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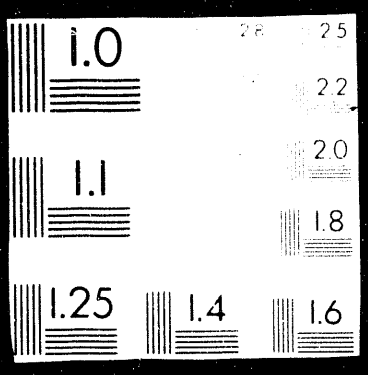

BIOMONITORING OF FISH COMMUNITIES, USING THE INDEX OF BIOTIC INTEGRITY, AS AN INDICATOR OF THE SUCCESS OF SOIL CONSERVATION MEASURES IN THE RABBIT CREEK AND MIDDLE CREEK WATERSHEDS, MACON COUNTY, NORTH CAROLINA

Report to: Macon County Soil Conservation District

Sponsored by: Western North Carolina Alliance
Water Management, TVA

Project Director: Dr. William O. McLarney

Field Assistance: Ken MacGregor and Community Volunteers

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SUMMARY

Fish communities in two upper Little Tennessee River tributaries, Rabbit Creek and Middle Creek, both located in Macon County, North Carolina, were monitored using IBI methods in 1990 and again in 1992. A single site, each on the lower reaches of its respective creek, was chosen to reflect the influence of conditions throughout the watershed and to provide a measure of water quality exiting the watershed.

The Rabbit Creek watershed (Holly Springs community) has a long history of settlement and agricultural use. Dominant land uses today are pasture in the bottom lands and residential development at higher elevations. Much of the upper portion of the Middle Creek watershed on the slopes of Scaly Mountain is devoted to cabbage farming, often on steep slopes and highly erodible soils. From the cabbage growing area, the creek drops 400 feet to the lower valley. Other common land uses include residential, livestock, and forest. Both streams are characterized by heavy sedimentation and frequent high turbidity.

Both streams showed marked improvement between 1990 and 1992. In 1990, Rabbit Creek's IBI score was 31.0, for a bioclass rating of "poor." In 1992, the IBI score was 42.1 for a bioclass rating of "fair." For Middle Creek, the corresponding figures and ratings are 42.1 (fair) and 54.5 (good). Examination of the data for Rabbit Creek shows a reduction in the proportion of pollution-tolerant species, a higher proportion of specialized insectivores, a higher catch rate (reflecting higher total numbers of fish), and an additional intolerant species. In both cases, the data (supported by visual observation) suggests the causative factor is reduced sedimentation.

The principal factor leading to reduced sediment levels would appear in both cases to be adoption of land use practices promoted by the Macon County Soil Conservation District under the Agricultural Cost Sharing Program. In Rabbit Creek, the key factor is fencing cattle out of streams and related alternatives for reducing damage to stream banks by livestock. In Middle Creek, the probable cause of improvement is measures taken to curb soil loss on cabbage farms.

Rabbit Creek has been selected as the site for further watershed improvement measures, in collaboration with Holly Springs residents. Both sites will be monitored annually. If our hypotheses are correct, further improvements should be observed with flushing of sediments over time.

INTRODUCTION

The Index of Biotic Integrity (IBI) has been used as a measure of water and habitat quality in streams in the upper Little Tennessee River watershed (defined as that portion of the watershed upstream of the Little Tennessee River arm of Fontana Reservoir) since 1989. It is one of several measures being used as part of an ongoing project carried out by the Western North Carolina Alliance, funded by Water Management of TVA, and staffed largely by community volunteers.

Water quality and biotic integrity of the Little Tennessee as it enters Fontana Reservoir are generally high, as determined in this study and through TVA monitoring since 1989 of a fixed station at Needmore (on the Little Tennessee River about three miles above Fontana). This is largely due to the relative absence of point sources of pollution in the watershed. The Little Tennessee, unlike other rivers in the region, has no history of gross industrial pollution; sewage treatment plants are relatively few and small, and agricultural areas are fairly small and concentrated in a few areas.

Almost certainly the major factor causing degradation of aquatic habitat in the upper Little Tennessee and its tributaries is erosion and sedimentation. In part this is the inevitable consequence of the unusually erodible soils in some parts of the watershed. However, anthropogenic factors exacerbate the situation. They include:

1. deforestation of stream banks, with subsequent bank erosion;
2. overgrazing of pastures;
3. trampling of stream banks by livestock (often associated with the first two factors);
4. inappropriate agricultural practices, particularly on steep slopes;
5. logging practices, principally road building;
6. residential and commercial development.

Much of the damage caused by development is temporary in nature, but damage resulting from agricultural and livestock use generally persists for many years on a given site.

Two tributary watersheds of the upper Little Tennessee which appear to have been particularly severely degraded by agricultural and/or livestock practices are Rabbit Creek and Middle Creek. This report includes IBI data from 1990 and 1992 for both watersheds and suggests that better management practices carried out by landowners through the Macon County Soil Conservation District have resulted in gradual but measurable improvement.

THE RABBIT CREEK WATERSHED

Rabbit Creek, draining an area of 11.2 square miles, empties into Lake Emory on the Little Tennessee River just above Porter's Bend Dam (River Mile 114). The Rabbit Creek watershed is virtually coterminous with the Holly Springs Community and was one of the first areas of Macon County to be settled. Much of the watershed has been in continual agricultural use since the early nineteenth century.

With the exception of three small, steep, wooded watergap areas, almost the entire length of the valley of Rabbit Creek and most of its tributaries is in intensive use, mostly as pasture. There is also some agriculture, chiefly of corn and tobacco. Land use in the middle elevations, especially the low hills separating Rabbit Creek from its largest tributary, Cat Creek, is primarily residential subdivisions. Much of the highest elevation land (up to 2960 feet) is forested. One tributary watershed to Cat Creek has been

totally modified to become the Holly Springs Golf Course, with associated residential development. Around 1980, the lower course of Cat Creek was deforested and channelized to expand the golf course, but the work was never completed and much of the area is now in pasture.

All of the factors mentioned (livestock, agriculture, residential development, golf course) could contribute to the frequent turbidity and high levels of sedimentation observed in Rabbit Creek and its tributaries. However, based on visual inspection, livestock appear to be the major factor. Agriculture covers only a small area. There has been little new residential development in recent years, and most existing residential areas are well cared for. Golf course construction is long completed and the effect of the golf course is buffered by several ponds on site and a series of beaver ponds along Cat Creek below the golf course.

An IBI monitoring site was established in 1990, just above the lowermost bridge on SSR 1504 (Holly Springs Road), 1.0 mile above Lake Emory. This point is below all livestock or agricultural activity and the great majority of agricultural development in the watershed, as well as downstream of all major tributaries. The site was sampled again in 1992 and plans are to monitor it annually as part of a stream improvement project in collaboration with Holly Springs residents.

THE MIDDLE CREEK WATERSHED

Middle Creek, draining 12.8 square miles, empties into the Little Tennessee River at River Mile 131, 10 miles south of Franklin. Most of the Middle Creek watershed is in Macon County, North Carolina, but a minor portion of the headwater area is in Rabun County, Georgia. The upper reaches of the watershed (comprising the majority) are located on the slopes of Scaly Mountain at elevations of 2600 to 4800 feet. Much of this area is in intensive agricultural use, principally for cabbage. There are also residential developments, a ski slope, and national forest lands.

From Scaly Mountain, Middle Creek drops 400 feet through a mostly wooded gorge, with three major waterfalls. The narrower lower valley has residential developments, pastures and agricultural land.

Middle Creek has been characterized by severe sedimentation problems (muted somewhat by the high gradient of the stream) and tremendous turbidity (levels of over 500 standard turbidity units have been recorded). It is generally considered to be a major contributor of sediments to the Little Tennessee. All of the factors mentioned probably play a role, but it is generally conceded that the major source of sediments transported by Middle Creek is cabbage farming on the steep slopes of Scaly Mountain, where some of the highest rates of soil loss in the eastern United States (up to 500 tons/acre from some fields) have been recorded.

From 1984 through 1988, the Scaly Mountain cabbage growing area was the subject of a major Agricultural Cost Sharing Project carried out by the Macon County Soil Conservation District. IBI monitoring

was conducted in 1990 at a point on Middle Creek 2.0 miles above the mouth at Doug Young Road. This point is below all major tributaries and potential pollution sources. Subsequently this site was selected as a fixed station for annual monitoring, with the intent of determining the effectiveness of upstream work.

ABOUT IBI

IBI is a method for evaluating the health of a body of water at a particular point through assessing the community of fishes present. The assumption is that the various species potentially present respond in different ways to different stresses. Through sampling the fishes in a representative stretch of stream and assigning numerical values ("metrics") to the selected data, we can arrive at an IBI number, placing the stream somewhere on a scale from 12 (a dead stream) to 60 (a perfect natural situation with no major signs of human-induced disturbance). Table 1 outlines the "Biotic Integrity Classes" described by this system.

The sampling method used on Rabbit Creek and Middle Creek was to block off a section of stream (200 feet on Rabbit Creek, 225 feet on the slightly larger Middle Creek) with nets and attempt to capture as close to 100 percent of the fish within the section as possible. Capture was effected through use of backpack electrofisher, seine, and hand nets. All fish were identified on site by the project director and returned to the stream unharmed. Young-of-the-year fish were not included in the counts.

Table 2 shows IBI "metrics" and scoring criteria used in these studies. (Note that some numbers are omitted from the sequence because these metrics are not employed on streams as small as Rabbit Creek and Middle Creek.)

RESULTS - RABBIT CREEK

Tables 3 and 4 show the results of monitoring at the Rabbit Creek site in 1990 and 1992. The dramatic improvement in Rabbit Creek between 1990 and 1992 results from increased scores for metrics 5, 6, 8, and 10. Improvement is also noted for metrics 7 and 11, but increases in measured attributes were not sufficient to affect the score. Comments on individual metrics follow:

Metric 2: Continued absence of darters suggests heavy sedimentation affecting riffle areas in the past. Although Rabbit Creek may, now or in the future, be suitable as habitat for any or all of the four darter species known from streams of this size in the upper Little Tennessee River watershed, recolonization may not occur, since Lake Emory may constitute a barrier.

Metric 5: In 1990, the only intolerant species was the northern hogsucker which is intolerant of chemical pollution but is actually fairly tolerant of sedimentation. In 1992, the rosyside dace was added to the intolerants list, and the number of northern hogsuckers captured increased from two to 18. In 1990, many young-of-the-year northern hogsuckers were observed, suggesting the start of a comeback for this species.

Table 1. Biotic integrity classes used in assessing fish communities along with general descriptions of their attributes

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

Table 2. IBI metric scoring criteria for streams draining seven to 15 square miles in the upper Little Tennessee River watershed

METRIC	POSSIBLE SCORES 2.2	4.4	6.7
1. Total number of native fish species	<6	6-10	>10
2. Number of darter or sculpin species	0	1-2	>2
5. Number of intolerant species	<2	2	>2
6. Percent of individuals as tolerant species	>20%	10-20%	<10%
7. Percent of individuals as omnivores	>20%	10-20%	<10%
8. Percent of individuals as specialized insectivores	<20%	20-45%	>19%
10. Catch rate per unit of effort*	<11	11-18	>18
11. Number of species as simple lithophilic spawners (species which exercise no parental care of eggs or young)	<2	2-3	>3
12. Percent of individuals with disease, tumors, parasites, fin damage, 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 3. Species and number of fish taken at Site 1, Rabbit Creek, in 1990 and 1992.

SPECIES	NUMBER - 1990	NUMBER - 1992
Central stoneroller	7	17
River chub	14	8
Rosyside dace	-	1
Whitetail shiner	1	1
Tennessee shiner	2	21
Warpaint shiner	1	23
Blacknose dace	4	13
Longnose dace	1	3
Creek chub	4	1
White sucker	-	5
Northern hogsucker	2	18
River redhorse	3	-
Brown bullhead	1	-
Rock bass	4	6
Redbreast sunfish	15	1
Bluegill	6	-
Largemouth bass	1	-
Mottled sculpin	5	11
	71	129

Table 4. IBI metrics and scores, Site 1, Rabbit Creek, 1990 and 1992.

METRIC	1990 TOTAL	SCORE	1992 TOTAL	SCORE
1. Total number native species	14	6.7	13	6.7
2. Darter and sculpin species	1	4.4	1	4.4
5. Number intolerant species	1	2.2	2	4.4
6. Percent tolerant species	28.2%	2.2	5.4%	6.7
7. Percent omnivores, generalists and herbivores	42.3%	2.2	34.1%	2.2
8. Percent specialized insectivores	7.1%	2.2	38.0%	4.4
10. Catch rate	7.1	2.2	12.9	4.4
11. Number species simple lithophils	7	6.7	9	6.7
12. Percent with disease or anomalies	5.6%	2.2	8.5%	2.2
Total		31.0 (poor)		42.1 (fair)

Metric 6: This apparently reflects improvement in pool habitat, where the highly tolerant redbreast sunfish was almost totally replaced by the warpaint shiner, which needs a relatively "clean" substrate.

Metric 8: Specialized insectivores (in this case the three shiners and the rosyside and longnose dace) reflect improvement in the qualitative and quantitative aspects of the benthic invertebrate community, which in turn responds positively to reduced sedimentation.

Metric 10: In 1990, riffles and pools yielded fair to good catch rates, but the score was depressed by "run" habitats. Average catch from five runs was 5.6 fish in 1990. The same runs yielded 20.7 fish per unit of effort in 1992.

Metric 12: Diseases observed were contagious forms, associated with organic enrichment (as from livestock) not toxics.

Interviews with local residents and personal observations suggest that the only significant change in the Rabbit Creek watershed over the past few years has been the increasing tendency to fence cattle out of streams. It is not impossible that toxic factors are also involved; use of a given chemical in agriculture, golf course management, etc., could be begun and discontinued without being detected. It is also possible that reduction in sediments reflects weather patterns, or gradual flushing of sediments released during golf course construction. What appears certain is that, as of 1992, Rabbit Creek is a stream in the process of recovery, and that this recovery coincides with a reduction in sediment loads. It is reasonable to assume that recovery could be further assisted by fencing major portions of creekside pasture which remain unfenced and other measures to reduce damage to streams by cattle.

RESULTS - MIDDLE CREEK

Tables 5 and 6 show results of IBI monitoring of Middle Creek in 1990 and 1992. The apparent dramatic improvement in Middle Creek between 1990 and 1992 results from higher scores for metrics 1, 5, 10, and 12. Interpretation must be tempered by the observation that measured attributes for metrics 6, 7, and 8 deteriorated. In the case of metrics 6 and 7, the deterioration was not sufficient to affect the score, and Middle Creek already scored as low as possible for metric 8. The appearance of a single juvenile rainbow trout (definitely not a stocked fish), although not reflected in any of the metrics, is an optimistic note. Comments on individual metrics follow:

Metric 1: In addition to the intolerant rosyside dace, appearance of the mirror shiner is an encouraging sign.

Metric 5: As in Rabbit Creek, the rosyside dace was present in 1992, but not in 1990. Additional intolerants are gilt darter and northern hogsucker. The latter apparently increased in number, although less dramatically than in Rabbit Creek. The total number of individuals of intolerant species increased from nine to 28.

Table 5. Species and number of fish taken from Middle Creek in 1990 and 1992.

SPECIES	NUMBER - 1990	NUMBER - 1992
Rainbow trout	-	1
Central stoneroller	9	12
Rosyside dace	-	11
River chub	1	6
Warpaint shiner	1	-
Tennessee shiner	3	3
Mirror shiner	-	1
Fatlips minnow	1	-
Blacknose dace	-	1
Longnose dace	22	7
Creek chub	-	1
White sucker	-	1
Northern hogsucker	6	13
Redbreast sunfish	1	4
Gilt darter	3	4
Mottled sculpin	126	154
Total	173	219

Table 6. IBI metrics and scores, Middle Creek, 1990 and 1992.

METRIC	1990 TOTAL	SCORE	1992 TOTAL	SCORE
1. Total number native species	9	4.4	12	6.7
2. Darter and sculpin species	2	4.4	2	4.4
5. Number intolerant species	2	4.4	3	6.7
6. Percent tolerant species	0.1%	6.7	2.8%	6.7
7. Percent omnivores, generalists and herbivores	0.6	6.7	9.6%	6.7
8. Percent specialized insectivores	17.3%	2.2	13.3%	2.2
10. Catch rate	12.4	4.4	19.8	6.7
11. Number species simple lithophils	7	6.7	9	6.7
12. Percent with disease or anomalies	6.9%	2.2	1.8%	6.7
Total		42.1 (fair)		53.5 (good)

Metric 10: It was apparent during sampling that shoreline habitat and pools (the zones most heavily affected by sedimentation) were being recolonized. In 1990, there were three shocker runs over badly sedimented habitat which yielded only one fish each. The lowest number captured in a shocker run in 1992 was seven fish.

Metric 12: The chief contributor to this metric in 1990 was leeches on longnose dace, which were absent in 1992. This could reflect a reduction in sediments, organic enrichment, and/or toxic pollutants. Incidences of other diseases, parasites, and anomalies were similar in both years.

Visual examination of shoreline habitat confirms what the IBI data suggest, that sedimentation of Middle Creek is significantly reduced, presumably largely as a result of soil conservation measures applied on Scaly Mountain. There was some concern at the outset of the soil conservation effort that since no-till methods were to be introduced, a possible outcome was to trade off sediment damage for agrochemical pollution, with continuing negative effects on the aquatic community. To date, this does not appear to be the case. In fact, the appearance of rosyside dace and the disappearance of leeches are suggestive of a reduction in agrochemical pollution, perhaps through reduced runoff.

CONCLUSIONS

Dramatic improvement in IBI scores for Rabbit Creek and Middle Creek between 1990 and 1992 suggest that soil conservation measures (better management of cattle with exclusion from streams, and erosion control on agricultural land, respectively) have produced gradual improvement in the quality of downstream aquatic environments. While we may never be able to "prove" the cause and effect suggested, the indication is strong enough to imply that these measures should be maintained and extended where appropriate throughout the Little Tennessee River watershed.

An ultimate purpose of the Western North Carolina Alliance/TVA project, of which this is a part, is to reduce or eliminate sources of pollution to degraded streams, thereby protecting and improving water and habitat quality throughout. The data from Rabbit Creek and Middle Creek provide a valuable tool for the Alliance in promoting such measures with landowners, citizens groups, and government agencies. We will also be following up on these and other sites with continuing monitoring efforts. If our hypotheses are correct, further improvement would be expected with gradual flushing of sediments over time.

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