

**Fish and Macroinvertebrate Surveys
Harpeth River, City of Franklin
Williamson County, Tennessee**

MARCH 2006

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EXECUTIVE SUMMARY

Objectives of the March 2006 study included the physio-chemical, benthic macroinvertebrate and fish community characterization of the Harpeth River in Franklin, Tennessee. Six locations were sampled for benthic macroinvertebrate community composition, fish community structure, physio-chemical composition (pH, temperature, conductivity, and dissolved oxygen) and habitat characterization.

The two upstream stations were similar with a substrate of gravel and sand while the four lower stations had substrates with high amounts of cobble and boulder. Flow was approximately 100 cfs throughout the study reach during the two days of sampling. Habitat was assessed to be “Sub-Optimal” at all stations when using habitat guidelines (Barbour et al. 1999). A comparison to Tennessee’s Habitat Assessment guidelines (TDEC 2003) rank stations 1, 2 and 3 as moderately impaired and stations 4, 5, and 6 as not impaired. In terms of water quality, the major differences between the stations were minimal. Benthic macroinvertebrates were collected and analyzed according to Tennessee Bioassessment procedures. Additional community measures including Shannon’s Index of Diversity, Pielou’s Evenness, Jaccard’s Coefficient and Percent Similarity were also applied to the data set. The Harpeth River supports a fairly diverse benthic macroinvertebrate community within the study reach. At least 97 species were taken from all stations. Midges and blackflies were the numerically dominant groups at all stations. Station 5 had a minimum of 52 species while Station 6 had 47 species. Station 1 had 43; Station 2, 37; Station 3, 32; and Station 4 yielded 30 species. Diversity Indices and evenness values were high and indicative of a diverse benthic community structure existing under fairly good water quality conditions. A comparison of the stations using Tennessee Bioassessment metrics scored all sites as slightly impaired or partially supporting when compared to the target scores for Bioregion 71b.

A minimum of 33 species of fish was taken from all stations. Fish communities at stations 1 and 2 were both represented by 17 species. Station 3 had 18, Station 4, 20; Station 5, 22; and Station 6 had 21 species. IBI scores for Station 1, 2, 4, and 5 are indicative of “Fair” conditions while those at stations 3 and 6 are representative of “Poor to Fair” conditions when compared to reference stream data provided by the Tennessee Valley Authority for the Nashville Basin Ecoregion (TDEC 1996).

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INTRODUCTION

Pennington and Associates, Inc. (PAI) surveyed the Harpeth River in the vicinity of the City of Franklin, Williamson County, Tennessee on March 7 and 8, 2006. The survey was conducted at six pre-selected locations to determine physio-chemical, fish and benthic fauna characteristics of the river within the limits of the City of Franklin. The survey was accomplished as part of an on going study to establish minimum flow requirements to maintain a viable biological fauna in the Harpeth River downstream of the water intake for the city.

Since macroinvertebrate populations are more indicative of the relative health of a stream, attention is normally focused on this group. Macroinvertebrates are found in all aquatic habitats, they are less mobile than most other groups of aquatic organisms, such as fish, they are easily collected, and most have relatively long periods of development in the aquatic environment. Thus, macroinvertebrate species should reflect deleterious events that have occurred in the aquatic environment during any stage of their development. Although fish are generally considered more mobile than aquatic macroinvertebrates, mobility alone does not disqualify fish populations from use as valid water quality indicators (Yoder and Smith 1999). Fish have long been recognized as indicators of degradation and fish assemblages can accurately reflect environmental quality (Karr et al. 1986).

SAMPLING LOCATION

Sampling sites in the Harpeth River are show in Figure 1. The sites were located in the following areas:

Station 1 – Harpeth River mile 89.7, adjacent to Lewisburg Pike just downstream of dam near confluence of Watson Branch (Latitude 35°54.564', Longitude 86°51.362')

Station 2 – Harpeth River mile 89.4 approximately 1,500 feet downstream of Station 1 and just downstream of tributary draining golf coarse reservoir (Latitude 35°354.720', Longitude 86°51.660').

Station 3 – Harpeth River mile 88.6 at Hwy 96 bridge (Latitude 35°55.259', Longitude 86°51.921').

Station 4 – Harpeth River mile 87.7 just downstream of Hwy 31 bridge (Latitude 35°55.657', Longitude 86°51.984').

Station 5 – Harpeth River mile 87.1 adjacent to Hillsboro Road between Del Reo and 4th Street in private park (Latitude 35°55.852', Longitude 86°52.537').

Station 6 – Harpeth River mile 86.5 adjacent to Chestnut Bend subdivision near Ploughman's Bend Street and Joel Creek Blvd (Latitude 35°56.213', Longitude 86°52.206').

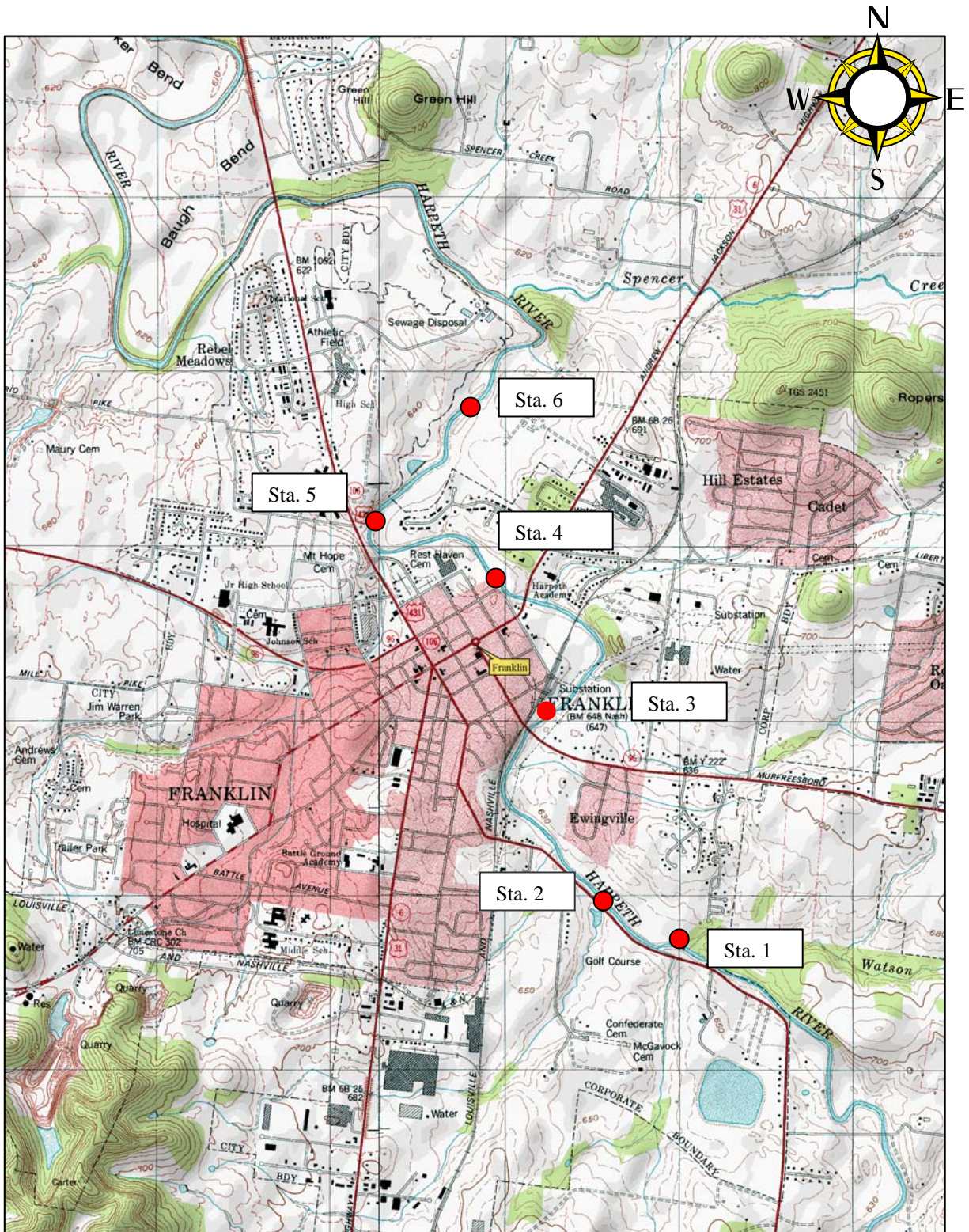


Figure 1. Aquatic fauna study sites, Harpeth River, Williamson County, Tennessee.

PHYSICAL CHARACTERISTICS

The Harpeth River originates approximately 24 miles southeast of the City of Franklin in the Nashville Basin (Rutherford County) at an elevation of approximately 1000 feet and flows northwest to west for approximately 124 miles to its confluence with the Cumberland River. Usage of the Harpeth River watershed upstream of the City of Franklin is primarily agriculture.

Physical characteristics of the sampling sites are summarized in Table 1. The Harpeth River at Station 1, the upstream location, was approximately 85 feet wide and a few inches to one to two feet deep. This site consisted of mostly a long run with few riffles. The flow at Station 1 was estimated to be near 154 cfs (most likely an overestimate since the downstream sites and the USGS gauging sites were near 100 cfs) and the substrate consisted mostly of sand and gravel, with a few boulders. At Station 2 the streambed was about 58 feet wide and also consisted of mostly a long run. The average depth of Station 2 was 1.1 feet. Flow at Station 2 was estimated to be 97 cfs. The substrate was mostly gravel, sand and cobble. Station 3 was approximately 54 feet wide and 0.9 feet deep where flow was taken. The flow at Station 3 was approximately 105 cfs and the substrate was gravel and cobble mixed with sand and boulders. Habitat at Station 3 consisted of riffles and pools. The Harpeth River at Station 4 was approximately 42 feet deep and averaged 0.9 feet wide. Flow at Station 4 was approximated at 118 cfs. Gravel, cobble and boulders were the dominant substrate in the study reach at Station 4. Station 5 was 48 feet wide and averaged 0.9 feet deep. A flow of 118 cfs was measured at Station 5. Substrate at Station 5 was mostly cobble and gravel mixed with boulders. Station 6, the most downstream location, was 43 feet wide and 1.0 foot deep on average. Flow was calculated to be 83 cfs (probably a slight under estimate) at Station 6. The study reach within Station 6 also had a substrate of mostly boulder and gravel mixed among cobble. According to the USGS gauging site (03432350) on the Harpeth River at the Highway 96 bridge (Station 3) flow ranged from a high of 97 cfs on March 7 to a low of 80 cfs on March 8, 2006.

Habitat assessment scores (Table 1) would indicate suboptimal conditions for all locations. A comparison to habitat assessment guidelines for the outer Nashville basin (TDEC 2003) ranks stations 1, 2, and 3 as moderately impaired while stations 4, 5, and 6 rank as not impaired.

BACKGROUND

In aquatic impact assessment, attention is usually focused on the macroinvertebrate species because they are more indicative of the relative health of a stream. Macroinvertebrates are found in all habitats, are less mobile than other groups of aquatic organisms such as fish, are easily collected, and most have relatively long periods of development in the aquatic environment. Thus, macroinvertebrate species can be used to indicate deleterious events that have occurred in an aquatic system during any stage of their development. As found in other similar studies, the alteration of the physical and/or chemical norms of an aquatic environment has the potential to influence all organisms residing in that environment (Goodnight 1973). A benthic macroinvertebrate community represented by numerous species with no particular numerical domination evident in the population is usually indicative of an unstressed environment (Weber 1973). Conversely, a benthic community composed of a few species with large numbers of individuals typifies a stressed community from which intolerant species have been reduced or eliminated by a pollutant or substrate change. The populations of tolerant species expand due to reduced competition or increased resources, or both. The often-dramatic shifts in the benthic community, which can occur under stressed conditions, are due to the varying sensitivities of the different macroinvertebrate species. Mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera), are generally less tolerant of most types of pollution and are considered intolerant or sensitive species, whereas many flies (Diptera) and worms (Oligochaeta) are more tolerant of environmental stress conditions (Brinkhurst 1962, Beck 1977, and Merritt and Cummins 1996). Stream reaches may be divided into several ecological categories depending upon whether or not they are subject to stressful agents and, if they are, to what extent or type. These reaches can usually be divided on the basis of the benthic fauna that is supported in that reach.

Although fish are generally considered more mobile than aquatic macroinvertebrates, mobility alone does not disqualify fish populations from use as valid water quality indicators (Yoder and Smith 1999). Fish have long been recognized as indicators of degradation (Karr et. al. 1986) and fish assemblages can accurately reflect environmental quality in larger streams and rivers.

Clean water streams with variable habitat features often have a high diversity of species with no species numerically dominant. Streams receiving organic pollution generally show a decrease in both taxa richness and diversity and an increase in density (Gaufin and Tarzwell 1956). Streams receiving toxic products frequently show a decrease in taxa richness, diversity and density (Cairns et al., 1971).

Increased sedimentation in streams is a problem most often the result of poor agriculture practices, construction activity and mining in the vicinity of the streams (Waters, 1995). The effects of increased sedimentation are varied, but the primary effect is scouring during high flows, habitat loss caused by the filling of cracks and crevices with sand and silt and general decrease in habitat diversity.

MATERIALS AND METHODS

At each of the six stations, 20 kick-net samples equivalent to an area of approximately 2m² were taken in the runs and riffles at the areas of low and high velocity. The 2m² Kicks were taken in equal proportions using a coarse (500 µm mesh) kick net. In the field, the samples were transferred to plastic containers labeled on the outside and inside and preserved with 10% formalin.

In the laboratory, all benthic samples were washed in a 120-micron mesh screen. After washing, the macroinvertebrates were removed from the detritus under 5x magnification and preserved in 85% ethanol. The organisms were identified to the lowest practical taxonomic level using available keys (Pennington and Associates, Inc. 1994) and counted. Identifications were made with a stereomicroscope (7X to 60X). Slide mounts were made of the chironomids; simuliids, oligochaetes and small crustaceans, and identifications were made with a compound microscope. The chironomids, simuliids, and oligochaetes were cleared for 24 hours in cold 10% KOH. Temporary mounts were made in glycerine and the animals returned to 80% ethanol after identification. When permanent mounts were desired, the organisms were transferred to 95% ethanol for 30 minutes and mounted in euperol.

SUBSTRATE DETERMINATION

A classification of substrate based on the size scale proposed by Wentworth (Compton 1962) was used to make field observations of the substrate present at each station. This classification of detrital sediments is by grain diameter and is as follows:

Diameters	Approximate Inch Equivalents	Name of Loose Aggregate
>256 mm	>10 inch	Boulder
64 to 256 mm	2.5 to 10 inch	Cobble
2 to 64 mm	0.08 to 2.5 inch	Gravel
1/16 to 2 mm	0.002 to 0.08 inch	Sand
1/256 to 1/16 mm	0.00015 to 0.002 inch	Silt
<1/256 mm	<0.00015 inch	Clay

COMMUNITY STRUCTURE MEASURES

Brower and Zar (1984) provide a detailed discussion of a variety of techniques for measuring community structure. The use of diversity indices is based upon the observation that normally undisturbed environments support communities with large numbers of species having no individuals present in overwhelming abundance. If the species of a disturbed community are ranked by numerical abundance, there may be relatively few species with large numbers of individuals. Mean diversity is affected by both "richness" of species (or abundance of different species) and by the distribution of individuals among the species. High species diversity indicates a highly complex community.

Species diversity (H) was calculated using:

Shannon's Index of Diversity

$$H = -\sum p_i \log p_i$$

Where p_i is the proportion of the total number of individuals occurring in species i ($p_i = n_i/N$), N is the total number of individuals in all species. Values range from 0 to $\log N$. Historically, values of diversity (H) greater than 2.0 were representative of unpolluted waters while values less than 1 were indicative of polluted water (Weber 1973).

Diversity indices take into account both the species (or taxa) richness and the evenness of the individuals' distribution among the species. Separate measures of these two components of diversity are often desirable. Species or taxa richness can be expressed simply as the number of species or distinct taxa in the community. Evenness may be expressed by considering how close a set of observed species diversity (H) values are to those from an aggregation of species having maximum possible diversity (H_{max}) for a given N and s (Brower and Zar 1984). Values of evenness range from 0 to 1.

Evenness is calculated using:

$$\text{Pielou } J' = H/H_{max}$$

Jaccards Coefficient, Community Loss Index, and Percent Similarity measure community similarity between sites.

$$\text{Jaccards Coefficient} = \frac{C}{S_1 + S_2 - C}$$

S = Species in each community (S₁ is reference Community in Community loss Index)

C = Species common to both communities

The values of Jaccards Coefficient range from 0 (no species common to both sites) to 1 (all species found at both locations).

$$\text{Community Loss Index} = \frac{S_1 - C}{S_2}$$

The Community Loss Index is an index of dissimilarity with values increasing as the degree of dissimilarity from the reference station (S₁) increases (Plafkin et al. 1989). Values range from 0 to infinity.

Percent Similarity (PS), for a two-community comparison, is calculated as follows: The number of individuals in each species is calculated as a fractional portion of the total community. The value for species i in community 1 is compared to the value for species i in community 2. The lower of the two is tabulated. This procedure is followed for each species. The tabulated list (of the lower of each pair of values) is summed. The sum is defined as the Percent Similarity of the two communities.

Bray-Curtis Percent dissimilarity (PD) is based on species abundance compared between any two communities. The index is expressed as

$$PD = 1 - PS/100$$

Where PS = Percent similarity

Cluster analysis sorts sampling units into groups based on the overall resemblance to each other (Ludwig and Reynolds 1988). By using Percent Dissimilarity or 1- Jaccard's Coefficient sampling units are sorted to permit grouping. The cluster analysis combines the distances between sampling units into a matrix table, and two strategies of clustering are used to calculate a distance for N-1 cycles (N=number of sampling units). The cluster analysis is interpreted graphically on a dendrogram to relate the similar communities (Eckblad 1989, Ludwig and Reynolds 1988).

Analysis of community structure was also interpreted using community indices were calculated at log base 2 where applicable using the software package ECOL ANAL (Eckblad 1989).

TENNESSEE PROTOCOL K-Data Reduction of Semi-Quantitative Sample

The Tennessee Division of Water Pollution has developed a macroinvertebrate index based on seven biometrics for use in semi-quantitative macroinvertebrate surveys (Arnwine and Denton 2001). The index is based on stream data from various ecoregions and calibrated by bioregion. According to the Division of Water Pollution the calibrated scoring criteria can be used in all streams that fit the sample criteria for that region (habitat sampled, sampling protocol, stream size) and have at least 80% of their upstream drainage in the same bioregion.

Conversely, according to Arwine and Denton (2001) streams that do not meet the profile are those that are non-riffle streams in bioregions that are calibrated to a SQKICK sample or streams that have more than 20% of their upstream drainage in other bioregions. The index tables cannot be used for assessments since these samples are not comparable to streams in the Tennessee ecoregion reference database. For streams not comparable to the ecoregion reference data, investigators should compare the seven biometrics to an appropriate upstream or watershed reference.

The seven Tennessee biometrics are calculated using the raw benthic data from the semi-quantitative subsample (TDEC 2003). The biometrics are calculated using taxa identified to the genus level except for specified taxa (Acari, Branchiobdellida, Nematomorpha, Nematoda, Hydra, immature Tubificidae, Lumbriculidae, etc.), very immature individuals, or too damaged to be identified to the genus level. Species identifications are not used in the Tennessee assessment.

a. **EPT** (Ephemeroptera, Plecoptera, and Trichoptera Richness)

The number of genera within the orders Ephemeroptera, Plecoptera, and Trichoptera are totaled. Taxa that can be identified to family are included only if they are the only taxon found in that family or it is probable that they are distinct from other taxa identified to genus within the family.

b. **TR** (Taxa Richness)

The total number of distinct genera found in the subsample. Taxa that could only be identified to family are included only if it is probable that they are distinct from other taxa identified to genus within the family.

c. **%OC** (Percent oligochaetes and chironomids)

$$\%OC = \frac{\text{Total number of Oligochaeta} + \text{Chironomidae} \times 100}{\text{Total number of individuals in the subsample}}$$

d. **%EPT** (EPT Abundance)

$$\%EPT = \frac{\text{Number of Ephemeroptera} + \text{Plecoptera} + \text{Trichoptera} \times 100}{\text{Total number of individuals in the subsample}}$$

e. **NCBI** (North Carolina Biotic Index)

$$NCBI = \sum \frac{x_i t_i}{n}$$

where: x_i = number of individuals within a taxon

t_i = tolerance value of a taxon

n = total number of individuals in the subsample

To calculate the biotic index, species are assigned pollution tolerance values of 0 to 10. A value of 0 is assigned to species found only in unaltered streams of very high water quality. A value of 10 is assigned to species known to occur in severely polluted or disturbed streams. Intermediate values are assigned to species that occur in streams with intermediate degrees of pollution tolerance (Hilsenhoff 1987).

f. **%Dominant** (Percent contribution of the single most dominant taxon)

$$\% \text{ Dominant} = \frac{\text{Total individuals in the single most dominant taxon} \times 100}{\text{Total individuals in the sample}}$$

A community that is dominated by a few species may be under environmental stress (Plafkin 1989).

g. **% Clingers** (Percent contribution of organisms that build fixed retreats or have adaptations to attach to surfaces in flowing water)

$$\% \text{ Clingers} = \frac{\text{Total number of clinger individuals} \times 100}{\text{Total individuals in the sample}}$$

After the values are calculated for the seven biometrics, the data is equalized by assigning a score of 0, 2, 4, or 6, based on comparison to the ecoregion reference database for the bioregion. The seven scores are added. The Non-impaired category is equal to or greater than the proposed biocriteria.

FISH

Fish were taken at each station using a Smith-Root Model GPP 5.0 Electrofisher with shore hook up and hand probes. At each of the sites a 300 to 600 foot section, including all habitats (riffle/runs, pools, undercut banks, etc.), were electroshocked. In addition to electroshocking, a 20-foot seine was used in the deeper pools. The seine was also used in riffles in conjunction with the electroshocker. Habitats were sampled a minimum of three consecutive units of sampling effort until no additional fish species were found. The time required to shock each section was recorded to determine effort.

The fish were identified to species, counted and checked for anomalies. Species not easily identified in the field, and representatives of all field identified species, were preserved in 10% formalin and transported to Pennington & Associates, Inc. laboratory for additional analyses.

The fish data were analyzed using a modification of Karr's Index of Biotic Integrity (Karr 1986) and follows guidelines stipulated in Tennessee's Standard Operating Procedures for fish (TDEC 1996) were followed. The 12 metrics, including modifications, are listed in Table 2 while Table 3 includes the biotic integrity classes used in assessing fish communities along with general descriptions of their attributes. In addition to the 12 IBI metrics used to assess fish communities, total number of species, Shannon Diversity (H), Jaccard Coefficient and Percent Similarity were also used to compare the fish populations at each location.

PHYSICAL AND CHEMICAL PARAMETERS

The physical and field chemical parameters measured included pH, dissolved oxygen, temperature, conductivity, stream width, depth, velocity and flow. Values of pH were

determined at each station with a Fisher Accument Field pH meter. Dissolved oxygen and temperature were determined with an YSI Model 51 Dissolved Oxygen Meter. Temperature was also verified with a field centigrade thermometer. A LaMotte conductivity meter was used to measure conductivity. Width of the streambed was taken at each station using a tape measure. Depth was taken at approximate one-foot intervals across the stream at the location used for width measurements. Average depth was determined by adding the readings taken across the stream at each location used for width measurement and dividing by one more than the number of readings. This is to allow for 0 depth at each side (Lagler 1973). Velocity was measured in triplicate using a timed float. Approximate flow was determined by the following formula:

$$R = V D a W$$

Where R is equal to the volume of flow in cubic feet per second (cfs); W is average width in feet; D is average depth in feet; V is the velocity (ft/sec); and a is a constant for correction of stream velocity (0.8 if the bottom is strewn with rocks and coarse gravel, 0.9 if smooth).

RESULTS AND DISCUSSION

Physical characteristics of the six locations in the Harpeth River are presented in Table 1. Table 4 contains water quality data collected from each site. A list of all species of aquatic benthic macroinvertebrates from each station with, assigned tolerance values and functional feeding groups are shown in Table 5. A summary of Tennessee Bioassessment benthic macroinvertebrate metrics, scoring and index rating are presented in Table 6. Table 7 contains comparisons of the benthic macroinvertebrate communities at each station using Jaccard's coefficient, Percent Similarity, Community Loss Index, Shannon Diversity and Pielou's evenness. Graphic presentations using cluster analyses are shown in Figure 2 for 1-Jaccard's Coefficient and Figure 3 for Percent Dissimilarity. Table 8 contains fish community data for all locations including the calculated Index of Biological integrity (IBI) scores and ratings. Table 9 contains comparisons of the fish community data using Jaccard's Coefficient, Percent Similarity and diversity indices. Graphic presentations of the fish data using cluster analyses are shown in Figure 4 for 1-Jaccard's Coefficient and Figure 5 for Percent Dissimilarity. All field data including habitat assessment field data sheets are presented in the Appendix.

In terms of physical habitat for aquatic life, all stations in the Harpeth River were scored as "Sub-Optimal" (Table 1). A comparison to Tennessee's Habitat Assessment guidelines for the Nashville Basin Bioregion (TDEC 2003) has stations 1, 2 and 3 ranked as moderately impaired mostly because of bank stability and lack of riparian vegetation. Stations 4, 5 and 6 were ranked as not impaired based on physical habitat.

Water quality varied little between each station (Table 4). Values of pH were indicative of slightly alkaline (8.3-8.6) conditions at all stations. Conductivity measurements were only slightly higher at the lower two stations (380 μ s) when compared to Station 1 (360 μ s). Temperature ranged from 10.8 to 13.0 °C throughout the Harpeth River. Dissolved oxygen ranged from 10.2 mg/l at Station 1 to 14.1 mg/l at Station 6.

The Harpeth River supports a fairly diverse aquatic benthic macroinvertebrate community within the study reach (Table 5). A minimum of 97 species of benthic macroinvertebrates representing 16 orders, and 39 families were taken from all stations. Most of

the species (68) were aquatic insects. Blackflies (Simuliidae) and non-biting midges (Chironomidae) were the numerically dominant groups at all stations. There were also four species of fresh dead unionid mussels found at Station 5. Station 5 had the highest number of benthic macroinvertebrate species with 52 followed by 47 at Station 6, 43 from Station 1, 37 at Station 2 and 32 from Station 4 and 30 species from Station 3.

A comparison of the six stations using Tennessee Bioassessment metrics is presented in Table 6. All six sites ranked as slightly impaired or partially supporting when compared to the target scores of Bioregion 71h.

Diversity values shown in Table 7 indicate Station 6 to be the most diverse (4.7) and Station 3 the least (3.17). A review of the values of diversity and evenness are according to Weber (1973), representative of benthic macroinvertebrate communities in the Southeast existing under fairly good water quality conditions unaffected by oxygen demanding wastes. The diversity value reflects the distribution of individuals among the species where an even distribution of individuals among species would yield the maximum diversity value and the restriction of individuals to a few species would produce a low value.

A comparison of the six sites using benthic macroinvertebrate species in common (Jaccard's Coefficient) is presented in Table 7 and clustered in Figure 2. Stations 5 and 6 are the most similar and cluster first. Station 4 forms a secondary cluster with station 5 and 6. Stations 1 and 2 form a third cluster while Station 3 was the least similar and clustered last (Figure 2).

In terms of percent similarity for the benthic macroinvertebrate communities (Table 7, Figure 3), stations 3 and 5 were the more similar (72.2%) and clustered first. A secondary cluster was formed with Station 4. Stations 1 and 2 again form a third cluster while Station 6 was the least similar and clustered last.

A summary of the fish data taken from the six locations in the Harpeth River is presented in Table 8. A minimum of 33 species was taken from all stations. The upstream stations 1 and 2 both yielded 17 species of fish while Station 3 had 18; Station 4, 20; Station 5, 22; and Station 6 had 21. One specimen of *Etheostoma microlepidum* (small scale darter) was taken at Station 4. This species is considered by the Tennessee Department of Environment and Conservation (2004) to be "Deemed in Need of Management" or a species of "Special Concern". The fish communities at stations 1, 2, 4 and 5 are considered to reflect "Fair" ecological conditions while fish populations at stations 3 and 6 reflect "Poor to Fair" environmental conditions when

compared to reference stream data provided by the Tennessee Valley Authority for the Nashville Basin Ecoregion (TDEC 1996) (Table 8).

A comparison of the six locations using fish species shared between stations is presented in Table 9 and clustered in Figure 4. In terms of fish species in common, the communities at stations 1 and 5 are the most similar and cluster first. Stations 3 and 4 cluster second while stations 2 and 6 cluster last. Even though three clusters are presented in Figure 4 the distance between clusters is not great indicating that the fish species are very similar between stations.

Percent Similarity includes a density component in addition to species shared (Table 9, Figure 5). When a density component is included the fish communities at stations 2 and 6 were the more similar followed by stations 3 and 4. Stations 2 and 6 also form a secondary cluster Station 5 while Station 1 forms a secondary cluster with stations 3 and 4. Diversity values of the fish communities were similar between stations with Station 1 (2.89) the least diverse and Station 4 (3.76) the most diverse (Table 9).

TABLE 1. PHYSICAL CHARACTERISTICS OF HARPETH RIVER, WILLIAMSON COUNTY, TENNESSEE, MARCH 2006.

STATION	RIFFLE WIDTH (ft)	AVERAGE DEPTH (ft)	VELOCITY (ft/sec)	FLOW ^a Ft ³ /Sec	HABITAT ASSESSMENT	SUBSTRATE
STATION 1	85	1.3	1.8	159	115 Suboptimal Moderately impaired	Sand and gravel, few boulders
STATION 2	58	1.1	1.9	97	116 Suboptimal Moderately impaired	Gravel, sand and cobble
STATION 3	54	0.9	2.7	105	119 Suboptimal Moderately impaired	Gravel, cobble, sand and boulder
STATION 4	42	0.9	3.9	118	127 Suboptimal Not impaired	Gravel, cobble and boulder
STATION 5	48	0.9	3.4	118	140 Suboptimal Not impaired	Cobble, gravel and boulder
STATION 6	43	1.0	3.4	83	131 Suboptimal Not impaired	Cobble, gravel and boulder

^a A correction for stream velocity (0.8 if bottom is strewn with rocks and coarse gravel, 0.9 if smooth).

TABLE 2. List of metrics used in calculating Index of Biotic Integrity * (TDEC 1997).

1. Number of native species
 2. Number of native darter species or (headwater streams) Number of riffle species
 3. Number of native sunfish species (less *Micropterus sp.*) or (headwater streams) Number of pool species
 4. Number of native sucker species or (headwater streams) Percent composition by two most dominate species
 5. Number of intolerant species or (headwater streams) Number of headwater intolerant species
 6. Percentage of fish as tolerant species
 7. Percentage of fish as omnivores and stoneroller species
 8. Percentage of fish as specialized insectivores
 9. Percentage of fish as piscivores
 10. Catch rate (average number/300ft² or 5 minutes of boat shocking)
 11. Percentage of fish as hybrids or (headwater streams) Percentage of fish as simple lithophilic spawners
 12. Percentage of fish with disease, tumors, fin damage, and other anomalies
-

*Each is assigned a value as follows: 1-poor, 3-intermediate, 5-the best to be expected. The IBI for a given site is the sum of those values

TABLE 3. Biotic integrity classes used in assessing fish communities along with general descriptions of their attributes (Karr et al. 1986).

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 distributions; 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.	40-44
Poor	Dominated by omnivores, pollution-tolerant forms, and habitat generalities; few top carnivores; growth rates and condition factors commonly depressed; hybrids and diseased fish often present.	28-34
Very Poor	Few fish present, mostly introduced or tolerant forms; hybrids common; disease, parasites, fin damage, and other anomalies regular.	12-22
No fish	Repetitive sampling fails to turn up any fish.	

TABLE 4. WATER QUALITY CHARACTERISTICS OF HARPETH RIVER, MARCH 2006.					
STATION	pH (std. Units)	Dissolved oxygen (mg/L)	Temperature (°C)	Conductivity (µmhos/cm)	Turbidity
Station 1	8.34	10.22	10.8	360	Slight
Station 2	8.31	10.46	11.4	358	Slight
Station 3	8.33	10.49	10.9	368	Clear-Slight
Station 4	8.47	11.32	13.0	361	Slight
Station 5	8.25	12.28	12.9	380	Clear
Station 6	8.6	14.09	12.7	381	Clear

Table 5. Benthic Macroinvertebrates, Harpeth River, Williamson County, Tennessee, March 7, 2006.									
SPECIES	T.V.	F.F.G.	CL	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6
				Total	Total	Total	Total	Total	Total
PLATYHELMINTHES									
Turbellaria									
Tricladida									
Planariidae									
<i>Dugesia tigrina</i>	7.23							1	
MOLLUSCA									
Bivalvia									
Unionoida									
Unionidae									
<i>Lamigona costata</i>								1	
<i>Leptodea fragilis</i>								1	
<i>Potamilus alatus</i>								1	
<i>Pygonoden grandis</i>								1	
Veneroida									
Corbiculidae									
<i>Corbicula fluminea</i>	6.12	FC			3	1			5
Sphaeriidae	6.6	FC							
<i>Pisidium sp.</i>	6.48	FC						2	1
<i>Sphaerium striatinum</i>	7.58	FC					3	2	3
Gastropoda									
Mesogastropoda									
Pleuroceridae									
<i>Elimia laqueata</i>	2.46	SC		2	3	2	2	2	17
Basommatophora									
Ancylidae									
<i>Ferrissia rivularis</i>	7	SC							
<i>Ferrissia rivularis</i>	6.55	SC				1	1	1	1
Lymnaeidae									
<i>Fossaria sp.</i>	6	SC						1	
Physidae									
<i>Physella sp.</i>	8.84	CG							1
ANNELIDA									
Oligochaeta									
Tubificida									
Enchytraeidae									
	9.84	CG			2		1	1	2
Lumbricidae									
		CG					1		
Naididae									
<i>Chaetogaster sp.</i>	6.1	CG							
<i>Chaetogaster sp.</i>	4	P		1					
<i>Nais behningi</i>	8.88	CG					1		
<i>Nais communis</i>	8.88	CG		20	2	1	3	2	
<i>Nais sp.</i>	8.88	CG			6	3	8	3	15
<i>Slavina appendiculata</i>	7.06	CG							3
Tubificidae w.h.c.	7.11	CG			2		2	1	

Table 5. Benthic Macroinvertebrates, Harpeth River, Williamson County, Tennessee, March 7, 2006.									
SPECIES	T.V.	F.F.G.	CL	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6
				Total	Total	Total	Total	Total	Total
Tubificidae w.o.h.c.	9.5	CG		2	5		1	5	2
<i>Branchiura sowerbyi</i>	8.28	CG			1	1	1	1	
<i>Limnodrilus sp.</i>	9.5	CG	*CL					1	
<i>Limnodrilus hoffmeisteri</i>	9.5	CG	*CL		1			2	1
Lumbriculida									
Lumbriculidae	7.03	CG							2
ARTHROPODA									
Crustacea									
Isopoda									
Asellidae		SH							
<i>Lirceus sp.</i>	7.85	CG		1				3	1
Amphipoda	7.4	CG							
Crangonyctidae									
<i>Crangonyx sp.</i>	8	CG		1	1	1		2	2
Decapoda									
Cambaridae	7.5								
<i>Cambarus sp.</i>	7.62	CG		1				2	1
<i>Orconectes sp.</i>	2.6	SH		1	1			2	1
Insecta									
Ephemeroptera									
Baetidae	6.1	CG							
<i>Acentrella ampla</i>	3.6	CG				2	2	1	
<i>Acerpenna sp.</i>	3.7			3					1
<i>Acerpenna pygmaea</i>	3.7				2		1		
<i>Dipheter hageni</i>	1.2			12			1		
<i>Plauditus sp.</i>	4.51	CG		7	11	4		4	1
Caenidae		CG							
<i>Caenis sp.</i>	7.41	CG		2			1	1	2
Ephemerellidae	1.9	SC							
<i>Attenella sp.</i>				3					
Heptageniidae	1.5	SC	CL						
<i>Leucrocuta sp.</i>	2.4	SC		2					
<i>Maccaffertium femoratum</i>	3.45	SC	CL				1		1
<i>Maccaffertium mediopunctatum</i>	3.45	SC	CL	1					1
<i>Maccaffertium sp.</i>	3.45	SC	CL				2	1	2
<i>Stenacron interpunctatum</i>	3.58	SC	CL	1	1		1	2	
Isonychiidae		FC							
<i>Isonychia sp.</i>	3.45	FC						1	
Leptophlebiidae	1.8	CG							
<i>Leptophlebia sp.</i>	6.23	CG						3	
Odonata									
Aeshnidae	5.6	P							
<i>Boyeria vinosa</i>	5.97	P							1

Table 5. Benthic Macroinvertebrates, Harpeth River, Williamson County, Tennessee, March 7, 2006.

SPECIES	T.V.	F.F.G.	CL	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6
				Total	Total	Total	Total	Total	Total
Coenagrionidae	6.1	P							
<i>Argia sp.</i>	8.17	P							1
Plecoptera									
Capniidae	0.9	SH							
<i>Allocapnia sp.</i>	2.52	SH	CL			1		1	3
Chloroperlidae	0.7	P			1				
Perlidae	1.5	P	CL						
<i>Perlesta sp.</i>	4.7	P	CL	8	4	1		3	2
Perlodidae	1.6	P	CL		2				
<i>Isoperla sp.</i>	1.5	P	CL	2					
Trichoptera									
Hydropsychidae	2.9	FC	CL						
<i>Cheumatopsyche sp.</i>	6.22	FC	CL			1	4	2	2
<i>Hydropsyche sp.</i>	4.3	FC	CL		1				
Leptoceridae	2.7	CG							
<i>Triaenodes sp.</i>	4.46	SH						1	
Polycentropodidae	4	FC	CL						
<i>Cymellus fraternus</i>	7.34	FC	CL			1			
Rhyacophilidae		P	CL						
<i>Rhyacophila carolina</i>	0.73	P	CL	1					
<i>Rhyacophila fenestrata</i>	0.73	P	CL				2	1	
<i>Rhyacophila torva</i>	0.73		CL	1			1		
Coleoptera									
Elmidae		CG							
<i>Dubiraphia sp.</i>	5.93	SC	CL	1	2				
<i>Dubiraphia vittata</i>	5.93	SC	CL						1
<i>Stenelmis sp.</i>	5.1	SC	CL	21	10	1	11	4	10
<i>Stenelmis sexlineatus</i>						1	1	2	
Psephenidae		SC							
<i>Psephenus herricki</i>	2.35	SC	CL	1					
Diptera									
Ceratopogonidae	5.9	P			1	1			
Chironomidae									
<i>Chaetocladius sp.</i>		CG							1
<i>Cladotanytarsus sp.</i>	4.09	FC			2				
<i>Conchapelopia sp.</i>	4.5	P			1			1	2
<i>Corynoneura sp.</i>	6.01	CG		11	3		2		2
<i>Cricotopus sp.</i>	5.78	CG	CL	35	27	14	31	12	25
<i>Cryptochironomus sp.</i>	6.4	P			4				1
<i>Dicrotendipes neomodestus</i>	8.1	CG		1		5			2
<i>Eukiefferiella claripennis gp.</i>	3.43	CG		14	14	18	7	7	8
<i>Glyptotendipes sp.</i>	9.47	FC		1					
<i>Nanocladius distinctus</i>	7.07	CG		1		1			

Table 5. Benthic Macroinvertebrates, Harpeth River, Williamson County, Tennessee, March 7, 2006.

SPECIES	T.V.	F.F.G.	CL	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6
				Total	Total	Total	Total	Total	Total
<i>Orthocladius sp.</i>	5.95	CG		25	21	39	15	16	18
<i>Orthocladius lignicola</i>	5.95	CG		1					
<i>Parakiefferiella sp.</i>	5.4	CG							1
<i>Paralauterborniella nigrohalteralis</i>	4.77	CG	CL		1				
<i>Parametrioctenus sp.</i>	3.65	CG		1					
<i>Parasmittia sp.</i>					1				
<i>Paratanytarsus sp.</i>	8.45	CG		1					1
<i>Paratendipes sp.</i>	5.11	CG						1	1
<i>Phaenopsectra punctipes gp.</i>				1					
<i>Polypedilum flavum (convictum)</i>	5.69	SH		5	7	3	1	3	2
<i>Polypedilum halterale gp.</i>	5.69	SH		4	1				
<i>Polypedilum illinoense</i>	5.69	SH		1	2	1		1	
<i>Pseudochironomus sp.</i>	5.36	CG				1			
<i>Rheocricotopus robacki</i>	7.3	CG						1	
<i>Rheotanytarsus sp.</i>	5.89	FC	CL	3	3			1	2
<i>Tanytarsus sp.</i>	6.76	FC		5	4	5	1	2	14
<i>Thienemanniella xena</i>	5.86	CG				4		2	2
<i>Tribelos jucundum</i>						1			
<i>Tvetenia bavarica gp.</i>	3.65	CG					1	1	1
Empididae	7.6	P							
<i>Hemerodromia sp.</i>	7.57	P		1		1			
Simuliidae	3.5	FC	CL						
<i>Prosimulium sp.</i>	4.01	FC	CL	1	1	84	74	88	3
<i>Simulium sp.</i>	4	FC	CL	5	29	39	47	27	8
Tipulidae	4.9	SH							
<i>Hexatoma sp.</i>	4.31	P						2	
<i>Tipula sp.</i>	7.33	SH		4				1	
TOTAL NO. OF ORGANISMS				216	183	239	231	231	180
TOTAL NO. OF TAXA				43	37	30	32	52	47

Table 6. Aquatic Macroinvertebrate Metrics, Harpeth River, Williamson County, March 2006.

METRIC	Station 1		Station 2		Station 3		Station 4		Station 5		Station 6	
	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score	Value	Score
Species Richness	43		37		30		32		52		47	
Taxa Richness (Genera)	40	6	36	6	27	6	27	6	50	6	46	6
EPT Index	11	6	8	4	6	2	8	4	13	6	7	2
% EPT	19.91	2	12.02	0	4.18	0	6.93	0	9.09	0	8.33	0
% Oligochaetes and Chironomids	61.97	2	60.11	2	40.59	4	32.90	4	27.71	4	60.00	2
North Carolina Biotic Index	5.33	4	5.32	4	4.79	4	4.79	4	4.90	4	5.63	4
% Dominant Taxon	16.20	6	15.30	6	35.15	6	32.03	6	38.10	4	13.89	6
% Clingers	37.96	4	44.81	4	59.83	6	75.76	6	63.64	6	33.89	2
TOTAL INDEX SCORE		30		26		28		30		30		22
INDEX SCORE RATING	Slightly impaired		Slightly impaired		Slightly impaired		Slightly impaired		Slightly impaired		Slightly impaired	

Target Index Score for Bioregion 71h from January-December = 32

Table 7. Aquatic Benthic Macroinvertebrates Community Measures, Harpeth River, Williamson County, Tennessee, March 2006.

JACCARD COEFFICIENT

	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6
Sta. 1	1	0.355	0.298	0.283	0.303	0.353
Sta. 2	0.355	1	0.346	0.352	0.397	0.354
Sta. 3	0.298	0.346	1	0.34	0.349	0.322
Sta. 4	0.283	0.352	0.34	1	0.419	0.35
Sta. 5	0.303	0.397	0.349	0.419	1	0.451
Sta. 6	0.353	0.354	0.322	0.35	0.451	1

PERCENT SIMILARITY

	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6
Sta. 1	100	60.3	35.9	37.4	31.6	52.8
Sta. 2	60.3	100	51.2	53.4	44.3	57.5
Sta. 3	35.9	51.2	100	70	72.2	37.4
Sta. 4	37.4	53.4	70	100	70.6	45.8
Sta. 5	31.6	44.3	72.2	70.6	100	40.1
Sta. 6	52.8	57.5	37.4	45.8	40.1	100

COMMUNITY LOSS INDEX

Sta. 1 (Reference)	0.55	0.90	0.79	0.38	0.42
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SHANNON DIVERSITY

BASE 2	4.47	4.40	3.17	3.36	4.0	4.7
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PIELOU EVENNESS

	0.82	0.83	0.65	0.67	0.69	0.84
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Table 8. Fish Species Taken from the Harpeth River, Franklin, Williamson County, Tennessee on March 7 and 8, 2006.

SPECIES	Native	Food source	Spawning guild	Habitat	Sensitivity	Tolerance	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
CHORDATA												
Osteichthyes												
Cypriniformes												
Cyprinidae (minnows)												
<i>Campostoma anomalum</i>												
central stoneroller	1	OM					47	6	34	39	1	3
<i>Hybopsis amblops</i>												
bigeye chub	1	SP	L	P	S			7	1	17		2
<i>Luxilus crysocephalus</i>												
striped shiner	1	OM	L	P		TO	30	1	11	10	14	5
<i>Lythrurus ardens</i>												
rosefin shiner	1	SP	L	P					1	32	3	1
<i>Notropis boops</i>												
bigeye shiner	1	SP	L	P	S	INT				5		
<i>Nortropi leuciodus</i>												
Tennessee Shiner	1	SP	L	P	S		2					
<i>Pimephales notatus</i>												
bluntnose minnow	1	OM		P			8	8	12	25	19	40
<i>Semotilus atromaculatus</i>												
creek chub	1	IN		P		TO			1			
Catostomidae (suckers)												
<i>Hypentelium nigricans</i>												
northern hogsucker	1	IN	L		S		19		8	13	3	
<i>Minytrema melanops</i>												
Spotted sucker	1	IN	L	P				1				
<i>Moxostoma duquesnei</i>												
black redbhorse	1	IN	L	P	S	INT	4	1		1	2	1
Siluriformes												
Ictaluridae (catfish)												
<i>Ameiurus natalis</i>												
yellow bullhead	1	OM		P		TO				1		
Cyprinodontiformes												
Fundulidae (top minnows)												
<i>Fundulus catenatus</i>												
Northern studfish	1	SP	L	R	S							1
<i>Fundulus olivaceus</i>	1	IN		P				3	2			6
black spotted topminnow												
Atheriniformes												
Atherinidae												
<i>Labidesthes sicculus</i>												

Table 8. Fish Species Taken from the Harpeth River, Franklin, Williamson County, Tennessee on March 7 and 8, 2006.

SPECIES	Native	Food source	Spawning guild	Habitat	Sensitivity	Tolerance	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
Brook silverside	1	IN		P					1	34	1	
Scorpaeniformes												
Cottidae (sculpins)												
<i>Cottus carolinae</i>												
banded sculpin	1	IN		R			8	2	8	5	8	3
Perciformes												
Centrarchidae (sunfishes)												
<i>Ambloplites rupestris</i>												
rockbass	1	PS		P	S	INT				1	3	4
<i>Lepomis cyanellus</i>												
green sunfish	1	IN		P		TO					5	1
<i>Lepomis cyanellus/megalotis hybrid</i>												
green/longear sunfish hybrid											1	
<i>Lepomis cyanellus/macrochirus hybrid</i>												
green/bluegill sunfish hybrid												1
<i>Lepomis gulosus</i>												
warmouth	1	IN		P			1				3	1
<i>Lepomis macrochirus</i>												
blue gill	1	IN		P			3	17	4		7	20
<i>Lepomis megalotis</i>												
longear sunfish	1	IN		P	S		1	27	1	7	22	21
<i>Lepomis microlophus</i>												
redeer sunfish	1	IN		P				3				1
<i>Lepomis macrochirus/Meglotis hybrid</i>												
bluegill/longear sunfish hybrid											2	
<i>Micropterus punctulatus</i>												
spotted bass	1	PS		P				1			2	3
Percidae (perches)												
<i>Etheostoma blennioides</i>												
greenside darter	1	SP	L	R			85	1	16	27	17	
<i>Etheostoma crossopterum</i>												
fringed darter	1	SP		P			2				3	1
<i>Etheostoma flabellare</i>												
fantail darter	1	SP		R	S	INT	1	2	12	14	70	4
<i>Etheostoma microlepidum</i>												
small scale darter	1	SP		R						1		
<i>Etheostoma rufilineatum</i>												
redline darter	1	SP	L	R			2		55	50	2	
<i>Etheostoma simoterum</i>												
snubnose darter	1	SP	L	R			19	9	21	22	7	13
<i>Etheostoma stigmaeum</i>												

Table 8. Fish Species Taken from the Harpeth River, Franklin, Williamson County, Tennessee on March 7 and 8, 2006.

SPECIES	Native	Food source	Spawning guild	Habitat	Sensitivity	Tolerance	Station 1	Station 2	Station 3	Station 4	Station 5	Station 6
speckled darter	1	SP	L	P	S	INT		3		4		
<i>Etheostoma virgatum</i>												
striped darter	1	SP		R			2		2		1	3
<i>Etheostoma zonale</i>												
<i>Banded darter</i>	1	SP	L	R					1	13		
<i>Percina caprodes</i>												
<i>logperch</i>	1	SP	L	P			4	1				
NUMBER OF SPECIES							17	17	18	20	22	21
NUMBER OF INDIVIDUALS							238	93	191	321	196	135
IBI SCORE							40	40	36	44	44	38
Community Index Ranking							Fair-	Fair	Poor-Fair-	Fair	Fair	Poor-Fair

^a HB= herbivore, In= insectivore, INT= intolerant species, OM=omnivore, PK=planktivore, PR=parasitic, SP=specialized insectivore, L=simple lithophilic spawner, P=pool species, R=riffle species, S=sensitive species, PS=piscivore, TO=tolerant species.

^b Shocking time: Station 1 (843 seconds), Station 2 (1352 seconds), Station 3 (975 seconds), Station 4 (952 seconds), Station 5 (1349 seconds) and Station 6 (1482 seconds).

Table 9 Fish Community Measures, Harpeth River, Williamson County Williamson County, Tennessee, March 2006

Jaccards Coefficient

STATION	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6
Sta. 1	1	0.478	0.522	0.423	0.625	0.462
Sta. 2	0.478	1	0.458	0.423	0.393	0.52
Sta. 3	0.522	0.458	1	0.583	0.538	0.444
Sta. 4	0.432	0.432	0.583	1	0.5	0.367
Sta. 5	0.625	0.393	0.538	0.5	1	0.593
Sta. 6	0.462	0.52	0.444	0.367	0.593	1

PERCENT DISSIMILARITY

	Sta. 1	Sta. 2	Sta. 3	Sta. 4	Sta. 5	Sta. 6
Sta. 1	100	26.3	54.6	41.5	33.9	24.3
Sta. 2	26.3	100	33.1	36	36	63.5
Sta. 3	54.6	33.1	100	64.9	41.6	32.8
Sta. 4	41.5	36	64.9	100	36.7	29.5
Sta. 5	33.9	36	41.6	36.7	100	44.2
Sta. 6	24.3	63.5	32.8	29.5	44.2	100

SHANNON DIVERSITY

	2.89	3.27	3.22	3.76	3.34	3.34
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1-Jaccard Coefficient

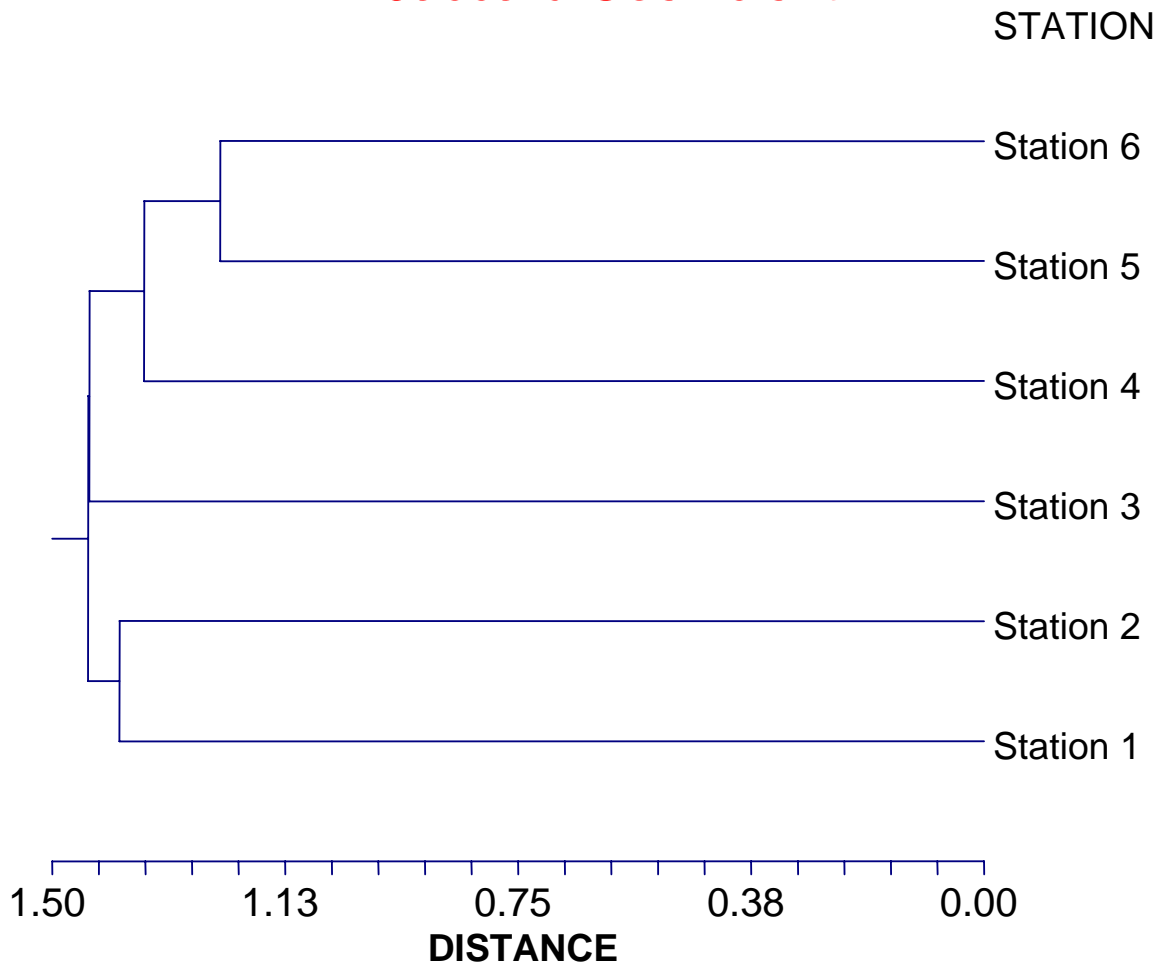


Figure 2. Cluster Analyses of Benthic Macroinvertebrate Communities based on 1-Jaccard's Coefficient (b = 0.25).

Percent Dissimilarity

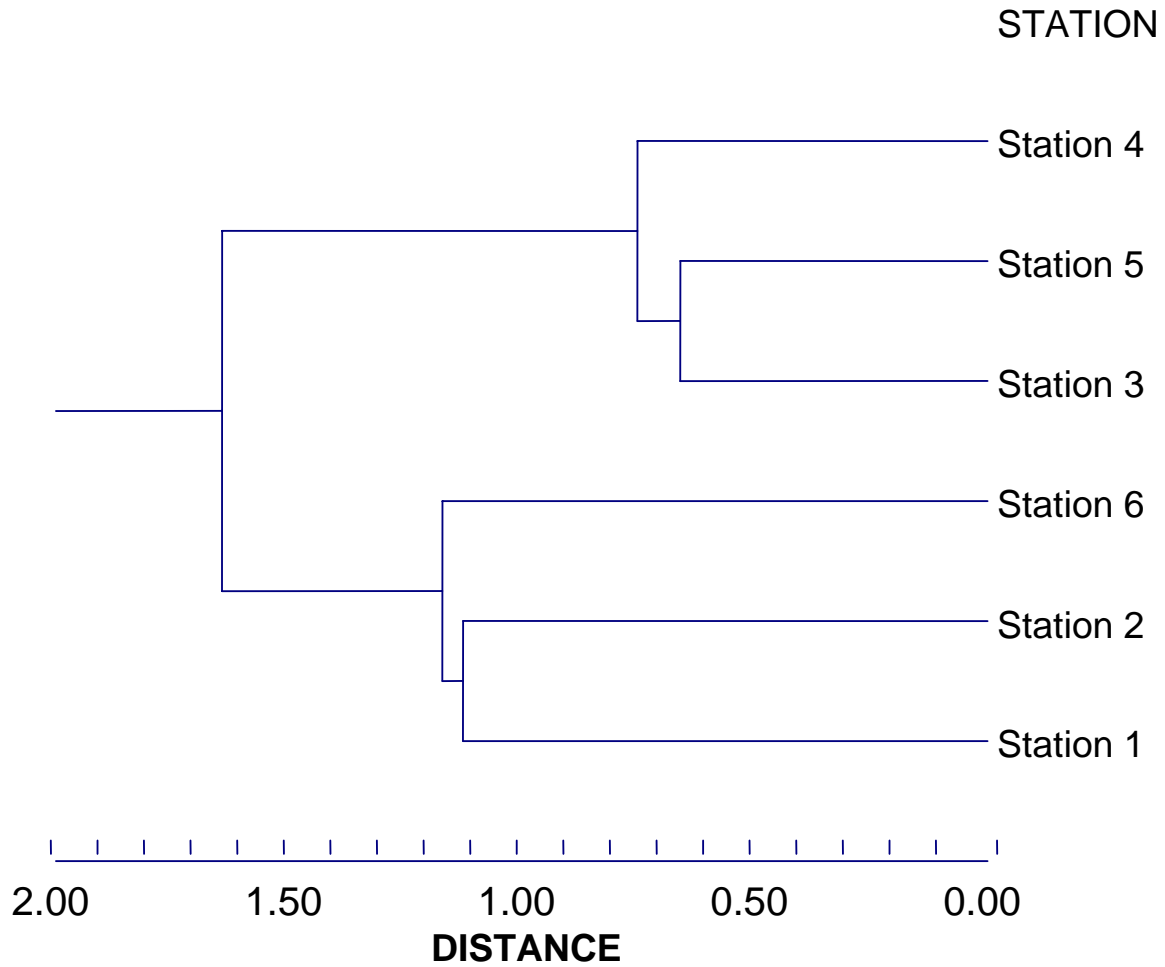


Figure 3. Cluster Analyses of Benthic Macroinvertebrate Communities based on Bray-Curtis Percent Dissimilarity ($b = 0.25$)

Jaccard Coefficient

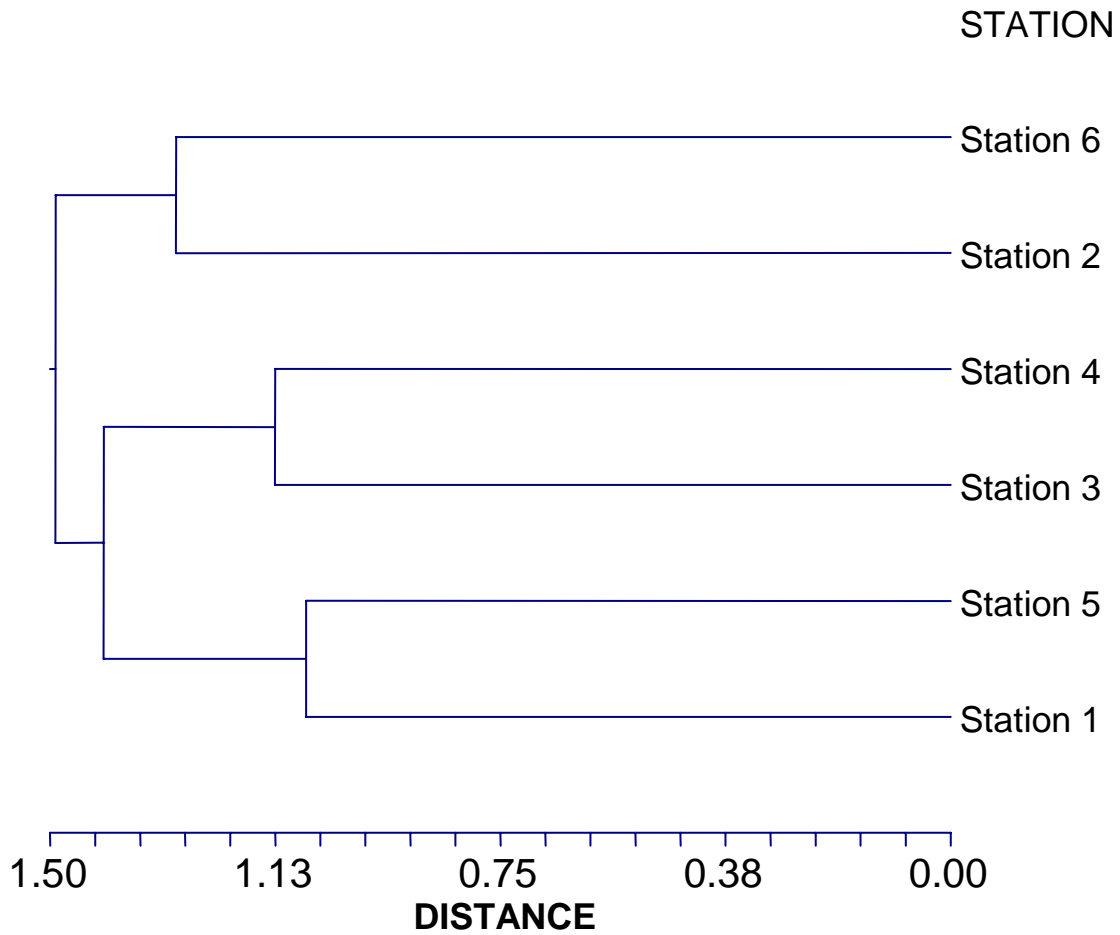


Figure 4. Cluster Analyses of Fish Communities Based on 1-Jaccards Coefficient (b=0.25).

Percent Dissimilarity

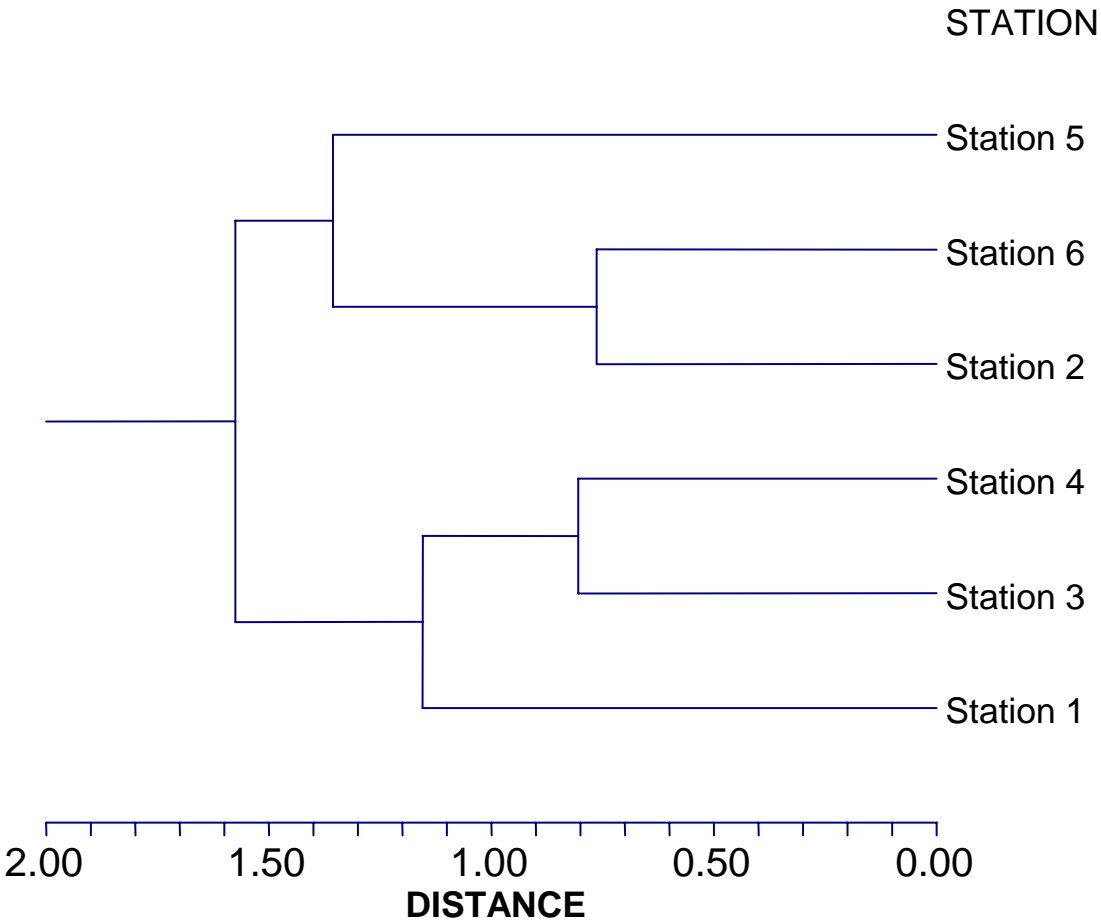


Figure 5. Cluster Analyses of Fish Communities based on Bray-Curtis Percent Dissimilarity (b=0.25).

CONCLUSIONS

The Harpeth River within the City of Franklin supports a diverse benthic macroinvertebrate fauna represented by a minimum of 97 species existing under slightly impaired ecological conditions. The fish community is represented by a minimum of 33 species which exist under fair ecological conditions at stations 1, 2, 4 and 5 and “Poor to Fair” conditions at stations 3 and 6.

REFERENCES

- Arnwine, D. H. and G. M. Denton. 2001. Development of Regionally-based Interpretations of Tennessee's Biological Integrity Criteria. Draft Report. Tennessee Department of Environmental and Conservation, Division of Water Pollution Control. Nashville, TN
- Barbour, M.T., J.L. Plafkin, B.D. Snyder and J. B. Stribling. 1999. Rapid Bioassessment Protocols for Use in Streams and Wadable Rivers: Periphyton, Benthic Macroinvertebrates, and Fish, Second Edition. EPA 841-B-99-002. U. S. Environmental Protection Agency's Office of Waters, Washington, D. C.
- Beck, W. M. 1977. Environmental requirements and pollution tolerance of common freshwater Chironomidae. U.S.E.P.A. Report No. EPA-600/4-77-024. Cincinnati, Ohio 261 pp.
- Brinkhurst, R.O. 1962. The biology of the Tubificidae with special reference to pollution. Pages 57 through 66. IN: Dr. Clarence Tarzwell, Biological Problems in Water Pollution, Third Seminar. Report A. Taft Sanitary Engineering Center.
- Brower, T.E. and J.H. Zar. 1984. Field and Laboratory Methods for General Ecology. Second Edition. W.C. Brown, Dubuque. 226 pp.
- Cairns, J. Jr., J. S. Crossman, K. L. Dickson and E. E. Herricks. 1971. The recovery of damaged streams. The ASB Bulletin 18(3):79-106.
- Compton, R. R. 1962. Manual of Field Geology. John Wiley and Sons, Inc., New York, NY. 378 pp.
- Eckbald, J. 1989. ECOL ANAL-PC Diversity Indices, Vol. 3
- Gaufin, A.R. and C. N. Tarzwell. 1956. Aquatic macroinvertebrate communities as indicators of organic pollution in Lytle Creek. Sewage Inc. Wastes 28(7):906-924.
- Goodnight, C. J. 1973. The use of aquatic macroinvertebrates as indicators of stream pollution. Trans. of the Amer. Micro. Soc. Vol. 92(1):1-13.
- Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. The Great Lakes Entomologist, Vol. 20(1):31-39.
- Karr, J.R., K.D. Fausch, P.L. Angermier, P.R. Yant, and I.J. Schlosser. 1986. Assessing Biological Integrity in Running Water: A Method and Its Rationale. Illinois Natural History Survey Special Publication 5.
- Ludwig, J.A. and J.F. Reynolds. 1988. Statistical Ecology: A Primer on Methods and Computing. John Wiley and Sons, New York. 337 pp.

- Merritt, R.W. and K.W. Cummins. 1996. *An Introduction to the Aquatic Insects of North America*. Third Edition. Kendall/Hunt Publishing Company, Dubuque, Iowa. 862 pp.
- OPEA (Ohio Environmental Protection Agency). 1987. *Biological criteria for the protection of aquatic life, volume II: users manual for biological field assessment of Ohio surface waters*. Ohio Environmental Protection Agency, Division of Water Quality Monitoring and Assessment, Columbus.
- Pennington and Associates, Inc. 1994. *Standard Operating Procedures for Processing, Identification and Enumeration of Invertebrate Samples*. Pennington and Associates, Inc. Unpublished Document, Cookeville, TN. 85 pp.
- Tennessee Department of Environment and Conservation, Division of Water Pollution Control. 2003. *Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys (revised)*. Nashville, TN.
- Tennessee Department of Environment and Conservation, Division of Natural Heritage. 2004. *A Guide to the Rare Animals of Tennessee*. Nashville, TN. 16 pp.
- Waters, T.E. 1995. *Sediment in Streams, Sources, Biological Effects and Control*. American Fisheries Society. Monograph 7, Bethesda, Maryland. 251 pp.
- Weber, C., Ed. 1973. *Biological field and laboratory methods for measuring the quality of surface waters and effluents*. U.S.E.P.A. Report No. EPA 670/4-73-001.
- Yoder, C.O. and M. A. Smith. 1999. *Using Fish Assemblages in a State Biological Assessment and Criteria Program: Essential Concepts and Considerations* in Thomas P. Simon (Ed.), *Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities*. CRC Press, Boca Ration, FL, 17-63.

APPENDIX