms of the River" course. The Skeenah Creek site was made a fixed station because it is ideal for this purpose, and not for biological reasons. Due to time restraints and the necessity to devote extra time to teaching we have made some modifications in the biomonitoring methodology to accommodate this course. Individual subsamples are fewer and longer, and are worked a bit more rapidly. While the results appear satisfactory we have not had an opportunity to compare this methodology with our standard methods until 2002.

In 2002, due to the state budget crisis, the course was not offered, and we monitored the Skeenah Creek site with a very small crew (4 persons) using normal methodology. The only noticeable positive difference was reduced fish mortality. The IBI score was identical to that recorded for 2001 (30.0) and the number of individual fish and fish species was comparable to other years.

The results suggest that the sharp drop in IBI recorded between 2000 and 2001 (39.0 to 30.0 , with Bioclass Rating dropping from FAIR to POOR), was not anomalous. The reduced score in 2001 was occasioned by sharp drops in Metrics 6 (% tolerants) and 8 (% specialized insectivores). Observed values for both of these metrics were poorer in 2002 than in 2000, but better than in 2001. This would be consistent with the hypothesized source of the problem – sedimentation related to construction of the new Union School less than a mile upstream. The worst of the damage may have occurred, and flushing of sediments may be occurring. However, Skeenah Creek is far from "recovery", even to its previous Fair condition, as evidenced by:

- Abundance of the exotic yellowfin shiner (*Notropis lutipinnis*), with some degree of hybridization with the native warpaint shiner (*Luxilus coccogenis*).

- Continued high abundance of the tolerant, exotic redbreast sunfish (*Lepomis auritus*) at levels not seen here before 2001.

- Continued scarcity of intolerant species, represented in 2002 only by 2 smoky dace (*Clinostomus* sp.). (The rock bass, *Ambloplites rupestris* was present, but all 10 individuals captured were small juveniles, which are not counted as intolerants.)

One change which might be interpreted positively is the decline in abundance of the herbivorous central stoneroller (*Campostoma anomala*). This species recorded its highest abundance here in 1994, with 122 individuals, but numbers of stonerollers declined to 6 in 2001 and 0 in 2002. This may be a consequence of increased shade (from trees planted along the left bank, on the Welcome Center property) reducing sunlight available for algal growth.

In 2002 we plan to check on the Union School – sedimentation hypothesis by monitoring a site on Skeenah Creek upstream of the school.

Table 18. Skeenah Creek at North Carolina Welcome Center (RM 0.5)

Species and Numbers of Fish Taken

Species	Number of individuals taken		
	2000	2001	200
Mountain brook lamprey	7	3	8
Rainbow trout			
Brook trout			
Central stoneroller	13	6	
Smoky dace	7	1	2
Whitetail shiner			
Warpaint shiner	51	14	26
River chub	59	22	33
Tennessee shiner	23	9	16
Yellowfin shiner	94 *	34	
Fatlips minnow			
Creek chub	3	3	6
White sucker		3	
Northern hogsucker	6	7	9
Black redhorse			
Golden redhorse		2	
Brown bullhead			
Rock bass	10	13	10
Redbreast sunfish	25	52	53
Green sunfish	1	1	2
Warmouth	1		
Bluegill	1		2
Tuckaseigee darter			
Greenfin darter	4		1
Gilt darter			
Mottled sculpin	120	58	86
TOTALS	425	228	387

* Includes 4 probable hybrids with warpaint shiner in 2000 and 3 in 2002, scored as yellowfins.

Metrics and Scoring

Metric	2000	2001	200

	Observed value	Score	Observed value	Score	Obs val	Score
1. No. native species	13	7.5	13	7.5	12	7.5
5. No. intolerant species	2	4.5	2	4.5	1	1.5
6. % individuals as tolerants	6.8	7.5	26.3	1.5	15.	4.5
7. % individuals as omnivores & herbivores	19.3	4.5	16.2	4.5	12.	4.5
8. % individuals as specialized insectivores	20.0	4.5	10.5	1.5	11.	1.5
10. Catch per unit effort	32.9	7.5	18.5	7.5	23.	7.5
11. % individuals as darters & sculpins	29.2	1.5	25.4	1.5	22.	1.5
12. % individuals w. disease or anomaly	6.4	1.5	11.4	1.5	5.4	1.5
TOTALS		39.0 FAIR		30.0 POOR		30.0 POOR

Fixed Stations 12 and 13 – Sutton Branch at Rabun Gap-Nacoochee School (RM 0.0 and 0.5) (Table 19)

These two sites, monitored annually since 1998, but first listed as Fixed Stations in 2001, may be removed from the list of Fixed Stations, but not necessarily for the reason suggested in our previous report (McLarney, in prep. b). It appears that problems with timely analysis of macroinvertebrate samples will be resolved, but in the case of Sutton Branch, the rationale for incorporating it as a Fixed Station has been thrown into question.

The two Sutton Branch sites were considered for Fixed Station status because of our interest in following the progress of a stream restoration project on a stream small enough to yield measurable results in a short period of time. Based on results since 1998, with both sites oscillating within a fairly narrow range (26-38) of IBI scores, always judged as falling within the POOR Bioclass, Sutton Branch is not being successfully restored, at least not in terms of biotic integrity, and in fact biotic integrity may be declining slightly.

If restoration is in fact not occurring, it is not the fault of restoration measures per se. Fencing has been effective in keeping cattle out of most of the stream length in both sectors. Survival of planted trees and shrubs in the riparian zone has been high, and is complemented by natural regeneration of native vegetation (with selective management and removal of exotics.) The experimental method of placing large rocks in the stream as "nuclei" for colonization by aquatic insects seems to be working.

However, it is noteworthy that cattle still have access to the stream at two points, one located near the upper end of each of the monitoring sections. Above the upper end of the lower reach and just downstream of Neville Rd. (unpaved) cattle have access from both banks. On two occasions we have noticed a great increase in turbidity and a modest increase in water level around midday when the air temperature rises and cattle seek drinking water and immerse themselves in the creek. The observable changes are undoubtedly accompanied by spikes in nutrient levels. And just above the upstream end of the upper site, a farm road crosses Sutton Branch at a point where cattle gain entry. The combination of the dirt road and denuded bank where cattle access the stream is clearly a tremendous erosion source, and of course cattle occasion the same problems as at the lower site. Above this point, Sutton Branch passes for perhaps 0.2 mi. through unfenced, unbuffered pasture.

Ongoing research carried out by Coweeta Hydrological Laboratory (personal communication, Jim Vose) shows that fencing and establishment of a vegetative buffer have dramatically reduced the flux of nutrients to Sutton Branch from the adjacent pasture. However, the Coweeta Lab work has not included in-stream measurement of nutrient levels. Our data underline the point that you can't fully restore a stream unless you restore it all. While the combined effort of Rabun Gap-Nacoochee School and Coweeta Lab on Sutton Branch provides a convincing demonstration of the effectiveness of certain Best Management Practices and other restorative measures, our biomonitoring work suggests that, in terms of the aquatic system the net effect has been to concentrate (and maybe even increase) nutrient inputs.

If these problems are corrected by some time during the 2003 monitoring season, we may continue to monitor Sutton Branch as a Fixed Station. Otherwise it will probably be discontinued until such time as they are corrected.

While the extremely high catch rate recorded at both sites in 2001 was not repeated in 2002, resulting in improvement in Metric 4, and while the incidence of disease and anomalies (Metric 5) dropped significantly at RM 0.0, observed values for Metrics 6 (proportion of individuals as tolerant species) and 8 (proportion of individuals as omnivores and herbivores) remain poor at both sites.

As in 2001, the fish community at the upper site remained singularly undiverse, comprising only 3 species – down from as many as 6 in previous years. There is at least an argument (Scott and Helfman, 2001) for interpreting this change in a positive way.

The macroinvertebrate data are more ambivalent. The number of Ephemeroptera taxa recorded at both sites was similar for 2001 and 2002 and yielded a high score for RM 0.0 and a medium score for RM 0.5. There is no apparent hypothesis to explain why the downstream site should have a more diverse mayfly fauna. EPT count, and the score derived from it, declined at RM 0.0 and improved at RM 0.5 over the period 2001-2002. Again there is no apparent reason.

Superficial inspection of the macroinvertebrate data from earlier years when the quality of analysis of the collections was much better than for 2001 makes a case for ongoing degradation. (In 2001 identification was taken only to family level, although the number of visibly different taxa in each family was noted.) Number of Ephemeroptera taxa and EPT count for RM 0.0 in 2000 were, respectively, 11 and 21. The corresponding figures for RM 0.5 were 14 and 26. All of these figures are significantly higher than for 2001 or 2002, and in the case of RM 0.5, they elevate the IBI score by 3-6 points.

The only macroinvertebrate fauna unique to Sutton Branch in our samples were the Perlid stonefly *Eccoptura xanthenes* and the Tipulid *Ormosia* sp., both represented by single specimens from RM 0.5.

Before making overmuch of the comparative data across years, it would be well to point out some inconsistencies. The EPT taxa listed in parentheses in Table 19 are those which were identified in 2000, but not in 2001 or 2002; they include 10 mayflies, 3 stoneflies and 5 caddisflies, for a total of 18 EPT taxa. At the same time, 11 EPT taxa reported for 2001 and/or 2002 do not appear in the list from 2000. Even allowing for differences in nomenclature, the degree of inconsistency is disturbing, and makes it difficult to state with confidence that there was greater diversity of Ephemeroptera and EPT taxa at both sites in 2000 than in 2001 or 2002.

The clearest statement which can be made is that the health of the biotic community at both sites on Sutton Branch has so far not risen consistently risen above POOR. Thus the effectiveness of restoration efforts to date is at best partial, and vulnerable to continuing degradation.

Table 19. Sutton Branch at Rabun Gap - Nacoochee School (RM 0.0 and 0.5)

Species and Numbers of Fish Taken

Species	Number of individuals taken			
	RM 0.0		RM 0.5	
	2001	2002	2001	200
Mountain brook lamprey	2	2		
Central stoneroller	13	4		
Smoky dace	65	36	80	19
River chub	2	1		
Tennessee shiner				
Yellowfin shiner	6	4		
Mirror shiner				
Creek chub	58	34	68	80
Rock bass	5	4		
Redbreast sunfish				
Green sunfish				
Mottled sculpin	15	24	7	33

TOTALS			166	109	155	132	

Macroinvertebrate sample results (2001 results as presence/absence for EPT groups only)
EPT taxa in parentheses were identified in 2000, but not in 2001 or 2002.

				RM 0.0 2001	200	RM 0.5 2001
Turbellaria						
	Tricladida					
		Planariidae				
			Cura foremanii			
Bivalvia						
	Veneroidea					
		Sphaeridae				
			Pisidium sp.		8	
Gastropoda						
	Mesogastropoda					
		Pleuroceridae				
			Elimia sp.		22	
	Bassommatophora					
		Physidae				
			Physella sp.		1	
Oligochaeta						
	Haplotaxida					
		Lumbricidae			4	
		Naididae				
			unid.			
			Nais behningi			
			N. communis			
			Slavina appendiculata			
			Vejdovskyella comata			
	Lumbruculida					
		Lumbriculidae				
Arachnoidea						
	Acariformes					
		Hgrobatidae				
			Atractides sp.		1	
Crustacea						
	Decapoda					
		Cambaridae			pres	
			Cambarus bartoni			
Insecta						
	Ephemeroptera					
		Baetidae				

		unid.	3		1
		Baetis sp.		25	
		B. intercalaris		1	
		(*B. pluto* - both sites)			
		(*Pseudocloeon propinquus* - both sites)			
	Ephemerellidae				
		unid.	2		2
		(Attenella attenuata - RM 0.5)			
		(Ephemerella catawba - RM 0.5)			
		Serratella sp.		6	
		(S. deficiens - both sites)			
	Ephemeridae				
		Ephemera sp.	1		
	Heptageniidae				
		unid.			1
		(*Epeorus rubidus/subpallidus* - RM 0.0)			
		Stenacron interpunctatum			
		(S. meririvulanum- RM 0.5)			
		(S. pallidum - RM 0.0)			
		Stenonema modestum		105	
		S. terminatum			
	Isonychiidae				
		unid.	1		
		Isonychia sp.		5	
	Leptophlebiidae				
		unid.	1		
		(*Habrophlebiodes* sp. - RM 0.5)			
		Paraleptophlebia sp.		14	
		(P. adoptiva/mollis - both sites)			
	Oligoneuridae				1
Odonata					
	Aeshnidae				
		Boyeria vinosa		3	
	Calopterygidae				
		Calopteryx sp.		7	
	Coenagrionidae				
		Argia sp.		3	
	Cordulegastridae				
		Cordulegaster sp.		4	
	Gomphidae				
		Gomphus sp.		1	
		Lanthus sp.			
		Stylurus sp.		1	
Plecoptera					
	Leuctridae				

		unid.	1		
		Leuctra sp.		9	
	Peltoperlidae				
		Tallaperla sp.			
	Perlidae				
		Eccoptura xanthanes (*Perlesta* sp. - RM 0.0)			
	Perlodidae				
		unid.			1
		Isoperla sp.		1	
		(*I. holochlora* - both sites)			
		Remensus bilobatus			
	Pteronarcidae				1
		(*Pteronarcys proteus* sp. gp. - RM 0.0)			
Megaloptera					
	Corydalidae				
		Nigronia fasciatus		2	
Trichoptera					
	Glossosomatidae				
		unid.	1		
		Glossosoma sp.			
	Hydropsychidae				
		unid.	3	2	1
		Cheumatopsyche sp.		2	
		Diplectrona modesta			
		Hydropsyche sp.			
		Hydropsyche betteni gp.		1	
	Lepidostomatidae				
		unid.			1
		Lepidostoma sp.			
	Limnephilidae				
		unid.	1		1
		Pycnopsyche sp.		5	
		(*P. guttifer* sp. gp. - RM 0.0)			
		(*P. luculentta* sp. gp. - RM 0.5)			
	Molannidae		1		
	Philopotamidae				
		unid.	1		
		Dolophilodes sp.		1	
	(Polycentropidae)				
		(*Polycentropus* sp. - RM 0.5)			
	Psychomyiidae				
		Lype diversa			
	Ueonidae				
		unid.	1		1
		Neophylax sp.		5	
		(*N. auris/etnieri* - RM 0.5)			

		(*N. ornatus* - RM 0.0)	
Coleoptera			
	Elmidae		
		Optioservus sp.	6
		O. ovalis	4
		O. trivittatus	2
		Promoresia sp.	
		P. tardella	2
		Stenelmis sp.	19
	Ptilodactylidae		
		Anchytarsus bicolor	2
	Staphylinidae		
Diptera			
	Ceratopogonidae		
		Atrichopogon sp.	1
		Bezzia/Palpomya gp.	4
	Chironomidae		
		Chironomus sp.	
		Cricotopus sp.	1
		Cryptochironomus fulvus	1
		Eukiefferiella claripennis grp.	3
		Macropelopia sp.	1
		Odontomesa fulva	
		Pagastia orthogonia	1
		Pareleuterborniella nigrohalteralis	
		Parametriocnemus lundbecki	2
		Paratendipes sp.	
		Phaenopsectra sp.	1
		Polypedilum fallax	
		P. flavum (convictum)	8
		P. halterale	1
		P. illinoense	1
		Prodiamesa olivacea	
		Rheocricotopus robacki	
		R. tuberculatus	
		Rheotanytarsus sp.	1
		Tanytarsus sp.	5
		Thienemanniella xena	
		T. gp.	3
		Tribelos sp.	1

		Tvetenia bavarica gp.		1	
		Zavrelimyia sp.		1	
	Dixidae				
		Dixa sp.			
	Dolocopodidae				
	Simulidae				
		Simulium sp.		62	
	Tabanidae				
		Tabanus sp.			
	Tipulidae				
		Omosia sp.			
		Tipula sp.		6	
TOTAL ORGANISMS				394	
TOTAL TAXA				56	
EPT taxa			16	14	11
Ephemeroptera taxa			8	6	5

Metrics and Scoring (for parameters for metrics, see Table 8)

Metric	RM 0.0 2001	RM 0.0 2001	RM 0.0 2002	RM 0.0 2002	RM 0.5 2001	RM 0.5 2001	RM 200	RM 0.5 2002
	Observed value	Score	Observed value	Score	Observed value	Score	Obs val	Score
1	8	7.5	6	7.5	5	4.5	5	4.5
2	17	7.5	14	4.5	11	4.5	20	7.5
3	Absent	1.5	Absent	1.5	Absent	1.5	Abs	1.5
4	60.2	4.5	14.6	7.5	93.5	4.5	27.	7.5
5	6.0	1.5	1.8	6.0	0.6	6	0.0	7.5
6	34.9	1.5	31.2	1.5	43.9	1.5	60.	1.5
7	0.0	1.5	0.0	1.5	0.0	1.5	0.0	1.5
8	45.2	1.5	37.6	1.5	43.9	1.5	75.	1.5

TOTALS	27.0	31.5	25.5	33.0
	POOR	POOR	POOR	POOR

Sawmill Creek at Sawmill Creek Rd. (RM 0.1) (Tables 20 and 21)

Sawmill Creek, which drains a watershed area of 3.6 sq. mi., joins the Little Tennessee River at the upper pool level of Fontana Reservoir (downstream limit of our study area). It originates in a moderately settled area upstream of NC Highway 28, and for much of its length is unbuffered, with residential and some agricultural use.

After it crosses NC 28, the creek passes through a low gradient reach frequently dammed by beavers, and enters a small canyon which could be a beauty spot, had it not long functioned as a traditional dump site. Much of this mess was cleaned up by Swain County a few years ago, but some dumping still occurs. The last 0.25 mi. pass through the Needmore Tract.

Sawmill Creek was one of a series of 30 small streams (watershed drainage areas of 1-4 sq. mi.), draining directly to the Little Tennessee, which were monitored in 1995 (McLarney, 1996a; in prep. a). If we had religiously followed the criteria for site selection at that time, the monitoring site would have been further upstream. However, the trash situation was so bad that we were literally afraid of being injured by a falling large appliance – numerous washers, refrigerators, etc. were hung up in the rhododendrons which arch over the stream. The 1995 monitoring site (replicated in 2002) is located downstream of a ford where Sawmill Creek crosses the creek as a 4-wheel drive road, occasioning considerable sedimentation.

The most immediately apparent characteristic of the fish assemblage of Sawmill Creek at this point is the incredible numbers of warpaint shiners (*Luxilus coccogenis*). The warpaint shiner was by far the most abundant fish species in both years, comprising 42.7% of the total sample in 1995 and 74.3% in 2002. Both numbers should be considered approximate, since the warpaint shiners in Sawmill Creek spanned the complete range of sizes, necessitating the exercise of considerable judgement in determining which individuals were young-of-the-year.

A few individuals of the threatened spotfin chub (*Cyprinella monacha*) were found in this reach of Sawmill Creek during a fall, 2001 survey (McLarney, 2001a). This species was neither expected nor found during the summer IBI sample.

The only notable difference between the 1995 and 2002 IBI fish samples is the greatly reduced proportion of omnivores and herbivores (Metric 8) in 2002 (4.2% vs. 22.7%). All three species falling under this metric (Central stoneroller, *Campostoma anomala*; blacknose dace, *Rhinichthys atratulus* and creek chub *Semotilus atromaculatus* had reduced numbers in 2002, with the last species disappearing altogether from the sample.

A total of 17 fish species (both natives and exotics) were taken in the 1995 sample, as compared with 13 upon completion of the planned sample in 2002. Upon observing this difference we decided to qualitatively sample a large pool/run complex located above the ford. In this endeavor we took only 1 additional species, the rainbow trout (*Oncorhynchus mykiss*), represented in the 1995 sample by 2 individuals. Rainbow trout were considered to be present for purposes of scoring Metric 7, i.e. the proportion of wild trout was assumed to be greater than 0%, but these fish were not taken into account in scoring other metrics.

The fish assemblage at this site may be inherently dynamic due to proximity to Fontana Reservoir. In addition to species present in the 1995 IBI sample, but not the 2002 sample (creek chub; fatlips minnow, *Phenacobius crassilabrum*; black redhorse, *Moxostoma duquesni* and bluegill, *Lepomis macrochirus*), the following species have been taken at this site during non-IBI sampling: spotfin chub, golden shiner (*Notemigonus crysoleucas)*, mirror shiner (*Notropis spectrunculus*) and green sunfish (*Lepomis cyanellus*). With the gilt darter (*Percina evides*) observed for the first time in Sawmill Creek during the 2002 IBI sample, the total number of fish species found at this site at one time or another ascends to 26, an unusually high number for such a small stream.

In the field, we noted the macroinvertebrate collection to be sparse, apparently due to the large amount of sand in the substrate, but it turned out to be the second most numerous of 14 samples. Taxonomic diversity appeared to be greater, across the board, than in 1995. However, this is not directly reflected in the IBI since Sawmill Creek scored high for both macroinvertebrate-based metrics in 1995.

The dramatic improvement in Metric 8 resulted in what would normally be interpreted as a significant improvement in biotic integrity in Sawmill Creek between 1995 and 2002. Normally we would be cautious about attributing significance to a change in score based on only one metric. However, note that observed values for metrics 1,2,5 and 6 also improved substantially. Nevertheless Sawmill Creek remains in the FAIR bioclass category.

In the fall, 2001 spotfin chub survey we discovered a strikingly patterned unknown crayfish at this site. On the basis of a single specimen, Dr. John E. Cooper of the North Carolina State Museum tentatively identified it as an exotic *Orconectes*, perhaps introduced to Fontana Reservoir through use as bait. During the IBI sample we found numerous crayfish, with about half of them being the ubiquitous *Cambarus bartoni*, and the other half comprised of the presumptive *Orconectes.* If the unidentified crayfish is in fact an exotic, it could constitute a threat to our native *Cambarus* species.
However, when we returned in the fall to attempt to make a collection which would permit positive identification, all but one of the crayfish collected were *C. bartoni*. Perhaps this crayfish inhabits principally the lake, and moves into the lower reaches of Sawmill Creek in the summer.

Table 20. Sawmill Creek at Sawmill Creek Rd. (RM 0.1)

Species and numbers of fish taken

Species	Number of individuals taken	
	1995	2002
Rainbow trout	2	*
Central stoneroller	29	5
Whitetail shiner	2	23
Warpaint shiner	111	492
River chub	18	20
Tennessee shiner	9	8
Telescope shiner	3	37
Fatlips minnow	3	
Blacknose dace	7	3
Creek chub	5	
Northern hogsucker	13	1
Black redhorse	4	
Golden redhorse	5	1
Bluegill	1	
Smallmouth bass	2	1
Largemouth bass	4	5
Gilt darter		2
Motttled sculpin	42	64
TOTALS	**260**	**662**

* See text

Macroinvertebrate Sample Results (1995 data not available)

Gastropoda				
	Mesogastropoda			
		Pleuroceridae		
			Elimia sp.	17
Annelida				
	Oligochaeta			
		Lumbricidae		8
Insecta				
	Ephemeroptera			
		Baetidae		
			unid.	2
			Baetis sp.	10
			B. intercalaris	1
		Ephemerellidae		
			Eurylophella sp.	1
			Serratella sp.	88
		Heptageniidae		
			unid.	3
			Epeorus rubidus/subpallidus	19

		Heptagenia sp.	6
		Leucrocuta sp.	3
		Stenonema modestum	36
	Isonychiidae		
		Isonychia sp.	17
	Leptophlebiidae		
		Paraleptophlebia sp.	3
Odonata			
	Aeshnidae		
		Boyeria vinosa	8
	Gomphidae		
		Gomphus sp.	2
		Lanthus sp.	4
Plecoptera			
	Leuctridae		
		Leuctra sp.	22
	Peltoperlidae		
		Tallaperla sp.	39
	Perlidae		
		Acroneuria abnormis	20
		Paragnetina immarginata	3
		Perlesta sp.	4
	Pteronarcidae		
		Pteronarcys (Allonarcys) sp.	45
Hemiptera			
	Veliidae		
		Rhagovelia obesa	2
Megaloptera			
	Corydalidae		
		Nigronia serricornis	1
Trichoptera			
	Glossosomatidae		
		Glossosoma sp.	2
	Hydropsychidae		
		unid.	2
		Ceratopsyche sp.	96
		Cheumatopsyche sp.	3
		Diplectrona modesta	99
	Lepidostomatidae		
		Lepidostoma sp.	1
	Limnephilidae		
		Pycnopsyche sp.	3
	Philopotamidae		
		Dolophilodes sp.	12
	Psychomiidae		
		Psychomiia sp.	1
	Rhayacophilidae		

			Rhyacophila fuscula	15
		Ueonidae		
			Neophylax sp.	9
	Coleoptera			
		Elmidae		
			Macronychus glabratus	1
			Optioservus ovalis	3
			Stenelmis sp.	7
		Hydrophilidae		
			Sperchopsis tesselatus	12
		Psephenidae		
			Psephenus herricki	17
		Staphylinidae		1
	Diptera			
		Chironomidae		
			Cryptochironomus fulvus	1
			Microtendipes sp.	2
			Pagastia orthogonia	1
			Parametriocnemus lunbergi	2
			Polypedilum illinoense	3
			Prodiamesa olivacea	1
			Psectrocladius sp.	2
			Rheotanytarsus sp.	1
			Robackia demeijerei	1
			Tanytarsus sp.	5
			Thienemannimiyia gp.	1
			Tvetenia bavarica gp.	6
		Simuliidae		
			Simulium sp.	1
		Tabanidae		
			Tabanus sp.	1
		Tipulidae		
			Dicranota sp.	13
			Tipula sp.	2
Total organisms				702
Total taxa				61
Ephemeroptera taxa				13
EPT count				31

Metrics and Scoring

Metric	**1995 Observed**	**Score**

	value	
1. No. Ephemeroptera taxa	9	7.5
2. No. EPT taxa	20	7.5
3. Brook trout presence	Absent	1.5
4. Catch per unit effort	59.1	4.5
5. % individuals w. disease or anomaly	1.9	6.0
6. % individuals as tolerant species	1.9	7.5
7. % individuals as wild trout	0.8	4.5
8. % individuals as omnivores & herbivores	22.7	1.5
TOTAL		**40.5**
		FAIR

* See text

Table 21. Selected Physical Parameters of Sawmill Creek at Sawmill Creek Rd. (RM 0.1)

Watershed area at site (sq. mi.)	3.6
Width (ft.)	
Mean	14.5
Range	11 to 21
Mean depth (ft.)	
Riffles	0.6
Runs	0.7
Pools	1.3
Maximum depth	1.4
Substrate composition (%)	
Bedrock	14
Boulder	14
Rubble	16
Gravel	5
Sand	46
Silt	5
Large Woody Debris	Rare
Canopy cover (%)	80
Raw bank (%)	5
Adjacent land use	
Left bank	wooded road bank, scrub
Right bank	buffered agricultural field, with road

Wiggins Creek at Sutton Lease, off Wiggins Creek Rd. (RM 0.3) (Tables 22 and 23)

Wiggins Creek (total watershed drainage area 2.5 sq. mi.) is one of the Little Tennessee tributaries with the greatest length on the Needmore Tract (1.0 mi.). As a consequence the lower reaches are little developed, although there is an agricultural lease at the monitoring site and a residence across Wiggins Creek Rd. It was included in the 1995 IBI survey of Little Tennessee tributaries with drainage areas of 1-4 sq. mi. (McLarney, 1996a; in prep. a), and revisited in 2002 after several Threatened spotfin chubs (*Cyprinella monacha*) were found at this site in the fall of 2001 (McLarney, 2001a). (None were expected, or found, in the 2002 summer IBI sample.)

The upper reaches of the Wiggins Creek watershed contain some National Forest lands, but in recent years the portion outside the National Forest has been subject to considerable development pressure, much of it on steep slopes. The result is sedimentation and loss of pool habitat in a stream where unstable sand already predominated in the substrate in the pools and slower runs. (See Table 23 for changes in the physical habitat of Wiggins Creek at RM 0.3 between 1995 and 2002.) Nevertheless, in 2002 as in 1995, lower Wiggins Creek contained a strong population of rainbow trout (*Oncorhynchus mykiss*), mostly juveniles but with some “catchable” adults, and all in good condition.

Overall numbers of fish were up from 1995 (more than double, according to our catch per unit effort data). The proportion of both tolerant species (Metric 6) and omnivores and herbivores (Metric 8) was significantly reduced, and the only disease observed in 1995 (fin rot on creek chubs, *Semotilus atromaculatus*) was completely absent.

Perhaps the most significant change in the fish assemblage was the tremendous increase in the number of warpaint shiners (*Luxilus coccogenis*) from 6 to 126. This species in 2002 presented the same problem as in Sawmill Creek – a complete range of sizes so that it was difficult to know where to draw the line between young-of-the-year and small yearlings. However, even if half of the warpaint shiners counted were discounted, it would not affect the IBI score.

Also notable was a modest increase in number (3 to 9) and size diversity of the intolerant telescope shiner (*Notropis telescopus*).

The macroinvertebrate community was slightly more diverse than in 1995, but with a marked dominance by small organisms. One large organism which was abundant, as might be expected with so much sand in the substrate, was the burrowing mayfly *Ephemera*. Megalopterans were represented by a single specimen of *Nigronia* and damselflies were completely absent. Wiggins Creek in 2002 was our first record of the Sericostomatid caddislfy *Fattigia pele* (a single specimen). This was the only one of 14 macroinvertebrate samples taken this year where we did not record a single highly tolerant taxon (rated > 8 in the Hilsenhoff or North Carolina Tolerance Values).

Evidence of increased sedimentation notwithstanding, the biological health of Wiggins Creek appears to have improved from FAIR to GOOD between 1995 and 2002.

Table 22. Wiggins Creek at Sutton Lease, off Wiggins Creek Rd. (RM 0.3)

Species and Numbers of Fish Taken

Species	Number of Individuals Taken	
	1995	2002
Rainbow trout	15	13

Central stoneroller	4	
Whitetail shiner		2
Warpaint shiner	6	126
River chub	2	11
Tennessee shiner	1	4
Telescope shiner	3	9
Blacknose dace	2	28
Creek chub	11	2
Mottled sculpin	31	87
TOTALS	75	282

Macroinvertebrate sample results (1995 data not available)

Turbellaria				
	Tricladida			
		Planariidae		
			Cura foremanii	1
Gastropoda				
	Mesogastropoda			
		Pleuroceridae		
			Elimia sp.	35
	Basommatophora			
		Ancylidae		
			Ferrissis rivularis	1
	Oligochaeta			
		Lumbricidae		13
Crustacea				
	Decapoda			
		Cambariidae		
			Cambarus bartoni	5
Insecta				
	Ephemeroptera			
		Baetidae		
			Baetis sp.	2
			B. c.f. *flavistriga*	1
		Ephemerellidae		
			Drunella sp.	1
			Eurylophella sp.	1
		Ephemeridae		
			Ephemera sp.	26
			Epeorus rubidus/subpallidus	8
			Heptagenia sp.	3
			Stenonema sp.	33
			Stenonema modestum	11
		Isonychiidae		

		Isonychia sp.	5
	Leptophlebiidae		
		Paraleptophlebia sp.	6
Odonata			
	Aeshnidae		
		Boyeria vinosa	1
	Cordulegastridae		
		Cordulegaster sp.	4
	Gomphidae		
		Gomphus sp.	1
		Lanthus sp.	3
Plecoptera			
	Leuctridae		
		Leuctra sp.	16
	Perlidae		
		Acroneuria abnormis	17
	Pteronarcidae		
		Pternoarcys(Allonarcys) sp.	14
Megaloptera			
	Corydalidae		
		Nigronia sp.	1
Trichoptera			
	Hydropsychidae		
		unid.	20
		Cerratopsyche sparna	12
		Cheumatopsyche sp.	1
		Diplectrona modesta	13
	Lepidostomatidae		
		Lepidostoma sp.	4
	Limnephilidae		
		Goera sp.	1
		Pycnopsyche sp.	4
	Philopotamidae		
		Dolophilodes sp.	10
	Psycomyiidae		
		Lype diversa	2
	Rhyacophilidae		
		Rhyacophila fusca	2
	Sericostomatidae		
		Fattigia pele	1
	Uenoidae		
		Neophylax sp.	10
Coleoptera			
	Elmidae		
		Optioservus sp.	2
		Optioservus ovalis	9

		Oulimnius latiusculus	2
		Promoresia sp.	2
	Psephenidae		
		Psephenus herricki	24
	Ptilodactylidae		
		Anchytarsus bicolor	2
Diptera			
	Ceratopogonidae		
		Bezzia/Palpomyia gp.	1
	Chironomidae		
		Epoicocladius sp.	3
		Polypedilum fallax	3
		Prodiamesa olivacea	13
		Rheotanytarsa sp.	14
		Tanytarsus sp.	1
		Tribelos sp.	1
	Dixidae		
		Dixa sp.	2
	Simuliidae		
		Simulium sp.	1
	Tipulidae		
		Dicranota sp.	11
		Tipula sp.	13
TOTAL ORGANISMS			414
TOTAL TAXA			54
No. Ephemeroptera taxa			11
EPT Count			27

Metrics and Scoring

Metric	1995		200 Obs	
	Observed	Score		Score
1. No. Ephemeroptera taxa	11	7.5	11	7.5
2. No. EPT taxa	22	7.5	27	7.5
3. Brook trout presence	Absent	1.5	Abs	1.5
4. Fish catch rate per unit effort	21.0	7.5	45.	7.5

5. % individual fish w. disease or anomaly	2.7	4.5	0.0	7.5
6. % individual fish as tolerant species	14.7	4.5	0.7	7.5
7. % individual fish as wild trout	25.0	7.5	4.6	4.5
8. % individual fish as omnivores & herbivores	25.3	1.5	14.	4.5
TOTALS		42.0		48.0
		FAIR		GOOD

Table 23. Selected Physical Characteristics of Wiggins Creek at Sutton Lease, off Wiggins Creek Creek Rd. (RM 0.3) for two years.

	1995	2002
Watershed area at site (sq. mi.)	2.2	2.2
Width (ft.)		
Mean	11.9	9.0
Range	8 to 15	6 to 13
Mean depth (ft.)		
Riffles	0.6	0.4
Runs	0.6	0.5
Pools	1.2	0.7
Maximum depth	1.5	1.2
Substrate composition (%)		
Boulder	17	19
Rubble	32	26
Gravel	15	9
Sand	35	38
Silt	13	8
Large Woody Debris	Common	Common
Canopy cover (%)	90	90
Raw bank (%)	5	5
Adjacent land use		
Left bank	Young forest	Young forest
Right bank	Buffered agricultural field	Buffered agricultural field

Burningtown Creek above mouth of Left Prong (RM 9.4) (Tables 24 and 25)

This site completes a series of sites in the Burningtown Creek watershed, bracketing the 2 major tributaries, Left Prong Burningtown and Younce Creek, and including one site on each, plus this site above the last major tributary. Above this site Burningtown Creek flows mostly through a lightly populated residential area, with some agriculture, for 1.7 mi., above which point the entire watershed is in National Forest. The upper reaches are known as a brook trout (*Salvelinus fontinalis*) stream. The site itself is somewhat atypical in being totally forested, but we chose a site near the confluence with the Left Prong to maximize stream size. Even so, it barely misses the minimum size for a fish-based IBI, with a drainage area of 3.9 sq. mi.

Even had the watershed measured over 4 sq. mi., we would have included a macroinvertebrate component, based on a 1997 sample from the lower reaches of Left Prong Burningtown. Left Prong Burningtown has a watershed drainage area of 6.5 sq. mi., but in a 1997 sample we took only 7 species of fish (the same 7 taken from Burningtown Creek above the Left Prong), which was judged to be insufficient to calculate an IBI. Factors limiting fish diversity were judged to be gradient (over 100 ft./mi.) and elevation (about 2,200 ft.). The present site on the smaller Burningtown Creek is at the same elevation, but appears to have a somewhat lower gradient.

This may be the place to clear up some confusion about names. From the name, one would expect the Left Prong to be the tributary system. However, as can be seen from the watershed area data, the Left Prong is actually a larger stream than Burningtown Creek at the point where the two come together. (Perhaps Burningtown Creek is so named at this point because it flows out of Burningtown Gap, one of the more prominent features of the Nantahala Range in this area.) To compound the confusion, if one looks at the two streams in the conventional manner (facing downstream), the “Left Prong” is actually the right branch. Be that as it may, the names as used here are those found on the topo quad and also the names in popular usage in the Burningtown area.

The appearance of Burningtown Creek at this point is of a healthy stream, and the IBI sample does nothing to refute that notion. Wild rainbow trout (*Oncorhynchus mykiss*) were the second most abundant fish species (after the mottled sculpin, *Cottus bairdi*). The majority of trout taken were small parr, suggesting that this reach is important as a nursery area, but some “catchable” adults were also taken.

What appeared to be a very healthy macroinvertebrate community featured the highest EPT and Ephemeroptera taxa counts (33 and 16, respectively) of any of the 14 small stream sites monitored this year. Three taxa (the Peltoperlid stonefly *Viehoperla* sp., the Odontocentrid caddisly *Psilotreta* sp. and the highly intolerant Hydropsychid caddisfly *Ceratopsyche slossoni*) were unique to this sample.

This site on Burningtown Creek scored high for all metrics except Metric 3 (brook trout presence). Brook trout have presumably been displaced here through invasion of rainbow trout from the lower reaches of Burningtown Creek. The GOOD bioclass rating appears to be fully justified, although the observed value for Metric 8 is marginal for receiving a “good” score. The comparable value for the Left Prong Burningtown, which joins this stream just 0.3 mi. downstream, was 1.2%, when it was monitored in 1997. (No macroinvertebrate sample was taken; McLarney, 1998b). This suggests that the Left Prong, which is larger, has a higher gradient and drains a greater percentage of National Forest land than the mainstem at their juncture, has a dominant role in maintaining water quality in lower Burningtown Creek.

Table 24.   Burningtown Creek above mouth of Left Prong (RM 9.4)

Species and Numbers of Fish Taken

Rainbow trout
Smoky dace
Blacknose dace
Longnose dace
Creek chub
Northern hogsucker
Mottled sculpin

TOTAL

Macroinvertebrate sample results

Bivalvia
Veneroidea
Sphaeriidae
Pisidium sp.
Gastropoda
Mesogastropoda
Elimia sp.
Oligochaeta
Haplotaxida
Lumbricidae
Crustacea
Decapoda
Cambariidae
Cambarus bartoni
Insecta
Ephemeroptera
Baetidae
Baetis sp.
B. tricaudatus
Ephemerellidae
Drunella cornutella
D. wayah
Ephemerella catawba
Ephemeridae
Ephemera sp.
Heptageniidae
Epeorus sp.
E. rubidus/subpallidus
Heptagenia sp.
Leucrocuta sp.
Leucrocuta cf. *thetis*
Rhithrogena exilis

Stenonema modestum

S. pudicum

Leptophlebiidae

Paraleptophlebia sp.

Neoephemeridae

Neoephemera purpurea

Odonata

Calopterygidae

Calopteryx maculata

Gomphidae

Gomphus abbreviatus

Lanthus parvulus

Plecoptera

Leuctridae

Leuctra sp.

Peltoperlidae

Viehoperla sp.

Perlidae

Acroneuria abnormis

Perlodidae

Isoperla bilineata

Pteronarcidae

Pteronarcys(Allonarcys) sp.

Hemiptera

Gerridae

Megaloptera

Corydalidae

Nigronia serricornis

Trichoptera

Brachycentridae

Brachycentrus sp.

Hydropsychidae

Ceratopsyche slossoni

C.
spa
rna

Diplectrona modesta

Lepidostomatidae

Lepidostoma sp.

Limnephilidae

Pycnopsyche sp.

Odontoceridae

Psilotreta sp.

Philopotamidae

Dolophilodes sp.

Polycentropidae

Polycentropus sp.

Psychomiidae

Lype diversa
Rhyacophilidae
Rhyacophila fuscula
Uenoidae
Neophylax auris/etnier gp.
Coleoptera
Elmidae
Optioservus ovalis
Stenelmis sp.
Hydrophilidae
Sperchopsis tessellatus
Psephenidae
Psephenus herricki
Staphylinidae
Diptera
Chironomidae
Conchapelopia sp.
Cryptochironomus fulvus
Orthocladius sp.
Pagastia orthogonia
Polypedilum flavum (convictum)
Prodiamesa olivacea
Rheotanytarsus sp.
Tanaytarsus sp.
Tvetenia bavarica gp.
Dixidae
Dixa sp.
Simuliidae
Simulium sp.
Tipulidae
Dicranota sp.
Hexatoma sp.

TOTAL ORGANISMS
TOTAL TAXA
EPT count
Ephemeroptera taxa

Metrics and Scoring

Metric

1. No. Ephemeroptera taxa
2. No. EPT taxa
3. Brook trout presence
4. Fish catch per unit effort

5. % individual fish w. disease or anomaly
6. % individual fish as tolerants
7. % individual fish as wild trout
8. % individual fish as omnivores & herbivores

TOTAL

Table 25. Selected Physical Parameters of Burningtown Creek Above Mouth of Left Prong (RM 9.4)

Watershed area at site (sq. mi.)	3.9
Width (ft.)	
Mean	14.3
Range	9 to 25
Mean depth (ft.)	
Riffles	0.7
Runs	0.7
Pools	1.7
Maximum depth (ft.)	2.1
Substrate composition (%)	
Boulder	2
Rubble	50
Gravel	10
Sand	36
Silt	2
Large woody debris	Abundant
Canopy cover (%)	100
Raw bank (%)	5
Adjacent Land Use	
Left bank	forest
Right bank	forest

Lakey Creek at Oak Grove Church Rd. (RM 0.2) (Tables 26 and 27)

Lakey Creek was included in a 1995 IBI survey of direct tributaries to the Little Tennessee River with watershed areas of 1-4 sq. mi. (McLarney, 1996a; in prep. a). When a 2001 fall survey (McLarney, 2001a) turned up the threatened spotfin chub (*Cyprinella monacha*) in a number of tributaries with watershed areas in the 2-4 sq. mi. range, it was decided to include Lakey Creek (watershed area 3.0 sq. mi.) in the 2002 IBI monitoring. No spotfin chubs were expected or found in this sample. This relatively high gradient, shallow, straight, boulder-strewn stream would not appear to offer good habitat for the species. However, 2 small adults were taken in a survey of the lowermost 0.1 mi. of Lakey Creek on November 1, 2002.

Our perception at the site was that Lakey Creek had "gotten smaller", that there were less pools and less deep pockets in the runs and riffles. This is not borne out by the physical habitat data (Table 27), which do show a reduction of riparian shade. Trash dumping along the left bank continues to be a minor problem.

For whatever reason, the fish assemblage was notably less diverse, although not all the 7 missing species are species associated with larger streams. One of the missing species was the most notable component of the 1995 sample. At that time we found what appeared to be two breeding pairs of the greenfin darter (*Etheostoma chlorobranchium*). This is the only occasion on which we have found adults of this species in a stream with a watershed area of less than 6 sq. mi. (Both samples were taken in mid-June.)

Two of the fish metrics from 2002 produce an improvement in the IBI, but the improvement in observed values is small. The higher score is based on increases in scoring for Metric 4 (catch per unit effort) and Metric 7 (% of individual fish as wild trout). In 1995 the observed value for Metric 4 (50.5%) barely exceeded the threshold for lowering the score due to apparent overfertility. Similarly, the higher score for Metric 7 was based on the capture of a single juvenile rainbow trout (*Oncorhynchus mykiss*). On the other hand, improvements in observed values for Metrics 4 (disease and anomalies) and 8 (omnivores and herbivores) are substantial.

The 7 fish species which were found in 1995 but not in 2002 represent a wide variety of tolerance levels, habitat preferences and feeding modes. It could be hypothesized (following the conclusions of Scott and Helfman, 2001) that reduction in fish diversity corresponds to some improvement in water or habitat quality, but there is no physical evidence of any such improvement, nor any apparent causative factor. Moreover, 2 of the missing species (longnose dace, *Rhinichthys cataractae* and creek chub, *Semotilus atromaculatus*) are often associated with very small streams.

When taken together with the considerable increases in observed value for both of the macroinvertebrate-based metrics, it may be that the 6 point increase in IBI score for Lakey Creek between 1995 and 2002 is justified. However no visible improvements in habitat are apparent nor are changes which would have resulted in an improvement in water quality known to us.

One Philopotamid caddisfly (*Chimarra alterrima*) and two Chironomids (*Orthocladius lignicola* and *Tvetenia discoloripes* gp.) were unique to Lakey Creek among 14 sites sampled for macroinvertebrates in 2002.

Table 26. Lakey Creek at Oak Grove Church Rd. (RM 0.2)

Species and Numbers of Fish Taken

	Numbers of Individuals Taken	
Species	1995	2002
Rainbow trout		1
Central stoneroller	37	20

Warpaint shiner	28	32
River chub	7	22
Tennessee shiner	8	
Fatlips minnow	4	
Blacknose dace	50	13
Longnose dace	6	
Creek chub	3	
Northern hogsucker	4	
Redbreast sunfish	1	
Green sunfish		2
Greenfin darter	4	
Gilt darter	2	
Mottled sculpin	47	147
TOTALS	201	237

Macroinvertebrate sample results (1995 data not available)

Bivalvia				
	Veneroidea			
		Sphaeriidae		
			Sphaerium sp.	5
Gastropoda				
	Mesogastropoda			
		Pleuroceridae		
			Elimia sp.	20
	Basommatophora			
		Physidae		
			Physella sp.	1
Oligochaeta				
	Haplotaxida			
		Lumbricidae		14
Arachnoidea				
	Acariformes			
		Lebertiidae		
			Lebertia sp.	1
Crustacea				
	Decapoda			
		Cambaridae		
			Cambarus bartoni	present
Insecta				
	Ephemeroptera			
		Baetidae		
			Baetis sp.	58
			B. intercalaris	2
			B. c.f. *flavistriga*	18
		Ephemerellidae		

		Drunella sp.	6
		Ephemerella catawba	8
		Serratella sp.	142
		Timpanoga sp.	1
	Ephemeridae		
		Ephemera sp.	3
	Heptageniidae		
		Epeorus rubidus/subpallidus	16
		Heptagenia sp.	2
		Leucrocuta sp.	1
		Stenonema modestum	57
	Leptophlebiidae		
		Paraleptophlebia sp.	10
Odonata			
	Calopterygidae		
		Calopteryx sp.	6
	Gomphidae		
		Gomphus sp.	3
Plecoptera			
	Leucrtidae		
		Leuctra sp.	25
	Perlidae		
		Acroneuria abnormis	7
		Perlesta sp.	25
		Perlesta placida sp. gp.	1
	Perlodidae		
		Isoperla sp.	12
	Pteronarcidae		
		Pteronarcys(Allonarcys) sp.	3
Hemiptera			
	Veliidae		
		Rhagovelia obesa	1
Megaloptera			
	Corydalidae		
		Nigronia serricornis	4
Trichoptera			
	Glossosomatidae		
		Glossosoma sp.	2
	Hydropsychidae		
		Ceratopsyche sp.	84
		C. bronta	3
		Cheumatopsyche sp.	66
		Diplectrona modesta	1
		Hydropsyche betteni gp.	1
	Limnephilidae		
		Pycnopsyche sp.	3
	Philopotamidae		
		Chimarra aterrima	15

		Dolophilodes sp.	6
	Polycentropidae		
		Polycentropus sp.	8
	Rhyacophilidae		
		Rhyacophila fuscula	12
	Uenoidae		
		Neophylax sp.	4
Coleoptera			
	Dryopidae		
		Helichus basalis	4
	Elmidae	*Macronychus glabratus*	10
		Optioservus sp.	2
		O. ovalis	3
		Promoresia sp.	4
		P. tardella	3
		Stenelmis sp.	10
	Hydrophilidae		
		Sperchopsis tesselatus	4
	Psephenidae		
		unid.	1
		Psephenus herricki	49
	Ptilodactylidae		
		Anchytarsus bicolor	1
Diptera			
	Blephariceridae		
		Blepharicera sp.	1
	Ceratopogonidae		
		Bezzia/Palpomyia gp.	3
	Chironomidae		
		unid.	2
		Cricotopus sp.	3
		Cryptochironomus fulvus	2
		Eukiefferiella claripennis gp.	1
		Microtendipes sp.	8
		Orthocladius lignicola	1
		Pagastia orthogonia	1
		Polypedilum fallax	1
		P. flavum(convictum)	2
		P. halterale	1
		Psectrocladius sp.	3
		Tanytarsus sp.	3
		Thienemanniella xena	2
		Thienemannimyia gp.	6
		Tvetenia discoloripes gp.	1
	Simulidae		
		Simulium sp.	2

Tipulidae		
	Antocha sp.	7
	Dicranota sp.	2
	Tipula sp.	8
TOTAL ORGANISMS		809
TOTAL TAXA		73
EPT Taxa		31
Ephemeroptera taxa		13

Metrics and Scoring

Metric	1995 Observed value	1995 Score	2002 Observed value	2002 Score
1. No. Ephemeroptera taxa	7	7.5	13	7.5
2. No. EPT taxa taxa	16	7.5	31	7.5
3. Brook trout presence	Absent	1.5	Absent	1.5
4. Catch per unit effort	50.5	4.5	39.1	7.5
5. % individual fish w. disease or anomaly	1.9	6.0	0.4	6.0
6. % individual fish as tolerants	2.0	7.5	0.8	7.5
7. % individual fish as wild trout	0.0	1.5	0.4	4.5
8. % individual fish as omnivores & herbivores	48.3	1.5	23.2	1.5
TOTALS		37.5		43.5
		FAIR		FAIR

Table 27. Selected Physical Parameters for Lakey Creek at Oak Grove Church Rd. (RM 0.2) for two years.

		1995	2002
Watershed area at site (sq. mi.)		2.9	2.9
Width (ft.)			
	Mean	10.0	8.5
	Range	7 to 12	5 to 15
Mean depth (ft.)			
	Riffles	0.6	0.5
	Runs	0.6	0.6
	Pools	0.9	0.6
Maximum depth		0.9	0.8
Substrate composition (%)			
	Boulder	13	15
	Rubble	38	45
	Gravel	14	2
	Sand	35	38
	Silt	t	1

Large woody debris	Rare	Rare
Canopy cover (%)	90	60
Raw bank (%)	10	10
Adjacent land use		
left bank	lawn, old field, agriculture, dump site - mostly buffered	lawn, old field, agriculture, dump site - mostly buffered
right bank	buffered pasture	partially buffered pasture

Bradley Creek below NC Highway 28 (RM 0.3) (Tables 28 and 29)

Bradley Creek is similar in size to the neighboring Lakey Creek (total watershed drainage area 3.0 sq. mi.), and was monitored this year for the same reason. It was not sampled in our fall 2001 survey for the Threatened spotfin chub (*Cyprinella monacha*) (McLarney, 2001a), but this species was found in Bradley Creek at the IBI monitoring site in the fall of 2002 (but not during the summer) (McCown, 2002).

Bradley Creek arises in the Cowee Mountains not far from the headwaters of Lakey Creek and flows parallel to at a distance of 0.5 – 1.0 mi. over all its length. Not surprisingly, there are similarities in the biotic communities of the 2 streams However, Bradley Creek, where it passes through the Little Tennessee River Valley, is a lower gradient stream. On the one hand it has finer substrates. On the other in 1995 it had deeper pools. This distinction has been largely erased due to erosion related to upstream development and the rechannelization of the lower reaches of its principal tributary, Stillhouse Branch, which joins Bradley Creek just across Highway 28 (Bryson City Rd.). We have noted reduced pool depth and a greatly increased proportion of sand in the substrate. (See Table 29.)

Despite what would appear to be negative physical changes, and despite the disappearance of a population of the intolerant gilt darter (*Percina evides*) which we were surprised to find in this small stream in 1995, the fish data present the appearance of slight improvement in the biotic community, with the first appearance of wild trout (a small adult brown trout, *Salmo trutta*) and the virtual disappearance of finrot, which lowered the score for Metric 5 in 1995.

The macroinvertebrate community appeared to be somewhat more diverse in 2002 than in 1995, but this did not affect the score, since Bradley Creek scored high for both macroinvertebrate-based metrics in 1995. The modest improvement in IBI score (39.0 to 43.5, for a FAIR Bioclass Rating in both cases), may or may not be significant.

The baetid mayfly *Pseudocloeon* sp. was unique to Bradley Creek among 14 small stream sites sampled for macroinvertebrates in 2002.

Table 28. Bradley Creek below NC Highway 28 (RM 0.2)

Numbers and species of Fish Taken

Species	Number of individuals taken 1995	2002
Brown trout		1
Central stoneroller	29	31
Warpaint shiner	8	36
River chub	5	27
Tennessee shiner	3	5
Telescope shiner		1
Fatlips minnow	2	1
Blacknose dace	30	14
Longnose dace	6	
Creek chub	2	3
Northern hogsucker	3	
Rock bass	1	
Tuckaseigee darter		1
Gilt darter	8	
Mottled sculpin	65	250
TOTAL	162	370

Macroinvertebrate sample results (1995 data not available)

Bivalvia				
	Veneroidea			
		Sphaeriidae		
			Pisidium sp.	2
Gastropoda				
	Basommatophora			
		Physidae		
			Physella sp.	1
Oligochaeta				
	Haplotaxida			
		Lumbricidae		8
Crustacea				
	Decapoda			
		Cambaridae		
			Cambarus bartoni	1
Insecta				
	Emphemeroptera			
		Baetidae		
			Acentrella ampla	1
			Baetis tricaudatus	7
			Plauditus sp.	8
			Pseudocloeon sp.	11
		Ephemerellidae		
			Drunella cornutella	8
			D. wayah	1

		Serratella sp.	67
	Heptageniidae		
		Epeorus rubidus/subpallidus	6
		Heptagenia sp.	9
		Rhithrogena sp.	1
		Stenacron carolina	1
		Stenonema modestum	55
	Leptophlebiidae		
		Paraleptophlebia sp.	9
Odonata			
	Aeshnidae		
		Boyeria vinosa	2
	Calopterygidae		
		Calopteryx maculata	8
	Gomphidae		
		Gomphus sp.	4
Plecoptera			
	Leuctridae		
		Leuctra sp.	17
	Perlidae		
		Paragnetina immarginata	1
		Perlesta sp.	7
	Pteronarcidae		
		Pteronarcys (Allonarcys) sp.	2
Megaloptera			
	Corydalidae		
		Nigronia serricornis	10
Trichoptera			
	Glossosomatidae		
		Glossosoma sp.	7
	Hydropsychidae		
		Ceratopsyche bronta	2
		C. sparna	48
		Diplectrona modesta	2
	Lepidostomatidae		
		Lepidostoma sp.	1
	Limnephilidae		
		Goera sp.	3
		Pycnopsyche sp.	15
	Philopotamidae		
		Dolophilodes sp.	14
	Rhyacophilidae		
		Rhyacophila fuscula	2
	Uenoidae		
		Neophylax sp.	1
Coleoptera			
	Dryopidae		
		Helichus basalis	1

	Elmidae			
		Optioservus sp.		1
		O. ovalis		1
		Stenelmis sp.		5
Diptera				
	Chironomidae			
		unid.		1
		Brillia flavivrons		1
		Cryptochironomus fulvus		1
		Eukiefferiella sp.		2
		Microtendipes sp.		1
		Pagastia orthogonia		2
		Parametriocnemus lundbecki		3
		Polypedilum flavum (convicta)		4
		Priodiamesa olivacea		4
		Psectrocladias sp.		3
		Rheotanytarsus sp.		2
		Tvetenia bavarica gp.		1
	Simulidae			
		Simulium sp.		2
	Tipulidae			
		Antocha sp.		3
		Dicranota sp.		2
		Tipula sp.		4
TOTAL ORGANISMS				428
TOTAL TAXA				59
EPT taxa				28
Ephemeroptera taxa				13

Metrics and Scoring

Metric	1995 Observed value	Score
1. No. Ephemeroptera taxa	8	7.5
2. No. EPT taxa	20	7.5
3. Brook trout presence	Absent	1.5
4. Fish catch per unit effort	31.0	7.5
5. % individuals w. disease or anomaly	2.5	4.5
6. % individual fish as tolerants	1.2	7.5
7. % individual fish as wild trout	0.0	1.5
8. % individual fish as omnivores & herbivores	40.7	1.5
TOTALS		39.0 FAIR

Table 29. Selected Physical Parameters of Bradley Creek Below NC Highway 28 (RM 0.2) During 2 years

		1995	2002
Watershed area at site (sq. mi.)		2.9	2.9
Width (ft.)			
	Mean	13.2	9.0
	Range	8 to 22	6 to 13
Mean depth (ft.)			
	Riffles	0.5	0.5
	Runs	0.7	0.5
	Pools	1.8	0.9
Maximum depth (ft.)		2.5	1.2
Substrate composition (%)			
	Boulder	2	0
	Rubble	62	49
	Gravel	17	8
	Sand	3	42
	Silt	16	1
Large woody debris		Absent	Absent
Canopy cover (%)		45	50
Raw bank (%)		5	5
Adjacent land use			
	Left bank	forest	forest
	Right bank	lawn	lawn

Cowee Creek at Wests Mill (RM 0.7) (Table 30)

In 1997, when this site was last monitored, the only metric to receive less than the top score was Metric 11 (% of individuals as darters and sculpins). While Cowee Creek is in relatively good condition for such a large tributary (watershed drainage area 25.8 sq. mi.), an EXCELLENT Bioclass Rating seems unrealistic in a watershed experiencing considerable development, and which was at that time the center of the tourist gem mining industry, a considerable source of sediment. It should be noted that this site is difficult to sample by virtue of the frequent large and deep pools. In 2002 we had unusually low water, which facilitated sampling of these pools, and the IBI score of 49.5 (Bioclass Rating GOOD) seems more realistic. The difference hinged on:

- drastically reduced numbers of the two principal benthic riffle dwellers (mottled sculpin, *Cottus bairdi* and gilt darter, *Percina evides*. Sculpins have been declining in numbers at almost all sites in recent years (McLarney, in prep. b), but no such effect has been observed for the gilt darter.

- increased numbers of the omnivorous river chub (*Nocomis micropogon*) and herbivorous central stoneroller (*Campostoma anomalum*), which directly affected Metric 7 (% individuals as omnivores and herbivores) and indirectly affected Metric 8 (% individuals as specialized insectivores).

One specialized insectivore, the whitetail shiner (*Cyprinella galactura,* represented by 10 individuals) appeared for the first time in Cowee Creek in the summer. Presence of numbers of this mainstem fish, customarily found in tributaries principally in the fall, may provide an example of "native invasion" (Scott and Helfman, 2001).

Two other observations which did not affect the IBI score may be significant:

- 2002 marked the first record for the exotic yellowfin shiner, *Notropis lutipinnis* (a single individual) here or anywhere in the Cowee Creek watershed. The typical pattern for this invasive fish would be to persist in low numbers (0 – 2 individuals in samples of this size), then suddenly "explode" and begin to hybridize with other Cyprinids. (See Table 57.)

- This is the first year the banded darter (*Etheostoma zonale*) was not recorded from lower Cowee Creek. This species, strongly associated with aquatic vegetation, is largely restricted in the upper Little Tennessee watershed to the mainstem downstream of Lake Emory. With the exceptions of an apparent stray from Rose Creek in 1995, and an anomalous 1996 record from the Cullasaja River, the only banded darters we have seen away from the mainstem have been from Cowee Creek and from Watauga Creek, which arises within 0.5 mi. of the headwaters of Cowee Creek on Rocky Face Knob.

Table 30. Cowee Creek at Wests Mill (RM 0.7)

Species and numbers of fish taken

Species	Number of individuals taken	
	1997	2002
Mountain brook lamprey	10	9
Rainbow trout		1
Brown trout		1
Central stoneroller	16	39
Whitetail shiner		10
Warpaint shiner	43	44
River chub	25	80
Tennessee shiner	60	45
Yellowfin shiner		1
Silver shiner	3	
Telescope shiner	7	15
Fatlips minnow	9	5
Northern hogsucker	12	29
River redhorse	1	*
Rock bass	7	19

Redbreast sunfish	13	16
Green sunfish	23	18
Bluegill	4	
Smallmouth bass	1	2
Largemouth bass		**
Tuckaseigee darter	8	7
Greenfin darter	29	23
Banded darter	1	
Gilt darter	117	42
Walleye	1	
Mottled sculpin	134	81
TOTALS	524	487

* A single adult redhorse was seen in a pool but not captured or identified to species, included in species count, but not in other aspects of scoring.

** One young-of-the-year, included in species count, but not in other aspects of scoring.

Metrics and Scoring

Metric	1997 Observed value	1997 Score	2002 Observed value	2002 Score
1. No. of native species	20	6.7	17	6.7
2. No. of darter species	4	6.7	3	6.7
5. No. of intolerant species	3	6.7	3	6.7
6. % individuals as tolerants	6.9	6.7	7.0	6.7
7. % individuals as omnivores & herbivores	9.7	6.7	26.3	4.0
8. % individuals as specialized insectivores	52.9	6.7	37.2	4.0
10. Catch per unit effort	17.9	6.7	14.0	6.7
11. % individuals as darters and sculpins	55.2	4.0	31.4	1.3
12. % individuals w. disease or anomaly	0.8	6.7	0.4	6.7
TOTALS		57.6 EXCELLENT		49.5 GOOD

Cowee Creek between Matlock Creek and Caler Fork (RM 1.8) (Tables 31 and 32)

Matlock Creek and Caler Fork are the two principal tributaries to Cowee Creek, and have a curious history with regard to IBI. In 1997, when the two tributaries were first monitored, Caler Fork, which has been partially channelized in the past, and which drains the area where the Cowee Valley gem mines are concentrated, scored 45.0 (Bioclass Rating FAIR), while Matlock Creek, which drains a fairly heavily developed, and developing area, scored 51.0 (Bioclass Rating GOOD). In 2000, the situation was reversed. Matlock Creek showed signs of increased sedimentation, and scored 42.0 (FAIR) while Caler Fork scored 49.5 (GOOD), possibly as a result of closing of many of the gem mines. Whatever the case may be, it underlines the importance of bracketing these two tributaries in monitoring Cowee Creek. (See also preceding section on Cowee Creek at Wests Mill, below Matlock Creek, and following section on Cowee Creek above Caler Fork.)

The GOOD Bioclass rating for this site (IBI score 52.2) is surprising in view of recent history. Much of this reach of Cowee Creek, which flows through pasture on both sides, was channelized in the 1980's. While the channel has naturalized to a surprising degree, with abundant hard substrate, good riffle-pool structure, some sinuosity and a modest amount of shade from individual trees (although lacking a well developed vegetative buffer) it is a far cry from its former condition. Table 32 describes physical parameters of the habitat at RM 1.8 as of summer, 2002.

The main factor limiting biotic integrity is probably lack of quality riffle habitat, potentially influencing results for Metrics 8 (% individuals as specialized insectivores), 10 (catch per unit effort) and 11 (percentage of individuals as darters and sculpins). Riffles at RM 1.8 had large amounts of sand embedding the larger particles.

See the following section on Cowee Creek above Caler Fork for further comments.

Table 31. Cowee Creek between Matlock Creek and Caler Fork (RM 1.8)

Species and Numbers of Fish Taken

Species	Number of Individuals Taken 2002
Mountain brook lamprey	18
Brown trout	1
Central stoneroller	28
Whitetail shiner	1
Warpaint shiner	17
River chub	32
Tennessee shiner	18
Telescope shiner	11
Fatlips minnow	5
Blacknose dace	1
Longnose dace	1
Creek chub	1
Northern hogsucker	22
Mosquitofish*	3
Rock bass	9
Redbreast sunfish	11
Green sunfish	13
Smallmouth bass	4
Tuckaseigee darter	2
Greenfin darter	9
Gilt darter	51
Mottled sculpin	182

TOTAL	440

* Not identified to species, probably eastern mosquitofish.

Metrics and Scoring

Metric	2002 Observed value	Score
1. No. native species	19	6.7
2. No. darter species	3	6.7
5. No. intolerant species	3	6.7
6. % individuals as tolerants	6.4	6.7
7. % individuals as omnivores & herbivores	18.2	6.7
8. % individuals as specialized insectivores	26.8	4.0
10. Catch per unit effort	10.2	4.0
11. % individuals as darters & sculpins	55.5	4.0
12. % individuals w. disease or anomaly	0.5	6.7
TOTAL		52.2 GOOD

Table 32. Selected Physical Parameters of Cowee Creek Between Matlock Creek and Caler Fork (RM 1.8)

Watershed area (sq. mi.)		18.7
Width (ft.)		
	Mean	20.5
	Range	14-31
Mean depth (ft.)		
	Riffles	0.7
	Runs	0.7
	Pools	1.3
Maximum depth (ft.)		1.8
Substrate composition (%)		
	Rubble	40
	Gravel	7
	Sand	47
	Silt	6
Large woody debris		Rare
Canopy cover (%)		65
Raw bank (%)		25
Adjacent land use		
	Left bank	Fenced pasture with scattered trees, single tree buffer
	Right bank	Fenced pasture, single tree buffer

Cowee Creek above Caler Fork (RM 2.1 and 2.4) (Tables 33 and 34)

Only one site (RM 2.1) was planned for Cowee Creek above Caler Fork (the farthest upstream tributary, not counting Beasley Creek, which joins with Huckleberry Creek to form Cowee Creek). However, the results suggested the need for another sample just upstream. Not only was the IBI score at RM 2.1 surprisingly low (41.4, Bioclass Rating FAIR), but aspects of the biotic community were unusual for the upper Little Tennessee watershed. Particularly notable were:

- the capture of an exotic apple snail (*Ampullaria*)

- the presence of large numbers of mosquitofish (*Gambusia*, probably an exotic, see discussion below)

- the presence of the tolerant green sunfish (*Lepomis cyanellus*) not only in large numbers, but with many specimens larger than any others taken in the upper Little Tennessee watershed.

The presence of the two presumed Florida exotics, the unusual abundance and large size of the green sunfish (known to be particularly tolerant of chemical toxins), and a perceived scarcity of column-dwelling cyprinids, particularly the shiner group, drew our attention to the proximity of the site to a large "water garden" operation, which deals in aquatic ornamentals and regularly imports plants from Florida. The water garden is located on low ground between Cowee Creek and Caler Fork and has drainage ditches to both streams. Several times during the course of the sample we noticed brief flushes of turbid water, suggesting drainage or cleaning operations. Suspecting that the effects of the water garden on the streams were not limited to the occasional release of exotic biota, and might in other ways be implicated in the surprisingly low score, we planned another sample 0.3 mi. upstream at RM 2.4.

Somewhat to our surprise, the site at RM 2.4 received the identical IBI score and Bioclass Rating as that at RM 2.1. However, as tables 33 and 34 show, the fish assemblage, IBI metric values and physical habitat of Cowee Creek at the two sites are very different. Physical habitat will be discussed first, since it undoubtedly plays a major role in shaping the fish assemblage.

The site at RM 2.1 is fairly typical of the lower 2.5 miles of Cowee Creek. Gradient is moderate and there is a fair percentage of fines in the substrate. Nevertheless, riffle/pool structure is adequate. The banks are densely shaded in some places by alder and river cane, while other parts of the reach have only single large trees or no tall vegetation whatsoever. (A single large pool at the upstream end of the site was dammed up with rocks between the day the site was planned and when the sample was actually executed, contributing artificially deep conditions and trapping a large quantity of silt. Since the dam was not discovered until the sample was largely completed, the sample was carried out as originally planned.)

Above the water garden site, the habitat changes rapidly. The RM 2.4 site represents a transition zone between the type of habitat just described and a high gradient "mountain trout stream". Cowee Creek at RM 2.4 is characterized by dominance of riffles and larger particle size (although with about an equal amount of fine sediments, suggesting that the water garden operation is not proportionally a dominant contributor of sediments). Unlike Cowee Creek further downstream, large woody debris plays an important habitat function. The only known factors affecting water quality above this point are residential development and a modest amount of agricultural and forestry activity.

Of a total of 24 fish species (19 native) found at both sites, only 9 (7 native) were found at both sites. Of 20 species (15 native) found at the lower site, more than half (11, with 7 native) were absent from the upper site. Of a total of 13 species (11 native) found at the upper site, 4 (all native) were found only at that site.

The most notable absences at RM 2.4 were the green sunfish and mosquitofish. In our experience the pattern of distribution of green sunfish in the upper Little Tennessee watershed is patchy. In some tributary watersheds it is quite common, while in others it is rare or absent. Numbers also tend to fluctuate greatly from year to year. The Cowee Creek watershed has normally had a relatively high population of green sunfish, but even so the capture of 37 individuals was unprecedented. Even more striking was the size of the individuals captured. While the green sunfish, as a species, has the potential to reach a fair size (Lee, et al., 1989 list a maximum standard length of 250 mm.), we have rarely seen a specimen half that size in the upper Little Tennessee watershed. However, 10 of the individuals at RM 2.1 were in the range of 100-150 mm. SL.

The mosquitofish (not identified to species, but probably eastern mosquitofish, *Gambusia holbrooki*, see "Comments on individual species") were concentrated at the margins of pools. However, none were taken in apparently ideal habitat in the large pool above the rock dam. We have previously recorded mosquitofish in the Cowee Creek watershed from Caler Fork (McLarney, 2001b) and this year also took a few from Cowee Creek at RM 1.8.

Several of the species found at RM 2.1 but absent at RM 2.4 are species more characteristic of the mainstem and/or large tributaries than of small streams. These include the whitetail shiner (*Cyprinella galactura*), smallmouth bass (*Micropterus dolomieui*), greenfin darter (*Etheostoma chlorobranchium*) and brown bullhead (*Ameiurus nebulosus*). The brown bullhead was represented by a single large (estimated 14 inches TL) individual taken from the dammed up pool. This is by far the largest individual of this exotic species we have ever seen in the upper Little Tennessee watershed, and may have been stocked.

The observation of shiner scarcity did not pan out as an indicator of anything affecting exclusively RM 2.1. While the total number of shiners (11 individuals, representing 4 species) and proportion of this group in the sample (3.3%) was low compared to most medium sized streams in our watershed, the same held true for RM 2.4. There only 1 species (warpaint shiner, *Luxilus coccogenis*) was present, represented by 10 individuals (1.7% of the sample). All but one of these individuals were taken from a single large pool at the lower end of the site. It may be that the scarcity of shiners at RM 2.4 is gradient-related.

The most immediately notable distinctive feature of the fish sample at RM 2.4 is the super-abundance of sculpins (76.4% of the total sample). This is not altogether atypical for moderately swift, rocky streams in our watershed. However, the total absence of the darter group from a stream of this size is atypical. Consideration has been given in the past to looking at the ratio of the two groups counted in Metric 11 (sculpins and darters) as an indicator of sedimentation/riffle quality. In this case, the lower gradient site at RM 2.1 would appear healthier, with 13.9% of the darter plus sculpin total as darters, versus no darters at all at RM 2.4.

With respect to riffle dwellers, the absence of the longnose dace (*Rhinichthys cataractae*) at RM 2.1, despite the presence of highly suitable physical habitat, is notable. We captured 21 longnose dace at RM 2.4.

Mention should also be made of the far greater abundance of the 2 trout species at RM 2.4, where they constituted 6.5% of the total sample, vs. 1.5% at RM 2.1. Individuals of both species, but particularly the brown trout (*Salmo trutta*) tended to be larger at the lower site.

For 4 of a total 9 metrics employed, observed value and score were significantly different between the two sites. The lower site (RM 2.1) scored better for:

- Metric 2 (no. of darter species): presence of 2 darter species versus no darters at RM 2.4.

- Metric 5 (no. of intolerant species): RM 2.1 scored better because of presence of the gilt darter (*Percina evides*). It would score 6.7 if the single specimen of the telescope shiner (*Notropis telescopus*) were allowed. However, it was judged to be a stray.

The upper site (RM 2.4) scored better for:

- Metric 6 (% of individuals as tolerant species). The superabundance of the green sunfish at RM 2.1 was the key factor here. However, note that this difference obtains despite the presence of fair numbers of creek chubs (*Semotilus atromaculatus*) at RM 2.4 and the surprising total absence of this species at RM 2.1.

- Metric 11(% of individuals as darters and sculpins). For this metric, the lower site almost made the cut-off point (65%) for receiving the higher score.

Values for the other 5 metrics are very similar, except for the extremely low value (5.2%) for Metric 8 (% individuals as specialized insectivores) at RM 2.4. For this metric, and in the two instances where metric scoring might be doubtful (Metric 5 – exclusion of the telescope shiner) and Metric 11 (marginal value at RM 2.1), any judgement call or assessment of possible errors would favor the lower site. That is to say, biotic integrity at RM 2.1 may be equal to that at RM 2.4 or it could be better, but it is not worse. This leads to the conclusion that despite at least one obvious effect of the water garden (presence of mosquitofish), it cannot be concluded that the water garden is a major factor impacting biotic integrity in Cowee Creek.

It would appear that the FAIR Bioclass Rating assessed to Cowee Creek at RM 2.4 and RM 2.1 is a consequence of sedimentation distributed throughout the watershed and/or to unknown factors originating upstream of RM 2.4. It would also appear from results at RM 1.8 and RM 0.7 (see above) that lower valley tributaries, or at least Caler Fork, play a positive role in determining water quality in lower Cowee Creek.

Table 33. Cowee Creek Above Caler Fork (Rm 2.1 and 2.4)

Species and Numbers of Fish Taken

Species	Numbers of individuals taken - 2002	
	RM 2.1	RM 2.4
Mountain brook lamprey	5	5
Rainbow trout	2	33
Brown trout	3	6
Central stoneroller	27	16
Whitetail shiner	2	
Warpaint shiner	7	10
River chub	8	20
Tennessee shiner	1	
Telescope shiner	1	
Fatlips minnow	1	
Blacknose dace		3
Longnose dace		21
Creek chub		19
Northern hogsucker	7	4
Mosquitofish*	18	
Brown bullhead	1	
Rock bass	3	4
Redbreast sunfish	1	
Green sunfish	37	
Bluegill		1
Smallmouth bass	2	
Greenfin darter	5	
Gilt darter	24	
Mottled sculpin	179	459
TOTALS	334	601

* Not identified to species, see text

Metrics and Scoring

Metric	RM 2.1 Observed value	Score	RM 2.4 Observed value	Score
1. No. native species	15	6.7	11	6.7
2. No. darter species	2	4.0	0	1.3
5. No. intolerant species	2*	4.0	1	1.3
6. % individuals as tolerants	17.1	4.0	3.2	6.7
7. % individuals as omnivores & herbivores	12.3	4.0	10.5	4.0
8. % individuals as specialized insectivores	18.0	1.3	5.2	1.3
10. Catch per unit effort	26.7	6.7	22.7	6.7
11. % individuals as darters and sculpins	62.3	4.0	76.4	6.7
12. % individuals w. disease or anomaly	0.6	6.7	0.5	6.7
TOTALS		41.4 FAIR		41.4 FAIR

Table 34. Selected Physical Parameters of Cowee Creek above Caler Fork (RM 2.1 and 2.4)

		RM 2.1	RM 2.4
Watershed area at site		11.0	10.7
Width (ft.)			
	Mean	15.8	18.3
	Range	11 to 23	11 to 25
Mean depth (ft.)			
	Riffles	0.7	0.6
	Runs	1.1	0.7
	Pools	1.8* 1.4	1.3
Maximum depth (ft.)		2.8* 1.8	2.5
Substrate composition (%)			
	Bedrock		4
	Boulder	1	11
	Rubble	45	25
	Gravel	3	5
	Sand	39	49
	Silt	12* *	6
Large woody debris		Rare	Common
Canopy cover (%)		70	75
Raw bank		10	5
Adjacent land use			
	left bank	Lower half - mowed field, garden; upper half - water garden lawn with silt fence. Partially	Hay field (buffered)

right bank	buffered abandoned field/second growth, small mowed area around trailer	Buffered pasture (not presently in use)

* including dammed up pool
** value probably inflated by accumulation of silt in dammed up pool.

Iotla Creek at Old Malonee Mill Site (RM 1.1) (Tables 35 and 36)

In the first year of biomonitoring in the upper Little Tennessee River watershed (1990), fish samples were taken in the lower reaches of all 17 river tributaries with watershed drainage areas of 4 sq. mi. or more, including Iotla Creek (drainage area 10.0 sq. mi.) At that time, based on monitoring of a site located upstream of the present site, at the Macon County Airport, Iotla Creek received an IBI score of 14.4 (Bioclass Rating VERY POOR). (McLarney, 1991). This was the lowest score received by any Little Tennessee tributary, and on that basis the airport site was selected as a fixed station. In subsequent years, IBI scores for Iotla Creek improved, concomitant with the disappearance of frequent oil slicks of unknown origin. However, biotic integrity remained low (from 17.1 – VERY POOR in 1992 to a high of 30.6 – POOR in 1997) (McLarney, 1998b). For various reasons, it was often necessary to move this site and, following the 1998 monitoring season it was decided to discontinue Iotla Creek as a fixed station site (McLarney, 1999b, 2000b).

The various Iotla Creek "fixed station" sites were all located upstream of a possible barrier to upstream fish migration in the form of a falls at the old Malonee Mill site (RM 1.1). We assumed that this accounted for the low diversity of fish in the IBI samples (total of 9 species from all samples); it also cast some doubt on the validity of the IBI's, since diversity was marginal for assessment based on fish alone.

In a fall, 2001 survey (McLarney, 2001a) the Threatened spotfin chub (*Cyprinella monacha*), long assumed to be an obligate mainstem inhabitant, was found to be using at least 9 Little Tennessee tributaries between Lake Emory dam and Fontana Reservoir, including Iotla Creek. In Iotla Creek the spotfin chub was found to penetrate as far upstream as Malonee Mill. The need to assess water and habitat quality in tributary streams used by this Threatened species, plus the opportunity to verify or refute our IBI assessment of Iotla Creek based on the species-poor reach above Malonee Mill led to the selection of the Malonee Mill site for biomonitoring in summer, 2002.

No spotfin chubs were found (or expected) in the summer IBI sample. The study did confirm the importance of the falls at the mill site as a fish barrier; we took 20 species of fish (18 native), as compared to 9 species (7 native to the watershed) in all 1990-2000 samples above Malonee Mill combined. Table 35 shows presence/absence for all species above the falls along with numbers of each species taken below the falls in the 2002 IBI sample.

The IBI score (33.3) was slightly higher than the best score recorded above the falls, but Bioclass Rating was still POOR. Table 35 includes comparative metric scoring data from the 1997 IBI sample taken upstream of Malonee Mill (IBI score 30.6). Although the Bioclass Rating is the same for both sites and the IBI scores are not significantly different, the score for 7 of the 9 individual metrics is different. In 4 cases the 2002 site scores higher, while in the other 3 the 1997 site above the falls receives the higher score. The poor score upstream is strongly related to diversity (Metrics 1, 2 and 3). This suggests that similarity in IBI score and Bioclass Rating notwithstanding, the upstream sites were not really suitable for bioassessment based on fish alone, without a benthic macroinvertebrate component.

The most notable aspects of the 2002 fish sample not related to previous years are the abundance of the exotic yellowfin shiner (*Notropis lutipinnis*) and the extreme scarcity of the mottled sculpin (*Cottus bairdi*). Iotla Creek represents the strongest population of the invasive yellowfin shiner downstream of Lake Emory. Several individuals appeared to be hybrids with the native warpaint shiner (*Luxilus coccogenis*) or Tennessee shiner (*Notropis leuciodus*).

While Iotla Creek represents less than optimum habitat for the mottled sculpin, parts of the sample reach are certainly not unsuitable, particularly in the area just below the mill dam site. In most rocky streams in the upper Little Tennessee watershed the mottled sculpin is the single dominant fish species, and even totally sedimented low gradient streams apparently less suitable than Iotla Creek at Malonee Mill have greater numbers. This same scarcity of sculpins was noted in the fall, 2001 spotfin chub search at this site; no hypothesis is offered to explain this phenomenon.

Metric 12 (% individuals with disease or anomaly) was barely over the threshold value to receive the lowest score (actual observed value was 5.04%). The case for the low score is supported by the prevalence of skin lesions, in addition to such common conditions as blackspot and finrot. Five species, in 3 families, were affected.

One aspect of the habitat at the Malonee Mill site which is not favorable to sculpins, or to other benthic fishes or invertebrates, is the unusual amount of unstable pea gravel, some of it "floating" on a bed of sand. Conditions at the site may generally be described as unstable. There is a great deal of high raw bank, and very little riparian shade. (The landowner has made efforts to control bank erosion by dumping large rock along the bank, but is reluctant to establish a vegetative buffer, believing it will encourage activity by beavers, which are already a serious problem affecting agriculture on the site.) Quantitatively, there is a good amount of riffle and pool habitat, but most of the riffles have an unstable gravel substrate, with few large rocks to provide habitat. Pools are of the "scour" type, and equally devoid of habitat structure. Woody debris and overhanging riparian vegetation are almost non-existent. Conditions are very dissimilar to, but apparently equally as bad as those at the former upstream IBI sites, where riffles and pools are few and the substrate is dominated by loose silt and, to a lesser degree, sand. On the other hand at the upstream sites both woody debris and riparian shade are present. (See Table 36.)

It must be noted that the 2002 sample could underrate Iotla Creek, since we were unable to complete the sample as planned. Although we had obtained access permission (as for the fall 2001 spotfin chub survey) through two members of the landowners' family, including the owner of record, during the process a third family member appeared and unilaterally rescinded the permission. Since we had completed 7 of 8 projected subsamples, it was decided to proceed with scoring. The eighth subsample would have been in the highest quality riffle habitat on the site, with some large rock, and could conceivably have resulted in a higher IBI score. Nevertheless, we believe that this work confirms that, relative to other major tributaries, Iotla Creek is a negative contributor to water quality in the upper Little Tennessee. This is particularly true when it is compared to other streams tributary to the critical habitat reach between Lake Emory Dam and Fontana Reservoir.

One interesting sidelight to the fish sample, was our serendipitous capture of a healthy live mussel from one of the pea gravel riffles. This represents the first record of a mussel from an upper Little Tennessee tributary; until now mussels in the watershed have been presumed to be confined to the river mainstem below Lake Emory. (See also "Comments on Individual Species".) Although following capture of the mussel all crew members were alert for shell relicts along the bank or in shallow water, none were found.

It was at first assumed that this mussel belonged to one or other of the several species (2 of them federally listed) known from the adjacent reach of the Little Tennessee, and had perhaps been introduced as a glochidium larva carried on the gills of a migrating fish. However, it was subsequently identified by Steve Fraley of TVA (personal communication) as a Tennessee heelsplitter (*Lasmigona holstonia*), a species characteristic of smaller streams. Terwilliger (1991) considered the Tennessee heelsplitter to be "extremely rare, and declining throughout its range", although it has no official federal or state listing. The only population known from North Carolina is a marginal one from the Mills River (French Broad River watershed); this is the first record from anywhere in the Little Tennessee watershed.

The Tennessee heelsplitter record (along with the discovery of the spotfin chub's seasonal presence in Iotla Creek and other tributaries), serves to underline how much we have to learn about the upper Little Tennessee River watershed, including its most degraded components.

Table 35. Iotla Creek at Old Malonee Mill Site (RM 1.1)

Species and Numbers of Fish Taken

Species	2002	Previous years*
Mountain brook lamprey	4	
Rainbow trout		X
Central stoneroller	55	
Smoky dace		X
Whiltetail shiner	1	
Warpaint shiner	30	
River chub	42	
Tennessee shiner	17	

Yellowfin shiner	42	
Telescope shiner	5	
Fatlips minnow	1	
Blacknose dace	20	X
Creek chub	11	X
Northern hogsucker	8	
Golden redhorse	5	
Rock bass	17	X
Redbreast sunfish	21	X
Green sunfish	5	
Bluegill	5	X
Smallmouth bass	1	
Largemouth bass		X
Gilt darter	22	
Mottled sculpin	5	X
TOTAL	317	

* Refers to presence of species in previous samples from Iotla Creek mainstem (See text.)

Metrics and Scoring, 2002 IBI Site and 1997 site at RM XXXXXXX

Metric	2002 - RM 1.1		1997 - RM XXXXXXX	
	Observed value	Score	Observed value	Score
1. No. native species	18	6.7	5	1.3
2. No. darter species	1	4.0	0	1.3
5. No. intolerant species	3	6.7	2	4.0
6. % individuals as tolerants	11.7	4.0	5.2	6.7
7. % individuals as ominvores & herbivores	41.6	1.3	54.7	1.3
8. % individuals as specialized insectivores	24.0	4.0	11.7	1.3
10. Catch per unit effort	17.0	4.0	19.6	6.7
11. % individuals as darters & sculpins	8.5	1.3	20.9	1.3
12. % individuals w. disease or anomaly	5.0	1.3	1.3	6.7
TOTAL		33.3 POOR		30.6 POOR

Table 36. Selected Physical Parameters of Iotla Creek at Old Malonee Mill Site (RM 1.1) and at a 1997 IBI monitoring site at the Macon County Airport (RM XXXXXXX)

	2002 - RM 1.1	1997 - RM XXXXX
Watershed area at site (sq. mi.)	9.3	XXXXXX
Width (ft.)		
Mean	15.3	17.7

	Range	13-19	15-20
Mean depth (ft.)			
	Riffles	0.5	1
	Runs	0.8	1.7
	Pools	1.4	2.1
Maximum depth (ft.)		2.5	2.5
Substrate composition (%)			
	Boulder (artificial)	7	
	Rubble	4	5
	Gravel	24	10
	Sand	42	30
	Silt	22	55
Large woody debris		Absent	Abundant
Canopy cover (%)		5	25
Raw bank (%)		50	50
Adjacent land use			
	left bank	mowed field	scrub (airport fringe)
	right bank	field, short grass near mill site mill site	Agriculture (buffered)

Rocky Branch (Halls Ford Creek) above Riverbend Rd. (RM 0.2) (Tables 37 and 38)

Rocky Branch (watershed drainage area 3.3 sq. mi.) was one of 30 direct tributaries to the upper Little Tennessee River with drainage areas of 1-4 sq. mi. which were surveyed in 1995, in an effort to develop IBI criteria for this type of stream McLarney, 1996a; in prep. a). At the time the reach of Rocky Branch immediately above Riverbend Rd. was conspicuously degraded. Cattle had full access to 400 ft. of stream and had effectively eliminated all large riparian vegetation. About a third of the widened, ill-defined channel was dry at normal flow levels, and sedimentation was severe. Although Rocky Branch was the second largest (as measured by watershed area) of 30 streams included in this study it had the second lowest average pool depth (after Mason Branch, with a watershed drainage area of 1.1 sq. mi.). Most “pools” were reduced to broad muddy flats with largely undifferentiated habitat. These conditions were perhaps exacerbated by the condition of the immediate upstream property, where the stream had been channelized and tightly constricted, so that at times of high flow it entered the study reach property with explosive force.

In 2001 a fall survey (McLarney, 2001a) revealed that the Threatened spotfin chub (*Cyprinella monacha*), generally considered to be confined to the mainstem of the Little Tennessee River, made fall migrations into tributary streams with drainage areas as small as 2 sq. mi., accompanied by its common congener, the whitetail shiner (*Cyprinella galactura*, likewise considered a mainstem species). Rocky Branch was included in the survey and, while no spotfin chubs were found, a substantial whitetail shiner migration was detected.

In the process, it was observed that at some time between 1995 and 2002, cattle had been removed from the pasture area on both sides of Rocky Branch. No other attempt at restoration was visible, but the effects were remarkable. Whereas in 1995 Rocky Branch was "wide open" and wadable, the fall 2001 (and subsequent 2002 IBI) sample required crouching and kneeling under a canopy of alders and other vegetation. Whereas before the substrate had been silty and foul smelling, it was firm and devoid of unpleasant odors. (As one indication of change, consider that in 1995, sampling a 351 ft. reach of Rocky Branch with a two person crew required 18 minutes of shocker time, in 2002 it took 38 minutes of shocker time to sample the exact same reach.)

While there are notable differences in the biota of Rocky Branch between 1995 and 2002, the physical differences are even more striking, as a glance at Table 38 will confirm. Highlights include a decrease in mean stream width from 16.4 to 7.2 ft., an increase in average and maximum pool depth from 0.7 and 0.8 ft., respectively to 1.1 and 1.5; an increase in canopy cover from 0 to 90% and the complete elimination of raw bank conditions, which in 1995 accounted for 75% of the reach. The result is a much more attractive stream, where much of the silt component has been replaced by freshly exposed gravel beds.

Rocky Branch in 1995 was highly overfertile, as expressed in a phenomenal fish catch rate of 175.0 individuals per 300 sq. ft. of water surface (reduced to 19.4 in 2002.) Surprisingly, this was not accompanied by changes in Metrics 6 (% individuals with disease or anomaly – which was not poor in 1995) or 8 (% individuals as omnivores and herbivores), and the proportion of the sample as tolerant species actually increased from 8.9 to 14.5 % (although the absolute number of tolerant individuals in the sample decreased from 56 to 22).

Of 9 species represented by 10 or more individuals in 1995, 7 experienced a drop in numbers. The most spectacular declines were recorded for the herbivorous stoneroller (*Campostoma anomalum*, which might be expected to profit most from the former combination of heavy nutrient input and total exposure to sunlight) which went from 117 individuals (18.6% of the sample) to 11 (7.2%) and the tolerant, omnivorous white sucker (*Catostomus commersoni*), represented by 15 individuals in 1995 and totally absent in 2002.

A species which seems to find the altered environment more congenial is the intolerant, piscivorous rock bass (*Ambloplites rupestris*). In 1995, even with extremely high availability of prey, this species was represented only by a few young-of-the-year. In 2002, we captured 10 large adults.

The macroinvertebrate sample from Rocky Branch was by far the most diverse from any site sampled this year, with a total taxa count of 83. This number would appear to reflect a transitional state, with many organisms typical of degraded streams as well as a fair representation of less tolerant types. This observation is supported by the presence of equal numbers (9) of very tolerant and very intolerant taxa (defined as taxa with Hilsenhoff or North Carolina Tolerance Values of 8-10 or 0-2, respectively). This was the largest number of very tolerant taxa for any site monitored this year.

In addition to 29 EPT taxa we recorded 4 mollusks, 7 oligochaetes, 7 Odonata, 8 beetles and 15 chironomids, plus 2 families of Diptera (Pychopteridae or false crane flies and Empedididae or dance flies), considered to be very tolerant of pollution. A considerable number of these taxa were not recorded from any other of the 14 small stream sites where macroinvertebrate samples were taken this year.

The improvement in the IBI score for Rocky Branch (34.5 to 37.5, Bioclass Rating FAIR in both cases) is not statistically significant, and does not seem to accurately reflect the improvement in habitat quality which clearly has occurred. A higher score was recorded for both macroinvertebrate-based metrics in 2002 than in 1995. If the decline in score for Metric 7 (based on capture of a single brown trout, *Salmo trutta* which may have been a stray) is disregarded, the 1995 score would be considered POOR, and the change would be significant. This would seem to more reasonably represent the observed situation in Rocky Branch; it would be desirable to revisit this site next year.

Table 37. Rocky Branch (Halls Ford Creek) Above Riverbend Rd. (RM 0.2)

Species and Numbers of Fish Taken

Species	Number of Individuals Taken	
	1995	2002
Mountain brook lamprey	3	
Brown trout	1	
Central stoneroller	117	11
Whitetail shiner	3	10
Warpaint shiner	102	11
River chub	19	31
Tennessee shiner	165	3
Mirror shiner	1	
Telescope shiner shiner		19
Blacknose dace	91	10
Creek chub	41	17
White sucker	15	
Northern hogsucker	54	10
Golden redhorse	5	
Rock bass	*	10
Redbreast sunfish		5
Green sunfish	*	
Bluegill		1
Smallmouth bass	1	
Largemouth bass	1	
Mottled sculpin	11	14
TOTALS	630	152

* young-of-the-year, included in species count, but not in other aspects of scoring

Metrics and Scoring

Metric	1995 Observed value	1995 Score	2002 Observed value	2002 Score
1. No. Ephemeroptera taxa	5	4.5	11	7.5
2. No. EPT taxa	12	4.5	29	7.5
3. Brook trout presence	Absent	1.5	Absent	1.5
4. Fish catch per unit effort	175.0	4.5	19.4	7.5
5. % individual fish w. disease or anomaly	1.3	6.0	1.3	6.0
6. % individual fish as tolerants	8.9	7.5	14.5	4.5
7. % individuals as wild trout	0.2	4.5	0.0	1.5
8. % individuals as omnivores & herbivores	45.4	1.5	45.4	1.5
TOTALS		34.5 POOR		37.5 FAIR

Macroinvertebrate sample results (1995 data not available)

Bivalvia				
	Veneroidea			
		Sphaeriidae		
			Pisidium sp.	5
Gastropoda				
	Mesogastropoda			
		Pleuroceridae		
			Elimia sp.	32
	Bassommatophora			
		Ancylidae		
			Ferrissia rivularis	4
		Planorbidae		
			Helisoma anceps	1
Oligochaeta				
	Haplotaxida			
		Lumbricidae		11
		Naididae		
			unid.	1
			Nais sp.	7
			N. behningi	7
			Slavina appendiculata	1
	Lumbriculida			
		Lumbriculidae		2
Arachnoidea				
	Acariformes			
		Lebertiidae		

			Lebertia sp.	2
Hirudinea				2
Crustacea				
	Decapoda			
		Cambaridae		
			Cambarus bartoni	2
Insecta				
	Collembola			1
	Ephemeroptera			
		Baetidae		
			Acentrella ampla	2
			Baetis sp.	35
			B. intercalaris	7
		Baetiscidae		
			Baetisca carolina	1
			B. gibbera	1
		Caenidae		
			Caenis sp.	5
		Ephemerellidae		
			Serratella sp.	13
			Stenacron interpunctatum	2
			Stenonema modestum	10
		Leptophlebiidae		
			Parleptophlebia sp.	7
		Neoephemeridae		
			Neoephemera purpurea	2
	Odonata			
		Aeshnidae		
			Boyeria vinosa	24
		Calopterygidae		
			Haeterina sp.	6
		Coenagrionidae		
			Argia sp.	1
		Cordulegastridae		
			Cordulegaster sp.	2
		Gomphidae		
			Gomphus sp.	1
			Ophiogomphus sp.	2
			Stylurus sp.	2
	Plecoptera			
		Leuctridae		
			Leuctra sp.	33
		Perlidae		

		Acroneuria abnormis	2
		Perlesta placida sp. gp.	1
	Pteronarcidae		
		Pteronarcys (Allonarcys) sp.	3
Hemiptera			
	Corixidae		1
Megaloptera			
	Corydalidae		
		Nigronia serricornis	6
	Sialidae		
		Sialis sp.	1
Trichoptera			
	Brachycentridae		
		Brachycentrus sp.	2
	Hydropsychidae		
		unid.	1
		Ceratopsyche sp.	2
		Cheumatopsyche sp.	2
		Diplectrona modesta	4
		Hydropsyche sp.	1
		H. betteni gp.	2
	Lepidostomatidae		
		Lepidostoma sp.	1
		Nectopsyche sp.	1
		Triaenodes sp.	1
	Limnephilidae		
		Goera sp.	1
		Pycnopsyche sp.	12
	Psychomyiidae		
		Lype diversa	2
	Uenoidae		
		Neophylax sp.	4
Coleoptera			
	Elmidae		
		unid.	10
		Macronychus glabratus	32
		Optioservus sp.	1
		O. ovalis	10
		Promoresia sp.	5
		P. tardella	3
	Psephenidae		
		Psephenus herricki	2

	Staphylinidae		2
Diptera			
	Chironomidae		
		unid.	2
		Ablabesmyia mallochi	1
		Cryptochironomus fulvus	1
		Microtendipes sp.	7
		Nanocladius sp.	14
		Pagastia orthogonica	2
		Parametriocnemus lundbecki	4
		Paratendipes sp.	2
		Phaenopsectra sp.	1
		Polypedilum halterale	2
		P. illinoense	3
		Rheocricotopus robacki	4
		Rheotanytarsus sp.	20
		Thienemannimyia gp.	4
		Tribelos sp.	1
	Empididae		
		Hemerodromia sp.	6
	Ptychopteridae		
		Ptychoptera sp.	3
	Simulidae		
		unid.	1
		Simulium sp.	36
	Tabanidae		
		Tabanus sp.	1
	Tipulidae		
		unid.	1
		Antocha sp.	2
		Tipula sp.	3
TOTAL ORGANISMS			468
TOTAL TAXA			83
EPT TAXA			29
Ephemeroptera taxa			11

Table 38. Selected Physical Parameters of Rocky Branch (Halls Ford Creek) above Riverbend Rd. (RM 0.2) for Two Years

		1995	2002
Watershed area at site (sq. mi.)		2.9	2.9
Width (ft.)			
	Mean	16.4	7.2
	Range	9 to 25	5 to 11

Mean depth (ft.)			
	Riffles	0.3	0.5
	Runs	0.7	0.8
	Pools	0.7	1.1
Maximum depth (ft.)		0.8	1.5
Substrate composition (%)			
	Boulder	t	t
	Rubble	4	4
	Gravel	22	36
	Sand	29	29
	Silt	45	31
	Clay		t
Large woody debris		Absent	Absent
Canopy cover (%)		0	90
Raw bank (%)		75	0
Adjacent land use			
	left bank	Unfenced pasture	bufferred hay field
	right bank	Unfenced pasture	bufferred hay field

Big Creek (Cullasaja River Tributary) below Randall Dam (RM 1.0) (Table 39)

This Big Creek, tributary to Lake Sequoyah (an impoundment on the Cullasaja River in Highlands) is not to be confused with another Big Creek, also in the Highlands area, which is part of the Chattooga River watershed. This Big Creek (which forms part of the Town of Highlands' municipal water supply) has been the subject of controversy since 1999. In that year, just after we did our first ever combined fish-macroinvertebrate sample at RM 1.0 (IBI Score 48, Bioclass Rating GOOD), the owner of Randall Dam decided to flush accumulated sediment out of the 2 acre impoundment by the simple expedient of opening the dam.

The physical effect on Big Creek downstream was obvious. What had been a stream reach dominated by pockets between boulders became a bed of sand, with only occasional patches of habitat. However, IBI biomonitoring was not able to detect any difference; a 2000 sample yielded the identical IBI score and Bioclass Rating. Given the very undiverse nature of the fish assemblage, and the low numbers of fish characteristic of infertile streams on the Highlands Plateau, it is not surprising that the fish-based metrics were not informative. As for the macroinvertebrates, although there was a decline in the number of mayfly (Ephemeroptera) and EPT taxa, both remained within the range necessary to achieve the high score on the IBI.

Abundance of most forms was clearly less, and it is our contention that a quantitative assessment of benthic macroinvertebrates would have been revelatory. Other indicators of degradation were the almost total absence of young-of-the-year brown trout (*Salmo trutta*) in 2000, and the relatively poor condition of trout in that year, compared to 1999. An attempt to do a follow-up sample in 2001 was aborted by high water.

In 2002, at the request of a group of Highlands residents, we revisited the Big Creek site, with the agreement that if a fish sample did not indicate severe changes in the biotic community, we would not do the macroinvertebrate sample. While there were differences in the fish sample between 2000 and 2002, they were not of a nature that would negatively affect the IBI, or suggest severe damage to the macroinvertebrate assemblage. When the 6 fish-based metrics in the modified Williams IBI are calculated, none of them score differently than in previously years. Consequently a benthic macroinvertebrate sample was not carried out. Were the macroinvertebrate metrics to give the same result as in 1999 and 2000, the IBI score would be the same (48).

The most immediately apparent biological difference is the greater number of fish. The number of brown trout returned to 1999 levels, while the number of the other principal species (longnose dace, *Rhinichthys cataractae*) reached its highest level ever. Part of the reason in both cases may have been low water levels facilitating capture. And/or continuous flow of water through the dam during dry weather may have conduced to higher survival of fish

The single young-of-the-year golden shiner (*Notemigonus crysoleucas*) was the first of this species taken from Big Creek. Like the 2 sunfish species found in Big Creek it probably is a displaced fish from Randall Lake. It may be worth noting that the 4 bluegills (*Lepomis macrochirus*) taken, all of them small adults, had the form of fish which have grown very rapidly, with small heads and large bodies.

Perhaps the most significant change in the fish assemblage, however, is the presence of the blacknose dace (*Rhinichthys atratulus*). In 1993 a single individual of this species (probably native to the Highlands Plateau) was taken in a non-IBI survey at this site, but it has not been seen here since. All 8 blacknose dace in 2002 were taken from shallow, heavily sedimented sites along shore. It appears as though the draining of Randall Lake, in addition to the spectacular deposition of sand in the main channel, has created more habitat of this type.

Benthic habitat in Big Creek is clearly recovering; there is more rock and gravel exposed than there was in 2000. The dam remains open. On the one hand, this insures a more constant flow rate below the dam. On the other hand, there is still a considerable quantity of sediment stored behind the dam, some of which moves downstream with each rain event. Lower Big Creek cannot be considered biologically secure (nor can the Highlands Water Treatment Plant or residents along the Big Creek arm of Lake Sequoyah count on no further damage) until there is some sort of agreement about the management of Randall Lake and its dam. So far, the owner has not been willing to enter into discussions toward this end, and our biomonitoring results have not been of a nature to contribute much toward creating such a situation. Were it possible to carry out a quantitative study of the benthic macroinvertebrates of Big Creek it might conduce to that end.

Table 39. Big Creek (Cullasaja River Tributary) Below Randall Dam (RM 1.0)

Species and Numbers of Fish Taken

Species	2000	2002
Brown trout	12	28
Golden shiner		*
Blacknose dace		8
Longnose dace	15	26
Redbreast sunfish		1
Bluegill	2	4
TOTALS	29	67

* 1 young-of-the-year only

Blaine Branch above Confluence with Cartoogechaye Creek (RM 0.0) (Tables 40 and 41)

Most of the 1.6 sq. mi. watershed of Blaine Branch is more or less wooded and in fairly good condition. However, the lowermost 900 ft., from Patton Rd. to its confluence with Cartoogechaye Creek, have been severely degraded for some years. Up until 2001, this area was in unfenced pasture. Cattle had full access to the stream, which was deeply incised, fully sedimented, highly nutrient enriched, and largely devoid of riparian vegetation other than grass. Most of the bank was raw, with numerous blow-outs. The combination of deep, canyon-like incision with lack of bank protection made Blaine Branch a major contributor to sedimentation downstream in Cartoogechaye Creek.

This reach of Blaine Branch is now slated for restoration, as a DOT mitigation project. The goal is not only to eliminate Blaine Branch as a source of excess sediment to Cartoogechaye Creek, but to restore it to something approaching its natural state, with natural vegetation and meanders and associated riparian wetland areas. At the time of our survey cattle had been removed from the pasture for over a year, and vegetation allowed to grow. Other than some preliminary survey work nothing else had been done toward restoration. Thus, while we may not have gotten in absolutely on the “ground floor”, we now have something approaching baseline data.

At present, there is a modest amount of gravel in the substrate, but soft sediments predominate. Most fish habitat is provided by undercuts and overhanging vegetation. The banks are becoming covered with grass, but several major blowout areas remain, particularly near the tops of the banks. Small cherries, alders and multiflora rose dot the banks, and some stretches are all but impenetrable because of these plants. This condition becomes increasingly prevalent as one moves upstream.

The sample began above the first riffle before Cartoogechaye Creek, essentially at RM 0.0. This was done for two reasons: 1) Given the small size of the stream, it was decided that sampling in the extreme lower reaches would produce more fish, and 2) to avoid the more impenetrable reaches.

In order to avoid having to cut our way through thickets, the actual sample reach was a composite one, consisting of 3 sectors of stream, each about 100 ft. long. This provided a mix of habitats – mostly slow moving with soft bottom near the mouth, swifter and sandy in the middle, and studded with gravel riffles at the top. All of the 5 fish species found in substantial numbers were taken from all 3 sectors.

Not surprisingly for a stream of this size and type, the fish assemblage was dominated by the blacknose dace (*Rhinichthys atratulus*). Although a total of 10 species were found, this single species, a generalist feeder, made up 65.5% of the sample. Other fish species are those which would be predicted.

The fish assemblage is dominated by omnivores and herbivores (blacknose dace and 4 other species). None of the fish-based metrics achieved the high score, so there is ample room for improvement.

The 2 yellowfin shiners (*Notropis lutipinnis*) represent the farthest upstream record for this invasive exotic in the Cartoogechaye Creek watershed.

The endemic Little Tennessee River crayfish (*Cambarus georgiae*) outnumbered the ubiquitous *Cambarus bartoni* by about 3 to 1. Blaine Branch was the only one of 14 small streams where macroinvertebrate samples were taken in 2002 where we recorded the Elmid beetle *Ancyronyx variegata*.

The only high scores in the IBI were provided by the two macroinvertebrate-based metrics. Particularly surprising to us was the abundance of Limnephilid caddisfly *Pycnopsyche* sp. ("stickbait" in local parlance). However it should also be noted that the number of very tolerant macroinvertebrate taxa (Hilsenhoff or North Carolina tolerance values of 8-10) was 5, barely exceeded by the number of very intolerant taxa (tolerance values 0-2). The total of 6 very intolerant taxa was tied with McDowell Branch for the second lowest count among small streams monitored in 2002.

It appears that while habitat conditions are presently poor in lower Blaine Branch, water quality upstream is good enough to significantly offset any problems related to historic cattle access. Blaine Branch provides us with an opportunity to follow an active restoration project on a small stream over a period of years. Other opportunities of this type have been compromised by limited cattle access (Sutton Branch – see this and previous reports) or human intervention in the riparian buffer zone (Mashburn Branch, McLarney, 1998a; 2001b).

Cartoogechaye Creek at Killian Farm (RM 10.7)

Paired sites (Treatment and Control) on Cartoogechaye Creek at the Killian Farm were established in 1996 and have since been monitored, using a fish-based IBI protocol, on what has turned out to be a 3 year rotation, as part of a multi-institutional effort under the umbrella of Coweeta Hydrological Laboratory to measure the effects of riparian restoration on water and habitat quality. Major components of the restoration effort have been:

- Stabilization of eroding banks through use of whole tree revetments, root wads and some rock, with enhanced shoreline habitat as a complementary benefit.

- Creation of a riparian buffer zone through exclusion of livestock, tree planting and allowing natural vegetation to grow.

Monitoring since 1996 has already demonstrated several benefits of this work:

- Stream bank erosion, with consequent on-site and downstream sedimentation effects, has clearly been drastically reduced (although some structures may yet prove to be impermanent).

- Chemical monitoring has shown that the riparian buffer zone (by no means yet fully established) is already effective in reducing nutrient fluxes from adjacent pasture land to the stream.

- Structural approaches to bank stabilization have created additional habitat for fish, particularly game species (see below).

- The esthetic of the site is vastly improved.

What has not been demonstrated is any measurable effect on biotic integrity at the site. This problem was foreseen from the start, as a simple consequence of scale. It would be unrealistic to expect improvements made along XXX ft. of stream bank to have a major effect on a biotic community which is continually affected by the sum of conditions throughout a 24 sq. mi. watershed.

To this statement must be added the realization - made clear through experience on a smaller restoration site, Sutton Branch (see elsewhere in this report) - that expectations from restoration work must be proportional to the scope of the restoration. At Sutton Branch, exclusion of cattle from most of the stream through fencing and riparian restoration appears merely to have had the effect of concentrating livestock-related nutrient inputs at particular places. At the Killian Farm the situation is somewhat better; cattle have been excluded from the entire stream save for a crossing at the downstream end of the lower (Treatment) reach. Nevertheless there is still drainage from pasture areas to the creek via ditches, and the natural functioning of riparian wetland areas continues to be impeded through maintenance and use of pasture.

Here we will report on those changes which appear to have occurred at the Killian Farm site, whether or not related to the restoration work, and continuing differences between the Treatment and Control sectors:

The establishment of “controls” in the natural environment is necessarily compromised in all cases. In the case of the Killian Farm site, the Control reach, located just upstream of the Treatment sector, had larger, deeper pools at the start of the experiment. Riffles were shorter, but also deeper and more powerful, with larger substrate. Whereas the Treatment sector was largely unshaded, much of the Control sector was bordered by large trees. Until trees planted in the riparian zone of the Treatment sector achieve their full growth, shade will remain a factor favoring biotic integrity in the Control sector. (It should be noted that in the last year the landowner has planted trees along a ca. 100 ft. reach at the upstream end of the Control sector, which has been characterized by vertical raw bank and a total lack of shade.)

As Table 42 shows, there is very little difference in the fish assemblage at the Killian Farm between years or sites. The most conspicuous difference is one which has little effect on the IBI. In 1999 there was a suggestion that shoreline structures were attractive to game fish. (This has not been the case at all stream bank stabilization sites in the upper Little Tennessee watershed. See McLarney, 2000b and 2001b. Clearly there is a need for further study of the effects of shoreline structures on game fish and fish in general.) This was clearly confirmed in 2002.

In 1996 the principal game fish (and piscivore) at the Killian Farm site (brown trout, *Salmo trutta*) was more abundant in the deep pools and shaded environment of the Control sector. In 1999 there appeared to be a trend toward more even distribution of brown trout. In 2002, it was clear that sport fishing opportunities were greater in the Treatment sector. Of 23 brown trout taken in the Treatment sector, 11 were "catchables", up to an estimated 18 inches TL. Of 15 brown trout taken in the Control sector, only 2 were "catchables" and one of these barely met the criterion (7 inches TL). Similarly, while rock bass (*Ambloplites rupestris*) were more abundant in the Control sector (17 individuals), there they were entirely represented by small and medium sized individuals of minimal interest to anglers, while 5 of 8 rock bass from the Treatment sector were considered as "large" to "very large".

The species lists for the two sectors in 2002 are virtually identical, with two species (rainbow trout, *Oncorhynchus mykiss* and golden redhorse, *Moxostoma erythrurum*) missing from the Control sector, and one (fatlips minnow, *Phenacobius crassilabrum*) missing from the Treatment sector. However, the Treatment sector species list merits a comment. At the conclusion of the regularly planned sample for the Treatment sector, 3 "expected" species, taken on previous occasions (and subsequently taken from the Control sector in 2002) were missing – smoky dace, *Clinostomus* sp.; Tuckaseigee darter, *Etheostoma blennioides gutselli* and longnose dace, *Rhinichthys cataractae*. Omission of the first two from the species list could affect metric scoring (through Metrics 5 and 2, respectively.)

It was decided to target these 3 species by electrofishing, with a 2 person crew, in selected habitat, allowing 20 minutes for each species. Smoky dace were captured within 2 minutes and longnose dace in 4 minutes, while it took 14 minutes to turn up a Tuckaseigee darter. As Table 42 indicates, all 3 species are included in species counts for purposes of calculating the IBI, but not taken into account in other aspects.

Prime habitat for the Tuckaseigee darter is scarce in the Treatment sector, and concentrated at the upstream end, close to the Control sector; it was represented in the sample by single individuals in both 1996 and 1999. However, the other two species definitely should have been taken. Revision of field notes showed that, although we had the impression of having carried out a complete sample, the surface area of water covered was substantially less than in 1996 and 1999. This will be taken into account in any future monitoring efforts.

We did not categorize the fatlips minnow, also missing from the Treatment sector sample, as “expected”. This species, widespread but characteristically rare in much of the upper Little Tennessee watershed, is apparently increasing in abundance in upper Cartoogechaye Creek (the 1996 sample at this site marked the first record of this species above RM 1.0) However, it is still of sporadic occurrence, and its absence was not treated as significant.

The most apparent difference between 1999 and 2002 at the Killian Farm site is the greatly reduced number of redhorses (*Moxostoma*), although the black redhorse (*Moxostoma duquesni*) was taken for the first time (1 individual at each site). Total numbers of golden redhorses (*Moxostoma erythrurum*) for both sites combined were 29 in 1996 and 26 in 1999, compared to 1 (from the Treatment sector) in 2002. This may not be significant, since redhorses are migratory in Little Tennessee tributaries. Redhorses taken in our samples likely represent adults returning from spawning migrations or juveniles descending from nursery areas upstream.

A potentially more serious difference between years has to do with Metric 12 (% individuals with disease or anomaly). In 1996, the observed value for this metric was 0.7% (meriting the high score) at both sites. In 1999 and 2002, these values ranged from 6.1 to 16.3%, all above the threshold for the lowest score. The 1996 sample was not carried out by our crew, and there is some concern that less attention was paid to diseases, parasites and anomalies at that time. However, this data corresponds to very high observed values for this metric (usually in excess of 10%) at all sites on Cartoogechaye Creek, both up and downstream of the Killian Farm, during this period (but not in Cartoogechaye Creek tributaries), a condition not generally observed during prior to 1999.

By far the most prevalent condition was blackspot, especially on river chubs (*Nocomis micropogon*). In 2002, 57.2% of river chubs (both sites combined) had blackspot, which was also observed on 6 other species. We also noted an extremely heavy incidence of an unidentified parasite (superficially similar to blackspot, but with a raised and irregular form) on young-of-the-year Cyprinids (not counted in calculating the IBI) in both sectors.

The high incidence of parasitization suggests an increase in nutrient loading from an unknown upstream source, notwithstanding the progress which has been made in controlling local nutrient sources. Since use of the watershed for agriculture and livestock is presumably declining, there is no readily available hypothesis for increased nutrients (if this is in fact the case.)

In summary, there is little difference in the fish assemblage between Treatment and Control sectors of Cartoogechaye Creek at the Killian Farm. There may be changes occurring over time in terms of available habitat for piscivorous fish, nutrient loading and redhorse populations. A FAIR-to-GOOD Bioclass Rating would seem to fairly describe both sites. A general characterization would include the following observations:

- There is a normal diversity and abundance of fish, with all expected species. The only exotic species significantly affecting assemblage structure is the brown trout.

- There are no apparent effects of toxic pollutants, (See Metrics 5 and 6), nor any suspected sources.

- Less than full biotic integrity is probably due in part to sedimentation in excess of natural levels, reflected in medium scores for Metrics 7, 8 and 11.

- There is a suggestion of excess organic content, possibly reflected by overabundance of omnivores and herbivores (Metric 7), but more particularly by the extremely high incidence of parasitization (Metric 12).

Any future changes at this site are more likely to be due to changes in the watershed upstream than to any effect of the restoration work. However, with 3 years of data already accumulated, it might be prudent to maintain the Killian Farm as a biomonitoring site. Future investigations might profitably focus on more careful evaluation of natural and enhanced shoreline fish habitat.

Table 42. Cartoogechaye Creek at Killian Farm (RM 10.7)

Species and Numbers of Fish Taken

Species	**Control**		**Treatment**	
	1999	**2002**	**1999**	**2002**
Mountain brook lamprey	25	11	24	6
Rainbow trout			1	4
Brown trout	27	15	21	23
Brook trout		(1) *		
Central stoneroller	84	85	98	77
Smoky dace	18	13	14	**
Whitetail shiner	1	13	3	12
Warpaint shiner	54	111	36	82
River chub	139	133	198	75
Tennessee shiner	96	29	65	50
Mirror shiner	40	21	47	30
Fatlips minnow	4	11	3	
Blacknose dace	28	28	47	15
Longnose dace	10	3	2	**
Creek chub	9	5	2	1
White sucker		1		2
Northern hogsucker	46	27	37	17
Black redhorse		1		1
Golden redhorse	4		13	1

Rock bass	9	17	18	8
Redbreast sunfish	45	7	22	19
Bluegill			1	
Tuckaseigee darter	7	5	1	**
Greenfin darter	29	28	23	28
Gilt darter	8	12	3	4
Mottled sculpin	437	336	476	201
TOTALS	**1120**	**912**	**1155**	**656**

* Stocker, not counted in scoring
** Not taken in the IBI sample, but found in subsequent targeted sampling, included in species counts, but not in other aspects of IBI scoring

Metrics and Scoring

Metric*	**Control**				**Treatment**			
	1999		**2002**		**1999**		**2002**	
	Observed value	**Score**	**Observed value**	**Score**	**Observed value**	**Score**	**Observed value**	**Score**
1	18	6.7	20	6.7	20	6.7	20	6.7
2	3	6.7	3	6.7	3	6.7	3	6.7
5	3	6.7	3	6.7	3	6.7	3	6.7
6	4.8	6.7	1.4	6.7	2.1	6.7	3.4	6.7
7	26.5	4.0	28.8	4.0	31.9	6.7	26.8	4.0
8	30.5	4.0	27.0	4.0	17.1	1.3	31.6	4.0
10	30.7	6.7	23.9	6.7	33.0	6.7	24.6	6.7
11	43.1	4.0	41.8	4.0	43.5	4.0	35.5	4.0
12	6.1	1.3	12.7	1.3	11.9	1.3	16.3	1.3
TOTALS		**46.8 FAIR**		**46.8 FAIR**		**44.1 FAIR**		**46.8 FAIR**

* For metric descriptions see Table 3.

McDowell Branch above Wide Horizon Drive (RM 0.3) (Tables 43 and 44)

McDowell Branch (watershed drainage area 1.6 sq. mi.) was one of 30 direct tributaries to the Little Tennessee with watershed drainage areas of 1-4 sq. mi. monitored in 1995 in an effort to better develop IBI criteria for small streams (McLarney, 1996a; in prep. a). At that time it presented the appearance of a recovering stream. The monitoring site flows through a totally forested property and, except for the amount of silt in the substrate, presents the appearance of a nearly pristine stream. However, it received an IBI score of 30.0 (Bioclass Rating POOR) based on a reduced benthic insect assemblage (particularly lacking in Ephemeroptera), high percentage of omnivores and herbivores in the fish assemblage and absence of trout. (Note also that the catch per unit effort – 9.1 fish per 5 minutes of shocker time – barely exceeds the threshold for the high score. (Only 1 of the 30 small streams sampled in 1995 received less than the high score for this metric, suggesting that values may need to be adjusted downward for low altitude streams.)

According to a local resident, prior to 1995 large quantities of "suds" were frequently seen floating down McDowell Branch. These were attributed to a laundromat located about a mile upstream on a tributary (Setser Branch) which crosses US Highway 441 in a heavily developed area. This condition has not been seen in recent years, although the amount of sediment in the channel seems to have increased somewhat as development along the busy highway has proceeded.

Although there is still a high percentage of omnivores and herbivores in the fish assemblage, the incidence of disease and parasitism was reduced to one mild case of blackspot on a river chub (*Nocomis micropogon*). Scoring for other fish based metrics did not change, but the observed value for Metric 4 (catch rate) nearly tripled.

Fish diversity also increased dramatically between 1995 and 2002. All 9 fish species present in 1995 were taken in 2002, with 6 in increased numbers, and 7 new species were recorded. Although two of the new species (white sucker, *Catostomus commersoni* and green sunfish, *Lepomis cyanellus*) are tolerants, and one (yellowfin shiner, *Notropis lutipinnis*) is an invasive exotic, the data nonetheless suggest repopulation from the Little Tennessee.

While the EPT count (18 taxa) crossed the threshold for receiving the high score, McDowell Branch continues to have very low diversity of Ephemeroptera (4 species) and Plecoptera (2 taxa). Very intolerant taxa (Hilsenhoff or North Carolina Tolerance Values of 2 or less) were represented by only 6 taxa, but only 1 very tolerant taxon (Tolerance Value 8-10) was present. Diversity of Chironomidae was startlingly low with 3 taxa. The picture which emerges is of across the board low diversity, suggesting, if not ongoing pollution, then some sort of toxic residue in McDowell Branch.

On the other hand, *Elimia* snails were abundant in numbers barely suggested by the sample data. No less than 4 macroinvertebrate taxa were unique to McDowell Branch among the 4 small stream sites sampled this year. They were the Gomphid dragonfly *Stylogomphus albistylus*, the Hydropsychid caddisfly *Hydropsyche venularis*, the Elmid beetle *Optioservus immunis* and the Psephenid beetle *Ectopria* sp. All but the latter were represented by single individuals.

In general it appears that the fish assemblage is recovering more rapidly than the macroinvertebrates. If the rate of sedimentation can be kept within limits, and recovery continues to encompass the benthic macroinvertebrate community, this reach of McDowell Branch might merit efforts at preservation as an example of a small Little Tennessee River valley tributary within a natural forested environment.

Table 43. McDowell Branch above Wide Horizon Drive (RM 0.3)

Species and Numbers of Fish Taken

Species	Number of Individuals Taken	
	1995	2002
Mountain brook lamprey		1
Central stoneroller		1
Smoky dace	25	15
Warpaint shiner	12	38
River chub	12	26
Tennessee shiner		3
Yellowfin shiner		34
Blacknose dace	3	12
Creek chub	11	16
White sucker		5
Northern hogsucker	3	2
Golden redhorse		1
Rock bass	2	2
Redbreast sunfish	1	4
Green sunfish		2
Mottled sculpin	53	73
TOTAL	122	235

Macroinvertebrate sample results (1995 data not available)

Gastropoda				
	Mesogastropoda			
		Pleuroceridae		
			Elimia spp.	22
Oligochaeta				
	Haplotaxida			
		Lumbricidae		9
Crustacea				
	Decapoda			
		Cambaridae		
			Cambarus bartoni	6
Insecta				
	Ephemeroptera			
		Ephemerellidae		
			Eurylophella sp.	1
		Heptageniidae		
			Stenonema modestum	65
		Isonychiidae		
			Isonychia sp.	1
		Leptophlebiidae		
			Paraleptophlebia sp.	10
	Odonata			

	Aeshnidae		
		Boyeria vinosa	12
	Calopterygidae		
		Calopteryx maculata	3
	Cordulegastridae		
		Cordulegaster sp.	5
	Gomphidae		
		unid.	7
		Gomphus sp.	5
		Stylogomphus albistylus	1
Plecoptera			
	Leuctridae		
		Leuctra sp.	21
	Perlidae		
		Acroneuria abnormis	5
Hemiptera			
	Veliidae		
		Rhagovelia obesa	4
Megaloptera			
	Corydalidae		
		Nigronia serricornis	28
Trichoptera			
	Glossosomatidae		
		Glossosoma sp.	1
	Hydropsychidae		
		unid.	2
		Ceratopsyche sparna	26
		Cheumatopsyche sp.	78
		Diplectrona modesta	4
		Hydropsyche betteni gp.	5
		H. venularis	1
	Limnephilidae		
		Pycnopsyche sp.	3
	Philopotamidae		
		Dolophilodes sp.	4
	Psychomyiidae		
		Lype diversa	1
	Uenoidae		
		Neophylax sp.	2
Coleoptera			
	Dryopidae		
		Helichus basalis	3
	Elmidae		
		Optioservus immunis	1
		O. ovalis	8
		Stenelmis sp.	11
	Psephenidae		
		Ectopria sp.	4

	Psephenus herricki	10
Ptilodactylidae		
	Anchytarsus bicolor	7
Chironomidae		
	Polypedilum fallax	5
	Rheotanytarsus sp.	2
	Thienemannimyia sp.	1
Dixidae		
	Dixella sp.	1
Simulidae		
	Simulium sp.	15
Tipulidae		
	Antocha sp.	1
	Tipula sp.	19
TOTAL NO. ORGANISMS		430
TOTAL TAXA		43
EPT taxa		18
Ephemeroptera taxa		4

Metrics and Scoring

Metric	1995 Observed value	Score	2002 Observed value	Score
1. No. Ephemeroptera taxa	4	4.5	4	4.5
2. No. EPT taxa	13	4.5	18	7.5
3. Brook trout presence	Absent	1.5	Absent	1.5
4. Catch rate of fish per unit effort	9.1	7.5	26.4	7.5
5. % individual fish w. disease or anomaly	2.5	4.5	0.4	6.0
6. % individual fish as tolerants	9.8	7.5	11.5	4.5
7. % individual fish as wild trout	0.0	1.5	0.0	1.5
8. % individual fish as omnivores & herbivores	21.3	1.5	26.0	1.5
TOTALS		30.0 POOR		34.5 POOR

Table 44. Selected Physical Parameters of McDowell Branch above Wide Horizon Drive (RM 0.3)

	1995	2002
Watershed area at site	1.5	1.5
Width (ft.)		
Mean	11.6	9.3
Range	7 to 20	6 to 18
Mean depth (ft.)		

Riffles	0.4	0.2
Runs	0.8	0.5
Pools	1.2	1
Maximum depth (ft.)	1.6	1.5
Substrate composition (%)		
Bedrock	8	7
Boulder	6	7
Rubble	18	17
Gravel	20	17
Sand	4	6
Silt	44	47
Large Woody Debris	Common	Common
Canopy cover (%)	100	100
Raw bank (%)	10	10
Adjacent land use		
Left bank	forest	forest
Right bank	forest	forest

Norton Branch (West Bank) above US Highway 441 (RM 0.3) (Tables 45 and 46)

Two streams which appear on the topo quads as "Norton Branch" empty into the Little Tennessee River 1.9 miles apart in the Norton area of Macon County (part of the Otto community). For purposes of reporting we have distinguished them as Norton Branch – West Bank and Norton Branch – East Bank. Both were included in our 1995 study of small Little Tennessee tributaries (McLarney, 1996a; in prep. a). Norton Branch – West Bank is the larger of the two, and was included in this study because of clearly visible physical changes in the study reach.

Norton Branch – West Bank has a history of being dammed by beavers, and about half of the 0.3 mi. reach below US 441, directly downstream of the study reach, was in beaver ponds in both 1995 and 2002. Some beaver ponds were removed during the 4-laning of US 441 during the early 1990's, and ongoing beaver activity was discernible during the 1995 sample. At that time there was a large, deep (to 5 ft.) beaver pond, located in a wooded area upstream of the study reach (just upstream of the principal tributary, Bradley Branch).

Between 1995 and 2002, all beaver dams upstream of US 441 for at least 0.5 mi. were removed, and the reach has been maintained free of dams. The young forest around the pond and along the right bank downstream has been cleared, leaving only a few scattered shade trees (and almost none along the immediate bank of the stream). In addition, an agricultural field parallel to the left bank has been converted to pasture. In 1995, there were some cattle in a fenced pasture area several hundred yards from the stream; today cattle have access to and across the study reach and (apparently) for some distance upstream. (Most of the length of the mainstem of Norton Branch – West Bank is contained within a single large farm.) Table 46 shows the predictable consequences in terms of fish habitat.

The effects of modification on the fish community are also evident.

- A small population of rainbow trout (*Oncorhynchus mykiss*), with some individuals up to 14 inches TL, has completely disappeared, and appears to have been replaced by a growing population of the tolerant, omnivorous creek chub (*Semotilus atromaculatus*). Our sample included several large creek chubs.

- The herbivorous central stoneroller (*Campostoma anomala*) appeared for the first time in 2002, presumably in response to the removal of shade and the addition of nutrients in the form of cattle waste.

These changes affect the IBI score (Metrics 7 and 6, respectively). The observed value for Metric 8 (% omnivores and herbivores) also increased significantly, from 11.1% to 19.5%, falling just short of the threshold (20%) to assign a lower score for Metric 8.

Another change in the fish assemblage which may or may not be related to physical alteration in the environment is the increased abundance of the exotic yellowfin shiner (*Notropis lutipinnis*). This invasive species was represented in 1995 by a single individual (which may have been a hybrid with the native smoky dace (*Clinostomus* sp.), but in 2002 we captured 20 individuals, 2 of which appeared to be hybrids.

Norton Branch – west bank scored high for both macroinvertebrate-based metrics in 1995. Curiously, the macroinvertebrate community did not reflect habitat change in the same manner as the fish community. Not only do scores for Metrics 1 and 2 remain high, but both EPT count and number of Ephemeroptera taxa increased substantially.
A few (largely anecdotal) observations of changes in the macroinvertebrate assemblage between 1995 and 2002 follow:

- More large Ephemeroptera (dominated by Baetids and small *Isonychia* in 1995).
- Plecoptera abundant (rare in 1995), but dominated by *Pteronarcys*.
- Elmid beetles, common in 1995, rare in 2002.
- Tipulids, rare in 1995, common in 2002.
- The dominant crayfish in 2002 was the endemic Little Tennessee River crayfish (*Cambarus georgiae*), whereas in 1995 only *Cambarus bartoni* was present.

The Chironomid fauna at Norton Branch – west bank was unique. Of a total of 15 taxa reported, 7 (including both very tolerant forms and the highly intolerant *Epoicladius* sp.) were not found at any other of the 14 small stream sites monitored in 2002. The Heptageniid mayfly *Stenacron pallidum* was also unique to this site.

The IBI score dropped only 3 points (42.0 to 39.0) between 1995 and 2002 and the Bioclass Rating remained FAIR. However, we suggest the fish data (see two bullets above) strongly suggest a decline in ecosystem health commensurate with the damage done to the physical habitat, and we are more inclined to trust this evidence. It may be that there are complex interactions related to beaver pond removal which we are unable to account for. It may be instructive to compare the information on Norton Branch – West Bank to the results from Lamb Creek (below) which suffered similar damage during the same time period (although damage was already well underway in 1995), but without the possibly complicating factor of recent beaver activity.

Table 45. Norton Branch (West Bank) above U.S. Highway 441 (RM 0.3)

Species and Numbers of Fish Taken

Species	Number of Individuals Taken	
	1995	2002
Mountain brook lamprey	18	15
Rainbow trout	9	
Central stoneroller		8
Smoky dace	48	36
River chub		2
Yellowfin shiner	1	20
Creek chub	7	34
Mottled sculpin	142	188
	225	303

Macroinvertebrate sample results (1995 data not available)

Nematoda - Nematophora				1
Bivalvia				
	Veneroidea			
		Sphaeriidae		
			Pisidium sp.	6
Gastropoda				
	Mesogastropoda			
		Pleuroceridae		
			Elimia sp.	25
Oligochaeta				
	Haplotaxida			
		Lumbricidae		2
Crustacea				
	Decapoda			
		Cambaridae		
			Cambarus bartoni	present
			C. georgiae	present
Insecta				
	Ephemeroptera			
		Baetidae		
			Baetis intercalaris	12
			B. c.f. *flavistriga*	1
			B. tricaudatus	8
			Plauditus sp.	4

	Baetiscidae		
		Baetisca carolina	1
	Ephemerellidae		
		Drunella tuberculata	2
		Eurylophella sp.	1
		Serratella sp.	23
	Ephemeridae		
		Ephemera sp.	8
	Heptageniidae		
		Epeorus dispar	5
		Stenacron pallidum	1
		Stenonema modestum	24
	Isonychiidae		
		Isonychia sp.	4
	Leptophlebiidae		
		Paraleptophlebia sp.	1
	Odonata		
		Boyeria sp.	1
	Calopterygidae		
		Calopteryx sp.	1
	Cordulegastridae		
		Cordulegaster sp.	6
	Gomphidae		
		Gomphus sp.	4
Plecoptera			
	Leuctridae		
		Leuctra sp.	24
	Perlidae		
		unid.	1
		Acroneuria abnormis	2
		Perlesta placida sp. gp.	1
	Perlodidae		
		unid.	1
		Isoperla holochlora	2
	Pteronarcidae		
		Pteronarcys (Allonarcys) sp.	5
Megaloptera			
	Corydalidae		
		Corydalis cornutus	1
		Nigronia fasciatus	1
Trichoptera			
	Hydropsychidae		
		unid.	21
		Ceratopsyche bronta	1
		C. sparna	53
		Diplectrona modesta	21
		Hydropsyche betteni gp.	4
	Lepidostomatidae		

		Lepidostoma sp.	2
	Limnephilidae		
		Goera sp.	7
		Pycnopsyche sp.	4
	Philopotamidae		
		Dolophilodes sp.	10
	Rhyacophilidae		
		Rhyacophila fuscula	1
	Uenoidae		
		Neophylax sp.	5
Coleoptera			
	Elmidae		
		Dubiraphia sp.	1
		Optioservus sp.	8
		O. ovalis	6
	Hydrophilidae		
		unid.	1
		Sperchopsis tessellatus	2
Diptera			
	Athericidae		
		Atherix lanta	1
	Blephariceridae		
		Blepharicera sp.	1
	Chironomidae		
		Atrichopogon sp.	6
		Cardiocladius obscurus	2
		Cladotanytarsus sp.	2
		Conchapelopia sp.	4
		Epoicocladius sp.	2
		Eukiefferiella brehmi gp.	1
		Nilothauma sp.	1
		Orthocladius sp.	1
		Pagastia orthogonia	4
		Parametriocnemus lundbecki	3
		Polypedilum flavum (convictum)	1
		P. halterale	1
		Procladius sp.	1
		Prodiamesa olivacea	1
		Tvetenia bavarica gp.	3
	Dixidae		
		Dixa sp.	1
	Simulidae		
		Simulium sp.	9
	Tipulidae		
		Antocha sp.	8
		Tipula sp.	5
TOTAL ORGANISMS			385

TOTAL TAXA	69
EPT taxa	32
Ephemeroptera taxa	14

Metrics and Scoring

Metric	1995		2002	
	Observed value	Score	Observed value	Score
1. No. Ephemeroptera taxa	8	7.5	14	7.5
2. No. EPT taxa	21	7.5	32	7.5
3. Brook trout presence	Absent	1.5	Absent	1.5
4. Fish catch per unit effort	43.5	7.5	53.6	4.5
5. % individual fish w. disease or anomaly	3.1	4.5	0.0	7.5
6. % individual fish as tolerants	3.1	7.5	11.2	4.5
7. % individual fish as wild trout	4.0	4.5	0.0	1.5
8. % individual fish as omnivores and herbiv.	11.1	4.5	19.5	4.5
TOTALS		42.0 FAIR		39.0 FAIR

Table 46. Selected Physical Parameters of Norton Branch (West Bank) Above US Highway 441 (RM 0.3)

		1995	2002
Watershed area at site (sq. mi.)		1.3	1.3
Width (ft.)			
	Mean	9.2	6.6
	Range	8 to 12	5 to 10
Mean depth (ft.)			
	Riffles	0.4	0.5
	Runs	0.7	0.5
	Pools	1.2	0.9
Maximum depth (ft.)		1.2	1.2
Substrate composition (%)			
	Bedrock		4
	Boulder	10	8
	Rubble	49	29
	Gravel	7	3
	Sand	33	44
	Silt		12
Large woody debris		Common	Rare
Canopy cover (%)		75	5
Raw bank (%)		20	60
Adjacent land use			

Left bank	Agricultural field w. grass buffer	Unfenced pasture
Right bank	Young forest	Unfenced pasture

Tessentee Creek at Tessentee Farm (RM 0.1 and 0.3) (Tables 47 and 48)

The lower of these two sites was first monitored in 2001 as part of a biotic inventory at the Land Trust for the Little Tennessee's Tessentee Farm (McLarney, 2001a). The site was selected near to the mouth of Tessentee Creek with the goal of maximizing species count. In the process of doing the sample, it was observed that the lowermost ca. 0.2 mi. of Tessentee Creek, where it passes through the Little Tennessee River floodplain, is somewhat atypical for this stream in being deeply incised, with an unstable substrate dominated by fine gravel. Immediately upstream, still on the Land Trust property, is a well shaded, non-incised reach with a more stable substrate with larger average particle size. It was decided to repeat the 2001 sample at RM 0.1 in 2002 and add a site at RM 0.3, as a reach more "typical" of Tessentee Creek.

Table 48 shows a considerable difference between the two reaches in terms of physical habitat. However, Table 47 shows that there was no significant difference between the two sites (or between 2001 and 2002 at the lower site) in terms of species composition of the fish assemblage or biotic integrity. The upper site in 2002 and the lower site in both years rated FAIR.

Two possibly significant differences are related to substrate composition. Abundance of the mottled sculpin (*Cottus bairdi*) was greater at the upper site, as would be expected from the greater availability of large rocks as cover. We also captured 2 specimens of another species associated with large rocks, the greenfin darter (*Etheostoma chlorobranchium*) at the upper site. (The greenfin darter is a significant member of the fish assemblage further upstream in Tessentee Creek.) These two species contributed to a higher observed value for Metric 11 (% darters and sculpins), but the difference was not sufficient affect the IBI score.

However, the only difference which affected the IBI score resulted in the upstream reach scoring lower than the downstream reach. A high incidence of parasitization (primarily blackspot on river chubs, *Nocomis micropogon*; warpaint shiners, *Luxilus coccogenis* and Tennessee shiners, *Notropis leuciodus*) may be due to the proximity of a small hog operation to the upper end of this reach. This may also explain the unexpected abundance of the herbivorous central stoneroller (*Campostoma anomala*) in this well shaded reach. (A site with similar substrate conditions, located above the hog operation, at RM 1.3, scored 52.2 – GOOD, when monitored in 1998; McLarney, 1999b.)

The only other aspect of the sample worthy of mention is the continued abundance of the exotic, invasive yellowfin shiner (*Notropis lutipinnis*) at both sites. Although yellowfin shiners were even more abundant in 2001, no hybrids were noted. In 2002, however, we noted an alarming incidence of hybridization (10-20%), apparently with 3 other cyprinid species (smoky dace, *Clinostomus* sp.; warpaint shiner, *Luxilus coccogenis* and Tennesssee shiner, *Notropis leuciodus*). In the case of the endemic smoky dace, hybridization could be construed as a threat to the continued existence of the species in Tessentee Creek, where it is relatively rare.

Table 47. Tessentee Creek at Tessentee Farm (RM 0.1 and RM 0.3)

Species and Numbers of Fish Taken

	RM 0.1 2001	RM 0.1 2002	RM 0.3 2002
Mountain brook lamprey	38	42	59
Rainbow trout	1	5	3
Brown trout		2	
Central stoneroller	63	49	83
Smoky dace	2	6	4
Warpaint shiner	58	67	105
River chub	75	85	71
Golden shiner	1		
Tennessee shiner	71	41	86
Yellowfin shiner	217	122	162
Mirror shiner	8	3	1
Fatlips minnow	1	3	5
Creek chub	4	2	2
White sucker	4		3
Northern hogsucker	17	9	8
Golden redhorse			4
Snail bullhead		1	
Rock bass	4	14	31
Redbreast sunfish	3	1	15
Bluegill		1	
Greenfin darter			2
Gilt darter	15	23	24
Mottled sculpin	33	41	173
TOTALS	615	517	841

Metrics and Scoring

Metric	RM 0.1 - 2001		RM 0.1 - 2002		RM 0.3 - 2002	
	Observed value	Score	Observed value	Score	Observed value	Score
1. No. native spp.	15	6.7	15	6.7	16	6.7
2. No. darter spp.	1	4	1	4	2	4
5. No. intolerant spp.	3	6.7	3	6.7	3	6.7
6. % individuals as tolerants	1.3	6.7	0.8	6.7	2.6	6.7

7. % individuals as omnivores & herbivores	29.9	1.3	33.1	1.3	25.9	1.3
8. % individuals as specialized insectivores	25.2	4.0	27.7	4.0	27.0	4.0
10. Catch per unit effort	27.6	6.7	23.1	6.7	31.1	6.7
11. % individuals as darters & sculpins	7.8	1.3	12.4	1.3	22.8	1.3
12. % individuals w. disease or anomaly	11.2	1.3	3.9	4.0	6.5	1.3
TOTALS		38.7		41.4		38.7
		FAIR		FAIR		FAIR

Table 48. Selected Physical Parameters of Tessentee Creek at Tessentee Farm (RM 0.1 and 0.3)

		RM 0.1	RM 0.3
Watershed area at site (sq. mi.)		15	15
Width (ft.)			
	Mean	15.1	19.1
	Range	10 to 30	11 to 34
Mean depth (ft.)			
	Riffles	1	0.8
	Runs	0.9	1.2
	Pools	1.8	1.6
Maximum depth (ft.)		3.4	3.2
Substrate composition (%)			
	Bedrock		3
	Boulder		2
	Rubble	t	16
	Gravel	45	34
	Sand	45	37
	Silt	5	8
	Clay	5	
Large woody debris		Common	Abundant
Canopy cover (%)		10	90
Raw bank (%)		40	10
Adjacent land use			
	Left bank	Agricultural field, unbuffered	Agricultural field, narrow buffer
	Right bank	Old field, being reforested	Mature forest

Lamb Creek at Kiera Rd. (RM 0.3) (Tables 49 and 50)

This site presents a story similar to that of Norton Branch – West Bank (which see). Both streams were monitored in 1995, as part of a survey of small Little Tennessee River tributaries (McLarney, 1996b; in prep. b). Both underwent severe and stressful changes between 1995 and 2002 due to human activities upstream and (in the case of Norton Branch) onsite. In both cases, the most apparent changes in the fish assemblage were:

- Apparent total replacement of a small population of rainbow trout (*Oncorhynchus mykiss*), including some large individuals, by a larger number of the tolerant, omnivorous creek chub (*Semotilus atromaculatus*).

- Approximate 20-fold increase in numbers of the exotic, invasive yellowfin shiner (*Notropis lutipinnis*), with some evidence of hybridization with the endemic smoky dace (*Clinostomus* sp.).

However, as a glance at Tables 49 and 50 will show, the changes in instream habitat were very different for the two sites. Although the character of riparian lands upstream was radically altered, land use and habitat at the Lamb Creek site were unchanged. At Norton Branch – West Bank severe alteration occurred both upstream of and at the monitoring site. More interestingly, while the induced changes in instream habitat observed at Norton Branch – West Bank were those which might be expected from observed alterations (deforestation of the banks and riparian zone, beaver dam removal, introduction of cattle), instream changes at Lamb Creek between 1995 and 2002 were the opposite of what might be expected following creation of a large development 0.5 mi. upstream.

Beginning in April, 1995, riparian vegetation was removed from approximately 0.75 mi. of stream bank and extensive grading and road construction was done with minimal precautions against erosion and sedimentation. Our 1995 fish and macroinvertebrate samples were taken on August 11, while the damage was ongoing. Movement of sandy sediment through the site was obvious, as was the accumulation of sediment in pools. It was noted during the macroinvertebrate sample that an unusual number of insect larvae, especially large *Pteronarcys* stoneflies, were encountered on the upper sides and tops of large rocks, apparently seeking refuge from the sediment.

By 2002, the development area had stabilized somewhat (though riparian zones in the development remain virtually devoid of large vegetation), so that input of sediment from the site must be significantly less. This is the probable cause of the increase in depth and higher percentage of coarse substrate as shown in Table 50. In other words, instead of “before and after” monitoring, what we took are probably best described as “during and after” samples.

While we have no data for the years between 1995 and 2002, it appears that the rates of degradation and recovery for the fish and macroinvertebrate assemblages are very different. Temperature data are not available, but it is quite possible that elevated summer water temperatures related to the large unshaded stream area which was created upstream are retarding return of trout and favoring creek chubs and yellowfin shiners. Without understanding all the causes, it can be stated that the fish assemblage is more stressed now than in 1995, with significant drops in scoring values for Metrics 6 (tolerants), 7 (wild trout) and 8 (omnivores and herbivores), as well as a decline in catch rate and the aforementioned increase in yellowfin shiner numbers.

The macroinvertebrate assemblage, however, appears healthier overall, with modest increases in observed values for both Metrics 1 (Ephemeroptera taxa) and 2 (EPT count). (One possible negative change is the decreased abundance and size of *Pteronarcys* stoneflies. All of a reduced number of *Pteronarcys* taken in 2002 were small individuals.) The Ephemerellid mayfly *Ephemerella invaria* gp., represented by 29 individuals, was unique to Lamb Creek among 14 small streams sampled for macroinvertebrates in 2002.

It may be that at the time of the 1995 "during" sample, some of the smaller and more delicate macroinvertebrates had already been eliminated, whereas the fish were treating the new sedimentation as "just one more storm event". In other words, the macroinvertebrates responded to the immediate physical changes, while the rainbow trout and other fishes responded later, to the shortage of food organisms or perhaps to the reduced availabity of spawning habitat.

Whatever, it is clear that biotic recovery has not kept pace with physical recovery at the monitoring site, and it cannot be predicted when or if rainbow trout will ever replace creek chubs in Lamb Creek. Nor can it be said with certainty that continued development of the property (still sparsely occupied) will not produce further sedimentation episodes. We believe that the IBI score from 1995 (48.0, Bioclass Rating GOOD) accurately reflects stream conditions which had prevailed up to that year. The 2002 score (36.0, Bioclass Rating POOR) appears to accurately reflect present conditions, and may in fact document partial recovery. Had the site been monitored in the intervening years it is possible that even lower IBI scores would have been recorded, reflecting a degraded macroinvertebrate assemblage.

When considered together, the results from Lamb Creek and Norton Branch – West Bank argue for more frequent monitoring, if possible, if we want to use biomonitoring and habitat assessment methods to document the process of anthropogenic degradation.

Table 49. Lamb Creek at Kiera Rd. (RM 0.3)

Species and Numbers of Fish Taken

Species	Numbers of individuals taken	
	1995	2002
Mountain brook lamprey	8	4
Rainbow trout	4	
Smoky dace	16	18
Yellowfin shiner	2	23
Creek chub		39
Mottled sculpin	83	50

TOTALS			113		134

Macroinvertebrate sample results (1995 data not available)

Bivalvia				
	Veneroidea			
		Sphaeriidae		
			Pisidium sp.	1
Gastropoda				
	Mesogastropoda			
		Pleuroceridae		
			Elimia sp.	48
Oligochaeta				
	Lumbricidae			2
Crustacea				
	Decapoda			
		Cambaridae		
			Cambarus bartoni	present
Insecta				
	Ephemeroptera			
		Baetidae		
			Baetis sp.	1
		Ephemerellidae		
			Drunella sp.	1
			Drunella cornutella	1
			Eurylophella sp.	29
		Heptageniidae		
			Stenacron carolina	4
			Stenonema modestum	56
		Isonychiidae		
			Isonychia sp.	7
		Leptophlebiidae		
			Paraleptophlebia sp.	3
	Odonata			
		Calopterygidae		
			Calopteryx maculata	8
		Cordulegastridae		
			Cordulegaster sp.	1
		Gomphidae		
			Gomphus sp.	4
			Lanthus sp.	4
			Ophiogomphus sp.	1
	Plecoptera			
		Leuctridae		
			Leuctra sp.	23
		Nemouridae		
			Amphinemura sp.	1

	Peltoperlidae		
		Tallaperla sp.	1
	Perlidae		
		unid.	1
		Acroneuria abnormis	2
		Perlesta placida sp. gp.	1
	Perlodidae		
		Isoperla holochlora	10
	Pteronarcidae		
		Pteronarcys (Allonarcys) sp.	4
Trichoptera			
	Hydropsychidae		
		unid.	4
		Diplectrona modesta	4
	Lepidostomatidae		
		Lepidostoma sp.	4
		Triaenodes	1
	Limnephilidae		
		Pycnopsyche sp.	9
	Philopotamidae		
		Dolophilodes sp.	16
	Polycentropidae		
		Polycentropus sp.	1
	Rhyacophilidae		
		Rhyacophila sp.	1
Coleoptera			
	Elmidae		
		Optioservus ovalis	2
		Stenelmis sp.	1
	Gyrinidae		
		Dineutus sp.	1
	Psephenidae		
		Psephenus herricki	1
	Ptilodactylidae		
		Anchytarsus bicolor	2
Diptera			
	Chironomidae		
		Brilla flavifrons	1
		Conchapelopia sp.	5
		Polypedilum flavum (convictum)	2
		Prodiamesa olivacea	1
	Dixidae		
		Dixa sp.	1
	Simulidae		
		Prosimulium sp.	2
	Tipulidae		
		Dicranota sp.	1
		Tipula sp.	40

TOTAL ORGANISMS	315
TOTAL TAXA	46
EPT taxa	24
Ephemeroptera taxa	8

Metrics and Scoring

Metric	1995 Observed value	1995 Score		2002 Observed value	2002 Score
1. No. Ephemeroptera taxa	7	7.5		8	7.5
2. No. EPT taxa	16	7.5		24	7.5
3. Brook trout presence	Absent	1.5		Absent	1.5
4. Fish catch per unit effort	40.5	7.5		16.4	7.5
5. % individual fish w. disease or anomaly	2.7	4.5	2.7	0	7.5
6. % individual fish as tolerants	0.0	7.5		29.1	1.5
7. % individual fish as wild trout	3.5	4.5		0.0	1.5
8. % individual fish as omnivores & herbivores	2.1	7.5		32.1	1.5
TOTALS		48.0 GOOD			36.0 POOR

Table 50. Selected Physical Parameters of Lamb Creek at Kiera Rd. (RM 0.3) for 2 years

	1995	2002
Watershed area at site (sq. mi.)	1.1	1.1
Width (ft.)		
Mean	11.8	10.2
Range	9 to 16	7 to 14
Mean depth (ft.)		
Riffles	0.4	0.4
Runs	0.6	0.6
Pools	0.7	1.2
Maximum depth (ft.)	1.0	1.8
Substrate composition (%)		
Bedrock	1	4
Boulder	3	5
Rubble	15	15
Gravel	15	28
Sand	48	42

Silt	18	5
Large woody debris	Common	Common
Canopy cover (%)	80	80
Raw bank (%)	5	5
Adjacent land use		
Left bank	Rhododendron thicket	Rhododendron thicket
Right bank	Lawn with narrow buffer	Lawn with narrow buffer

Betty Creek Below US 441 at Dillard (RM 0.6) (Table 51)

This site, last monitored in 2000, was revisited in 2002 because of a decline in biotic integrity between 1997 and 2001 on Betty Creek at RM 4.8 (See Betty Creek at Messer Creek Rd., below). The RM 4.8 site represents our uppermost IBI site on Betty Creek, which over the years has established a reputation as the healthiest major tributary of the upper Little Tennessee River. Because of concern over this stream as a whole, we decided to revisit both the RM 4.8 site and our other most frequently monitored (and lowermost) site on Betty Creek at RM 0.6 during the 2002 monitoring season.

While Betty Creek at RM 4.8 continues to be cause for concern (IBI score 44.1, Bioclass Rating FAIR), the RM 0.6 site continues to rate GOOD, and in fact there was a slight increase in IBI score, from 52.2 to 54.9. The change in score resulted from a modest decrease in the incidence of parasitization (Metric 12), but it should be noted that observed values improved for 5 of the 9 metrics.

One notable, and presumably positive, change in the fish assemblage is the reduction in abundance of the tolerant, omnivorous creek chub (*Semotilus atromaculatus*). The relative abundance of this species and its putative relation to the intolerant, piscivorous rock bass (*Ambloplites rupestris*) was commented on in our report for 1999 (McLarney, 2000b) and it may be appropriate to revisit this discussion here.

In 1990, when this site was first sampled we took 8 mostly large rock bass and no creek chubs, a not surprising result for a large stream with no serious pollution problems. The next time the site was monitored (1996) we took a single creek chub and 17 rock bass. In 1998, creek chubs outnumbered rock bass 10 to 5. What was most notable was the size of the creek chubs and their location within the site. That year, 7 of the 10 creek chubs were large, and they were taken in pool shoreline habitat formerly dominated by rock bass. Large creek chubs can function as piscivores, and the suggestion was that they were replacing the rock bass. This trend had begun to reverse by 1998; in 2002 we recorded a record number of rock bass, of all sizes, and a single small creek chub. The ratio of rock bass to creek chubs in our samples over the years is as follows:

1990: No creek chubs
1996: 17.0:1

1998: 0.5:1
1999: 2.0:1
2000: 8.5:1
2002: 37.0:1

Observations in other streams suggest a similar pattern. This is particularly notable in Watauga Creek, where the relative abundance of rock bass and large creek chubs in pools closely parallels changes in biotic integrity. At RM 0.6 in Betty Creek, however, this change occurred under conditions of continual GOOD biotic integrity.

The exotic yellowfin shiner (*Notropis lutipinnis*) continues to be of concern. In 2002, we observed individuals which appeared to be hybrids with all 3 of the native species with which we have previously observed hybridization (the endemic smoky dace, *Clinostomus* sp.; warpaint shiner, *Luxilus coccogenis* and Tennessee shiner, *Notropis leuciodus*.)

Two species (largemouth bass, *Micropterus salmoides* and black redhorse, *Moxostoma duquesni*) were recorded for the first time here in 2002. This represents our first record for any redhorse at RM 0.6, which is surprising both for the size of Betty Creek and in view of the numerous records of this species and the golden redhorse, *Moxostoma erythrurum*, from upstream sites.

The complete disappearance of the longnose dace (*Rhinichthys cataractae*) from this site was a surprise. We have no hypothesis to explain this occurrence.

The single brown trout (*Salmo trutta*) in the sample was a “trophy” specimen – ca. 19 inches TL.

Table 51. Betty Creek below US Highway 441 at Dillard (RM 0.6)

Species and numbers of fish taken

Species	Number of individuals taken	
	2000	2002
Mountain brook lamprey	12	8
Rainbow trout		
Brown trout	1	1
Central stoneroller	27	45
Smoky dace	9	3
Whitetail shiner	4	2
Warpaint shiner	67	79
River chub	101	47
Golden shiner		1
Tennessee shiner	53	27
Yellowfin shiner	77	65
Mirror shiner	14	16

Fatlips minnow	3	9
Longnose dace	7	
Creek chub	4	1
White sucker		
Northern hogsucker	22	3
Black redhorse		1
Rock bass	34	37
Redbreast sunfish	4	1
Green sunfish		
Warmouth		
Bluegill		
Largemouth bass		1
Tuckaseigee darter	6	3
Greenfin darter	7	5
Gilt darter	21	17
Mottled sculpin	300	301
TOTALS	773	673

Metrics and Scoring

Metric	2000 Observed value	Score	2002 Observed value	Score
1. No. native species	17	6.7	19	6.7
2. No. darter species	3	6.7	3	6.7
5. No. intolerant species	3	6.7	3	6.7
6. % individuals as tolerant species	1.2	6.7	0.3	6.7
7. % individuals as omnivores & herbivores	18.6	6.7	15.0	6.7
8. % individuals as specialized insectivores	25.6	4.0	23.9	4.0
10. Catch per unit effort	30.6	6.7	20.0	6.7
11. % individuals as darters & sculpins	43.1	4.0	48.4	4.0
12. % individuals w. disease or anomaly	2.8	4.0	1.9	6.7
TOTALS		52.2 GOOD		54.9 GOOD

Patterson Creek at Hambidge Center (RM 0.0 – 0.6) (Tables 52 and 53)

Patterson Creek was monitored in 1996 as part of an evaluation of streams on the property of the Hambidge Center for Creative Arts and Sciences (McLarney, 1997a). It is of particular concern as one of the principal tributaries of Betty Creek, which has generally been considered to be the healthiest major tributary of the upper Little Tennessee River. However, Patterson Creek has experienced some problems of sedimentation and probably nutrient loading related to development and a small trout farming operation upstream of the

Hambidge Center property. McLarney (1997a) determined that while IBI scores in Betty Creek were GOOD at all sites along Betty Creek from RM 0.6 to RM 4.8 (Patterson Creek is tributary at RM 4.5), wild trout numbers dropped dramatically immediately below the mouth of Patterson Creek.

Much of the riparian area of Patterson Creek below Patterson Creek Falls (ca. RM 0.6) was described as a beaver meadow in 1996, but there were no dams at that time. In the intervening years, beaver activity has resumed. As of July, 2002 there were only about 250 ft. of free flowing stream below the lowermost beaver dam. Approximately half of the remaining distance between the lower dam and the falls is directly affected by 4 beaver dams of varying size. Not all of this distance is ponded, but riffles are largely absent and sediment deposition is enhanced in this reach. For purposes of this study, we divided Patterson Creek below the falls into 3 sectors, as follows:

- The lowermost 250 ft. is totally shaded by forest on both banks and flows swiftly over a predominantly gravel/cobble substrate. Slack water is almost completely lacking in this reach save for a plunge pool at the base of the beaver dam.
- The beaver pond reach (ca. 1,500 ft.) is largely unshaded (by virtue of being in old beaver meadow) and completely sedimented, with much woody debris, and current varying from moderate to none.
- The upper reach, (ca. 1,200 ft. extending to the base of the falls) is shaded by forest on both banks and has a higher gradient and coarser substrate than either the 2002 "lower reach" or the ponded reach in its previous state.

For our sample, we excluded 80 ft. immediately above the mouth and fished the remainder intensively. We then sampled roughly similar lengths of stream in the beaver pond and upper sectors, endeavoring in both cases to include all different types of habitat present, roughly in proportion to their area in the total reach. (Due to relative scarcity of fish, a larger area of the beaver pond reach was sampled.) Length and surface area of the 3 sample reaches were as follows:

- Lower reach – 163 linear ft., 1,753 sq. ft.

- Beaver ponds – 206 linear ft., 2,600 sq. ft.

- Upper reach – 167 linear ft., 2,765 sq. ft.

The macroinvertebrate sample and habitat parameter determinations were carried out only in the lower monitoring reach. IBI is calculated for both the combined sample and for the lower reach separately. However it should be noted that neither the IBI nor the habitat parameter data are strictly comparable with the 1996 data. The following observations may be relevant:

- The reduction in fish diversity (13 total species, with 10 native in 2002 vs. 17 total and 15 native in 1996) may reflect reduced access from Betty Creek due to the beaver dams.

- This is the first time we have taken any species of trout from Patterson Creek on the Hambidge Center property, despite the historic presence of both brown trout (*Salmo trutta*) and rainbow trout (*Oncorhnychus mykiss*) in Betty Creek and of both pond-reared and wild rainbow trout above the falls. The presence of 2 juvenile and 1 adult brown trout below the first beaver dam may reflect reduced input of sediment (the trout facility is under new ownership) and/or the effect of the beaver ponds in trapping sediment.

- The principal intolerant species (smoky dace, *Clinostomus* sp.) continues to be the second most abundant fish species overall (after the ubiquitous mottled sculpin, *Cottus bairdi*), but it is relatively scarce in and below the beaver ponds. Another intolerant, the rock bass (*Ambloplites rupestris*) appeared for the first time in Patterson Creek.

- The exotic and invasive yellowfin shiner (*Notropis lutipinnis*) was not found above the lower beaver pond. This may be a positive factor for the endemic smoky dace, since the yellowfin shiner is known to hybridize, and presumably competes, with the smoky dace.

- The disappearance of the warpaint shiner (*Luxilus coccogenis*) since 1996 (when it was the third most abundant species, comprising 12.5% of the sample) is a surprise. The beaver ponds provide habitat which is superficially similar to pool habitat where warpaint shiners are often dominant in small streams. It may be that this species requires ready access to and from Betty Creek to maintain a population in a stream as small as Patterson Creek.

- The tolerant omnivorous creek chub (*Semotilus atromaculatus*) has responded positively to the presence of beaver ponds, going from a single individual in 1996 to 39 (23 of them in the ponded reach) in 2002. In the ponds it appears to divide the habitat with the other common omnivorous cyprinid, the river chub (*Nocomis micropogon*), with the river chub in deep water with perceptible current, and the creek chub in slower reaches.

- Two golden shiners (*Notemigonus crysoleucas*) taken in the beaver ponds were not especially large, but displayed the brilliant brassy coloration typical of large golden shiners in coastal plain environments. This coloration has not been seen in golden shiners in our watershed, except for large individuals kept in ponds.

The greatest value of this sample is probably not in the comparative aspects of the data, but as a clue to the importance of beaver ponds in the upper Little Tennessee River watershed. It is well known that beavers were extirpated in western North Carolina and north Georgia early in this century, and that only in recent years have they begun to occur in anything like their earlier numbers. Impoundment of small, low gradient streams, such as Patterson Creek below the falls, may thus be seen as a return to "natural" conditions.

However, in terms of biotic integrity, as currently measured, it seems unlikely that beaver ponds will enhance IBI scores anywhere in our watershed. In this instance there may be one positive effect which will be reflected in the IBI (restriction of movement by invasive species such as the yellowfin shiner), but impoundment also tends to result in lower fish abundance, reduced species diversity, and greater dominance by tolerant and omnivorous species. The effect on the macroinvertebrate assemblage is of course much more drastic. (As noted above, our macroinvertebrate sample is drawn from the free-flowing reach below the beaver dam.)

In the North and West, beaver ponds are often considered to enhance fish habitat, and to improve sport fishing for trout. However, we have never found trout of any species in a beaver pond in the upper Little Tennessee watershed. It is interesting to speculate as to what might have been the response, in precolonial times, of the native brook trout (*Salvelinus fontinalis*) which presumably inhabited streams like Patterson Creek, to beaver ponds under conditions of more riparian shade, lower ambient water temperatures, lower nutrient loads and less sediment passing through the system.

One of the purposes for including low altitude streams with watershed drainage areas in the range of 1-4 sq. mi. in this project has been to adapt the methods developed by Williams (1996) for high altitude brook trout streams for use in small streams throughout the watershed. However, sites like Patterson Creek may serve to suggest that an IBI based on "natural" conditions in lotic habitats is simply not suitable for evaluating such streams.

Any differences in the fish fauna notwithstanding, the macroinvertebrate fauna of Patterson Creek below the beaver dam appeared to be substantially the same as in 1996. (The higher EPT count for 2002 reflects mainly the fact that macroinvertebrates were identified only to genus in 1996.) Taxa unique to Patterson Creek among the 14 sites sampled for macroinvertebrates in 2002 were the Baetid mayfly *Baetisca gibbera*, the Aeshnid dragonfly *Boyeria grafiana* and the Chironomid midge *Microtendipes pedellus* gp.

The differences among the 3 IBI's (1996, 2002 including the reach above the beaver dam, and 2002 based only on the reach below the beaver dam) are minor, and it seems reasonable to assume that there has been no significant change in water or habitat quality during the intervening period. With the reservation mentioned above about using an IBI based on lotic habitats in a frequently impounded reach, the FAIR Bioclass Rating seems reasonable.

Table 52. Patterson Creek at Hambidge Center (RM 0 0-XXXX)

Species and Numbers of fish taken

Species	1996 total	2002 total	2002 below ponds	2002 beaver ponds	2002 above ponds
Mountain brook lamprey	13	9	6	1	2
Brown trout		3	3		
Central stoneroller	1	4	2		2
Smoky dace	53	63	9	9	45
Warpaint shiner	35				

River chub	9	22	10	10	2
Golden shiner	1	2		2	
Tennessee shiner	6				
Yellowfin shiner	8	10	10		
Mirror shiner	1				
Fatlips minnow	1				
Longnose dace	1				
Creek chub	1	39	4	23	12
Northern hogsucker	4	2		2	
Rock bass		6		4	2
Redbreast sunfish	1	1	1		
Green sunfish	4		1		
Bluegill		1			
Gilt darter	4				
Mottled sculpin	136	219	110	17	92
TOTALS	279	381	156	68	157

Macroinvertebrate sample results (1996 results for insects only, less Chironomidae - identified to genus only)

				1996	2002
Bivalvia					
	Veneroidea				
		Sphaeriidae			
			Pisidium sp.		7
Gastropoda					
	Mesogastropoda				
		Pleuroceridae			
			Elimia sp.		53
Oligochaeta					
	Haplotaxida				
		Lumbricidae			4
Crustacea					
	Decapoda				
		Cambaridae			
			Cambarus bartoni		present
Insecta					
	Ephemeroptera				
		Baetidae			
			(Baetis)	X	
			Baetis intercalaris		1
			(Pseudocloeon)	X	
		Baetiscidae			
			Baetisca gibbera		1
		Ephemerellidae			
			Drunella cornutella		2
			Serratella sp.		9
		Ephemeridae			

		Ephemera sp.		2
	Heptageniidae			
		(*Epeorus*)	X	
		Epeorus dispar		8
		Heptagenia sp.	X	4
		(*Stenonema*)	X	
		Stenonema modestum		20
	Isonychiidae			
		Isonychia sp.	X	3
	Leptophlebiidae			
		(Leptophlebia)	X	
	Neoephemeridae			
		(Neoephemera)	X	
Odonata				
	Aeshnidae			
		(*Aeshna*)	X	
		Boyeria grafiana		2
		B. vinosa		6
	Calopterygidae			
		Calopteryx maculata		7
	Cordulegastridae			
		Cordulegaster sp.	X	6
	Gomphidae			
		(*Dromogomphus*)	X	
		Gomphus sp.		3
		Lanthus sp.	X	4
Plecoptera				
	Leuctridae			
		Leuctra sp.	X	17
	Peltoperlidae			
		(*Peltoperla*)	X	
		Talloperla sp.		10
	Perlidae			
		(*Acroneuria*)	X	
		Acroneuria abnormis		13
		(Paragnetina)	X	
		Perlesta sp.	X	4
		P. placida sp. gp.		3
	Perlodidae			
		Isoperla sp.	X	1
	Pteronarcidae			
		Pteronarcys (Allonarcys) sp.	X	16
Hemiptera				
	Veliidae			3
Megaloptera				
	Corydalidae			
		(*Neohermes*)	X	
		Nigronia serricornis		11

Trichoptera				
	Brachycentridae			
		Brachycentrus sp.	X	20
	Glossosomatidae			
		Glossosoma sp.		1
	Hydropsychidae			
		unid.		19
		Ceratopsyche sparna		16
		Cheumatopsyche sp.	X	33
		(Symphitopsyche)	X	
	Lepidostomatidae			
		Lepidostoma sp.	X	7
		Triaenodes sp.		1
	Leptoceridae			
		Ceraclea sp.		1
	Limnephilidae			
		Goera sp.	X	3
		Pycnopsyche sp.	X	3
	Philopotamidae			
		unid.		2
		Dolophilodes sp.		4
	Polycentropidae			
		(Neureclipsis)	X	
		(Polycentropus)	X	
	Psychomyiidae			
		(Lype)	X	
		Lype diversa		2
		Psychomyia sp.		1
	Rhyacophilidae			
		Rhyacophila fusca		1
Coleoptera				
	Dryopidae			
		(Helichus)	X	
	Elmidae			
		(Macronychus)	X	
		Macronychus glabratus		5
		Optioservus ovalis		3
		O. trivittatus		1
		(Stenelmis)	X	
	Gyrinidae			
		Gyrinus sp.		1
	Haliplidae			
		Peltodytes sp.		2
	Psephenidae			
		(Psephenus)	X	
		Psephenus herricki		9
	Staphylinidae			1
Diptera				

Athericidae			
	(Atherix)	X	
Ceratopogonidae			
	Bezzia/Palpomyia gp.		2
Chironomidae		X	
	Cladotanytarsus sp.		1
	Conchapelopia sp.		1
	Cryptochironomus fulvus		1
	Microtendipes pedellus gp.		1
	Pagastia orthogonia		1
	Parametriocnemus lundbecki		1
	Polypedilum flavum (convictum)		3
	P. halterale		1
	Thienemanniella xena		1
	Tvetenia bavarica gp.		1
Dixidae			
	Dixa sp.	X	1
Simulidae			
	Prosimulium sp.		5
	(Simulium)	X	
Tabanidae			
	Chrysops sp.		1
Tipulidae			
	Antocha sp.		1
	Dicranota sp.	X	3
	Hexatoma sp.		8
	Tipula sp.	X	1
TOTAL ORGANISMS			392
TOTAL TAXA			69
Total insect genera (minus Chironomidae)		38	46
EPT taxa			31
EPT genera		24	26
Ephemeroptera taxa			9
Ephemeroptera genera		8	9

Metrics and Scoring

Metric	1996		2002 Overall		2002 Lower reach only	
	Observed value	Score	Observed value	Score	Observed value	Score
1. No. Ephemeroptera taxa	6	7.5	9	7.5	9	7.5
2. No. EPT taxa	16	7.5	31	7.5	31	7.5
3. Brook trout presence	Absent	1.5	Absent	1.5	Absent	1.5

4. Fish catch per unit effort	25.4	7.5	34.2	7.5	46.6	7.5
5. % individual fish w. disease or anomaly	1.1	6.0	0.8	6.0	1.3	6.0
6. % individual fish as tolerants	2.2	7.5	10.5	4.5	3.2	7.5
7. % individual fish as wild trout	0.0	1.5	0.8	4.5	1.9	4.5
8. % individual fish as omnivores & herbivores	9.0	7.5	19.4	4.5	14.1	4.5
TOTALS		46.5 FAIR		43.5 FAIR		46.5 FAIR

Table 53. Selected Physical Parameters of Patterson Creek below first beaver dam (ca. 250 ft.), in 2002 and lowermost ca. 475 ft. in 1996.

	1996	2002
Watershed area at site (sq. mi.)	1.9	1.9
Width (ft.)		
Mean	17	12.8
Range	11 to 26	9 to 25
Mean depth (ft.)		
Riffles	0.8	0.5
Runs	1	0.7
Pools	1.3	0.8
Maximum depth (ft.)	3	1
Substrate composition (%)		
Boulder	1	3
Rubble	28	42
Gravel	29	29
Sand	34	22
Silt	8	4
Large woody debris	Common	Rare
Canopy cover (%)	80	100
Raw bank (%)	10	0
Adjacent land use		
Left bank	Forest, beaver meadow	Forest
Right bank	Forest, beaver meadow	Forest

Betty Creek at Messer Creek Rd. (RM 4.8) (Table 54)

This site, monitored in 2001, was revisited in 2002 as a reaction to the alarming result of 2001 (IBI Score 44.1, Bioclass Rating FAIR, down from 52.2 GOOD the last time it was monitored, in 1997). This result was particularly startling because Betty Creek is considered to be the healthiest major tributary of the upper Little Tennessee and GOOD Bioclass Ratings have been the norm at all sites.

As Table 54 shows, except for the fact that levels of disease and parasitism (Metric 12) returned to normal, the other 4 metrics which scored lower in 2001 than in 1997 continued to score low in 2002.

Evidence that the assemblage of fishes at this site is unstable is provided by the fact that record high catches were recorded for 5 species (including the exotic yellowfin shiner, *Notropis lutipinnis* and the herbivorous central stoneroller, *Campostoma anomala*), 2 species occurred for the first time (including the tolerant white sucker, *Catostomus commersoni*) and one species (Tennessee shiner, *Notropis leuciodus*) was recorded in record low numbers. One of the yellowfin shiners was believed to be a hybrid with the endemic smoky dace (*Clinostomus* sp.).

As mentioned in last year's report (McLarney, in prep. b), the trends toward greater abundance of tolerant, omnivorous and herbivorous species often associated with increased sedimentation and nutrient levels, together with a corresponding decline in rainbow trout (*Oncorhynchus mykiss*) and mottled sculpin (*Cottus bairdi*), both associated with clean, unsedimented substrates, is not supported by known changes in anthropogenic inputs to the stream. On the contrary, two possible contributors of nutrients (a trout farm and an ornamentals nursery) have significantly reduced their levels of production. A worthwhile task for 2003 would be to look for possible causes for the biological effects observed in 2001 and 2002.

Table 54. Betty Creek at Messer Creek Rd. (RM 4.8)

Species Taken and Numbers

Species	Number of individuals taken		
	1997	2001	2002
Mountain brook lamprey	45	26	38
Rainbow trout	27	6	6
Brown trout	1		
Central stoneroller	16	9	30
Smoky dace	41	26	38
Warpaint shiner	64	55	67
River chub	9	61	55
Tennessee shiner	19	8	3
Yellowfin shiner		12	13
Fatlips minnow		3	6
Longnose dace	10	13	18
Creek chub	1	9	6
White sucker			1
Northern hogsucker	18	19	16
Black redhorse		2	
Golden redhorse			

Rock bass	1	14	5
Redbreast sunfish	10	5	3
Green sunfish	3	1	2
Largemouth bass		1	1
Tuckaseigee darter	1	2	2
Gilt darter	4	7	8
Mottled sculpin	718	270	329
TOTALS	978	549	649

Metrics and Scoring

Metric	1997		2001		2002	
	Observed value	Score	Observed value	Score	Observed value	Score
1. No. native species	14	6.7	18	6.7	17	6.7
2. No. darter species	2	4.0	2	4.0	2	4.0
5. No. intolerant species	3	6.7	3	6.7	3	6.7
6. % individuals as tolerants	1.4	6.7	2.7	6.7	1.8	6.7
7. % individuals as omnivores & herbivores	7.2	6.7	19.1	4.0	20.0	1.3
8 % individuals as specialized insectivores	14.1	1.3	20.8	4.0	22.2	4.0
10. Catch per unit effort	28.2	6.7	14.7	4.0	17.4	4.0
11. % individuals as darters & sculpins	73.2	6.7	50.8	4.0	52.2	4.0
12. % individuals w. disease or anomaly	0.6	6.7	2.6	4.0	0.9	6.7
TOTALS		52.2 GOOD		44.1 FAIR		44.1 FAIR

Jerry Branch at Rabun Gap-Nacoochee School (RM 0.3) (Tables 55 and 56)

When Jerry Branch was first monitored in 1995 (McLarney, 1996a, in prep. a) it scored 27.0 (Bioclass POOR). At that time the lower half of the sample reach had been freshly rechannelized. The site was characterized by a paucity of habitat. Riffles were just short of non-existent and riparian vegetation was largely limited to grasses over much of the stream's length. The one notable piece of habitat was a plunge pool formed by a culvert where a farm road crosses. This pool was up to 44 inches deep. It covered 32.7% of the sample area, but produced 55.5% of the total fish catch, and all of the large individuals. The unusually diverse fish assemblage was dominated by omnivores and tolerants.

Jerry Branch was revisited this year because it is rumored to be slated for restoration. It stands in need of restoration; its 2002 condition is even worse than in 1995. In 1995 cattle did not have access to the stream, but now they have access to the entirety of the stream above the culvert. They tend to concentrate at a watering area directly above the culvert which results in both a high rate of bank erosion and high levels of nutrient enrichment.

The culvert pool has completely disappeared; nowhere in the reach were we able to find water deeper than 12 inches. This may not be entirely due to erosion; a pile of sand on the bank just below the culvert suggest that Jerry Branch is being used to dispose of sand extracted from elsewhere. The few riffles present in 1995 have completely disappeared – the great majority of the site is best described as run habitat. Although a modest (ca. 10 ft. wide) vegetative buffer is being allowed to establish downstream of the culvert, vegetation is less than a year old and cover is still principally in the form of grasses growing or falling into the stream. Several times during the course of sampling the water turned from a clear, grayish color to an opaque green-brown, graphically demonstrating the contribution of cattle to the stream. Upstream of the culvert there is no hard substrate, and cover is mainly in the form of odds and ends of brush fallen into the stream.

We had originally intended to replicate the 1995 sample, which consisted of an equal length of stream above and below the culvert. However the physical condition of the habitat and our superficial impression of the fish assemblage was so different for the two reaches that we initially separated the two fish samples. The entire macroinvertebrate sample was taken downstream of the culvert. In Table 55 we present the two fish samples both combined and separately. Despite the obvious differences, there is little difference in the fish-based IBI metrics, and a single IBI combining the two reaches probably best represents the site. The one difference which affects the scoring when the upstream reach is included is the chance occurrence of a single juvenile rainbow trout (*Oncorhynchus mykiss*). This fish may well have been in transit between the upper watershed of Jerry Branch and the Little Tennessee River.

A more significant difference is the presence of the intolerant, endemic smoky dace (*Clinostomus* sp.) in the upstream reach. The smoky dace is normally one of the most abundant fishes in small low altitude streams in the Georgia portion of the watershed; its absence in 1995 was taken as a strong indicator of poor water quality.

One additional species (river chub, *Nocomis micropogon*) was found only above the culvert, while 3 species (whitetail shiner, *Cyprinella galactura*; warpaint shiner, *Luxilus coccogenis* and mottled sculpin, *Cottus bairdi*) were found only below the culvert.

There is no apparent logic to the list of fish species found in Jerry Branch in 1995 and not in 2002. They include mountain brook lamprey (*Ichthyomyzon greeleyi*), Tennessee shiner (*Notropis leuciodus*), northern hogsucker (*Hypentelium nigricans*), golden redhorse (*Moxostoma erythrurum*) and warmouth (*Lepomis gulosus*). The only new species found in 2002 were the rainbow trout and smoky dace.

As at many sites, the absolute and proportional abundance of the exotic yellowfin shiner (*Notropis lutipinnis*) has increased in Jerry Branch over the years. In 1995 it accounted for 4.1% of our sample. By 2002 it was the single most abundant species, comprising 25.7% of the fish sample.

When the two reaches are considered separately, observed values for all the fish based metrics are better for the upper reach. However, it is doubtful whether this is significant. A concentration of sunfishes and golden shiners (*Notemigonus crysoleucas*) upstream of the culvert may reflect the influence of an elongate beaver pond (not present in 1995) which commences just above the upstream end of the monitoring reach.

As of 2002, and since at least 1995, Jerry Branch continues to support a high (and unnatural) diversity of fish, including some species more characteristic of larger streams. It suffers from severe channelization (with frequent maintenance), loss of riparian vegetation, sedimentation from various causes and, at least in recent years, nutrient inputs from cattle (which also have access to the stream above the beaver pond). There may be other nutrient or chemical pollution factors related to agricultural use of adjacent lands. A further factor may be a small artificial lake (Indian Lake) in the upper reaches; at the time of sampling in 2002, this impoundment had been drained nearly dry.

The macroinvertebrate sample serves to emphasize the poor quality of the stream. Given the absence of true riffle habitat, we did our kicknet samples in run areas with a superficial layer of fine gravel on top of the predominantly sandy substrate. Not only was the diversity of all 3 EPT groups the lowest among 14 small streams where macroinvertebrate samples were taken this year, but the total abundance of organisms was the lowest for any site sampled. Total taxa count exceeds two other sites only by virtue of the numbers of Odonata (6 taxa) and Chironomidae (15 taxa). As one might surmise from these numbers, tolerant forms were unusually common in Jerry Branch. It was the only one of the 14 sites where we recorded more extremely tolerant forms (Hilsenhoff or North Carolina Tolerance Values > 8) than extremely intolerant forms (Tolerance Values >2) – 6 vs. 2 taxa respectively. Especially notable was the presence of tubificids, not encountered at any other site, and commonly associated with deposits of animal manure.

Restoration of Jerry Branch will be a tremendous challenge. Plans supposedly call for restoration of natural meanders in the hayfield reach between the culvert and US Highway 441 (nearly 0.2 mile of stream). However, the problem of cattle access must be addressed if the ambiguous results achieved on another small stream restoration site on the Rabun Gap-Nacoochee School campus (Sutton Branch, also described in this report) are not to be repeated. Severely polluted meanders are only marginally better habitat than a severely polluted ditch.

Table 55. Jerry Branch at Rabun Gap-Nacoochee School (RM 0.3)

Species and Numbers of Fish Taken

Species	Number of individuals taken			
	1995	2002		
		Total	Lower	Upper
Mountain brook lamprey	6			

Rainbow trout		1		1
Central stoneroller	12	12	3	9
Smoky dace		6		6
Whitetail shiner	5	2	2	
Warpaint shiner	10	4	4	
River chub	13	1		1
Golden shiner	33	23	2	21
Tennessee shiner	11			
Yellowfin shiner	9	47	24	23
Creek chub	10	40	20	20
White sucker	39			
Northern hogsucker	15			
Golden redhorse	3			
Rock bass	2	5	3	2
Redbreast sunfish	29	15	5	10
Green sunfish	1	16	4	12
Warmouth	1			
Bluegill	8	4	1	3
Largemouth bass	3	3		3
Mottled sculpin	8	4	4	
TOTALS	218	183	72	111

Macroinvertebrate sample results (1995 data not available)

Bivalvia				
	Veneroidea			
		Sphaeriidae		
			Pisidium sp.	4
Gastropoda				
	Basommatophora			
		Physidae		
			Physella sp.	24
Oligochaeta				
	Haplotaxida			
		Naididae		
			Slavina appendiculata	2
			Vejdovskyella comata	1
		Tubificidae w.h.c.		3
		Tubificidae w.o.h.c		3
	Lumbriculida			
		Lumbriculidae		18
Crustacea				
	Decapoda			
		Cambaridae		
			Cambarus bartoni	present
Insecta				
	Ephemeroptera			

	Baetidae		
		Baetis sp.	2
	Ephemerellidae		
		Serratella sp.	17
	Heptageniidae		
		Stenonema modestum	4
	Isonychiidae		
		Isonychia sp.	3
Odonata			
	Aeshnidae		
		Boyeria vinosa	6
	Calopterygidae		
		Calopteryx sp.	2
	Coenagrionidae		
		Argia sp.	13
	Cordulegastridae		
		Cordulegaster sp.	5
	Gomphidae		
		Gomphus sp.	11
		Ophiogomphus sp.	22
Plecoptera			
	Leuctridae		
		Leuctra sp.	2
	Perlidae		
		Perlesta placida sp. gp.	6
Hemiptera			
	Veliidae		
		Rhagovelia obesa	1
Megaloptera			
	Corydalidae		
		Nigronia serricornis	2
Trichoptera			
	Hydropsychidae		
		Chemuatopsyche sp.	16
		Diplectrona modesta	1
		Hydropsyche betteni gp.	8
	Lepidostomatidae		
		Nectopsyche sp.	1
	Limnephilidae		
		Pycnopsyche sp.	2
Coleoptera			
	Dryopidae		
		Helichus basalis	1
	Dytiscidae		1
	Elmidae		
		Macronychus glabratus	1
	Gyrinidae		
		Dineutus sp.	1

Diptera			
	Ceratopogonidae		
		Bezzia/Palpomyia gp.	10
	Chironomidae		
		Clinotanypus pinguis	1
		Chironomus sp.	2
		Cricotopus sp.	2
		Cryptochironomus fulvus	1
		Microtendipes sp.	1
		Parametriocnemus lundbecki	1
		Paratendipes sp.	9
		Polypedilum flavum (convictum)	3
		P. halterale	6
		P. illinoense	11
		Rheocricotopus robacki	3
		Rheotanytarsus sp.	9
		Tanytarsus sp.	2
		Thienemannimyia gp.	2
	Psychodidae		1
	Simuliidae		
		Simulium sp.	2
	Tipulidae		
		Antocha sp.	3
		Tipula sp.	6
TOTAL ORGANISMS			238
TOTAL TAXA			49
EPT taxa			11
Ephemeroptera taxa			4

Metrics and Scoring

Metric	1995		2002 Combined sample		2002 Lower reach only	
	Observed value	Score	Observed value	Score	Observed value	Score
1. No. Ephemeroptera taxa	3	4.5	4	4.5	4	4.5
2. No. EPT taxa	8	4.5	11	4.5	11	4.5
3. Brook trout presence	Absent	1.5	Absent	1.5	Absent	1.5
4. Fish catch rate per unit effort	30.5	7.5	20.0	7.5	16.8	7.5
5. % individual fish w. disease or anomaly	2.8	4.5	2.7	4.5	4.2	4.5
6. % individual fish as tolerants	36.7	1.5	38.8	1.5	40.3	1.5
7. % individual fish as wild trout	0.0	1.5	0.5	4.5	0.0	1.5

8. % individual fish as omnivores & herbivores	36.7	1.5	28.0	1.5	31.9	1.5
TOTALS		27.0 POOR		30.0 POOR		27.0 POOR

Table 56. Selected Physical Parameters of Jerry Branch at Rabun Gap - Nacoochee School (RM 0.3) for Two Years

		1995	2002 Lower	2002 Upper
Watershed area at site (sq. mi.)		1.5	1.5	1.5
Width (ft.)				
	Mean	7.3	3.6	5.2
	Range	5 to 16	2 to 6	4 to 7
Mean depth (ft.)				
	Riffles	0.5	no riffles	no riffles
	Runs	0.9	0.5	0.5
	Pools	2.2	0.6	no pools
Maximum depth (ft.)		3.7	1.0	1.0
Substrate composition (%)				
	Bedrock	t		
	Rubble	t		
	Gravel	26	11	7
	Sand	49	46	51
	Silt	24	44	42
	Clay	1		
Large woody debris		Absent	Absent	Rare
Canopy cover (%)		20	0	10
Raw bank (%)		5	5	20
Adjacent land use				
	Left bank	Agricultural field, hay field	Hay field	Fenced pasture
	Right bank	Hay field, old field young forest	Hay field	Old field, young forest

COMMENTS ON INDIVIDUAL FISH SPECIES

American eel (*Anguilla rostrata*) The American eel has never been reported from the North Carolina or Georgia portions of the Little Tennessee River watershed. However, its theoretical range includes the entire watershed, and it is reasonable to assume that it occurred here prior to the construction of numerous power dams on the Little Tennessee further downstream. We have still not seen an American eel in the watershed, but there is a reliable observer record from this summer in the lower reaches of the Cullasaja River. The observer spoke of observing a small adult eel, which as described was too large to be the mountain brook lamprey (*Ichthyomyzon greeleyi*), the only native fish for which it might reasonably be mistaken. He further described it as having a "smiling" mouth (a description which may be applied to the American eel) rather than a sucking mouth as in a lamprey. It is not beyond the realm of possibility that an eel could ascend all of the numerous dams on the Tennessee and Little Tennessee Rivers and ascend to this point. At this point in time it would be prudent to regard the American eel as present, but very rare in our watershed.

Spotfin chub (*Cyprinella monacha*) and whitetail shiner (*Cyprinella galactura*): Elsewhere (McLarney, 2001a) we have reported on the hitherto unsuspected migration of these two species, generally considered to be river mainstem inhabitants into Little Tennessee River tributaries in the fall. This work was extended during August- November, 2002 through a survey of 3 Little Tennessee tributaries (Burningtown, Bradley and Watauga Creeks) by Deb McCown, an intern at the Highlands Biological Station (McCown, 2002), which resulted in the addition of Bradley Creek to the list of tributaries used by the spotfin chub in the fall.

To date we have documented use of the following tributaries by both species: Sawmill, Wiggins, Brush, Rattlesnake, Tellico, Burningtown, Lakey, Bradley, Cowee, Iotla and Watauga Creeks. The whitetail shiner only was found in Rose Creek and Rocky Branch. This list covers all tributaries with watershed areas of 2 sq. mi. or more located downstream of Lake Emory, with the single exception of Licklog Creek. Licklog Creek has relatively high quality water (1995 IBI score 48), but low fish diversity (5 species). This is apparently due to the fact that it drops nearly 3 feet to the river from a culvert at Needmore Road, thus preventing upstream migration of fish into the creek. These findings suggest an important role for exchange between the mainstem and tributaries in maintaining biodiversity in both environments. In none of these streams are whitetail shiners found in numbers during the summer, and the spotfin chub has been recorded during summer only on rare occasions from 4 of the 5 largest tributaries (Tellico, Burningtown, Cowee and Watauga Creeks.)

This investigation has been concentrated in the portion of the watershed known to be inhabited by the Threatened spotfin chub. It is probable that similar fall migrations by the whitetail shiner occur in tributaries to the Little Tennessee upstream of Lake Emory.

This may be the last report in which we refer to the spotfin chub as *Cyprinella monacha*. Behavioral similarities notwithstanding, the spotfin chub is being replaced and placed in a monotypic genus as *Erimonax monachus*.

Yellowfin shiner (*Notropis lutipinnis*): This invasive exotic species, first recorded from the Little Tennessee watershed in 1989, has been frequently discussed in these reports. In 1989 we took a few specimens from the mouth of Commissioners Creek, tributary to the Little Tennessee just downstream of the Georgia/North Carolina state line. Since then it has spread steadily downstream along the mainstem, and upstream into the tributary watersheds. Until 1993 it appeared that the presence of a sizable impounded area (Lake Emory) might halt its advance, but in that year a single specimen was found at RM 0.5 on Rabbit Creek, tributary to Lake Emory just above the dam. It did not reappear in Rabbit

Creek until 2000, but is now abundant there (32 specimens in the 2002 IBI sample at RM 0.5).

The first yellowfin shiner taken below Lake Emory was a single individual taken at RM 0.5 on Watauga Creek (tributary to the river immediately below the Lake Emory dam). Until 2002, we had recorded a total of only 7 individuals from 3 tributaries (and none from the mainstem) below the dam, but in that year we took 42 individuals in our first IBI sample at RM 1.1 on Iotla Creek, tributary to the river about 2 miles below the dam. The furthest downstream penetration was a single individual taken at RM 0.2 on Burningtown Creek, tributary to the river about 13 miles below the dam. There are now what appear to be established populations of the yellowfin shiner in Watauga and Iotla Creeks, but not elsewhere below Lake Emory as yet. In October, 2002 a single individual was encountered in Bradley Creek near the mouth. With the exception of another single fish taken in 2000 from Burningtown Creek, this marks the furthest downstream penetration by the yellowfin shiner.

Table 57 shows the pattern of spread on the yellowfin shiner using data from 8 sites (2 on the mainstem and 6 on tributaries) for which we have multi-year data. In most cases it appears that 2-6 years of rare or sporadic occurrence are succeeded by explosive growth in numbers, after which it assumes the pattern of fluctuating abundance typical of most common fish species.

A similar pattern is suggested by less frequent sampling data from some small tributaries. Below are numbers of yellowfin shiners in IBI samples from some such streams which have been sampled only twice:

McDowell Br. (tributary at RM 122) – 0 in 1995 and 34 in 2002
Hickory Knoll Cr. (RM 126) – 1 in 1995 and 47 in 2001
Lamb Cr. (RM 138) – 2 in 1995 and 23 in 2002
Mud Cr. (RM 138) – 18 in 1990 and 139 in 1997
Jerry Br. (RM 140) – 9 in 1995 and 47 in 2002.

In small streams, particularly those with moderate gradient and sandy substrates, the yellowfin shiner may become the single dominant species. It may be more tolerant and omnivorous than most of the native cyprinids, and is known to hybridize with at least 3 species (the endemic smoky dace, *Clinostomus* sp.; warpaint shiner, *Luxilus coccogenis* and Tennessee shiner, *Notropis lutipinnis*). It would appear to be associated with declines in numbers of at least the last named species.

Mosquitofish (*Gambusia* spp.): In a previous report (McLarney, 2001b) we discussed the occurrence of mosquitofish in the upper Little Tennessee watershed, and mentioned that specimens from Lake Emory had been determined by Dr. Edward Menhinick, of the U. of North Carolina at Charlotte to be western mosquitofish (*Gambusia affinis*). Questions were raised about how western mosquitofish (theoretically native) would spread to the upper Little Tennessee, and the likelihood of intentional or accidental introduction of eastern mosquitofish (*Gambusia holbrooki*, certainly not native) was discussed. Here we offer additional information on the distribution of mosquitofish in the watershed.

During 2002 we took mosquitofish from 4 new sites – Cowee Creek at RM 1.8 and 2.1, a small Lake Emory tributary draining the area recently dubbed "Suli Marsh" on the new Franklin Greenway, and a single individual taken in October from the mouth of Bradley Creek (tributary at RM 112). With these occurrences (and if we consider the Bradley Creek specimen to be a stray) we can define 2 "clusters" of mosquitofish in the upper Little Tennessee watershed:

Lake Emory has a considerable population of mosquitofish; they may usually be observed in the shallows. The Suli Marsh observation was of a very large number of fish trapped in a pool which was drying up under drought conditions. It is reasonable to assume that mosquitofish are abundant in the wetland areas which surround the impoundment. Lake Emory is the likely source of a single specimen taken from Crawford Branch at E. Main St., Franklin (RM 0.3) in 1998. (Crawford Branch is tributary to Lake Emory). McCown (2002) found mosquitofish at RM 0.2 in Watauga Creek, tributary to the Little Tennessee immediately below Porters Bend Dam, which impounds Lake Emory. These fish could easily have invaded from Lake Emory.

A second "cluster" is located around Perry's Water Gardens, an ornamental aquatic plant business located in the triangle formed by the confluence of Caler Fork with Cowee Creek. The ornamental ponds drain to both streams. In 2001, a single mosquitofish was taken from Caler Fork directly opposite the water gardens. In 2002, mosquitofish appeared at 2 nearby sites on Cowee Creek (Neither had been sampled previously.) The RM 2.1 site on Cowee Creek is located on the opposite side of the water gardens, and the RM 1.8 site is 0.2 mi. downstream of the confluence of the two streams. (No mosquitofish were taken at RM 2.4, upstream of the water gardens, in a reach characterized by more riffles and generally swifter flow.) Mosquitofish are present in the water garden ponds, and there is reason to suppose they are eastern mosquitofish brought in with aquatic plants from Florida.

No mosquitofish have been taken from the river or any of its tributaries along the ca. 5 miles between Watauga and Cowee Creeks. An isolated downstream population which had been present in a spring-fed riparian wetland along the Little Tennessee in the Oak Grove area of northern Macon County, ca. RM 105, has apparently disappeared. No fish of any kind were found in the wetland in the summer of 2002. The single specimen from Bradley Creek represents the farthest downstream occurrence of this species in the watershed. For the time being it is being treated as a stray. It is not impossible that the Lake Emory and Perry's Water Garden clusters represent separate populations of mosquitofish, of distinct origin. Were that the case, then one could assume that Menhinick's identification of the Lake Emory specimens as *G. affinis* is correct, while still assuming the introduction of *G. holbrooki* via Perry's Water Gardens. However, this would leave the question of the apparent absence of mosquitofish in riparian wetlands and other apparently suitable habitat below Lake Emory – plus the question of how mosquitofish passed upstream over the dam.

Further collections should be made for the sake of taxonomic accuracy. For the time being, we will identify all mosquitofish as *Gambusia* sp.

Smallmouth bass (*Micropterus dolomieui*): In McLarney, 2001b we reported our first Georgia record for this species, from RM 138.4 (Greenwood Rd.). During the 2001 sampling season we further extended the Georgia range with the capture of a small adult at RM 142.9 (Wolf Fork) at which point the Little Tennessee is really a small creek (watershed drainage 8 sq. mi.). We also recorded smallmouth bass from two locations (up to RM 1.1) on Iotla Creek and at RM 2.1 on Cowee Creek(above the junction of Caler Fork). This was the first record for Iotla Creek and the farthest upstream penetration on Cowee Creek. The Cowee Creek record was of 2 ca. 12 inch adults.

It is not unusual to take one or two small juvenile smallmouth bass in even the smaller tributaries, but this year we noticed a tendency for more and larger smallmouths in several tributaries. This is consistent with the observation of trout and panfish fishermen that they are taking more smallmouths in streams like Burningtown, Cowee and Cartoogechaye Creeks in recent years.

Yellow perch (*Perca flavescens*): Prior to about 1999, yellow perch were known from the upper Little Tennessee watershed only from the mainstream around the upper end of Lake Emory, where they have appeared annually in our monitoring samples since 1995. In McLarney, 2001b, we reported on the expansion of their range upstream well into Georgia (RM 142.9 at Wolf Fork) and downstream nearly to (and probably beyond) the mouth of Cowee Creek (RM 116). This year we took our first yellow perch from tributary streams. Adult yellow perch appeared in both of our fixed station samples on the Cullasaja River (RM 0.9 and 8.3) and at the Rec Park site on Cartoogechaye Creek (RM 1.0). It can thus now be stated that yellow perch inhabit or at least travel through over 40 miles of stream in the upper Little Tennessee watershed. Notwithstanding the fact that yellow perch are thought to be native in the neighboring Hiwassee River watershed, given the frequency of our sampling, the pattern of our records strongly suggests expansion from an initial introduction in Lake Emory.

Asian clam (*Corbicula*): It was probably inevitable that *Corbicula* would arrive in the upper Little Tennessee. It was first observed near the downstream end of the free flowing portion of the river (just above the mouth of Sawmill Creek) in 2000. By the summer of 2002 it was to be found in great abundance throughout the reach below Porters Bend Dam. So far no specimens have been observed above Lake Emory or in tributary streams.

Tennessee heelsplitter (*Lasmigona holstonia*): See section on Iotla Creek at Malonee Mill site (RM 1.1) for a report on this species, new to the watershed.

Pond papershell (*Utterbackia imbecillis***):** During an emergency drawdown of Lake Emory, several specimens of this species were recovered. The pond papershell is an extremely tolerant species, often introduced inadvertently with fish, and is probably not native to the watershed. It is significant only as the first record of any species of mussel from the Little Tennessee upstream of Porters Bend Dam.

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Expansion of the project would not have occurred without the efforts of several people at SAMAB, including Executive Director Robb Turner, Susan Schexnayder and especially Tommy Gilbert. Without Tommy's ability to see how the pieces might fit together, we might all be left with our good intentions and a smaller, less effective project.

Involvement continues on the part of all the above at SAMAB. In addition, Andy Brown has played a key role in building our capacity to share with and learn from other watershed groups in the TVA/SAMAB region. Shelaine Curd has made a tremendous contribution by organizing 13 years of biomonitoring data in a format which will be both more usable within the upper Little Tennessee Watershed and more accessible throughout the region and beyond. Thanks to Shelaine and P.J. Nabors we were able to unveil a color-coded water quality map of our watershed at the 2002 SAMAB Annual Conference in November, 2002. This map, to be updated annually, represents the culmination of work undertaken with the help of Gary Williams of TVA, plus Noreen Miller and Mike Wilkins of the Nantahala National Forest, Wayah Ranger District. It is being incorporated as part of the database of SAIN (the Southern Appalachian Information Node) of the NBII (National Biological Information Infrastructure).

This report is the first such report prepared entirely under the administration of Little Tennessee Watershed Association (LTWA) Executive Director Carla Norwood. The efforts of an Executive Director capable of seeing the vision of the project have been most opportune in this expansion year. Within the LTWA, special thanks also go to Kay Coriell, for filtering multiple volunteer inquiries.

Our principal field assistant this year was Cal Yonce, back for his second tour of duty. (He was also the main field assistant in 2001.) Last year's field assistant, Jeff Alexander was indispensable for spot duty on complex sites.

A complete list of the 146 volunteers who contributed a total of 865 hours during the 2002 biomonitoring season appears at the end of this section; "frequent flyers" are marked with asterisks. Our most frequent volunteer for this season was Rose McLarney.

A special category of volunteers is those who recruit groups to help us. This year we are indebted to Joan Willis of Franklin High School, Ron Huff of the Upward Bound Math and Science Program at Western Carolina University, Kristi Perino at Project Challenge, Sue Steiner and Barry Clinton at Coweeta Hydrologic Laboratory, Cub Scout den mother Stephanie Ramsey, Dr. Ed Menhinick of UNC-Charlotte, Lenora Clifton of Serve Our Students/Macon Program for Progress, Kim Ingram of The Mountain, Stephanie

French of Rabun County 4H, Buzz Williams of the Chattooga Conservancy and Evelyn Brow of the ELF Home School Group. Without these groups, our task of organizing field crews would be much harder.

As in many years past, Dave Matthews of American Aquatics went out of his way to be cooperative and helpful with use of the boat shocker. He was assisted by Steve Holderman (macroinvertebrate sample at Needmore), Chris Underwood and Josh Stephens.

Special thanks to Wendell Pennington of Pennington Associates for prompt and high quality work on the macroinvertebrate samples, and to Steve Akers of TVA for his role in facilitating this effort.

Valuable supplemental information on fall movement of fishes in tributary streams was provided through a study by UNC-Chapel Hill student and Highlands Biological Station intern Deb McCown. She was regularly assisted in the field by Matt Curtin and occasionally by Eric Morris. Thanks to Dr. Robert Wyatt of the Highlands Biological Station and Alyssa Wittenborn of UNC for the opportunity to participate in this intern program.

Once again Roger Turner made the Franklin office of the Western North Carolina Alliance, located in Franklin, available for photocopying, phone calls, meetings and storage. Storage of equipment has been a difficult issue for years, and one which has called for patience, forbearance and a cooperative attitude over and above the norm, qualities we have found in most of those on whom we have depended. This year special thanks go to Roger and to George and Sharon Taylor and Carla Norwood for their good examples in this regard.

A final category of acknowledgement (over all the years) is to the many landowners who cheerfully grant us access permission, without which almost none of the work reported here could occur. These anonymous individuals merit special thanks this year, considering the amount of heated rhetoric about concepts such as biodiversity conservation, buffer zones and sustainability which fills the air in our region. Over the years we have a near 100% rate of positive answers to our requests to march troops of strangers across people's property and through their streams, and it comes from people of every political persuasion.

Thanks should also go to the people who use the information generated by this work. In some cases we may not even know who they are, but we would like to especially thank the Macon County Board of Commissioners, Harold Corbin, Chair for making history. We have not researched the matter, but we assume it is rare for county governments to take biotic integrity information into account in making planning decisions. In the recent past this has happened on at least 3 occasions in Macon County – Sedimentation and Erosion Control Ordinance, resolution favoring protection of the Needmore Tract (in which the Swain County Commission followed suit) and most recently, the Clean Water Amendment to the Watershed Ordinance, which erects the category of "Excellent Quality Waters", prohibiting point source discharges to the critical portion of the Little Tennessee Watershed in Macon County between Lake Emory and the Swain County line. We believe this is a truly historic step, as well as one which validates our monitoring work and encourages us to continue.

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Reed Bauman
Russell Bauman
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Andrew Bogan
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Matt Boyer
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