Index of Biotic Integrity (IBI) Monitoring In The Upper Little Tennessee Watershed 2008

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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 (IBI) protocol, at a total of (to date) 156 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 additional fixed stations is offered in McLarney, 1996 (Little Tennessee at head of Lake Emory, Rabbit Creek at Rabbit Creek Rd. and Skeenah Creek at North Carolina Welcome Center), McLarney, 2000, (Little Tennessee River at Wolf Fork) and McLarney, 2001 (two stations on Sutton Branch at Rabun Gap-Nacoochee School).

Five stations have subsequently been dropped from the fixed station list. Iotla Creek at Macon County Airport was abandoned in 1999 (See McLarney, 1999, 2000). Little Tennessee River at Wolf Fork (RM 142.9) was not sampled in 2002, and formally abandoned as a fixed station in 2003, although it was revisited in 2005, 2006 and 2007. (It was originally selected as a fixed station for pedagogical purposes, in a program which was discontinued in 2002.) Two sites on Sutton Branch were dropped as fixed stations after the 2002 season (McLarney, 2003), when it became apparent that a projected stream restoration project was not likely to occur in the near future. And after the 2007 season, extreme channel instability in the lower Cullasaja River made it impractical to maintain a fixed station there (See McLarney, 1996).

It has gradually become clear that it will be useful to monitor Peeks Creek above Peeks Creek Rd. as a fixed station, and in 2007 it was so designated. At this time 10 sites are designated as fixed stations. Table 1 lists these stations and their years of monitoring. All 10 fixed stations were monitored in 2008, supplemented by 18 sites previously monitored at least once and 2 new sites. Location of all sites is shown in Figure 1. Rationale for selection of all non-fixed station sites monitored in 2008 is given in the following section.

Following discussion of rationale for site selection, and a presentation of monitoring criteria (Tables 2 through 8), the bulk of this report is devoted to presentation and interpretation of monitoring results, including fish sampling data (all sites) and macroinvertebrate sampling data (4 small stream sites).

RATIONALE FOR NON-FIXED STATION SITES

For most significant sites we try to maintain roughly a 5 year sampling rotation. Sites chosen on that basis in 2008 were *Burningtown Creek below Lower Burningtown Rd., Little Tennessee River at Tessentee Farm, Coweeta Creek at Coweeta Creek Campground and Betty Creek at Messer Creek Rd.

Ten sites were selected based on two new projects sponsored by the North Carolina Ecosystem Enhancement Program (EEP):

- A recently completed short term project (Leslie 2008; McLarney 2009) seeks to evaluate the importance of culverts and other structures as barriers to upstream fish movement, building on the discovery (McLarney 2000; McCown 2002) of extensive upstream fall cyprinid migrations in upper Little Tennessee tributaries. While most of the anthropogenic barriers identified were on streams smaller than those normally monitored using IBI, one failing culvert on a larger stream was evaluated and is scheduled for replacement. We therefore felt it was necessary to do comparative IBI samples above and below this culvert (an old site designated as *Watauga Creek above Jim Berry Rd. and a new one referred to as *Watauga Creek above John Brown culvert).

- On a longer term basis, the EEP is developing a Local Watershed Plan, with multiple stakeholder involvement, focusing on the watershed of the Little Tennessee River and its tributaries between Rabbit Creek in Macon County and Brush Creek in Swain County. Five sites selected for other reasons (marked with an asterisk in the text) fall into this area, as does the fixed station on the *Little Tennessee River at Needmore. Sites selected principally for their relation to the EEP project are:
    - Cat Creek above its mouth at Rabbit Creek
    - Cat Creek at the Waldroop farm in Holly Springs
    - Matlock Creek below Snow Hill Rd.
    - Caler Fork at the Tucek property along Ruby Mine Rd.
    - Cowee Creek above Caler Fork
    - Dalton Creek below Dalton Creek Rd.
    - Burningtown Creek at Outside Inn Campground
    - Brush Creek (Swain Co.) at the Hampton Farm site (Needmore Game Lands)

- Three sites:
    - *Burningtown Creek below Lower Burningtown Rd.
    - *Cowee Creek above the Wests Mill bridge
    - *Little Tennessee River at Iotla Bridge

  -were scheduled to be monitored in 2008 by the Tennessee Valley Authority (TVA) and were sampled in collaboration with TVA biologists.

- Four other sites were selected in response to particular events:
    - Mill Creek (Cartoogechaye watershed) above Old Murphy Rd., although it was monitored in 2007, it was monitored again in response to a change in ownership of the Mill Creek Club, a large golf and residential development located farther up the

watershed, which has been the apparent source of some of Mill Creek's problems. The new owners are promising a "green" approach to management of the property, and have expressed a willingness to collaborate with the LTWA. Getting baseline data from the downstream site was the first step.

- Walnut Creek above Walnut Creek Rd. was monitored for the first time since 2004 in response to a massive land failure in an upstream development which sent a heavy load of sediment down Walnut Creek in March.
- The Little Tennessee River above GA highway 246 (Scaly Rd.) was first monitored in 2007. It was repeated again in 2008, and may be monitored for several more years in response to a complex of issues around industrial and municipal wastewater treatment, with potential 2 way interbasin transfers of both river water and treated waste water in the Rabun Gap, Georgia area. While our fixed station at the North Carolina/Georgia state line provides relevant information, that station also suffers from poor physical habitat quality. The newer site has better substrate and riparian conditions, and is thus better suited as a test site related to monitor the water quality-related effects related to activities in Rabun Gap.
- Betty Creek at the Hambidge Center for Creative Arts and Sciences was monitored in an attempt to help that institution see their way through the complexities of a wetland and riparian zone restoration project which has not necessarily yielded the desired results in the terrestrial sphere, but which does substantially protect the creek.

IBI SCORING CRITERIA

IBI scoring criteria (presented in Tables 2-7) here applied to sites with watershed drainage areas of 4 sq. mi. or more are those proposed by McLarney (1995), as modified from Saylor and Ahlstedt (1990).

For certain types of stream sites, including those draining less than 4 sq. mi., with gradients of greater than 100 ft./mi., or located at high altitudes above barriers to fish movement, an exclusively fish-based IBI is not appropriate. Such streams (accounting for 4 of the 30 sites monitored in 2008) are normally considered 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 based on combined fish and benthic macroinvertebrate samples, here presented (Table 7) in a modified version proposed by this author (McLarney 1999). While results of the "brook trout" IBI are reported here, we are increasingly doubtful as to its applicability at the low elevations (2000-2100 ft.) of the streams discussed here and other small streams monitored in previous years. We urge the critical reader to consider the fish and benthic macroinvertebrate data separately, as well as together.

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). No sites in that size range were monitored in 2008. 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).

RESULTS AND DISCUSSION

Following the format established in McLarney (1995), in Tables 9-75 data are presented for each of the 30 monitoring sites for 2008 and for the previous year of monitoring, if any (plus other years as deemed necessary for interpretation of the data).

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 River watershed, with scientific names, see McLarney (2001).

We rarely see recognizable inter-species hybrid fish in the upper Little Tennessee watershed, with the significant exception of hybrids of the yellowfin shiner, *Notropis lutipinnis*, with at least 4 other cyprinid species (smoky dace *Clinostomus* sp.; warpaint shiner, *Luxilus coccogenis*; river chub, *Nocomis micropogon*, and Tennessee shiner, *Notropis leuciodus*). When hybrids are detected, for purposes of assigning points in the IBI score they are attributed to whichever of the parent species would tend to lower the score. (For example, any hybrid of the yellowfin shiner with a native cyprinid would be scored as a yellowfin shiner, since the yellowfin shiner is an exotic. A redbreast sunfish, *Lepomis auritus* x bluegill hybrid (*Lepomis macrochirus*) would be scored as a redbreast sunfish, since that species is considered a tolerant, and is also an exotic.)

A General Comment:

This section builds on a similar section in the 2007 IBI report, in which it was pointed out that "IBI results are normally site or watershed-specific; we do not normally see strong trends across watershed lines". However, the data for 2007 and 2008 show two remarkable consistent and presumably related trends. The size of samples (total number of fish with all species combined) has been higher than in previous years, and one species in particular, the central stoneroller (*Campostoma anomala*) has tracked this effect by increasing its proportional abundance as total fish abundance increases.

There is a strong suggestion that the overall increase in fish abundance is related to water levels, as a comparision with 2007 and 2008 figures with data from the years 2003-2006, characterized by frequent high water levels, with 2 major flood events, will show. A total of 20 medium sized" stream sites (watershed areas of 4-70 sq. mi.) were monitored 1-4 times during 2003-2006 and also in 2007 and/or 2008, with the following results:

- For 14 such sites monitored in 2007, in all cases the total fish catch was higher than the mean of the 2003-2006 catch; in 13 of these instances the 2007 catch exceeded all individual 2003-2006 samples.

- For 17 such sites monitored in 2008, the total fish catch exceeded the 2003-2006 mean in 12 instances, and the 2008 catch exceeded all 2003-2006 totals in 8 instances. If we extend the comparison to include all sites in the same size range monitored 1-16 times during 1990-2006 and also in 2007 and/or 2008, there are a total of 32 sites to consider. For these sites:

- The total fish catch for 2007 and/or 2008 was higher than the 1990-2006 mean in 27 instances.
- In 15 instances, the highest total fish catch ever was recorded in 2007 or 2008. It is not difficult to construct a hypothesis connecting low flow and high total fish abundance. Most of our fish species spawn in spring and early summer, so that young, small, relatively weak swimming fish are subject to displacement and mortality during high flows. (We noted a particular scarcity of fish following the huge December, 2004 flood.) When such flows do not occur, survival of small fish is enhanced, leading to greater overall numbers. This hypothesis, however, does not explain why the central stoneroller seems to have benefitted disproportionately from an altered weather pattern.

The herbivorous central stoneroller is rarely absent from our samples, although only under ideal conditions does it become a dominant species. During the high water period of 2005-2006 we carried out 37 fish samples at sites with watershed drainage areas of 4-70 sq. mi. Central stonerollers were taken on 35 of these occasions, but were never the most abundant species. They ranked among the 3 most abundant species in only 9 (24.3%) of the samples. The maximum proportion of stonerollers in a sample was 26.2%, and they accounted for >10% of the sample on 6 occasions (16.2% of the total). The total proportion of stonerollers (all samples) was 7.4%.

During the low water years of 2007-2008 we carried out 46 such samples, with stonerollers present in every instance (proportions of 0.3 – 39.7%). Stonerollers were the single dominant fish on 2 occasions and ranked among the 3 most abundant species on 23 occasions (50.0%). They also accounted for >10% of the total sample on 23 occasions (50.0%). The total proportion of stonerollers over all samples nearly doubled, to 13.8%, in 2007-2008.

It may be that stonerollers are unusually susceptible to displacement during high flows and/or attracted to low flows, but logic suggests that column-dwelling fish would be more vulnerable than a benthic species such as the stoneroller. However, there is another plausible explanation, based on the central stoneroller's unique ecological niche as our only algivore. While no measurements were made, it appeared that periphyton growth on rocky substrates peaked early in 2007, presumably as a consequence of sustained low, clear water. Apparently, stoneroller populations responded to this opportunity just as they do to a sudden spike in concentration of organic material in the water, by concentrating or increasing their numbers.

While (pending needed modification of IBI Metric 10, based on catch per unit effort) an increase in total fish abundance can have a positive effect on the IBI, an increase in proportional abundance of stonerollers tends to have the opposite value through its effect on Metric 7 (proportion of individuals as omnivores and herbivores). Observed values for this metric were generally high in 2007-2008, with 11 sites recording record high proportions of omnivores and herbivores.

IBI was designed to evaluate anthropogenic effects on natural assemblages; one of the characteristics of stream sites with high biotic integrity is resiliency with respect to natural events, including floods and droughts. However, in this case whether or not we are dealing with a "natural" phenomenon can be discussed. While there certainly are natural cycles of high and low precipitation and stream flow, there is ample reason to suspect that the gradual decline in precipitation (and

extreme winter weather) in our region over the past 2 decades or more, and the ongoing drought are related to anthropogenically induced climate change. In which case the IBI, and within it Metric 7, may be serving as an early indicator.

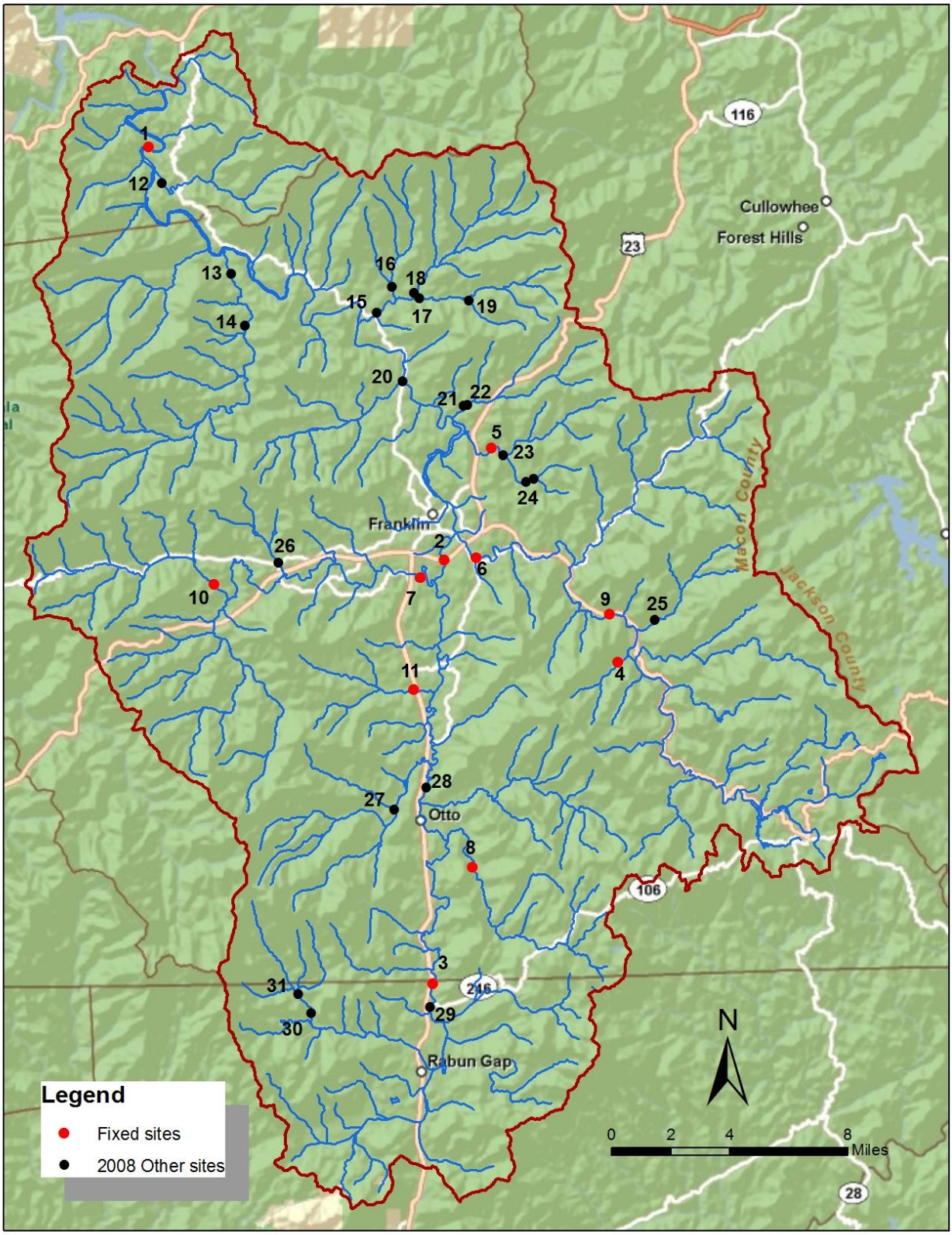

Figure 1. Location of sites sampled during the 2008 biomonitoring season in the upper Little Tennessee Watershed.

Table 1. Location and general information for fixed biomonitoring stations in the upper Little Tennessee River Watershed.

Stream	River Mile	Site Name	Watershed area (mi^2)	Years monitored	Rationale for adoption/abandon.
Little Tennessee R.	95.5	Needmore	445	1990-2002, 2004, 2006, 2008	Original TVA Little Tennessee fixed station
Little Tennessee R.	118.0	Head L. Emory	200	1995-2000, 2002, 2004, 2006, 2008	Transition between upper and lower river
Little Tennessee R.	136.9	State Line	55	1990,1992-2002, 2004, 2006, 2008	NC/GA state line
Rabbit Cr.	0.8	Above Rabbit Cr. Rd.	8	1992, 1992-2008	Ideal for high school class
Cullasaja R.	0.9	Wells Grove	93	1995-2002, 2004, 2006, 2008	Lower end of largest Little T tributary
Peeks Cr.	0.3	Above Peeks Creek Rd.	2	2005-2007	Document recovery from mudslide disaster
Cartoogechaye Cr.	1.0	Macon Co. Rec Park	59	1992, 1992-2008	Second largest Little T tributary
Middle Cr.	2.2	W. Middle Cr. Rd.	10	1992, 1992-2008	Follow results of restoration upstream
Cullasaja R.	8.3	Peaceful Cove	55	1991, 1993-2008	Track effects of Highlands WWTP
Wayah Cr.	0.6	Crawford Rd.	13	1990,1993,1996-2008	Track effects of package treatment plant
Skeenah Cr.	0.5	NC Welcome Center	6	1994-1995,1997-2008	NCCAT - ideal teaching site

Table 2. IBI metric scoring criteria for the Upper Little Tennessee River Watershed for stream sites with watershed areas of 4-7 square miles.

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

* If catch rate is less than 3, low scores should be automatically given for metrics 8, 11 and 12.
** The omitted metrics are deleted for this size stream.

Table 3. IBI metric scoring criteria for the Upper Little Tennessee River Watershed for stream sites with watershed areas of 7-15 square miles.

Metric	Score 1.3	4	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***			
4. Number of sucker species**			
5. Number of intolerant species	<2	2	>2
6. Percentage of individuals as tolerant species	>20%	10-20%	<10%
7. Percentage of individuals as omnivores, generalist feeders and herbivores	>20%	10-20%	<10%
8. Percentage of individuals as specialized insectivores	<20%	20-45%	>45%
9. Number of species as piscivores**			
10. Catch rate per unit of effort*	<11	11-18	>18
11. Percentage of individuals as darters and sculpins	<35%	35-65%	>65%
12. Percentage of individuals with disease, tumors, fin damage and/or other anomalies	>5%	2-5%	<2%

* If catch rate is less than 3, low scores should be automatically given for metrics 8, 11 and 12.
** The omitted metrics are deleted for this size stream.

Table 4. IBI metric scoring criteria for the Upper Little Tennessee River Watershed for stream sites with watershed areas of 15-40 square miles.

Metric	Score 1.3	4	6.7
1. Total number of native species	Varies with drainage		
2. Number of darter species	0	1-2	>2
3. Number of centrarchid species, other than *Micropterus***			
4. Number of sucker species**			
5. Number of intolerant species	<2	2	>2
6. Percentage of individuals as tolerant species	>20%	10-20%	<10%
7. Percentage of individuals as omnivores, generalist feeders and herbivores	>20%	10-20%	<10%
8. Percentage of individuals as specialized insectivores	<20%	20-45%	>45%
9. Number of species as piscivores**			
10. Catch rate per unit of effort*	<7	7-13	>13
11. Percentage of individuals as darters and sculpins	<35%	35-65%	>65%
12. Percentage of individuals with disease, tumors, fin damage and/or other anomalies	>5%	2-5%	<2%

* If catch rate is less than 3, low scores should be automatically given for metrics 8, 11 and 12.
** The omitted metrics are deleted for this size stream.

Table 5. IBI metric scoring criteria for the Upper Little Tennessee River Watershed for stream sites with watershed areas of 40-70 square miles.

Metric	Score 1.1	3.3	5.5
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***			
4. Number of sucker species	0	1	>1
5. Number of intolerant species	<2	2	>2
6. Percentage of individuals as tolerant species	>20%	10-20%	<10%
7. Percentage of individuals as omnivores, generalist feeders and herbivores	>20%	10-20%	<10%
8. Percentage of individuals as specialized insectivores	<20%	20-45%	>45%
9. Number of species as piscivores	0		≥1
10. Catch rate per unit of effort*	<7	7-13	>13
11. Percentage of individuals as darters and sculpins	<35%	35-65%	>65%
12. Percentage of individuals with disease, tumors, fin damage and/or other anomalies	>5%	2-5%	<2%

* If catch rate is less than 3, low scores should be automatically given for metrics 8, 11 and 12.
** The omitted metrics are deleted for this size stream.

Table 6. IBI metric scoring criteria for the Upper Little Tennessee River Watershed for stream sites with watershed areas of 150-600 square miles.

Metric	Score 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	<2	2	>2
6. Percentage of individuals as tolerant species	>20%	10-20%	<10%
7. Percentage of individuals as omnivores, generalist feeders and herbivores	>20%	10-20%	<10%
8. Percentage of individuals as specialized insectivores	<20%	20-45%	>45%
9. Percentage of individuals of piscivores	<1%	1-2%	>2%
10. Catch rate per unit of effort*	<7	7-13	>13
11. Percentage of individuals as darters and sculpins	<10%	35-25%	>25%
12. Percentage of individuals with disease, tumors, fin damage and/or other anomalies	>5%	2-5%	<2%

* If catch rate is less than 3, low scores should be automatically given for metrics 8, 11 and 12.

Table 7. Proposed modifications to Williams' (1996) "Brook Trout" IBI table for stream sites draining less than an area of 4 square miles, and located at elevations of 1,700 ft. or more in the upper Little Tennessee river watershed.

Metric	Score 1.5	4.5	7.5
1. Total Ephemeroptera families	<3	3-5	>5
2. Total EPT families	<8	8-15	>15
3. Brook trout present/absent	Absent	Sympatric	Allopatric
4. Catch rate (mean number of individual fish per 5 min. of electrofisher time)	<5	5-9	>9*
5. Percentage of individuals with disease, tumors, fin damage and/or other anomalies	>5%	2-5%	<2%**
6. Percentage of individuals as tolerant species	>20%	10-20%	<10%
7. Proportion of individual fish as wild trout (all spp.)	Absent	0-10%	>10%
8. Proportion of individual fish as omnivores, generalist feeders and herbivores	>20%	20-10%	<10%

*Score 6 if >50
**Score 6 if >0 and <2%

Table 8. Biotic integrity classes used in assessing fish communities and general descriptions of class attributes.

IBI Range	Class	Attributes
58-60	Excellent	Comparable to the best situations without human impacts. Includes all expected species for the particular type and size of stream. All species, including the least tolerant, with full array of sizes and ages. Balanced trophic structure. Low incidence of diseases, parasites and anomalies.
48-52	Good	Species richness may be somewhat below expectations, especially due to the loss of most intolerant forms. Some species with less than optimal abundance or size distribution. Trophic structure shows some signs of stress.
39-44	Fair	Fewer intolerant forms. More skewed trophic structure. In some cases older age classes for predators may be rare.
28-35	Poor	Dominance of pollution-tolerant species. Species with specialized habitat requirements scarce. Carnivores scarce. Diseases, parasites and anomalies common.
12-23	Very Poor	Fish may be scarce or over-abundant (in nutrient-enriched rivers). Tolerant species dominant. Diseases, parasites and anomalies common.

- When the IBI score falls between the designated ranges, a Bioclass Rating is assigned according to the professional judgment of the biologist in charge.

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

We would like to monitor this fixed station annually, but since it requires collaboration by TVA (use of shocker boat) and TVA has the site on a 2 year rotation, it is being monitored biennially. The 2008 results are in line with the common Excellent rating of this site and interrupt several negative trends we had tentatively identified over the period 2002-2006. Specifically we note:

- Recovery of the threatened spotfin chub (*Erimonax monachus*), with 19 individuals in the sample, the largest number recorded here since 2000. This apparent recovery is consistent with other 2008 observations both in the Little Tennessee mainstem (Russ and Fraley 2009) and in tributary streams (McLarney 2009).

- Similar reversal of decline in numbers by 3 other intolerant species (telescope shiner, *Notropis telescopus*; rock bass, *Ambloplites rupestris* and wounded darter, *Etheostoma vulneratum*), all of which posted their highest numbers since 2001-2002.

- Doubling in numbers of darters other than the usually dominant gilt darter (*Percina evides*), with consequent improvement in the observed value for Metric 11 (proportion of darters and sculpins), which recorded its highest value since 1999.

These recoveries are to some degree offset by the highest observed value (15.4%) ever recorded here for Metric 7 (proportion of omnivores and herbivores). One contributing factor to this metric was an unusual number of the herbivorous central stoneroller (*Campostoma anomala*). Not only did we record 28 individuals of this species (double the previous high total, from 1994), but this number included several large adults. (This species is normally represented here only by juveniles, whichhave been taken in the shallowest riffle areas.) This observation parallels a watershed-wide increase in stoneroller abundance in tributary streams during 2007-2008. (See discussion under "Results and Discussion," above.)

The IBI would rise to 58 if Metric 10 (catch per unit effort) were awarded the high score. The actual total fish catch per 300 sq. ft. of water surface comes out to 12.9986; the value required to receive the high score is >13. However it is scored, this represents the highest catch rate here since 1998.

While for Metric 1 (no. of native species) the 2008 sample recorded all species which have been taken every year here, several frequently observed species, which might be considered as "expected", are missing. They are: mountain brook lamprey (*Ichthyomyzon greeleyi*), represented by 1-6 individuals in 11 of the past 15 years; silver redhorse (*Moxostoma anisurum*), 1-4 individuals in each of the past 12 years, and mottled sculpin (*Cottus bairdii*), 1-10 individuals in each of the past 10 years.

The undescribed regional endemic sicklefin redhorse (*Moxostoma* sp.) was represented by a single individual, which had PIT tag No. 4B1D68776F.

A record number (4) of the stonecat (*Noturus flavus*) is probably an artifact of continuing low water levels which rendered the habitat of this rare, cryptic species (fissures in deep bedrock runs) unusually accessible. (See also Little Tennessee River at Iotla Bridge.)

With all cautions noted, a Bioclass Rating of Excellent is probably still merited at Needmore.

Table 9. IBI metrics and scores from fixed station 1: Little Tennessee River at Needmore (RM 95.5).

	2004		2006		2008	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	33	5	30	5	28	33
2. Number of darter species	5	5	6	5	5	5
3. Number of centrarchid species	5	5	2	5	3	5
4. Number of sucker species	7	5	5	5	6	5
5. Number of intolerant species	5	5	4	5	5	5
6. Percentage as tolerant species	0.7	5	0.0	5	1.1	5
7. Percentage as omnivores, herbivores	7.7	5	14.2	5	15.4	3
8. Percentage as specialized insectivores	77.8	5	62.3	5	64.2	5
10. Catch rate per unit of effort	3.9	5	2.9	5	11.0	5
11. Percentage as darters and sculpins	6.3	3	11.3	3	13.0	3
12. Percentage with disease, tumors, fin damage and/or other anomalies	9.4	1	17.6	3	26.4	5
Total		54 Excellent		56 Excellent		56 Excellent

Table 10. Fish capture data from fixed station 1: Little Tennessee River at Needmore Rd. (RM 95.5).

	Number of individuals		
Species (common name)	2004	2006	2008
Mountain brook lamprey		5	
Gizzard shad			
Rainbow trout			
Muskellunge			
Central stoneroller	9	10	28
Whitetail shiner	176	102	79
Spotfin chub	10	1	19
Common carp			2
Warpaint shiner	213	128	30
River chub	36	104	40
Golden shiner			
Tennessee shiner	7	24	9
Silver shiner	2	62	7
Rosyface shiner	38	55	4
Mirror shiner	14	11	12
Telescope shiner	1		10
Fatlips minnow		2	2
Blacknose dace		3	
Creek chub	1		
Northern hogsucker	26	107	12
Silver redhorse	1		
River redhorse	3	2	2
Black redhorse	8	8	4
Golden redhorse	8	4	5
Shorthead redhorse	10	40	7
Sicklefin redhorse	2	1	1
Unidentified redhorse	2	1	
Channel catfish	6	10	4
Stonecat		2	4
Flathead catfish	2	1	1
White bass			
Rock bass	12	9	28
Redbreast sunfish	3		3
Green sunfish	1		
Warmouth			
Bluegill	5	2	1
Redear sunfish			
Smallmouth bass	8	14	21
Largemouth bass			
Black crappie	3		
White crappie			
Tuckaseigee darter			
Greenfin darter	18	26	43
Wounded darter	1	5	10
Banded darter	11	1	25
Yellow perch			
Tangerine darter	2	7	2
Gilt darter	30	112	40
Walleye	1	1	
Mottled sculpin	1		
Total	671	850	455

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

Overall, this site which involves a narrow, deep, incised, U-shaped channel has been one of the most difficult sites for us to work with a backpack electrofisher. In 2008, for the second year in a row we encountered optimum conditions of water level and clarity. So, in contrast to the situation in some previous years, we can report with confidence that the changes observed between 2007 and 2008 are real.

IBI for the Little Tennessee at this site dropped from 40 (Bioclass Fair) to 34 (Poor), the lowest score and first Poor rating since 1996. While the immediate environs of this reach of the river are, and will continue to be, impacted by development and construction activity, the observed changes in the fish assemblage would appear to be largely due to the loss of what was the only riffle in the free flowing 1-1.5 mile of the Little Tennessee between the mouth of Cartoogechaye Creek and the head of impoundment of Lake Emory. For reasons unknown, what at least since 1990 has been clearly a degraded riffle with gravel between rocks and a strong growth of riverweed (*Podostemum*) is now a stretch of slightly faster water with a few large rocks interspersed. Perhaps the change is best indicated anecdotally: The TVA shocker boat was able to pass over the "riffle" without problem, something which would have been impossible in previous years.

In 2007, 5 shocker/seine sets in this riffle produced 202 fish of 19 species, amounting to 58.4% of the total backpack sample. In 2008, the comparable numbers were 52 fish, 14 species and 34.7% of the total. In particular, this site had been the stronghold of the gilt darter (*Percina evides*) and the Tennessee shiner (*Notropis leuciodus*). In 2008, the gilt darter (present in small numbers in 8 of 10 previous samples) was not taken in our sample. (The TVA boat crew did observe one individual in a shallow run not far upstream of the sample reach.) The Tennessee shiner count dropped from 77 to 11 individuals, the lowest number here since 1996 (10 year mean 39.8 individuals).

These changes directly affected scores for Metrics 1 (number of native species), 5 (number of intolerant species), 8 (proportion of specialized insectivores) and 10 (catch per unit effort). They also contributed indirectly to the record abundance (99) of redbreast sunfish (*Lepomis auritus*) lowering the score for Metric 6 (proportion of tolerants).

Some of the metrics present difficulties of interpretation:

- Metric 4 (no. of sucker species) requires 5 sucker species to achieve the high score. We recorded 4 species, including one very small (possibly young-of-the-year) white sucker (*Catostomus commersoni*). However, unless we assume that one or more of 4 redhorse (*Moxostoma*) species not known from above Porters Bend Dam were at one time present above the low falls which formerly occupied that point, 4 is the maximum number of sucker species which can be expected here. We therefore tentatively award the high score for Metric 4. (This change should perhaps be retroactive for 1995, if not for all previous years. Three sucker species - northern hogsucker, *Hypentelium nigricans*; black redhorse, *Moxostoma duquesni* and golden redhorse, *Moxostoma erythrurum* have been recorded in significant numbers at this site every year since we began using the boat shocker in 1995. That year marks the last previous record for white sucker, also a single individual.)

- Metric 5 (no. of intolerant species) would score higher were we to include the single gilt darter observed just outside the sample reach or were we to join TVA in designating black redhorse as an intolerant (a conclusion difficult to support in our watershed given the abundance of this species in the polluted and totally sedimented Lake Emory). The only intolerant species reported was rock bass (*Ambloplites rupuestris*) represented by 11 individuals, only 1 of which met the minimum total length requirement of 3 inches to be counted as an intolerant.

- Overall, scoring declined for 6 of the 12 metrics. Metrics 2, 5 and 10 have been discussed.

In addition:

- The total number of native species (Metric 1), which has totalled 18-21 in all previous years, qualifying for the high score in every year but 2006, dropped to 17. Two expected species were missing – largemouth bass (*Micropterus salmoides*) taken in every previous sample and green sunfish (*Lepomis cyanellus*) taken in every previous year but one.

- The proportion of specialized insectivores (Metric 8) declined to 11.4%; the previous low was 13.7%. (The mean value for this metric over 10 previous years is 23.8%.) As for the metrics which improved, Metric 4 has already been discussed, while Metric 9 (proportion of piscivores) which has scored high at this site in every previous year save 2007, returned to its previous high level, with a record observed value of 9.3%

The most curious improvement was in Metric 7 (proportion of omnivores and herbivores), which posted a record low observed value of 9.9%. A curious component of this change was the virtual disappearance of the central stoneroller (*Campostoma anomala*) which has been increasing in abundance virtually throughout the watershed during the drought years of 2007 and 2008. (See discussion under "Results and Discussion," above.) It was represented by only 5 small individuals, the lowest number ever reported for this site.

Equally curious is the continuing decline and record low count for the invasive exotic yellowfin shiner (*Notropis lutipinnis*), represented by only 2 individuals (plus one hybrid with the Tennessee shiner). As recently as 2002, the yellowfin shiner was the single most abundant species at this site.

A single large goldfish (*Carassius auratus*) represents only the second record for this exotic species in 19 years of monitoring the upper Little Tennessee watershed. It was a large, highly colored individual of the "doubletail" variety, and probably represents a very recent pet release.

2008 is the second year in a row during which the rare olive darter (*Percina squamata*) was taken here, after a 4 year hiatus. Despite its problems this is the site with the highest frequency of occurrence of this Special Concern species in our watershed.

For the near future at least, the instability of this site, which represents the condition of the Little Tennessee River as it enters Lake Emory and the Franklin urban complex, can only worsen with the development of multiple infrastructure along its banks.

Table 11. IBI metrics and scores from fixed station 2: The Little Tennessee River at the head of Lake Emory (RM 118.0).

Metric	2007 Value	2007 Score	2008 Value	2008 Score
1. Number of native species	21	5	17	5
2. Number of darter species	3	3	1	3
3. Number of centrarchid species, other than M*icropterus*	5	5		5
4. Number of sucker species	3	3	4	3
5. Number of intolerant species	2	3	1	3
6. Percentage as tolerant species	17.7	3	30.9	3
7. Percentage as omnivores, herbivores	16.0	3	9.9	3
8. Percentage as specialized insectivores	26.6	3	11.4	3
9. Percentage as piscivores	1.7	3	9.3	3
10. Catch rate per unit of effort	15.3	5	9.1	5
11. Percentage as darters and sculpins	10.0	1	4.4	1
12. Percentage with disease, tumors, fin damage and/or other anomalies	4.0	3	2.9	3
Total		40 Fair		34 Poor

Table 12. Fish capture data from fixed station 2: The Little Tennessee River at the head of Lake Emory (RM 118.0).

	Number of individuals	
Species (common name)	2007	2008
Mountain brook lamprey		1
Rainbow trout		
Brown trout		
Central stoneroller	16	5
Goldfish		1
Smoky dace		
Common carp	2	4
Whitetail shiner	27	16
Warpaint shiner	26	10
River chub	65	22
Golden shiner		
Tennessee shiner	77	11
Yellowfin shiner	19	2
Tennessee x yellowfin shiner	3	1
Silver shiner		
Mirror shiner	2	
Fatlips minnow	3	1
Creek chub	1	
White sucker		1
Northern hogsucker	41	13
Black redhorse	39	78
Golden redhorse	25	23
Unid. Redhorse	1	
Snail bullhead	1	1
Rock bass	4	11
Redbreast sunfish	89	99
Green sunfish	Present*	
Warmouth	1	
Bluegill	7	6
Redear sunfish		1
Smallmouth bass	2	7
Smallmouth x spotted bass		1
Largemouth bass	3	
Black crappie	1	
Tuckaseigee darter	3	
Greenfin darter		
Yellow perch	20	13
Gilt darter	3	Present**
Olive darter	2	1
Mottled sculpin	47	14
Total	530	343

* One specimen taken during equipment testing, not part of sample
** One individual seen just above the sample reach

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

We begin by quoting from our 2007 and 2006 IBI reports:

2007 report: "There was some expectation of improvement at this site due to the closure of the Fruit of the Loom plant located 2.2 mi. upstream, a facility which accounted for over 95% of the total industrial discharges to the upper Little Tennessee watershed. The significance of this facility was well described in our report for 2006:"

2006 report: "In 2000, the North Carolina Division of Water Quality reported conductivity values of 350-427 umnos/cm below the state line. This condition was still present on the 2006 sampling date, as evidenced by the necessity to operate electrofishers at an output of 200-300V (Nowhere else in the watershed do we use settings below 500 V, and 800 V is more normal.), and by discoloration and odor of the water. However, since 2002-2003 we have noted recovery of aquatic macrophyte growth (*Podostemum*) at this site, suggesting some improvement in treatment."

2007 report: "In 2007, improvement was indicated by the more normal color and odor of the water. However, whereas during 1992-1993, following a 12 month period with no discharge from this plant, IBI increased from 29.7 to 34.1 (Poor to Fair), as of June, 2007, after 9 months with the plant offline, there was no measurable response by the fish assemblage."

One limiting factor may be the presence of residual toxins in sediments. Virtual absence of fish was noted in a backwater area over accumulated soft sediment. Elsewhere in the watershed we would have expected a concentration of tolerant species in such habitat.

The expected biological improvement appears to have taken place between the 2007 and 2008 samples, as the IBI score increased from 42.9 to 47.3. The latter value is very close to the lower limit of the range for which we are required to assign a Good Bioclass Rating (48-52). However, for reasons to be explained we continue to classify this site as Fair. Nevertheless, the biological improvement is real.

While scores improved for only 2 of the 11 metrics used, observed values improved for 9 metrics and declined for only one. These and other improvements are detailed as follows:

- The score for Metric 2 (no. of darter species) increased from 3.3 to 5.5 with the reapperance of the Tuckaseigee darter (*Etheostoma blennioides gutselli*) and greenfin darter (*Etheostoma chlorobranchium*). This is only the second record for greenfin darter from this site. This species appears to have been largely extirpated from the Georgia waters of the Little Tennessee watershed perhaps because of the chemical barrier posed by the plant discharge. Previous improvements at the plant during 1992-1993 were followed by scattered records of the greenfin darter in the watershed upstream of this point.

- Scores and observed values for Metric 8 (proportion of specialized insectivores) increased from 1.1 to 3.3 and 20.7% to 32.6%, respectively, largely as a consequence of a population explosion by the Tennessee shiner (*Notropis leuciodus*), with a record high catch of 107 individuals.

Other apparent improvements, not directly reflected in the IBI, are as follows:

- Metric 1 (no. of native species) posted its highest value ever – 22 species, including all expected species.

- The observed value for Metric 10 (catch per unit effort), at 20.3 fish per 300 sq. ft. of water surface, was the highest at this site since 1994 (following the closure of Fruit of the Loom's predecessor, Burlington Industries).

- Tennessee shiner appears to be regaining its dominance over its exotic, invasive congener, the yellowfin shiner (*Notropis lutipinnis*), which it outnumbered for the first time since 1997. In 2007, the yellowfin shiner was the single most abundant species here, accounting for 32.1% of the sample vs. 12.2% in 2008.

- The reestablishment of the mountain brook lamprey (*Ichthyomyzon greeleyi*), absent in 2007 may be due to reduced toxicity in the sediments where it lives most of its life.

Some of these biological improvements may also be due to apparent improvements in physical habitat:

- One of the two riffles at the site, which had nearly disappeared as of last year, has reestablished, providing more habitat for darters and sculpins.

- Much of the main channel has become deeper and swifter, with more exposed gravel in the substrate.

- Woody debris in midchannel has increased somewhat, providing additional habitat.

However when the site is compared with a site 0.7 mi. upstream (Little Tennessee River at GA highway 246 – Scaly Rd., discussed below) which received the identical IBI score, its defects become apparent in terms of channel stability, shade and riparian zone structure, riffle/pool sequences and availability of hard substrate.

If habitat differences incline us toward a more conservative stance in assigning a bioclass rating at this site as compared to the upstream site, the observed values for Metrics 2 (no. of darter species), 5 (no. of intolerant species) and 9 (no. of piscivore species) reinforce the decision. All are based on marginal numbers or sizes of individuals, as follows:

- For Metric 2 the total number of greenfin darters (3) represents a population which may not be established, and is certainly at risk. Loss of one darter species would reduce the score.

- Of 7 rock bass (*Ambloplites rupestris*) only 3 reached the minimum total length of 3 inches to be counted as intolerants in scoring Metric 5, and these individuals barely qualified. If these individuals were disallowed the score for this metric would drop.

- Of 10 individuals representing 4 piscivore species (rock bass; smallmouth bass, *Micropterus dolomieui*; largemouth bass, *Micropterus salmoides* and the exotic yellow perch, *Perca flavescens*) only the single yellow perch taken was of full adult size, so that it could be supposed to function primarily as a piscivore. An argument could be made for disallowing the presence of piscivores in the sample, which would reduce the score for Metric 9.

Reduction of the score for any one of these metrics would drop the IBI to 45.1, closer to the obligatory Fair range. Our argument for assigning the Fair bioclass rating here will become clearer if results for this site are compared to those at RM 137.6.

There exists a complex of water treatment and discharge issues surrounding this site, the GA 246 site and the future of the former Fruit of the Loom facility, to which we cannot do justice in this report. Suffice to say that these two sites will be extremely important in evaluating Little Tennessee Rivers trends for some years to come.

Table 13. IBI metrics and scores from fixed station 3: The Little Tennessee River at the North Carolina/Georgia state line (RM 136.9).

	2007		2008	
Metric	Value	Score	Value	Score
1. Number of native species	16	5.5	22	5.5
2. Number of darter species	1	3.3	3	5.5
4. Number of sucker species	4	5.5	4	5.5
5. Number of intolerant species	2	3.3	2	3.3
6. Percentage as tolerant species	5.3	5.5	3.9	5.5
7. Percentage as omnivores, herbivores	30.8	1.1	31.9	1.1
8. Percentage as specialized insectivores	20.7	1.1	32.6	3.3
9. Percentage as piscivores	2	5.5	4	5.5
10. Catch rate per unit of effort	16.6	5.5	20.3	5.5
11. Percentage as darters and sculpins	6.6	1.1	14.2	1.1
12. Percentage with disease, tumors, fin damage and/or other anomalies	1.2	5.5	0.7	5.5
Total		42.9 Fair		47.3 Fair

Table 14. Fish capture data from fixed station 3: The Little Tennessee River at the North Carolina/Georgia state line (RM 136.9).

	Number of individuals	
Species (common name)	2007	2008
Mountain brook lamprey		13
Rainbow trout	1	
Brown trout	2	
Central stoneroller	89	83
Whitetail shiner	6	3
Warpaint shiner	25	57
River chub	77	86
Golden shiner	3	3
Tennessee shiner	69	107
Yellowfin shiner	189	73
Warpaint x yellowfin shiner		1
Tennessee x yellowfin shiner	5	2
Mirror shiner	13	21
Fatlips minnow		1
Longnose dace		
Creek chub	13	12
White sucker	4	1
Northern hogsucker	30	37
Black redhorse	7	6
Golden redhorse	5	7
Brown bullhead		
Snail bullhead	2	1
Rock bass	7	7
Redbreast sunfish	6	6
Green sunfish	9	4
Redbreast x green sunfish		
Warmouth		
Bluegill		
Smallmouth bass		1
Largemouth bass		1
Tuckaseigee darter		7
Greenfin darter		3
Yellow perch	1	1
Gilt darter	12	7
Mottled sculpin	29	70
Total	604	622

Fixed Station 4: Peeks Creek at Jones property above Peeks Creek Rd. (RM 0.3)

Physical habitat improvement at this site, heavily damaged in the disastrous flood and mud slide of December, 2004, is scarcely evident between 2007 and 2008. There is some degree of natural reforestation by early successional trees and shrubs along the right bank, but the loose, gravelly nature of this bank impedes development of a significant riparian buffer. Any similar trend along the left bank would be largely inhibited by highway right-of-way maintenance (Peeks Creek Rd., SR 1678). Measurements were not made in the channel, but if there is any change since 2007 it is a negative one, in the form of a moderate degree of widening. Overall, lower Peeks Creek remains highly unstable.

Fish data are somewhat equivocal, although fish diversity is clearly increasing, with 3 new species recorded for 2008. (Sparse sampling in previous years at a site downstream of the present monitoring site yielded only 4 species – rainbow trout, *Oncorhynchus mykiss;* brown trout, *Salmo trutta,* longnose dace, *Rhinichthys cataractae* and mottled sculpin, *Cottus bairdii*.)

In addition to capturing 6 young creek chubs (*Semotilus atromaculatus*) from backwaters and 3 central stonerollers (*Campostoma anomala*) from the main channel, we also took one medium sized *Nocomis* chub. In most parts of the upper Little Tennessee watershed we would suppose this to be a river chub (*Nocomis micropogon*), but in recent years the exotic bluehead chub (*Nocomis leptocephalus*) has been documented in the Cullasaja River (to which Peeks Creek is tributary) just above Cullasaja Falls (1.4 upstream of the mouth of Peeks Creek) so there is a degree of doubt with non-breeding *Nocomis*. This individual resembled a river chub in terms of the tubercle scar pattern, circumferential scale count and breast scalation, but appeared to correspond more closely to bluehead chub in preopercular edge alineation and circumbody scale count, and may have been a hybrid. (Dissection to determine intestine length was not done.) In any event, it is the first *Nocomis* chub reported for Peeks Creek, bringing total species count for 2008 to 5.

However, results for the 2 most abundant fish species are confusing. Rainbow trout declined in abundance for the second year in a row, and size distribution was different, with more 3-6 inch specimens and only 3 individuals measuring more than 6 inches TL. There was also a slight decline in numbers of longnose dace.

Perhaps more surprising is the failure of the mottled sculpin to repopulate Peeks Creek. A single specimen was taken in 2006, and in 2007 one was observed just below the sample reach, but no evidence of this species was encountered in 2008.

Our macroinvertebrate sample for this site was taken more than a month after the fish sample (June 11 and July 18). However, no extreme weather or other events likely to affect the biotic condition of Peeks Creek occurred during this interval, so we assume the validity of including both sets of results in the same evaluation.

Since the rationale for monitoring Peeks Creek is to track natural recovery in the wake of the 2004 disaster, in Table 12 we have included both fish and macroinvertebrate results for all 4 years of sampling to date. However, we question the validity of the 2007 macroinvertebrate data. As noted in our 2007 report: "Our field notes refer to "apparent high diversity" and mention one Ephemerid

family (Baetidae) present in 2005 and 2006, but not reported in 2007 as well as *Pteronarcys* stoneflies and a notation "Odonata rare", although no Odonata were reported. *Pteronarcys*, at least, are unmistakable; we can only hypothesize that specimens were lost somewhere in the process."

While macroinvertebrate diversity did drop at various sites in North Carolina during the low flows of 2007 (personal communication, Dave Penrose) and thus we cannot discount the possibility of such an event in Peeks Creek, we note that flows have been equally low for most of 2008. If the 2007 data is disallowed, a more coherent interpretation of the remaining data is possible. Data from 2005 reflect survival of hardy forms and the early stages of recolonization. Doubling of the Ephemeroptera count and near doubling of the total EPT count between 2005 and 2006, and a more gradual increase in diversity between 2006 and 2008 conforms to what would be expected in a recovering stream, and roughly parallels the increase in fish diversity. Note that in the 2008 sample at least 12 taxa not recorded for any of the previous 3 samples are identified.

Observations on abundance of macroinvertebrates suggest that recovery is far from complete: "EPT abundance values, particularly within the stonefly and caddisfly populations, were much lower at Peeks Creek than at (2 other good quality streams sampled at the same time). Only one taxon within each of these two orders (Plecoptera and Trichoptera) was abundant using NCDWQ criteria. This may indicate that Peeks Creek following extremely high flows may not be incorporating organic material into interstitial habitats" (Penrose 2008).

A further suggestion of recovery is provided by crayfish counts (taken during the fish sample). Again quoting from our 2007 report: "In 2005 we took only one crayfish (*Cambarus bartoni*), last year (2006) we took 27, but all were medium to large size. The 22 *C. bartoni* which appeared in the 2007 fish sample represented a full spectrum of sizes, indicating successful reproduction on or near the site." The 2008 crayfish count was 38, with numerous large individuals.

Table 12 includes calculation of a modified Williams "brook trout" IBI – recognizing both the limitations of this index at low altitude (ca. 2000 ft. in this case) and the doubtfulness of its applicability under the particular conditions of Peeks Creek. In previous years we have not even attempted such an analysis, based on artificially low diversity of fish (and on our doubts about the macroinvertebrate data for 2007). Bearing all reservations in mind, a Bioclass Rating of Fair corrresponds to our perception of conditions in lower Peeks Creek at this time.

We also note high scores reflecting very high observed values for the 2 macroinvertebrate-based metrics in the IBI, whereas the 6 fish-based metrics present a more mixed result, in terms of both observed values and scores. Of a total of 31 EPT taxa collected, 19 are considered "indicator" taxa (intolerant or habitat specialists). All of this is in line with our observation that as compared to fish-based IBI, macroinvertebrate monitoring better reflects water quality, while fish respond more strongly to habitat alterations. Apart from continual flushes of sediment, there are no known significant sources of pollution to Peeks Creek at this time, whereas physical habitat is obviously still severely compromised from the events of December, 2004.

Table 15. Fish capture data from fixed station 4: Peeks Creek at Jones property above Peeks Creek Rd. (RM 0.3).

	Number of individuals		
Species (common name)	2006	2007	2008
Rainbow trout	87	66	44
Brown trout	4	0	
Longnose dace		8	5
Mottled sculpin	1	Present	
Central stoneroller			3
River chub*			1
Creek chub			6
Total	92	74	59

* Not positive I.d.; possible bluehead chub (Nocomis leptocephalus)

Table 16. Macroinvertebrate capture data from fixed station 4: Peeks Creek at Jones property (RM 0.3) (A=abundant, C=common, R=rare, P=present).

Macroinvertebrate Classification	2005	2006	2007	2008
Ephemeroptera				
Baetidae				
Acentrella turbida				A
Baetis intercalaris				C
Baetis pluto				A
Baetis tricaudatus	A	A		A
Baetis spp.				C
Plauditus sp.		A		
Baetiscidae				
Baetisca carolina				R
Ephemerellidae				
Drunella cornutella				C
Drunella lata			P	
Drunella sp.	R	A		
Ephemerella excrucians			P	
Ephemerella sp.	C	A		
Serratella seratoides				A
Seratella spiculosa				A
Timpanoga sp.		R		
Heptageniidae				
Epeorus dispar	C	A	P	C
E. rubidus/subpallidus		R	P	
Heptagenia marginalis				C
Maccaffertium (Stenonema) modestum		C		C
M. (S.) pudicum			P	
M. (S.) sp.		C		
Isonychiidae				
Isonychia sp.	C	C	P	C
Leptophlebiidae				
Paraleptophlebia spp.				R

Plecoptera				
Leuctridae				
Leuctra sp.	C	R		C
Peltoperlidae			P	
Tallaperla sp.		A		R
Perlidae				
Unid.		R		
Acroneuria abnormis	R	R		A
A. sp.	R			
Beloneuria sp.		R		
Eccoptur xanthenes		R		
Paragnetina immarginata		R		R
Perlesta placida				C
Perlesta sp.		C	P	
Perlodidae				
Isoperla holochlora				R
Isoperla sp.		A		
Malirekus hastatus	R	R		
Remenus bilobatus			P	
Pteronarcidae				
Pteronarcys (Allonarcys) sp.	R	C		R
Trichoptera				
Glossosomatidae				
Unid.	R			
Glossosoma nigrior			P	
Glossosoma sp.		C		C
Hydropsychidae				
Ceratopsyche sparna			P	
Ceratopsyche sp.		A		
Cheumatopsyche sp.	A			
Diplectrona modesta	C			C
Hydropsyche sp.			P	
Symphitopsyche morosa				C
Symphitopsyche sparna				A
Lepidostomatidae				
Lepidostoma sp.		R		R
Limnephilidae				
Hydatophylax sp.		R		
Philopotamidae				
Dolophilodes distinctus			P	
Dolophilodes sp.				C
Rhyacophilidae				
Rhyacophila carolina				R
Rhyacophila fuscula	R	A	P	C
Uenoidae				
Neophylax oligius				R
Neophylax mitchelli				R
Neophylax sp.		C		
Total Ephemeroptera taxa	5	10	6	14
Total EPT taxa	14	27	14	31

Table 17. Macroinvertebrate collection data and corresponding IBI values and score from fixed station 4: Peeks Creek at Jones property above Peeks Creek Rd. (RM 0.3).

	2008	
Metric	Value	Score
1.Total Ephemeroptera taxa	14	7.5
2.Total EPT taxa	31	7.5
3.Brook trout presence	Absent	1.5
4.Catch per unit effort	9.3	7.5
5.Percent with disease/anomaly	1.6	6.0
6.Percent tolerants	10.2	4.5
7.Percent wild trout	74.6	7.5
8.Percent omnivores/hervivores	12.7	4.5
Total		46.5
		Fair

Fixed Station 5: Rabbit Cr. above Rabbit Creek Rd (RM 0.8)

While the decline in IBI score for Rabbit Creek between 2007 and 2008 (36.0 to 33.3), resulting from a decline in the proportional abundance of specialized insectivores (Metric 8), is probably not significant, the 2008 results confirm that the Fair Bioclass Rating achieved in 2006 was either an anomaly or reflected temporary improvement resulting from 2 years of relatively high flows. The decline in condition of this stream from Fair to Poor which occurred between 2000 and 2001 appears to be permanent, and the establishment of an 85 acre tomato farm just 1.1 mi. upstream on the lower reaches of Cat Creek, the largest tributary of Rabbit Creek, does not augur well for this site. (See results of two samples on Cat Creek, below.)

The proportion of specialized insectivores (17.2%) was the lowest recorded for this site since 1990. Observed values for other metrics were within the general ranges reported during 2001-2007 (with the exception of 2006).

The low gradient, heavily sedimented Rabbit Creek provides ideal habitat for the invasive exotic yellowfin shiner (*Notropis lutipinnis*), which often hybridizes with native cyprinids, especially Tennessee shiner (*Notropis leuciodus*). While at most sites in 2008 we observed reduced numbers of yellowfin shiner, the Rabbit Creek population remains strong, and we observed a mixed spawning group of yellowfin and Tennessee shiners over a chub nest.

A macroinvertebrate sample conducted by personnel from the North Carolina Ecosystem Enhancement Program resulted in an EPT Biotic Index of 4.04 and a Bioclass Rating of Good, which would appear to overstate the quality of Rabbit Creek at this point. (See section below on Macroinvertebrate monitoring.)

Table 18. IBI metrics and scores from fixed station number 5: Rabbit Creek at Rabbit Creek rd. (formerly Holly Springs Rd.) (RM 0.8).

	2006		2007		2008	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	14	6.7	14	6.7	13	6.7
2. Number of darter species	0	1.3	0	1.3	0	1.3
5. Number of intolerant species	2	4.0	1	1.3	1	1.3
6. Percentage as tolerant species	3.3	6.7	2.9	6.7	7.0	6.7
7. Percentage as omnivores, herbivores	10.2	4.0	29.0	1.3	21.2	1.3
8. Percentage as specialized insectivores	28.9	4.0	21.4	4.0	17.2	1.3
10. Catch rate per unit of effort	23.8	6.7	49.0	6.7	25.6	6.7
11. Percentage as darters and sculpins	38.5	4.0	24.1	1.3	31.1	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.8	6.7	1.7	6.7	0.3	6.7
Total		44.1		36.0		33.3
		Fair		Poor		Poor

Table 19. Fish capture data from fixed station number 5: Rabbit Creek at Rabbit Creek Rd. (formerly Holly Springs Rd.) (RM 0.8).

	Number of individuals		
Species (common name)	2006	2007	2008
Central stoneroller	24	104	24
Smoky dace	1		
Whitetail shiner	15	6	6
Warpaint shiner	71	95	33
River chub	25	60	33
Tennessee shiner	13	38	19
Yellowfin shiner	20	94	49
Yellowfin x Tennessee shiner	5	1	2
Yellowfin x smoky dace			1
Warpaint x Tennessee shiner			
Telescope shiner	1		
Blacknose dace	6	19	2
Longnose dace		3	1
Creek chub	4	8	9
White sucker	2	1	5
Northern hogsucker	13	34	21
Golden redhorse	5	12	3
Brown bullhead			
Rock bass	7	15	19
Redbreast sunfish	6	9	9
Green sunfish			
Redbreast x green sunfish		1	
Warmouth			1
Bluegill		2	
Largemouth bass			
Mottled sculpin	143	159	107
Total	361	661	344

Fixed Station 6: Cullasaja River at Macon Middle School (RM 0.9)

While the importance of the Cullasaja River as the largest tributary of the upper Little Tennessee (watershed area 93.0 sq. mi.) argues strongly for the maintenance of a fixed monitoring station on the lower Cullasaja, the extremely unstable character of the lower 2 mi. of the Cullasaja have rendered it difficult to plan and execute comparable samples in consecutive years. Over the years 1990-2007 the location of riffles and workable pools has changed almost annually, and we have been compelled to move the site twice, so that the lowermost and uppermost point included in our samples for Fixed Station 6 are separated by almost a mile.

In 2007 we were able to complete a satisfactory pool sample only thanks to the cooperation of a TVA crew and the use of their boat shocker. This of course throws into doubt the comparability of data from samples made with and without the shocker boat.

In 2008 we found that, while there was no pool habitat in the lower Cullasaja which could be sampled using backpack electrofishers, access by the shocker boat would have been extremely difficult under prevailing low water conditions. We are already dependent on the cooperation of the TVA crew to carry out annual sampling on the extremely important "Head of Lake Emory" site on the Little Tennessee mainstem, and decided not to attempt to avail ourselves of this resource in 2008.

Fixed Station 6 thus remains inactive for the moment. We will again conduct wading surveys in 2009 to see if a suitable monitoring site on the lower Cullasaja can be found.

Table 20. IBI metrics and scores from fixed station number 6: Cullasaja River at Macon Middle School (RM 0.9).

	2006		2007	
Metric	Value	Score	Value	Score
1. Number of native species	19	5.5	21	5.5
2. Number of darter species	2	5.5	2	5.5
4. Number of sucker species	3	5.5	3	5.5
5. Number of intolerant species	3	5.5	2	3.3
6. Percentage as tolerant species	6.8	5.5	11.2	3.3
7. Percentage as omnivores, herbivores	33.9	1.1	13.3	5.5
8. Percentage as specialized insectivores	22.9	1.1	30.5	3.3
9. Percentage as piscivores	2	5.5	1	5.5
10. Catch rate per unit of effort	11.4	3.3	6.3	1.1
11. Percentage as darters and sculpins	15.6	1.1	13.3	1.1
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.8	5.5	6.3	1.1
Total		45.1		40.7
		Fair		Fair

Table 21. Fish capture data from fixed station number 6: Cullasaja River at Macon Middle School (RM 0.9).

	Number of individuals	
Species (common name)	2006	2007
Mountain brook lamprey		2
Brown trout		
Central stoneroller	82	18
Smoky dace		
Whitetail shiner	11	31
Comon carp		
Warpaint shiner	26	31
River chub	31	30
Golden shiner	1	
Tennessee shiner	18	27
Yellowfin shiner	1	
Silver shiner		
Mirror shiner	1	6
Telescope shiner	3	
Flatlips minnow	5	12
Blacknose dace		1
Creek chub		
White sucker		
Northern hogsucker	37	51
Goldon redhorse	17	15
Black redhorse	6	23
Snail bullhead	2	
Flat bullhead		
Rock bass	23	19
Redbreast sunfish	22	43
Green sunfish		
Warmouth	1	
Bluegill	2	3
Smallmouth bass	2	8
Largemouth bass	3	1
White crappie		1
Tuckaseigee darter	2	2
Greenfin darter		1
Yellow perch	4	10
Gilt darter	15	7
Olive darter		
Mottled sculpin	38	41
Total	353	383

Fixed Station 7: Cartoogechaye Creek at Macon County Rec Park (RM 1.0)

While IBI at this site still has not fallen to the low levels recorded during 2003-2005 (36.3, Bioclass Rating Poor), the optimism expressed in our 2007 report must be tempered by the reality that the IBI has now fallen for 3 consective years – from 47.3 in 2006, to 45.3 and now 40.7. The last drop, at least, must be considered significant.

Observed values for most metrics, if not always the metric scores, reflect decline. The two most notable metrics in this regard are:

Metric 10 (catch per unit effort) dropped dramatically between 2007 and 2008. While total fish abundance here still does not approach the low levels observed during 2003-2005 (observed values of 4.0-5.3 fish per square foot of water surface), we did note large expanses of essentially barren water, particularly in shallow riffles and along sedimented shorelines.

Metric 12 (incidence of disease and parasites) did return to earlier levels. Until 2006, lower Cartoogechaye Creek was notable for extremely high incidence of parasitization of fish, particularly by what appeared to be a form of blackspot marked by large, irregularly shaped, swollen cysts. This condition disappeared in 2006 and overall levels of disease and parasitization dropped to more moderate levels. In 2008 the incidence level of diseases and parasites rose to 12.0% and the unusual form of blackspot (?) returned, affecting principally river chubs (*Nocomis micropogon*) and Tennessee shiners (*Notropis lutipinnis*).

While the score for Metric 6 (proportion of tolerant species), remains high, there is a noticeable negative trend in observed values, from 0.7% in 2006, to 4.8 and now 7.7%. The two species which contribute to this trend (redbreast sunfish, *Lepomis auritus* and creek chub, *Semotilus atromaculatus*) both occurred in record numbers in 2008 – which marked the first occasion on which we have taken more than 1 creek chub from this site.

One other ongoing shift in the composition of the fish assemblage in lower Cartoogechaye Creek merits continuing mention. Not only have observed values for our metric aimed specifically at evaluating riffle habitat (Metric 11, proportion of darters and sculpins) declined over the years (mean of 55.1% during the first years of monitoring - 1990-2006, to a mean 34.6% over the past 4 years, including 27.3% in 2008), but the relative proportions of darters and sculpins in the riffles has changed.

Our observations suggest that in the healthiest reaches of our larger tributaries darters (all species combined) compare favorably in abundance with the mottled sculpin (*Cottus bairdii*); in a few cases darters are even found to be more numerous than the ubiquitous sculpin. At the Rec Park site the ratio of sculpins to darters ranged between 1.3 and 4.3:1 during all but one of 14 years prior to 2005, while during the past 4 years this ratio has been 6.9, 7.5, 5.9 and 7.6:1, respectively. This suggests degradation of riffle habitat quality, possibly through accumulation of fine sediments.

We could indulge in further speculation about observed trends in lower Cartoogechaye Creek in relation to habitat alteration, toxic pollution and organic enrichment but, given the lack of supporting data, for now we will limit ourselves to repeating the observation from our 2007 report

that lower Cartoogechaye Creek, as a large urban stream, is subject to multiple and varying stresses. Teasing out these factors and proposing remedies for at least some of them is a challenge for the future.

Table 22. IBI metrics and scores from fixed station number 7: Cartoogechaye Creek at Macon County Recreation Park (RM 1.0).

	2006		2007		2008	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	19	5.5	20	5.5	17	5.5
2. Number of darter species	4	5.5	3	5.5	3	5.5
4. Number of sucker species	1	3.3	4	5.5	2	5.5
5. Number of intolerant species	2	3.3	2	3.3	2	3.3
6. Percentage as tolerant species	0.7	5.5	4.8	5.5	7.7	5.5
7. Percentage as omnivores, herbivores	24.9	3.3	33.9	1.1	33.0	1.1
8. Percentage as specialized insectivores	33	3.3	18.5	1.1	24.1	1.1
9. Percentage as piscivores	2	5.5	3	5.5	3	5.5
10. Catch rate per unit of effort	12.9	3.3	16.1	5.5	11.3	3.3
11. Percentage as darters and sculpins	35.8	3.3	39.7	3.3	27.3	3.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	1.1	5.5	3.6	3.3	12.0	1.1
Total		47.3 Fair		45.1 Fair		40.7 Fair

Table 23. Fish capture data from fixed station number 7: Cartoogechaye Creek at Macon County Recreation Park (RM 1.0).

	Number of individuals		
Species (common name)	2006	2007	2008
Mountain brook lamprey	3	8	6
Rainbow trout	3*	2	
Brown trout	4	2	3
Brook trout	2*	4*	
Central stoneroller	70	159	82
Smoky dace			
Whitetail shiner	1	3	18
Common carp			
Warpaint shiner	33	26	22
River chub	67	84	50
Tennessee shiner	122	67	49
Yellowfin shiner	12	23	8
Yellowfin x warpaint shiner	1		
Yellowfin x Tennessee shiner	1		
Mirror shiner	1	6	1
Fatlips minnow	6	3	2
Blacknose dace			
Creek chub	1	1	6
White sucker		5	
Northern hogsucker	26	16	26
Black redhorse		1	4
Golden redhorse		1	
unidentified redhorse			2
Brown bullhead		1	
Snail bullhead			2
Rock bass	12	14	11
Redbreast sunfish	2	28	26
Green sunfish	1	1	
Warmouth			
Bluegill	1		
Smallmouth bass	1	2	1
Largemouth bass			
Black crappie			
Tuckaseigee darter	1	3	1
Greenfin darter	10	16	10
Yellow perch			
Gilt darter	12	16	3
Olive darter	1		
Mottled sculpin	179	266	106
Total	568	754	440

* Stockers, not included in scoring

Fixed Station 8: Middle Creek at West Middle Creek Rd. (RM 2.2)

The 2008 data from this site support at least one of our conclusions from 2007, "that it is entering upon the up and down oscillation pattern characteristic of streams in decline". Beginning in 2003, when it first dropped out of the Good category it had occupied since 1992, Middle Creek has posted the following IBI scores – 44.1, 49.5, 38.7, 49.5, 41.4, and this year 46.8, oscillating between Good and Fair. While the 2008 score of 46.8 could be qualified as Good, we have opted for Fair, based on doubts about Metric 5 (no. of intolerant species).

The intolerant telescope shiner (*Notropis telescopus*) has been taken in Middle Creek during only 2 of 17 previous samples, most recently in 1999. Since this species appears to undertake occasional group migrations for reasons we have been unable to relate to any behavioral need or ecological stimulus, the occurrence of 6 telescope shiners in the sample may have little indicator value. Disallowing telescope shiner as an intolerant would lower the score for this metric, lowering the IBI to 44.1, with an obligatory Bioclass Rating of Fair.

For the second year in a row, Middle Creek recorded unprecedented numbers of the herbivorous central stoneroller (*Campostoma anomala*), with 127 individuals in 2007 and 134 in 2008, against a previous high of 40, in 1994. This directly affects scoring for Metric 7 (proportion of omnivores and herbivores), and appears to also indirectly affect Metric 11 (proportion of darters and sculpins) as stonerollers compete for benthic habitat with darters and sculpins.

Interestingly, all 5 species of column-dwelling shiners broke or equalled their 17 year abundance record in 2008, including the invasive exotic yellowfin shiner (*Notropis lutipinnis*), which was taken in reduced numbers at most sites this year.

Our conclusion from 2007 bears repeating: "Whereas historically (and primarily well in advance of the initiation of the Biomonitoring Program) the main concern in Middle Creek has been sedimentation, recent trends suggest an increase in nutrient loading, which would be consistent with increasing development in the watershed upstream of the fixed station. The proportion of tolerant species in the sample (Metric 6) remains extremely low, suggesting that toxic pollutants are not a concern."

Table 24. IBI metrics and scores from fixed station number 8: Middle Creek at West Middle Creek Rd. (RM 2.2).

Metric	2006 Value	2006 Score	2007 Value	2007 Score	2008 Value	2008 Score
1. Number of native species	13	6.7	11	6.7	15	6.7
2. Number of darter species	2	4.0	1	4.0	2	4.0
5. Number of intolerant species	2	4.0	1	1.3	3	6.7
6. Percentage as tolerant species	0.8	6.7	0.0	6.7	0.2	6.7
7. Percentage as omnivores, herbivores	8.9	6.7	22.1	1.3	21.6	1.3
8. Percentage as specialized insectivores	11.6	1.3	10.0	1.3	20.9	4.0
10. Catch rate per unit of effort	22.6	6.7	47.8	6.7	52.5	6.7
11. Percentage as darters and sculpins	73.6	6.7	63.3	4.0	53.0	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.2	6.7	0.1	6.7	0.7	6.7
Total		49.5 Good		41.4 Fair		46.8 Fair

Table 25. IBI metrics and scores from fixed station number 8: Middle Creek at West Middle Creek Rd. (RM 2.2).

	Number of individuals		
Species (common name)	2006	2007	2008
Rainbow trout	23	43	4
Brown trout	7	9	1
Central stoneroller	17	127	134
Smoky dace	9	16	21
Warpaint shiner	3	24	41
River chub	29	109	83
Tennessee shiner	33	27	134
Yellowfin shiner	6	11	40
Yellowfin shiner x smoky dace	1		1
Yellowfin x warpaint shiner			1
Yellowfin x Tennessee shiner	1	1	
Mirror shiner			5
Telescope shiner			6
Fatlips minnow	3	10	5
Blacknose dace	6	2	1
Longnose dace	20	10	5
Creek chub	4		2
White sucker			
Northern hogsucker	4	3	4
Rock bass		2	
Redbreast sunfish	1		
Green sunfish			
Tuckaseigee darter	1		
Greenfin darter			1
Gilt darter	4	21	5
Mottled sculpin	430	660	534
Total	602	1075	1018

Fixed Station 9: Cullasaja River at Peaceful Cove (RM 8.3)

In 2008, a second consecutive drought year in western Norrth Carolina, IBI in the Middle Cullasaja rebounded to 49.5, for a Bioclass Rating of Good (its rating for 14 of 17 monitoring years), as two important aspects of the fish assemblage returned to normal:

- Catch per unit effort (Metric 10), with a range of 8.6-29.5 fish per 300 sq. ft. of water surface during 1991-2006, ballooned to 33.2 in 2007, then dropped back to a "normal" 14.8 in 2008.

- Similarly, the number of the herbivorous central stoneroller (*Campostoma anomala*) in the sample, which had a range of 14-132 during 1991-2006, was 289, more than double the previous maximum, in 2007, but fell back to 90 in 2008. This was the principal factor in improving the score for Metric 7 (proportion of omnivores and herbivores) in 2008. (It should be noted that this is in some respects an atypical result, as most of our monitoring sites recorded higher than normal numbers of stonerollers in both 2007 and 2008.)

Our hypothesis has been that fish-based IBI reflects not only local perturbations, but global climate change, and is supported by:

1. The combination of lack of vigorous flushing during high flow periods (typically resulting in mortality or displacement of many small fish) results in exaggerated total fish numbers.

2. Prolonged periods of low water enhance insolation to the stream bottom, with the result of enhanced periphyton production, favoring the herbivorous stoneroller.

Although overall, 2008 was as dry as 2007, there were more high flows in the spring. Perhaps this had more effect on a stream as large as the Cullasaja than on the smaller streams we typically monitor.

One perceived and continuing negative trend on the middle Cullasaja is increased accumulation of fine sediments in riffle areas, with the apparent result of lower observed values and scores for Metric 11 (proportion of darters and sculpins). During the period 1991-2000, this metric received the high score (5.5) on 8 of 9 occasions, whereas since 2001 it has received the high score on only 1 of 8 occasions (2005, following an extreme high flow event).

If we assume that darters are more sensitive to sedimentation than sculpins and examine the proportion of the darter group alone, the trend is even more alarming. The proportion of darters (all species) in our samples was 24.2% (annual range 16-29%) during 1991-1997 and 12.7% since then, with a record low of 9.0% in 2007. This would indicate that sediment deposition reached problematic levels several years before the onset of atypically low spring flows.

Embedded in the darter data is the decline in the middle Cullasaja of what was once the strongest upper Little Tennessee watershed population of the intolerant, regional endemic wounded darter (*Etheostoma vulnerata*). The mean number of individuals of this species in our samples was 20.0

(range 12-25) during 1991-1997, but declined abruptly after 1997 to a mean of 6.3 individuals, with a range of 1-10, during 1998-2006. It was missing from the 2007 sample and represented by a single individual in 2008.

Another worrisome observation from the 2008 sample is the high disease rate (6.8%), mostly resulting from blackspot on river chubs (*Nocomis micropogon*) and Tennessee shiners (*Notropis leuciodus*). Even higher rates of disease and parasitization were recorded during 1997-2002, but have tapered off since then.

A possible future concern is the potential appearance in the middle Cullasaja of the exotic bluehead chub (*Nocomis leptocephalus*) introduced on the Highlands Plateau. In 2007 we captured breeding adults of this species not far above Cullasaja Falls, 1.4 mi. above the Peaceful Cove site. Careful examination of all adult *Nocomis* from the sample did not suggest the presence of bluehead chub. (However, see discussion of Peeks Creek, above.)

Two positive results from the 2008 sample are:

- Capture of a large olive darter (*Percina squamata*) in breeding color. This is only our fourth record of this rare Special Concern species from this site in 17 years of sampling, and the first breeding adult we have seen.

- Two large hellbenders (*Cryptobranchus allegheniensis*) captured during the fish sample represent the first records for this Special Concern salamander from the middle Cullasaja.

Depending on the weather over the next few years, continued monitoring of the middle Cullasaja may offer the opportunity to support or weaken our case for the ability of fish-based IBI to reflect anthropogenic effects on climate.

Table 26. IBI metrics and scores from fixed station number 9: Cullasaja River at Peaceful Cove (RM 8.3).

	2006		2007		2008	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	17	5.5	18	5.5	18	5.5
2. Number of darter species	4	5.5	4	5.5	5	5.5
4. Number of sucker species	2	5.5	3	5.5	3	5.5
5. Number of intolerant species	3	5.5	2	3.3	3	5.5
6. Percentage as tolerant species	1.4	5.5	0.5	5.5	0.7	5.5
7. Percentage as omnivores, herbivores	29.1	3.3	32.0	1.1	23.4	3.3
8. Percentage as specialized insectivores	26.7	3.3	24.3	1.1	28.8	3.3
9. Percentage as piscivores	2	5.5	2	5.5	3	5.5
10. Catch rate per unit of effort	19.1	5.5	37.2	5.5	14.8	5.5
11. Percentage as darters and sculpins	48.0	3.3	47.0	3.3	53.9	3.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	1.5	5.5	4.2	3.3	6.8	1.1
Total		53.9		45.1		49.5
		Good		Fair		Good

Table 27. Fish capture data from fixed station number 9: Cullasaja River at Peaceful Cove (RM 8.3).

	Number of individuals		
Species (common name)	2006	2007	2008
Mountain brook lamprey	9	14	4
Rainbow trout	3	1	1
Rainbow trout		1*	3
Brown trout	5	1	
Brown trout		3*	
Brook trout		1*	
Central stoneroller	127	289	90
Whitetail shiner	6	24	11
Warpaint shiner	35	60	23
Bluehead chub			
River chub	35	95	41
Golden shiner			
Tennessee shiner	43	66	44
Mirror shiner	3	31	10
Fatlips minnow	3	7	
Longnose dace			
Creek chub			
Northern hogsucker	12	20	6
Black redhorse		5	8
Golden redhorse	2	8	2
Unid. Redhorse		1	
Rock bass	9	21	14
Redbreast sunfish	8	6	4
Green sunfish			
Warmouth			
Bluegill			
Redbreast sunfish x warmouth			
Smallmouth bass	5	2	3
Tuckaseigee darter	7	14	5
Greenfin darter	52	54	58
Wounded darter	5		1
Banded darter			
Yellow perch			2
Gilt darter	3	41	13
Olive darter		1	1
Mottled sculpin	215	467	233
Total	587	1215	557

*Stockers, not included in scoring.

Fixed Station 10: Wayah Creek at Crawford Rd. (RM 0.6)

Recent trends at this site are puzzling. On one hand the IBI, which has mostly hovered on the margin between the Fair and Good Bioclass Ratings since an upstream package waste water treatment plant went offline in 2001, has been in the low portion of the Fair range during 3 of the last 4 years. On the other, species diversity continues to grow, presumably as a result of repopulation by native species.

Positive trends include:

- Record numbers of the following reestablishing species: mountain brook lamprey (*Ichthyomyzon greeleyi*), warpaint shiner (*Luxilus coccogenis*), Tennessee shiner (*Notropis leuciodus*), greenfin darter (*Etheostoma chlorobranchium*) and the intolerant rock bass (*Ambloplites rupestris*). The two shiner species had reappeared in 2007 after a long absence from the site.

- The undescribed, intolerant, watershed endemic smoky dace (*Clinostomus* sp.) has always been present at this site, but recorded consecutive record numbers, with full distribution of sizes, in 2007 and 2008.

- The first appearance of the Tuckaseigee darter (*Etheostoma blennioides gutselli*), represented by 6 individuals of all sizes, since 2003.

- The number of small individuals of mountain brook lamprey and greenfin darter suggests reestablishment of these species.

- The second year in a row in which the fatlips minnow (*Phenacobius crassilabrum*), has appeared. It was first recorded from Wayah Creek in 2007 (2 individuals) and was represented by 5 individuals in 2008.

- Column-dwelling shiners comprised 5.0% of the sample in 2007 and 6.7% in 2008, but 0.0-3.3% in 13 previous samples.

- The proportion of specialized insectivores in 2008, while still meriting only the low score for Metric 8, was the highest ever recorded here (14.8%).

- 2008 marked the first time we have recorded whitetail shiner (*Cyprinella galactura*), represented by a single individual, here.

Were the intolerant gilt darter (*Percina evides*), common just 0.6 mi. downstream in Cartoogechaye Creek, to establish in Wayah Creek, this would raise the score for Metrics 2 (no. of darter species) and 5 (no. of intolerant species), probably bringing the IBI close to the Good range.

On the other hand, it must be noted that both the herbivorous central stoneroller (*Campostoma anomala*) and the tolerant, omnivorous creek chub (*Semotilus atromaculatus*) recorded consecutive record numbers here in 2007 and 2008, contributing to a low score for Metric 7 (proportion of

omnivores and herbivores). In the case of the stoneroller, Wayah Creek merely forms part of a watershed-wide trend which we believe is related to enhanced periphyton production as a consequence of low water during spring and early summer. (See Results and Discussion section, above.)

The creek chub data is more troubling. Creek chubs are a normal part of the fauna of lower Wayah Creek, and since 2002 we have counted on taking one to a few small individuals in backwater areas around the outlet of a small riparian wetland. However, in the last 3 years adult individuals have appeared with increasing frequency in a large pool at the upstream of the sample reach, where they appear to compete for food and habitat with rock bass and trout.

A further possibly negative indicator is the absence, for the first time, of rainbow trout (*Oncorhynchus mykiss*) from the sample here. This, and the smaller average size of both this species and brown trout (*Salmo trutta*), may be related to the appearance of stocked trout in lower Wayah Creek for the first time in the past 2-3 years.

We also carried out a benthic macroinvertebrate sample at this site on July 18 (fish sample done July 29). Results are shown in Table 17, and lead to a bioclassification of Excellent with 23 "indicator" (intolerant or habitat specialist) taxa. This result is radically different from the fish IBI. The discrepancy can be most plausibly explained in terms of relative recolonization time for macroinvertebrates and fish. Perhaps the benthic macroinvertebrate fauna in lower Wayah Creek have recovered to pre-pollution levels, while the fish assemblage is still in the process of recovery. Several more years of monitoring may be required to determine if this is the case.

Table 28. IBI metrics and scores from fixed station number 10: Wayah Creek at Crawford Rd. (RM 0.6).

	2006		2007		2008	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	13	6.7	15	6.7	18	6.7
2. Number of darter species	1	4.0	2	4.0	2	4.0
5. Number of intolerant species	2	4.0	2	4.0	2	4.0
6. Percentage as tolerant species	1.4	6.7	1.3	6.7	1.2	6.7
7. Percentage as omnivores, herbivores	9.2	6.7	24.0	1.3	22.9	1.3
8. Percentage as specialized insectivores	5.6	1.3	11.8	1.3	14.8	1.3
10. Catch rate per unit of effort	16.9	4.0	18.4	1.3	23.8	6.7
11. Percentage as darters and sculpins	77.3	6.	62.0	4.0	63.9	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.8	6.7	2.3	4.0	0.8	6.7
Total		46.8 Fair		38.7 Fair		41.4 Fair

Table 29. Fish capture data from fixed station number 10: Wayah Creek at Crawford Rd. (RM 0.6).

	Number of individuals		
Species (common name)	2006	2007	2008
Mountain brook lamprey	9	2	16
Rainbow trout	32	4	
Brown trout	30	9	6
Brook trout		1*	
Central stoneroller	13	67	111
Smoky dace	23	38	39
Whitetail shiner			1
Warpaint shiner		6	21
River chub	9	54	41
Tennessee shiner		22	37
Mirror shiner		17	14
Fatlips minnow		2	5
Blacknose dace	36	83	68
Longnose dace	20	17	9
Creek chub	11	12	13
Northern hogsucker	1	7	5
Black redhorse			
Golden redhorse	3		
Rock bass	5	5	6
Redbreast sunfish			
Green sunfish	1		
Bluegill			1
Tuckaseigee darter			6
Greenfin darter	5	5	29
Mottled sculpin	652	558	660
Total	850	908	1088

* Stocker, not counted in scoring.

Table 30. Macroinvertebrate collection data from fixed station number 10: Wayah Creek at Crawford Rd. (RM 0.6).

Taxa	2008 Classification
Ephemeroptera	
Baetidae	
Acentrella turbida	C
Baetis intercalaris	R
Baetis pluto	R
Baetiscidae	
Baetisca carolina	C
Caenidae	
Brachycercus spp.	R
Ephemerellidae	
Drunella cornutella	C
Serratella deficiens	A
Serratella serratoides	C
Ephemeridae	
Ephemera spp.	R
Heptageniidae	
Epeorus dispar	A
Leucocreuta spp.	R
Stenacron pallidum	R
Stenonema modestum	A
Stenonema pudicum	R
Rithrogena spp	R
Leptophlebiidae	
Paraleptophlebia spp.	C
Oligoneuridae	
Isonychia spp.	C
Plecoptera	
Leuctridae	
Leuctra spp.	A
Peltoperlidae	
Tallaperla spp.	C
Perlidae	
Acroneuria abnormis	C
Paragnetina inmarginata	C
Perlesta placida	A
Pteronarcyiidae	
Pteronarcys spp.	C
Trichoptera	
Brachycentridae	
Brachycentrus spinae	A
Glossosomatidae	
Glossosoma spp.	C
Goeridae	
Goera spp.	R
Hydropsychidae	

Diplectrona modesta	R
Cheumatopsyche spp.	C
Symphitopsyche bronta	C
Symphitopsyche sparna	C
Hydroptilidae	
Hydroptila spp.	R
Lepidostomatidae	
Lepidostoma spp.	C
Leptoceridae	
Oecetis spp.	R
Setodes spp.	R
Limnephilidae	
Pycnopsyche guttifer	A
Philopotamidae	
Dolophilodes spp.	A
Polycentropidae	
Polycentropus spp.	R
Psychomyidae	
Lype diversa	R
Rhyacophilidae	
Rhyacophila fuscula	R
Ueonidae	
Neophylax oligius	A
Total by order	
Ephemeroptera	17
Plecoptera	6
Trichoptera	17
Total EPT taxa	40

Fixed Station 11: Skeenah Creek at North Carolina Welcome Center (RM 0.5)

The data for the past 3 years reflect a gradual recovery of this site from the Poor Bioclass Rating it has received since 2001 to the Fair Scores it previously registered. However, it is difficult to detect a consistent trend for any one of the 8 metrics used. If improvement is occurring, it would be in response to gradual stabilization of sediment flow originating at a school construction site 2,114 feet upstream. However, it is difficult to visually detect any improvement in the heavily sedimented substrate.

The only visibly perceptible change in the physical condition of Skeenah Creek at this point is continual loss of habitat along the right shoreline, as a consequence of clearing by a landowner which has deprived this bank of shade and opened it up to erosion. This may be reflected in the replacement along this bank, since 2006, of the tolerant redbreast sunfish (*Lepomis auritus*), which requires shoreline structure as habitat, by the equally tolerant, omnivorous creek chub (*Semotilus atromaculatus*) which is less dependent on physical habitat.

Table 31. IBI metrics and scores from fixed station number 11: Skeenah Creek at North Carolina Welcome Center (RM 0.5).

	2006		2007		2008	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	10	4.5	14	7.5	12	7.5
5. Number of intolerant species	1	1.5	1	1.5	0*	1.5
6. Percentage as tolerant species	6.3	7.5	7.9	7.5	6.5	7.5
7. Percentage as omnivores, herbivores	21.6	1.5	25.0	1.5	25.7	1.5
8. Percentage as specialized insectivores	16.5	1.5	24.1	4.5	18.4	1.5
10. Catch rate per unit of effort	16.8	4.5	32.6	7.5	23.6	7.5
11. Percentage as darters and sculpins	38.4	4.5	26.4	1.5	37.9	4.5
12. Percentage with disease, tumors, fin damage and/or other anomalies	1.6	7.5	2.8	4.5	1.8	7.5
Total		33.0 Poor		36.0 Poor		39.0 Fair

* All rock bass less than 3 inches TL.

Table 32. Fish capture data from fixed station number 11: Skeenah Creek at North Carolina Welcome Center (RM 0.5).

	Number of individuals		
Species (common name)	2006	2007	2008
Mountain brook lamprey	25	1	23
Rainbow trout			
Brown trout	1		
Brook trout			
Central stoneroller	7	42	38
Smoky dace		1	
Whitetail shiner			
Warpaint shiner	30	75	41
River chub	21	37	18
Tennessee shiner	12	27	29
Yellowfin shiner	24	83	44
Yellowfin x Tennessee shiner	1		
Yellowfin x warpaint shiner			1
Fatlips minnow			
Creek chub	2	26	19
White sucker		2	1
Northern hogsucker	12	8	12
Black redhorse			
Golden redhorse		2	
Brown bullhead			
Rock bass	7	7	7
Redbreast sunfish	14	6	4
Green sunfish			1
Warmouth			
Bluegill	1		
Smallmouth bass		1	
Tuckaseigee darter		1	
Greenfin darter			1
Gilt darter			
Mottled sculpin	98	113	145
Total	255	432	385

Brush Creek (Swain County) at Hampton Farm (RM 0.5)

Although the observed value for catch per unit effort (Metric 10) was much lower in 2008 than in 4 previous years, the IBI remains unchanged and individual metric scores are virtually identical in all important respects. While a score of 46.8 is closer to the obligatory Good range than to Fair, a Bioclass Rating of Fair is assigned. This is consistent with the rating the last time this site was sampled (2006), but also reflects ambiguity about Metric 5 (no. intolerant species). The observed value for this metric is 3 (required for the high score of 6.7) only if a single adult rock bass (*Ambloplites rupestris*), taken by targeting rock bass habitat after completion of the formal sample, is included.

IBI at this site has been 46.8 each time it has been monitored, with the exception of 2005, when it scored 44.1. In 1990, 1998 and 2000 it was assessed as Good, but this was dropped to fair in the light of 2 observations:

- Doubts about the status of intolerant species: Smoky dace (*Clinostomus* sp.), present in each of the first 4 samples, disappeared after 2005. Of the other 3 intolerant species known from lower Brush Creek, only one (gilt darter, *Percina evides*) is consistently present. Rock bass and telescope shiner (*Notropis telescopus*) have each been reported from 4 of a total 6 samples, the former usually in very small numbers and the latter as what appear to be migratory groups.

- Decline, after 2005 of the proportion of darters and sculpins (Metric 11) in the sample: Although this proportion rebounded substantially between 2006 and 2008 this is at least partly in response to lower numbers of most other species, and still merits the low score (1.3).

The disappearance of smoky dace here is of particular concern, especially so since Brush Creek is generally considered to be one of the most important tributaries to the Needmore Game Lands reach of the Little Tennessee, and is key to the maintenance of normal annual migratory patterns by the Threatened spotfin chub (*Erimonax monachus*, not expected in summer samples) and other cyprinids in the larger watershed.

Table 33. IBI metrics and scores from Brush Creek at Hampton farm (RM 0.5).

Metric	2006 Value	2006 Score	2008 Value	2008 Score
1. Number of native species	16	6.7	12	6.7
2. Number of darter species	2	4.0	2	4.0
5. Number of intolerant species	3	6.7	3	6.7
6. Percentage as tolerant species	0.7	6.7	0.0	6.7
7. Percentage as omnivores, herbivores	23.8	1.3	22.8	1.3
8. Percentage as specialized insectivores	52.6	6.7	53.9	6.7
10. Catch rate per unit of effort	54.6	6.7	20.7	6.7
11. Percentage as darters and sculpins	12.7	1.3	23.9	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.2	6.7	0.3	6.7
Total		46.8 Fair		46.8 Fair

Table 34. Fish capture data from Brush Creek at Hampton farm (RM 0.5).

Species (common name)	Number of individuals 2006	2008
Rainbow trout	2	3
Central stoneroller	54	54
Smoky dace		
Whitetail shiner	2	
Warpaint shiner	241	87
River chub	84	27
Tennessee shiner	28	67
Mirror shiner	4	
Telescope shiner	32	17
Fatlips minnow		1
Blacknose dace	1	2
Creek chub	5	
Northern hogsucker	54	19
Golden redhorse	14	
Shorthead redhorse	1	
Rock bass	6	P*
Green sunfish		
Smallmouth bass	1	
Greenfin darter	5	5
Gilt darter	7	19
Mottled sculpin	65	63
Total	606	364

* All rock bass less than 3 inches TL.

Burningtown Creek below Lower Burningtown Rd. (RM 0.6)

This site presents the opportunity to compare results of 3 different IBI monitoring methodologies on lower Burningtown Creek. The site was monitored in 2004 by a North Carolina DWQ crew, in 2006 by the LTWA crew and in 2008 by a crew from TVA. (LTWA staff assisted with both the NCDWQ and TVA samples.)

The NCDWQ selected a slightly different (and in our opinion atypical) monitoring site which was, however, contiguous to the LTWA/TVA site, with its lower extreme just upstream of a bridge on Lower Burningtown Road (SR 1364) whereas the LTWA/TVA site has its upper limit just below the bridge.

As compared to the LTWA/TVA site the NCDWQ site:

- Closely parallels the road over its entire length (where it is unbuffered), whereas the LTWA/TVA site is located at some distance from the road and has some degree of buffering over most of its length on both banks.

- Has near zero sinuosity (suggesting past channelization when the road was constructed) while the LTWA/TVA site has natural sinuosity.

- Has weak and heavily sedimented riffles, whereas the the LTWA/TVA site has a variety of riffles, some of them deep, powerful and relatively sediment-free.

These differences notwithstanding, all 3 samples resulted in a Bioclass Rating of Good, although the scores resulting from the application of LTWA metrics to the NCDWQ sample in 2004 and the TVA sample in 2008 appear more credible than the score achieved by our own crew in 2006. In examining these results it may be useful to discuss what appear to be the respective biases of the 3 sampling methodologies:

- The NCDWQ methodology, which does not employ seines set across the stream, appears to bias in favor of shoreline species; it produced the highest numbers of river chub (*Nocomis micropogon*), rock bass (*Ambloplites rupestris*) and sunfishes (*Lepomis* spp.).

- The LTWA methodology uses a seine set across the stream and multiple dipnetters following the electrofisher, resulting in high catches of benthic species. Note that the LTWA crew recorded 2.6-2.8 times the number of mottled sculpin (*Cottus bairdii*) as the other crews.

- The TVA methodology uses seines but proceeds much more rapidly, thus covering more water in the same amount of time, and does not depend heavily on expert dipnetting. It appears to bias toward column dwelling cyprinids, and produced the highest catches of all shiner species across the 3 samples.

Of course there is no way of knowing to what degree these results reflect sampling bias as compared to the actual abundance of the various species in different years. To cite one example, it is

highly probable that the increased abundance of the benthic central stoneroller (*Campostoma anomala*) in the 2008 sample reflects the real condition of the fish assemblage, since similar increases in stoneroller abundance were recorded for many of our monitoring sites in 2008 (see "Results and Discussion" section above for a discussion of this phenomenon).

If we examine the individual metrics, the only one which shows a clear trend over the 3 samples spanning 5 years is Metric 12 (proportion of fish with disease or anomaly) which recorded its highest observed value ever (5.3%) for lower Burningtown Creek in 2008. This was entirely due to high incidence of blackspot on rock bass and Tennessee shiners (*Notropis leuciodus*), and suggests increased organic content. This would be consistent with both growing human population in the upper Burningtown Creek watershed and the effects of 2 years of more or less consistently low water levels.

Of perhaps greater concern is what appears to be the continuing tendency of LTWA methods to overrate streams in the 15-40 sq. mi. watershed size bracket. While lower Burningtown Creek may very well merit a Bioclass Rating of Good, the 2006 IBI of 54.9 is scarcely credible. However, we also note that for no single metric do the other two methodologies applied at this site produce consistently lower scores. This topic will be further discussed below for Cowee Creek at Wests Mill, the only other 2008 monitoring site in this size category.

However, it should be noted that a macroinvertebrate sample carried out on Burningtown Creek near this site by a team from the North Carolina Ecosystem Enhancement Program resulted in an EPT Biotic Index of 2.05 and a Bioclass rating of Excellent. See further discussion in the section on Macroinvertebrate Monitoring, below.

Table 35. IBI metrics and scores from Brush Creek at Hampton farm (RM 0.5).

	2006		2008	
Metric	Value	Score	Value	Score
1. Number of native species	18	6.7	20	6.7
2. Number of darter species	3	6.7	3	6.7
5. Number of intolerant species	3	6.7	4	6.7
6. Percentage as tolerant species	0.2	6.7	0.04	6.7
7. Percentage as omnivores, herbivores	12.6	6.7	19.3	6.7
8. Percentage as specialized insectivores	43.9	4.0	62.3	6.7
10. Catch rate per unit of effort	21.6	6.7	24.0	6.7
11. Percentage as darters and sculpins	44.8	4.0	22.6	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.4	6.7	5.3	1.3
Total		54.9		49.5
		Good		Good

Table 36. Fish capture data from Brush Creek at Hampton farm (RM 0.5).

	Number of individuals	
Species (common name)	2006	2007
Rainbow trout (stockers)		
Rainbow trout	1	
Brown trout (stockers)	1*	
Brown trout		
Brook trout (stockers)		1*
Central stoneroller	21	67
Smoky dace	5	4
Whitetail shiner		7
Warpaint shiner	145	198
River chub	80	77
Tennessee shiner	155	175
Mirror shiner	24	30
Telescope shiner		9
Blacknose dace	1	1
Longnose dace	1	1
Creek chub	1	3
Northern hogsucker	12	6
Black redhorse		2
Golden redhorse		
Sicklefin redhorse		
Rock bass	2	9
Redbreast sunfish		
Green sunfish	1	
Bluegill	1	1
Smallmouth bass	1	4
Tuckaseigee darter	2	1
Greenfin darter	6	9
Gilt darter	21	44
Mottled sculpin	337	119
Total	817	767

* Not included in scoring

Burningtown Creek at Outside Inn (RM 2.0)

Based on the IBI, this site, here given a Fair Bioclass Rating, could as easily be assessed as Good. We have opted for Fair in part to draw attention to two apparently significant negative changes:

- Disappearance of the watershed endemic, undescribed, intolerant smoky dace (*Clinostomus* sp.), represented by 8 individuals in 2000.

- Near doubling of an already high incidence of disease and parasitization (Metric 11).

While at most of our sites with moderate to high observed values for Metric 11, blackspot on 2 species (river chub, *Nocomis micropogon* and Tennessee shiner, *Notropis leuciodus*) is the principal contributing offender, here the range of both conditions and species affected was much higher. Some blackspot was seen on warpaint and Telescope shiners (*Luxilus coccogenis* and *Notropis telescopus*), and we also observed leeches on both rock bass (*Ambloplites rupestris*) and smallmouth bass (*Micropterus dolomieui*). An unidentified parasite and fin erosion were also observed on rock bass.

This sample serves to demonstrate the upstream spread of the smallmouth bass in much of the upper Little Tennessee watershed, but particularly in Burningtown Creek. When we began monitoring in 1990, smallmouth bass appeared to occur only in the extreme lower reaches of Burningtown Creek, below a series of cascades at about RM 0.3. Today it appears to be established to and well above the Outside Inn, to at least RM 8.5. All of the specimens taken in this sample were small adults. This phenomenon is probably attributable to the phenomenon of "native invasion", described by Scott and Helfman (1999).

The only rainbow trout taken was huge (21 inches TL), and may be was being fed by campground guests or management. However, in other respects it appeared and behaved like a wild fish and is included in the IBI data.

One other capture of note was an unusual (and unidentified) adult newt with a plain black back in a backwater habitat formed by a shallow, disconnected, secondary channel. (The only fish present here were adult and juvenile creek chubs, *Semotilus atromaculatus*.)

Table 37. IBI metrics and scores from Burningtown Creek at Outside Inn (RM 2.0).

Metric	2000 Value	2000 Score	2008 Value	2008 Score
1. Number of native species	17	6.7	18	6.7
2. Number of darter species	3	6.7	3	6.7
5. Number of intolerant species	4	6.7	3	6.7
6. Percentage as tolerant species	2.8	6.7	1.3	6.7
7. Percentage as omnivores, herbivores	18.4	6.7	21.2	4.0
8. Percentage as specialized insectivores	58.6	6.7	56.1	6.7
10. Catch rate per unit of effort	15.4	6.7	25.6	6.7
11. Percentage as darters and sculpins	20.8	1.3	17.3	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	4.2	4.0	8.3	1.3
Total		52.2 Good		46.8 Fair

Table 38. Fish capture data from Burningtown Creek at Outside Inn (RM 2.0).

Species (common name)	Number of individuals 2000	2008
Rainbow trout	2	1
Brown trout		1
Brook trout	1*	
Central stoneroller	14	80
Smoky dace	8	
Whitetail shiner	1	
Warpaint shiner	81	130
River chub	55	89
River chub x warpaint shiner		1
Tennessee shiner	69	190
Mirror shiner	81	88
Telescope shiner	11	41
Fatlips minnow		1
Blacknose dace	2	
Longnose dace	3	1
Creek chub	13	10
Northern hogsucker	12	46
Sicklefin redhorse	1	
Unid. Redhorse		1**
Rock bass	9	7
Bluegill		2
Smallmouth bass		7
Tuckaseigee darter	3	5
Greenfin darter	3	9
Gilt darter	8	10
Mottled sculpin	81	122
Total	709	845

Cowee Creek at Wests Mill (RM 0.7)

Three years worth of data from this site offer another opportunity (See also Burningtown Creek at Lower Burningtown Rd., RM 0.6 and 0.7.) to evaluate the efficacy of our IBI for sites with drainage areas of 15-40 sq. mi., and to compare LTWA (2006 and 2007) vs. TVA (2008) sampling methodologies. Before proceeding to this discussion and before commenting on the IBI and Bioclass Rating for this site, there are a number of individual species and species groups which merit special attention:

- As it happens, this site was visited on May 17, just 12 days before the sampling date, for a staff training exercise. While the emphasis was on training we did keep notes on fish observed, which included one species (the tolerant exotic redbreast sunfish, *Lepomis auritus*), which has appeared in all previous samples from this site, but was not taken in the 2008 sample.

- An observation from May 17 which was confirmed in the IBI sample was the unprecedented abundance of the fatlips minnow (*Phenacobius crassilabrum*), a benthic specialized insectivore. This species is of common occurrence but characteristically low abundance in our samples. The capture of 34 individuals by far exceeds the total for any previous sample anywhere. (The number of fatlips minnows in 6 previous samples at this site ranges from 0 to 9, mean 5.0.)

- This sample, along with one other on Cowee Creek (see below) marks the second record for adults of the undescribed regional endemic sicklefin redhorse (*Moxostoma* sp.) from a Little Tennessee tributary. It also includes the third report for Cowee Creek of an adult of our largest redhorse, the river redhorse (*Moxostoma carinatum*). Both of these species sometimes enter large tributaries such as Cowee and Burningtown Creeks in the late winter or early spring to spawn, but by summer most have returned to the river.

- In addition to the fatlips minnow, record high catches were reported for the Tennessee shiner (*Notropis leuciodus*) and smallmouth bass (*Micropterus dolomieui*). Four species (mountain brook lamprey, *Ichthyomyzon greeleyi*; rock bass, *Ambloplites rupestris*; greenfin darter, *Etheostoma chlorobranchium* and mottled sculpin, *Cottus bairdii*) had record low catches.

- The rare, Special Concern olive darter (*Percina squamata*) has been taken here in the fall, but the capture of a small adult in this sample represents the first summer record for this species in Cowee Creek.

If we look at the individual metrics, there are 2 which display a consistent trend over the years 2006 – 2008. Observed values for Metric 8 (proportion of specialized insectivores) increased each year, with an improvement in the score between 2006 and 2007. Both observed values and scores for Metric 11 (proportion of darters and sculpins) declined each year. This may be taken at face value, or one may ask if the increase in proportion of specialized insectivores is primarily a function of decreased total fish abundance, mediated mainly by a decline in abundance of all benthic species

other than fatlips minnow. The latter would be consistent with the bias suggested above (Burningtown Creek at Lower Burningtown Rd.) for the TVA sampling methodology.

In lower Cowee Creek the differences in the results of the two methodologies are not as pronounced as for Burningtown Creek (though the drastic difference in numbers of the mottled sculpin and mountain brook lamprey between 2007 and 2008 is evocative). The difference in IBI scores (identical for 2007 and 2008) does not appear to be significant. However, comparing the results of both methodologies to our intuitive perceptions, the IBI seems to overrate lower Cowee Creek.

Over the past few years we have observed a huge buildup of sediment in the largest pool at this site; based on visual estimation pool volume has been reduced by nearly half. Two major contributing factors can be identified:

- A nearly mile long, completely unfenced and virtually unshaded pasture reach located just a few hundred yards upstream must certainly be a significant source of sediments (as well as nutrients and elevated temperatures).

- A 900 acre megadevelopment in the upper watershed of Caler Fork, tributary to Cowee Creek 1.4 mi. upstream, contributed enormous amounts of sediment to that stream in 2005-2006, with severe (but apparently temporary) effects on biotic integrity. (See discussion of Caler Fork, below.) Without doubt a significant portion of that sediment has passed down through Cowee Creek.

Both of these effects have been at least temporarily mitigated. The pasture mentioned above was in hay during all of 2008, with no livestock present. And with the economic downturn the pace of development upstream has slowed drastically, allowing sediment to be flushed out. However, it still seems doubtful that lower Cowee Creek has consistently merited a high Good classification during 2006-2008.

Returning to consideration of the individual metrics, however, the only one which inspires much doubt is Metric 8 (proportion of specialized insectivores). On other occasions we have seen several species of shiners (classified as specialized insectivores) respond positively to increased amounts of sandy sediment. Only 3 streams in the upper Little Tennesssee watershed (Cowee, Burningtown and Ellijay Creeks) offer the opportunity to revisit scoring criteria for this and other metrics in the 15-40 sq. mi. category. We therefore suggest that it might be worthwhile to reexamine historic fish sample and IBI data for streams of this size throughout the Tennessee Valley.

Table 49. IBI metrics and scores from Cowee Creek at Wests Mill (RM 0.7).

	2006		2007		2008	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	18	6.7	20	6.7	21	6.7
2. Number of darter species	3	6.7	3	6.7	4	6.7
5. Number of intolerant species	2	4.0	3	6.7	3	6.7
6. Percentage as tolerant species	4.6	6.7	2.5	6.7	1.9	6.7
7. Percentage as omnivores, herbivores	8.0	6.7	24.4	4.0	17.7	4.0
8. Percentage as specialized insectivores	27.6	4.0	40.6	4.0	62.5	6.7
10. Catch rate per unit of effort	24.8	6.7	19.6	6.7	23.6	6.7
11. Percentage as darters and sculpins	66.6	6.7	35.8	4.0	32.8	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.7	6.7	0.1	6.7	0.2	6.7
Total		54.9 Good		52.2 Good		52.2 Good

Table 40. Fish capture data from Cowee Creek at Wests Mill (RM 0.7).

	Number of individuals		
Species (common name)	2006	2007	2008
Mountain brook lamprey	12	52	5
Rainbow trout	14	4	1
Brown trout	3	2	2
Central stoneroller	31	69	31
Whitetail shiner	5	4	6
Warpaint shiner	54	58	26
River chub	27	67	24
Tennessee shiner	45	76	77
Yellowfin shiner	2	1	
Yellowfin x Tennessee Shiner	1		
Silver shiner			
Mirror shiner		5	
Telescope shiner		42	68
Fatlips minnow	6	7	34
Blacknose dace	1		
White sucker			
Northern hogsucker	44	67	20
River redhorse			1
Black redhorse			
Golden redhorse	1	5	1
Sicklefin redhorse			1
Unid. Redhorse		1	
Rock bass	5	9	4
Redbreast sunfish	2	3	
Green sunfish	39	16	9
Bluegill	1	3	1
Smallmouth bass	2	3	6
Largemouth bass		1	
Tuckaseigee darter	4	14	7
Greenfin darter	32	18	14
Banded darter			
Gilt darter	97	88	62
Olive darter			1
Walleye			
Mottled sculpin	455	155	71
Total	883	770	472

Matlock Creek below Snow Hill Rd. (RM 0.7)

There is a strong parallel here to the history of the other main low elevation tributary of Cowee Creek, Caler Fork (discussed below). At Caler Fork, there was a well-documented development-related source of massive sedimentation between 2005 and 2006. Here there was a presumptive (though less well-documented) similar source of sediment (development of a large farm 0.7 upstream, with channelization of a portion of Matlock Creek) between the two previous sample years of 1997 and 2001. In both cases there was a significant drop in IBI (50 to 33 and 51 to 42, respectively) followed by a recovery to former levels.

However, the narrative of "recovery" for Matlock Creek is compromised by what appears to be a wholesale change in the structure of the fish assemblage. In 2008, as compared to previous years:

- There were 3 new species for the site (mountain brook lamprey, *Ichthyomyzon greeleyi*; telescope shiner, *Notropis telescopus* and the invasive exotic yellowfin shiner, *Notropis lutipinnis*. For the yellowfin shiner, this represents its furthest upstream penetration in the Cowee Creek watershed, where it was first reported in 2002.

- Not counting the 3 new species, 9 of 16 species (including all species ever reported here except for the bluegill, *Lepomis macrochirus*, represented by a single, probably stray, individual in 2001) occurred in record high numbers in the 2008 sample.

- Both *Rhinichthys* dace species, on the other hand, were taken in record low numbers. And our catch of the mottled sculpin (*Cottus bairdii*), while significantly larger than in 2001, was only 29.3% that of 1997.

What seems to be occurring is a change from a community dominated by benthic fishes to one dominated by column dwellers and/or from one where the greatest abundance of fish is in the riffles to one where it is in the pools. If all marginal and doubtful cases are eliminated and we compare obligate benthic fishes characteristic of riffles (darters, sculpins and longnose dace) to column dwellers characteristic of pools and deep runs (the shiner group), the proportion of the first group in our samples declines from 97.6% to 62.6% to 42.7% in 1997, 2001 and 2008, respectively. Meanwhile the proportion of the shiner group rises from 1.3% to 10.0% to 29.6% in the same years.

Several of the fish which are increasing in numbers in Matlock Creek, including the benthic fatlips minnow (*Phenacobius crassilabrum*) are generally considered mainstem species. If what is occurring is in fact a case of "native invasion" (Scott and Helfman, 2001), and if our criterion of biotic integrity is based on approximation of a "natural" condition, how valid is it to assert (as the IBI implicitly does) that the ecological condition of lower Matlock Creek has improved between 2001 and 2008?

Table 41. IBI metrics and scores from Matlock Creek below Snow Hill Rd. (RM 0.7).

Metric	1997 Value	1997 Score	2001 Value	2001 Score	2008 Value	2008 Score
1. Number of native species	13	7.5	12	7.5	16	7.5
5. Number of intolerant species	2	4.5	2	4.5	3	7.5
6. Percentage as tolerant species	21.1	7.5	1.4	7.5	3.5	7.5
7. Percentage as omnivores, herbivores	6.8	7.5	22.8	1.5	16.4	4.5
8. Percentage as specialized insectivores	7.2	1.5	18.3	1.5	38.5	4.5
10. Catch rate per unit of effort	45.7	7.5	26.3	7.5	41.5	7.5
11. Percentage as darters and sculpins	87.3	7.5	60.3	4.5	42.3	4.5
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.6	7.5	0.0	7.5	0.0	7.5
Total		51.0 Good		42.0 Fair		51.0 Good

Table 42. Fish capture data from Matlock Creek below Snow Hill Rd. (RM 0.7).

Species (common name)	Number of individuals 1997	2001	2008
Mountain brook lamprey			1
Rainbow trout	9	2	3
Brown trout	1	1	1
Central stoneroller	14	11	23
Warpaint shiner	9	18	26
River chub	11	23	37
Tennessee shiner		4	52
Yellowfin shiner			1
Telescope shiner			55
Fatlips minnow	1		12
Blacknose dace	11	13	5
Longnose dace	7	5	2
Creek chub	10	3	8
Northern hogsucker	7	3	19
Rock bass	2	3	8
Green sunfish	4		8
Bluegill		1	
Tuckaseigee darter	2		3
Gilt darter	30	13	24
Mottled sculpin	558	119	164
Total	676	219	452

Caler Fork at Holbrook/Tucek property line (RM 0.4)

This sample confirms the recovery of Caler Fork from the disastrous effects of heavy sedimentation during late 2005 and early 2006, with a slight (but not necessarily significant) increase in the IBI. However, it should be noted that observed values for the metric most dependent on the quality of benthic habitat (Metric 11, proportion of darters and sculpins) remain at little over half of their original level.

The improvement in the IBI is due to reestablishment of the intolerant rock bass (*Ambloplites rupestris*, represented by 3 young adults), thus raising the score for Metric 5 (no. of intolerant species). However, this observation must be tempered by observing that 2008 was the first year at this site in which neither rainbow trout (*Oncorhynchus mykiss*) nor brown trout (*Salmo trutta*) appeared in the sample.

It may be, however, that as hypothesized in the case of Matlock Creek (the other main low elevation tributary of Cowee Creek, see above) a healthy fish assemblage dominated by benthic species is being replaced by a new assemblage dominated by column dwellers. As the data for Metric 11 in Table 23 show, the proportion of darters and sculpins (fishes with strong preference for hard substrate in riffles) is still only half what it originally was, while column-dwelling shiners, which accounted for 17.6% of the sample in 2005 (the year before the sedimentaion episode) and 7.3% of the sample in 2006, have comprised 46.9 and 40.1% of the sample in 2007 and 2008, respectively. (In 2008, the most abundant fish in the Caler Fork sample was the intolerant telescope shiner, *Notropis telescopus*. This is probably the first time this species has been the most abundant species in any of our samples.)

In Caler Fork, the picture is somewhat less clear due to the previous history of this stream, which in the past has been heavily impacted by channelization and by sedimentation from the formerly active gem mine industry. The future is also less clear, pending the effects of the economic situation on development in the upper watershed and also because there have been no major high flow episodes since the one which impacted Caler Fork in 2005-2006.

Note should be made of what appeared to be two unusual Centrarchid hybrids taken from a large pool on this site: One (reported as a bluegill, *Lepomis macrochirus*) had vertical bars and a short, uniformly dark opercular flap, strongly suggesting bluegill parentage. However, the eyes and mouth were unusually large and the body was more slender than a typical bluegill. On the basis of appearance it appeared possible that the other parent was a rock bass. However, this hybrid is not known in nature; bluegill x green sunfish (*Lepomis cyanellus*) is the more probable lineage, but the fish did not resemble other examples of this hybrid we have seen.

The other hybrid was reported as a green sunfish, and had most of the characteristics of this species (large mouth, slender body for a sunfish, overall dark coloration, blue lines on the head, light border on the opercular flap), but the body was mottled very much like a warmouth (*Lepomis gulosus*). So far, we have only one record of warmouth from the Cowee Creek watershed, taken in 2008 from Cowee Creek above the mouth of Caler Fork.

A macroinvertebrate sample taken by a team from the North Carolina Ecosystem Enhancement Program also gave a Bioclass rating of Good, with an EPT Biotic Index of 3.28.

Table 43. IBI metrics and scores from Caler Fork at Holbrooks/Tucek property line (RM 0.4).

	2006		2007		2008	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	10	4.0	17	6.7	19	6.7
2. Number of darter species	1	1.3	1	4.0	1	4.0
5. Number of intolerant species	1	1.3	2	4.0	3	6.7
6. Percentage as tolerant species	11.8	4.0	3.9	6.7	7.1	6.7
7. Percentage as omnivores, herbivores	17.1	4.0	12.5	4.0	15.2	4.0
8. Percentage as specialized insectivores	16.7	1.3	63.5	6.7	53.9	6.7
10. Catch rate per unit of effort	16.7	4.0	39.6	6.7	25.6	6.7
11. Percentage as darters and sculpins	51.8	4.0	27.0	1.3	27.9	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.8	6.7	0.6	6.7	0.0	6.7
Total		33.3 Poor		46.8 Good		49.5 Good

Table 44. Fish capture data from Caler Fork at Holbrooks/Tucek property line (RM 0.4).

	Number of individuals		
Species (common name)	2006	2007	2008
Mountain brook lamprey	28	13	8
Rainbow trout	9	2	
Brown trout	5	3	
Central stoneroller		4	2
Whitetail shiner	18	4	8
Warpaint shiner		150	40
River chub	6	45	30
Tennessee shiner		89	23
Yellowfin shiner		1	
Telescope shiner		12	56
Fatlips minnow		13	1
Blacknose dace	7	4	2
Creek chub	1	1	1
White sucker			2
Northern hogsucker	5	20	15
Golden redhorse		4	1
Mosquitofish	7	1	2
Rock bass			3
Redbreast sunfish	3	1	
Green sunfish	18	18	17
Bluegill	1	4	2
Smallmouth bass			1
Largemouth bass		3	
Gilt darter	23	72	30
Mottled sculpin	114	73	53
Total	245	537	297

Cowee Creek above Caler Fork (RM 2.2)

This site, as originally conceived, had two halves: The lower half, bordered on the left bank by a farm field, had essentially no riparian vegetation on that side, but dense second growth on the right bank between the creek and Leatherman Gap Rd. (SR 1341). The upper half had a wooded left bank, buffering it from an aquatic ornamental plants business, and a shady lawn along most of the right bank. The entire reach received drainage from the ornamental plant operation via 2 ditches, one upstream of the head of the sample reach and the other at the division between the two halves. The proportion and quality of shade and riparian buffering was thus typical for Cowee Creek above Caler Fork and it was assumed that whatever pollution the two ditches might contribute was approximately equal.

In 2008, due to access problems, we had to move the site upstream about 100 ft. so that most of the unshaded reach was omitted. We noted that vegetation on the bank on the farm side of this reach had been recently cut to ground level and herbicided. We mention this change because we are at a loss to explain the increase in IBI here from 41.4 (Bioclass Poor) in 2002 to 49.5 (Bioclass Good) in 2008 if not on the basis of incorporating more of the shaded reach and very little of that exposed to full sun (and at least in 2008, herbicide). No other significant changes are apparent in the watershed.

Superimposed on the improvement is a pattern similar to that observed for the 2 major tributaries of Cowee Creek, nearby Caler Fork and Matlock Creek (which see, above). Between 2002 and 2008 we documented a tremendous increase in the abundance of column dwelling shiners (from 3.3% of the sample in 2002 to 46.7% in 2008) and a corresponding decline in riffle-dwelling benthic species (62.3 to 24.9%). In the cases of Caler Fork and Matlock Creek, there is a plausible explanation for this shift as a response to severe sedimentation events, but we know of no such event affecting Cowee Creek above Caler Fork. It may be a flow rate and water level related event contingent on the drought conditions of 2007 and 2008 (See Results and Discussion, above) or it may correspond to some other causal factor we have not detected.

Another difference between this and the two tributary sites is that whereas in Caler Fork and Matlock Creek we documented the decline of a site which had previously had a Good Bioclass Rating and its subsequent recovery, in this case the site rated only Fair when first monitored in 2002. Interestingly, the same IBI and Bioclass Rating (41.4, Good) was recorded, also in 2002, for a higher gradient, lower diversity site on Cowee Creek located just 0.3 mi. upstream, above the possible pollution source represented by the aquatic plant business. At this site, the proportions of column dwelling shiners and riffle-dwelling benthic species in 2002 were, respectively, 1.7% and 76.4%.

A well constructed rock dam located in the middle of the sample reach is a putative barrier to fish movement. However, only one species (greenfin darter, *Etheostoma chlorobranchium*) was found below the dam and not above, and 3 species normally more associated with downstream environments (whitetail shiner, *Cyprinella galactura*; redbreast sunfish, *Lepomis auritus* and sicklefin redhorse, *Moxostoma* sp.) were found only above the dam. The sicklefin redhorse, together with another individual taken 1.2 mi. downstream on Cowee Creek at Wests Mill, represent the first records for this undescribed regional endemic from Cowee Creek. Cowee Creek at this point, with a watershed area of 11.0 sq. mi, is the smallest stream where we have found sicklefin redhorse in the

upper Little Tennessee watershed, although it is known from still smaller streams in some neighboring watersheds.

Some aspects of this sample are alarming. The presence of an exotic apple snail (Ampullaria) in both this and the 2002 sample and the large numbers of the exotic mosquitofish (presumably eastern mosquitofish, *Gambusia holbrooki*) are surely attributable to the aquatic plant business. So may be the extreme abundance of green sunfish (*Lepomis cyanellus*) compared to other sites in the watershed. In 2002 (though not in 2008) several individuals larger than any we have seen elsewhere were taken here, suggesting a southern origin.

Another curious phenomenon is the distribution of the central stoneroller (*Campostoma anomala*) at this site. It was not abundant in either of the 2 samples here (nor in the upstream sample from 2002), but in 2008 it was concentrated in the shady upper portion of the sample reach (all 12 individuals taken) whereas 22 of 27 individuals taken in 2002 were from the sunny lower half. This suggests an effect, perhaps short term, of herbicide use excluding stonerollers from what would normally be their preferred habitat, and perhaps preventing the increase in stoneroller numbers we have noted at many sites during 2007-2008.

The improvement between 2002 and 2008 must be accepted as real, at least for now. However, note that the improvement obscures the combination of a tremendous improvement in the observed value for Metric 8 (proportion of specialized insectivores), offset by a lower observed value for Metric 11 (proportion of darters and sculpins). This pair of metrics are linked with the putative phenomenon of replacement of a benthic fish-dominated fish assemblage with one dominated by column dwellers, and perhaps mediated by anthropogenically induced "native invasion" (Scott and Helfman, 1993), as described above and in the sections on Caler Fork and Matlock Creek. This raises some doubt as to whether the changes tracked by IBI between 2002 and 2008 actually qualify as improvement, in ecological terms.

A macroinvertebrate sample carried out by a team from the North Carolina Ecosystem Enhancement Program resulted in an EPT Biotic Index of 2.52 and a Bioclass rating of Excellent, which would seem to overstate the quality of Cowee Creek at this point. See the section below on macroinvertebrate monitoring for further discussion.

Table 45. IBI metrics and scores from Cowee Creek above Caler Fork (RM xx).

Metric	2002 Value	2002 Score	2008 Value	2008 Score
1. Number of native species	15	6.7	20	6.7
2. Number of darter species	2	4.0	3	6.7
5. Number of intolerant species	2	4.0	3	6.7
6. Percentage as tolerant species	17.1	4.0	11.1	4
7. Percentage as omnivores, herbivores	12.3	4.0	10.3	4
8. Percentage as specialized insectivores	18.0	1.3	59.0	6.7
10. Catch rate per unit of effort	26.7	6.7	37.0	6.7
11. Percentage as darters and sculpins	62.3	4.0	25.7	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.6	6.7	0.4	6.7
Total		41.4 Fair		49.5 Good

Table 46. Fish capture data from Cowee Creek above Caler Fork (RM xx).

Species (common name)	Number of individuals 2002	2008
Mountain brook lamprey	5	6
Rainbow trout	2	6
Brown trout	3	1
Central stoneroller	27	13
Whitetail shiner	2	1
Warpaint shiner	7	133
River chub	8	43
Tennessee shiner	1	195
Telescope shiner	1	30
Fatlips minnow	1	12
Blacknose dace		10
Longnose dace		1
Creek chub		7
Mosquito fish	18	29
Northern hogsucker	7	20
Sicklefin redhorse		1
Brown bullhead	1	
Rock bass	3	4
Redbreast sunfish	1	3
Green sunfish	37	45
Warmouth		1
Smallmouth bass	2	1
Tuckaseigee darter		1
Greenfin darter	5	6
Gilt darter	24	45
Mottled sculpin	179	145
Total	334	768

Dalton Creek below Dalton Creek Rd. (RM 0.2)

Both the location and the physical condition of this site are different from the previous sample in 2005. In 2005, it was necessary to concentrate our effort in a historically channelized reach downstream of a ditch which enters on the right bank. Upstream of that point, to Dalton Creek Rd., the creek was in its natural channel, but so choked with woody debris (presumably originating with the same upstream megadevelopment which occasioned extreme sedimentation of the stream following heavy rains in 2005) as to be impassable. Near the upper end of the workable reach, a down tree functioned as a digger log creating a pool far deeper than any other portion of the stream (to 3 ft.).

Since 2005, the landowner has cleared away much of the debris and surrounding brush, while planting walnut trees on the bank, thus freeing the channel. The digger log is gone, so that the maximum depth is more nearly 1 foot. The stream is still extremely heavily sedimented, with no real pools. Hard substrate is visible only in the swiftest riffle reaches. Under these conditions, we decided to concentrate the fish sample in the area above the ditch, where the stream remains in its natural channel. All other things being equal, this selection should have resulted in a higher IBI.

In fact, the "brook trout" IBI came out slightly lower, as a consequence of a drastically reduced number of rainbow trout (*Oncorhynchus mykiss*) – 2 individuals, or 1.7% of the sample vs. 19 individuals (18.8%) in 2008, thus lowering the score for Metric 7 (proportion of wild trout). We suggest that this may be a delayed effect. The 2005 sample was taken just a few months after heavy rains filled Dalton Creek with sediment; it may have taken some time for resident trout to respond to a reduced supply of food and cramped habitat by moving out of the area.

Four juvenile largemouth bass (*Micropterus salmoides*) were almost certainly escapees from ponds on the upstream development.

Scores for the 2 macroinvertebrate metrics in the "brook trout" IBI remained the same as for 2005, although the number of Ephemeroptera taxa dropped to 6. This was compensated for by increases in the numbers of taxa for the other two EPT orders. The North Carolina EEP team which carried out the macroinvertebrate sample noted that 10 stonefly taxa is an extraordinary number for such a small stream (watershed area 1.6 sq. mi. at this point).

The EEP team reached a conclusion of "not impaired" for this site, which is coherent with our IBI of 51 and a Bioclass Rating of Good. However, we suggest that this does not correspond to the true condition of the stream. As we have observed on other occasions (See especially our account for Big Creek in our 2000 report.), while a qualitative evaluation of benthic macroinvertebrates, as was carried out, correctly reflects what is presumably good water quality in Dalton Creek, it fails to account for the quantitative loss of habitat in this stream which is still visibly altered from the catastrophic 2005 sedimentation episode. While we lack data to support a lower bioclass rating, in our opinion Dalton Creek at this site is more accurately described as in Fair condition.

Table 47. IBI metrics and scores from Dalton Creek below Dalton Creek Rd. (RM 0.2).

Metric	2005 Value	2005 Score	2008 Value	2008 Score
1. No. Ephemeroptera taxa	10	7.5	6	7.5
2. No. EPT taxa	25	7.5	25	7.5
3. Brook trout presence	Absent	1.5	Absent	1.5
4. Catch rate	13.9	7.5	20.6	7.5
5. Percentage as individuals w. disease, parasites or anomaly	1.0	6.0	0.0	7.5
6. Percentage as tolerants	1.0	7.5	0.0	7.5
7.Percentage as wild trout	18.8	7.5	1.7	4.5
8. Percentage as omnivores and herbivores	5.0	7.5	4.2	7.5
Total		52.5 Good		

Table 48. Fish capture data from Dalton Creek below Dalton Creek Rd. (RM 0.2).

Species (common name)	Number of individuals 2005	2008
Rainbow trout	19	2
River chub		1
Blacknose dace	5	4
Black redhorse	1	
Green sunfish	1	
Largemouth bass		4
Mottled sculpin	75	107
Total	101	118

Table 49. Macroinvertebrate collection data (EPT taxa only) from Dalton Creek below Dalton Creek Rd. (RM 0.2).

Macroinvertebrate Classification	2005	2008
Ephemeroptera		
Baetidae		
Baetis tricaudatus	R	
Plauditus sp.	C	
Plauditus dubius gr		R
Baetis pluto		C
Ephemerellidae		
Drunella wayah	R	
D. sp.	A	
Ephemerella sp.	R	
Epeorus dispar	C	
E. rubidus/subpallidus	R	
Serratalla sp.	A	
Heptageniidae		
Heptagenia sp.	A	
Maccaffertium (Stenonema) sp.	C	
Maccaffertium modestum		A
Maccaffertium pudicum		C
Isonychiidae		
Isonychia sp.	R	
Leptophlebiidae		
Paraleptophlebia sp.		C
Plecoptera		
Capniidae		A
Allocapnia sp.		A
Chloroperlidae		
Sweltsa sp. (w)		R
Leuctridae		
Leuctra sp.	C	
Peltoperlidae		
Tallaperla sp.	R	R
Perlidae		
unid.	R	
Acroneuria abnormis	C	A
Paragnetina immarginata	R	
Perlesta sp.	R	
Eccoptura xanthenes		R
Perlodidae		
Malirekus hastatus	C	R
Cultus decisus (w)		C
Pteronarcyidae		
Pteronarcys (Allonarcys) sp.	A	C
Trichoptera		
Brachycentridae		
Brachycentrus nigrosoma		R
Glossosomatidae		
Agapetus sp.	R	
Glossosoma sp.	C	C

Hydropsychidae		
Ceratopsyche bronta		C
Ceratopsyche sparna		A
Ceratopsyche sp.	A	
Diplectrona modesta	C	C
Hydropsyche betteni sp.	R	C
Cheumatopsyche sp.		C
Limnephilidae		
Pycnopsyche sp.	R	C
Philopotamidae		
Dolophilodes sp.		A
Rhyacophilidae		
Rhyacophila fuscula	A	
Uenoidae		
Neophylax sp.	C	
TOTAL EPHEMEROPTERA TAXA	**10**	**5**
TOTAL EPT TAXA	**27**	**23**

Little Tennessee River at Iotla Bridge (RM 110.2)

The high total fish count here (742 vs. 523 and 596 in 2 previous years of sampling) reflects extra effort, since catch per unit effort (Metric 10) was well within the normal range for this site. So the fact that we achieved record catches for 17 of 30 total species may not be of great interest. Perhaps of greater interest is the addition of 2 new species to the list for this site:

The exotic brown trout (*Salmo trutta*) seems to be spreading in the watershed generally, and is beginning to appear as an occasional angler's catch in the mainstem below Lake Emory.

This is the first verified occurrence of the stonecat (*Noturus flavus*) above Needmore. It could indicate the spread of the only North Carolina population of this species (first discovered in the Little Tennessee at Needmore in 1994), but it is equally likely that it has been here all along. The low water levels of 2008 have favored capture of this cryptic species, whose typical habitat (fissures in bedrock in deep, swift runs) is among the most difficult to sample with electrofishers. (Note the capture of 4 stonecats at Needmore this year, a record high.)

Two other species whose record numbers in our sample may be significant are the Tennessee shiner (*Notropis leuciodus*) and the intolerant telescope shiner (*Notropis telescopus*) which, though physically similar, tend to occupy different habitats (Tennessees in medium depth runs and telescopes in pools). The degree of increase of these species (x 3.6 for the Tennessee shiner and x 5.0 for the telescope, as compared to the mean of previous years) greatly exceeds the increase for total fish catch (x 1.3) and is the principal factor in elevating the score for Metric 8 (proportion of specialized insectivores) back into the high range.

While there have been changes in score for 4 other metrics over the 3 years of monitoring at this site, the other significant change between 2001 and 2008 is the return of the observed value for Metric 6 (proportion of tolerants) to natural levels. An extraordinary catch (108 individuals) of the exotic redbreast sunfish (*Leopmis auritus*) in 2001 was almost entirely responsible for the lower score for this metric in 2001. This was taken as a clear symptom of degradation of the site, probably through some form of organic pollution, and was the key factor in the decision to lower the Bioclass Rating for that year from Excellent to Good (IBI of 54). For 2008, with an IBI of 58, an Excellent rating is obligatory, and is supported by the return of the redbreast sunfish catch, and the total proportion of tolerant species (5.2%), to natural levels.

Other observations which must be taken as positive:

- Continued presence of the threatened, intolerant spotfin chub (*Erimonax monachus*), which was absent from this site in 1999.

- Unprecedented abundance of the Special Concern tangerine darter (*Percina aurantiaca*), represented by 20 individuals.

- Apparent resurgence of the regional endemic, intolerant wounded darter (*Etheostoma vulneratum*), represented by only 2 individuals in 2001 but 10 in 2008. These were mostly small and medium sized specimens, suggesting reproductive success. This is encouraging

considering the numeric decline of wounded darter in our samples at two other sites where it is normally present (Little Tennessee River at Needmore and Cullasaja River at Peaceful Cove, which see.)

One other darter, the gilt darter (*Percina evides*), normally the most abundant darter at this site declined in numbers. In 1999 and 2001 it was the most numerous darter in our samples at Iotla Bridge, comprising, respectively, 38.7 and 47.1% of the total darter catch. In 2008 it comprised 20.0% of the total darter catch, tied for second most abundant darter with the banded darter (*Etheostoma zonale*), and behind the greenfin darter (*Etheostoma chlorobranchium*). This shift is difficult to interpret since, while the gilt darter is classified as an intolerant, among the darters it appears to be the most tolerant to sedimentation. What is certain is that it is the most abundant darter in a large majority of our samples from sites throughout the watershed.

One possible negative trend is the absence of one expected species, the mirror shiner (*Notropis spectrunculus*), represented by 3 and 4 individuals in 1999 and 2001, respectively. No explanation for this phenomenon is offered, and the mirror shiner was normally abundant at our Needmore fixed station (described above).

As compared to the Needmore fixed station at RM 95.5, the Little Tennessee at Iotla Bridge is much more exposed to anthropogenic stress: It is located only 2.9 miles below Porters Bend Dam and Lake Emory, which roughly marks the boundary of the Franklin urban zone. The reach between the dam and Iotla Bridge lacks the riparian protection afforded by the Needmore Game Lands, and access by cattle and development activities near the river continue to affect this reach. Also, Iotla Creek, consistently the poorest of the Little Tennessee's main tributaries below Lake Emory, enters the river in the lower part of the sample reach (pool sector.) So an Excellent rating, clearly deserved in 2008, is both good news and – considering the lower IBI's recorded upstream and in most tributaries – testimony to the recuperative powers of a large river.

Table 51. IBI metrics and scores from the Little Tennessee River at Iotla bridge (RM 110.2).

	1999		2001		2008	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	29	5	30	5	30	5
2. Number of darter species	6	5	5	5	5	5
3. Number of centrarchid species, other than M*icropterus*	5	5	5	5	5	5
4. Number of sucker species	5	5	5	5	5	5
5. Number of intolerant species	4	5	5	5	5	5
6. Percentage as tolerant species	8.6	5	19.0	3	5.2	5
7. Percentage as omnivores, herbivores	7.8	5	7.0	5	5.4	5
8. Percentage as specialized insectivores	51.6	5	41.4	3	66.1	5
9. Percentage as piscivores	9.2	5	14.9	5	10.9	5
10. Catch rate per unit of effort	15.0	3	13.0	5	14.1	5
11. Percentage as darters and sculpins	25.0	5	11.6	3	19.5	3
12. Percentage with disease, tumors, fin damage and/or other anomalies	2.3	3	1.2	5	0.5	5
Total		56		54		58
		Excellent		Good		Excellent

Table 52. Fish capture data from Little Tennessee River at Iotla Bridge (RM 110.2).

	Number of individuals		
Species (common name)	1999	2001	2008
rainbow trout	1		
brown trout			1
central stoneroller	7	6	12
whitetail shiner	71	67	49
spotfin chub		3	1
common carp	3	4	
warpaint shiner	53	18	22
river chub	50	32	28
golden shiner		1	
Tennessee shiner	41	15	102
silver shiner	2		9
rosyface (highland) shiner	24	39	13
mirror shiner	3	4	
telescope shiner	32	34	166
fatlips minnow	1	1	3
northern hogsucker	2	5	11
river redhorse	6	4	8
black redhorse	1	21	24
golden redhorse	12	21	10
shorthead (smallmouth) redhorse	4	5	9
channel catfish	1		4
stonecat			2
flathead catfish		1	1
rock bass	35	67	61
redbreast sunfish	45	108	38
warmouth	1		1
bluegill	4	47	5
smallmouth bass	6	17	18
largemouth bass	5	3	1
black crappie	1	1	1
white bass	1		
Tuckaseigee darter	12	7	16
greenfin darter	13	11	36
wounded darter	20	2	10
banded darter	11	16	22
tangerine darter	2		20
gilt darter	56	32	22
walleye		1	
mottled sculpin	17	4	19
Total	523	596	742

Watauga Creek above Berry Mill Rd. (RM 0.5)

Over the years since it was first monitored in 1990, this site has oscillated more than most in terms of IBI score (range of 39 to 52), individual metric scores and numbers of some species and groups of fish. This history can roughly be broken into 3 periods:

- 1990-1993: Lower Watauga Creek presented the appearance of a stream in steep decline, with virtual disappearance of darters. In 1993 we found only 1 darter species, represented by 2 individuals. Fish diversity was very low (range of 6-9 native species), and IBI dipped to 39 (Bioclass Rating Poor in 1993. After 1993, this site was given a low priority for monitoring, but was revisited in 1997 in the course of normal rotation of sites.

- 1997-2001: Beginning in 1997 this site had greatly enhanced fish diversity (12-16 native species), resurgent darter populations with 4 species represented and IBI's in the Good range (scores of 50-52). No reason is apparent for the improvement between 1993 and 1997.

- 2003-2008: High species diversity has persisted (11-15 native species), but Bioclass Rating has dropped into the Fair range, with IBI's in the range of 44-47. Scores for those metrics which reflect organic pollution and/or high rates of sedimentation, have usually been lower. The decline after 2003 may reflect two notable changes:

- Loss of pool habitat through increasing sedimentation.

- Increased organic enrichment related to a livestock holding area on the left bank, and possibly other agricultural practices. (A strong manure odor is normally present at the site. In 2006 we noted that this odor was particularly strong when leaf litter and sediments along the left bank were disturbed.)

The latter change, and perhaps the former as well, is reflected in a nearly fivefold increase in abundance by the herbivorous stoneroller (*Campostoma anomala*), accompanied by a lesser but probably significant increase in abundance by the omnivorous river chub (*Nocomis micropogon*), together leading to what is by far a record high observed value for Metric 7 (proportion of omnivores and herbivores) in 2008. It should be noted, however, that between 2006 and 2008 increases in stoneroller abundance occurred at numerous sites where there is no indication of increase in organic loading. This phenomenon appears to be related to almost consistently low water levels in the upper Little Tennessee watershed in 2007 and 2008 (see Results and Discussion, above).

Given these conditions, the sustained low observed values and high scores for Metrics 6 (proportion of tolerants) and 12 (proportion of individuals with disease or anomaly) are surprising. In the same sense it is surprising that, over the course of 9 samples since 1990, the tolerant, omnivorous creek chub (*Semotilus atromaculatus*) has only been recorded on 4 occasions, and always in low numbers.

The darter assemblage deserves special mention in any review of this site. In our first year of sampling (1990) we noted that the banded darter (*Etheostoma zonale*) was characteristically a mainstem species, very rarely found in tributary streams. The only exceptions to this rule were

Watauga and Cowee Creeks, which arise within 0.5 mile of each other on Rocky Face Knob (suggesting a geological similarity), but which are in most other respects very different streams. Over the years, the banded darter has been a sporadic presence, appearing in 4 of 10 samples, usually in small numbers, but with an apparent, but short-lived resurgence in 2001, when we took 12 individuals. The Tuckaseigee darter (*Etheostoma blennioides gutselli*) has also been sporadic, appearing in 4 of 10 samples, always in small numbers.

Fluctuations in the number of banded darters in our samples almost certainly reflect changes in population levels at this site. However, our experience this year (and in a fall non-IBI fish sample) suggests that we may have missed the Tuckaseigee darter in some years by not targeting the strongest riffles at this site. On both occasions we captured single individuals of this species by targeting the very strongest riffles.

To this puzzle must be added the relative numbers of the gilt darter (*Percina evides*) and greenfin darter (*Etheostoma chlorobranchium*). As at most sites in our watershed, the relatively sediment-tolerant gilt darter has always been the most abundant darter at this site. During 8 of 9 previous sampling years it formed a majority of all darters taken, and on 2 occasions it was the only darter species in the sample. However in 2008, it dropped to second place in darter abundance, forming 37.3% of the total darter catch, while the greenfin darter accounted for 55.8%.

The generally good numbers of darters in recent years, including 2008, are puzzling given the sudden sharp decline in abundance of the mottled sculpin (*Cottus bairdii*) at this site, which resulted in a lowered score for Metric 11 (proportion of darters and sculpins). Normally, where sedimentation of riffle areas is a problem, we expect darter numbers to decline before sculpins. The scarcity of sculpins in 2008 appears to be the principal factor contributing to the higher observed value for Metric 8 (proportion of specialized insectivores), which barely misses making the cut-off point for receiving a medium score of 4.0.

There are modest expectations for improvement in lower Watauga Creek. This site and one immediately upstream, were selected for monitoring in 2008 to complement an ongoing study of anthropogenic barriers to upstream fish movement in upper Little Tennessee tributaries (Leslie 2008; McLarney 2009). One of the probable products of this study is a project to replace a failing culvert located on a private road just upstream of the sample reach. This has sparked interest in stream restoration among landowners along approximately ½ mile of Watauga Creek at and above this site; the future may hold replacement of the culvert by a free span bridge, riparian zone restoration, fencing out of livestock, elimination of organic pollution sources and other improvements. For a better understanding of the situation, the reader is referred to the following section ("Watauga Creek above John Brown's culvert") where an upstream reach of considerably different character is compared to the "above Jim Berry Rd." site.

Table 53. IBI metrics and scores from Watauga Creek at Berry Mill Rd. (RM 0.5).

Metric	2005 Value	2005 Score	2006 Value	2006 Score	2008 Value	2008 Score
1. Number of native species	15	6.7	11	6.7	15	6.7
2. Number of darter species	2	4.0	2	4.0	4	6.7
5. Number of intolerant species	2	4.0	2	4.0	2	4.0
6. Percentage as tolerant species	1.0	6.7	0.5	6.7	0.2	6.7
7. Percentage as omnivores, herbivores	26.3	1.3	13.8	4.0	47.2	1.3
8. Percentage as specialized insectivores	12.8	1.3	12.2	1.3	19.96	1.3
10. Catch rate per unit of effort	40.7	6.7	55.6	6.7	39.7	6.7
11. Percentage as darters and sculpins	65.3	6.7	83.1	6.7	37.1	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.2	6.7	0.2	6.7	0.4	6.7
Total		44.1 Fair		46.8 Fair		44.1 Fair

Table 54. Fish capture data from Watauga Creek at Berry Mill Rd. (RM 0.5).

Species (common name)	Number of individuals 2005	2006	2008
Rainbow trout			
Central stoneroller	127	46	207
Warpaint shiner	23	11	32
River chub	20	5	36
Tennessee shiner	1	2	20
Yellowfin shiner		1	5
Silver shiner			
Telescope shiner			
Fatlips minnow	1		1
Blacknose dace	6	35	3
Longnose dace			
Creek chub	3	2	
Northern hogsucker	10	1	7
Golden redhorse	1		1
Mosquitofish		1	
Snail bullhead			
Rock bass	10	4	13
Redbreast sunfish			1
Green sunfish	3		
Bluegill			
Smallmouth bass	1		1
Tuckaseigee darter			P*
Greenfin darter	14	12	29
Banded darter			3
Gilt darter	37	53	19
Mottled sculpin	337	466	143
Total	594	639	521

***** One individual taken in extra effort just upstream of the sample reach.

Watauga Creek above John Brown's culvert (RM 0.7)

Although located directly upstream of the "Watauga Creek above Jim Berry Rd." site, with which it is compared in Table 24, this site is physically very different from the downstream site:

- Riparian cover and shade, virtually lacking downstream, are a dominant factor here. The left bank is entirely in forest, while most of the right bank has a wide riparian buffer separating the stream from an adjacent pasture. Canopy cover approaches 100%.

- While the downstream site is deficient in both quantity and quality of pools, the upstream site has large and well developed pools with high diversity of in-pool habitat.

- Conversely, while the downstream site has strong (albeit sedimented) riffles with large to very large cobble as a dominant component, the upstream site has poorly developed, mostly gravelly riffles.

- Although there is an exposed pasture reach just upstream, the immediate environs of the upstream site contribute little in the way of sediments and nutrient; the downstream site is directly impacted by erosion from roads, a livestock feedlot and a short stretch of unbuffered lawn.

The species list for the 2 sites is largely the same, with the following differences.

- The tolerant omnivorous creek chub (*Semotilus atromaculatus*), found in the downstream reach during some years but absent in 2008, was represented upstream by 8 small individuals, taken from backwaters and sedimented shorelines. This is more than have been taken in any of 10 samples from the downstream reach.

- The banded darter (*Etheostoma zonale*) and Tuckaseigee darter (*Etheostoma blennioides gutselli*), both present downstream in 2008 and other years, were absent upstream. In the latter case, at least, this is probably due to lack of suitable riffle habitat.

- A large adult black redhorse (*Moxostoma duquesni*) taken from the upstream site was the first confirmed record for this species in Watauga Creek. The similar golden redhorse (*Moxostoma erythrurum*) is of fairly common occurrence downstream, including in 2008, but was not taken from the upstream site. However, it is virtually certain that both species move in and out of Watauga Creek from the river to and above our sampling sites on a regular basis.

- A large brown trout (*Salmo trutta*) taken after completion of the upstream sample from a pool just below the sample reach represents the first record for this species from Watauga Creek.

Between-site differences of abundance in several other species, notably central stoneroller (*Campostoma anomala*), blacknose dace (*Rhinichthys atratulus*) and greenfin darter (*Etheostoma chlorobranchium*) are readily explainable on the basis of relative availability of suitable habitat.

All but 2 of the IBI metrics received the same score for both sites:

- Limited habitat for riffle-dwelling darters resulted in a lower score upstream for Metric 2 (no. of darter species).

- This was offset by the score for Metric 8 (proportion of specialized insectivores). The observed value for this metric at the lower site was 19.96%, just barely short of the threshold to receive the high score, whereas the value observed upstream was 28.6%, qualifying for the high score. This difference appears to be related primarily to the lack upstream of suitable habitat for the central stoneroller, which was super-abundant (58.6% of the total sample) downstream and can thus be said to have "swamped" the data for insectivores.

As different as the two sites are, and allowing for the fact that the upstream site is intuitively more attractive, the IBI's probably reflect the lack of any significant difference between the sites in terms of ecological health. Both are subject to a wide variety of stresses originating upstream in the heavily developed Watauga Creek watershed, and which probably override local effects. This should be noted as limiting expectations about the biological outcome of an incipient restoration project focusing on a reach of Watauga Creek which encompasses the two reaches reported on here.

Table 55. IBI metrics and scores from Watauga Creek above John Brown's culvert. (RM 0.7).

	2008	
Metric	Value	Score
1. Number of native species	14	6.7
2. Number of darter species	2	4.0
5. Number of intolerant species	2	4.0
6. Percentage as tolerant species	3.7	6.7
7. Percentage as omnivores, herbivores	29.5	1.3
8. Percentage as specialized insectivores	28.6	4.0
10. Catch rate per unit of effort	23.7	6.7
11. Percentage as darters and sculpins	42.8	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.3	6.7
Total		44.1 Fair

Table 56. Fish capture data from Watauga Creek above John Brown's culvert. (RM 0.7).

Species (common name)	2008 Number of individuals
Rainbow trout	
Brown trout	P*
Central stoneroller	56
Warpaint shiner	38
River chub	32
River chub x warpaint shiner	1
Tennessee shiner	28
Yellowfin shiner	1
Silver shiner	
Telescope shiner	
Fatlips minnow	2
Blacknose dace	7
Longnose dace	
Creek chub	8
Northern hogsucker	10
Black redhorse	1
Golden redhorse	
Mosquitofish	
Snail bullhead	
Rock bass	12
Redbreast sunfish	5
Green sunfish	
Bluegill	
Smallmouth bass	1
Tuckaseigee darter	
Greenfin darter	5
Banded darter	
Gilt darter	27
Mottled sculpin	119
Total	353

* One individual taken just below the sample reach.

Cat Creek above the mouth at Rabbit Creek (RM 0.1)

Despite major changes upstream over the last several years, and in the surrounding landscape during 2007-2008, this site, which has rated Poor on each of 3 previous monitoring dates (1992, 1997, 2001 and 2003) continued to rate Poor, receiving the identical IBI score (33.0) as for the previous 2 samples. It may serve as an illustrative example of the relative merits of fish and benthic macroinvertebrates as tools for measuring ecological health of streams. This discussion will focus primarily on the fish work.

In 2002 Cat Creek was heavily modified through removal of multiple beaver dams, rechannelization and removal of all riparian vegetation taller than grass, in what ultimately became a failed development project. This happened approximately ¾ of a mile upstream of the property on which the sample site is located. No significant difference was noted in the IBI between 2001 and 2003. It was hypothesized that the negative effects of this activity (release of large quantities of sediment, elevated water temperatures, and upstream habitat loss) were offset by enhanced flow following beaver dam removal.

At that time the area downstream of the beaver dams was entirely devoted to unfenced pasture, with no significant riparian vegetative buffer. This was modified during 2007-2008 when the property was sold and 85 acres along the creek were converted to a tomato farm. In addition to agrochemical usage (Neighboring property owners have complained of odors and "dusting" of their properties.), alterations include installation of drain tiles, sedimentation during farm development and vehicle crossings in the stream. However, once again the fish sample fails to detect any effect. And once again there are compensatory improvements which may offset any negative effects of the new stresses:

- Nutrient input from manure has obviously been eliminated.

- A narrow but dense riparian buffer, composed almost entirely of grasses and herbs, has been allowed to establish. This has tended to stabilize what was a widened, eroding channel and also provides shade. The latter change is truly spectacular. Previously shade was virtually non-existent on lower Cat Creek. In 2008 nearly half of the sample reach could be classified as a "grass tunnel". At some points we had to cut our way through to collect the fish sample.

It should be noted that in 2008, for logistical reasons, the fish sample site was moved a distance of approximately 1500 feet from the upper end of the property on which the sample is located, to the lower end, near Rabbit Creek. Since conditions are largely homogeneous over the entire property, we do not believe this represents a significant change. And lower Cat Creek is fairly well buffered from "visits" by fish resident in Rabbit Creek due to some very shallow riffles below the lower end of our sample reach.

Scores for only 2 of the 8 IBI metrics changed between 2003 and 2008, but 4 metrics merit comment:

- The observed value for Metric 1 (no. of native species) for 2008 (10 species) is more realistic than that for 2003 (12). The total for 2003 (and some previous years) includes 2

species (largemouth bass, *Micropterus salmoides* and bluegill, *Lepomis macrochirus*) which, while native to the upper Little Tennessee watershed, are not typically found in small creeks. Occurrences of both species probably represent strays from ponds on an upstream golf course development. Elimination of these 2 species would equalize the observed value and score for Metric 1 for both years.

- The observed value for Metric 6 (proportion of tolerants) dropped from 12.2% in 2003 to 7.6 % in 2008, raising the score from the middle to the high bracket. This was occasioned by the disappearance of the white sucker (*Catostomus commersoni*). The latter species was recorded from Cat Creek only in 2003, and this record may represent individuals formerly resident in the beaver ponds.

- The 2008 observed value of 52.7 fish per 300 sq. ft. of water surface illustrates the need to establish a maximum value for receiving the high score for this metric. This record catch rate almost certainly reflects excess nutrient input, but currently we are obliged to assign the high score for Metric 10.

- Surprisingly for a pasture stream, the rate of infestation by diseases and parasites in Cat Creek for both the 2001 and the 2003 samples was very low, meriting the high score for Metric 12. However, 2008 was the first year in which we observed no disease symptoms. Based on observations here and at other sites, it is possible to hypothesize that agrochemicals are serving as disinfectants.

As of 2008, the tomato farm was still very new; effects on the fish assemblage may be observed in years to come. Continuing drought conditions could also affect this small stream. During the sample fish were heavily concentrated in a few deep sections. If we calculate catch rate for individual subsamples, the fish catch per 300 sq. ft. of water surface varies from 3.7 to 120.8.

Lower Cat Creek was also sampled for benthic macroinvertebrates on October 7th and 8th by a team from the North Carolina Ecosystem Enhancement Program. There were drastic declines in EPT richness below the tomato farms, demonstrating clear-cut toxic impacts to the benthic macroinvertebrate community. The team sampled a site on Cat Creek and a site on Rabbit Creek, both below the tomato farm in October. Both of these sites were rated Poor, as opposed to their rating of Good (Rabbit Creek) and Good-Fair (Cat Creek) when sampled before the tomato growing season in May 2008.

Table 57. IBI metrics and scores from Cat Creek above the mouth at Rabbit Creek. (RM 0.1).

Metric	2003 Value	2003 Score	2008 Value	2008 Score
1. Number of native species	12	7.5	10	4.5
5. Number of intolerant species	1	1.5	1	1.5
6. Percentage as tolerant species	12.2	4.5	7.6	7.5
7. Percentage as omnivores, herbivores	57.1	1.5	57.6	1.5
8. Percentage as specialized insectivores	11.7	1.5	7.6	1.5
10. Catch rate per unit of effort	34.6	7.5	52.7	7.5
11. Percentage as darters and sculpins	10.2	1.5	17.9	1.5
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.5	7.5	0.0	7.5
Total		33.0 Poor		33.0 Poor

Table 58. Fish capture data from Cat Creek above the mouth at Rabbit Creek. (RM 0.1).

Species (common name)	Number of individuals 2003	2008
Central stoneroller	45	73
Warpaint shiner	5	10
River chub	28	37
Tennessee shiner	19	7
Yellowfin shiner	6	9
Blacknose dace	28	10
Longnose dace		
Creek chub	9	9
White sucker	7	
Northern hogsucker	9	18
Rock bass	7	3
Redbreast sunfish	9	6
Green sunfish		2
Bluegill	11	
Largemouth bass	1	
Mottled sculpin	21	40
Total	205	224

Cat Creek at 2 sites on the James Waldroop farm (RM 1.0 and RM 1.2)

Two fish samples were carried out on upper Cat Creek using an IBI protocol, our doubts about the applicability of "brook trout" IBI at such low altitude sites notwithstanding. This work was done in conjunction with a restoration project being implemented by the North Carolina Ecosystem Enhancement Program (EEP). The restoration site consists of approximately 1.6 miles of pasture stream which was channelized in 1914 and which now has narrow to non-existent riparian vegetative buffers. The fish sample at the restoration site was divided into two halves – a narrow, entrenched lower reach from which cattle are fenced out and which has a narrow vegetative buffer dominated by alders, and an upper reach which passes through a barnyard. In the upper half, the stream exists in a widened channel with no riparian vegetation other than short grass, and cattle have free access. At this site the fish data are accompanied by results from a macroinvertebrate sample taken by EEP personnel.

The upper fish sample was added based on the capture of a single large, highly colored smoky dace (*Clinostomus* sp.) at the originally planned site. Upstream fish sampling was undertaken to determine if there was a population of this intolerant, undescribed watershed endemic upstream. If so, its reestablishment downstream would provide a measurable parameter for successful restoration. Cattle were completely excluded from the upper reach, which was fairly well buffered.

No smoky dace were encountered upstream; this and the intolerant rock bass (*Ambloplities rupestris*) are the only species encountered at one of the sites and not at the other. The sole rock bass taken was a small adult surprisingly found in a fully sedimented pool in the barnyard reach of the lower site.

The only apparently significant difference between the two fish samples are in the abundance of three species:

- Surprisingly two tolerant species, the omnivorous creek chub (*Semotilus atromaculatus*) and the exotic redbreast sunfish (*Lepomis* auritus) were much more abundant upstream (47 and 16 individuals respectively vs. 19 and 1). No hypothesis suggests itself for this observation.

- Central stoneroller (*Campostoma anomala*) was much more abundant at the downstream site, where 54 of a total 61 individuals were taken in the barnyard reach. This directly reflects the positive response of this herbivorous species to lack of shade.

Our hope was that the fish survey at the upper site would aid in establishing fish-based parameters for evaluating restoration, but the data are not very helpful. Clearly, establishment of a smoky dace population from the upstream reach is not to be expected, nor were wild trout of any species encountered in the upstream sample. Reduced abundance of stonerollers is to be expected once the barnyard reach is shaded, but no other criteria useful for evaluating the success of restoration measures are suggested by the data.

Numbers of Ephemeroptera and EPT taxa from the restoration reach result in high scores for the two macroinvertebrate-based metrics, which (and despite the presence of only two Plecoptera taxa) is supported by the presence of 3 highly intolerant Trichoptera taxa (*Dolophilodes* sp.,

Brachycentrus nigrosoma and *Rhyacophila carolina*). This resulted in a determination of "Not Impaired" by the EEP team.

Taking the fish data into account, the IBI is 37.5, midway between the scores for obligatory assignation of a Poor and Fair Bioclass Rating. Making allowance for the relatively good macroinvertebrate results, we rate the site as Fair. However note that, assuming that results from a macroinvertebrate sample on the upper reach were to come out as good or better as those for the restoration reach then IBI for the upper reach would be 36, barely above the obligatory Poor range. This is due to the low score for Metric 6 (tolerant species), based on the surprisingly high abundance of the creek chub and redbreast sunfish compared to the restoration reach.

Table 59. IBI metrics and scores from Cat Creek at 2 sites on the James Waldroop farm (RM 1.0 and RM 1.2).

	RM 1.0		RM 1.2*	
Metric	Value	Score	Value	Score
1. Number Ephemeroptera taxa			NA	
2. Number EPT taxa			NA	
3. Brook trout presence	Absent	1.5	Absent	1.5
4. Catch rate	39.2	7.5	38.1	7.5
5. Percentage with disease, tumors, fin damage and/or other anomalies	0.3	6	0.0 34.4	7.5 1.5
6. Percentage as tolerant	10.8	4.5	0.0	1.5
7. Percentage as wild trout	0.0	1.5	42.0	1.5
8. Percentage as omnivores and herbivores	37.6	1.5		
Total		NO SCORE		

*With no macroinvertebrate sample, no IBI can be calculated; metric values offered for comparative purposes.

Table 60. Fish capture data from Cat Creek at 2 sites on the James Waldroop farm (RM 1.0 and RM 1.2).

	2008 Number of individuals	
Species (common name)	RM 1.0	RM 1.2
Central stoneroller	61	15
Smoky dace	1	
Warpaint shiner	6	8
River chub	15	14
Yellowfin shiner	6	2
Blacknose dace	19	9
Creek chub	19	47
White sucker	9	4
Northern hogsucker	25	22
Rock bass	1	
Redbreast sunfish	1	16
Green sunfish	2	6
Mottled sculpin	122	69
Total	287	212

Walnut Creek above Walnut Creek Rd. (RM 1.1)

This stream, with a gradient of over 100 ft./mi., requires a macroinvertebrate sample in order to be able to calculate an IBI. While the "brook trout" IBI calculated on the basis of a 1999 sample and again in 2008 produces the same scores for all 8 metrics, leading to a Good Bioclass Rating, close examination of the fish data from 1999, through a 2004 sample when macroinvertebrates were not sampled, to 2008, suggests a trend.

Numbers and proportional abundance of the 2 species which make up the great majority of the fish samples (rainbow trout, *Oncorhynchus mykiss* and mottled sculpin, *Cottus bairdi*) are fairly stable over time. In each sampling year we noted good physical condition and a full range of sizes of trout, from young-of-the-year through large adults, confirming the rating of Good.

However, while scores for Metric 6 (proportion of tolerants) and 8 (proportion of omnivores and herbivores) remain high, the observed values for these metrics, particularly Metric 6, suggest a negative trend. Turning first to Metric 6, in 1999 there were no tolerant species present. In 2004, a single creek chub (*Semotilus atromaculatus*) appeared. And 2008 marked the first appearance of the green sunfish (*Lepomis cyanellus*), with 6 individuals, plus 4 creek chubs. While a 4.2% component of tolerants is far from the threshold (10%) for a lower score, it is clearly significantly worse than the previous proportions of 0.0 and 0.3%.

As for Metric 8, it dropped between 1999 and 2004, as the number of blacknose dace (*Rhinichthys atratulus*) in the sample declined, but surged back in 2008 when the first river chubs (*Nocomis micropogon*) appeared, along with increased numbers of both blacknose dace and creek chubs. This would seem to be a clear example of the phenomenon of native invasion (Scott and Helfman, 1993) in its early stages.

The macroinvertebrate data are a bit more ambiguous. While observed values for both macroinvertebrate metrics in the IBI are virtually identical for both years, with high scores assigned, there has apparently been a major shift in the composition of the macroinvertebrate assemblage. Of 50 total taxa identified, only 12 were present in both years. Similarly, of 32 EPT families collected, only 15 were present in both years. One of the taxa missing from the 2008 sample is the Glossosomatid caddisfly *Agapetus* sp. which created a bit of an entomological stir when it appeared in our collections from Walnut Creek, as well as from Brush, Turtle Pond and Big Creeks, further up the Cullasaja watershed in 1999. Still the 2008 Walnut Creek sample portrays a diverse, healthy benthic community, and contained 6 highly intolerant (North Carolina Tolerance Rating < 1.0) taxa.

The causative factor of negative trends in Walnut Creek is not water quality-related, but rather has to do with sedimentation. As far back as 1999, Walnut Creek contained an unusually high proportion of sand in its substrate, but it has been largely "saved" by high gradient. However, in 2008, following the breaking of a dam at an upstream development, not only was even more sand apparent, we also observed the margins of the pools to be filled with soft, dark silt. This is where the creek chubs and green sunfish were collected. It remains to be seen if this material will be adequately scoured, or if degradation of this stream will continue.

Table 61. IBI metrics and scores from Walnut Creek above Walnut Creek Rd. (RM 1.1).

Metric	1999 Value	1999 Score	2004* Value	2004* Score	2008 Value	2008 Score
1. Number Ephemeroptera taxa	13	7.5	NA	NA	13	7.5
2. Number EPT taxa	34	7.5	NA	NA	36	7.5
3. Brook trout presence	Absent	1.5	Absent	1.5	Absent	1.5
4. Catch rate	17.6	7.5	High	7.5	41.0	7.5
5. Percentage with disease, tumors, fin damage and/or other anomalies	0.5	6.0	0.0	7.5	0.4	6.0
6. Percentage as tolerant	0.0	7.5	0.3	7.5	4.2	7.5
7. Percentage as wild trout	28.9	7.5	14.5	7.5	23.7	7.5
8. Percentage as omnivores and herbivores	2.5	7.5	0.9	7.5	5.1	7.5
Total		52.5 Good		No Score		52.5 Good

* With no macroinvertebrate sample, no IBI can be calculated; metric values offered for comparative purposes.

Table 62. Fish capture data from Walnut Creek above Walnut Creek Rd. (RM 1.1).

Species (common name)	Number of individuals 1999	2004	2008
mountain brook lamprey	1		
rainbow trout	58	49	56
brown trout		1	
brook trout		1*	
river chub			3
blacknose dace	4	2	5
longnose dace	4	7	3
creek chub		1	4
green sunfish			6
mottled sculpin	134	285	159
Total	201	345	236

*Stocker, not counted in scoring.

Table 63. Macroinvertebrate sample data from Walnut Creek above Walnut Creek Rd. (RM 1.1) (A=abundant, C=common, R=rare).

	Classification		
Taxa	1999	2004*	2008
Ephemeroptera			
Baetidae			
Acentrella femorella	C		
Baetis pluto	A		
Baetis tricaudatus	C		A
Baetiscidae			
Baetisca carolina			R
Ephemerellidae			
Dannella lita	R		
Drunella conestee	R		
D. cornutella	R		
D. walkeri	A		
Ephemerella catawba	C		
Ephemerella invaria gr.			C
Eurylophella funeralis			C
Serratella deficiens	C		A
Heptageniidae			C
Epeorus rubidus	A		
Epeorus spp.			R
Heptagenia marginalis			C
Heptagenia spp.	C		
Leucrocuta spp			R
Stenonema modestum			A
S. merivulanum			R
S. pudicum			R
Leptophlebiidae			
Paraleptophlebia spp.	R		A
Oligoneuridae			
Isonychia sp.	C		
Plecoptera			
Capniidae			
Allocapnia spp.			A
Chloroperlidae			
Sweltsa spp.			R
Leuctridae			
Leuctra spp.	A		
Peltoperlidae			
Tallaperla spp.	A		C
Perlidae			
Acroneuria abnormis			A
Paragnetina inmarginata	R		A
Perlesta spp.	C		
Perlodidae			
Diploperla duplicata			R
Isoperla holochlora	A		

Isoperla spp.		A
Helopicus subvarians		A
Malirekus hastatus	R	
Pteronarcyidae		
Pteronarcys spp.	A	C
Taeniopterygidae		
Strophopterys spp.		A
Trichoptera		
Brachycentridae		
Brachycentrus spinae	A	
Brachycentrus spp.		A
Glossosomatidae		
Agapetus sp.	A	
Glossosoma spp.	A	R
Matrioptila jeanae	R	
Goeridae		
Goera spp.		R
Hydropsychidae		
Diplectrona modesta	A	A
Cheumatopsyche spp.		A
Symphitopsyche bronta		R
S. sparna	A	A
Lepidostomatidae		
Lepidostoma sp.	R	
Limnephilidae		
Pycnopsyche guttifer		R
Pycnopsyche sp.	C	
Philopotamidae		
Dolophilodes spp.	R	A
Polycentropidae		
Polycentropus sp.	R	
Psychomyidae		
Lype diversa	R	
Rhyacophilidae		
Rhyacophila fuscula	C	A
R. carolina		R
R. nigrita		R
Uenoidae		
Neophylax mitchelli	R	
Neophylax oligius	A	R
Total Ephemeroptera taxa	**13**	**13**
Total EPT taxa	**34**	**36**

Mill Creek (Cartoogechaye trib) above Old Murphy Rd. (RM 0.3)

While the IBI remains the same for 2007 and 2008, the data suggest a gradual and continuing decline of biological health in lower Mill Creek from 2005-2008. Note that observed values for Metrics 7 (proportion of omnivores and herbivores), 11 (proportion of darters and sculpins) and 12 (proportion of individuals with disease, parasites or anomalies) all show continuous decline over the period (so far reflected in scoring only for Metrics 7 and 11).

One observable symptom of this decline is the increase in numbers of the generalist blacknose dace (*Rhinichthys atratulus*) a phenomenon often observed in small, impacted and deteriorating streams.

Also linked to the low 2008 IBI is a reduction in the total number of fish present (See Metric 10, catch per unit effort.) between 2007 and 2008. This is primarily a function of a drastic decline in numbers of the mottled sculpin (*Cottus bairdii*).

It should be noted that both of the phenomena just cited may be due to continuing low water levels (which is still arguably due to anthropogenic impacts measurable by IBI – see Results and Discussion section above). Blacknose dace have a competitive advantage in very shallow streams, while sculpins are the principal inhabitants of what has become extremely shallow riffle habitat in Mill Creek.

Riffle samples were very poor in 2008. If catch per unit effort is calculated separately for subsamples in riffles, the catch per unit effort (all species) is 3.1, with 84.0% of these fish being sculpins. Low quality of riffles (here comprised principally of large gravel, with much sediment in the interstices) may be involved, as well as depth.

There are also some positive trends between 2007 and 2008:

- While the warpaint shiner (*Luxilus coccogenis*) is missing from Mill Creek for the first time this year (including a 1999 sample not included in Table 27), but 3 species whose absence contributed to the lowered score for Metric 1 (no. of native species) in 2007 were taken this year – river chub (*Nocomis micropogon*), Tennessee shiner (*Notropis leuciodus*) and rock bass (*Ambloplites rupestris*).

- The dramatic increase in numbers of the mountain brook lamprey (*Ichthyomyzon greeleyi*) recorded for 2007 appears to be permanent, with an equal number taken in 2008. Physical habitat in lower Mill Creek appears to be ideal for this species; one possible explanation for its scarcity prior to 2007 is residual toxicity in sediments (possibly related to agrochemical use at a golf course upstream).

Two other metrics merit comment:

- The intolerant rock bass, absent from the 2007 sample and represented by only 2 individuals in each of 2 earlier samples, was represented by one individual in 2008. This individual barely met the length threshold (3 inches TL) to qualify as an intolerant. Our decision was not to include it in scoring for Metric 5 (no. of intolerant species). An argument could be

made for inclusion, in which case Metric 5 would receive the high score and the IBI would rise to 36.0 (still meriting a Poor Bioclass Rating).

- Two species (largemouth bass, *Micropterus salmoides* and bluegill, *Lepomis macrochirus*) included in the count for Metric 1 (no. of native species) are likely escapees from ponds on the golf course upstream. However, even if these species are disallowed, observed value for Metric 1 is 11, resulting in the high score.

New management at the Mill Creek Club upstream is promising better golf course and other land management practices which may have a long term positive effect on IBI in lower Mill Creek. If these changes are not implemented rapidly, Mill Creek may for some years serve as a natural laboratory for tracking climate and flow level effects on biotic integrity.

Table 64. IBI metrics and scores from Mill Creek (Cartoogechaye watershed) above Old Murphy Rd. (RM 0.3).

	2005		2007		2008	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	12	7.5	9	4.5	13	7.5
5. Number of intolerant species	2	4.5	1	1.5	1	1.5
6. Percentage as tolerant species	12.4	4.5	15.7	4.5	16.6	4.5
7. Percentage as omnivores, herbivores	18.8	4.5	35.3	1.5	49.2	1.5
8. Percentage as specialized insectivores	14.7	1.5	4.7	1.5	10.4	1.5
10. Catch rate per unit of effort	15.7	4.5	24.6	7.5	19.3	7.5
11. Percentage as darters and sculpins	53.2	4.5	36.7	4.5	23.8	1.5
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.0	7.5	0.7	7.5	1.6	7.5
Total		39.0		33.0		33.0
		Fair		Poor		Poor

Table 65. Fish capture data from Mill Creek (Cartoogechaye watershed) above Old Murphy Rd. (RM 0.3).

	Number of individuals		
Species (common name)	2005	2007	2008
Mountain brook lamprey	1	31	31
Rainbow trout	1		
Brown trout	3	4	2
Central stoneroller	5	20	2
Smoky dace	15	14	19
Smoky dace x yellowfin shiner?		1	
Whitetail shiner	3		
Warpaint shiner	15	1	
River chub	9		2
Tennessee shiner	2		1
Blacknose dace	14	23	36
Creek chub	12	32	22
White sucker			2
Northern hogsucker	5	38	16
Rock bass	2		1
Redbreast sunfish	15	15	8
Bluegill		11	4
Largemouth bass			1
Mottled sculpin	116	110	46
Total	218	300	193

Coweeta Creek at Coweeta Creek Campground (RM 2.1)

The increase in total fish catch and catch per unit effort (Metric 10) here between 2001 and 2008 is probably due to a slight change in the sample site. In 2008 we began a bit further downstream, thus incorporating a more sinuous channel, with more pool and high quality riffle area in the sample. If this change were to have any effect on the IBI it should be to raise it, but the opposite occurred, as IBI dropped from 54.9 to 49.5, while retaining a Bioclass Rating of Good.

The most immediately noticeable and significant change at this site is the tremendous increase in numbers of the herbivorous central stoneroller (*Campostoma anomala*) – from 27 to 109 individuals, or 3.9 to 11.2% of the sample. This is an extreme example of a change noted at many sites this year, and possibly related to climate change and consequent prevalence of low flows and water levels during 2007-2008. (See Results and Discussion section above for further discussion).

In the case of Coweeta Creek, the stoneroller population explosion apparently affected all 3 of the IBI metrics for which the score declined. The effect is most obvious for Metric 7 (proportion of omnivores and herbivores). If stonerollers were omitted from this metric, observed values for 2001 and 2008, respectively, would be 5.2 and 8.2%.

In the case of Metric 11 (proportion of darters and sculpins) it can be argued that stonerollers compete with other benthic species for riffle habitat. (The total number of darters and sculpins in the sample actually increased from 463 in 2001 to 506 in 2008, but this is likely a function of including better quality riffle habitat in the site.)

The decline in observed value for Metric 8 (proportion of specialized insectivores) is marginal (20.5 to 19.2%) but crosses the threshold between the high and medium scores for this metric. If this change is in fact significant, it may again be partially attributed to stonerollers competing for space in riffles and/or to reduction in benthic macroinvertebrate productivity due to increased periphyton production (which in turn favors stonerollers), in riffles. The notion of a significant decline in specialized insectivores is supported by the ratio of sculpins to darters in the riffles, which went from 7.7 in 2001 to 21.0 in 2008, despite the higher quality riffle habitat sampled.

The change in Metric 8 is partially buffered by another change observed at several sites in 2008 – increase in the proportional representation of column-dwelling specialized insectivore cyprinids (smoky dace, *Clinostomus* sp., warpaint shiner, *Luxilus coccogenis* and Tennessee shiner, *Notropis leuciodus*). These 3 species plus the mirror shiner (*Notropis spectrunculus*, absent in 2008), accounted for 11.9% of the sample in 2007 and 15.9% in 2008. (Absence of the mirror shiner may be significant, however it must be noted that we have found this species to be characterized by local "boom and bust" population cycles.)

The only new species at this site in 2008 was the tolerant exotic redbreast sunfish (*Lepomis auritus*), represented by 8 individuals of all sizes. This in itself could be taken as a negative indicator. The various negative indicators cited were partially offset by Metric 12 (proportion of fish with disease, parasites or anomalies) which dropped significantly (4.7 to 1.4%) between 2001 and 2008, for unknown reasons.

Data from this site are of particular interest in discussing the significance, and possible anthropogenic component, of changes due to almost constant low flows and water levels during 2007 and 2008. No other negative impacts are known to have occurred in the Coweeta Creek watershed upstream of this site, reduced incidence of disease and parasitization (Metric 12) was observed, and repositioning of the sample reach in 2008 resulted in sampling better habitat, yet the IBI declined (while clearly remaining in the Good range).

Table 66. IBI metrics and scores from Coweeta Creek at Coweeta Creek Campground (RM 2.1).

	2001		2008	
Metric	Value	Score	Value	Score
1. Number of native species	17	6.7	17	6.7
2. Number of darter species	3	6.7	3	6.7
5. Number of intolerant species	3	6.7	3	6.7
6. Percentage as tolerant species	0.3	6.7	1.3	6.7
7. Percentage as omnivores, herbivores	8.5	6.7	19.2	4.0
8. Percentage as specialized insectivores	20.5	4.0	19.2	1.3
10. Catch rate per unit of effort	18.6	6.7	29.6	6.7
11. Percentage as darters and sculpins	66.4	6.7	52.0	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	4.7	4.0	1.4	6.7
Total		54.9 Good		49.5 Good

Table 67. Fish capture data from Coweeta Creek at Coweeta Creek Campground (RM 2.1).

	Number of individuals	
Species (common name)	2001	2008
Mountain brook lamprey	1	5
Rainbow trout	1	21
Brown trout	12	2
Central stoneroller	27	109
Smoky dace	35	22
Warpaint shiner	13	65
River chub	29	68
Tennessee shiner	21	68
Yellowfin shiner	56	57
Yellowfin x Tennessee shiner		1
Mirror shiner	14	
Fatlips minnow		4
Blacknose dace		2
Longnose dace	6	6
Creek chub	2	5
White sucker		
Northern hogsucker	6	10
Black redhorse	1	4
Golden redhorse	6	
Rock bass	4	11
Redbreast sunfish		8
Tuckaseigee darter	1	1
Greenfin darter	17	10
Gilt darter	36	12
Mottled sculpin	409	483
Total	697	974

Little Tennessee River below Tessentee Creek (RM 126.9)

On the one hand, visual inspection of this reach of the Little Tennessee, with its fully sedimented substrate and total lack of riffle habitat, strongly supports the IBI Bioclass Rating of Poor. On the other hand, this is probably the most doubtful result of 2008. Depending on interpretation of several metrics the range of possible IBI's is 19.8 (clearly Very Poor) to 38.5 (optional Fair Bioclass Rating).

The most readily observable result of the fish sample here, in 2007 but even moreso in 2008, is low catch per unit effort. This is presumably due to heavy sedimentation and unstable substrate, but it is interesting to note that in 2008, surprisingly, midstream habitat (at least where there was woody debris in midchannel) was more heavily populated than similar shoreline habitat (both whole tree revetments and naturally occurring elements).

The importance of woody debris in otherwise low quality habitat of this type is illustrated by a single seine set which bracketed a midstream brush pile/log dam. There we took a total of 39 fish, representing 9 of a total 19 species in the sample. For 8 other midchannel sets covering the same area of water surface, but without prominent debris jams, the range of fish capture numbers was 0-16 (mean 8.5) and species counts were 0-6 (mean 4.5).

The best way to further elucidate the situation will be to discuss the metrics one by one:

- Metrics 1 (no. of native species), 4 (no. of sucker species), 8 (proportion of specialized insectivores) and 11 (proportion of darters and sculpins) have similar observed values and identical scores for both years, and are altogether credible, so merit no further discussion.

- Metric 2 (no. darter species): Inclusion of the gilt darter (*Percina evides*) in 2008, based on capture of a single small specimen, could be questioned. We have counted the gilt darter based on the capture of 4 individuals in 2007 and its continued presence, in low numbers, at other nearby sites on the mainstem, suggesting the presence of a small permanent population in this reach of the Little Tennessee. Were gilt darter to be disallowed, observed value for Metric 2 would drop to 0, score to 1.1, and the IBI to. 34.1 (Poor). (See also Metric 5.)

- Metric 5 (no. intolerant spp.), as scored includes gilt darter; its exclusion would drop the observed value to 0, but would not affect the IBI. However, a case could be made for including rock bass (*Ambloplites rupestris*). This intolerant piscivore (See also Metric 9) was represented by 10 individuals, but only 2 of these barely reached the size threshold (total length 3 inches) to be counted as intolerants. It was decided to disallow rock bass (represented by only 1 very small individual in 2007) as an intolerant. If it is included, observed value for Metric 5 rises to 2, score to 3.3 and the IBI to 34.1 (Poor). (TVA considers black redhorse, *Moxostoma duquesni*, to be an intolerant, which we have not accepted. Its acceptance would have the same effect on Metric 5 as inclusion of rock bass.)

- Metrics 6 and 7 (proportion of tolerants and proportion of omnivores and herbivores) raise the question of the status of the invasive exotic yellowfin shiner (*Notropis lutipinnis*), which is currently not included in TVA biomonitoring guidelines. The Georgia DNR considers

yellowfin shiner as a tolerant and omnivore in calculating IBI's. So far we have follwed the TVA system, but:

- If yellowfin shiner is considered to be a tolerant the observed value for Metric 6 would rise to 30.0%, score would fall from 5.5 to 1.1 and the IBI would drop to 31.9 (Poor).
- If yellowfin shiner is considered to be an omnivore the observed value for Metric 7 would rise to 44.7%, score would fall from 3.3 to 1.1 and the IBI would drop to 34.1 (Poor).
- And if yellowfin shiner is considered, per Georgia DNR, as both a tolerant and an omnivore, then the IBI would drop to 29.7 (Poor.) and to 33.0, Poor, for 2007.

The same change would occur for Metric 6 in both the 2007 and 2008 samples. While for purposes of this report we have retained the TVA scoring system, our inclination is to reclassify the yellowfin shiner as an omnivore (Metric 7), based on its dominance in this highly degraded enviroment. It was the most abundant species both years, forming 44.4% of the total sample in 2007 and 23.5% in 2008 – a year in which yellowfin shiner counts declined at almost all sites.

We are not as convinced of the Georgia listing of yellowfin shiner as a tolerant (Metric 6), based on the moderate numbers of other tolerants at this site in both years. When no specimens of the tolerant creek chub, *Semotilus atromaculatus* (represented by 6 individuals in 2007) appeared in the sample as planned, we carried out additional sampling, targeting backwater habitats, but found no creek chubs nor many other tolerant species; in fact we found the dominant fish in backwater habitats to be the river chub (*Nocomis micropogon*).

- Metric 9 (no. of piscivore species) rated the high score by virtue of inclusion of rock bass. Although the observed value for this metric in 2007 was 0, for a score of 1.1, based on disallowing single small juveniles of rock bass and smallmouth bass (*Micropterus dolomieui*), we felt that the increased abundance of rock bass in 2008 (10 individuals) merited its inclusion. If rock bass is disallowed as a piscivore, observed value for Metric 9 drops to 0, score to 1.1 and the IBI to 31.9 (Poor).

- Metric 10 (catch per unit effort): While neither the observed value for 2007 (9.7, score 3.3) nor that for 2008 (3.3, score 1.1) is equivocal, it is worth noting the drastic reduction in observed value between 2007 and 2008. No reason is apparent, but 86.4% of the reduction is attributable to the 3 species most clearly associated with sandy substrates – yellowfin shiner, mirror shiner (*Notropis spectrunculus*) and northern hogsucker (*Hypentelium nigricans*).

- Metric 12 (proportion of individuals with disease, parasites or anomalies): The high observed value for 2008 was due primarily to blackspot on river chubs (7 of 29 individuals), but the number of cysts visible on individual fish was not as high as at most 2008 sites where this parasite was present. No hypothesis suggests itself for the increase in observed value for this metric.

- In summary, below we list the minimum and maximum possible scores for all 12 metrics:

Metric	Possible score
1	5.6
2	1.1-3.3
4	5.5
5	1.1-3.3
6	1.1-5.5
7	1.1-3.3
8	3.3
9	1.1-5.5
10	1.1
11	1.1
12	1.1

Lowest possible score: 23.1 (Very Poor)
Highest possible score: 38.5 (Fair-Poor)
Assigned score: 36.3 (Poor)

For all the uncertainties, this site clearly merits a Poor, or perhaps Very Poor bioclass rating. Benthic macroinvertebrate sample and physical habitat assessment data would be helpful in refining the classification.

Table 68. IBI metrics and scores from Little Tennessee River below Tessentee Creek (RM 126.9).

	2007		2008	
Metric	Value	Score	Value	Score
1. Number of native species	15	5.5	16	5.5
2. Number of darter species	1	3.3	1	3.3
4. Number of sucker species	3	5.5	3	5.5
5. Number of intolerant species	1	1.1	1	1.1
6. Percentage as tolerant species	4.0	5.5	6.5	5.5
7. Percentage as omnivores, herbivores	16.9	3.3	21.1	3.3
8. Percentage as specialized insectivores	26.6	3.3	27.6	3.3
9. Percentage as piscivores	0	1.1	1	5.5
10. Catch rate per unit of effort	9.7	3.3	3.3	1.1
11. Percentage as darters and sculpins	1.1	1.1	1.2	1.1
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.8	5.5	5.9	1.1
Total		38.6 Fair		36.3 Poor

Table 69. Fish capture data from Little Tennessee River below Tessentee Creek (RM 126.9).

	Number of individuals	
Species (common name)	2007	2008
Mountain brook lamprey	6	3
Central stoneroller	6	3
Common carp		
River chub	41	29
Whitetail shiner	9	10
Warpaint shiner	16	6
Golden shiner	1	1
Tennessee shiner	29	24
Yellowfin shiner	156	40
Yellowfin x Tennessee shiner	1	
Silver shiner		1
Mirror shiner	36	5
Creek chub	6	
White sucker		
Northern hogsucker	27	15
Black redhorse	4	3
Golden redhorse	2	3
Unid. Redhorse		2
Snail bullhead		
Unid. Bullhead	1*	
Rock bass	1	10
Redbreast sunfish	8	10
Warmouth		1
Bluegill		2
Smallmouth bass	1	
Gilt darter	4	1
Mottled sculpin		1
Total	354	170

* Young-of-the-year, not included in scoring.

Little Tennessee River above GA Highway 246, Scaly Rd. (RM 137.6)

Table 30 presents data for this site from 2007 (the first year it was monitored) and 2008, but the more important comparison is perhaps between the 2008 data and 2008 data from our State Line Fixed Station 0.8 mi. downstream. In the past, both of these stations have suffered the effects of the only significant industrial discharge in the upper Little Tennessee watershed, located 1.9 mi. upstream. In 2008, both presumably benefitted from the closure of that plant, with cessation of discharge. However, as compared to the State Line station, the site under discussion here has a largely rocky substrate, a normal distribution of riffles and pools, and near 100% shade with an adequate to ample riparian vegetative buffer including mature trees. In contrast the State Line station has a shifting, sandy substrate, fewer pools and mostly poor quality riffles, with little or no vegetative buffer over much of its length. Taken together, therefore, the 2 stations present an opportunity to evaluate the relative impact of industrial pollution and severe physical habitat alteration.

Looking at within-site comparisons first, the IBI's for 2007 and 2008 at the GA 246 station show virtually no difference apart from a marked reduction in catch per unit effort (Metric 10). No reason for this effect is apparent, which brings this site into line with typical catch rates in the Georgia reach of the Little Tennessee mainstem. In the IBI, this change is offset by an improvement in score for Metric 8 (proportion of specialized insectivores). However, note that the 2007 observed value for this metric (24.7%) is barely below the threshold to receive the medium score of 3.3.

However, there are some suggestions of improvement at the site following cessation of the industrial discharge:

- Numbers of the herbivorous central stoneroller (*Campostoma anomala*) dropped precipitously. In 2007 this species formed 16.1% of the total fish sample (an enormous number for a densely shaded site); for 2008 this number drops to 8.8%. That this occurred during a year when, on a watershed-wide basis, stoneroller numbers tended to rise (presumably due to low flow rates and water levels – see Results and Discussion section above) adds to its potential significance.

- In 2007 the native Tennnessee shiner (*Notropis leuciodus*) outnumbered the invasive exotic yellowfin shiner (*Notropis lutipinnis*), with which it competes and hybridizes, and no hybrids were observed. (This effect also occurred at the State Line station.)

- In 2007 the intolerant gilt darter (*Percina evides*) was represented only by small individuals, and no nuptial colors were observed. In 2008 a full range of sizes of gilt darters, with many in nuptial colors, were taken.

- A juvenile hellbender (*Cryptobranchus allegheniensis*) was taken in 2008. This Special Concern salamander is known from well above and below the industrial outfall, but this is the first hellbender taken from the Little Tennessee in Georgia below the outfall.

- Riverweed (*Podostemum*) completely covered the bottom of the river in shallow reaches in 2008. In prior years, riverweed growth largely stopped at the industrial outfall, and did not

return until well downstream in North Carolina. (This may account for the reduction in stoneroller numbers, since riverweed necessarily competes with the benthic algae on which stonerollers feed.)

The State Line sample received the same IBI (47.3) as the GA 246 site, but was given a Bioclass Rating of Fair, based on low abundance and small size of indicator species used in determining the scores awarded for Metrics 2 (no. of darter species), 5 (no. of intolerant species) and 10 (no. of piscivore species). If any of these scores were lowered by disallowing species, the IBI would drop to 45.1, within the range of scores obligating us to assign a Fair Bioclass Rating. (For a fuller explanation, see the discussion for the State Line Fixed Station, above.) At the present site, however, we opted for a Bioclass Rating of Good.

Whether or not we are correct in assigning different bioclass ratings to these 2 sites with identical IBI's, the data strongly suggest that in this instance industrial pollution has historically impacted the river more severely than physical habitat alteration. Whether the improvement in chemical water quality is permanent, or polluting activities resume, it will be interesting to see whether the presumable greater resilience of the upper site is evidenced by more rapid recovery or greater resistence to renewed degradation in the years to come.

Table 70. IBI metrics and scores from the Little Tennessee River above GA highway 246 (RM 137.6).

	2007		2008	
Metric	Value	Score	Value	Score
1. Number of native species	20	5.5	19	5.5
2. Number of darter species	2	5.5	2	5.5
4. Number of sucker species	4	5.5	4	5.5
5. Number of intolerant species	3	5.5	3	5.5
6. Percentage as tolerant species	1.3	5.5	1.1	5.5
7. Percentage as omnivores, herbivores	38.9	1.1	37.5	1.1
8. Percentage as specialized insectivores	24.7	1.1	31.5	3.3
9. Percentage as piscivores	1	5.5	2	5.5
10. Catch rate per unit of effort	16.7	5.5	10.0	3.3
11. Percentage as darters and sculpins	12.0	1.1	9.9	1.1
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.6	5.5	1.1	5.5
Total		47.3 Good		47.3 Good

Table 71. Fish capture data from the Little Tennessee River above GA highway 246 (RM 137.6).

	Number of Individuals	
Species (common name)	2007	2008
Mountain brook lamprey	10	7
Rainbow trout	1	
Brown trout		1
Central stoneroller	114	39
Smoky dace	5	4
Whitetail shiner	2	
Warpaint shiner	69	36
River chub	148	116
Golden shiner	1	1
Tennessee shiner	76	81
Yellowfin shiner	136	62
Yellowfin shiner x smoky dace	1	
Yellowfin shiner x warpaint shiner		
Yellowfin shiner x Tennessee shiner		
Mirror shiner	3	6
Fatlips minnow	1	
Blacknose dace		1
Longnose dace		
Creek chub	1	2
White sucker	2	1
Northern hogsucker	24	13
Black redhorse	7	10
Golden redhorse	3	2
Brown bullhead		
Snail bullhead		
Rock bass	12	14
Redbreast sunfish	6	2
Green sunfish		1
Redbreast x green sunfish		
Warmouth		
Bluegill	1	
Smallmouth bass		
Largemouth bass		
Tuckaseigee darter	2	1
Greenfin darter		
Yellow perch	1	2
Gilt darter	17	12
Mottled sculpin	66	31
Total	709	445

Betty Creek at the Hambidge Center (RM 4.3)

This site has experienced some improvement in physical habitat since 2003 with the revegetation and stabilization of a significant reach of raw bank, as part of a larger (and not altogether successful) restoration effort by the landowner, focused primarily on an adjacent forest/wetland site. However, changes in the fish assemblage during 2003-2008 are offsetting – improvements in Metrics 8 (proportion of specialized insectivores) and 10 (catch per unit effort) and declines in Metrics 7 (proportion of omnivores and herbivores) and 11 (proportion of darters and sculpins). When viewed over a longer time span (including a 1996 sample), Metric 10 may reflect nothing more than an unexplained temporary dip in total fish abundance in 2003, but the other 3 metrics suggest long term trends.

These trends appear to be interconnected, with the clearest of the three being Metric 7, for which the score declined over both the 1996-2003 and 2003-2008 periods. Three of the 4 species which contribute to this metric (the herbivorous central stoneroller, *Campostoma anomala*; and the omnivorous river chub, *Nocomis micropogon* and creek chub, *Semotilus atromaculatus*, but not the herbivorous mountain brook lamprey, *Icthyomyzon greeleyi*) show sustained increases in both absolute and proportional abundance in our samples over both periods.

The stoneroller trend is part of what appears to be an upper Little Tennessee watershed-wide trend toward increasing numbers of this species. In this case, while the parallel increase in omnivores suggests that some factor peculiar to the Betty Creek watershed (probably an increase in nutrient content) is involved, we also posit an effect at the scale of the larger watershed, related to consistent low flow and water levels during the drought of 2007-2008. (See Results and Discussion section above for further discussion.)

Increased stoneroller abundance probably reflects increased production of periphyton, on which stonerollers feed. This may in turn drive the results for Metric 11, either directly through stonerollers competing with darters and sculpins for riffle habitat, or indirectly through the effect of increased periphyton in suppressing benthic macroinvertebrate production. (A 2008 macroinvertebrate sample, discussed below, makes it seem unlikely that the latter is the case.)

Whatever the cause, the drop in observed value for Metric 11 between 2003 and 2008 is dramatic. Darter abundance has never been high at this site, so trends in Metric 11 are due primarily to declining abundance of the mottled sculpin (*Cottus bairdii*). However, we must also note a small trend in the opposite direction, with the apparent establishment between 2003 and 2008 of a population of the fatlips minnow (*Phenacobius crassilabrum*), a benthic specialized insectivore.

At some of our sites we have noted a decline in darter numbers (all species) over time, with a corresponding effect on the proportion of specialized insectivores in our samples, driving down the score for Metric 8. Darters are too scarce at the Hambidge Center site to draw conclusions based on this group. However, if we look at combined numbers for benthic specialized insectivores (darters, fatlips minnow and longnose dace, *Rhinichthys cataractae*), there may be a decline. This group accounted for 5.0 and 5.4% of the total sample in 1996 and 2003, respectively, but only 2.6% in 2008. The main factor driving this trend is a decline in longnose dace numbers. The Hambidge

Center site contains several very high gradient riffles which provide ideal habitat for this species, but only 6 individuals were taken in 2008, compared with 30 and 24 in the preceding years.

A possible negative trend in benthic specialized insectivores notwithstanding, overall the proportion of specialized insectivores, and with it the score for Metric 8 increased dramatically between 2003 and 2008. The metric data mask a curious and unexplained trend here. Between 1996 and 2008, including the 2003 sample, the Tennessee shiner (*Notropis leuciodus*) disappeared completely from this site, and simultaneously from other occasional sample sites in Betty Creek above RM 2, although it maintained normal abundance in lower Betty Creek. If Tennessee shiners had maintained normal numbers in middle Betty Creek over the entire period, a consistent gradual increase in the proportion of specialized insectivores in the sample during 1996-2008 would have been observed. Instead there was a slight (14.3% to 13.5%), probably non-significant dip in the observed value for Metric 8 between 1996 and 2003.

Apart from the fatlips minnow, the species contributing to the increased proportion of specialized insectivores at this site are column-dwelling cyprinids, particularly the Tennessee shiner and warpaint shiner (*Luxilus coccogenis*). A similar effect has been noted at other sites. A possible explanation for this phenomenon is that increased frequency of clear water facilitates feeding by column-dwelling insectivores, which are predominantly sight feeders.

One other negative trend in the fish sample, not reflected in the IBI, is the surprising capture of 4 adult yellow perch (*Perca flavescens*) for the first time from Betty Creek. The presence of this rapidly spreading exotic carnivore is not encouraging for the maintenance of either biotic integrity or a popular recreational trout fishery in Betty Creek.

We also carried out a benthic macroinvertebrate sample at the Hambidge Center site on July 18. (The fish sample was done on July 30.) Results are shown in Table 31, and tend to refute the hypothesis that increased periphyton production (as reflected in a population explosion by the central stoneroller) is impacting the macroinvertebrate assemblage. The sample registered high overall and EPT taxa richness and EPT abundance. In addition to 7 highly intolerant taxa (North Carolina tolerance values <1.0), we note the presence of the extremely intolerant Elmid beetle *Promoresia tardella*, rated as Abundant at the site.

At this point in time, the biota of middle Betty Creek seem to be experiencing a certain amount of flux while maintaining Good overall biotic health. The system may, however, be vulnerable to further perturbations. There is reason to hope for one positive change. Middle Betty Creek offers good habitat for the regional endemic greenfin darter (*Etheostoma chlorobranchium*), found sporadically and in small numbers in lower Betty Creek, up to at least RM 2, but never taken further upstream. At least temporary elimination of a major industrial pollution source to the Little Tennessee River not far below the mouth of Betty Creek has permitted the reestablishment of a small population of greenfin darters in the Georgia portion of the Little Tennessee mainstem. If, as we believe, the greenfin darter requires connectivity to maintain populations, and if elimination of the pollution source turns out to be permanent, we may eventually see the increase and spread of the greenfin darter population in Betty Creek. Addition of this species at the Hambidge Center site would increase the observed value for Metric 2 (no. of darter species) to 3, the metric score to 6.7 and the IBI to 49.5 (Good).

Table 72. IBI metrics and scores from Betty Creek at the Hambidge Center (RM 4.3).

Metric	1996 Value	1996 Score	2003 Value	2003 Score	2008 Value	2008 Score
1. Number of native species	16	6.7	15	6.7	18	6.7
2. Number of darter species	2	4.0	2	4.0	2	4.0
5. Number of intolerant species	3	6.7	3	6.7	3	6.7
6. Percentage as tolerant species	1.7	6.7	0.7	6.7	2.0	6.7
7. Percentage as omnivores, herbivores	6.4	6.7	11.6	4.0	25.2	1.3
8. Percentage as specialized insectivores	14.3	1.3	13.5	1.3	23.3	4.0
10. Catch rate per unit of effort	25.4	6.7	15.6	4.0	29.7	6.7
11. Percentage as darters and sculpins	76.9	6.7	73.0	6.7	45.4	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	1.2	6.7	0.5	6.7	1.0	6.7
Total		52.2 Good		46.8 Good		46.8 Good

Table 73. Fish capture data from Betty Creek at the Hambidge Center (RM 4.3).

Species (common name)	Number of Individuals 1996	2003	2008
Mountain brook lamprey	36	15	33
Rainbow trout	16	4	21
Brown trout			4
Central stoneroller	9	35	101
Smoky dace	17	14	24
Warpaint shiner	21	30	92
River chub	11	17	77
Tennessee shiner	38		52
Yellowfin shiner		1	3
Yellowfin shiner x smoky dace			1
Yellowfin shiner x Tennessee shiner			1
Mirror shiner		4	12
Fatlips minnow			7
Longnose dace	30	24	6
Creek chub	1	2	9
Northern hogsucker	5	7	13
Black redhorse			2
Golden redhorse	1	2	
Rock bass	1	4	2
Redbreast sunfish	4	1	8
Green sunfish	9	1	3
Bluegill			1
Tuckaseigee darter	2	1	2
Yellow perch			4
Gilt darter	13	7	8
Mottled sculpin	672	425	386
Total	892	594	872

Table 74. Macroinvertebrate sample data from Betty Creek at the Hambidge Center (RM 4.3).

Taxa	2008 Classification
Ephemeroptera	
Baetidae	
Acentrella turbida	C
Baetis intercalaris	C
Baetis bimaculatus	R
Baetis pluto	A
Baetis tricaudatus	A
Ephemerellidae	
Ephemerella dorothea	R
Drunella cornutella	C
Serratella deficiens	A
Serratella seratoides	R
Ephemeridae	
Hexagenia spp.	R
Heptageniidae	
Epeorus dispar	A
Heptagenia marginalis	C
Stenacron pallidum	R
Stenonema modestum	A
Stenonema pudicum	C
Rithrogena spp.	C
Leptophlebiidae	
Paraleptophlebia spp.	A
Oligoneuridae	
Isonychia spp.	C
Plecoptera	
Leuctridae	
Leuctra spp.	A
Peltoperlidae	
Tallaperla spp.	A
Perlidae	
Acroneuria abnormis	A
Paragnetina inmarginata	C
Perlesta placida	A
Perlodidae	
Isoperla holochlora	C
Pteronarcyidae	
Pteronarcys spp.	A
Trichoptera	
Brachycentridae	
Brachycentrus spinae	A
Glossosomatidae	
Glossosoma spp.	C
Goeridae	
Goera spp.	R
Hydropsychidae	
Cheumatopsyche spp.	A

Symphitopsyche bronta	A
Symphitopsyche sparna	A
Lepidostomatidae	
Lepidostoma spp.	R
Limnephilidae	
Pycnopsyche guttifer	R
Philopotamidae	
Dolophilodes spp.	A
Polycentropidae	
Polycentropus spp.	R
Rhyacophilidae	
Rhyacophila fuscula	A
Rhyacophila carolina	R
Uenoidae	
Neophylax oligius	C
Ephemeroptera taxa	**18**
Total EPT taxa	**38**

Betty Creek at Messer Creek Rd. (RM 4.8)

In our first visits to this site (1996 and 1997), it maintained a Good bioclass rating (IBI's of 49.5 and 52.2). But during 4 samples over the period 2001-2004 we found it to rate only Fair (IBI 44.1, dropping to 41.4 in 2004), while 3 downstream sites continued to rate Good during 8 monitoring visits during 1998-2007. In 2008, the IBI at Messer Creek Rd. rebounded to 49.5 (Good), but with some differences compared to 1996-1997. (To facilitate comparison, data from the 1996 sample are shown in Table 32 together with those from the 2 most recent samples. Omitted are data from 1997, 2001, 2002 and 2003.)

Inspection of the data for the 3 samples shown in Table 32 shows long term negative trends in observed value for 3 metrics often associated with increased nutrient concentration and/or sedimentation – Metrics 6 (proportion of tolerants), 7 (proportion of omnivores and herbivores) and 11 (proportion of darters and sculpins), with a drop in score for the latter two. It also shows a clear trend of improvement in Metric 8 (proportion of specialized insectivores), based almost entirely on a population explosion between 2004 and 2008 by a single species (warpaint shiner, *Luxilus coccogenis*). These are all trends observable elsewhere in Betty Creek and throughout the upper Little Tennessee watershed, with the exception that increase in observed values for Metric 8 usually involves several species of column-dwelling cyprinids, rather than just the warpaint shiner.

Although total fish abundance at this site ranked 3d among 8 years of sampling, record numbers of individuals were recorded for 8 species. In addition to the warpaint shiner, these include one other normally rare column-dwelling specialized insectivore, the mirror shiner (*Notropis spectrunculus*), 2 benthic specialized insectivores (Tuckaseigee darter, *Etheostoma blennioides gutselli* and gilt darter, *Percina evides*), an omnivore and an herbivore (creek chub, *Semotilus atromaculatus* and mountain brook lamprey, *Ichthyomyzon greeleyi*, respectively), and three tolerants (creek chub; green sunfish, *Lepomis cyanellus* and the tolerant exotic redbreast sunfish, *Lepomis auritus*). Two other species which increased in numbers between 2004 and 2008 are the herbivorous central stoneroller (*Campostoma anomala*) and the omnivorous river chub (*Nocomis micropogon*), although neither recorded record abundance. The only species for which longterm population decline is suggested are the exotic rainbow trout (*Oncorhynchus mykiss*) and the column-dwelling specialized insectivore Tennessee shiner (*Notropis leuciodus*).

It is difficult to know what to make of such an eclectic mix of trends, particularly since the most conspicuous trend, across numerous sample sites during 2007-2008, explosive population growth by the central stoneroller, is not evident here. In an attempt to tease out causes and effects we note two changes, one positive and one negative, at the Messer Creek Rd. site:

- A plant nursery located not far upstream closed between 2004 and 2007. This facility may have been a source of agrochemical pollution. In 2004 a noticeable increase in green algae at this monitoring site was tracked to a flood plain pond at the nursery with a severe algal bloom, suggesting it was a source of nutrients as well.

- An ongoing negative trend is increased sedimentation, visually detectable along the bank of a large pool located above the Messer Creek Rd. bridge.

Reduction in the level of chemical toxins would presumably benefit insectivorous species, reduction in nutrient pollution and algal crop could cancel out other factors favoring stonerollers, and an increase in the availabilty of heavily sedimented shoreline and backwater habitat could benefit the tolerant creek chub and sunfishes. However, all of this is conjecture; especially in the context of undefined trends on lower Betty Creek, interpretation of the data from this site awaits further sampling in the years to come.

Table 75. IBI metrics and scores from Betty Creek at Messer Creek Rd. (RM 4.8).

	1996		2004		2008	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	14	6.7	14	6.7	18	14
2. Number of darter species	2	4.0	1	4.0	2	2
5. Number of intolerant species	3	6.7	3	6.7	3	3
6. Percentage as tolerant species	2.6	6.7	6.6	6.7	7.4	2.6
7. Percentage as omnivores, herbivores	7.2	6.7	13.4	4.0	16.7	7.2
8. Percentage as specialized insectivores	16.2	1.3	17.2	1.3	27.9	16.2
10. Catch rate per unit of effort	25.0	6.7	10.4	1.3	21.9	25.0
11. Percentage as darters and sculpins	68.1	6.7	64.4	4.0	47.4	68.1
12. Percentage with disease, tumors, fin damage and/or other anomalies	2.1	4.0	0.2	6.7	0.3	2.1
Total		49.5		41.4		49.5
		Good		Fair		Good

Table 75. Fish capture data from Betty Creek at Messer Creek Rd. (RM 4.8).

	Number of Individuals		
Species (common name)	1996	2004	2008
Mountain brook lamprey	8	38	49
Rainbow trout	24	10	8
Brown trout		1	1
Central stoneroller	25	9	22
Smoky dace	30	13	31
Warpaint shiner	32	26	117
River chub	7	5	23
Warpaint shiner x river chub			1
Tennessee shiner	7		1
Yellowfin shiner			1
Mirror shiner			3
Fatlips minnow			
Longnose dace	14	24	8
Creek chub		4	10
White sucker			
Northern hogsucker	16	7	9
Black redhorse			2
Golden redhorse	1		1
Rock bass	1	5	3
Redbreast sunfish	5	4	22
Green sunfish	10	1	14
Bluegill		1	1
Largemouth bass		1	
Tuckaseigee darter	3		4
Gilt darter	5	3	10
Mottled sculpin	378	267	281
Total	552	419	623

A few words on benthic macroinvertebrate monitoring and physical habitat assessment:

The Index of Biotic Integrity (IBI), based on sampling the fish assemblage, is just one way to assess the biological health of aquatic ecosystems. It is one we have emphasized in the upper Little Tennessee watershed for two reasons:

- It takes advantage of the particular skills and knowledge of the biomonitoring program founder and director.

- It provides an excellent opportunity to involve local volunteers in the monitoring process in a way which is fun, educational, and yields understandable results with a short time (starting 15 minutes after the completion of the sample).

However, volunteers sometimes walk away with the impression that fish-based IBI is the be-all and end-all of aquatic biomonitoring, which it is not. This is particularly evident in certain situations (sites with drainage areas of <4 sq. mi, gradients of >100 ft. mi., or at high elevations above barriers to upstream fish movement) which have naturally low fish diversity.

During most years between the initiation of the program in 1990 and 2008, we have endeavored to incorporate some level of analysis of the benthic macroinvertebrate assemblage (a practice with a longer history than fish-based biomonitoring) into our work on such sites. However, we have been limited by the simultaneous lack of expertise to do taxonomic analysis of macroinvertebrate samples and funds to pay experts to provide this service. A further limitation is our relative lack of interpretative capability for macroinvertebrate data, as compared to what we can bring to bear on fish sample results.

We have made the best of the situation by each year selecting only a few sites in the above categories, collecting macroinvertebrate samples using a TVA protocol, sending them to a variety of experts for identification and, in recent years, plugging the macroinvertebrate data into a small stream IBI developed by Gary Williams of TVA (Williams, 1996) for use in monitoring high altitude brook trout (*Salvelinus fontinalis*) streams in the Hiwassee watershed of North Carolina, Tennessee and Georgia. Even with our own modifications (McLarney, 1999), the limitations of the "brook trout" IBI in our watershed, and particularly in the valley level streams which comprise the majority of our small stream sites, is manifest.

Our monitoring schedule for 2008 included only 3 sites on streams so small (Dalton Creek and Cat Creek at the James Waldroop farm) or high gradient (Walnut Creek) as to preclude the use of an exclusively fish-based IBI, but we were fortunate to be able to incorporate macroinvertebrate data for these and 3 other sites.

For 2009 we plan to increase the number of sites on which we carry out macroinvertebrate samples. While we will still not be able to do so for all sites (economic realities continue to prevail) we will incorporate benthic macroinvertebrate indices in our analyses, not only for those sites which, by virtue of size, gradient or altitude, obligate incorporation of macroinvertebrates in any biotic index, but also for a selection of other sites considered to be the most important or where macroinvertebrate data will add the most value.

In past years we have also occasionally applied and reported on physical habitat assessment of monitoring sites, using a variant of the USDA Stream Visual Assessment Protocol (SVAP) (USDA 1998; Little Tennessee Watershed Association 1996), but we have yet to fully integrate this method into our routine procedures.

We hope to eventually reach the point where we can include both physical habitat assessment and benthic macroinvertebrate sampling, along with the fish sample, at every one of our monitoring sites each year. The model for this approach exists in a program directed by the director of the LTWA Biomonitoring Program for the Asociacion ANAI Stream Biomonitoring Program in Talamanca, Costa Rica and Bocas del Toro, Panama (McLarney and Mafla, 2008). The approach there involves carrying out all 3 methodologies and applying all 3 indices on the same day for all monitoring sites, in conjunction with local volunteers, then arriving at an overall Bioclass Rating through consensus, incorporating information and results from all 3 indices.

In general, we have found that fish-based monitoring works best when dealing with the effects of habitat alteration, including sedimentation, while benthic macroinvertebrates are more sensitive indicators for point source pollution, and particularly for toxic effects. Physical habitat assessment aids in integrating the results of the two biologically based methods and in analyzing cause and effect and interpreting these mechanisms to lay volunteers. We will not consider the upper Little Tennessee Watershed Program to be complete until we are able to consistently apply and integrate these 3 monitoring protocols and their respective indices.

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This has been a year of positive transition for the Upper Little Tennessee Watershed Biomonitoring Program. In her second year as Executive Director of the Little Tennessee Watershed Association, which manages this program, Jenny Sanders, with the help of a revitalized Board of Directors (Stephanie Laseter, president) has begun to achieve not only maintenance of the program, but needed growth.

One of the tangible results of this growth is the hiring of Noa Sparks as a part time technical assistant. Along with administrative assistant Jill Wiggins he will play a major role in finalizing, publicizing and circulating this report (and past reports as well).

Former volunteer Warren Stiles assumed the role of seasonal field assistant in 2008 and will return for 2009 as a worthy successor to several other excellent young people who have occupied this post.

A total of 91 volunteers contributed one or more days of their time to the field work in 2008. The most frequent participant was Danielle Bouchonnet. A complete list of volunteers follows this section.

While many volunteers come to us as individuals, we need to acknowledge those individuals and organizations that help in volunteer recruitment or organize groups of volunteers. For 2008 they include Barry Clinton (Coweeta Hydrologic Lab), Gillian Denham and Brian Gifford (The Mountain), Brent Martin (The Wilderness Society) and Tammy Stanfield.

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Macroinvertebrate monitoring services were generously provided by Watershed Science, Inc. (Dave Penrose and Steve Foster), with whom we plan to collaborate more closely in the years to come. We were also provided with macroinvertebrate data for several sites by the North Carolina Ecosystem Enhancement Program (Cathy Tyndall and Andrea Leslie).

Josh Pope of the Macon County Mapping Department and Macon County Planner Stacy Guffey provided invaluable assistance with mapping related to the program.

Our expanding role in educational outreach was facilitated through outstanding effort by Highlands High School teacher Adrian Holt who has built a curriculum we hope will eventually be widely applied in schools throughout the watershed, building on an initiative begun by Fabiana Silva of Coweeta Hydrologic Lab and supported by Ted Gragson of the same institution.

As the reach of the Biomonitoring Program expands, it is increasingly difficult to tell where our work stops and others' work begins. This is especially true in the case of the Ecosystem Enhancement Program, who is embarked on a study of a major portion of our watershed aimed at leading to community involvement in restoration, under the direction of Andrea Leslie. She has also been the principal force giving direction to a study of barriers to upstream fish movement in Little

Tennessee tributaries which overlaps broadly with our biomonitoring work, in addition to serving as a more than occasional volunteer.

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Volunteers

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Avery Alexander
Brandon Andreu
Caleb Andreu
Mike Barber
Kristi Barber
Eddie Barker
Betsy Baste
Danny Beavers
Laura Berrier
George Blakely
Bart Blichmann
Leslie Bondurant
Chad Boniface
Bob Bouchonnet
Denielle Bouchonnet
Chris Brouwer
Holly Bullis
Matt Bullis
Samantha Bullis
Mark Cantrell
Amber Chiarelli
Ayres Christ
Joyce Coombs
Mary D'Onofrio
Sarah Duberdorff
Casey Dunn
Mitch Dye
Susan Ervin
Conner Esterwood
Danitza Flores
Brian Gifford
Anita Goetz
Emily Goodheart
Jim Grode
Adam Hart
Casey Hatmaker
Jessie Hewitt
Dick Heywood
Josh Hina
Adrian Holt
Christy Hopes
Rita Hubbs
Norma Ivey
Darron Keenan
Jess Keenan
Reggie Kilmer
Amy Lebo
Andrea Leslie
Emily Lorisch
Conner Magill
Chelsea Maier
Brent Martin
Dave Matthews
Julie Mayfield
Mike Millette
Tim Milling
Mike Miltner
Berney Pellett
Eliza Pemberton
Sally Petrie
Stan Polanski
Steve Poole
Jacob Rekoon
Angie Rogers
Dan Roland
Crystal Rubel
Jenny Sanders
Charlie Saylor
Greg Shafer
J.R. Shute
Fabiana Silva
Danielle Steine
Elbie Stiles
Elsa Stiles
Kaitlyn Sutton
Camile Tucker
Scharf Turner
Kathy Tyndall
Ty Underwood
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