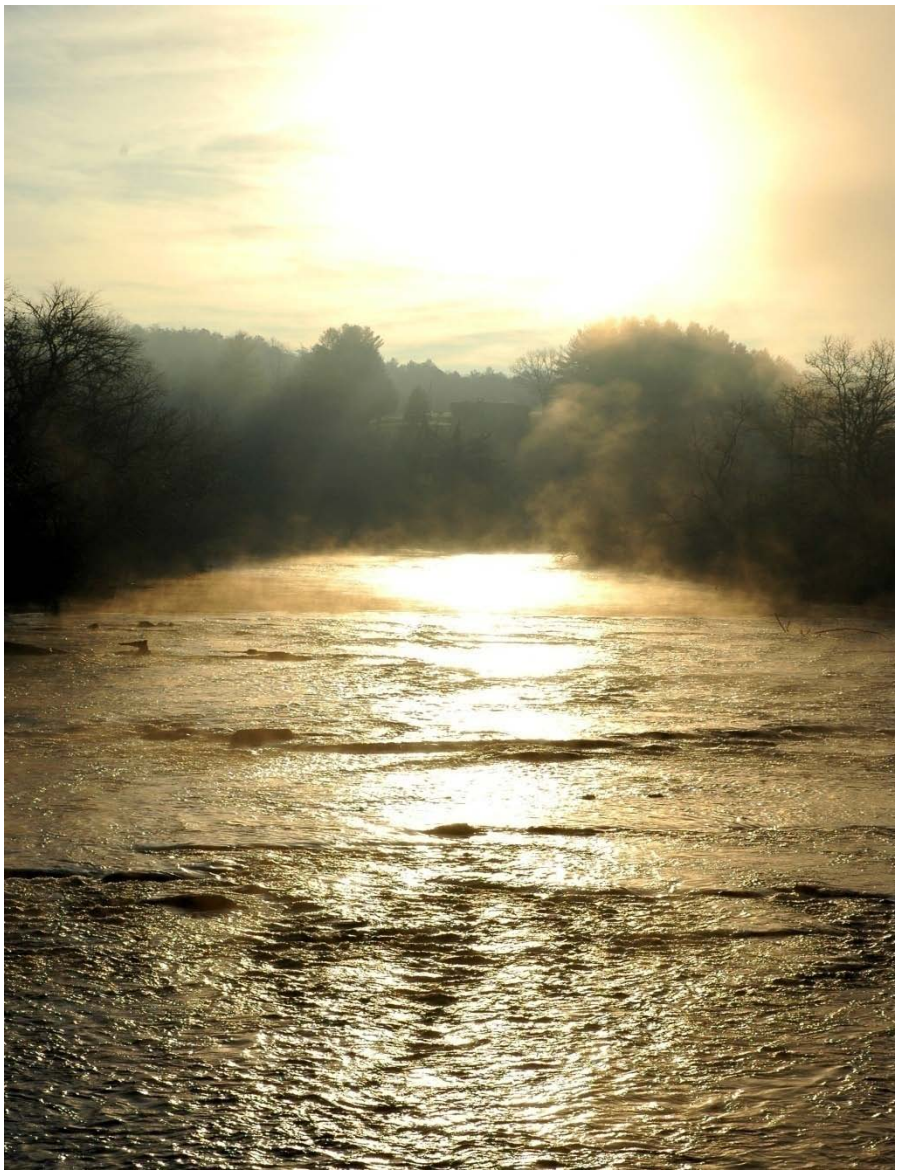
Index of Biotic Integrity (IBI) Monitoring

In The Upper Little Tennessee Watershed

2007



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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 154 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 (2000 annual report, two stations on Sutton Branch at Rabun Gap-Nacoochee School).

Over the course of time, it was found necessary to move one fixed station (Cullasaja River at Wells Grove, see McLarney, 1996); although this station was monitored in 2007 its validity as a fixed station is in doubt as a consequence of extreme channel instability. Four stations have 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. 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.

It has gradually become clear that it will be useful to monitor Peeks Creek above Peeks Creek Rd. as a fixed station, and from now on it will be so designated. Including Peeks Creek, at this time 11 sites are designated as fixed stations. All fixed stations along with years of monitoring are listed in table 1 along with all stations monitored in 2007. During some years (as recently as 2005) high water has been an impediment to monitoring some of the larger fixed stations. In contrast, the 2007 season featured record low water throughout the season. Nevertheless, one of the fixed stations was not monitored this year, for reasons which will be detailed in the section on results. The 9 fixed stations visited in 2007 are supplemented by 19 sites previously monitored at least once and 2 new sites. Location of all sites is shown in Figure 2. Rationale for selection of all non-fixed station sites monitored in 2007 is given in the following section.

Following discussion of rationale for site selection, and a presentation of monitoring criteria (tables 3-9), the bulk of this report is devoted to presentation and interpretation of monitoring results, including fish sampling data (all sites) and macroinvertebrate sampling data (2 small stream sites). Stimulated by the first capture of a new exotic fish species (spotted bass, *Micropterus punctulatus*) in the Little Tennessee, we have added a short section updating the presence and status of invasive aquatic animals, principally fishes, in the Upper Little Tennessee Watershed.

Rationale for Non-Fixed Station Sites

For most significant sites we try to maintain a 5 year sampling rotation. Sites chosen on that basis in 2007 were Cullasaja River above Cullasaja Falls, Hickory Knoll Creek above Hickory Knoll Road, Little Tennessee River at Tessentee Farm and Little Tennessee River above Franklin Road.

A major and ongoing emphasis for the Little Tennessee Watershed Association in 2007 is the Cartoogechaye Creek Municipal Watershed Assessment project, of which IBI biomonitoring is but one component. The Assessment seeks to help the Town of Franklin plan for conservation of what is presently their only source of municipal water supply. As part of the assessment, we sampled 4 sites on the Cartoogechaye Creek mainstem above the municipal water supply intake at RM 6.0 and one site in the lower reaches of each of the creek's 4 major tributaries. (Our Cartoogechaye Creek fixed station at the Macon County Rec Park is located below the intake.) All of these sites except for one on the mainstem immediately upstream of the water intake have been monitored in 2-13 previous years.

The Cowee Creek watershed, presently being impacted by megadevelopment in the headwaters of its tributary Caler Fork, continues to be a cause of concern. We monitored one site in the lower reaches of the Cowee Creek mainstem and did a repeat visit to a site on Caler Fork which between 2005 and 2006 showed spectacular degradation apparently due to sedimentation caused by development activity. We were unfortunately unable to complete a third site on Cowee Creek above Caler Fork due to landowner access problems.

Two sites in Georgia were visited in relation to monitoring activities by the Georgia Department of Natural Resources. The Georgia DNR requested that we monitor a site on the Little Tennessee mainstem above Georgia Highway 246 (Scaly Mountain Rd.); this was a new site for us. The other Georgia DNR-related site, on Mud Creek above Kelly Creek Rd. was sampled because of our doubts about site selection for a 2004 Georgia DNR biomonitoring sample (included in our annual report for that year) which yielded results substantially different from our previous samples on this reach of Mud Creek.

We began annual monitoring of Blaine Branch just above its mouth in 2003, with the understanding that it was to be a DOT restoration site. This plan was cancelled, but we continued to monitor, hoping to document natural improvement following removal of cattle from the site. However, beavers have essentially taken over this site, and it is probable that 2007 will represent the last year of sampling for this site.

Peeks Creek above Peeks Creek Rd. was first monitored in 2005, following a December, 2004 mudslide which ranks among the greatest natural disasters in Little Tennessee Watershed history. As in the case of Blaine Branch, restoration efforts have stalled, but three consecutive years of monitoring have documented significant improvement, and beginning in 2008 the Peeks Creek site will be treated as a fixed station.

Two previously monitored sites we might not otherwise have selected in 2007 (Little Tennessee River in Wolf Fork Valley and Coweeta Creek below the old McClure Mill site) were monitored at the request of landowners.

IBI Scoring Criteria

IBI scoring criteria here applied to sites with watershed drainage areas of 4 square miles or more are those proposed by McLarney (1995a), as modified from Saylor and Ahlstedt (1990). These criteria are presented in tables 3-9.

For certain types of stream sites, including those draining less than 4 square miles, 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 3 of the sites monitored in 2007) are thought to be characterized by naturally low fish diversity, such that another assemblage of organisms (benthic macroinvertebrates) must be taken into account in assessing biotic integrity. One of these sites, Cullasaja River above Cullasaja Falls, is so atypical that no index was attempted; we simply report results of the fish sample. 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 8) in a modified version proposed by this author (McLarney, 1999).

Note that no criteria are given for stream sites with watershed areas of 70-150 square miles, 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). One site in this size range (Cullasaja River at Wells Grove) was monitored in 2007. It is scored using metrics for streams in the 40-70 square miles watershed size category.

Table 9 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 class (Karr, et al. 1986).

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	Original TVA Little Tennessee fixed station
Little Tennessee R.	118.0	Head L. Emory	200	1995-2000, 2002, 2004, 2006	Transition between upper and lower river
Little Tennessee R.	136.9	State Line	55	1990,1992-2002, 2004, 2006	NC/GA state line
Rabbit Cr.	0.8	Above Rabbit Cr. Rd.	8	1992, 1992-2007	Ideal for high school class
Cullasaja R.	0.9	Wells Grove	93	1995-2002, 2004, 2006	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, 1992-2007	Second largest Little T tributary
Middle Cr.	2.2	W. Middle Cr. Rd.	10	1992, 1992-2007	Follow results of restoration upstream
Cullasaja R.	8.3	Peaceful Cove	55	1991, 1993-2007	Track effects of Highlands WWTP
Wayah Cr.	0.6	Crawford Rd.	13	1990,1993,1996-2007	Track effects of package treatment plant
Skeenah Cr.	0.5	NC Welcome Center	6	1994-1995,1997-2007	NCCAT - ideal teaching site

Table 2. Sites monitored in the Little Tennessee watershed with corresponding year (unless otherwise noted) and IBI class.

Site	2005	2006	2007
Fixed Station 1: Little Tennessee River at Needmore Rd. (RM 95.5)	2004 Good	Good	
Fixed Station 2: Little Tennessee River at Head of Lake Emory (RM 118.0)		Fair	Fair
Fixed Station 3: Little Tennessee River at North Carolina/Georgia state line (RM 136.9)	2004 Fair	Fair	Fair
Fixed Station 4: Peeks Creek at Jones property Above Peeks Creek Rd. (RM 0.3)			
Fixed Station 5: Rabbit Creek above Rabbit Creek Rd (RM 0.8)	Poor	Fair	Poor
Fixed Station 6: Cullasaja River at Macon Middle School (RM 0.9)		Fair	Fair
Fixed Station 7: Cartoogechaye Creek at Macon County Recreation Park (RM 1.0)	Fair	Fair	Fair
Fixed Station 8: Middle Creek at West Middle Creek Rd. (RM 2.2)	Fair	Good	Fair
Fixed Station 9: Cullasaja River at Peaceful Cove (RM 8.3)	2004 Fair	Good	Fair
Fixed Station 10: Wayah Creek at Crawford Rd. (RM 0.6)	Fair	Fair	Fair
Fixed Station 11. Skeenah Creek at North Carolina Welcome Center (RM 0.5)	Poor	Poor	Poor
Cowee Creek at Wests Mill (RM 0.7)		Good	Good
Caler Fork at Holbrook/Tucek property line (RM 0.4)	Good	Poor	Good
Cullasaja River above Cullasaja Falls (RM 11.9)			
Blaine Branch above Mouth (RM 0.1)			
Cartoogechaye Creek above Franklin Municipal Drinking Water Plant (RM 6.1)			Fair
Mill Creek (Cartoogechaye tributary) above Old Murphy Rd. (RM 0.3)	1999 Poor	2005 Fair	Poor
Cartoogechaye Creek at Mt. Hope Baptist Church (RM 7.5)	2003 Good	2004 Good /Fair	Good
Cartoogechaye Creek at Killian Farm, Experimental Sector (RM 10.7)	2002 Fair		Fair

Site	2005	2006	2007
Poplar Cove Creek above Corpening Fd. (RM 0.4)	1993 Fair	1999 Fair	Fair
Cartoogechaye Creek at Cartoogechaye Baptist Church (RM 11.2)	1999 Fair	2001 Fair	Good
Allison Creek below W. Old Murphy Rd. (RM 0.4)	1999 Good	2001 Fair	Fair
Jones Creek below N. Jones Creek Rd. (RM 0.6)	1999 Fair	2001 Fair	Fair
Hickory Knoll Creek above Hickory Knoll Rd. (RM 0.4 - 0.5)	1995 Fair	2001 Fair	Fair
Coweeta Creek at Old McClure Mill dam site (RM 0.5)	2003 Good	2004 Good /Fair	Good
Little Tennessee River at Tessentee Farm (RM 126.9)	2001 Poor		Poor
Little Tennessee River above Ga Highway 246 (Scaly Rd.) (RM 137.6)	*2007* *Above 246* Good		*2007* *State Line* Fair
Mud Creek at Kelly Creek Rd. (RM 0.7)	2003 Poor	2005 Very Poor	Fair
Little Tennessee River above Franklin Rd. (RM 139.6)	Poor	Fair	Fair
Little Tennessee River at Wolf Fork Valley (RM 142.9)	Poor	Fair	Fair

Table 3. 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 4. 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 5. 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 6. 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 7. 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 8. 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 9. 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.

Results and Discussion

Following the format established in McLarney (1995), in Tables 10-67 data are presented for each of the 30 monitoring sites for 2007 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, regardless of their presence in 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, *Lepomis macrochirus* hybrid would be scored as a redbreast sunfish, since that species is considered a tolerant, and is also an exotic.)

General Comment

IBI results are normally site or watershed-specific; we do not normally see strong trends across watershed lines. However, the 2007 data show two remarkably consistent and presumably related trends. Of a total of 28 sites monitored in 2007, 23 had been monitored, with the IBI calculated, on 2 to 17 previous occasions. For 19 of these 23 sites, we recorded a higher total fish catch than in the previous year of sampling, and in 15 instances the catch rate was the highest ever recorded at the site. The trend was strongest during the first half of the monitoring season (May 22-July 6). For all 13 sites monitored during this period the total fish catch was higher than in the previous year of sampling, with 11 record highs.

The only species which tracked this trend (although it was far from totally responsible for the increase in total fish numbers)was the herbivorous central stoneroller (*Campostoma anomala*), which on 19 of 23 sites was captured in greater numbers than in the previous year of sampling, with record catches at 15 sites. As with total catch, this trend was strongest during the first half of the season – higher stoneroller catch compared to the previous year of sampling at 12 of 13 sites, with 11 record catches.

Over the years we have seen differences in total fish catch related to flow rate. For example, following the December, 2004 flood, catch rate was down at nearly all sites, presumably as a consequence of a high rate of displacement of small and weak swimming fish during peak flows. In 2006-2007, the reverse trend occurred; there were no flows approaching flood level between the end of our summer 2006 sampling season and the start of the 2007 season and total fish catch was uniformly high.

With regard to the stoneroller data, it may be that stonerollers are unusually susceptible to displacement during high flows and/or attracted to low flows, but there is another plausible explanation. 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 stonerollers reacted 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.

In 12 instances, the increase in stoneroller abundance resulted in a higher observed value for Metric 7 (proportion of individuals as omnivores and herbivores); in 5 cases observed value for Metric 7 was the highest ever recorded at the site. While our metric criteria still do not permit us to alter the score for Metric 10 (catch per unit effort) when the observed value rises above a certain level, several sites had what appeared to us to be exaggerated overall abundance of fish; 7 sites recorded catch rates more than double the previous rate.

IBI was designed to evaluate anthropogenic effects on natural assemblages; normal practice would be to not rate a stream site immediately after a natural event of catastrophic proportions. Since one of the characteristics of a site with high biotic integrity is resiliency, we would expect high quality sites to recover rapidly and previously stressed sites to show less resilience. 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 Western North Carolina over the past 2 decades or more, and the ongoing drought of 2006-2007 are related to anthropogenically induced climate change. In which case the IBI may be serving as an early indicator; it will be interesting to follow the trends suggested here, and others which may develop if the present drought continues into 2008 and beyond.

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

This site, which cannot be properly sampled without the use of the TVA shocker boat, was not monitored in 2007 due to unavailability of this boat. We consider this unfortunate, since this is the single most important monitoring site in our watershed, and because although in 2006 it received an IBI score of 56 (Excellent), over the past several years we have identified several negative trends at Needmore, not all of which are immediately or directly reflected in the Metric values.

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

This site was done in two phases: The boat shocker sample was carried out on July 24, but due to high water levels it was not possible to complete the backpack sample until August 10. While such a long interval between samples is certainly undesirable, it may have been compensated for somewhat by the excellent conditions (low, clear water) when the backpack sample finally was done. Often on this site we have difficulty holding the seine in the riffle and deep run samples and in perceiving and netting fish on some of the shoreline samples; no such difficulties were experienced in 2007.

We can therefore with some confidence say that, although development on the downstream left corner of the US 441 bridge and eroding pasture on the upstream right side continue to bleed sediment into this site, no significant changes in its biotic integrity have occurred over the past several years (Bioclass Rating consistently Fair, with IBI scores in the 40-42 range since 2004.)

However, the stability of the biotic condition at this site which a casual perusal of the IBI scores might suggest, is thrown into question by oscillations in the individual metrics. In our report on 2006 biomonitoring we noted for this site that "the 2006 sample at the Bypass Fixed Station sends mixed signals, with improvement in some aspects offset by the disappearance of some species and apparent deterioration of some portions of the habitat." The same might be said of the 2007 sample - between 2006 and 2007 scoring values changed for 5 of the 12 metrics, with 3 improving and 2 declining. Some of these changes are of doubtful significance, but two stand out:

- On the negative side, the proportion of tolerant species in the sample (Metric 6) which had improved greatly between 2003 and 2005, returned to normal for this site (score of 1) in 2007. On the other hand, while darter catches have been declining here over a period of years, with 3 of 4 species historically known from the site largely disappearing between 1995 and 1999, and culminating in no adult darters of any species being taken in 2006, the 2007 sample contained 2 darter species. The intolerant gilt darter (*Percina evides*) was represented by 3 large individuals, including a breeding pair. Perhaps more significant was the capture of 2 adult olive darters (*Percina squamata*), last documented on this site in 1999 (McClarney 1999).

- Also encouraging was the increased numbers of the Tennessee shiner (*Notropis leuciodus*). Low catches of this species in some earlier years were attributed to the difficulty of sampling this site, where the Tennessee shiner almost exclusively inhabits a deep, swift run area. However, for both the 2006 and 2007 samples conditions were optimal for sampling this run, inclining us to believe that the observed increase in abundance is real.

The record catch of the exotic yellow perch (*Perca flavescens*), first documented from the upper Little Tennessee watershed at this site in 1995 was also notable for the large size of some individuals – up to 12 inches TL.

We customarily remark on the development pressures impinging on this site, given its location near the most significant highway interchange serving Franklin. However, this year the pressure has increased, with the completion of construction of the new Southwestern Community College Franklin campus and Franklin Public Library nearby. These developments, plus economic pressures, have led to a DOT proposal to build a new access road which could involve a second bridge across the Little Tennessee at this point. This project is being opposed by a coalition of forces taking into account, among many other issues, the importance of this reach of the Little Tennessee, between the confluences of Cartoogechaye Creek and the Cullasaja River, as a buffer between the upper river and the urban area of Franklin, including Lake Emory.

Table 10. IBI metrics and scores from fixed station 2: The Little Tennessee River at the head of Lake Emory (RM 118.0).

	2006		2007	
Metric	Value	Score	Value	Score
1. Number of native species	18	3	21	5
2. Number of darter species	1	1	3	3
3. Number of centrarchid species, other than M*icropterus*	5	5	5	5
4. Number of sucker species	3	3	3	3
5. Number of intolerant species	1	1	2	3
6. Percentage as tolerant species	6.2	5	17.7	3
7. Percentage as omnivores, herbivores	18.7	3	16.0	3
8. Percentage as specialized insectivores	31.2	3	26.6	3
9. Percentage as piscivores	5.2	5	1.7	3
10. Catch rate per unit of effort	14.4	5	15.3	5
11. Percentage as darters and sculpins	11.1	3	10.0	1
12. Percentage with disease, tumors, fin damage and/or other anomalies	1.2	5	4.0	3
Total		42 Fair		40 Fair

Table 11. 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)	2006	2007
Mountain brook lamprey	2	
Rainbow trout	1	
Brown trout	1	
Central stoneroller	34	16
Smoky dace		
Common carp		2
Whitetail shiner	18	27
Warpaint shiner	61	26
River chub	71	65
Golden shiner		
Tennessee shiner	88	77
Yellowfin shiner	47	19
Tennessee x yellowfin shiner		3
Silver shiner		
Mirror shiner	12	2
Fatlips minnow	1	3
Creek chub	1	1
White sucker		
Northern hogsucker	41	41
Black redhorse	46	39
Golden redhorse	13	25
unid. Redhorse		1
Snail bullhead	2	1
Rock bass	9	4
Redbreast sunfish	30	89
Green sunfish	3	Present
Warmouth	2	1
Bluegill	12	7
Smallmouth bass	3	2
Largemouth bass	7	3
Black crappie		1
Tuckaseigee darter		3
Greenfin darter		
Yellow perch	10	20
Gilt darter		3
Olive darter		2
Mottled sculpin	64	47
Total	579	530

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

Three years of data are reported for this site because the 2006 sample was done as a TVA sample, with a combined TVA/LTWA crew. Whereas the LTWA fixed station is located downstream of the Lamb Rd. bridge, TVA selected a site upstream of the bridge in order to better represent the riffle component, and the two sites are not totally comparable.

Riffles are few, generally poorly developed, heavily sedimented and widely spaced in the reach of the Little Tennessee around the North Carolina/Georgia state line. Our IBI site monitored since 1990 normally features a low quality riffle which presents varying conditions, even disappearing as a riffle in some years. Our 2004 sample included nothing which could properly be termed a riffle, but the 2007 sample, laid out exactly as in 2004, included two low quality riffle areas, which had been riffles in some previous years, but which in 2004 were shallow runs with a substrate of sand and fine gravel. It could be argued that such shifts are normal in this reach of the river, and that variability in the availability of riffle habitat ought to be taken into consideration in tracking ecosystem health.

Be that as it may, the 2006 site selected by TVA included two riffles, described as follows in their report:

- The Lamb Road culvert creates a large plunge pool (too deep for us to sample), but at the downstream end of the culvert there is a short, very powerful, artificial riffle with a substrate composed of large, angular rubble used in road construction. At normal water levels, this riffle is too strong to securely hold a seine in, and the abrupt drop off to the deep pool creates dangerous conditions. However, under the low water conditions of summer, 2006 it was feasible to do a single subsample in this riffle and, as can be seen in table 12, it affected the IBI by enhancing the score for Metric 2 (no. of darter species).

- At the upper end of the 2006 IBI reach (located above Lamb Road) there is a steep, shallow, gravelly natural riffle which appears to be somewhat more stable than the one usually sampled. We carried out 3 sub samples there in 2006; omission of this data would not alter any IBI metric scores.

As can be seen from a cursory examination of Table 12, neither the change of site between 2004 and 2006, nor the change in physical conditions between 2004 and 2007 had a significant effect on the IBI. There are, however, significant differences in the composition of the fish assemblage among these samples. Two of these are directly related to the change in site location:

- In 2006 the culvert riffle yielded several large specimens of two darter species (Tuckaseigee darter, *Etheostoma blennioides gutselli* and greenfin darter, *Etheostoma chlorobranchium*) rarely seen in the Georgia waters of the Little Tennessee.

In 2007, water levels were again suitable for sampling this riffle, but the only fish species taken were central stoneroller, *Campostoma anomala*; river chub, *Nocomis micropogon* and mottled sculpin, *Cottus bairdii*; these fish were not included in computing the IBI.

- The 2006 sample yielded 81 golden shiners (*Notemigonus crysoleucas*), normally represented by 0-3 individuals at the State Line site. Almost all of these fish were taken directly off the mouth of Goldmine Creek, a small tributary which drains the 14 acre State Line wetland, which comprises prime golden shiner habitat.

Observed differences between the 2004 and 2007 samples were:

- Complete disappearance of the mountain brook lamprey (*Ichthyomyzon greeleyi*). While never abundant at this site, the only other time it was completely absent was in 1995, following a summer, 1994 flood/pollution episode which dramatically (but temporarily) lowered the IBI.

- A record catch of the exotic yellowfin shiner (*Notropis lutipinnis*). LTWA and TVA still lack accepted IBI scoring criteria for this species, but the Georgia DNR considers it a tolerant. If it were so scored in this sample, then the observed value for Metric 6 (% tolerants) would rise to 36.9, the score for this metric would drop from 5.5 to 1.1, leading to an IBI of 38.5, barely within the limits of the Fair Bioclass Rating.

- The lowest proportion of specialized insectivores (20.7%) since 2001, despite the partial natural restoration of riffle habitat.

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:

"In 2000, the North Carolina Division of Water Quality reported conductivity values of 350-427 umnos/cm microsiemens 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."

In 2007, improvement was indicated by the more normal color and odor of the water. However, whereas during 1990-1993, following a 12 month period with no discharge from this plant, IBI increased from 30 to 43 (Poor to Fair), as of June, 2007, after 9 months with the plant offline, there was no measurable response by the fish assemblage.

Upstream of this site 2.1 river miles in Georgia and an equal distance in North Carolina from the state line down to the confluence of Mulberry Creek and the Little Tennessee, remain on their

states' respective 303(d) lists by reason of "possible toxicity problems and low dissolved oxygen conditions, but not severe organic loading" (North Carolina) and "non-point urban runoff" (Georgia). It is interesting to note that a site just 2.7 river miles upstream (Little Tennessee River above GA Highway 246, which see), subject to the same history of stress from pollution, but with slightly better physical habitat, presented a marginally better IBI when monitored for the first time in 2007.

As in the previous closure in 1991, there is understandable pressure to find an occupant for the plant, which was Rabun County's largest employer. There is also a proposal for Rabun County to manage operations of the wastewater treatment facility, which could result in an interbasin transfer of treated wastewater from the main population center of Rabun County (located to the south, over the Eastern Continental Divide, in the Chattooga/Savannah watershed) to the Little Tennessee. These proposals are controversial and many local actors, including the LTWA and other conservation organizations, are involved in the decision process. The significance of the State Line site as a fixed station for biomonitoring is manifest. It will be interesting to see if there is an improvement in its biotic integrity in summer, 2008, after at least 21 months of no industrial discharge.

Table 12. IBI metrics and scores from fixed station 3: The Little Tennessee River at the North Carolina/Georgia state line (RM 136.9).

	2004		2006		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	18	5.5	21	5.5	16	5.5
2. Number of darter species	1	3.3	3	5.5	1	3.3
4. Number of sucker species	4	5.5	4	5.5	4	5.5
5. Number of intolerant species	2	3.3	2	3.3	2	3.3
6. Percentage as tolerant species	4	5.5	12.8	3.3	5.3	5.5
7. Percentage as omnivores, herbivores	30.7	1.1	36.9	1.1	30.8	1.1
8. Percentage as specialized insectivores	44.2	3.3	25.3	3.3	20.7	1.1
9. Percentage as piscivores	1	5.5	3	5.5	2	5.5
10. Catch rate per unit of effort	11.3	3.3	12.6	3.3	16.6	1.1
11. Percentage as darters and sculpins	7.3	1.1	13.3	1.1	6.6	1.1
12. Percentage with disease, tumors, fin damage and/or other anomalies	2.3	3.3	0.7	5.5	1.2	5.5
Total		40.7 Fair		42.9 Fair		42.9 Fair

Table 13. 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)	2004	2006	2007
Mountain brook lamprey	1	5	
Rainbow trout		7	1
Brown trout		1	2
Central stoneroller	44	12	89
Whitetail shiner	8	1	6
Warpaint shiner	94	76	25
River chub	73	45	77
Golden shiner	3	81	3
Tennessee shiner	44	12	69
Yellowfin shiner	44	47	189
Tennessee x yellowfin shiner	3	2	5
Mirror shiner	11	3	13
Fatlips minnow	4		
Longnose dace			
Creek chub		8	13
White sucker	1	2	4
Northern hogsucker	11	4	30
Black redhorse	3	5	7
Golden redhorse	2	1	5
Brown bullhead			
Snail bullhead			2
Rock bass	6	2	7
Redbreast sunfish	13	13	6
Green sunfish	2	29	9
Redbreast x green sunfish		1	
Warmouth			
Bluegill	1	1	
Smallmouth bass			
Largemouth bass	1	2	
Tuckaseigee darter		3	
Greenfin darter		4	
Yellow perch			1
Gilt darter	15	9	12
Mottled sculpin	14	39	29
Total	389	415	604

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

We have determined that it will be desirable to continue to monitor this site for many years into the future, thus de facto it becomes a fixed station. We here assign the number "Fixed Station 4" to fill the blank left by abandonment of the Iotla Creek fixed station site in 1999, and to maintain continuity.

Based on visual observation, the physical condition of the habitat in Peeks Creek is at best moderately improved over its post-disaster condition in 2005. There does seem to be some narrowing and redefinition of the channel (although a reduction in measured width may be principally a function of reduced flow in 2007) and the proportions of particle size in the substrate seems to be improving, with an increase in gravel suitable for fish spawning. (We did not carry out a numerical evaluation of physical habitat in 2007, since our SVAP index, adapted for local conditions, is under discussion.)

This year marked the first reappearance of the longnose dace (*Rhinichthys cataractae*), represented by 8 large and medium size adults. With the addition of brown trout (*Salmo trutta*) and mottled sculpin (*Cottus bairdii*) in 2006, we have now documented all 4 fish species known from Peeks Creek prior to the December, 2004 flood.

The dominant species continues to be the rainbow trout (*Oncorhynchus mykiss*), represented by a full range of sizes up to young adults. Most of these fish appeared to be in excellent condition. As in 2005 and 2006, the fish assemblage is still essentially "artificial"; any attempt to incorporate fish data in an IBI would produce misleading results, based on the high proportion of trout in the sample, but clearly there is improvement (although the absence of brown trout in 2007 was a surprise).

In 2005 we took only one crayfish (*Cambarus bartoni*), last year 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. However, the macroinvertebrate sample indicates a return to 2005 conditions, a conclusion which appears doubtful. 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.

Doubts about the macroinvertebrate sample render any attempt to apply the Williams "brook trout" IBI of doubtful value. Further comments about Peeks Creek will have to await the results of the 2008 sample.

Table 14. 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)	2005	2006	2007
Rainbow trout	51	87	66
Brown trout	0	4	0
Longnose dace	0	0	8
Mottled sculpin	0	1	Present*
Total	51	92	74

*Two individuals taken in voltage check just below monitoring reach, but none in actual fish sample.

Table 15. Macroinvertebrate capture data from fixed station 4: Peeks Creek at Jones property (A=abundant, C=common, R=rare).

Macroinvertebrate Classification	2005	2006
Ephemeroptera		
Baetidae		
Baetis tricaudatus	A	A
Plauditus sp.		A
Ephemerellidae		
Drunella sp.	R	A
Ephemerella sp.	C	A
Timpanoga sp.		R
Heptageniidae		
Epeorus dispar	C	A
E. rubidus/subpallidus		R
Maccaffertium (Stenonema)		
Modestum		C
M. (S.) sp.		C
Isonychiidae		
Isonychia sp.	C	C
Plecoptera		
Leuctridae		
Leuctra sp.	C	R
Peltoperlidae		
Tallaperla sp.		A
Perlidae		
unid.		R
Acroneuria abnormis	R	R
A. sp.	R	
Beloneuria sp.		R
Eccoptur xanthenes		R

Paragnetina immarginata		R
Perlesta sp.		C
Perlodidae		
Isoperla sp		A
Malirekus hastatus	R	R
Pteronarcidae		
Pteronarcys (Allonarcys) sp.	R	C
Trichoptera		
Glossosomatidae		
unid.	R	
Glossosoma sp.		C
Hydropsychidae		
Ceratopsyche sp.		A
Cheumatopsyche sp.	A	
Diplectrona modesta	C	
Lepidostomatidae		
Lepidiostoma sp.		R
Limnephilidae		
Hydatophylax sp.		R
Rhyacophilidae		
Rhyacophila fuscula	R	A
Uenoidae		
Neophylax sp.		C
Total Ephemeroptera taxa	5	10
Total EPT taxa	14	27

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

With renewed development-related disturbance of Cat Creek just upstream of the monitoring site, perhaps aggravated by consistently low flows resulting in poor flushing of accumulated sediment, the fixed station at Rabbit Creek returned to the Poor Bioclass Rating it has achieved every year since 2001, except for 2006. Improvements in Metrics 5 (intolerant species) and 7 (proportion of omnivores and herbivores) were erased, as two species (the herbivorous central stoneroller, *Campostoma anomala* and the exotic yellowfin shiner, *Notropis lutipinnis*) reached record levels of abundance, while the proportion of darters and sculpins (Metric 11) declined.

Rabbit Creek differs from other upper Little Tennessee tributaries of its size in two respects:

- Presumably because it drains into Lake Emory, rather than a free flowing portion of the Little Tennessee, it has no darters, thus guaranteeing a low score for Metric 2 (no. of darter species).
- It has a relatively low gradient (only Iotla Creek is similar in this respect) so that in low flow years there is on the one hand little displacement of small young fish, but also poor flushing of sediments. In 2007, these effects were reflected in the record high catch rate of 49.0 individuals per 300 sq. ft. of water surface (resulting in the high score for Metric 10) on the one hand, at the same time as declines were recorded in observed values for Metrics 8 (% specialized insectivores) and 11 (% darters and sculpins) which are sensitive to sedimentation.

One positive change between 2006 and 2007 was the return of the longnose dace (*Rhinichthys cataractae*) to the one strong riffle on the site. Although longnose dace have never been abundant here, 2006 was the first year the species failed to appear in the sample.

Although some environmental factors in the Rabbit Creek watershed have improved over the years (presumed decrease in golf course pollution, reduction of livestock in the creek) it would seem doubtful that Rabbit Creek can rise permanently above the Poor category so long as so much land in the watershed is subject to frequent disturbance due to development activities.

Table 16. IBI metrics and scores from fixed station number 5: Rabbit Creek at Rabbit Creek rd. (formerly Holly Springs Rd.) (RM 0.8).

	2005		2006		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	13	6.7	14	6.7	14	6.7
2. Number of darter species	0	1.3	0	1.3	0	1.3
5. Number of intolerant species	1	1.3	2	4.0	1	1.3
6. Percentage as tolerant species	6.2	6.7	3.3	6.7	2.9	6.7
7. Percentage as omnivores, herbivores	20.8	1.3	10.2	4.0	29.0	1.3
8. Percentage as specialized insectivores	15.9	1.3	28.9	4.0	21.4	4.0
10. Catch rate per unit of effort	17.4	4.0	23.8	6.7	49.0	6.7
11. Percentage as darters and sculpins	37.4	4.0	38.5	4.0	24.1	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	1.5	6.7	0.8	6.7	1.7	6.7
Total		33.3 Poor		44.1 Fair		36.0 Poor

Table 17. Fish capture data from fixed station number 5: Rabbit Creek at Rabbit Creek Rd. (formerly Holly Springs Rd.).

	Number of individuals		
Species (common name)	2005	2006	2007
Central stoneroller	37	24	104
Smoky dace		1	
Whitetail shiner	14	15	6
Warpaint shiner	23	71	95
River chub	10	25	60
Tennessee shiner	2	13	38
Yellowfin shiner	20	20	94
Yellowfin x Tennessee shiner		5	1
Warpaint x Tennessee shiner	1		
Telescope shiner		1	
Blacknose dace	8	6	19
Longnose dace	3		3
Creek chub	1	4	8
White sucker	1	2	1
Northern hogsucker	21	13	34
Golden redhorse		5	12
Brown bullhead			
Rock bass	14	7	15
Redbreast sunfish	15	6	9
Green sunfish			
Redbreast x green sunfish			1
Warmouth			
Bluegill	1		2
Largemouth bass			
Mottled sculpin	102	143	159
Total	273	361	661

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

This is the second year in which we have used the TVA boat shocker on the lower Cullasaja, so that comparisons between 2006 and 2007 results are perhaps more valid than those between 2006 and previous years. Nevertheless, and although as contrasted to 2006 we were able to carry out the boat shocker and backpack portions of the sample on consecutive days, we are not satisfied with this site as a fixed station for the lower Cullasaja, and it may be moved.

Given the consistently low flows between the summers of 2006 and 2007 it is not surprising that physically the site appeared little changed, and in both years it received a Fair Bioclass Rating. However, individual metric scoring values are quite different. For 6 of the 12 metrics used, the score was different in 2007 as compared to 2006, with score increasing for 2 metrics and decreasing for 4. One metric (no. 7, % of omnivores and herbivores) went from the lowest to the highest score, whereas another (no. 12, % with disease or anomaly), went from the highest to the lowest.

Despite low flows, and contrary to the overall trend for the upper Little Tennessee watershed, total abundance of fish in the lower Cullasaja was extremely low in 2007. There was a near absence of fish in much of the mid channel area, over unstable sandy substrates. Catches were also low along the muddy left shoreline (dominated by the exotic, tolerant redbreast sunfish, *Lepomis auritus*).

The muddy left bank was also a major contributor to the high incidence of disease and parasites (6.3%) which included a river chub (*Nocomis micropogon*) and a mottled sculpin (*Cottus bairdi*) with advanced finrot which had eaten into the body, and a redbreast sunfish with what appeared to be a cancerous condition around the vent, plus blackspot, leeches and emaciation. We have no hypothesis to explain the sudden upsurge in serious pathological conditions.

As is typical of the lower Cullasaja in summer, and despite remarkably low numbers of central stonerollers (*Campostoma anomala*), the relative abundance of small fish forced us to make a number of judgment calls re young-of-the-year vs. adult fish. Depending on one's judgment re Year Class 1, three species (fatlips minnow, *Phenacobius crassilabrum*; largemouth bass, *Micropterus salmoides* and Tuckaseigee darter, *Etheostoma blennioides gutselli*) could be disallowed. Further, single individuals of 2 species (blacknose dace, *Rhinichthys atratulus* and white crappie, *Pomoxis annularis*) could be disallowed as strays. Even so, Metric 1 would score high with 16 species as would Metric 2, with 2 darter species (including the greenfin darter, *Etheostoma chlorobranchium*, rare as adults in the lower Cullasaja).

Scarcity of the central stoneroller and the Tennessee shiner (*Notropis leuciodus*) was striking, as was the distribution of these species. We expected to find both species generally distributed at the site, but both were taken only in association with the scant areas of medium depth water with rocky substrate.

We have twice reported individuals of the common mudpuppy (*Necturus maculosus*), which according to Martof, et al. (1980) "is thought to occur in the Little Tennessee River drainage"

from this site. If there were any doubt as to the presence of a population, the capture of 2 adults during the 2007 fish sample should dispel it.

The Cullasaja River is the largest tributary of the Little Tennessee, and there can be no doubt of the importance of good information from its lower reaches to an understanding of biotic integrity trends in the watershed. However, we are not confident that, since drastic alteration of the habitat following extreme high water levels in December, 2004, we have established an adequate sampling site and routine.

Table 18. 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 Fair		40.7 Fair

Table 19. 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)

The improvement in IBI at this site observed last year after 3 identical and atypically low scores (36.3) from 2003-2005 was maintained in 2007, but lower Cartoogechaye Creek still has not returned to the Good Bioclass Rating it maintained in all but 2 years between 1990-2000.

The years 2003-2005 were characterized by unusually low total fish abundance (catch rates of 4.0-5.3 fish per 300 square foot sample); the 2007 catch rate was the highest since 1996. However, this was accounted for largely by an increase in the abundance of herbivorous and omnivorous fishes; the two principal contributors to this category (central stoneroller, *Campostoma anomala*) and river chub (*Nocomis micropogon*) both posted record abundance levels in 2007. As a consequence, the observed value for Metric 7 (proportion of omnivores and herbivores) was the highest ever observed at the Rec Park. At the same time Metric 8 (proportion of specialized insectivores) had a record low value. The low score of 1.1 is atypical for both of these metrics at this site.

These low scores were offset by the high catch rate (Metric 10) and also by the presence for the first time of all 4 possible sucker species (Metric 4). The value of the sucker metric may be overstated, however, because the 2 species of redhorse (*Moxostoma*) were each represented by single specimens, and because the white sucker (*Catostomus commersoni*), while it contributes positively to Metric 4, is an omnivorous, tolerant species. This is only the fourth year out of 17 that this site has been sampled that the white sucker was recorded, and the first time that more than one individual has been taken. Another tolerant species, the exotic redbreast sunfish (*Lepomis auritus*) also recorded its highest abundance ever here in 2007.

A surprise was the capture of an adult smallmouth bass (*Micropterus dolomieui*) measuring 14 inches TL. This may be presumed to be a response to the abundance of forage fish. While we lack hard data, it is interesting to speculate on the changes in biotic integrity at this site in terms of the level of the 3 major categories of stressors:

- Toxic pollution: A point source of toxic pollution was found to be the cause of an abrupt decline in the IBI in 1998, accompanied by a precipitous drop in catch rate to levels similar to those observed in 2003-2005. The problem was corrected, and by 2000 catch rate and IBI had returned to normal. A similar cycle may have occurred between 2003 and 2006, without our knowledge.

- Nutrient enrichment: The increasing abundance of herbivorous and omnivorous fishes would logically reflect an increase in organic pollution, partially offsetting the benefits of a reduction in toxic pollution.

- Physical habitat quality: A shallow riffle at the lower end of the sample reach has been unstable in recent years, presenting varying amounts and quality of riffle habitat, but with a general tendency toward decline. Our metric aimed specifically at evaluating riffle habitat (M11, proportion of darters and sculpins), declined after about 1996 (mean of 55.1% during 1990-1996, vs. 37.8% during 1997-2007). Within that metric, we are inclined to believe that the proportion of sculpins to darters reflects the quality of riffle habitat, with greater abundance of darters indicating healthier conditions. This ratio, which ran from 1.3 to 4.3:1 in all but one of 14 years prior to 2005, has been 6.9:1, 7.5:1 and 5.9:1 during the past 3 years.

In any attempt at analysis, it needs to be pointed that Cartoogechaye Creek in its lower reaches is a large urban stream, subject to multiple and varying stresses about which we have only a very general idea. The simultaneity of positive and negative trends is probable in such a situation. Nevertheless, we maintain some hope that lower Cartoogechaye Creek can return to the Good quality in enjoyed before 2000.

Table 20. IBI metrics and scores from fixed station number 7: Cartoogechaye Creek at Macon County Recreation Park (RM 1.0).

	2005		2006		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	15	5.5	19	5.5	20	5.5
2. Number of darter species	2	3.3	4	5.5	3	5.5
4. Number of sucker species	1	3.3	1	3.3	4	5.5
5. Number of intolerant species	2	3.3	2	3.3	2	3.3
6. Percentage as tolerant species	3.1	5.5	0.7	5.5	4.8	5.5
7. Percentage as omnivores, herbivores	16.9	3.3	24.9	3.3	33.9	1.1
8. Percentage as specialized insectivores	41.7	3.3	33	3.3	18.5	1.1
9. Percentage as piscivores	0	1.1	2	5.5	3	5.5
10. Catch rate per unit of effort	5.3	1.1	12.9	3.3	16.1	5.5
11. Percentage as darters and sculpins	35.5	3.3	35.8	3.3	39.7	3.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	3.1	3.3	1.1	5.5	3.6	3.3
Total		36.3		47.3		45.1
		Fair		Fair		Fair

Table 21. Fish capture data from fixed station number 7: Cartoogechaye Creek at Macon County Recreation Park (RM 1.0).

	Number of individuals		
Species (common name)	2005	2006	2007
Mountain brook lamprey	5	3	8
Rainbow trout		3*	2
Brown trout		4	2
Brook trout		2*	4*
Central stoneroller	18	70	159
Smoky dace			
Whitetail shiner	2	1	3
Common carp			
Warpaint shiner	47	33	26
River chub	25	67	84
Tennessee shiner	53	122	67
Yellowfin shiner	9	12	23
Yellowfin x warpaint shiner	1	1	
Yellowfin x Tennessee shiner		1	
Mirror shiner	4	1	6
Fatlips minnow	2	6	3
Blacknose dace			
Creek chub	1	1	1
White sucker			5
Northern hogsucker	2	26	16
Black redhorse			1
Golden redhorse			1
Brown bullhead			1
Snail bullhead			
Rock bass	9	12	14
Redbreast sunfish	8	2	28
Green sunfish		1	1
Warmouth			
Bluegill	1	1	
Smallmouth bass		1	2
Largemouth bass			
Black crappie			
Tuckaseigee darter		1	3
Greenfin darter	6	10	16
Yellow perch			
Gilt darter	7	12	16
Olive darter		1	
Mottled sculpin	90	179	266
Total	290	568	754

* Stockers, not included in scoring

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

While speculation about the consequences of annual differences in water level and flood regimes may be appropriate, the more obvious conclusion to be drawn from the recent history of this site is that it is entering upon the up and down oscillation pattern characteristic of streams in decline. From 1992-2002 this site consistently received a Good Bioclass Rating, but beginning in 2003 it has rated Fair and Good in alternating years. 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.

While the very high catch rate corresponds to a situation observed at most of our sampling sites for 2007, the high proportion of omnivores and herbivores (Metric 7) and the fact that 86.7% of the increase in total fish numbers between 2006 and 2007 was accounted for by the dominant omnivore (river chub, *Nocomis micropogon*), the dominant herbivore (central stoneroller, *Campostoma anomala*) and the mottled sculpin (*Cottus bairdii*), which we have often observed to increase its abundance in response to increased organic content, suggest nutrient enrichment.

The other fishes which increased their abundance, less explicably, between 2006 and 2007 are the rainbow and brown trout (*Oncorhynchus mykiss* and *Salmo trutta*), fatlips minnow (*Phenacobius crassilabrum*) and gilt darter (*Percina evides*), all of which posted record numbers in 2007.

While all 7 species which have been taken in every year since 1992 were present, 3 species taken in most years were absent:

- Mirror shiner (*Notropis spectrunculus*), taken in 11 of 16 years (but never more than 5 individuals) but absent beginning in 2005.
- Creek chub (*Semotilus atromaculatus*), taken in 14 years: 1-13 individuals.
- Redbreast sunfish (*Lepomis auritus*), taken in 12 years: 1-6 individuals).

It may be several years before a clear trend is observable at this site.

Table 22. IBI metrics and scores from fixed station number 8: Middle Creek at West Middle Creek Rd. (RM 2.2).

	2005		2006		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	8	4.0	13	6.7	11	6.7
2. Number of darter species	0	1.3	2	4.0	1	4.0
5. Number of intolerant species	1	1.3	2	4.0	1	1.3
6. Percentage as tolerant species	0.3	6.7	0.8	6.7	0.0	6.7
7. Percentage as omnivores, herbivores	5.2	6.7	8.9	6.7	22.1	1.3
8. Percentage as specialized insectivores	8.2	1.3	11.6	1.3	10.0	1.3
10. Catch rate per unit of effort	11.8	4.0	22.6	6.7	47.8	6.7
11. Percentage as darters and sculpins	83.7	6.7	73.6	6.7	63.3	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.3	6.7	0.2	6.7	0.1	6.7
Total		38.7		49.5		41.4
		Fair		Good		Fair

Table 23. 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)	2005	2006	2007
Rainbow trout	1	23	43
Brown trout		7	9
Central stoneroller	4	17	127
Smoky dace	2	9	16
Warpaint shiner	9	3	24
River chub	12	29	109
Tennesee shiner	12	33	27
Yellowfin shiner	4	6	11
Yellowfin shiner x smoky dace	1	1	
Yellowfin x warpaint shiner			
Yellowfin x Tennessee shiner		1	1
Mirror shiner			
Telescope shiner			
Fatlips minnow		3	10
Blacknose dace		6	2
Longnose dace	2	20	10
Creek chub		4	
White sucker			
Northern hogsucker	2	4	3
Rock bass			2
Redbreast sunfish	1	1	
Green sunfish			
Tuckaseigee darter		1	
Greenfin darter			
Gilt darter		4	21
Mottled sculpin	256	430	660
Total	306	602	1075

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

2007 marked the end of a 3 year period of improvement at Peaceful Cove, as the IBI for this site abruptly dropped to the Fair Bioclass Rating which had characterized it during 2002 and 2003, prior to which it had consistently rated Good. We continue to believe that the health of the middle Cullasaja is dependent on sustained flow. Last year we attributed, "the apparent improvement in the Cullasaja", to the flushing action of frequent high water during 2003-2005. Recovery of overall fish abundance did not occur until the low water year of 2006, but in this large, powerful stream the positive effect on trophic structure resulting from flushing of sediments from riffles appears to have been significant."

At that time we also suggested that, "if a series of dry, low water years ensue, biotic integrity will lapse back into the Fair range". This appears to be what happened between 2006 and 2007. Our present hypothesis is that the lack of flushing in 2006-2007 permitted the resurgence of the herbivorous central stoneroller (*Campostoma anomala)* and the omnivorous river chub (*Nocomis micropogon*), which together formed the main factor in raising the observed value for proportion of omnivores and herbivores (Metric 7) from 20.1% to a record high 32.0%, thus lowering the score for this metric.

Low flows contributing to deposition of sediment which would otherwise have been flushed may have been a determining factor in the decline in the proportion of specialized insectivores (Metric 8), also lowering the IBI.

Another alarming note was the failure for the first time to capture even one specimen of the wounded darter (*Etheostoma vulnerata*). What was once the strongest population of this intolerant, regional endemic species in the upper Little Tennessee watershed has been in decline for some time. The mean representation 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. At the same time, the proportion of darters (all species) in our samples, which was 24.2% (range 16-29%) during 1991-1997; declined to 13.1% (range 10-19%) during 1998-2006, and was a record low 9.0% in 2007. These figures suggest a decline in the quality/quantity of hard substrate, especially in the riffles, although an increase in the abundance of the mottled sculpin (*Cottus bairdii*) has maintained the proportion of darters and sculpins in the sample (Metric 11) fairly constant.

The flushing effect of occasional very high flows may be especially important to the maintenance of biotic integrity in streams such as the middle Cullasaja, which while of moderate gradient, is situated just downstream from the Cullasaja Gorge, which generates torrential flows. The combination of naturally rocky substrate with high potential for deposition of sediment at low flows can have significant short term effects on several IBI metrics.

It could be stated that the cyclic effect just described is a weakness of the IBI, allowing the results of natural cycles to be superimposed on or confounded with the anthropogenic events the index is supposed to measure. However, if we are in fact entering a period of anthropogenically induced climate change leading to less frequent high flows, then in fact the IBI is recognizing this change. This is of particular importance on the middle Cullasaja, where most of the stressors originate in the upper watershed, on the Highlands Plateau, but can have much of their effect further downstream.

Table 24. IBI metrics and scores from fixed station number 9: Cullasaja River at Peaceful Cove (RM 8.3).

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

Table 25. Fish capture data from fixed station number 9: Cullasaja River at Peaceful Cove (RM 8.3).

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

*Stockers, not included in scoring.

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

Between 2006 and 2007, this site recorded one of the largest one year changes in IBI in the 18 year history of the Biomonitoring Program, going from 46.8 (conservatively evaluated as Fair) to 38.7 (still with a Fair rating, but near the bottom of possible scores for this bioclass rating). No reasons are apparent, but the drop is similar to those observed during 2006-2007 for two other fixed stations (Middle Creek at W. Middle Creek Rd. and Cullasaja River at Peaceful Cove) which, like the Wayah Creek site are of moderate gradient, but located not far below a very high gradient reach. In those cases, our hypothesis was that the decline in IBI was due to the lack, in 2006-2007, of normal flushing of sediments during high flow periods.

A hypothesis of flow-related impacts on the fish assemblage is, however, difficult to support in the case of Wayah Creek, in part because it is unusually clear and sediment-free for a valley stream, but also in light of the fact that in 2007 the observed value for Metric 8 (proportion of specialized insectivores, considered to be particularly responsive to sedimentation) was the highest ever recorded here. It should be noted that, for reasons not related to sedimentation, even a "highest ever" value for this metric (11.8%) results in the lowest score.

Other indicators are equally confusing: Record numbers of the herbivorous central stoneroller (*Campostoma anomala*), the omnivorous river chub (*Nocomis micropogon*) and the tolerant, omnivorous creek chub (*Semotilus atromaculatus*) suggest nutrient enrichment, as does a record high rate of disease and parasites (Metric 12). This although theoretically the elimination, in 2000 of an upstream point source in the form of a frequently malfunctioning package waste water treatment plant should have reduced nutrient loading.

Another effect posited for the removal of the point source was the gradual restoration of a fish fauna which lacked numerous elements found at other nearby sites in the Cartoogechaye Creek watershed. Although the intolerant gilt darter (*Percina evides*) is still absent (and, strangely, the Tuckaseigee darter, *Etheostoma blennioides gutselli* was absent after 2003), 3 species of shiner which were mostly absent before 2000 have started to come back. Two of these (Tennessee shiner, *Notropis leuciodus* and mirror shiner, *Notropis spectrunculus*) were present in record numbers in 2007. In addition, 2007 marked the first record for another cyprinid, the fatlips minnow (*Phenacobius crassilabrum*), represented by 2 large individuals. Yet another cyprinid, the intolerant smoky dace (*Clinostomus* sp.) has never been absent, but was also present in record numbers in 2007.

Another apparent anomaly was the sudden drop in numbers of both rainbow and brown trout (*Oncorhynchus mykiss* and *Salmo trutta*). This coincided with the first appearance of stocked brown trout and brook trout (*Salvelinus fontinalis*) here. (One must question the utility of stocking trout in a reach which is not open to public fishing.) One rainbow trout parr was curiously deformed, with a normal head and fins, but a body shaped like a sunfish; it appeared healthy in other respects.

Since we began monitoring Wayah Creek in 1990 both the IBI score and the abundance of individual species has fluctuated greatly, and not very predictably. Two things are clear: 1) Sediment load remains low compared to other streams of its size and type. 2) Periodic small fish

kills have ceased to occur since the package treatment plant went offline. Prior to that time, Wayah Creek, although visually attractive and "healthy" according to any physical habitat index, was clearly a disturbed habitat, as evidenced by the absence or extreme scarcity of at least 5 expected fish species.

Our monitoring site suffered greatly during the extreme high water event of December, 2004, which likely set back recovery from stresses associated with the treatment plant. It may be that the combination of positive and negative impacts associated with the package plant and its elimination, the severe winter flooding of 2004 and the current drought are producing extremely complex interactions which will take longer to sort out than we have imagined.

Table 26. IBI metrics and scores from fixed station number 10: Wayah Creek at Crawford Rd. (RM 0.6).

	2005		2006		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	10	6.7	13	6.7	15	6.7
2. Number of darter species	1	4.0	1	4.0	2	4.0
5. Number of intolerant species	2	4.0	2	4.0	2	4.0
6. Percentage as tolerant species	1.7	6.7	1.4	6.7	1.3	6.7
7. Percentage as omnivores, herbivores	13.2	4.0	9.2	6.7	24.0	1.3
8. Percentage as specialized insectivores	4.5	1.3	5.6	1.3	11.8	1.3
10. Catch rate per unit of effort	*	1.3	16.9	4.0	18.4	1.3
11. Percentage as darters and sculpins	81.0	6.7	77.3	6.	62.0	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.8	6.7	0.8	6.7	2.3	4.0
Total		41.4		46.8		38.7
		Fair		Fair		Fair

* Catch rate not calculated due to doubtful sampling efficiency, but fish population densities appeared very low.

Table 27. Fish capture data from fixed station number 10: Wayah Creek at Crawford Rd. (RM 0.6).

	Number of individuals		
Species (common name)	2005	2006	2007
Mountain brook lamprey	5	9	2
Rainbow trout	Present*	32	4
Brown trout	2	30	9
Brook trout			1**
Central stoneroller	4	13	67
Smoky dace	3	23	38
Warpaint shiner			6
Warpaint x Tennessee shiner			
River chub	1	9	54
Tennessee shiner			22
Mirror shiner			17
Fatlips minnow			2
Blacknose dace	18	36	83
Longnose dace	6	20	17
Creek chub	4	11	12
Northern hogsucker		1	7
Black redhorse			
Golden redhorse		3	
Rock bass	3	5	5
Redbreast sunfish			
Green sunfish		1?	
Tuckaseigee darter			
Greenfin darter	2	5	5
Mottled sculpin	194	652	558
Total	242	850	908

* Rainbow trout not taken in sample, but counted as "present" on basis of 1 taken while setting voltage.

** Stocker, not counted in scoring.

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

The condition of lower Skeenah Creek remains largely unchanged. It appears to have recovered from a severe sedimentation episode occasioned by a major construction project not far upstream, which lowered the IBI during 2001-2004, and is once again maintaining the Fair-Poor Bioclass Rating which characterized it from 1994-2000.

It is probable that the 2006 total of 10 native species was low due to a technical error, and that the observed values of 15 and 14 for 2005 and 2007 more nearly represent reality. If this assumption is valid, then the 2006 score for Metric 1 (No. native species) would rise to 7.5, and there would be no difference in the IBI over the years 2005-2007.

We are doubtful about at least one of the native species recorded for 2007. The intolerant smoky dace (*Clinostomus* sp.) was present in good numbers here during 1994-1997, then diminished rapidly. The single individual reported for 2007 was the first seen at this site since 2002. The smoky dace does maintain a strong population further upstream in Skeenah Creek, and the 2007 record may well represent a stray. Given this doubt, we included the smoky dace in the observed value for Metric 1, but not for Metric 5 (Number of intolerant species).

Three other species were represented by single individuals and could conceivably be disallowed in scoring Metric 1:

- Tuckaseigee darter (*Etheostoma blennioides gutselli*): Although darters (total of 3 species) have been recorded at this site on occasion, darters are not expected in a stream of this size and this was only the second appearance for the Tuckaseigee darter. (We note that this species frequently appears as isolated individuals in streams as small as or smaller than Skeenah Creek.)

- Smallmouth bass (*Micropterus dolomieui*): This was only the second record here for the smallmouth bass, as well. Individuals of this species occur opportunistically in streams of this size, usually triggered by abundance of prey – a condition which obtained in most small Little Tennessee tributaries in this year of low flows.

- Mountain brook lamprey (*Icthyomyzon greeleyi*) has been present in every sample at this site, often in good numbers, and must be considered a member of the lower Skeenah Creek fish assemblage. (We offer no hypothesis for its scarcity in 2007, under what continue to appear to be ideal habitat conditions.)

Even if we assume that only one of the 4 species represented by a single individual “belongs”, then the observed value for Metric 1 is 11, and the high score is justified.

We were premature in 2006 in reporting a decline in numbers of the exotic yellowfin shiner (*Notropis lutipinnis*). While its absolute number, and proportion in the catch declined every year between 2002 and 2006 (from 133 to 24 individuals, or 34.4 to 9.4% of the total sample), it rebounded to account for 19.2% of the sample in 2007, once again becoming the most abundant species at the site, as it was in 1999, 2000 and 2002.

Another negative trend was the record catch rate of the tolerant omnivorous creek chub (*Semotilus atromaculatus*) in 2007. With 26 individuals it comprised 6.0% of the sample; creek chubs had not comprised more than 2% of the sample since1997.

The yellowfin shiner and creek chub observations may be significant, or may represent temporary oscillations, but it is not unusual for highly disturbed, but not grossly polluted streams like Skeenah Creek to gradually decline from Fair to Poor. Based on results of the last 3 years, lower Skeenah Creek is stable, but must be considered likely to respond negatively to any of a number of possible natural or anthropogenic stressors.

Table 28. IBI metrics and scores from fixed station number 11: Skeenah Creek at North Carolina Welcome Center (RM 0.5).

	2005		2006		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	15	7.5	10	4.5	14	7.5
5. Number of intolerant species	1	1.5	1	1.5	1	1.5
6. Percentage as tolerant species	5.8	7.5	6.3	7.5	7.9	7.5
7. Percentage as omnivores, herbivores	22.5	1.5	21.6	1.5	25.0	1.5
8. Percentage as specialized insectivores	25.4	4.5	16.5	1.5	24.1	4.5
10. Catch rate per unit of effort	*	7.5	16.8	4.5	32.6	7.5
11. Percentage as darters and sculpins	26.6	1.5	38.4	4.5	26.4	1.5
12. Percentage with disease, tumors, fin damage and/or other anomalies	2.0	4.5	1.6	7.5	2.8	4.5
Total		36.0 Poor		33.0 Poor		36.0 Poor

*Nature of sample did not permit calculation of this metric. Score based on subjective judgment about total fish abundance.

Table 29. Fish capture data from fixed station number 11: Skeenah Creek at North Carolina Welcome Center (RM 0.5).

	Number of individuals		
Species (common name)	2005	2006	2007
Mountain brook lamprey	12	25	1
Rainbow trout			
Brown trout		1	
Brook trout			
Central stoneroller	32	7	42
Smoky dace			1
Whitetail shiner			
Warpaint shiner	74	30	75
River chub	25	21	37
Tennessee shiner	12	12	27
Yellowfin shiner	52	24	83
Yellowfin x Tennessee shiner	5	1	
Fatlips minnow	1		
Creek chub	7	2	26
White sucker	1		2
Northern hogsucker	11	12	8
Black redhorse			
Golden redhorse	2		2
Brown bullhead			
Rock bass	6	7	7
Redbreast sunfish	8	14	6
Green sunfish	4		
Warmouth			
Bluegill	3	1	
Smallmouth bass	1		1
Tuckaseigee darter			1
Greenfin darter			
Gilt darter			
Mottled sculpin	86	98	113
Total	342	255	432

Cowee Creek at Wests Mill (RM 0.7)

Since 1997, the IBI for this site has consistently exceeded our intuitive evaluation. While riparian condition at the Wests Mill site is not bad, it is located immediately downstream of a horrendous pasture reach, where cattle have free access over more than a half mile of stream and riparian buffering vegetation is almost totally absent. Lower Cowee Creek also receives the discharge from a large ornamental aquatic plant business and, in recent years, has suffered from construction of a mega development on the headwaters of Caler Fork, a major tributary. Yet the site at RM 0.7 consistently rates Good.

This year it is the metrics most directly affected by sedimentation (M7, proportion of omnivores and herbivores; M8, proportion of specialized insectivores and M11, proportion of darters and sculpins) which lower the score. However, we did note an improvement in the darter:sculpin ratio. Typically this ratio is near 1:1 (unusually good) for Cowee Creek, and in 2005 it reached 2.06:1. However in 2006 it fell to 0:27:1. The proximate cause was what appeared to be a population explosion by the mottled sculpin (*Cottus bairdii)*, which appeared in nearly 4 times its previous maximum numbers. This may be related to the continual turbidity which was observed in 2006 as a consequence of upstream development activities. Whatever the cause, in 2007 the darter:sculpin ratio bounced back to 1.29:1.

Within the darter group, while the Tuckaseigee darter (*Etheostoma blennioides gutselli*) reached a record number in our sample, the opposite occurred with the greenfin darter (*Etheostoma chlorobranchium*) which in addition to recording a record low catch, was represented almost exclusively by small individuals and juveniles.

The intolerant telescope shiner (*Notropis telescopus*), absent for the first time in 2006, achieved by far its greatest abundance in 2007. We note that this species seems to perform non-seasonal group migrations resulting in apparently erratic numbers for it and, in the case of total absence, potentially affecting the score for Metric 5 (no. of intolerant species).

One rock bass (*Ambloplites rupestris*) had what was for us a new parasite which took the form of large, irregular black flecks on the body – not at all like the familiar blackspot.

All of our misgivings aside, there is no way to avoid continuing to give lower Cowee Creek a Bioclass Rating of Good.

Table 30. IBI metrics and scores from Cowee Creek at Wests Mill (RM 0.7).

Metric	2006 Value	2006 Score	2007 Value	2007 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	2	4.0	3	6.7
6. Percentage as tolerant species	4.6	6.7	2.5	6.7
7. Percentage as omnivores, herbivores	8.0	6.7	24.4	4.0
8. Percentage as specialized insectivores	27.6	4.0	40.6	4.0
10. Catch rate per unit of effort	24.8	6.7	19.6	6.7
11. Percentage as darters and sculpins	66.6	6.7	35.8	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.7	6.7	0.1	6.7
Total		54.9 Good		52.2 Good

Table 31. Fish capture data from Cowee Creek at Wests Mill (RM 0.7).

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

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

In 2006, as a presumed consequence of construction of a mega development in the upper watershed of Caler Fork, this site exhibited almost constant turbidity and considerable sediment deposition, leading to the greatest decline in IBI score (49.5 Good to 33.3 Poor), ever recorded over a one year period and marking the first time a site had ever declined by 2 bioclasses in a one year period in the upper Little Tennessee watershed. The score and absolute values for all 9 metrics either fell or remained the same. This year the site rebounded to an IBI of 46.8 (tentative Bioclass Rating of Good), and all metric scores and absolute values improved or stayed the same.

At first glance, this seems to be a testimonial to the resilience of mountain streams as impressive as that observed on Peeks Creek after the 2004 flood, but the situation is a bit more complicated:

To begin with the physical appearance of the site, neighbors did not report continual extreme turbidity, even during dry periods, as they did during 2006. Heavy sedimentation, mostly of silt (as opposed to the sandy sediments which have accumulated in this stream as a consequence of continual gem mining activity upstream over many years until recently) is still evident, particularly along the shoreline. However, especially in mid-channel, there is some reduction in the sediment load. We did not carry out a physical habitat assessment, but intuitively it is difficult to reconcile the appearance of the stream with a Good bioclass rating. From observations made during the fish sample, it also appears doubtful that a benthic macroinvertebrate sample would produce a high index value.

The stream appears to be repopulating with fish. Not only was catch rate and total number of fish the highest ever recorded for lower Caler Fork (including a previously used site further downstream), but 9 of a total 22 species known from Caler Fork appeared in record high numbers. With the single exception of the most abundant species (warpaint shiner, *Luxilus coccogenis*), all species were represented by small individuals and there were no really large individuals of any species. This is undoubtedly partly due to the low flow rates which prevailed during 2006-2007 throughout the upper Little Tennessee watershed, resulting in little downstream displacement of young fish. However, the observed size distribution also suggests new recruitment.

Breaking down the sample, we note that recovery has been much more rapid in pool and run habitat than in riffles. Catch per unit effort (300 square feet of water surface) was 48.7 in runs and pools, but only 20.3 in riffles.

One species new to Caler Fork (golden redhorse, *Moxostoma erythrurum*) was recorded, and the total number of native species (17) was by far the highest ever reported here.

It is probable that sedimentation due to upstream development will continue, but it may never again reach the exaggerated levels associated with initial construction, and if normal rainfall patterns return, some benefit due to flushing of sediments is to be expected. Bearing in mind that, as of 2005 before the most recent impacts, Caler Fork was still in the process of recovering from

the damage done during the heyday of the tourist gem mining industry along its banks, we can suppose that flushing of sediments will be a long process, interrupted by periods of deposition.

The tentative Good Bioclass Rating for 2007 notwithstanding, the present condition does not represent full recovery, even to the level of 2005. The 2007 result was certainly a pleasant surprise, but we consider that lower Caler Fork at this time is in an unstable condition and its future is uncertain. Until we see normal age class distribution and trophic structure, we cannot consider it to be in any meaningful sense "recovered".

Table 32. IBI metrics and scores from Caler Fork at Holbrooks/Tucek property line (RM 0.4).

	2005		2006		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	11	6.7	10	4.0	17	6.7
2. Number of darter species	1	4.0	1	1.3	1	4.0
5. Number of intolerant species	2	4.0	2	1.3	2	4.0
6. Percentage as tolerant species	2.9	6.7	11.8	4.0	3.9	6.7
7. Percentage as omnivores, herbivores	9.8	6.7	17.1	4.0	12.5	4.0
8. Percentage as specialized insectivores	32.7	4.0	16.7	1.3	63.5	6.7
10. Catch rate per unit of effort	18.1	6.7	16.7	4.0	39.6	6.7
11. Percentage as darters and sculpins	58.0	4.0	51.8	4.0	27.0	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.5	6.7	0.8	6.7	0.6	6.7
Total		49.5 Good		33.3 Poor		46.8 Good

Table 33. Fish capture data from Caler Fork at Holbrooks/Tucek property line (RM 0.4).

	Number of individuals		
Species (common name)	2005	2006	2007
Mountain brook lamprey	8	28	13
Rainbow trout	14	9	2
Brown trout	1	5	3
Central stoneroller			4
Whitetail shiner	1	18	4
Warpaint shiner	33		150
River chub	7	6	45
Tennessee shiner	3		89
Yellowfin shiner	1		1
Telescope shiner			12
Fatlips minnow			13
Blacknose dace	5	7	4
Creek chub		1	1
Northern hogsucker	6	5	20
Golden redhorse			4
Mosquitofish		7	1
Rock bass	1		
Redbreast sunfish		3	1
Green sunfish	6	18	18
Bluegill		1	4
Largemouth bass			3
Gilt darter	30	23	72
Mottled sculpin	89	114	73
Total	205	245	537

Cullasaja River above Cullasaja Falls (RM 11.9)

The Cullasaja River between Sequoyah Dam in Highlands and the 250 ft. Cullasaja Falls is an extremely atypical habitat, not only for the upper Little Tennessee watershed, but for the southern Blue Ridge in general. Isolated as it is by a barrier falls which drops from an elevation of 2,600 ft., in its natural state it presumably had a very limited fish fauna, dominated by southern strain brook trout (*Salvelinus fontinalis*), or speckled trout. But with a watershed area of 33 sq. mi. and width of over 60 ft. above the falls, it is much larger than the streams for which we feel comfortable applying the Williams (1996) "brook trout" IBI or its modified form (McLarney, 1999).

We did attempt to apply these indices in our previous monitoring effort here in 1999, resulting in an IBI of 48 (Good) for the original Williams index and 42 (Fair) for the modified index. A benthic macroinvertebrate sample taken at the same time indicated Good to Excellent conditions (Lenat, 1999). Our opinion at the time was that, taking into account both the macroinvertebrate results and the grossly altered condition of the fish assemblage, a Bioclass Rating of Fair better described the site. This time we made no attempt to assign a Bioclass; the intent of the sample was simply to update our knowledge of the fish assemblage here and answer a question about *Nocomis* chubs (See below).

The list of known fish species inhabiting the Cullasaja River watershed on the Highlands Plataeau above Cullasaja Falls presently stands at 21, of which no more than 5 are native to the plateau. (Table 35 updates information from McLarney, 2000 about this fauna). The native brook trout has long since been replaced by the exotic rainbow and brown trouts (*Oncorhynchus mykiss* and *Salmo trutta*) above the falls, but the presumably native longnose dace (*Rhinichthys cataractae*) is well represented, including outstandingly large and fat individuals. Another presumptive native species present at this site is the blacknose dace (*Rhinichthys atratulus*), which we found only in an isolated side channel in 1999, but which we located in small numbers in the mainstem in 2007 by targeting an area of shallow laminar flow over sand near shore.

Of particular interest here are the *Nocomis* chubs. The only *Nocomis* native to the upper Little Tennessee watershed is the river chub (*Nocomis micropogon*), virtually ubiquitous in the watershed outside the Highlands Plateau. However, in 1999 we identified the very similar bluehead chub (*Nocomis leptocephalus*), native to Atlantic Coast drainages, from Mill Creek, tributary to the Cullasaja in Highlands above two reservoirs (Sequoyah and Mirror Lakes). Based on examination of tubercle scars, we suspected the presence of bluehead chubs in our sample from this site in 1999 and from the Cullasaja at RM 250 above Dry Falls in 2000. However, we must point out that, except in the case of breeding males, it is difficult to distinguish between these two *Nocomis* sp. without dissection.

The 2007 report from this site was made while *Nocomis* spp. were still breeding, and we were able to capture several tuberculate males with the distinctive coloration and tubercle patterns of *N. leptocephalus;* no nuptial male *N. micropogon* were observed. This is the first confirmed record of bluehead chub in the Little Tennessee watershed below Sequoyah dam, where it may be replacing *N. micropogon*, but our findings preclude neither the continued presence of *N. micropogon* at this site nor the presence of *N. leptocephalus* further downstream in the

watershed. From a biotic integrity point of view, *N. leptocephalus* is more herbivorous than *N. micropogon*, but both would contribute to the total for IBI Metric 7 (proportion of omnivores and herbivores). Both must be viewed as invasive exotics above Cullasaja falls, whereas *N. leptocephalus* fulfills this role anywhere in the watershed; its spread must be viewed as a threat to the native ichthyofauna.

As in 1999, we observed a pattern of habitat use by rock bass (*Ambloplites rupestris*) different from that common below Cullasaja Falls, where it is the most widespread piscivore. We typically find rock bass to be closely associated with shoreline habitat, with smallmouth bass (*Micropterus dolomieui*), a larger piscivore, dominant in mid channel. However, in the Cullasaja above Cullasaja Falls, in the absence of *Micropterus* spp., large rock bass typically defend feeding stations in mid-channel, with brown trout functioning as the shoreline piscivore.

Despite the numbers of rock bass and brown trout, two cyprinid forage species (warpaint shiner, *Luxilus coccogenis* and mirror shiner, *Notropis spectrunculus*) are extremely abundant here. Both abundance and habitat use by the latter species are atypical. In the rest of the watershed, where it is native, we typically find mirror shiners in small groups, over sandy bottoms at moderate depths and medium flow. In the upper Cullasaja it forms large schools in slow runs and pools, favoring sites deeper and slower than in its native habitat.

From a strict biotic integrity point of view, the largely artificial assemblage of fishes in the Cullasaja River above Cullasaja Falls must rate very low. In the case of reservoir lakes, TVA, acknowledging that they are an artificial environment, uses a “Reservoir IBI” to evaluate any given reservoir lake using what are taken to be the healthiest such water bodies as Reference Sites. While philosophically debatable, this approach has its uses in reservoir management. However, were one to seek to apply the same approach to the upper Cullasaja, he or she would find that there are really no other environments against which to compare it. What we can state is that the reach of the Cullasaja immediately above Cullasaja Falls is a valuable recreational resource, the biological makeup of which has not changed significantly since 1999.

Table 34. Fish capture data from Cullasaja River above Cullasaja Falls (RM 11.9).

	Number of individuals	
Species (common name)	1999	2007
Rainbow trout	19	20
Brown trout	9	14
Warpaint shiner	113	216
River chub*	113	
Bluehead chub*		209
Mirror shiner	56	143
Blacknose dace	Present**	7
Longnose dace	52	51
Northern hogsucker	94	117
Rock bass	26	32
Redbreast sunfish	1	
Bluegill	1	
Total	486	809

*See text re-identification of Nocomis species.
**Captured in isolated side channel, but not included in sample.

Table 35. Known fish fauna of the Cullasaja Watershed above Cullasaja Falls (Highlands Plateau) (RM 11.9).

Species	Distribution	Native status
Rainbow trout *Oncorhynchus mykiss*	Widespread in streams	Exotic to Little Tennessee
Brown trout *Salmo trutta*	Lower mainstem and some tribs	Exotic to Little Tennessee
Brook (speckled) trout *Salvelinus fontinalis*	Headwater streams	Native (northern strain introduced)
Rosyside dace *Clinostomus funduloides*	Mill Creek above Mirror Lake	Exotic to Little Tennessee
Smoky dace *Clinostomus* sp.	Stephens Creek	Native?
Warpaint shiner *Luxilus coccogenis*	Mainstem	Exotic to Highlands Plateau
Bluehead chub *Nocomis leptocephalus*	Mill Creek and mainstem	Exotic to Little Tennessee
River chub *Nocomis micropogon*	Mainstem, rare in tribs	Exotic to Highlands Plateau
Golden shiner *Notemigonus crysoleucas*	Impoundments, river above dry falls, some creeks	Exotic to Highlands Plateau
Mirror shiner *Notropis spectrunculus*	Mainstem	Exotic to Highlands Plateau
Blacknose dace *Rhinichthys atratulus*	Most tribs, backwaters of mainstem	Native?
Longnose dace *Rhinichthys cataractae*	Swift tribs and mainstem	Native?
Creek chub *Semotilus atromaculatus*	A few small streams	Native?
Northern hogsucker *Hypentelium nigricans*	Mainstem	Exotic to Highlands Plateau
Rock bass *Ambloplites rupestris*	Mainstem	Exotic to Highlands Plateau
Redbreast sunfish *Lepomis auritus*	Impoundments, mainstem, larger tribs	Exotic to Little Tennessee
Green sunfish *Lepomis cyanellus*	Impoundments and streams	Exotic to Highlands Plateau
Bluegill *Lepomis macrochirus*	Impoundments, occasional in river and some tribs	Exotic to Highlands Plateau
Warmouth *Lepomis gulosus*	Impoundments	Exotic to Little Tennessee
Largemouth bass *Micropterus salmoides*	Impoundments, occasional in river	Exotic to Highlands Plateau
Mottled sculpin *Cottus bairdii*	Mill Creek above Mirror Lake (very recent introduction)	Exotic to Highlands Plateau

Blaine Branch above mouth (RM 0.1)

In addition to presenting data from 2007 and 2006, this section will serve as a final summary of the Blaine Branch biomonitoring station, which is being abandoned as of 2008. The reader seeking more detailed historic information and data (fish, macroinvertebrate and physical habitat monitoring, with index values for 2002, 2003, 2005 and 2006) is referred to our previous report. The conclusion here is that the data collected at this site is of minimal value, at least as related to the original purpose for selecting this site.

As of 2001-2002, the majority of the 0.9 mi. reach of Blaine Branch between Patton Rd. (SR 1148) and its mouth at Cartoogechaye Creek, was in a deplorable condition. This entire reach is located on a single property which, except for a small residential area near Patton Rd., was managed as pasture, with cattle having free access to the stream. The channel was deeply incised, riparian vegetation was largely confined to grasses, and there were extensive reaches of high, raw bank. At this time, the landowner announced plans to enter into an agreement with the North Carolina DOT to restore his piece of Blaine Branch (which appears to be in relatively good condition above Patton Rd.). This was the rationale for embarking on a long term biomonitoring plan for lower Blaine Branch.

The first step was to convert the pasture to a hay field, and remove the cattle, which was done between 2001 and 2002. Partial recovery of the riparian zone, in the form of shrubs and early successional trees, was apparent by the time of the first fish and macroinvertebrate samples in 2002. Over time this process has continued uninterrupted, largely mitigating the raw bank problem.

However, for reasons unknown to us, the DOT restoration plan was cancelled, and a decision made to “let nature take its course”. This has had its positive effects, as mentioned above. But not all short term changes have been positive. Uncontrolled growth of alder, willow, blackberry and multiflora rose on the steep slopes in the narrow, incised channel tended to restrict flow. This narrowed the channel but apparently also had the effect of restricting flushing of sediment. We perceived more sediment and a reduction in quantity and quality of already scarce riffle areas over the years 2002-2006.

At the same time, beavers moved into lower Blaine Branch. Their first dam was constructed well above our monitoring site (located at RM 0.0-0.2), but they moved gradually downstream. In 2007 we found that, after eliminating the lowermost river/pool sequence to minimize confounding of the sample by fish from Cartoogechaye Creek only 113 ft. of free-flowing stream remained between the lower end of our monitoring reach and the first beaver dam.

In that reach we were able to take a total of only 88 fish, representing 8 out of a total of 19 species reported from lower Blaine Branch through 2006. We generally consider that 200 fish represents the minimum sample size for calculation of the IBI. (We would normally expect to take more than 200 fish from this reach; contrary to the trend toward record high fish catches in almost all the larger streams we sampled in 2007, Blaine Branch appeared to hold far less fish than usual.)

Faced with a quantitatively inadequate sample, we made a decision to extend the sample into the reach impounded by beavers. (We generally do not include the reaches behind beaver dams in IBI samples because the dams restrict fish movement, and the ponds are generally unproductive, difficult to sample and in many respects represent atypical habitat.) In this way we were able to extend the sample by 87 ft. (impounded within the natural channel, with perceptible flow), before encountering an impenetrable wall of multiflora rose which extended completely across the channel for at least 100 ft. upstream.

In the beaver pond we took a total of 21 fish, representing 12 species; 9 of them represented by a single individual. The only fish which was present in numbers was the creek chub (*Semotilus atromaculatus*). The 12 species taken included 7 not represented in the downstream sample, including 2 species recorded for the first time from Blaine Branch (black redhorse, *Moxostoma duquesni* and smallmouth bass, *Micropterus dolomieui*).

With a total of 109 fish, some of them from highly atypical habitat, we decided not to attempt to calculate an IBI for 2007. The discussion that follows is based largely on results from 2002-2006. During that period we observed:

- Despite our efforts to minimize the influence of short-term migrants from Cartoogechaye Creek by not sampling close to the mouth, the presence of 61 whitetail shiners (*Cyprinella galactura*) in our 2003 sample suggests that in at least this instance we failed to achieve this goal (in other years the total number of whitetail shiners in our sample was 0-7 individuals).

- The blacknose dace (*Rhinichthys atratulus*), characteristic of very small, shallow, heavily sedimented streams, remained abundant through 2006. While its extreme dominance (65.5% of the sample in 2002, dropping to 29-40% in succeeding years) declined it was the most numerous species each year of sampling 2002-2006.

- The proportion of omnivores and herbivores, which in the case of effective natural or artificial restoration would have been expected to decline, increased sharply in 2005 and 2006, from values of less than 10% to over 70%.

- A similar trend occurred with tolerant species, the proportion of which increased dramatically between 2005 and 2006. If we include the doubtful 2007 example, this trend continues, principally as a consequence of the tolerant creek chub overtaking the blacknose dace as the most abundant species.

- Application of the modified Williams “brook trout” IBI yielded scores of 31-39, between the high range of Poor and the lower extreme of Fair, but no trend was discernible.

While a cursory examination of the data suggests that biotic integrity in lower Blaine Branch, far from improving, actually declined during a period of “natural restoration” spanning 2001-2007.

This suggests the inadequacy of existing IBI's to evaluate low elevation streams with drainage areas < 4 square miles. This brings up two points which may be useful in the future.

- Under certain conditions such as extreme incision, when the decision is made to permit natural, unmanaged restoration, we may have to expect that natural restoration of an adequately vegetated riparian buffer will have temporary negative effects on the aquatic biota. The Blaine Branch studies suggest that this "temporary" condition could endure for several years.

- Our assumptions about what should be the reference condition of southern Appalachian streams with watershed areas of up to at least 25 sq. mi. do not take adequate account of the effect of beavers. Our criteria for what constitutes the reference condition were established during a time when beavers were largely absent from the landscape. The temporary elimination of the beaver had at least two significant effects on the fish assemblage of our creeks. First, it altered sediment transport dynamics, favoring riffle dwellers and specialized insectivores in the tributary streams. Second, it enhanced biotic interchange between rivers and tributaries by permitting free passage of fish.

We tend to interpret frequent flushing of small tributaries, leading to maintenance of high quality riffles, and the lack of barriers to biotic interchange between mainstem and tributaries as positive indicators of biotic health in the tributaries. We need to consider the possibility that, if our intention is to measure biotic integrity against a reference condition that reference condition should perhaps allow for a certain amount of impounded, highly sedimented reaches with restriction of fish movement by beaver dams. Such reaches would logically favor the abundance of tolerant and omnivorous species. This possibility would seem to be especially pertinent in the case of very small streams such as Blaine Branch. It may be that real biotic integrity in lower Blaine Branch has improved during 2001-2007, but that our methods are inadequate to measure this improvement.

Table 36. Fish capture data from Blaine Branch above mouth (RM 0.1).

	Number of individuals	
Species (common name)	2006	2007
Mountain brook lamprey	37	6
Rainbow trout		
Brown trout	1	1
Central stoneroller		4
Smoky dace	5	9
Smoky dace x yellowfin shiner?		1
Whitetail shiner	3	1
Warpaint shiner	28	1
River chub	4	5
Golden shiner		
Yellowfin shiner		
Yellowfin x warpaint shiner		
Blacknose dace	83	23
Creek chub	50	33
White sucker		1
Northern hogsucker		
Black redhorse		1
Rock bass		1
Redbreast sunfish	3	
Bluegill		1
Smallmouth bass		1
Largemouth bass	1	
Mottled sculpin	28	20
Total	243	110

Cartoogechaye Creek above Franklin municipal drinking water plant (RM 6.1)

This new site is the key site in the IBI component of the Cartoogechaye Creek Watershed Assessment, undertaken by the LTWA in response to questions about the quality and quantity of Franklin's drinking water supply, which is drawn from Cartoogechaye Creek just a few hundred yards downstream of the lower end of the site. It is located downstream of all 5 major Cartoogechaye Creek tributaries (Mill, Wayah, Poplar Cove, Jones and Allison Creeks), but well upstream of our Cartoogechaye Creek fixed station at the Macon County Rec. Park (RM 1.0).

The banks of the creek are largely forested over the upper half of this site; however part of the upper left bank is an abandoned quarry. The lower half of the right bank consists of a mowed field with a narrow but full buffer zone. It is buffered from a factory located in the Macon County Industrial Park by a wooded slope, but the field does receive run-off from a paved parking lot. The lower left bank comprises a field shaded by large trees, with grass kept at lawn height for recreational use. As of the day of monitoring it had a narrow tree and shrub buffer, but more recently most of the shrub component has been cleared.

There is a full variety of riffle, run and pool habitat, with one powerful chute formed by boulder-size chunks of rock from the abandoned quarry. Below this point similar-sized rocks line the banks providing productive, if somewhat artificial shoreline habitat. The quarry rocks create a partial dam, resulting upstream in a long, sedimented flat reach of medium depth, with habitat principally in the form of woody debris. Part of this reach was included in the sample, in order to achieve a proportionate representation of the habitats present over the 1.5 mi. between the water intake and the first major tributary upstream (Mill Creek.). Just below the sample reach Cartoogechaye Creek is partially impounded by a low dam at the water works.

We were struck by the absence here of 2 species - the fatlips minnow (*Phenacobius crassilabrum*) and the intolerant gilt darter (*Percina evides*). Both were represented at all other sites on the Cartoogechaye Creek mainstem, including the downstream Rec Park site, and the fatlips minnow was also present in the 3 largest tributaries. This suggests the possibility of some localized stress factor. Absence of gilt darters lowered the score for Metrics 2 (No. darter species) and 5 (No. intolerant species).

Catch rate was depressed by inclusion of a portion of the sedimented "flat" at the upstream end of the sample reach. Catch per unit effort in this portion of the sample was 1.1 fish/300 sq. ft. of water surface. If these fish are excluded, overall catch per unit effort rises to 15.5, sufficient to merit the high score for Metric 10, but still only a third of the catch rate at the Mt. Hope Baptist Church site, just 1.5 mi. upstream. Again we must consider the possibility of some local stress reducing total fish abundance.

Historically we have recorded high levels of disease and parasites (primarily due to high incidence of blackspot) at all sites on the Cartoogechaye Creek mainstem, resulting in low scores for Metric 12. The same held true in 2007, but it should be noted that the second highest incidence of parasitization in the watershed (6.8%) was recorded at this site.

The other 4 sites monitored on the Cartoogechaye Creek mainstem recorded IBI's of 44-47 (Fair to Good), while the water works site received a low Fair score of 41. The observations reported above suggest that this difference is significant, raising the possibility of some unverified stressor between the mouth of Mill Creek and the Industrial Park/Water Plant complex. Two non-mutually exclusive possibilities merit investigation:

- Mill Creek received the lowest IBI score (33) of any site in the Cartoogechaye Creek watershed and the only Poor Bioclass Rating. It drains the Mill Creek Club and golf course, a likely source of agrochemical pollution.

- The combined effect of the dam and small impoundment just downstream of the monitoring site and the dam effect of quarry rocks placed in the creek near the upstream end could constitute an effective barrier to movement of fish. This would logically affect Metric 10 (Catch per unit effort) but could also contribute to skewing values for other metrics through differential effects on movement of or habitat suitability for different species, and/or by creating a reservoir for parasites in heavily sedimented reaches.

Table 37. IBI metrics and scores from Cartoogechaye Creek above Franklin municipal water intake (Rm 6.1).

	2007	
Metric	Value	Score
1. Number of native species	16	5.5
2. Number of darter species	2	3.3
5. Number of intolerant species	3	5.5
6. Percentage as tolerant species	1	1.1
7. Percentage as omnivores, herbivores	0.7	5.5
8. Percentage as specialized insectivores	21.1	3.3
9. Number of piscivore species	33.7	3.3
10. Catch rate per unit of effort	2	5.5
11. Percentage as darters and sculpins	43.1	3.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	6.8	1.1
Total		40.7 Fair

Table 38. Fish capture data from Cartoogechaye Creek above Franklin municipal water intake (RM 6.1).

Species (common name)	Number of individuals 2007
Mountain brook lamprey	4
Rainbow trout	1
Brown trout	11
Central stoneroller	60
Whitetail shiner	16
River chub	133
Warpaint shiner	44
Tennessee shiner	185
Mirror shiner	4
Creek chub	2
Northern hogsucker	34
Black redhorse	11
Golden redhorse	2
Rock bass	24
Redbreast sunfish	5
Smallmouth bass	1
Tuckaseigee darter	12
Greenfin darter	57
Mottled sculpin	337
Total	943

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

As Table 40 shows, any improvement occurring in Mill Creek downstream of the Mill Creek Club between 1999 and 2005 was cancelled out between 2005 and 2007. The score for 3 of a total 8 metrics dropped over this period. Perhaps more significantly, observed values for 7 of the 8 metrics were poorer in 2007 than in 2005. Only catch rate (Metric 10) showed an increase in observed value (not score), and this was a generalized condition across the upper Little Tennessee watershed, presumably related to consistent low flows allowing high survival, with little involuntary displacement of small fish.

Changes in observed values were particularly severe for Metrics 7 (proportion as omnivores and herbivores) and 8 (Percentage as specialized insectivores). Although Metric 8 received the low score in 2005 as well, a decline from 14.7 - 4.7% specialized insectivores must be considered extreme.

The native species count (Metric 1) of 9 was the lowest ever recorded here. Four species, including 2 specialized insectivores and one intolerant recorded in both previous samples were missing in 2007 – whitetail shiner (*Cyprinella galactura*), Tennessee shiner (*Notropis leuciodus*), rock bass (*Ambloplites rupestris*) and river chub (*Nocomis micropogon*). While numbers for these species in previous samples have been low, we expended extra effort at the end of the planned sample searching for them. Even had we found one or two of these species, it would require 3 more native species to justify the high score for Metric 1. And this does not take into account the doubtful validity of including the bluegill (*Lepomis macrochirus*), represented by 11 juveniles, in Metric 1. While the bluegill is native to the watershed, Mill Creek is not prime bluegill habitat and it is probable that these individuals are escapees from ponds upstream.

One curious hybrid fish was taken. It appeared to be a smoky dace (*Clinostomus* sp.) x yellowfin shiner (*Notropis lutipinnis*) cross. However we have never recorded yellowfin shiners from Mill Creek.

Physical habitat quality at the site was not notably different from previous years – with excess sediment in the substrate, but otherwise good. This makes it highly likely that the observed changes are due to water quality changes, possibly originating at the intensively developed Mill Creek Club upstream.

In terms of the Cartoogechaye Creek Assessment, of which this sample forms part, it must be noted that Mill Creek is the last major tributary of Cartoogechaye Creek above the Franklin municipal water intake, and the only site out of 10 in the watershed to receive a Poor Bioclass Rating.

Table 39. IBI metrics and scores from Mill Creek (Cartoogechaye watershed) above Old Murphy Rd. (RM 0.3).

	1999		2005		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	14	7.5	12	7.5	9	4.5
5. Number of intolerant species	2	4.5	2	4.5	1	1.5
6. Percentage as tolerant species	16.2	4.5	12.4	4.5	15.7	4.5
7. Percentage as omnivores, herbivores	26.1	1.5	18.8	4.5	35.3	1.5
8. Percentage as specialized insectivores	12.7	1.5	14.7	1.5	4.7	1.5
10. Catch rate per unit of effort	12.5	4.5	15.7	4.5	24.6	4.5
11. Percentage as darters and sculpins	38.0	4.5	53.2	4.5	36.7	4.5
12. Percentage with disease, tumors, fin damage and/or other anomalies	2.1	4.5	0.0	7.5	0.7	7.5
Total		33.0 Poor		39.0 Fair		30.0 Poor

Table 40. Fish capture data from Mill Creek (Cartoogechaye watershed) above Old Murphy Rd. (RM 0.3).

	Number of individuals		
Species (common name)	1999	2005	2007
Mountain brook lamprey	7	1	31
Rainbow trout		1	
Brown trout	2	3	4
Central stoneroller	3	5	20
Smoky dace	12	15	14
Smoky dace x yellowfin shiner?			1
Whitetail shiner	4	3	
Warpaint shiner	1	15	1
River chub	2	9	
Tennessee shiner	1	2	
Blacknose dace	12	14	23
Creek chub	13	12	32
Northern hogsucker	9	5	38
Rock bass	2	2	
Redbreast sunfish	10	15	15
Bluegill	8		11
Largemouth bass	2		
Mottled sculpin	54	116	110
Total	142	218	300

Cartoogechaye Creek at Mt. Hope Baptist Church (RM 7.5)

In 2004, this site, located just above the mouth of Mill Creek and below Wayah Creek, was sampled by a team from the North Carolina Division of Water Quality, using a protocol which does not permit calculation of parameters for Metrics 10 (catch per unit effort) and 12 (proportion of individuals with disease or anomaly). We therefore estimated values for these parameters based on visual observation, and offer two versions of the 2004 IBI, one including scores for Metrics 10 and 12, and one without. However, the better comparison of the 2007 data is probably with the 2003 sample.

As compared to either the 2003 or 2004 results, the 2007 sample shows a somewhat alarming drop in the proportion of darters and sculpins (Metric 11), which is offset in the IBI by a slight increase in the proportion of specialized insectivores between 2003 and 2007 (Metric 8). However, the other 9 metrics show no significant change over the 5 year period.

A number of possibly significant changes in individual species abundance may be noted:

- For the first time in 2007 we did not collect the tolerant exotic redbreast sunfish (*Lepomis auritus*), despite intensive effort along the shoreline.

- The Tuckaseigee darter (*Etheostoma blennioides gutselli*), missing from the sample in 2004, reappeared.

- This was the first year we took catchable brown trout (*Salmo trutta*), including one large individual, from this site.

- The Tennessee shiner (*Notropis leuciodus*) rebounded from a record low of 7 individuals in the 2004 sample to a record high of 107 in 2007. The Tennessee shiner, along with 3 other shiner species present in smaller numbers, was largely represented by small individuals. This presumably represents a response to the absence of strong flows capable of displacing small fish in 2006-2007.

A curious aspect of the 2007 sample is the simultaneous high counts for omnivores and herbivores (Metric 7) and specialized insectivores (Metric 8), with a slight increase in the proportion of specialized insectivores between 2003 and 2007 raising the score for Metric 8 and offsetting the more notable increase in proportion of omnivores and herbivores. These two metrics normally tend to balance each other – if one records a high value the other is likely to be low. Taking into account the situation with shiners described just above, we are inclined to take Metric 8 more seriously. The third and fourth most abundant species here, after the Tennessee shiner and the ubiquitous mottled sculpin (*Cottus bairdii*) were the omnivorous river chub (*Nocomis micropogon*) and the herbivorous central stoneroller (*Campostoma anomala*); unlike the situation with the shiners, both of these species were present in a full range of sizes.

Overall, the condition of Cartoogechaye Creek at RM 7.6, as reflected by the IBI, is remarkably stable. However, the consistently high observed values for Metrics 8 and 12, the latter based on the perennially high incidence of blackspot, suggest that this site might be susceptible to degradation in response to further stresses. One such potential stress is represented by a proposal to establish a large trailer park adjacent to Cartoogechaye Creek just upstream from this site. This proposal has proved controversial, resulting in the Macon County Commission establishing a moratorium on trailer park development.

Table 41. IBI metrics and scores from Cartoogechaye Creek at Mt. Hope Baptist Church (RM 7.5).

	2003		2004			2007	
Metric	Value	Score	Value	Score*	Score**	Value	Score
1. Number of native species	13	5.5	17	6.7	5.5	15	5.5
2. Number of darter species	3	5.5	2	6.7	5.5	3	5.5
4. Number of sucker species	2	5.5	3	6.7	5.5	2	5.5
5. Number of intolerant species	2	3.3	2	4.0	3.3	2	3.3
6. Percentage as tolerant species	0.5	5.5	1.3	6.7	5.5	0.0	5.5
7. Percentage as omnivores, herbivores	18.9	3.3	30.7	1.3	1.1	29.2	3.3
8. Percentage as specialized insectivores	25.3	3.3	14.1	1.3	1.1	30.7	5.5
9. Number of piscivore species	2	5.5	1	6.7	5.5	2	5.5
10. Catch rate per unit of effort	9.3	3.3	Med.		3.3	48.9	5.5
11. Percentage as darters and sculpins	57.0	5.5	51.6	6.7	5.5	35.6	3.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	12.8	1.1	High		1.1	8.1	1.1
Total		47.3		46.8	42.9		47.3
		Good		Good	Fair		Good

*Including estimations for metrics 10 and 11.
**Without estimated values.

Table 42. Fish capture data from Cartoogechaye Creek at Mt. Hope Baptist Church (RM 7.5).

	Number of individuals		
Species (common name)	2003	2004	2007
Mountain brook lamprey	13	64	9
Rainbow trout	1	5	3
Brown trout	1		
Brook trout			1*
Central stoneroller	24	15	83
Smoky dace			
Whitetail shiner	1		3
Warpaint shiner	26	20	59
River chub	49	65	95
Tennessee shiner	49	7	109
Mirror shiner		1	10
Fatlips minnow			2
Blacknose dace		1	
Longnose dace		4	
Creek chub		1	
Northern hogsucker	2	16	15
Black redhorse		3	
Golden redhorse	2	1	6
Rock bass	12	18	19
Redbreast sunfish	2	4	
Redbreast x green sunfish		1	
Bluegill		4	
Tuckaseigee darter	7		4
Greenfin darter	15	32	8
Gilt darter	9	3	2
Mottled sculpin	210	210	214
Total	423	475	641

* Stocker, not included in scoring

Cartoogechaye Creek at Killian Farm, Experimental Sector (RM 10.7)

This site, located just above the mouth of Wayah Creek, and downstream of Poplar Cove Creek, is designated "experimental sector" because when first sampled in 1996 it formed part of a pair with a control sector. The purpose of the experiment was to compare aspects of water quality in a restored reach of Cartoogechaye Creek (livestock excluded, banks stabilized, 30 ft. riparian buffer established, trees planted) with an untreated sector. While it was possible to demonstrate reduced nutrient input to the stream in the experimental sector, concurrent benefits in terms of biotic integrity did not materialize. If anything, biotic integrity at this site has declined since an initial IBI of 52.2 (Bioclass rating Good) was recorded in 1996.

At present, the site is remarkably stable; scores for all 9 IBI Metrics used were the same in 2007 as the last time this site was monitored, in 2002. Only 2 of the metrics merit discussion here:

- During 1997-2002 the incidence of blackspot in middle Cartoogechaye Creek was extremely high, with resulting low scores for Metric 12 (% disease and anomaly). The proportion of visibly infected fish reached an incredible high of 16.3% in 2002. The 2007 observed value of 6.0%, while still meriting the low score, represents a great improvement.

- Metric 5 (No. of intolerant species) might be interpreted differently. Of the 3 intolerant species reported, one (gilt darter, *Percina evides*) is clearly a permanent part of the fish assemblage, and was present in record numbers in 2007. However, none of the 7 rock bass (*Ambloplites rupestris*) recorded more than barely exceeded the minimum size (3 inches TL) to be counted as an intolerant, and the smoky dace (*Clinostomus* sp.) was represented by a single individual. Both species have historically been part of the fish assemblage at this site, although smoky dace appears to be in decline – it was necessary to mount a special search for it in 2002. If either species were disallowed, the number of intolerant species would fall to 2, mandating the middle score and dropping the IBI to 41.4 (Fair).

One effect of shoreline restoration which many observers will take to be positive is enhancement of sport fishery potential. Since 1999 we have taken 21-23 "catchable" brown trout (*Salmo trutta*) from this site, principally around whole tree revetments and root wads installed for bank stabilization purposes.

Table 43. IBI metrics and scores from Cartoogechaye Creek at Killian Farm experimental section (RM 10.7).

	2002		2007	
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	2	4.0	3	6.7
6. Percentage as tolerant species	4.6	6.7	2.5	6.7
7. Percentage as omnivores, herbivores	8.0	6.7	24.4	4.0
8. Percentage as specialized insectivores	27.6	4.0	40.6	4.0
10. Catch rate per unit of effort	24.8	6.7	19.6	6.7
11. Percentage as darters and sculpins	66.6	6.7	35.8	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.7	6.7	0.1	6.7
Total		46.8 Fair		46.8 Fair

Table 44. Fish capture data from Cartoogechaye Creek at Killian Farm, experimental section (RM 10.7).

	Number of individuals	
Species (common name)	2002	2007
Mountain brook lamprey	6	8
Rainbow trout	4	1
Brown trout	23	21
Central stoneroller	77	117
Smoky dace	*	1
Whitetail shiner	12	19
Warpaint shiner	82	45
River chub	75	89
Tennessee shiner	50	76
Mirror shiner	30	11
Fatlips minnow		2
Blacknose dace	15	12
Longnose dace	*	4
Creek chub	1	8
White sucker	2	2
Northern hogsucker	17	30
Black redhorse	1	2
Golden redhorse	1	1
unid. Redhorse		1
Rock bass	8	7
Redbreast sunfish	19	7
Bluegill		
Tuckaseigee darter	*	1
Greenfin darter	28	34
Gilt darter	4	12
Mottled sculpin	201	284
Total	656	795

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

Poplar Cove Creek above Corpening Rd. (RM 0.4)

Since it was last monitored in 1999, this site has been impacted by clearing of pasture, with reduction of buffer zone width along the left bank, and some trash dumping along the right bank. There has also been considerable development activity in the watershed upstream, though we are not aware of any unusually severe impacts. While we have not been able to document significant changes in the fish-based IBI, we do note changes in the composition of the fish assemblage. Viewed superficially, they seem to be positive, as the number of native fish species (Metric 1) increased from 7 in 1993 to 9 in 1999 and 11 in 2007 (allowing the high score for Metric 1 for the first time).

However, note also that total fish species (native plus exotic) steadily increased over the sample period – 8, 11, and 14. (So far no species has dropped out of the list for this site.) The new species for 1999 included one exotic (rainbow trout, *Oncorhynchus mykiss*), one herbivore normally absent from unsedimented streams (mountain brook lamprey, *Ichthyomyzon greeleyi*) and perhaps most significantly, the river chub (*Nocomis micropogon*), an omnivore associated with streams larger than Poplar Cove Creek. Additions for 2007 include the herbivorous central stoneroller (*Campostoma anomala*), the creek chub (*Semotilus atromaculatus*), a tolerant omnivore, and a tolerant exotic (redbreast sunfish, *Lepomis auritus*). Among the 8 total species recorded in 1993, 3 show clear trends in abundance over the years. The native warpaint shiner (*Luxilus coccogenis*), a specialized insectivore and especially the exotic brown trout (*Salmo trutta*) increased in abundance, while another specialized native insectivore, the longnose dace (*Rhinichtys atratulus*) declined.

Although the result is an increase in native and total biodiversity, these results appear to us to constitute a slight negative trend. They are not unequivocal, aspects which might argue against our conclusion include:

- The 3 new species taken in 2007 were each represented by a single individual.
- An argument can be made that the brown trout and rainbow trout, while exotics, fulfill apositive role by filling the niche formerly occupied by the native brook trout (*Salvelinus fontinalis*).
- The increase in warpaint shiner abundance contributes positively to the score for Metric 8 (proportion of specialized insectivores).

However, note also that:

- The warpaint shiner and Tuckaseigee darter (*Etheostoma blennioides gutselli*, a species not normally associated with streams this small) were represented by single individuals in 1993, and only single individuals of the mountain brook lamprey and rainbow trout were taken in their first year of appearance (1999). This was the prelude to what appears to be establishment by all 4 species.

- Brown trout are much more piscivorous than either brook or rainbow trout; their numbers are often correlated with the presence of abundant prey, often in the form of "weedy" fish, whose abundance in turn may be correlated with nutrient enrichment. (From a fishery management point of view, the brown trout population, which includes some unusually large individuals, would be viewed as a positive.)

- No tolerant fishes were recorded from this site prior to 2007.

- We might also cite a steady increase in the observed values for Metric 12 (proportion of individuals with disease and anomalies). However, it must be noted that this correlates exactly with the increasing abundance of the river chub, a species unusually propense to infestation with blackspot (especially in the Cartoogechaye Creek watershed).

The experience of Poplar Cove Creek throws into question the applicability of Metric 1 in streams with drainage areas of 4-7 sq. mi., and particularly toward the lower end of that range. (The watershed of Poplar Cove Creek at the monitoring site is almost exactly 4.0 sq. mi.) In 1999 we carried out a macroinvertebrate sample together with the fish sample in order to be able to calculate a modified Williams "brook trout" IBI. The result was an IBI score of 46.5, as compared to a fish-based IBI of 42.0. Intuitively, we concluded that the higher score, which permits us to assign a Good Bioclass Rating, was more in accord with our perception of the site.

In 2007 (motivated partly by the cost of analyzing macroinvertebrate samples) we determined not to carry out a macroinvertebrate sample if (as unexpectedly turned out to be the case) we turned up enough native fish species to justify the high score for Metric 1. If we had completed a macroinvertebrate sample and if, as seems probable, it had again produced high scores for both of the macroinvertebrate metrics in the combined IBI then, based on the 2007 fish data, the modified Williams "brook trout" IBI would have been 43.5.

In other words, while the fish-based IBI shows an improvement in Poplar Cove Creek between 1999 and 2007, as a consequence of a higher native species count, the combined IBI shows a drop, reflecting an exaggerated level of total fish abundance (catch rate of 61.5 fish per 5 minutes of electrofishing, mandating the medium score for Metric 4, based on total fish abundance). What we may be observing here is a case of the phenomenon of "native invasion" (Scott and Helfman 1999, 2001) whereby anthropogenic modifications to small streams producing higher water temperatures, increased sediment deposition and elevated nutrient levels result in conditions physically and chemically similar to those which naturally occur in larger streams, facilitating the establishment of "river" species not naturally present in these small streams. We have observed increases in native fish diversity similar to those observed in Poplar Cove Creek on the similar sized North Prong Ellijay Creek (McLarney, 2006), leading us to speculate on native invasions there, but the picture which emerges for Poplar Cove Creek seems clearer.

In summary, we are inclined to place more weight on the combined fish/macroinvertebrate IBI as a descriptor of trends in biotic integrity in Poplar Cove Creek between 1999 and 2007. This strongly suggests that for streams in the 4-7 sq. mi. watershed category, or at least for streams toward the lower end of that range, macroinvertebrate sampling should be routine procedure.

Table 45. IBI metrics and scores from Poplar Cove Creek above Corpening Rd. (RM 0.4).

Metric	1993 Value	1993 Score	1999 Value	1999 Score	2007 Value	2007 Score
1. Number of native species	7	4.5	9	4.5	11	7.5
5. Number of intolerants	1	1.5	1	1.5	1	1.5
6. Percentage as tolerant species	0.0	7.5	0.0	7.5	0.4	7.5
7. Percentage as omnivores, herbivores	3.6	7.5	15.1	4.5	11.6	4.5
8. Percentage as specialized insectivores	5.4	1.5	10.7	1.5	4.6	1.5
10. Catch rate per unit of effort	46.7	7.5	36.4	7.5	41.2	7.5
11. Percentage as darters and sculpins	88.7	7.5	69.8	7.5	75.4	7.5
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.9	7.5	1.0	7.5	1.8	7.5
Total		45.0 Fair		42.0 Fair		45.0 Fair

Table 46. Fish capture data from Poplar Cove Creek above Corpening Rd. (RM 0.4).

Species (common name)	Number of individuals 1993	1999	2007
Mountain brook lamprey		1	3
Rainbow trout		1	6
Brown trout	9	17	31
Central stoneroller			1
Smoky dace	11	15	7
Warpaint shiner	1	3	10
River chub		13	33
Creek chub			1
Blacknose dace	17	31	20
Longnose dace	13	9	3
Northern hogsucker	2	2	5
Redbreast sunfish			1
Tuckaseigee darter	1	5	3
Mottled sculpin	413	201	377
Total	467	298	435

Cartoogechaye Creek at Cartoogechaye Baptist Church (RM 11.2)

This site, located above the juncture of Poplar Cove Creek, was one of the few sites visited in 2007 where we did not take record or near-record numbers of fish; in fact catch per unit effort, while still rating the high score for Metric 10, was the lowest of 3 occasions on which this site was monitored. This was accompanied by what appeared to be a real improvement in biotic integrity.

Although the only two farms on Cartoogechaye Creek above the Franklin water treatment plant where cattle continue to have free access to the creek are located not far upstream of this point, and cattle access also affects Jones and Allison Creeks, which join to form Cartoogechaye Creek 6.5 mi. above this point, local residents maintain that the creek is "cleaner" than formerly due to reduced livestock numbers. This is consistent with the observed low catch rate and with improvement in observed values for Metrics 7 (proportion of omnivores and herbivores) and 12 (proportion of individuals with disease and anomaly).

We must note two factors not related to organic loading which may have affected catch rate:

- Efforts to sample a large deep pool with much cover in the form of tree roots and branches were not particularly successful, yielding only 27 fish, for a catch rate of 6.7 fish/300 sq. ft. of water surface in the pool, as compared to 30.5 for the whole sample. If this pool is eliminated from the sample, catch per unit effort rises to 35.3, no longer a record low, but much lower than catch rates of 78.0 and 51.2 in 1993 and 1999.

- An enormous number of the piscivorous brown trout (*Salmo trutta*), some of them quite large, may have reduced the number of forage species which normally make up the bulk of any IBI sample.

Clearly the outstanding change at this site since 2001 was the impressive improvement in Metric 12. For the past several years Cartoogechaye Creek, over its entire length, has displayed extremely high rates of blackspot infestation. The form of blackspot observed involves large, irregularly shaped, raised cysts rather than the more familiar small, round and more or less flat ones. The 2001 observed value of 19.5% (based primarily on blackspot) is the highest we have ever recorded from a non-urban stream. In contrast, in 2007 blackspot was much less prevalent (and almost entirely confined to river chub, *Nocomis micropogon*, which seem to be uniquely susceptible). The number of cysts per fish appeared to be much fewer, and they were of the small, round type. No other pathological conditions were observed.

A few negative trends were observed:

- Poor catch of specialized insectivores (20.8%, down from 32.3% in 1999), barely qualifying for the middle score for Metric 8.

- Ongoing decline of one specialized insectivore (longnose dace, *Rhinichthys cataractae*) expressed this year as complete absence of this species, despite abundant suitable habitat.

- One of the intolerant species (gilt darter, *Percina evides*) was represented by only a single individual. If this individual were disallowed as a stray, the score for Metric 2 (no. of intolerant species) would drop to 4.0 and we could not assign a Good Bioclass Rating. Since this individual was an adult in breeding color, and since the gilt darter is typically present at this site, it was counted in computing the IBI.

An IBI score of 46.8 permits either a Good or a Fair Bioclass Rating, but is numerically closer to the lower limit of the obligatory Good class. The main factor in deciding us on a Good classification was the spectacular improvement in Metric 12 due to dramatically reduced levels of blackspot infestation.

Table 47. IBI metrics and score from Cartoogechaye Creek at Cartoogechaye Baptist Church (RM 12.1).

	1999		2001		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	19	6.7	17	6.7	20	6.7
2. Number of darter species	3	6.7	3	6.7	3	6.7
5. Number of intolerant species	3	6.7	3	6.7	3	6.7
6. Percentage as tolerant species	1.9	6.7	1.2	6.7	1.3	6.7
7. Percentage as omnivores, herbivores	24.1	1.3	40.7	1.3	27.6	1.3
8. Percentage as specialized insectivores	29.8	4.0	32.9	4.0	20.8	4.0
10. Catch rate per unit of effort	51.2	6.7	30.8	6.7	30.5	6.7
11. Percentage as darters and sculpins	43.3	4.0	23.0	1.3	46.1	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	5.6	1.3	19.5	1.3	3.2	4.0
Total		44.1 Fair		41.4 Fair		46.8 Good

Table 48. Fish capture data from Cartoogechaye Creek at Caroogechaye Baptist Church (RM 12.1).

	Number of individuals		
Species (common name)	1999	2001	2007
Mountain brook lamprey	2	4	6
Rainbow trout	1	1	2
Brown trout	5	12	41
Central stoneroller	39	95	99
Smoky dace	19	4	5
Whitetail shiner		4	
Warpaint shiner	52	84	59
River chub	125	152	145
Tennessee shiner	143	98	103
Mirror shiner	3	3	6
Fatlips minnow			5
Blacknose dace	19	19	12
Longnose dace	1	2	
Creek chub	4	1	5
White sucker	1		2
Northern hogsucker	11	17	15
Black redhorse	2		2
Golden redhorse	1		1
unid. Redhorse			1
Rock bass	5	10	9
Redbreast sunfish	10	7	6
Bluegill			1
Largemouth bass	2		
Tuckaseigee darter	5	3	12
Greenfin darter	10	17	12
Gilt darter	2	4	1
Mottled sculpin	327	129	424
Total	789	666	974

Allison Creek below W. Old Murphy Rd. (RM 0.4)

While catch per unit effort (Metric 10) was up at this site, compared to the last time it was monitored in 2007, it did not exhibit the high total fish density typical of most sites monitored this year. A visual impression was that the centers of the pools were empty, and this is supported by the data for the most characteristic inhabitants of the open waters of pools, the shiner group. Two of 3 shiner species recorded for this site (Tennessee shiner, *Notropis leuciodus* and mirror shiner, *Notropis spectrunculus*), disappeared completely in 2007, while the count of warpaint shiners (*Luxilus coccogenis*) declined from 40 to 5. If we treat "column dwelling shiners" as a group, their proportion of the sample in 1999, 2001 and 2007 respectively was 14.7%, 16.9% and 0.9%.

The other noticeable change was in the number, and even more the size, of brown trout (*Salmo trutta*) in such a small stream. A record high total of 32 brown trout was taken, including individuals of up to 19 inches TL. It is tempting to implicate the brown trout in the disappearance of the shiners (as well as that of the only competing piscivore, the rock bass, *Ambloplites rupestris*), but of a total of 533 individual fish other than trout or shiners, at least 500 were of a size suitable as prey for adult brown trout. With the exception of the longnose dace (*Rhinichthys cataractae*), which appears to be declining in Allison Creek, no significant reduction in numbers by other forage species was observed.

A marked increase in abundance by the creek chub (*Semotilus atromaculatus*), a tolerant omnivore, is worrisome, but was not accompanied by increases on the part of any of 6 other omnivorous and/or tolerant species known from the site. (In fact, the score for Metric 7, proportion of omnivores and herbivores, improved between 2001 and 2007.)

One positive note was the capture of a small adult hellbender (*Cryptobranchus allegheniensis*).

The disappearance of the longnose dace, coupled with a reduction in total numbers of the darter group and a significant increase in numbers by the mottled sculpin (*Cottus bairdii*) is suggestive of degrading quality in riffle habitat, but is far from conclusive.

As of 2007, Allison Creek can serve as an excellent example of the divergence in perception of streams when evaluated as biodiversity sites or fishery resources. Any angler would be delighted to learn of the brown trout population at this site, but whether or not this exotic piscivore contributes directly to the scarcity of column dwelling cyprinids, our opinion is that a lowering of lower Allison Creek's Bioclass Rating from Good to Fair is justified.

Table 49. IBI metrics and scores from Allison Creek below W. Old Murphy Rd. (RM 0.4).

Metric	1999 Value	1999 Score	2001 Value	2001 Score	2007 Value	2007 Score
1. Number of native species	12	7.5	16	7.5	13	7.5
5. Number of intolerant species	2	4.5	3	7.5	1	1.5
6. Percentage as tolerant species	0.0	7.5	0.5	7.5	2.6	7.5
7. Percentage as omnivores, herbivores	11.3	4.5	20.9	1.5	15.6	4.5
8. Percentage as specialized insectivores	22.5	4.5	29.9	4.5	10.5	1.5
10. Catch rate per unit of effort	100.5	7.5	29.3	7.5	34.9	7.5
11. Percentage as darters and sculpins	61.9	4.5	42.5	4.5	67.8	7.5
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.3	7.5	2.0	7.5	0.2	7.5
Total		48.0 Good		48.0 Good		45.0 Fair

Table 50. Fish capture data from Allison Creek below W. Old Murphy Rd. (RM 0.4).

Species (common name)	Number of individuals 1999	2001	2007
Mountain brook lamprey	17	5	3
Brown trout	5	22	32
Central stoneroller	1	3	2
Smoky dace	29	35	47
Warpaint shiner	76	40	5
River chub	58	50	49
Fatlips minnow			3
Tennessee shiner	20	23	
Mirror shiner		5	
Blacknose dace	9	25	21
Longnose dace	18	7	3
Creek chub		1	14
White sucker	*		
Northern hogsucker	14	12	3
Rock bass	2	2	
Redbreast sunfish	*	1	1
Tuckaseigee darter	4	2	1
Greenfin darter		7	1
Gilt darter		1	
Mottled sculpin	400	161	385
Total	653	402	571

*Species taken in informal shocking after completion of sample, but not included in sample.

Jones Creek below N. Jones Creek Rd. (RM 0.6)

Over the period 1999-2007 this site has oscillated within the range of IBI's corresponding to the Fair Bioclass Rating, and this seems to fairly represent the condition of lower Jones Creek.

As at the nearby Allison Creek site (These 2 streams together form Cartoogechaye Creek.) a major increase in abundance of brown trout (*Salmo trutta*) was observed, though there were no individuals measuring over 12 inches TL. Unlike the case in Allison Creek, we did not observe a parallel large drop in numbers of column-dwelling shiners.

2007 marks the first record for the fatlips minnow (*Phenacobius crassilabrum*) from Jones Creek.

Table 51. IBI metrics and scores from Jones Creek below N. Jones Creek Rd. (RM 0.6).

	1999		2001		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	9	4.5	13	7.5	12	7.5
5. Number of intolerant species	1	1.5	2	4.5	2	4.5
6. Percentage as tolerant species	0.3	7.5	1.4	7.5	0.2	7.5
7. Percentage as omnivores, herbivores	18.2	4.5	28.2	1.5	25.8	1.5
8. Percentage as specialized insectivores	15.8	1.5	20.6	4.5	14.4	1.5
10. Catch rate per unit of effort	30.6	7.5	19.6	7.5	24.1	7.5
11. Percentage as darters and sculpins	60.7	4.5	42.8	4.5	53.1	4.5
12. Percentage with disease, tumors, fin damage and/or other anomalies	1.3	7.5	0.8	7.5	1.9	7.5
Total		39.0		45.0		42.0
		Fair		Fair		Fair

Table 52. Fish capture data from Jones Creek below N. Jones Creek Rd. (RM 0.6).

	Number of individuals		
Species (common name)	1999	2001	2007
Mountain brook lamprey	2	9	13
Rainbow trout	1	1	20
Brown trout	9	2	13
Central stoneroller		*	2
Smoky dace	22	40	55
River chub	4	32	45
Warpaint shiner	9	27	15
Mirror shiner		3	
Fatlips minnow			1
Blacknose dace	48	58	88
Longnose dace	17	6	12
Creek chub	1	5	1
White sucker			
Northern hogsucker	6	27	3
Rock bass		1	3
Mottled sculpin	184	158	307
Total	303	369	578

Hickory Knoll Creek above Hickory Knoll Rd. (RM 0.4-0.5)

The 2007 sample on Hickory Knoll Creek was taken at a point 0.1 mi. downstream of the site previously monitored, but which forms part of the same reach. It should be noted that for about a year a large amount of sawdust was piled along the lower part of this reach until its removal was mandated by the EPA. There is no evidence that this affected the IBI.

Although the IBI score and Bioclass Rating for this site remained the same (42 Fair) as when it was last monitored in 2001, there are changes in score for 4 of the 8 metrics. Of the two metrics which posted improved scores, at least Metric 1 (No. of native species) must be considered suspect, for reasons discussed below. We here suggest that gradual deterioration may be occurring at this site, but that our fish-based IBI may not be sufficiently sensitive to pick it up. In support of this argument:

- There is a continual downward trend in absolute values for Metrics 6 (% tolerants), 7 (% omnivores and herbivores) and 11 (% darters and sculpins) over the last 3 years of sampling. (The observed value for Metric 11 was 34.97%, precisely on the line between the values for the middle and low score. We opted for the middle score because sculpins are often undercounted, and are thus likely to have formed >35% of the actual fish assemblage. But note the extreme drop in observed values for this metric over the years.)

- The site is visibly more sedimented, which may be reflected in the first record here for mountain brook lamprey (*Ichthyomyzon greeleyi*), as well as in the observed changes for Metrics 7 and 11.

- Centrarchids in the pools (4 species) were largely replaced by the creek chub (*Semotilus atromaculatus*), a tolerant omnivore. There appeared to be a loss of pool volume over the period 2001-2007.

- No rainbow trout (*Oncorhynchus mykiss*) were reported in 2007, versus 7 and 18 in the two previous years of monitoring.

- The exotic yellowfin shiner (*Notropis lutipinnis*) represented by a single individual when this site was first monitored in 1995, has increased steadily in abundance. This was the first year we observed hybrids of yellowfin shiner with native species here. If the yellowfin were to be considered as a tolerant, as is done by the Georgia DNR, then the observed value for Metric 6 (% tolerants) would rise to 18.1% and the IBI would drop to 39.0.

- The two species for which consistent downward trends in abundance have been observed here are the intolerant smoky dace (*Clinostomus* sp.) and the principal inhabitant of the riffle habitat, the mottled sculpin (*Cottus bairdii*). Another obligate riffle species, the longnose dace (*Rhinichthys cataractae*), disappeared after 1995.

It must be noted, though, that the increase in number of specialized insectivores between 2001 and 2007 is real. All of this increase is accounted for by 2 column-dwelling cyprinid species, warpaint shiner (*Luxilus coccogenis*) and Tennessee shiner (*Notropis leuciodus*). This suggests that Hickory Knoll Creek's problems are principally in relation to benthic habitat and not to water quality problems affecting column dwellers.

Total watershed area of Hickory Knoll Creek at RM 0.4 is 4.0 square miles. While it thus qualifies for evaluation of biotic integrity based on sampling only fish, it may represent a situation similar to that of Poplar Cove Creek (See above.) where a combined fish/macroinvertebrate IBI, as required for streams with watershed drainage areas of 1-4 sq. mi., would give better results.

As in the case of Poplar Cove Creek, part of the discussion centers around Metric 1 (No. native species). While even if the single bluegill (*Lepomis macrochirus*) taken in 2007 is discounted as a stray from nearby ponds, the observed value for Metric 1 mandates the high score, it may be that some of the native species counted in scoring this metric are "native invaders" from the Little Tennessee River mainstem.

A macroinvertebrate sample from this moderately heavily sedimented site might produce a low score for Metrics 1 and or 2 in the modified Williams "brook trout" IBI. In addition, the wild trout metric (Metric 7) would be affected by the disappearance of rainbow trout between 2001 and 2007 and catch rate, as calculated for the combined IBI, would reflect overabundance of fish as a probable consequence of nutrient enrichment. It is thus possible that application of a fish/macroinvertebrate IBI in 2007 would have resulted in a Poor Bioclass Rating, and would have detected a decline in biotic integrity in lower Hickory Knoll Creek over the period 2001-2007. Budget permitting, it would be desirable to carry out a combined IBI sample at this site in the near future.

Table 53. IBI metrics and scores from Hickory Knoll Creek between Hickory Knoll Rd. and Slep Orchard Rd. (RM 0.4–0.5).

	1993		1999		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	11	7.5	10	4.5	12	7.5
5. Number intolerant species	1	1.5	2	4.5	1	1.5
6. Percentage as tolerant species	1.2	7.5	1.6	7.5	2.6	7.5
7. Percentage as omnivores, herbivores	5.7	7.5	17.6	4.5	24.8	1.5
8. Percentage as specialized insectivores	7.6	1.5	5.6	1.5	23.6	4.5
10. Catch rate per unit of effort	43.6	7.5	78.1	7.5	55.4	7.5
11. Percentage as darters and sculpins	84.1	7.5	63.3	4.5	35.0	4.5
12. Percentage with disease, tumors, fin damage and/or other anomalies	2.4	4.5	0.5	7.5	0.4	7.5
Total		45.0 Fair		42.0 Fair		42.0 Fair

Table 54. Fish capture data from Hickory Knoll Creek between Hickory Knoll Rd. and Slep Orchard Rd. (RM 0.4–0.5).

	Number of individuals		
Species (common name)	1995	2001	2007
Mountain brook lamprey			15
Rainbow trout	7	18	
Central stoneroller	24	68	77
Smoky dace	15	4	3
Warpaint shiner	4	21	53
River chub	11	32	22
Tennessee shiner	27	5	59
Yellowfin shiner	1	47	79
Yellowfin shiner x smoky dace			1
Yellowfin shiner x river chub			1
Fatlips minnow		6	2
Longnose dace	4		
Creek chub	2		12
White sucker		1	
Northern hogsucker	1		5
Rock bass		1	
Redbreast sunfish	4	1	
Green sunfish	2	7	1
Bluegill	2		1
Mottled sculpin	550	364	178
Total	654	575	509

Coweeta Creek at old McClure Mill dam site (RM 0.5)

Although at this site much of the Coweeta Creek riparian zone is in largely unbuffered lawn, and although the Coweeta Creek valley is largely developed from this point up to Coweeta Hydrologic Laboratory at RM 1.7, it consistently produces IBI scores at or near the Good Bioclass Rating, and this year's score of 46.8 at RM 0.5 seems appropriate. Perhaps this is testimony to the importance of maintaining forested conditions in headwater areas. The entire upper watershed of Coweeta Creek, comprising 8.4 sq. mi., is protected as the US Forest Service Coweeta Hydrologic Laboratory.

In 2004 this site was sampled by a team from the North Carolina Division of Water Quality, using a protocol which does not permit calculation of parameters for Metrics 10 (catch per unit effort) and 12 (proportion of individuals with disease or anomaly). We therefore estimated values for these parameters based on visual observation, and offer two versions of the 2004 IBI, one including scores for Metrics 10 and 12, and one without. However, the better comparison of the 2007 data is probably with the 2003 sample.

The data suggest a largely stable situation over the years 2003-2007, but with a slight trend toward a decreasing proportion of specialized insectivores (Metric 8) and an increase in omnivores and herbivores (Metric 7), which could eventually drive the IBI down. The effect on Metric 7 is driven largely by a tremendous increase in abundance of the herbivorous central stoneroller (*Campostoma anomala*) at this site, which is fully exposed to the sun.

Changes in Metrics 2 (no. darter species) and 3 (no. intolerant species) are offsetting for 2007, but may not be significant:

- The Tuckaseigee darteer (*Etheostoma blennioides gutselli*) is at best rare on this site; absent in 2007, it was represented by single individuals in 2003 and 2004, rendering doubtful the differences in score for Metric 2.

- The smoky dace (*Clinostomus* sp.) was disallowed as an intolerant in 2004, when it was represented by one small, possibly involuntarily displaced individual. This year, with little displacement of fish by high water anywhere, we took 2 smoky dace and decided to allow it as part of the count for Metric 3.

Four other observations were notable, although they did not affect the IBI:

- The large number of trout, with several "catchables", including one very large brown trout (*Salmo trutta*).

- The unusual abundance of the fatlips minnow (*Phenacobius crassilabrum*), normally present as a very few individuals at any monitoring site.

- The capture of 2 large adult hellbenders (*Cryptobranchus allegheniensis*).

- Surprising scarcity of fish of any kind in quiet pockets near shore.

Given riparian conditions at and above this site, the persistence of Good conditions in lower Coweeta Creek is remarkable.

Table 55. IBI metrics and scores from Coweeta Creek at Old McClure Mill Site (RM 0.5).

	2003		2004			2007	
Metric	Value	Score	Value	Score*	Score**	Value	Score
1. Number of native species	17	6.7	15	8.6	6.7	18	6.7
2. Number of darter species	3	6.7	3	8.6	6.7	2	4.0
5. Number of intolerant species	2	4.0	2	5.2	4.0	3	6.7
6. Percentage as tolerant species	1.5	6.7	0.6	8.6	6.7	0.5	6.7
7. Percentage as omnivores, herbivores	19.8	6.7	40.1	5.2	4.0	29.3	4.0
8. Percentage as specialized insectivores	32.6	4.0	26.0	5.2	4.0	21.9	4.0
10. Catch rate per unit of effort	14.6	6.7	High		6.7	21.2	6.7
11. Percentage as darters and sculpins	44.2	4.0	39.2	5.2	4.0	42.0	4.0
12. Percentage with disease, tumors, fin damage and/or other anomalies	4.5	4.0	High		1.3	2.5	4.0
Total		49.5		46.6	44.1		46.8
		Good		Good	Fair		Good

*Including estimations for metrics 10 and 12.
**Without estimated values.

Table 56. Fish capture data from Coweeta Creek at Old McClure Mill Site (RM 0.5).

	Number of individuals		
Species (common name)	2003	2004	2007
Mountain brook lamprey	6	24	9
Rainbow trout	2	5	13
Brown trout		2	5
Central stoneroller	45	196	197
Smoky dace	1		2
Warpaint shiner	57	55	53
River chub	53	93	111
Tennessee shiner	56	42	119
Tennessee x warpaint shiner			1
Yellowfin shiner	41	17	101
Yellowfin x Tennessee shiner		3	1
Mirror shiner	4		2
Fatlips minnow	4	2	20
Longnose dace	5	4	2
Creek chub			2
White sucker	1		1
Northern hogsucker	4	12	23
Black redhorse		2	4
Golden redhorse		3	
Snail bullhead		1	
Rock bass	9	12	5
Redbreast sunfish	7	4	2
Bluegill			1
Smallmouth bass	1		
Tuckaseigee darter	1	1	
Greenfin darter	16	23	4
Gilt darter	29	77	36
Mottled sculpin	188	206	380
Total	530	784	1094

Little Tennessee River at Tessentee Farm (RM 126.9)

In common with most other sites monitored in 2007 the total abundance of fish, as reflected in Metric 10, was well above normal at this one. Even so, it barely ascended into the range for the middle score, at 9.7 individuals per 300 sq. ft. of water surface.

There was significant improvement in Metric 12 (proportion of individuals with disease or anomaly). However observed values for this metric have oscillated greatly at this site (6.6, 0.8,8.2 and 0.8% respectively, in 1995, 1998, 2001 and 2007.

The absence of large fish of any kind, apart from 4 adult black redhorse (*Moxostoma duquesni*, also represented by several young-of-the-year) was striking. Both of the nominal piscivores present (rock bass, *Ambloplites rupestris* and smallmouth bass, *Micropterus dolomieui*) were small juveniles, so the observed value for metric 9 (No. of piscivore species) was 0.

The most apparent change in the data - the sudden increase in abundance of the yellowfin shiner (*Notropis lutipinnis*), which accounted for 44.4% of the 2007 sample, is not reflected in the IBI. However, if we were to follow the Georgia DNR's lead and consider the yellowfin shiner as an omnivore and a tolerant species, then the observed value for Metric 6 (% tolerants) would rise from 4.0 to 48.4% of the sample, and score for this metric would drop from the high to the low value, while for Metric 7 (% omnivores and herbivores) the corresponding changes would be from 16.9 to 61.3%, dropping the score from the medium to the low value. Depending on how one interprets the yellowfin shiner, then, the IBI score could be anywhere from 29.7 to 36.3, with the Bioclass Rating remaining Poor.

The low abundance of fish in this reach of the Little Tennessee is primarily due to the extremely unstable substrate, which consists mostly of continuously shifting fine sediments. The right bank at this site is part of the Land Trust for the Little Tennessee's (LTLT) Tessentee Farm. The LTLT has done excellent work stabilizing this bank with whole tree revetments, which have naturalized well, and in reestablishing a full vegetative buffer. However, this work is not reflected in the fish assemblage. With the exception of the 4 black redhorses, taken from the one deep pool on the site, the majority of fish captured were associated with occasional aggregations of woody debris. The shoreline did not appear to constitute preferred habitat for any species.

It is sobering to realize that this site, located just 0.2 mi. downstream from the positive influence of a relatively high quality tributary (Tessentee Creek), represents some of the best conditions occurring over the middle third of the southern Macon County reach of the Little Tennessee.

Table 57. IBI metrics and scores from the Little Tennessee River at Tessentee Farm (RM 126.9).

	2001		2007	
Metric	Value	Score	Value	Score
1. Number of native species	15	5.5	15	5.5
2. Number of darter species	1	3.3	1	3.3
4. Number of sucker species	4	5.5	3	5.5
5. Number of intolerant species	2	3.3	1	1.1
6. Percentage as tolerant species	8.2	5.5	4.0	5.5
7. Percentage as omnivores, herbivores	33.5	1.1	61.3	1.1
8. Percentage as specialized insectivores	28.2	3.3	26.6	3.3
9. Percentage as piscivores	1	5.5	0	1.1
10. Catch rate per unit of effort	4.5	1.1	9.7	3.3
11. Percentage as darters and sculpins	1.2	1.1	1.1	1.1
12. Percentage with disease, tumors, fin damage and/or other anomalies	8.2	1.1	0.8	5.5
Total		36.3 Poor		36.3 Poor

Table 58. Fish capture data from the Little Tennessee River at Tessentee Farm (RM 126.9).

	Number of individuals	
Species (common name)	2001	2007
Mountain brook lamprey	11	6
Central stoneroller	4	6
Common carp	1	
River chub	35	41
Whitetail shiner	1	9
Warpaint shiner	24	16
Golden shiner	4	1
Tennessee shiner	16	29
Yellowfin shiner	34	156
Yellowfin x Tennessee shiner		1
Mirror shiner	5	36
Creek chub		6
White sucker	1	
Northern hogsucker	5	27
Black redhorse	2	4
Golden redhorse	1	2
Snail bullhead	1	
unid. Bullhead		1*
Rock bass	10	1
Redbreast sunfish	11	8
Bluegill	2	
Smallmouth bass		1
Gilt darter	2	4
Total	170	354

*YOY, not included in scoring.

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

This site, sampled at the request of the Georgia DNR, offers an interesting contrast to the State Line Fixed Station, located just downstream. There are no significant tributaries nor pollution sources found between the two sites, and both are located not far downstream of what was until March, 2007, the only significant permitted industrial discharger in the upper Little Tennessee watershed. The differences between the sites are mainly physical. The State Line fixed station is largely unbuffered, with minimal shade, poor and unstable riffle habitat, and has a substrate composed largely of shifting sand, with silt deposits in the pools and backwater areas.

The new station described here is well shaded and for the most part well buffered, with half the bank in an essentially forested condition. While riffle/pool structure is poor, both habitats are much more stable here than at the state line. The substrate is a mix of sand, pea gravel and small rubble, with occasional large rocks and some woody debris. Habitat is both quantitatively and qualitatively superior at the upper site in terms of abundance, diversity, stability and the presence of some hard substrate.

At both sites, as on much of the Little Tennessee in Georgia and southern Macon County, North Carolina, much of the shoreline is reinforced with a layer of large rock, by now well naturalized, located at base flow level. Although much of the interstitial space is filled with silt, these rocks are important habitat at sites above and below the sites under discussion here. In 2007, probably due to a long period of dry weather and clear water, a heavy growth of filamentous green algae was apparent at both sites. Growth of riverweed (*Podostemum*) was much denser at the upper site, due to the availability of hard substrate for attachment.

Two small, incised, sandy bottom, low gradient tributaries enter the river above GA 246, one near the lower end of the sample reach, and one just above it. Both streams were seen to have fair populations of creek chub (*Semotilus atromaculatus*) and yellowfin shiner (*Notropis lutipinnis*); sampling was not conducted in proximity to their mouths to avoid confounding the data.

Discussion here will focus on differences between this and the State Line station; to this end sample data and metric scores from that station are repeated in Table 60 along with data from this site. The reader interested in the general condition of the Little Tennessee below the Fruit of the Loom Plant at Rabun Gap should first read the account for the State Line fixed station.

The higher IBI and Bioclass Rating for the upstream site are predicated on the presence of 2 species rare there and not found at the State Line station. Tuckaseigee darter (*Etheostoma blennioides gutselli*), represented by 2 individuals, raises the score for Metric 2 (No. of darter species) and smoky dace (*Clinostomus* sp.), with 5 individuals in the sample, raises the score for Metric 5 (No. of intolerant species). Note also that observed values were significantly higher for 5 of the remaining 9 metrics at the upper site. Only Metric 7 (proportion of omnivores and herbivores) scored better at State Line.

There was a notable shortage of fish in rocky/muddy shoreline habitats at both sites, a condition we have observed in previous years at the State Line station. This suggests a hypothesis of residual toxicity in sediments sequestered by the rocks placed along the lower bank.

If we assume that the difference between the two sites is real, then the results demonstrate that even at one of the very few sites in the upper Little Tennessee watershed where point source pollution has been a concern, the effect on biotic integrity of differences in physical habitat quality can be measured.

Table 59. IBI metrics and scoring from the Little Tennessee River above GA highway 246 (RM 137.6) compared to Little Tennessee River at North Carolina/Georgia state line (RM 136.9).

	2007			
	Above /GA 246		*NC/Ga State line*	
Metric	Value	Score	Value	Score
1. Number of native species	20	5.5	16	5.5
2. Number of darter species	2	5.5	1	3.3
4. Number of sucker species	4	5.5	4	5.5
5. Number of intolerant species	3	5.5	2	3.3
6. Percentage as tolerant species	1.3	5.5	5.3	5.5
7. Percentage as omnivores, herbivores	38.9	1.1	30.8	1.1
8. Percentage as specialized insectivores	24.7	1.1	20.7	1.1
9. Percentage as piscivores	1	5.5	2	5.5
10. Catch rate per unit of effort	16.7	5.5	16.6	5.5
11. Percentage as darters and sculpins	12.0	1.1	6.6	1.1
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.6	5.5	1.2	5.5
Total		47.3		42.9
		Good		Fair

Table 60. Fish capture data from the Little Tennessee River above GA highway 246 (RM 137.6) compared to Little Tennessee River at North Carolina/Georgia state line (RM 136.9).

	Number of individuals 2007	
Species (common name)	Above GA 246	NC/GA State line
Mountain brook lamprey	10	
Rainbow trout	1	1
Brown trout		2
Central stoneroller	114	89
Smoky dace	5	
Whitetail shiner	2	6
Warpaint shiner	69	25
River chub	148	77
Golden shiner	1	3
Tennessee shiner	76	69
Yellowfin shiner	136	189
Yellowfin shiner x smoky dace	1	
Yellowfin shiner x Tennessee shiner		5
Mirror shiner	3	13
Fatlips minnow	1	
Longnose dace		
Creek chub	1	13
White sucker	2	4
Northern hogsucker	24	30
Black redhorse	7	7
Golden redhorse	3	5
Brown bullhead		
Snail bullhead		2
Rock bass	12	7
Redbreast sunfish	6	6
Green sunfish		9
Redbreast x green sunfish		
Warmouth		
Bluegill	1	
Smallmouth bass		
Largemouth bass		
Tuckaseigee darter	2	
Greenfin darter		
Yellow perch	1	1
Gilt darter	17	12
Mottled sculpin	66	29
Total	709	604

Mud Creek at Kelly Creek Rd. (RM 0.7)

This site was sampled in 2007 primarily to clear up some confusion resulting from a 2005 sample by a Georgia DNR crew (results included in Table 62). Our established monitoring site on Mud Creek (previously visited in 1990, 1995 and 2003) is located immediately below Kelly Creek Rd.; the Georgia crew, attempting to replicate our work, mistakenly chose a site above Kelly Creek Rd. where the damming effect of the culvert creates a long, flat, fully sedimented segment of run habitat, where we have in the past noticed a paucity of fishes. In comparison to the downstream site, this reach also lacks large rocks placed along the shore at base flow level and a dense shrubby riparian buffer which provide additional habitat in a stream distinguished everywhere by very poor and unstable substrates.

The Georgia DNR uses a sampling methodology which does not permit calculation of our Metrics 10 (catch per unit effort) and 12 (proportion of individuals with disease or anomaly). In Table 62 we present two versions of an IBI based on their sample, one using values for total abundance of fish and incidence of diseases and parasites derived from the Georgia team's field notes to assign scores for Metrics 10 and 12, and one omitting these metrics.

The differences among the results could scarcely be greater. We rated Mud Creek below Kelly Creek Rd. as 36 Poor in 2003. The two versions of the IBI applied to the Georgia crew's data from above Kelly Creek Rd. give scores of 25.2 and 22.1, both Very Poor. And in 2007, below Kelly Creek Rd., we arrived at a score of 44.1, for a Bioclass Rating of Fair. What is more startling than the difference in IBI and Bioclass Ratings is the difference in abundance of fish. Catch per unit effort (no. fish per 300 sq. ft. of water surface) went from 20.0 below Kelly Creek Rd. in 2003 (meriting the high score for Metric 10) to 4.l (low score) above Kelly Creek Rd. in 2005 and back up to 60.0 below Kelly Creek Rd. in 2007. (While 60.0 receives the high score, this is largely because we have not yet quantified the threshold for assigning a lower score under conditions of excess fish abundance typical of sites suffering organic enrichment. A catch rate of 60.0 clearly falls into this category.)

In explaining these data, we will first dispose of the data from above the road crossing, then analyze the changes which apparently occurred between 2003 and 2007 below the road. Our initial selection of the Mud Creek sample site was predicated on representing the condition of lower Mud Creek as a way of evaluating its contribution to the health of the upper Little Tennessee River. We determined that the habitat over the entire 0.7 mi. of Mud Creek between Kelly Creek Rd. and its mouth was essentially the same. We chose a site immediately below the road for ease of access, but also because, all other things being equal, it was desired to be as far from the river as possible, in order to avoid the confounding presence in our samples of fish which were essentially "visitors" from the river.

We noted then, and underline now, that the reach beginning upstream of Kelly Creek Rd. represents a different habitat. We assume that the Georgia DNR sample was properly conducted and that the data, and our interpretation of them, properly represent the real condition of that reach of Mud Creek as Very Poor, due primarily to extreme sedimentation and lack of riparian habitat, the latter of which is substantially compensated for below the road.

Other than the enormous catch rate in 2007, the only factors setting the 2007 sample apart from that of 2003 are a major reduction in the incidence of disease and parasites (Metric 12) and the presence of rock bass (*Ambloplites rupestris*) large enough to be counted under Metric 3 (No. of intolerant species). What is interesting, and atypical, is that the increase in overall abundance encompasses not only "weedy" species expected to increase in abundance with increasing organic content, but such diverse species as smoky dace, *Clinostomus* sp. (an intolerant specialized insectivore), Tennessee shiner, *Notropis leuciodus* (specialized insectivore) and mottled sculpin, *Cottus bairdii* (which one would suppose to be severely limited by lack of suitable riffle habitat at this site). It should also be noted that such increases are often accompanied by an increase in the frequency of infectious diseases and parasites, but here the opposite was true. These factors partially offset any misgivings one might have about the higher IBI score and Bioclass Rating in 2007 as compared to 2003.

One species, the exotic, tolerant warmouth (*Lepomis gulosus*) was recorded for the first time from Mud Creek in 2007. The original decision to include a plunge pool below the Kelly Creek Rd. culvert in the sample was due to a dearth of true pool habitat at the site. Inclusion of this "atypical" habitat could lead to overestimating the IBI. However, if the plunge pool data are eliminated from the 2007 sample, only 3 species (whitetail shiner, *Cyprinella galactura;* golden redhorse, *Moxostoma erythrurum*) and the exotic, tolerant redbreast sunfish (*Lepomis auritus*), each represented by a single individual, are eliminated. The only effect on the IBI would be to lower the observed value and score for Metric 8 (% specialized insectivores). So if one wishes to disallow the plunge pool data, the IBI drops to 41.4, still for a Bioclass Rating of Fair.

Without understanding all the mechanisms involved, we are forced to include that biotic integrity in lower Mud Creek improved, at least temporarily, between 2003 and 2007.

Table 61. IBI metrics and scores from Mud Creek below Kelly Creek Rd. (RM 0.7) (2005 sample above Kelly Creek).

	2003		2005			2007	
Metric	Value	Score	Value	Score*	Score**	Value	Score
1. Number of native species	13	6.7	10	4.0	5.1	18	6.7
2. Number of darter species	1	4.0	0	1.3	1.7	1	4.0
5. Number of intolerant species	2	4.0	2	4.0	5.1	3	6.7
6. Percentage as tolerant species	2.1	6.7	15.3	4.0	5.1	4.2	6.7
7. Percentage as omnivores, herbivores	22.1	1.3	49.7	1.3	1.7	35.4	1.3
8. Percentage as specialized insectivores	21.0	4.0	11.7	1.3	1.7	26.4	4.0
10. Catch rate per unit of effort	20.0	6.7	4.1	1.3		60.0	6.7
11. Percentage as darters and sculpins	10.5	1.3	14.1	1.3	1.7	11.9	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	5.8	1.3	0.0	6.7		0.2	6.7
Total		36.0 Poor		25.2 Very	22.1 Very		44.1 Fair

*Including estimations for metrics 10 and 12.
**Without estimated values.

Table 62. Fish capture data from Mud Creek below Kelly Creek Rd. (RM 0.7) (2005 sample above Kelly Creek).

	Number of individuals		
Species (common name)	2003	2005	2007
Mountain brook lamprey	15	12	16
Rainbow trout			
Brown trout	1		
Central stoneroller	28	11	257
Smoky dace	5	2	36
River chub	48	39	132
Whitetail shiner			1
Warpaint shiner	79	17	116
Golden shiner			5
Tennessee shiner	11		173
Tennessee shiner x warpaint			1
Yellowfin shiner	173	8	263
Yellowfin shiner x smoky dace		12	6
Yellowfin x warpaint shiner	3		2
Yellowfin x Tennessee shiner	2		
Mirror shiner			1
Fatlips minnow			
Longnose dace			
Creek chub	5	19	42
White sucker			7
Northern hogsucker	11	8	56
Golden redhorse			1
unid. Redhorse		1	
Brown bullhead	1		
Rock bass	1	5	8
Redbreast sunfish	3	6	3
Green sunfish			3
Warmouth			10
Bluegill	3		3
Largemouth bass	1		
Gilt darter	2		1
Mottled sculpin	46	23	153
Total	438	163	1,296

Little Tennessee River above Franklin Rd. (RM 139.6)

Very little has changed at this site, which presents some of the best physical habitat in the Little Tennessee in Georgia, since it was last monitored in 2000. The following changes may be noted:

- Large reduction in total fish abundance, but site still merits the high score for Metric 10 (Catch per Unit Effort).
- Major drop in the proportion of fish with disease or parasites (Metric 12), possibly related to decline in total abundance.
- Return to abundance of the longnose dace (*Rhinichthys cataractae*) represented by large individuals in excellent condition.
- Disappearance of the intolerant smoky dace (*Clinostomus* sp.), which was common here in 1993 and 1994. (Shoreline habitat was searched diligently for this species.)

Table 63. IBI metrics and scores from the Little Tennessee River above Franklin Rd. (RM 139.4).

	2000		2007	
Metric	Value	Score	Value	Score
1. Number of native species	19	6.7	20	6.7
2. Number of darter species	3	6.7	3	6.7
5. Number of intolerant species	3	6.7	2	4.0
6. Percentage as tolerant species	2.4	6.7	1.3	6.7
7. Percentage as omnivores, herbivores	35.3	4.0	36.7	4.0
8. Percentage as specialized insectivores	19.3	1.3	22.6	4.0
10. Catch rate per unit of effort	41.5	6.7	14.2	6.7
11. Percentage as darters and sculpins	30	1.3	29.8	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	3.5	4.0	0.9	6.7
Total		44.1 Fair		46.8 Fair

Table 64. Fish capture data from the Little Tennessee River above Franklin Rd. (RM 139.4).

	Number of individuals	
Species (common name)	2000	2007
Mountain brook lamprey		8
Rainbow trout	2	1
Brown trout		3*
Central stoneroller	74	105
Smoky dace	3	
River chub	152	119
Warpaint shiner	27	38
Whitetail shiner	4	9
Tennessee shiner	39	50
Yellowfin shiner	86	46
Yellowfin shiner x warpaint shiner		1
Yellowfin shiner x Tennessee shiner	3	1
Mirror shiner	1	1
Fatlips minnow	3	
Longnose dace	1	19
Creek chub	5	1
White sucker	1	1
Northern hogsucker	11	19
Black redhorse	7	8
Golden redhorse		1
Rock bass	22	12
Redbreast sunfish	10	5
Green sunfish		1
Bluegill	1	
Largemouth bass		1
Tuckaseigee darter	21	9
Greenfin darter	3	2
Gilt darter	22	4
Mottled sculpin	152	175
Total	660	637

*Stockers, not counted in scoring.

Little Tennessee River at Wolf Fork valley (RM 142.9)

None of the differences in metric scoring values for this site over the period 2005-2007 appear to be significant, although changes in score have occurred due to, for example, the presence or absence of the intolerant gilt darter (*Percina evides*) in the sample. The significance of this is thrown into the doubt by the fact that the only numbers ever recorded for gilt darter at this site are 0 and 1 (though the continued presence of large adults suggests that there is a population at the site.) While an IBI of 36.0 is closer to the Poor range than Fair, the fact of little significance in the changes recorded inclines us to the conservative course of continuing to classify this site as Fair.

The increase in catch per unit effort (Metric 10) recorded in 2007 is part of a watershed-wide phenomenon, presumably due to the absence of flushing flows under the uniformly low water conditions of 2006-2007.

This is one of those sites which forces us to question the status of the exotic yellowfin shiner (*Notropis lutipinnis*) in our IBI. If yellowfin shiner were scored as a tolerant, as is done by the Georgia DNR, then the observed value for Metric 6 (% tolerants) would rise to 28.4, the score for this metric would drop from high to low and the IBI would be 31.6 – definitively Poor.

This year we captured a juvenile hellbender (*Cryptobranchus allegheniensis*) at this site; adults have been taken here before. The limiting factor in most of the Wolf Fork Valley reach of the Little Tennessee River is clearly habitat. Most of the substrate is composed of unstable sand, and the great majority of the fish are associated with the shoreline. At this site, placement of rocks along the bank at base flow level has clearly increased the abundance of some fish species, especially the mottled sculpin (*Cottus bairdii*). It is likely that the hellbender population is dependent on this habitat as well.

This site was damaged by the severe flooding of December, 2004, particularly through the loss of a pool at the lower end of the sample reach when a “digger log” washed out. To our surprise, this pool has restored itself, and was actually inconveniently deep on the day of sampling. Restoration of the pool coincides with the reappearance of the golden redhorse (*Moxostoma erythrurum*) which was absent from this site for the first time during 2005 and 2006.

Table 65. IBI metrics and scores from the Little Tennessee River at Wolf Fork Valley (RM 149.2).

	2005		2006		2007	
Metric	Value	Score	Value	Score	Value	Score
1. Number of native species	13	6.7	12	6.7	12	6.7
2. Number of darter species	0	1.3	1	4.0	0	1.3
5. Number of intolerants species	1	1.3	2	4.0	1	1.3
6. Percentage as tolerant species	5.0	6.7	5.4	6.7	5.0	6.7
7. Percentage as omnivores, herbivores	26.1	1.3	36.7	1.3	34.9	1.3
8. Percentage as specialized insectivores	13.3	1.3	14.2	1.3	22.2	4.0
10. Catch rate per unit of effort	11.8	4.0	18.2	6.7	26.0	6.7
11. Percentage as darters and sculpins	12.0	1.3	12.9	1.3	6.6	1.3
12. Percentage with disease, tumors, fin damage and/or other anomalies	0.8	6.7	0.8	6.7	1.1	6.7
Total		30.6 Poor		38.7 Fair		36.0 Fair

Table 66. Fish capture data from the Little Tennessee River at Wolf Fork Valley (RM 149.2).

	Number of individuals		
Species (common name)	2005	2006	2007
Mountain brook lamprey	8	33	22
Rainbow trout			
Central stoneroller	1	13	48
Smoky dace			
Whitetail shiner			
Warpaint shiner	29	50	91
River chub	51	85	109
Golden shiner			
Tennessee shiner	3	2	29
Yellowfin shiner	82	67	130
Yellowfin x Tennessee shiner	2	1	
Yellowfin shiner x river chub	1	1	
Mirror shiner			1
Creek chub	2	6	11
White sucker	1		
Northern hogsucker	9	40	31
Black redhorse	1		
Golden redhorse			4
Rock bass	8	5	14
Redbreast sunfish	9	14	16
Green sunfish			
Bluegill	4	1	
Smallmouth bass			
Largemouth bass	1	7	2
Tuckaseigee darter			
Yellow perch			
Gilt darter		1	
Mottled sculpin	29	47	36
Total	241	373	544

Exotic Fishes

Documentation in 2007 of a new exotic species in the upper Little Tennessee Watershed, suggests the need for an annotated list of exotic fishes in the watershed, which follows:

Rainbow trout, *Oncorhyncus mykiss*: ESTABLISHED. The rainbow trout, native to Pacific drainages from extreme northern Mexico to Alaska, Siberia and Japan, has since early in the 20th century been the dominant salmonid in the watershed, found in at least small numbers in nearly every flowing stream of suitable size, including on the Highlands Plateau. In most cases its presence signifies a breeding population, but in the mainstem of the Little Tennessee and in some of the warmer, low gradient tributaries it may be present only in the colder months. It is still stocked by the NC Wildlife Resources Commission for put-and-take recreational fishing and undoubtedly some of these individuals, as well as escapees from private commercial and recreational fishing ponds, become naturalized and contribute to the local *O. mykiss* gene pool. Although implicated in the elimination of the native "speckled trout" (See below, under "Subspecies"), the rainbow trout is a highly valued sport fish, as well as being of some aquaculture importance in our watershed.

Brown trout, *Salmo trutta*: ESTABLISHED. Like the rainbow trout, the brown trout, of Eurasian origin, is a long-established resident of the watershed, but it is not usually as common. Nor is it universally distributed; we have found it in the mainstem and tributaries from Brush Creek in Swain County to Betty Creek in Georgia and on the Highlands Plateau. However, the abundance of wild brown trout seems to be increasing. It is the dominant trout in the Cartoogechaye Creek watershed and a few other streams. It is still stocked by the NC Wildlife Resources Commission for put-and-take recreational fishing and undoubtedly some of these individuals become naturalized and contribute to the local *S. trutta* gene pool. Unlike the rainbow trout, it is rarely stocked in private ponds or aquaculture facilities. A popular sport fish, the brown trout is generally less frequently caught by anglers in our watershed than the rainbow trout.

Goldfish, *Carassius auratus*: NOT ESTABLISHED. In some parts of the United States, the goldfish, native to Eurasia, has become established in the wild. We have no evidence that this has happened in our watershed. The only specimen we have encountered in 18 years of monitoring was a small "feeder" goldfish taken in XXXX from Crawford Branch at Franklin Memorial Park in the center of Franklin. ("Feeder" goldfish are brown colored individuals not valued as pets or ornamentals, raised for use as bait or as food for predatory aquarium fish.) This individual was almost certainly the result of an intentional release. Undoubtedly other goldfish are released from time to time, but the species does not appear to have become established.

Rosyside dace, *Clinostomus funduloides*: LOCALLY ESTABLISHED Until XXXX, when the smoky dace (*Clinostomus* sp.), endemic to the Little Tennessee-Tuckasegee watershed, was split off, all *Clinostomus* in our watershed were referred to as "rosyside dace", a name now reserved for *C. funduloides*, native to Atlantic coast drainages from Chesapeake Bay to Georgia, plus some Ohio/lower Tennessee River drainages. However, in XXXX we found a well established population of *C. funduloides* in Mill Creek above Mirror Lake in Highlands. A nearby population in the headwaters of the Chattooga River (Savannah River system) is the probable source of this introduction. *C. funduloides* could present a threat to the integrity of native *Clinostomus*

populations, but so far has not passed the multiple barriers to its downstream spread posed by small reservoir lakes, dams and waterfalls.

Common carp, *Cyprinus carpio*: ESTABLISHED This Eurasian species was widely introduced in North America in the late 19th and early 20th centuries and is now of virtually cosmopolitan distribution below the sub-arctic. The most suitable habitat for common carp in our watershed, and its stronghold, is Lake Emory, where average size (and numbers?) of carp have declined since elimination of a hog raising facility directly tributary to the reservoir in XXXX. While the Little Tennessee mainstem downstream of Franklin is not prime habitat for carp, there are probably a few resident in all deep pools. It is more frequent, but still rare, in the mainstem from the head of Lake Emory up to Otto, and we have 2 records from Georgia, up to RM 142, above US 441 in the Wolf Fork Valley. We have on several occasions seen large carp in the lower mile of the Cullasaja River and have one record from RM 1 on Cartoogechaye Creek at the Macon County Rec Park. While the carp is much appreciated as a recreational and food fish in Europe, there is no established fishery for it in our watershed. It undoubtedly competes to some degree with some native benthic species, but its spread is limited by a shortage of suitable habitat outside Lake Emory.

Bluehead chub, *Nocomis leptocephalus*: LOCALLY ESTABLISHED. This species of the Atlantic piedmont and mountain drainages was discovered for the first time in our watershed in the same sample (Mill Creek, Highlands above Mirror Lake) which revealed the presence of *Clinostomus funduloides*. We have subsequently documented its establishment in the Cullasaja River down at least to Cullasaja Falls, and believe we have seen a few individuals downstream of the falls. Once established below Cullasaja Falls, there would appear to be nothing to prevent it from spreading throughout the watershed. While it is more herbivorous than its native omnivorous congener *Nocomis micropogon* (river chub) it would certainly compete with that species and may have already displaced it from the Cullasaja above Cullasaja Falls. Determining its status is difficult because, except for adult males in breeding season, it is hard to visually distinguish between the two species.

Golden shiner, *Notemigonus crysoleucas*: ESTABLISHED BUT RARE, NOT NECESSARILY EXOTIC. No one disputes that the golden shiner, widely distributed in eastern North America, is much more abundant at lower elevations and low gradients than in the mountains. The generally accepted belief is that it was introduced in the Little Tennessee above Fontana Reservoir at some time, but there is no documentation, and it may be that localized native populations exist or existed. As the most popular commercial bait minnow sold in the United States, there is no doubt that golden shiners have been introduced multiple times to our watershed, and that if there is in fact a native race, its gene pool has long since been swamped. It is abundant in our area only in wetlands from Needmore at least to just above the Georgia line. When it is found in flowing streams it will usually be in backwater areas, and often in the vicinity of a riparian wetland. Curiously, we have not found it in Lake Emory. Below Lake Emory, we have records of this species only from the watersheds of Sawmill, Brush, Iotla and Watauga Creeks; above Lake Emory we have found it in most watersheds, as far upstream as Pitt Branch in the Wolf Fork valley (RM 144 on the mainstem). If the golden shiner is not native here, it is probably of minimal importance as a competitor.

Striped shiner, Luxilus chrysocephalus: NOT ESTABLISHED. In 1995, we took a single individual of this species, and believe we saw another which escaped, from Bates Branch, tributary to the Little Tennessee upstream of Franklin. The striped shiner is native to the French Broad Basin in North Carolina, but otherwise not found east of Tennessee. The Bates Branch collection site was a pool directly adjacent to US 441, and this fish was probably a bait bucket discard.

Yellowfin shiner, *Notropis lutipinnis*: ESTABLISHED AND SPREADING. First documented in our watershed from the Little Tennessee near the North Carolina/Georgia state line in 1988, this species native to southern Atlantic and Gulf Coast drainages has since behaved like a true invasive, moving relentlessly downstream in the mainstem and upstream in tributaries, apparently limited only by high gradients. Verbal reports from Georgia DNR personnel suggest that it was already established throughout the Georgia portion of the watershed prior to our discovery. It is now firmly established everywhere there is suitable habitat in the watershed upstream of Lake Emory. Around 1993 it made its way through Lake Emory to become established in the Rabbit Creek Watershed. In 1997 we took the first specimens below Lake Emory and it is by now well established in the Watauga and Iotla Creek watersheds. We have no records from the mainstem below Lake Emory, but have found it in the Cowee, Bradley, Lakey and Burningtown Creek watersheds and in 2007 it appeared for the first time in Tellico Creek, only 33 river miles above Fontana Reservoir, which will presumably function as a permanent barrier to further downstream spread. In many of the watersheds from Rabbit Creek upstream, the yellowfin shiner now outnumbers the closely related native Tennessee shiner (*Notropis leuciodus*). On several occasions we have observed mixed spawning aggregations of yellowfin and Tennessee shiners, and we have captured hybrids with the latter species and also with smoky dace (*Clinostomus* sp.), warpaint shiner (*Luxilus coccogenis*) and river chub (*Nocomis micropogon*). The yellowfin shiner should definitely be considered a noxious invasive in our watershed.

Mosquitofish, *Gambusia* spp.: LOCALLY ESTABLISHED, NOT NECESSARILY EXOTIC. The Western mosquitofish, *Gambusia affinis*, is native to the Tennessee Valley below the mountains, so could theoretically spread to the upper Little Tennessee. However, it is difficult to imagine how this diminutive, weak swimming fish would spread upstream through many miles of swift flowing water. The eastern mosquitofish *Gambusia holbrooki*, native to southern Atlantic and Gulf of Mexico drainages, would be exotic here, but the high volume of human travel between western North Carolina and Florida renders it extremely likely that it has been deliberately or accidentally introduced here many times. It is not possible to distinguish between the two species in the field; we have one doubtful identification of western mosquitofish, based on a single specimen. We presently have records from 3 parts of the watershed – Lake Emory and at least 2 of its small tributaries (where deliberate introduction for mosquito control would be more than possible), a cluster of sites in Cowee Creek and its tributary Caler Fork around and just downstream of an ornamental aquatic plant facility, and a small riparian wetland at about RM 104, near Coggins Bend. Mosquitofish, of probable Florida origin, are known to be present in ponds at the ornamental plant facility, and could easily escape to Cowee Creek, with the possibility of being displaced downstream to places like the Coggins Bend wetland. Until proven otherwise, we are inclined to regard all mosquitofish from our watershed as exotic *G. holbrooki*. Mosquitofish do not appear to compete with any native species here.

Snail bullhead, *Ameiurus brunneus* and flat bullhead, *Ameirus platycephalus*: ESTABLISHED, BUT RARE. We are certain of the presence of the snail bullhead in our watershed. Some individuals have been identified as flat bullheads, but all doubtful bullheads we have been able to verify were snail bullheads. Both species are native to southern Atlantic Coast drainages. We have only one snail bullhead record from downstream of Lake Emory (lower Watauga Creek). We have not taken them from Lake Emory, but have heard talk of "mud cats" from there. Above Lake Emory they are found sporadically in the mainstem as far up as the Georgia line, and we have records from the lower reaches of Cartoogechaye, Coweeta and Tessentee Creeks. The only place we have found this species to be anything approaching numerous is in the mainstem between the mouths of the Cullasaja River and Cartoogechaye Creek, where it appears to share (compete for?) habitat with river chubs (*Nocomis micropogon*), various centrarchid species, and the Special Concern olive darter (*Percina squamata).*

Brown bullhead, *Ameiurus nebulosus*: ESTABLISHED, BUT RARE. This bullhead is native to almost all of the eastern United States and extreme southern Canada, but supposedly not to western North Carolina west of the French Broad Basin. We have records for brown bullheads, almost always single individuals, at sites on the mainstem and 6 tributary streams scattered from Cowee Creek to RM 140, just below the mouth of Betty Creek in Georgia. Most of the tributary records are from the lower reaches, but it ranges at least 4 mi. up the Cullasaja River. The brown bullhead is more likely than the snail or flat bullheads to be the basis of "mud cat" accounts from Lake Emory, but we have no records from there. Theoretically brown bullheads could be competitors with one or more of our 3 native Ictalurid species, but we have never found bullheads in the only portion of the watershed where native Ictalurids occur – the mainstem downstream of Lake Emory.

White bass, *Morone chrysops*: NOT ESTABLISHED? The white bass, native to the Great Lakes, Mississippi/Ohio valley and western Gulf of Mexico drainages, has been widely and successfully introduced in reservoir lakes throughout the South, including Fontana. There is an annual spring spawning run up the Little Tennessee, but most individuals do not reach beyond the high pool level of Fontana on the river, defined as just below the mouth of Sawmill Creek (RM 90). Undoubtedly some individuals make it into our study area, but we have recorded only occasional individuals at Needmore (RM 96) and on one occasion at Iotla Bridge (RM 110). The white bass spawning run is treated as a considerable fishery resource.

Redbreast sunfish, *Lepomis auritus*: ESTABLISHED. This species of the Atlantic drainages is a long-established member of the upper Little Tennessee fauna, and one of the two most important panfish (with the native rock bass, *Ambloplites rupestris*) of the watershed. It is found throughout the watershed (including the Highlands Plateau) in the mainstem and all tributaries, even occurring as juveniles in tiny branches. It competes for habitat with other centrarchid species, and may have historically reduced the abundance of the native bluegill (*Lepomis macrochirus*), being better suited to the flowing waters typical of our watershed.

Warmouth, *Lepomis gulosus*: ESTABLISHED, BUT RARE. The warmouth was probably first introduced to the upper Little Tennessee watershed with a shipment of bluegills stocked in Mirror Lake on the Highlands Plateau and appears to have escaped when that body of water was

drained for removal of sediments. We first observed it in 1993, in the highly atypical habitat of a swift flowing reach of the Cullasaja River at Peaceful Cove (RM 8.3), well below Mirror Lake and Lake Sequoyah with their respective dams, the Cullasaja Gorge and several waterfalls. It has subsequently turned up in the Little Tennessee mainstem from Needmore to just below Jerry Branch in Georgia at RM 141, and in the lower reaches of 9 tributaries of varying size between Cowee Creek and Jerry Branch. It is usually rare except in and near Lake Emory, but occasionally surprising numbers turn up, as in Mud Creek in 2007. The warmouth may compete with other Centrarchids, particularly the native green sunfish, *Lepomis cyanellus*, but a shortage of good habitat for this species typical of slow, weedy waters should minimize its abundance in most places. We have turned up a number of hybrids with redbreast sunfish (*Lepomis auritus*) and possibly other sunfishes. While the warmouth is an important panfish in some areas, it rarely reaches a size sufficient to be of fishery interest in our watershed.

Redear sunfish, *Lepomis microlophus*: POSSIBLY LOCALLY ESTABLISHED. This species of the lowland south is occasionally stocked in deep ponds for recreational fishery purposes. We know of one such pond in the Cowee area, which is the possible source of the first redear sunfish recorded from the upper Little Tennessee watershed, taken in a deep pool at Needmore in 1990. In 2006, we captured several large individuals from Lake Emory, plus one individual from the mainstem at RM 118, just above Lake Emory, suggesting the existence of a small population in the reservoir. Lack of suitable deep water habit will probably keep this species from spreading much beyond Lake Emory.

Spotted bass, *Micropterus punctulatus*: PROBABLY NOT YET ESTABLISHED. Rumors of spotted bass, native to the lower Tennessee, Ohio and Mississippi drainages, in the Little Tennessee have persisted for years. TVA has several records for Fontana Reservoir, mostly from the Tuckaseigee arm, in recent years, so presumably it was just a matter of time before one showed up in the Little Tennessee. On October 15, 2007 an adult of about 14 inches TL was captured on hook and line in the vicinity of Coggins Bend (RM 140). This may be a threat to the strong native population of smallmouth bass, *Micropterus dolomieui*; on several occasions spotted bass have outcompeted smallmouth under conditions of relatively turbid water.

Yellow perch, *Perca flavescens*: AT LEAST LOCALLY ESTABLISHED. Principally a northern fish, with a range extending into the Canadian Arctic, yellow perch are also native near the coast as far south as South Carolina, but their natural distribution does not include the Southern Appalachians. As of the initiation of the Biomonitoring Program, perch were known from the Hiawassee watershed just to the west, but not from the Little Tennessee. A single yellow perch was observed in the Little Tennessee at RM 118, just above the head of Lake Emory, in 1988, but further presence was not documented until 1995, when the first use of the TVA boat shocker at that site demonstrated a substantial population there and a smaller one in Lake Emory. Since then, yellow perch appear to be extending their range. We have records suggesting that they occupy the entire 25 mile reach between Lake Emory and Fontana Reservoir. Upstream of Lake Emory they occur sporadically up to RM 143 in the Wolf Fork valley of Georgia. We have also taken individuals in the Cullasaja River up to RM 8 and in the lower mile of Cartoogechaye Creek. A popular panfish in the north, yellow perch have yet to be appreciated in our region. They undoubtedly represent serious competition for other predatory fish of their size.

Subspecies

Here we describe two native species which have certainly (brook trout) or possibly (muskellunge) had their gene pool altered through stocking with strains or subspecies from other areas. One species from the list above (golden shiner, *Notemigonus crysoleucas*) could be moved to this list, depending on one's judgment as to whether *N. crysoleucas* is native to the upper Little Tennessee watershed. A similar case could be made for two undoubtedly native species. The bluegill (*Lepomis macrochirus*) and largemouth bass (*Micropterus salmoides*) support perhaps the two most popular recreational fisheries in the United States, but both species are marginal inhabitants of mountain watersheds, which reach their full expression only under lacustrine conditions. However, with the construction of recreational ponds in the region, stocking with largemouth bass and bluegills has become standard practice, undoubtedly leading to a degree of mongrelization of local native populations of these two species. They are not treated separately because, unlike in the case of the brook trout and the muskellunge, the source of stock would be difficult to trace, and alien strains or intraspecific hybrids of these species would not readily be distinguishable.

Brook trout, *Salvelinus fontinalis*: ESTABLISHED AT HIGH ALTITUDES. Only in recent years has it become apparent that the old timers' "claim that the "speckled trout" of the southern Appalachians are different from typical northern brook trout is valid. There is still not agreement on whether speckled trout are a "southern strain", a subspecies or even a new species, and the decision has economic and political overtones. What is certain is that 1) Unadulterated native populations of speckled trout can be distinguished with confidence from northern brook trout stock using modern genetic tools and 2) most such populations have long since been adulterated through stocking with hatchery fish, all of which are descended from northern strains. Based on the best available information, no more than 3 streams in the upper Little Tennessee watershed, located at elevations above 3,000 ft. in the southern part of the watershed, still contain reasonably pure populations of southern strain speckled trout. Both strains may be considered to be at risk in our watershed due to development, over fishing and climate change.

Muskellunge, *Esox masquinongy*: The upper Little Tennessee watershed is or was home to a small population of *Esox masquinongy ohiensis*, the Ohio muskellunge. Muskellunge stocking programs undertaken when Fontana reservoir was built used hatchery stock belonging to the subspecies *E. masquinongy masquinongy* (Great Lakes muskellunge), so that any native stock was almost certainly mongrelized. A later attempt at stocking Ohio muskellunge in the Little Tennessee was not successful, at least not to the point of establishing a sport fishery or convincing the NC Wildlife Resources Commission to continue investing in the effort. Nevertheless, rumors of muskellunge catches or sightings in the river below Lake Emory persist, suggesting the presence of a remnant population of natives and/or that visitation from what is at best a tiny Fontana population occasionally occurs. We have seen only one muskellunge (a 43 inch TL adult) taken at Needmore in 1990; it was released without attempting to identify it to subspecies.

Non-fish species

The emphasis in this report is fish. However, it would not be complete without reporting on two prominent exotic invertebrate species.

Asian clam, *Corbicula*: *Corbicula* "mussels" of Asian origin have been spreading in the United States for many years, but were not known from the Little Tennessee above Fontana Reservoir until the 1990's. Seemingly overnight, around 2000 they transformed from an occasional presence to a dominant member of the fauna. Today, at any point on the mainstem between Lake Emory and Fontana Reservoir, the most cursory inspection of the substrate will reveal hundreds of *Corbicula* shells. As filter feeders, there can be no doubt that they compete seriously with our unique native Unionid mussel fauna, and may be implicated in the recent decline of native mussels.

crayfish, *Orconectes*: In the fall of 2005 we noticed a substantial number of *Orconectes* crayfish in the lower reaches of Sawmill Creek, at the downstream limit of the free flowing section of the Little Tennessee. For some years there had been reports of exotic *Orconectes* in Fontana Reservoir, but this was the first documentation from a flowing stream in our watershed. Subsequently *Orconectes* was found in the mainstem at the same site. So far no further spread has been documented, but in other regions this species has been found to out-compete some native crayfish, and the same could happen with our native species, *Cambarus bartoni* and the endemic *Cambarus georgiae.*

Acknowledgements

Once again, the Little Tennessee Watershed Association has undergone a change of directorship. Jenny Sanders signed on in time to jump in for one full season of biomonitoring, as an occasional volunteer in the field and, equally important, helping make all the linkages of the program to the membership, board and community which make our work successful above and beyond solely biological criteria.

Rivers Woodward completed his third season as seasonal assistant, contributing his excellent people skills as well as his growing biological knowledge and the sweat of his brow. Off to college, he will be missed.

New board member Betsy Baste, in addition to volunteering in the field several times (nothing new for her) contributed mightily to volunteer recruitment and other coordination tasks.

Other individuals (with their institutions) who helped with recruiting groups of volunteers include Lisa Bates (Project Challenge), Ayres Christ (Carolina Mountain Land Conservancy), Barry Clinton (Coweeta Hydrologic Lab), Gillian Denham (The Mountain), Sara DiBacco (Southern Appalachian Forest Coalition), Brent Martin (The Wilderness Society), Mark Whitman (Save Our Students) and Joan Willis (Franklin High School).

A total of 133 individuals committed a total of 843 volunteer hours to the monitoring effort; 23 of these individuals came out multiple times. Old hand Josh Hina narrowly beat out Scharf Turner for the coveted title of most frequent volunteer.

As in several previous years, Dave Matthews brought and operated the TVA boat shocker for two large, deep sites on the Little Tennessee mainstem.

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Literature Cited

Karr, J.R., K.D. Fausch, P.L. Angermeir, R.R. Yant and I.J. Schlosser. 1986. Assessing Biological Integrity in running waters- a method and its rationale. Illinois Natural History Survey Special Publication No. 5. 28 pp.

Martof, B.S., W.M. Palmer, J.R. Bailey, and J.R. Harrison. 1980. Amphibians and Reptiles of the Carolinas and Virginia. Univ. of North Carolina Press. Chapel Hill, N.C. 264 pp.

McLarney, W.O. 1991. A Watershed Survey and Educational Program to Enhance Environmental Quality in the Upper Little Tennessee River Valley, Year 3. Report to the Western North Carolina Alliance and Division of Air and Water Resources, Tennessee Valley Authority, Chattanooga, Tennessee. 134 pp.

McLarney, W.O. 1993. A Watershed Survey and Educational Program to Enhance Environmental Quality in the Upper Little Tennessee River Valley. Year 4. Executive Summary. Report to Western North Carolina Alliance and Water Management, TVA. 10 pp.

McLarney, W.O. 1995. Draft. Index of Biotic Integrity (IBI) Metrics for the Upper Little Tennessee River Watershed: Comments and Changes. Report to TVA Water Management. 57 pp.

McLarney, W.O. 1996. Index of Biotic Integrity (IBI) Monitoring in the Upper Little Tennessee Watershed, 1995. Report to Western North Carolina Alliance and TVA Water Management. 66 pp.

McLarney, W.O. 1999. Index of Biotic Integrity (IBI) Monitoring in the Upper Little Tennessee Watershed, 1998. Report to Western North Carolina Alliance and Clean Water Initiative, TVA. 95 pp.

McLarney, W.O. 2000. Index of Biotic Integrity (IBI) Monitoring in the Upper Little Tennessee Watershed, 1999. Report to Little Tennessee Watershed Association and Tennessee Valley Authority, Watershed Action Team. 190 pp.

McLarney, W.O. 2001. Index of Biotic Integrity (IBI) Monitoring in the Upper Little Tennessee Watershed, 2000. Report to Little Tennessee Watershed Association and Tennessee Valley Authority, Watershed Action Team. 127 pp.

Saylor, C.S. and S.A. Ahlstedt. 1990. Little Tennessee River Biomonitoring Baseline Data and IBI Scoring Criteria. 1989. Tennessee Valley Authority, Water Resources, Biology Department. Norris, Tennessee. 16 pp.

Scott, M.C. and G.S. Helfman. 1999. Integrating the Stream and its Valley: Aquatic Habitat as a Link between Catchment Land Use and Fish Assemblage Structure. Institute of Ecology, University of Georgia. Athens, Georgia. 10 pp.

Williams, G.G. 1996. A Watershed Approach to Assessing Brook Trout (Salvelinus fontinalis) Distribution and Ecological Health in the Hiawassee Watershed. Tennessee Valley Authority, Hiawassee River Action Team, Norris, Tennessee. 386 pp.

Volunteers

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