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National Water-Quality Assessment Program

Results of Water-Quality Sampling and Ecological Characterization of Streams of Congaree Swamp, South Carolina 1995-98

U.S. Geological Survey
Water-Resources Investigations Report 99-4121

U.S. Department of the Interior
U.S. Geological Survey

Cover photograph: Cedar Creek, South Carolina, taken by Lance Wilhelm, U.S. Geological Survey.

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By Terry L. Maluk *and* Thomas A. Abrahamsen

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 99–4121

Prepared as part of the
NATIONAL WATER-QUALITY ASSESSMENT PROGRAM

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U.S. DEPARTMENT OF THE INTERIOR
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FOREWORD

The mission of the U.S. Geological Survey (USGS) is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policymakers at Federal, State, and local levels in making sound decisions. Assessment of water-quality conditions and trends is an important part of this overall mission.

One of the greatest challenges faced by water-resources scientists is acquiring reliable information that will guide the use and protection of the Nation's water resources. That challenge is being addressed by Federal, State, interstate, and local water-resource agencies and by many academic institutions. These organizations are collecting water-quality data for a host of purposes that include: compliance with permits and water-supply standards; development of remediation plans for a specific contamination problem; operational decisions on industrial, wastewater, or water-supply facilities; and research on factors that affect water quality. An additional need for water-quality information is to provide a basis on which regional and national-level policy decisions can be based. Wise decisions must be based on sound information. As a society we need to know whether certain types of water-quality problems are isolated or ubiquitous, whether there are significant differences in conditions among regions, whether the conditions are changing over time, and why these conditions change from place to place and over time. The information can be used to help determine the efficacy of existing water-quality policies and to help analysts determine the need for and likely consequences of new policies.

To address these needs, the Congress appropriated funds in 1986 for the USGS to begin a pilot program in seven project areas to develop and refine the National Water-Quality Assessment (NAWQA) Program. In 1991, the USGS began full implementation of the program. The NAWQA Program builds upon an existing base of water-quality studies of the USGS, as well as those of other Federal, State, and local agencies. The objectives of the NAWQA Program are to:

- Describe current water-quality conditions for a large part of the Nation's freshwater streams, rivers, and aquifers.
- Describe how water quality is changing over time.
- Improve understanding of the primary natural and human factors that affect water-quality conditions.

This information will help support the development and evaluation of management, regulatory, and monitoring decisions by other Federal, State, and local agencies to protect, use, and enhance water resources.

The goals of the NAWQA Program are being achieved through ongoing and proposed investigations of 60 of the Nation's most important river basins and aquifer systems, which are referred to as study units. These study units are distributed throughout the Nation and cover a diversity of hydrogeologic settings. More than two-thirds of the Nation's freshwater use occurs within the 60 study units and more than two-thirds of the people served by public water-supply systems live within their boundaries.

National synthesis of data analysis, based on aggregation of comparable information obtained from the study units, is a major component of the program. This effort focuses on selected water-quality topics using nationally consistent information. Comparative studies will explain differences and similarities in observed water-quality conditions among study areas and will identify changes and trends and their causes. The first topics addressed by the national synthesis are pesticides, nutrients, volatile organic compounds, and aquatic biology. Discussions on these and other water-quality topics will be published in periodic summaries of the quality of the Nation's ground and surface water as the information becomes available.

This report is an element of the comprehensive body of information developed as part of the NAWQA Program. The program depends heavily on the advice, cooperation, and information from many Federal, State, interstate, Tribal, and local agencies and the public. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Chief Hydrologist

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CONVERSION FACTORS, TEMPERATURE, WATER-QUALITY UNITS, AND ACRONYMS:

Multiply	By	To obtain
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
kilogram (kg)	2.205	pound
cubic feet per second (ft^3/s)	0.02832	cubic meter per second
kilometer (km)	0.6214	mile
square kilometer (km^2)	0.3861	square mile

Temperature in degrees Celsius (°C) can be converted to degrees Fahrenheit as follows:

$$°F = (°C \times 1.8) + 32$$

ABBREVIATED WATER-QUALITY UNITS:

mg/L	milligram per liter	mm	millimeter
µg/L	microgram per liter	cm	centimeter
g/kg	gram per kilogram	m	meter
µg/g	microgram per gram	km	kilometer
µg/kg	microgram per kilogram	su	standard unit
µm	micrometer	µS/cm	microsiemens per centimeter

ACRONYMS:

CUE	Catch per unit of effort
IBI	Index of biotic integrity
MDL	Method detection limit
MRL	Minimum reporting level
NAWQA	National Water-Quality Assessment Program
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NWQL	National Water Quality Laboratory
PAH	Polycyclic aromatic hydrocarbon
RTH	Richest targeted habitat
SANT	Santee River Basin and coastal drainages
SCDHEC	South Carolina Department of Health and Environmental Control
STORET	Storage and Retrieval
TEL	Threshold effect level
U.S. EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Results of Water-Quality Sampling and Ecological Characterization of Streams of Congaree Swamp, South Carolina, 1995–98

By Terry L. Maluk *and* Thomas A. Abrahamsen

ABSTRACT

Between October 1995 and September 1998, water-quality samples were collected at five sites in streams of Congaree Swamp, South Carolina, as part of the U.S. Geological Survey National Water-Quality Assessment Program. Water-quality samples were collected at one site on the Congaree River (at Columbia), Myers Creek, two sites on Cedar Creek (Cedar Creek and Cedar Creek near Wise Lake), and Toms Creek. Samples were analyzed for major ions, nutrients, pesticides, and suspended sediments.

Bed-sediment and tissue samples were collected at six sites in streams of Congaree Swamp and analyzed for 21 organochlorine pesticides and 43 major and trace elements. In addition to the five sites sampled for water quality, a second site on the Congaree River (at Highway 601) was sampled for bed sediment and tissue. Sixty-seven non-pesticide organic compounds were analyzed in sediment samples only. Aquatic community structure in each stream was characterized through qualitative and semi-quantitative collections of algae, macroinvertebrates, and fish. Habitat data and riparian zone tree data also were collected at four sites as part of the stream characterization.

Though most major ion concentrations were highest in the Congaree River at Columbia, iron and manganese concentrations were lower in the Congaree River at Columbia than in the other streams. Secondary drinking-water standards for iron (300 micrograms per liter) and manganese (50 micrograms per liter) were exceeded in at least one sample at each site. Nitrogen and phosphorus concentrations were low. Nitrite-plus-nitrate nitrogen concentrations were significantly higher in the Congaree River at Columbia; however, all concentrations were below 0.5 milligram per liter. Organic carbon concentrations generally were lowest in the Congaree River at Columbia. Twelve different pesticides were detected in samples from the five surface-water-quality sampling sites; tebuthiuron and atrazine were the most frequently detected pesticides. The Congaree River at Columbia had the highest number of different pesticides detected (9), and Cedar Creek had the lowest (5). Suspended-sediment concentrations were highest in the Congaree River at Columbia. Specific conductance, alkalinity, and pH were significantly higher in the Congaree River at Columbia than in the other streams.

Analyses of the structure of the macroinvertebrate communities of the streams, through qualitative and semi-quantitative collections, indicated that the water quality of Cedar Creek near Wise Lake was slightly impaired when compared with a reference stream. The water quality in Myers Creek, Cedar Creek, and Toms Creek was non-impaired when compared with the same reference stream. Fish fauna community analysis indicated that Cedar Creek water quality can be classified as “fair” in terms of an index of biotic integrity. Water quality in the Congaree River at Columbia, Myers Creek, Cedar

Creek near Wise Lake, and Toms Creek is classified as "poor," based on fish indices of biotic integrity.

Organochlorine pesticides, non-pesticide organic compounds, and trace and major elements in bed sediments had no discernible detrimental effect on the aquatic communities in any of the streams. Pesticides and major ion concentrations detected in the water column had no discernible detrimental effect on the aquatic communities.

Habitat structure, dissolved oxygen, and water temperature were the most important properties affecting species distribution and density of the macroinvertebrate community. No chemical product or by-product of land-use activities appeared to have detrimental effects on fish or macroinvertebrate community structure.

INTRODUCTION

As part of the National Water-Quality Assessment (NAWQA) Program, the U.S. Geological Survey (USGS) conducted a study of several streams of Congaree Swamp in South Carolina from October 1995 through September 1998. The study was a cooperative effort between the USGS and the National Park Service (NPS) to investigate the status of and trends in general water quality and to conduct an ecological characterization of three tributary streams to the Congaree Swamp National Monument (Myers, Cedar, and Toms Creeks), and the Congaree River that borders the Monument.

Purpose and Scope

This report presents results of a water-quality study and ecological characterization of selected streams of Congaree Swamp near Columbia, South Carolina. Six sites were sampled on four stream systems: three tributaries that flow into Congaree Swamp National Monument (Myers, Cedar, and Toms Creeks), one stream within the Monument (Cedar Creek near Wise Lake), and two sites on the Congaree River. Sampling consisted of monthly or quarterly water-quality analyses of major ions, nutrients, organic carbon, pesticides, and suspended sediment. Algae, macroinvertebrates, and fishes were collected in each stream to assess aquatic community structure. Bed-sediment and tissue samples were analyzed for selected organic compounds, major elements, and trace elements. Habitat was assessed at Myers Creek, the two Cedar Creek sites, and Toms Creek.

Acknowledgments

Appreciation is extended to the National Park Service, which provided partial funding for the Congaree Swamp study. The authors wish to thank the NAWQA team members who assisted with sampling, and the report team for their time spent reviewing and improving the quality of this report.

Description of the Study Area

The study area is located within the NAWQA Santee River Basin and coastal drainages study area along the Congaree River in South Carolina (fig. 1). The Congaree Swamp National Monument is located about 32 kilometers (km) southeast of Columbia, South Carolina (fig. 2). The Monument includes one of the last large stands of old-growth bottomland hardwood forest in South Carolina and contains about 90 species of trees (National Park Service, 1999). Water-quality and ecological samples were collected in the Congaree River at Columbia approximately 40 km upstream from Congaree Swamp National Monument; Myers Creek on State Road 734 at the Monument boundary; Cedar Creek on State Road 734 at the Monument boundary; Cedar Creek near Wise Lake within the Monument; and Toms Creek below State Road 489 (table 1). Additional sediment and tissue samples were collected in the Congaree River at Highway 601 approximately 3 km downstream of the Monument boundary.

General Hydrologic Setting

The Congaree River flows along the southern edge of the Monument boundary. Tributaries that flow through the Monument toward the Congaree River are blackwater streams and include Cedar Creek, Myers Creek, and Toms Creek. The basins of the tributaries are in the Upper Coastal Plain region (fig. 2). During low streamflow periods, the tributaries are supplied by seepage from ground water. During floods, water is transported from the Congaree River across the flood plain toward the tributaries (Patterson and others, 1985).

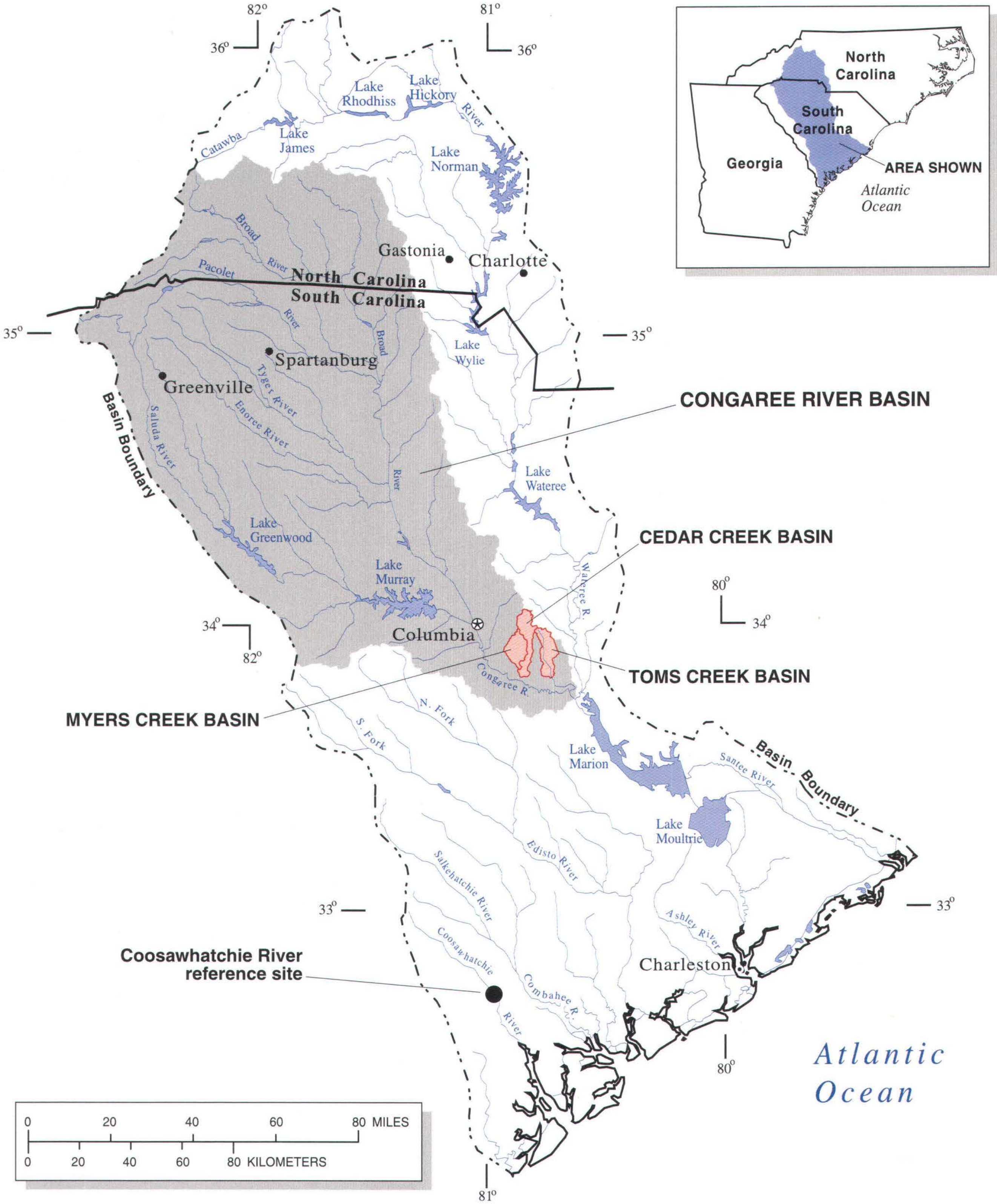

Figure 1. Location of the Congaree Swamp study area within the Santee River Basin and coastal drainages study area, North and South Carolina.

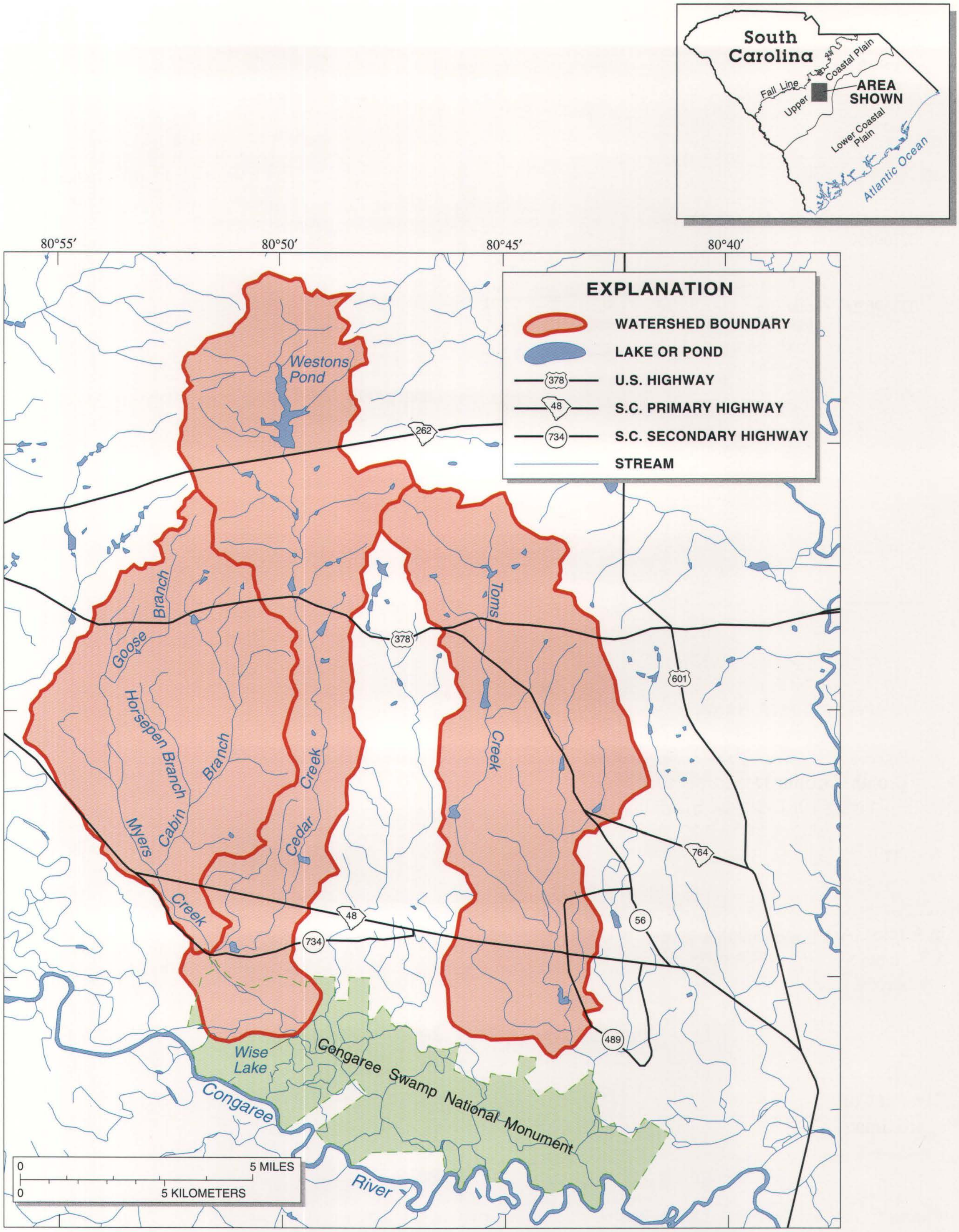

Figure 2. Location of Congaree Swamp National Monument and study area basin boundaries, South Carolina.

Table 1. Sampling sites

USGS downstream order number	USGS station name	Short name	Latitude	Longitude	Water quality	Bed sediment	Tissue	Community structure	Habitat
02169500	Congaree River at Columbia, S.C.	Congaree River at Columbia	33°59'35"	81°03'00"	X	X	X	X	
02169660	Myers Creek at S-40-734 near Hopkins, S.C.	Myers Creek	33°51'25"	80°49'48"	X	X	X	X	X
02169670	Cedar Creek below Myers Creek near Hopkins, S.C.	Cedar Creek	33°50'23"	80°51'38"	X	X	X	X	X
02169672	Cedar Creek at Cedar Creek Hunt Club near Gadsden, S.C.	Cedar Creek near Wise Lake	33°48'58"	80°49'39"	X	X	X	X	X
021696966	Toms Creek below S-40-489 near Gadsden, S.C.	Toms Creek	33°48'41"	80°43'30"	X	X	X	X	X
02169750	Congaree River near Fort Motte, S.C.	Congaree River at Highway 601	33°45'07"	80°38'45"		X	X		

The climate in central South Carolina includes mild winters and very hot summers. Average monthly temperatures for the years 1961–90 ranged from 6.4 degrees Celsius (°C) in January to 27.2 °C in July (South Carolina Department of Natural Resources, 1998). During 1961–90, the maximum monthly temperature in July was 33.2 °C, with daily highs more than 37.8 °C. Annual rainfall in Columbia is about 127 centimeters (cm) per year. Average monthly rainfall ranges from 7.4 cm in November to 15.4 cm in August. Average annual snowfall in Columbia is 5.3 cm per year (South Carolina Department of Natural Resources, 1998).

Land Cover

Land cover in the basin above the Congaree River at Columbia sampling site consists of approximately 70 percent mixed forests, 20 percent agriculture, 5 percent urban, 3 percent water and wetlands, and the remaining 2 percent barren land (fig. 3). The drainage area of the Congaree River at Columbia, formed at the confluence of the Saluda and Broad Rivers, is approximately 20,300 square kilometers (km^2; Cooney and others, 1998). The large urban areas in the basin are Columbia and Greenville-Spartanburg, S.C. Many industrial and municipal sources discharge treated wastewater into the Congaree River Basin (South Carolina Department of Health and Environmental Control, 1995).

Land cover in the Myers Creek Basin is approximately 48 percent forested with a mix of evergreen and deciduous forests, 33 percent agriculture, 15 percent wetlands or open water, and 4 percent urban (fig. 4). The drainage area of the basin is about 83 km^2. Several tributaries join Myers Creek—Goose Branch, Horsepen Branch, and Cabin Branch. These tributaries receive wastewater from several domestic and industrial sources (South Carolina Department of Health and Environmental Control, 1995). Myers Creek joins Cedar Creek at the northwest boundary of the Monument (fig. 4).

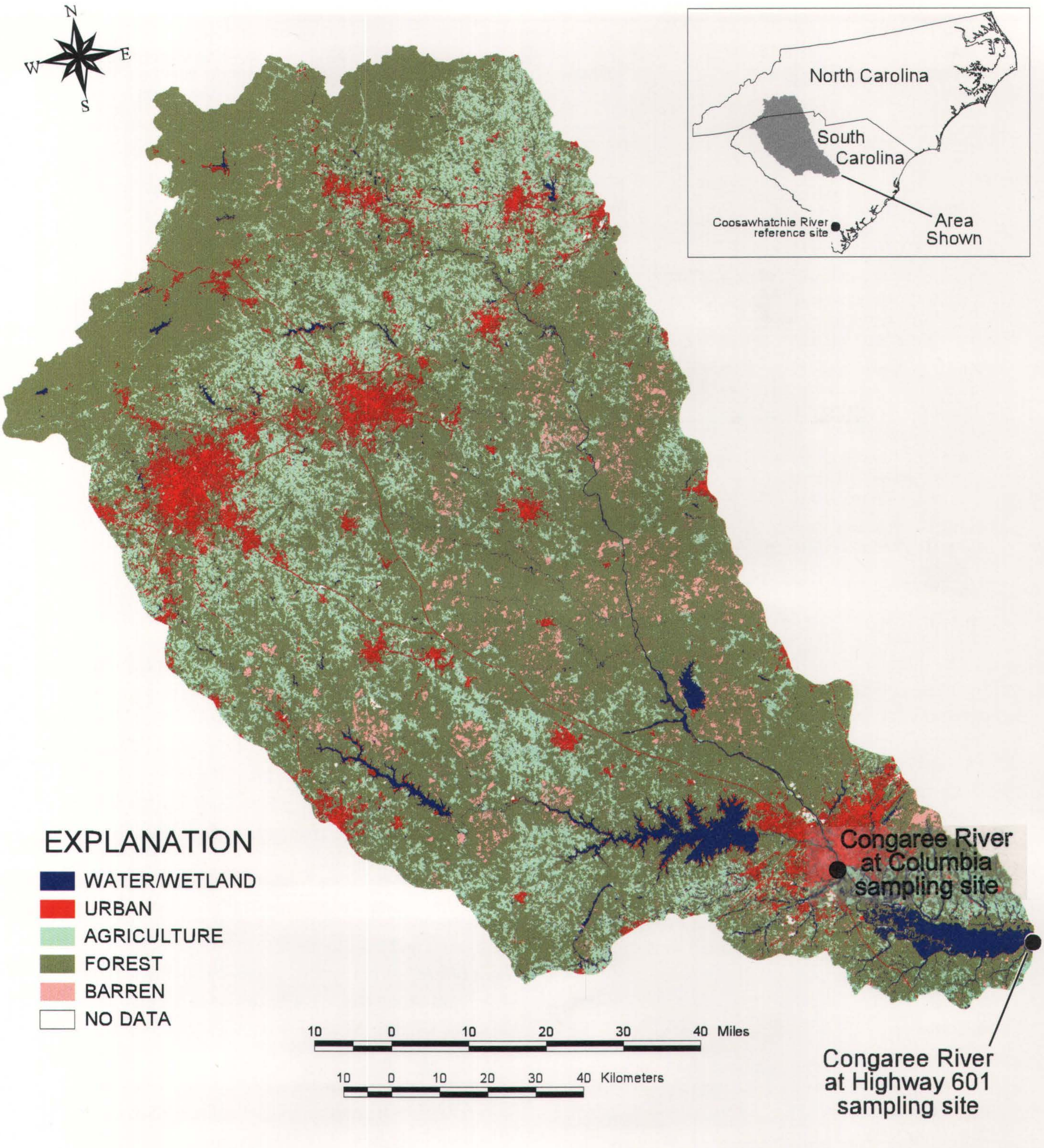

Figure 3. Land cover and location of sampling site in the Congaree River at Highway 601 Basin, North and South Carolina.

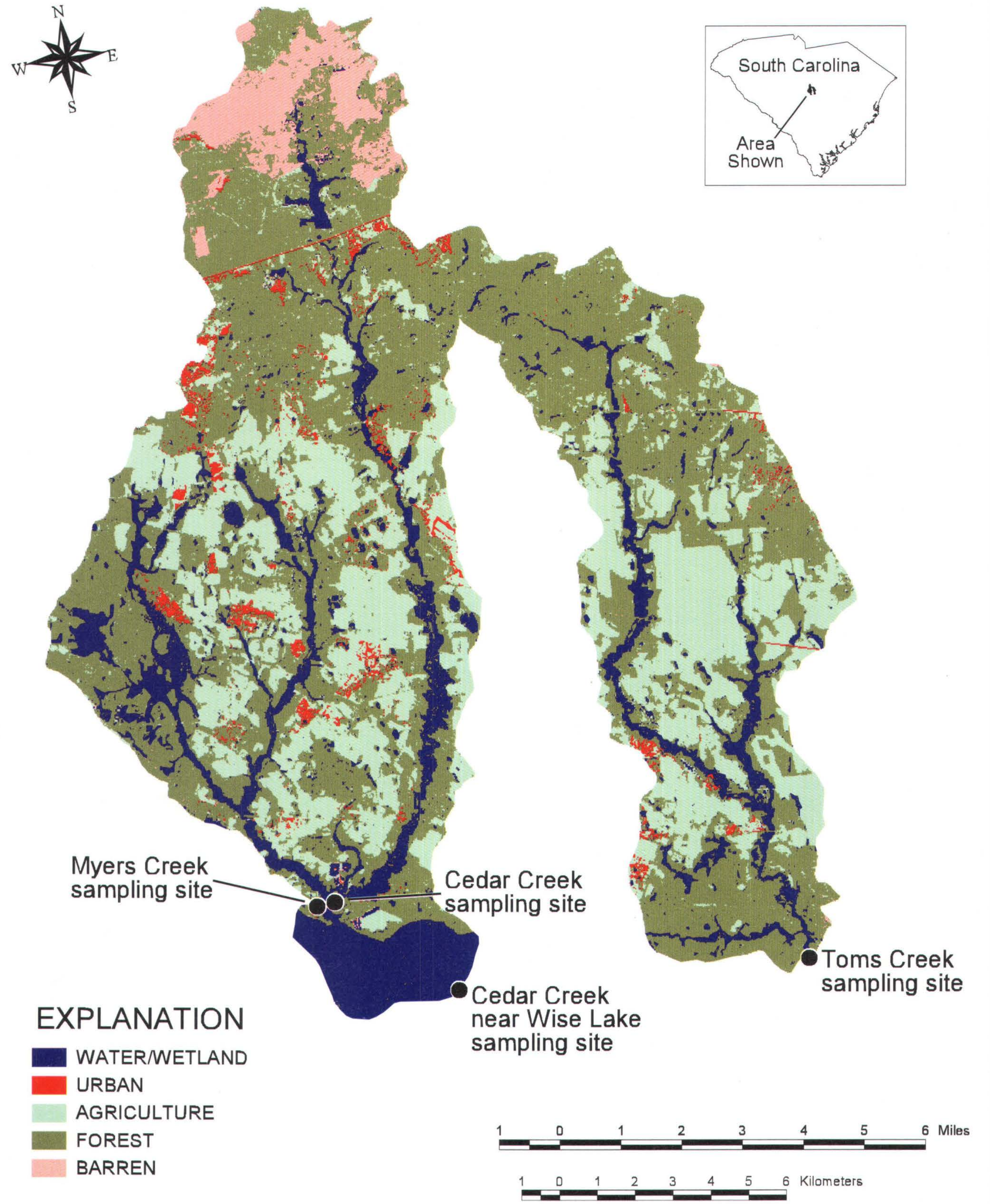

Figure 4. Land cover and location of sampling sites in the Myers Creek, Cedar Creek, Cedar Creek near Wise Lake, and Toms Creek Basins, South Carolina.

Land cover in the Cedar Creek Basin is approximately 58 percent forested with a mix of evergreens and deciduous hardwoods, 18 percent agriculture, and 8 percent wetlands in the lower part of the basin. Commercial and urban areas represent 2 percent of the basin, 12 percent of the basin is barren or in transition, and 2 percent consists of ponds along the length of Cedar Creek (fig. 4). The drainage area of the Cedar Creek Basin above the Monument is about 90 km^2. Two military bases are in the Cedar Creek Basin. Cedar Creek receives wastewater from several minor domestic sources and two minor industrial wastewater sources. Downstream from the confluence with Myers Creek, the total basin area of Cedar Creek near Wise Lake within the Monument is about 184 km^2.

Land cover in the Toms Creek Basin is approximately 56 percent forested, 10 percent wetlands or open water, 33 percent agriculture, and less than 1 percent each urban and barren lands (fig. 4). Toms Creek enters the northeast corner of the Monument and has a basin drainage area of about 100 km^2.

METHODS

Water-quality and ecological data were collected for this study in accordance with methods required by the NAWQA Program. NAWQA methods and protocols are available on the World Wide Web (U.S. Geological Survey, 1999b).

Quality Control

Field-blank samples were collected using certified water with undetectable concentrations of constituents being analyzed. Blank samples were analyzed for major ions, nutrients, organic carbon, and pesticides to assess possible cross contamination introduced during sample collection, processing, shipment, or laboratory analysis (Shelton, 1994). Fish identification was verified by Mr. Fritz Rohde, North Carolina Department of Marine Fisheries, Wilmington, N.C.

Statistical Analysis

Surface-water data were tested for correlations using the nonparametric Kendall's tau correlation coefficient and an acceptable error rate of 0.01 ($\alpha = 0.01$; Helsel and Hirsch, 1995). Significant differences in constituent concentrations between stations were tested using Tukey's test in an analysis of variance on the rank-transformed data ($\alpha = 0.05$). Bed-sediment and tissue data were tested for normal distribution using the Shapiro-Wilkes test. If normally distributed, the data were analyzed using a one-way analysis of variance with Tukey's pair-wise comparison to determine if streams were significantly different. If data were not normally distributed, analyses were conducted using a Kruskal-Wallis one-way analysis of variance. Statistical analyses of bed-sediment and tissue results were conducted using an acceptable error level of 0.05. Correlations of water-quality constituents with macroinvertebrate community diversity also were investigated using an acceptable error rate of 0.05.

Water-Quality Sampling

Surface-water samples were collected and processed according to guidelines specified by Shelton (1994). Streamflow generally was great enough to allow multiple vertical sections (3–20) to be sampled using a depth-integrated sampler. Samples were analyzed for major ions, nutrients, organic carbon, and pesticides at the USGS National Water Quality Laboratory (NWQL). Suspended-sediment samples were analyzed by the Kentucky District sediment laboratory. Specific conductance, stream temperature, pH, dissolved-oxygen concentration and percent saturation, and alkalinity were measured onsite.

Teflon sampling equipment (bottle, nozzle, and collar) was used to ensure sample integrity. A Teflon cone splitter was used to composite and split the samples into separate sample bottles for various analyses. Suspended-sediment sample bottles were filled directly from the cone splitter. After splitting, samples for dissolved major ions and dissolved nutrients were filtered immediately using a 0.45-micrometer (µm) pore size filter that was pre-rinsed with deionized water and stream water. Samples for dissolved major ions were preserved with nitric acid. Samples for dissolved pesticides were filtered immediately using a 0.7-µm pore size glass-fiber filter. Samples for suspended and dissolved organic carbon were collected from the centroid of flow using a baked glass bottle, and these samples were filtered using a 0.45-µm silver filter. The filtrate was collected for dissolved organic carbon analysis, and the filters were analyzed for suspended organic carbon.

All samples were chilled immediately after filtration and preserved for overnight transport to the NWQL in Denver, Colo. Samples were analyzed using NAWQA methods described in Patton and Truitt (1992), Fishman (1993), Zaugg and others (1995), and Werner and others (1996).

Method detection limit (MDL) is "the minimum concentration of a substance that can be identified, measured, and reported with 99-percent confidence that the analyte concentration is greater than zero, determined from the analysis of a sample in a given matrix containing the analyte" (U.S. Geological Survey, 1999a). At the MDL concentration, the risk of a false positive is predicted to be no more than 1 percent. Analytical uncertainty and many different possibilities for error are reflected in MDL's (Clark and Whitfield, 1994). Pesticides are listed in this report with MDL's from the NWQL. The NWQL reports all analytical concentrations if all quality-control and methods criteria are met. Pesticides that are positively identified at concentrations less than the MDL are reported from the NWQL as estimated.

Major ions, nutrients, and organic carbon are reported with minimum reporting levels (MRL's), which take into account MDL's and are based on the laboratory's best judgment of the concentration that can be reliably reported using a given analytical method (U.S. Geological Survey, 1999a).

Streamflow measurements in the tributaries were made at the time of sample collection in accordance with standard USGS procedures (Rantz and others, 1982). For the Congaree River at Columbia, streamflow data were obtained from the USGS continuous-measurement gage.

Ecological Characterization

All ecological samples and data were collected using NAWQA protocols. These protocols specify step-by-step procedures designed to standardize data collected for the NAWQA Program.

Habitat

Habitat data were collected in accordance with NAWQA protocols (Meador, Hupp, and others, 1993). A section of stream, called a "reach," approximately 150 meters (m) in length was selected for study at each site. Along each reach, six transect sites were constructed at approximately equidistant intervals (about 30 m). The following physical attributes were measured at each transect: bankfull width, bank height, water depth, substrate type, embeddedness, and habitat type. The riparian zone was assessed using a point-quarter method. At each transect, a pivot point was chosen at random on each side of the stream up to 3 m from the bank. From the pivot point, the nearest tree in each quarter (each 90-degree section) was identified. Distance to the pivot point and the diameter of each tree at chest height were measured. Thus, on each side of each transect, four trees were identified and measured. Forty-eight trees were identified at each site.

Aquatic Community

Algal samples were collected using procedures outlined in Porter and others (1993). For quantitative analysis and taxonomic enumeration, discrete areal samples ranging from 25 to 363 square centimeters (cm^2) were taken from logs and other woody snags. Discrete areal samples of the bottom material ranging from 98 to 196 cm^2 were collected in as many different habitats as were available. For taxonomic evaluation only, qualitative samples of macroalgae and aquatic mosses were collected where these organisms were observed in the streams. At the time of this printing, algal data were not available.

Macroinvertebrates were collected using qualitative and quantitative techniques (Cuffney and others, 1993). The faunistically richest habitat, known as the richest targeted habitat (RTH), in each stream was determined by observation and was sampled by discrete areal collections ranging from 1,155 to 4,745 cm^2. The RTH in all streams was judged to be woody snags, or branches and logs, and debris dams. The woody snag habitat is the most prevalent habitat in streams of Congaree Swamp and is relatively stable (compared to easily erodible sandy and muck bottoms).

Woody snag habitats provide cover for rich, diverse communities of macroinvertebrate fauna. Macroinvertebrates were collected from branches by picking the branches apart for the organisms of interest. Debris and loose material were processed through a standard brass 425-µm sieve. All material, except for the cleaned branches, was preserved in a 10-percent solution of formaldehyde and sent to the NWQL for taxonomic evaluation. Once the combined area was calculated for the branches from which samples were collected, the density of macroinvertebrate fauna was determined. Qualitative samples were collected from logs using forceps and fingers and by searching for individual organisms in leaves and organic detritus. All organisms were sent to the NWQL for taxonomic evaluation.

Fish collections were conducted in accordance with Meador, Cuffney, and Gurtz (1993). A scientific fish-collection permit was obtained from the South Carolina Department of Natural Resources before any collection activities began. Fishes were collected by power-fishing techniques, using a backpack power fisher (Smith-Root, model 12A POW) in all streams. In addition, a non-commercial, boat-mounted, power-fishing apparatus (courtesy of Mr. John Crane, Fisheries Biologist, South Carolina Department of Natural Resources) was used to collect fishes in Cedar Creek near Wise Lake. A commercial boat-mounted power-fishing apparatus (Smith-Root, customized for USGS use) was used to collect fishes in the Congaree River at Columbia.

Tissue

Tissue samples were collected using NAWQA procedures specified by Crawford and Luoma (1994). The Asiatic clam (*Corbicula fluminea*) is one of the organisms selected for tissue analysis in the NAWQA Program. The Asiatic clam is widespread in the continental United States and can be used as a common source to standardize information about the bioavailability of trace elements and organic compounds in stream sediments. However, Asiatic clams were not found in Congaree Swamp, so native freshwater clams (*Elliptio* sp.) were selected for tissue analyses. Because clams are bottom-dwelling filter feeders that only travel short distances, they tend to accumulate trace elements and organic contaminants and can be indicators of water-quality conditions in a discrete area over time (Rodgers and others, 1979; Crawford and Luoma, 1994). Suspected routes of accumulation are ingestion of food particles (algae, bacteria, and organic detritus) from the water column and absorption at the water-gill interface. Analyses for pesticides and trace elements were conducted on the soft tissues of the clams.

The common carp (*Cyprinus carpio*), also specified in the NAWQA protocols for tissue analyses as a common organism found in most areas of the country, was not present in Congaree Swamp streams. Carp liver tissue was designated for analysis for trace elements because carp are large fish and their livers are easily excised in the field. Analyses for organochlorine pesticides are conducted using the whole fish. However, for this study, the redbreast sunfish (*Lepomis auritus*) was selected for tissue analyses because it is one of the most popular game fishes in South Carolina (Barton and O'Brien-White, 1995). Information about this fish's potential as a source of contaminants is relevant and of interest to the fishing public. This fish also represents a higher trophic level (secondary consumer). Typically insectivorous, the redbreast preys on organisms that live in close association with sediments. Trace element analyses of redbreast sunfish liver tissues were not conducted because the fish are relatively small, and liver tissue extraction was not feasible. However, whole-fish analyses of organochlorine pesticides were conducted using redbreast sunfish from Myers Creek, Cedar Creek, and Toms Creek. Cedar Creek near Wise Lake yielded too few redbreast sunfish for analysis.

Bed Sediments

Bed-sediment samples were collected using procedures specified in the NAWQA Program (Shelton and Capel, 1994). Sediment samples from each of the six sites were collected between 1995 and 1997 from the top few centimeters within depositional zones of streambeds and were wet-sieved to provide a less than 63-µm fraction for trace element analysis (Shelton and Capel, 1994). Several sediment subsamples from each site were composited into representative samples and sent to the NWQL for analysis.

RESULTS OF WATER-QUALITY SAMPLING

Results from the water-quality samples are presented below. Results of the quality-control sample analyses also are presented in the following sections.

Major Ions

Concentrations of calcium, magnesium, sodium, potassium, sulfate, chloride, and silica were significantly higher in the Congaree River at Columbia than the four tributary streams (figs. 5, 6; Appendix 1). These ions are naturally occurring, but also are found in surface waters as a result of agricultural runoff or wastewater discharges from industrial and municipal treatment plants (Hem, 1992). A significant inverse correlation of streamflow with sodium and chloride concentrations was detected in the Congaree River at Columbia, possibly an indication of dilution of point sources of these ions. Streamflow was directly correlated with calcium, magnesium, potassium, and sulfate at Cedar Creek near Wise Lake and directly correlated with calcium and sulfate at Cedar Creek. Cedar Creek had significantly lower concentrations of calcium, magnesium, sodium, potassium, and chloride than the other streams (figs. 5, 6) and generally had the least variability in major ion concentrations. Fluoride concentrations in the streams were below or just above the MRL (0.01 milligram per liter [mg/L]). The ranges of major ion concentrations in streams in the study area are presented in table 2. The U.S. Environmental Protection Agency (U.S. EPA) parameter code identifies the specific form of the constituent analyzed and can be used for accurate comparison with other studies of the same constituent.

Concentrations of iron and manganese were significantly lower in the Congaree River at Columbia than in the four tributary streams (fig. 7). Iron and manganese often are present in streams as a result of ground-water discharge to the stream. Micro-organisms in subsurface sediments can reduce iron and manganese, making them more soluble in ground water. The higher concentrations of iron and manganese in the four tributary streams than in the Congaree River at Columbia may be because ground water constitutes a more significant portion of the flow in the tributary streams. Secondary drinking-water standards for iron (300 micrograms per liter [µg/L]) and manganese (50 µg/L) were exceeded in at least one sample at each site. Secondary drinking-water standards are Federal guidelines regarding taste, odor, color, and other non-aesthetic effects of drinking water (U.S. Environmental Protection Agency, 1996).

The surface-water quality-control data collected for this study indicate that contamination of samples was rare and minimal. Detections of major ions in the blank samples were infrequent and were at or close to the MRL's. The levels detected in the blanks were considered insignificant and do not affect the quality of the data.

Table 2. Ranges in major ion concentrations in streams of Congaree Swamp

[MRL, minimum reporting level; mg/L, milligram per liter; µg/L, microgram per liter]

Constituent	Parameter code	Minimum	Median	Maximum	MRL
Calcium (mg/L)	00915	0.63	1.1	4.4	0.02
Magnesium (mg/L)	00925	.39	.78	1.8	.004
Sodium (mg/L)	00930	1.7	3.2	11	.06
Potassium (mg/L)	00935	.4	1.0	3.3	.1
Silica (mg/L)	00955	.55	7.8	14	.05
Chloride (mg/L)	00940	2.5	4.4	8.7	.1
Fluoride (mg/L)	00950	.1	.1	.2	.1
Sulfate (mg/L)	00945	.43	2.2	17	.1
Iron (µg/L)	01046	39	305	960	10
Manganese (µg/L)	01056	5.0	27.5	374	3.0

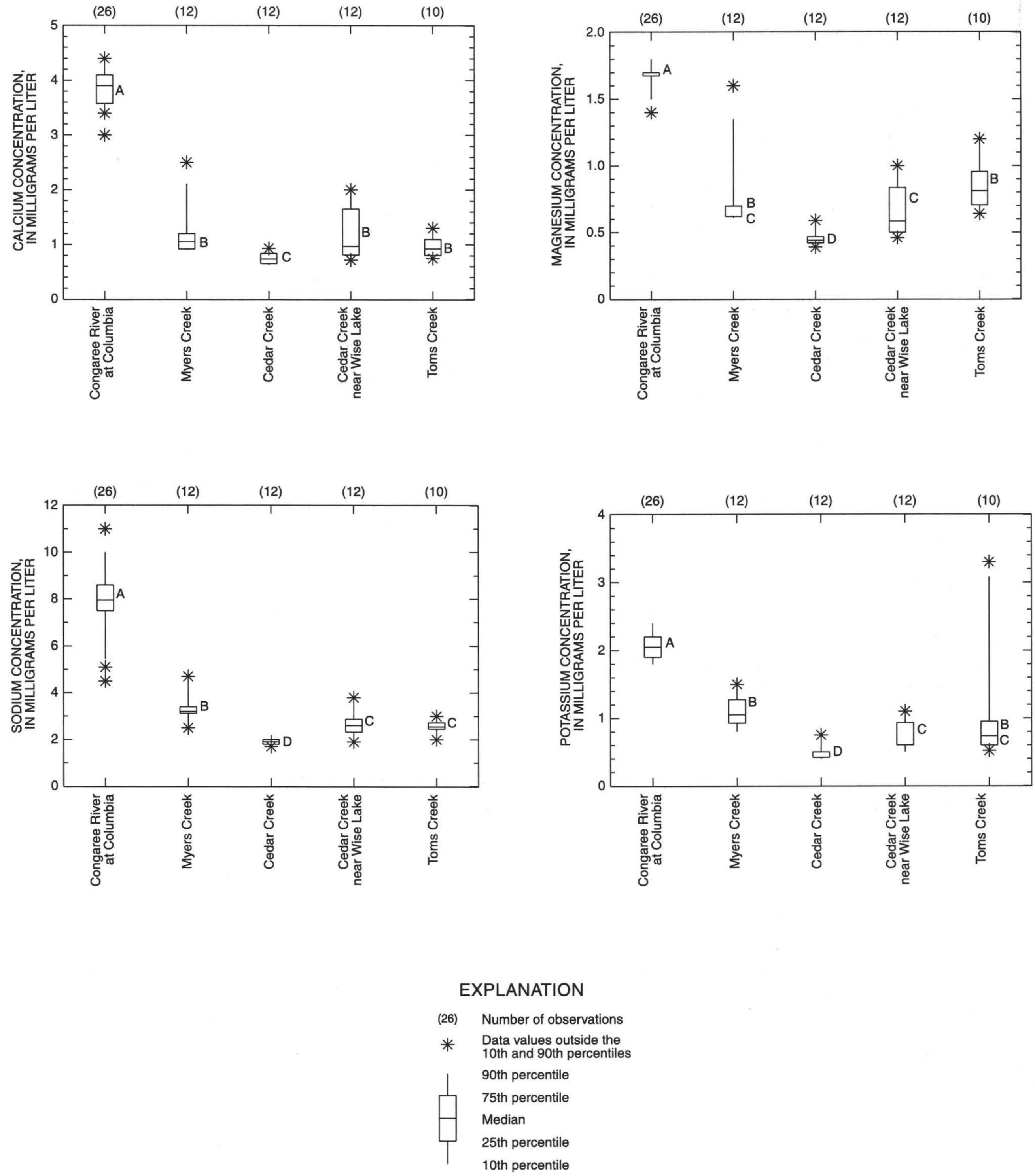

Figure 5. Statistical distribution of calcium, magnesium, sodium, and potassium in streams of Congaree Swamp. (Letters denote significantly different mean concentration ranks, with A being the highest, B being the next lower, and so on. Sites with letters in common are not significantly different from each other.)

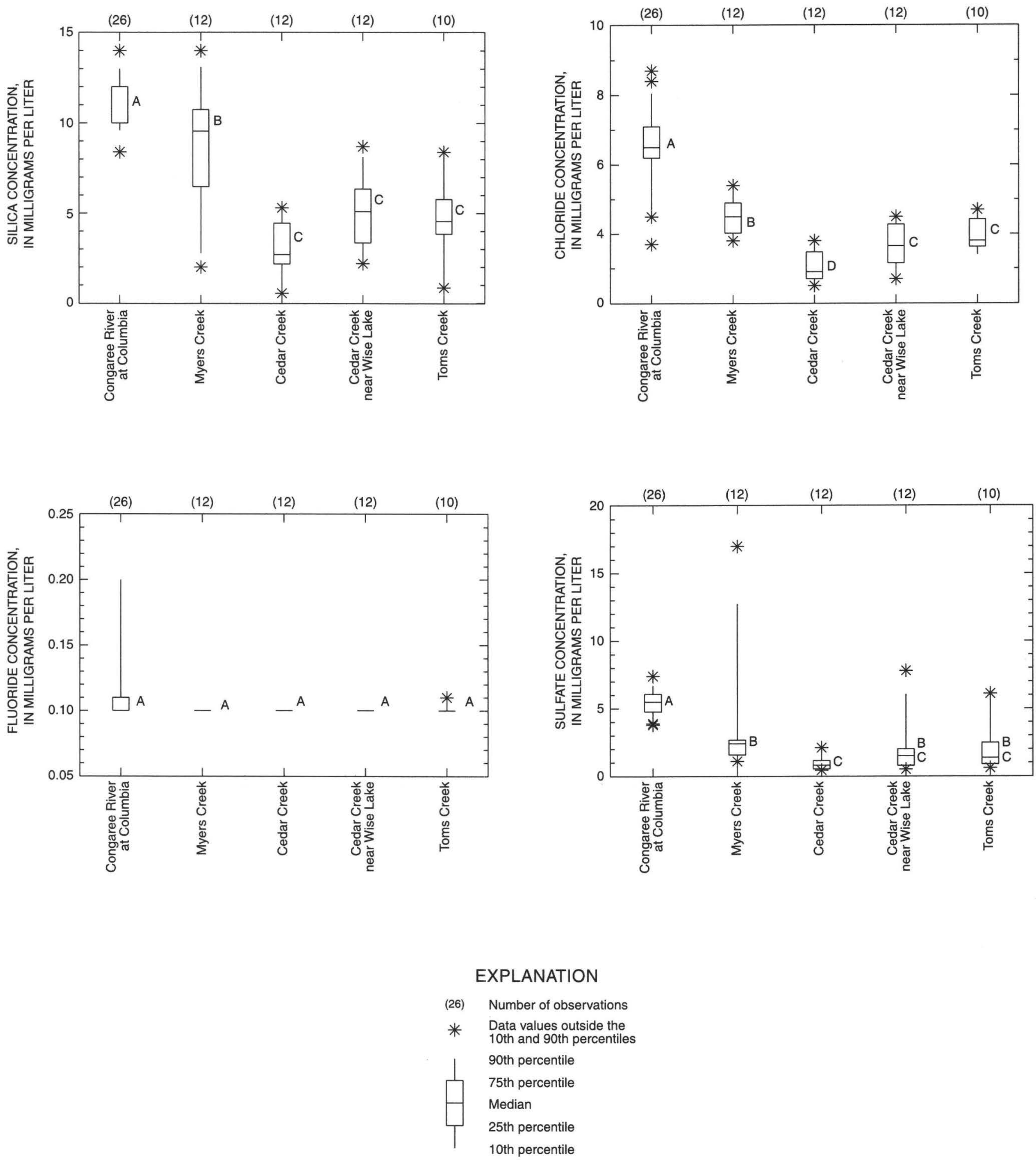

Figure 6. Statistical distribution of silica, chloride, fluoride, and sulfate in streams of Congaree Swamp. (Letters denote significantly different mean concentration ranks, with A being the highest, B being the next lower, and so on. Sites with letters in common are not significantly different from each other.)

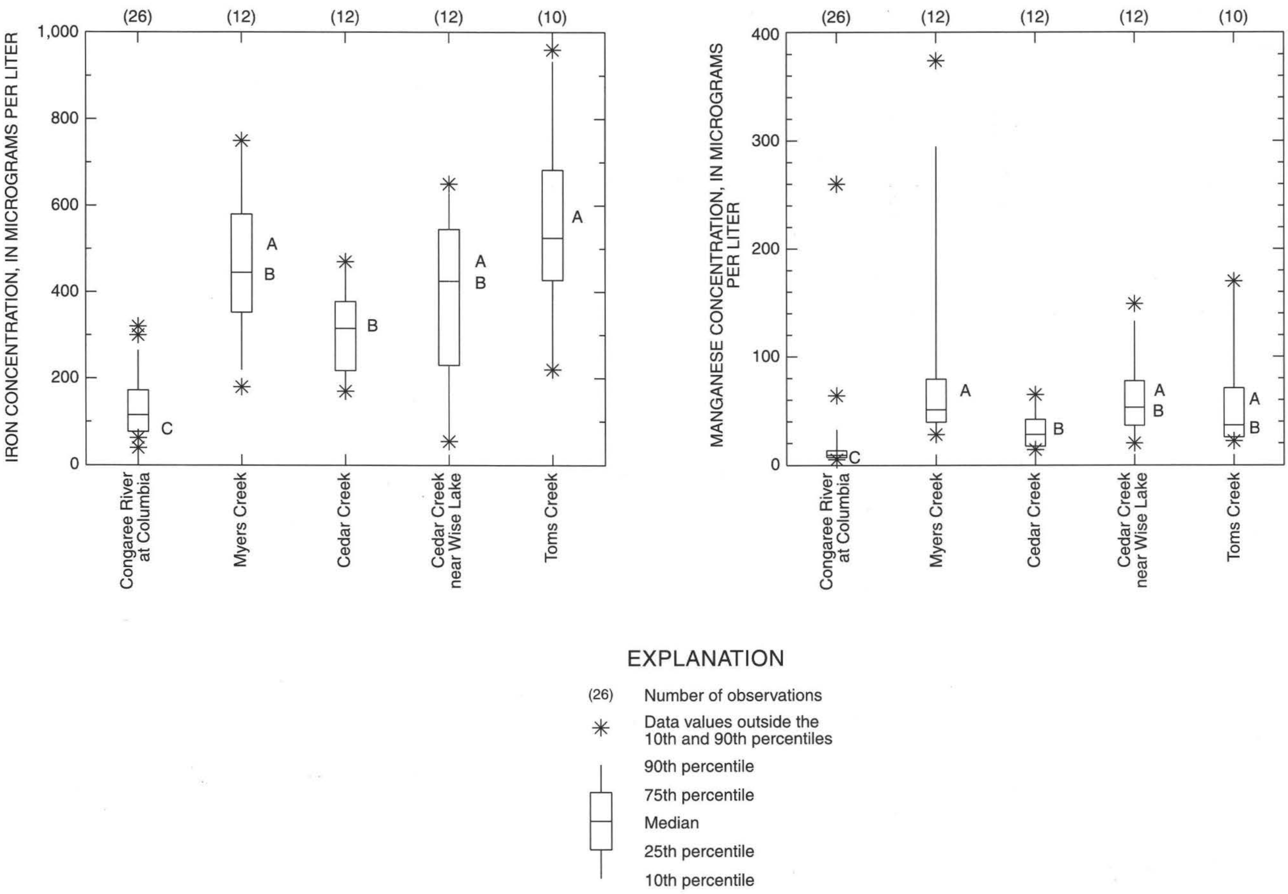

Figure 7. Statistical distribution of iron and manganese in streams of Congaree Swamp. (Letters denote significantly different mean concentration ranks, with A being the highest, B being the next lower, and so on. Sites with letters in common are not significantly different from each other.)

Nutrients

Nutrient concentrations in streams in the study area generally were low (table 3; Appendix 2). All ammonia nitrogen concentrations were below 0.15 mg/L, with no significant differences among sites (fig. 8). Myers and Toms Creeks had the highest median ammonia-plus-organic nitrogen concentrations, but variability in concentrations was low. Much of the ammonia-plus-organic nitrogen was in the dissolved phase in the four tributary streams, and in the particulate phase in the Congaree River at Columbia. Nitrite nitrogen concentrations were low with little variability. Nitrite-plus-nitrate nitrogen concentrations were significantly higher in the Congaree River at Columbia than in the four tributary streams, but no sample exceeded 0.5 mg/L. Detections of low-level nutrients in the quality-control samples were infrequent. Elevated concentrations of nitrite-plus-nitrate nitrogen and ammonia nitrogen were detected in one field-blank sample from the Congaree River at Columbia. The level detected was approximately twice the MRL. Because it was a single occurrence, sample data integrity was not affected.

Phosphorus concentrations varied little among sites (fig. 9). Dissolved phosphorus concentrations were highest in the Congaree River at Columbia, and total phosphorus concentrations in the Congaree River at Columbia were significantly greater than in Cedar and Toms Creeks. The U.S. EPA (1986) recommends that instream concentrations of total phosphorus not exceed 0.10 mg/L in flowing waters not entering lakes or impoundments, 0.05 mg/L in flowing waters at the point of entry to a lake or impoundment, and 0.025 mg/L within lakes or impoundments. All phosphorus concentrations in Myers Creek, Cedar Creek, Cedar Creek near Wise Lake, and Toms Creek were below 0.10 mg/L. Total phosphorus concentrations in the Congaree River at Columbia exceeded 0.10 mg/L in 5 of 26 samples.

Table 3. Ranges in nutrient concentrations in streams of Congaree Swamp

[Units in milligrams per liter; MRL, minimum reporting level]

Constituent	Parameter code	Minimum	Median	Maximum	MRL
Ammonia nitrogen	00608	0.015	0.020	0.120	0.015
Dissolved ammonia-plus-organic nitrogen	00623	.10	.20	.51	.10
Total ammonia-plus-organic nitrogen	00625	.10	.30	1.0	.10
Nitrite nitrogen	00613	.01	.01	.02	.01
Nitrite-plus-nitrate nitrogen	00631	.05	.20	.42	.05
Orthophosphorus	00671	.01	.01	.03	.01
Dissolved phosphorus	00666	.01	.01	.04	.01
Total phosphorus	00665	.01	.02	.35	.01
Dissolved organic carbon	00681	1.4	3.6	16	.1
Suspended organic carbon	00689	.1	.8	4.8	.2[a]

[a]MRL increased from 0.1 to 0.2 during the study.

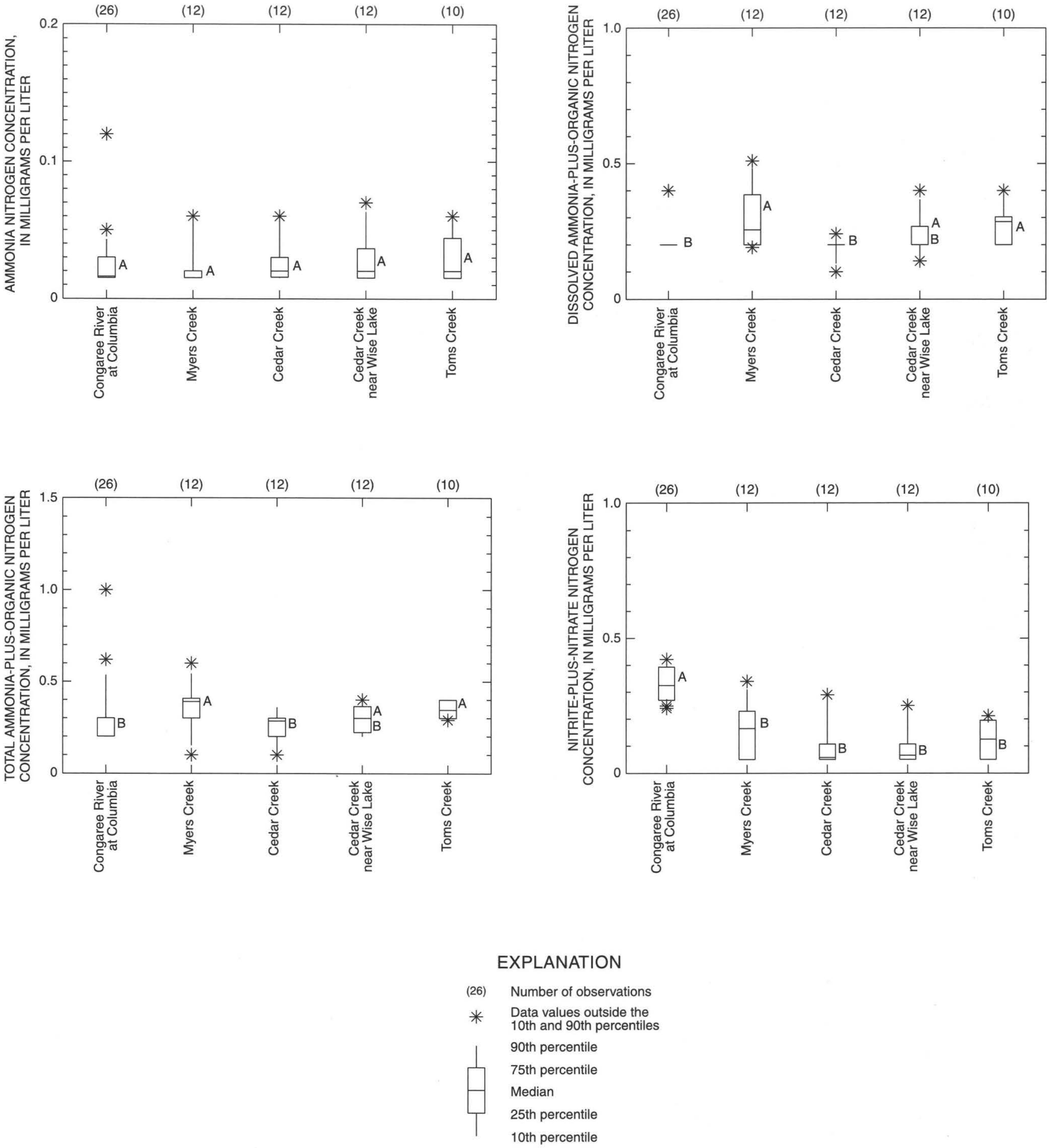

Figure 8. Statistical distribution of nitrogen species in streams of Congaree Swamp. (Letters denote significantly different mean concentration ranks, with A being the highest, B being the next lower, and so on. Sites with letters in common are not significantly different from each other.)

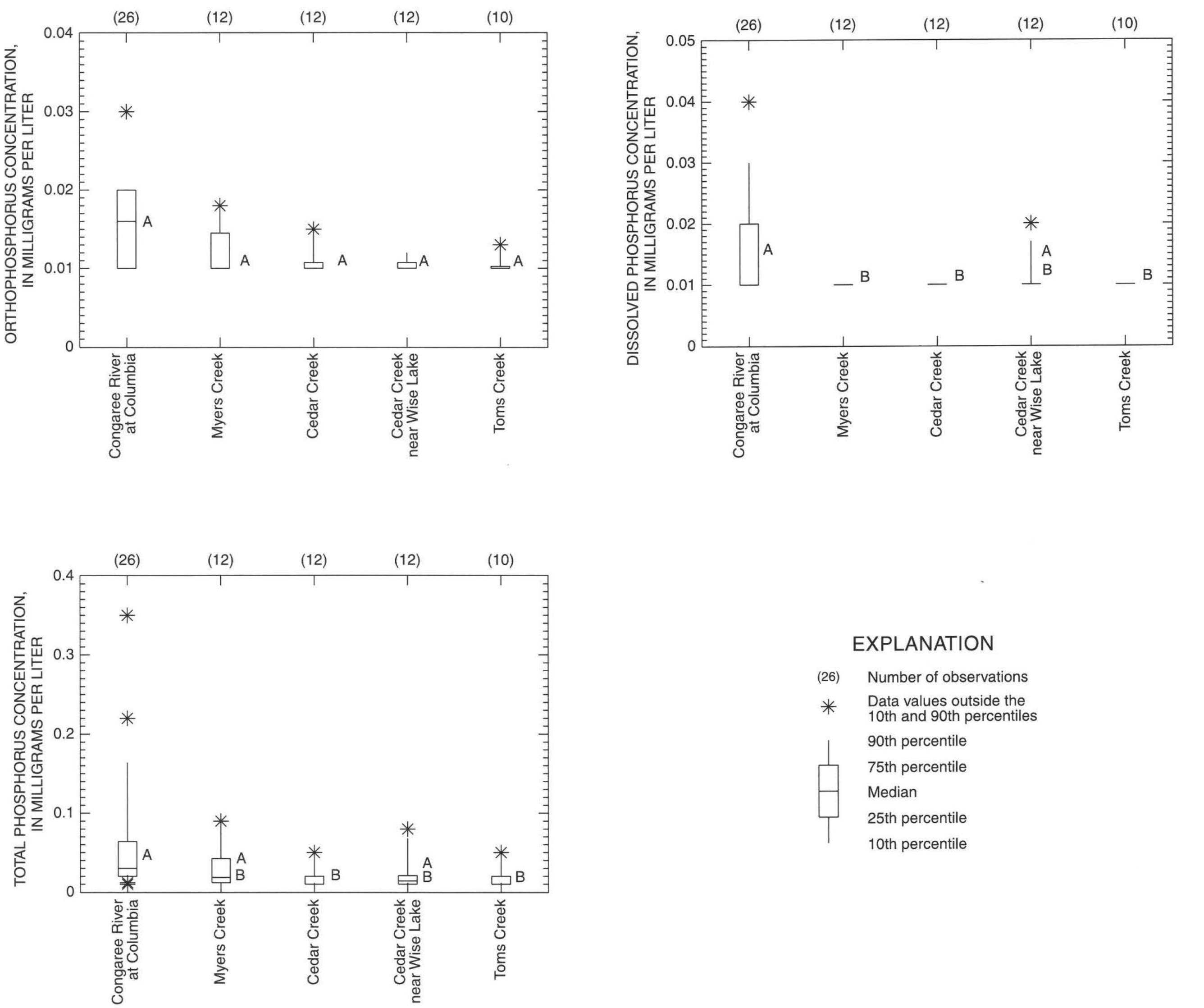

Figure 9. Statistical distribution of phosphorus species in streams of Congaree Swamp. (Letters denote significantly different mean concentration ranks with A being the highest, B being the next lower, and so on. Sites with letters in common are not significantly different from each other.)

Dissolved organic carbon concentrations were highest in Myers Creek (fig. 10). Suspended organic carbon concentrations were significantly lower in the Congaree River at Columbia than in the four tributary streams. Detections of organic carbon in the quality-control samples were close to the MRL.

Pesticides

Forty-two water samples were collected from the streams of Congaree Swamp and analyzed for 47 pesticides—3 samples from the Congaree River at Columbia, 10 each from Myers Creek, Cedar Creek, and Cedar Creek near Wise Lake, and 9 from Toms Creek (Appendixes 3, 4). The number of samples differs because of different sampling regimes among the sites. Quarterly pesticide sampling was conducted at the Congaree River at Columbia from February to October 1996; quarterly sampling at the other four sites was conducted approximately from January 1996 through September 1998. Twelve different pesticides were detected. Tebuthiuron, atrazine, metolachlor, and deethylatrazine were the most frequently detected pesticides (table 4; Appendix 4). The number of detections varied with each pesticide and ranged from 2 to 90 percent of the samples collected at all of the streams.

Pesticide concentrations ranged from below the MDL's to a high of 0.084 μg/L for tebuthiuron at Toms Creek. None of the pesticide concentrations exceeded criteria for the protection of human health or aquatic life (table 4). Significantly higher concentrations of atrazine and metolachlor were detected in the spring than in the fall or winter. These herbicides are typically

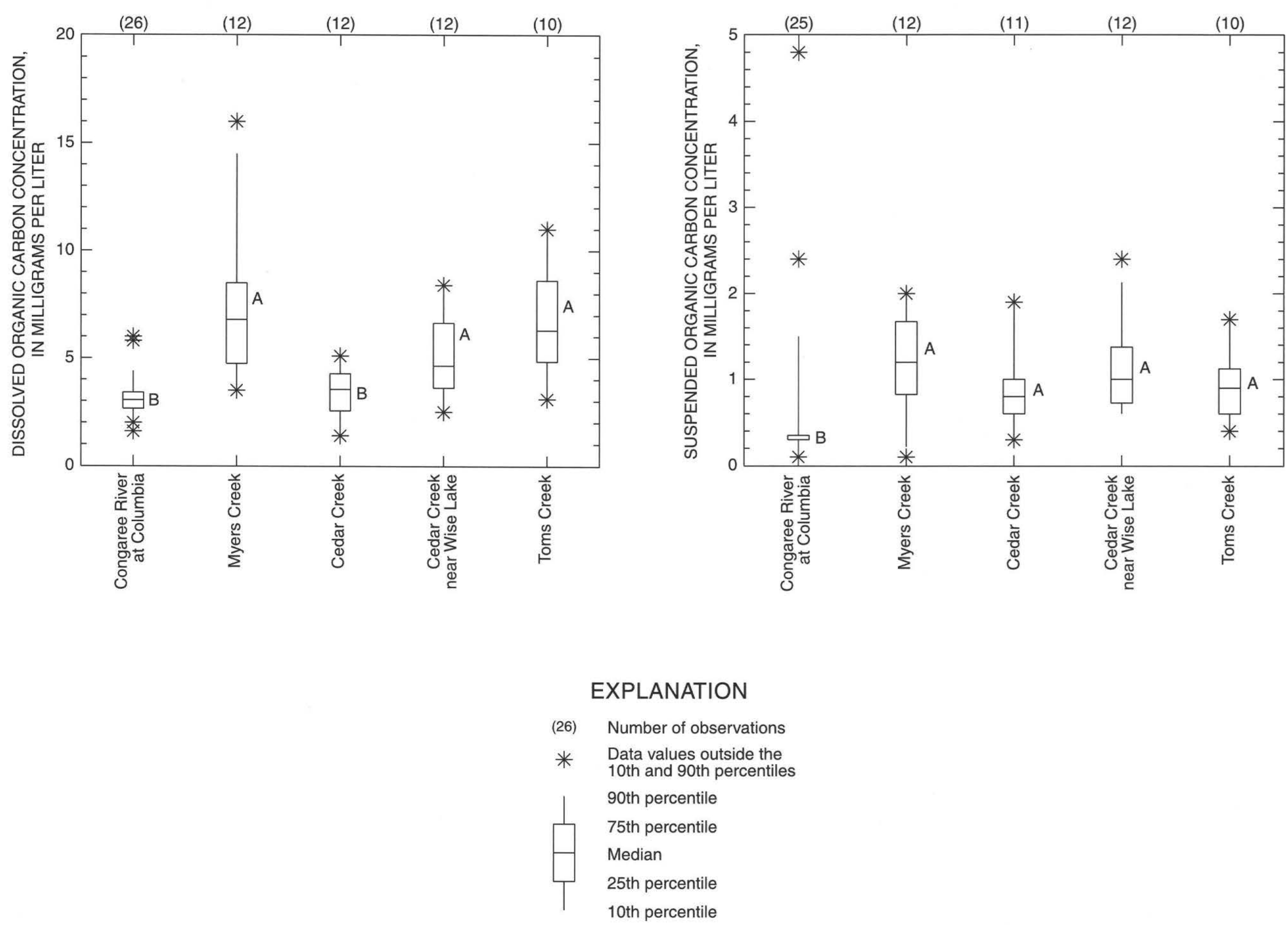

Figure 10. Statistical distribution of organic carbon in streams of Congaree Swamp. (Letters denote significantly different mean concentration ranks, with A being the highest, B being the next lower, and so on. Sites with letters in common are not significantly different from each other.)

Table 4. Summary of pesticides detected in streams of Congaree Swamp

[Units in micrograms per liter; HAL, health advisory level; MCL, maximum contaminant level; —, not established]

Pesticide	Number of detections	Percentage of detections	Maximum concentration	Aquatic criteria	Lifetime HAL	MCL
Herbicides						
Tebuthiuron	38	90	0.084	—	500	—
Atrazine	25	60	.058	—	3[a]	3
Metolachlor	23	55	.038	—	70	—
Deethylatrazine[b]	16	38	.004	—	—	—
Prometon[b]	5	12	.009	—	100[a]	—
Simazine	5	12	.053	10[c]	4	4
DCPA	2	5	.001	—	—	—
Alachlor[b]	1	2	.002	—	—	2
Pronamide	1	2	.006	—	50	—
Insecticides						
Carbaryl[b]	1	2	0.006	0.02[c]	700	—
Chlorpyrifos[b]	1	2	.004	.041[d]	20	—
Diazinon	1	2	.003	.009[c]	.6	—

[a]Under review (U.S. Environmental Protection Agency, 1996).

[b]Concentrations for these pesticides are qualitatively identified with an E code (estimated; Zaugg and others, 1995).

[c]Freshwater chronic water-quality criteria recommendations are from National Academy of Sciences and National Academy of Engineering (1973), modified from Nowell and Resek (1994).

[d]Freshwater chronic water-quality criteria (U.S. Environmental Protection Agency, 1997).

detected in higher concentrations during spring application and runoff periods.

Although the Congaree River at Columbia had the fewest number of pesticide samples (3), it had the highest number of different pesticides detected (9). Cedar Creek and Toms Creek (10 and 9 samples, respectively) had the lowest number of different pesticides detected (5). Myers Creek had the highest number of pesticide detections (28), and Cedar Creek had the lowest number (19; table 5). No pesticides were detected in the quality-control samples.

Tebuthiuron and prometon are herbicides used for broadleaf and grassy weed control in non-cropland areas, highway right-of-ways, and industrial sites. Atrazine and simazine are widely used triazine herbicides for control of broadleaf and grassy weeds on croplands and as non-selective herbicides on industrial and fallow lands. Deethylatrazine is a breakdown product of atrazine. Metolachlor is used as a pre-emergent herbicide for broadleaf and grassy weed control on croplands and highway right-of-ways. Chlorthal, also called DCPA, is a pre-emergent herbicide used on croplands and on home lawns and gardens. Alachlor is a selective herbicide used to control broadleaf weeds and grasses in field corn, soybeans, and peanuts. Pronamide, also known as propyzamide, is a herbicide used for both pre- and post-emergent weed control on lettuce, alfalfa, blueberries, ornamental plants, fruit trees, and fallow lands.

Carbaryl is used as a wide-spectrum carbamate insecticide for citrus and other fruit trees, cotton, forests, lawns, and other croplands, as well as on poultry, livestock, and pets. Chlorpyrifos is an organophosphate insecticide used on grain, cotton, fields, fruit and nut trees, vegetable crops, lawns, and ornamental plants. It also is used on sheep and turkeys, and to treat homes and farm buildings, dog kennels, and commercial buildings. Diazinon is an organophosphate insecticide used for residential control of roaches, silverfish, ants, and fleas. It also is used on home gardens and farms to control a wide variety of insects.

Table 5. Numbers of pesticide detections in streams of Congaree Swamp

Pesticide	Congaree River at Columbia (3 samples)	Myers Creek (10 samples)	Cedar Creek (10 samples)	Cedar Creek near Wise Lake (10 samples)	Toms Creek (9 samples)
Alachlor	0	0	1	0	0
Atrazine	3	6	5	6	5
Carbaryl	0	0	0	0	1
Chlorpyrifos	0	1	0	0	0
DCPA	2	0	0	0	0
Deethylatrazine	3	3	1	3	6
Diazinon	1	0	0	0	0
Metolachlor	3	7	3	5	5
Prometon	3	1	0	1	0
Pronamide	1	0	0	0	0
Simazine	3	1	0	1	0
Tebuthiuron	3	9	9	8	9
Total number of detections	22	28	19	24	26

Suspended Sediment

The Congaree River at Columbia had significantly higher concentrations of suspended sediment than Cedar and Toms Creeks (fig. 11; Appendix 5). Suspended-sediment concentrations ranged from 1 to 248 mg/L. The percentage of suspended sediment finer than 0.062 millimeters (mm) ranged from 14 to 96 percent. No significant differences were detected among study sites in the percentage of the suspended sediment finer than 0.062 mm.

Field Measurements

Measurements of streamflow, specific conductance, stream temperature, pH, dissolved oxygen concentration and percent saturation, and alkalinity were made at the study sites each time a water-quality sample was collected (Appendix 6). Streamflow ranged from 1 cubic foot per second (ft^3/s) to 160 ft^3/s on sampling dates in the four tributary streams, and from 2,400 ft^3/s to more than 53,000 ft^3/s during sampling on the Congaree River at Columbia. Specific conductance, alkalinity, and pH were significantly higher in the Congaree River at Columbia than in the four tributary streams. Specific conductance ranged from 11 microsiemens per centimeter at 25 °C (µS/cm) to more than 100 µS/cm. Alkalinity was generally below 10 mg/L in the four tributary streams and ranged from 12 mg/L to 36 mg/L in the Congaree River at Columbia. Low alkalinity, or buffering capacity, resulted in lower pH in the four tributary streams. The median pH in the tributaries was below 6.0 standard units (su), and was over 7.0 su in the Congaree. No significant differences were detected in stream temperatures. Stream temperatures ranged from 6 °C to 29 °C, and median stream temperatures ranged from 16 °C to 20 °C. No significant differences were detected in dissolved oxygen concentrations in the streams, but Cedar Creek had a significantly higher percentage of saturation of dissolved oxygen than the other three tributary streams, possibly due to less organic detritus in Cedar Creek. Median percentages of dissolved oxygen saturation ranged from more than 75 percent to about 99 percent.

RESULTS OF ECOLOGICAL CHARACTERIZATION

The characteristics of the tributary stream reaches were determined by onsite investigations. Measurements of physical, chemical, biotic, and geologic components were performed in accordance with NAWQA protocols.

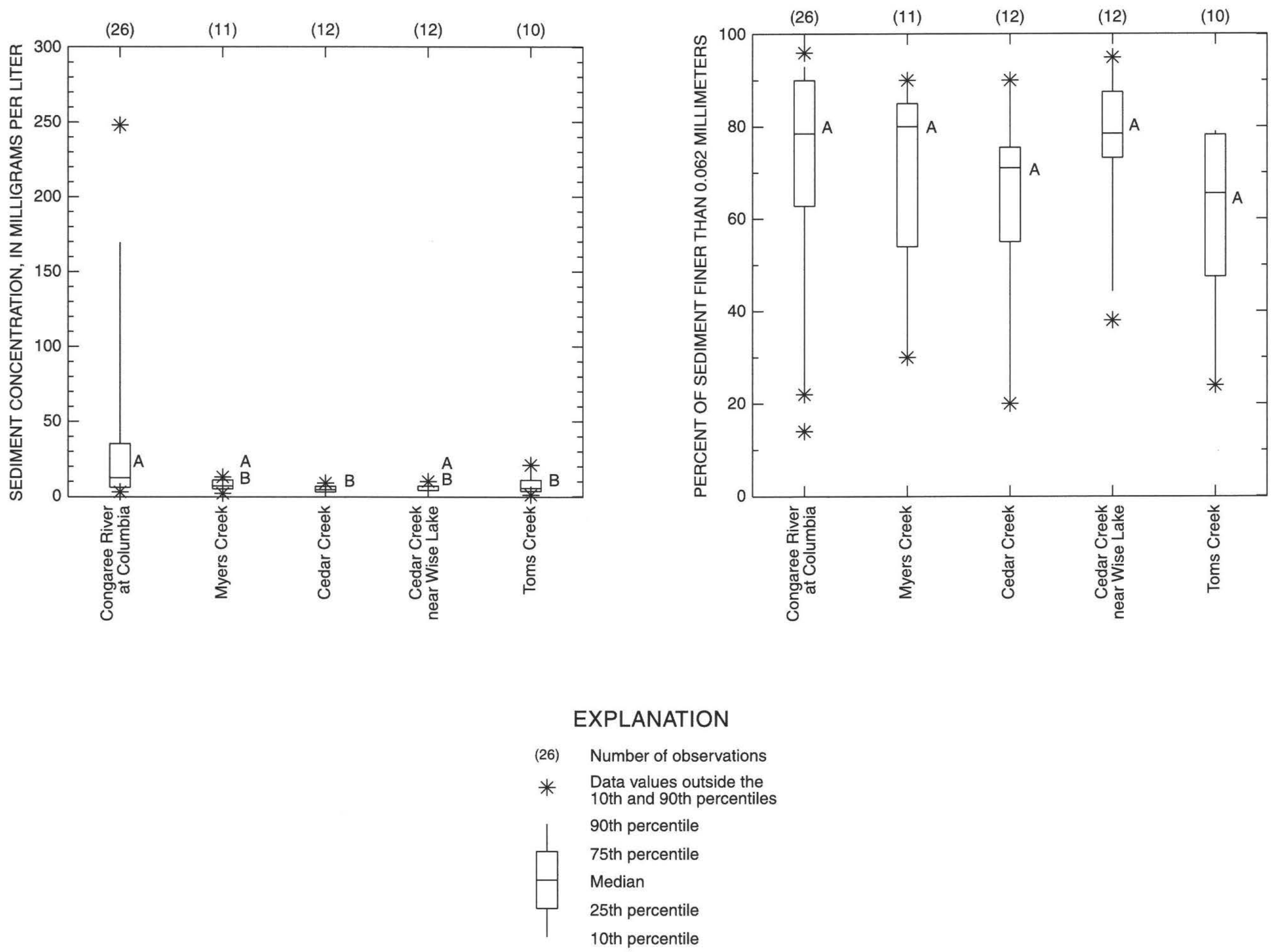

Figure 11. Statistical distribution of suspended sediment in streams of Congaree Swamp. (Letters denote significantly different mean concentration ranks, with A being the highest, B being the next lower, and so on. Sites with letters in common are not significantly different from each other.)

Habitat

Habitat and stream characteristics are important influences on aquatic fauna distribution. An inventory of habitat characteristics was conducted in each stream (table 6; Appendix 7). Cedar and Toms Creeks have clean sandy bottoms interspersed with patches of woody snags, defined as "trees, branches, or other woody debris of terrestrial origin that extend into the water column" (Meador, Hupp, and others, 1993) that cause debris dams to build up. Cedar Creek is relatively straight and shallow, but has one deep pool at the single bend in the reach. The reach in Cedar Creek is downstream from Duffies Pond. The reach at Toms Creek has a deep pool at the outside edge of each of two meanders.

Myers Creek and Cedar Creek near Wise Lake have different characteristics than the other streams. Bed sediments in Myers Creek and Cedar Creek near Wise Lake are characterized by a deep layer (0.25 to 1.0 m) of organic detritus (plant debris), fine particulate organic matter (muck), and silt along nearly the entire length of each reach. However, the reach in Myers Creek has dual characteristics. Transect T-1 has a sandy substrate at point 1, and the entire width of transect T-6 has a sandy substrate dominated by aquatic macrophytes. The reach at Myers Creek has a few deep pools but no meanders. The reach at Cedar Creek near Wise Lake is deeper (1.64-m average depth) than the other three streams (table 6; Appendix 7).

All four streams have extensive bank undercutting supported by thick masses of riparian tree

Table 6. Habitat characteristics of streams in Congaree Swamp

[m, meter; nm, not measured; SA, sand; OD, organic debris; SI, silt; MU, muck (fine particulate organic material); NO, none; <, less than; ft^3/s, cubic foot per second]

Characteristic	Congaree River at Columbia	Myers Creek	Cedar Creek	Cedar Creek near Wise Lake	Toms Creek
Reach length (m)	2,896	159	168	271	155
Mean width (m)	130–190	9.3	7.1	38	6.7
Mean depth (m) at thalweg[a]	nm	.92	1.46	1.64	.78
Dominant substrate	SA	OD	SA	OD	SA
Subordinate substrate	SI	MU	NO	MU	NO
Embeddedness[b]	2	0	0	0	0
Canopy angle[c] (degrees)	180	0	10	28	8
Percent woody snags	<1	21	27	22	30
Mean bank height[d] (m)	nm	.97	1.55	2.39	1.07
Bank vegetation stability[e]	nm	2	4	3	4
Mean discharge (ft^3/s)	6,120	14.35	37.5	52	23

[a]The thalweg is the deepest part of the channel.

[b]Embeddedness is a numerical rating that describes the extent to which coarse material, such as boulders, cobbles, and bedrock, is covered by fine material (sand, silt, muck). An embeddedness rating of zero (0) indicates that no coarse material is visible; 1 indicates that more than 75 percent of the surface area of gravel, cobble, and boulder particles are covered by fine sediment; 2 indicates that 51–75 percent of the surface area of gravel, cobble, and boulder particles are covered by fine sediment.

[c]The canopy angle is a measure of the openness of the vegetation overhanging the stream. The lower the canopy angle, the more vegetative shading over the stream at that point.

[d]Bank height is the vertical distance between the thalweg and the level of the bankfull discharge point at the transect being measured.

[e]Bank vegetation stability is an assessment of the ability of bank vegetation to resist erosion. It is evaluated using a rating based on four classes that represent percent coverage of the bank surface. The rating includes only that part of the bank that is within 2 m of either side of the transect, to the top of the bank. A rating of 4 indicates that more than 80 percent of the bank surface is covered by vigorous vegetation. A rating of 3 indicates that 50–79 percent of the bank surface is covered, and a rating of 2 indicates 25–49 percent coverage (Meador, Hupp, and others, 1993).

roots. Some of the undercuts extend more than 2 m into the streambank and provide sheltered habitat for fishes and other organisms.

The ecological site reach in the Congaree River at Columbia is representative of a large river reach. It is influenced by the combined flows of two rivers that have been impounded. Periodic and frequent flushing of the reach occurs as water is released from the impoundments causing scouring of habitat. Scouring occurs when sediments are forced against habitat structures by the water current in a process similar to sand blasting. The sandy substrate is unstable, and periods of low flow between flushing result in deposition of sediments carried by the streams.

The immediate banks (riparian zone) of streams in the study area can be characterized by the types of vegetation growing in these areas. Trees are the dominant vegetation along the riparian zones of the streams of Congaree Swamp. The red maple (*Acer rubrum*) is the dominant tree at Cedar, Toms, and Myers Creeks (table 7). At Cedar Creek near Wise Lake, the dominant tree is the tupelo (*Nyssa aquatica*), which represents 71 percent of the trees along the reach. Other trees present in large percentages in the study reaches include laurel oak (*Quercus laurifolia*), sweetgum (*Liquidambar styraciflua*), and American holly (*Ilex opaca*). Quarterpoint tree determinations were not required for the large rivers of the NAWQA study. Congaree River bank and island trees are predominantly willows (*Salix* sp.).

Aquatic Community

The aquatic community was assessed by studying the results of macroinvertebrate and fish collection. Standard NAWQA protocols were employed in all collections.

Table 7. Riparian zone dominant tree species and population percentages

[—, not a dominant tree, determined as presence greater than or equal to 15 percent of trees censused]

Scientific name	Common name	Myers Creek	Cedar Creek	Cedar Creek near Wise Lake	Toms Creek
Acer rubrum	Red maple	35	27	—	35
Ilex opaca	American holly	—	23	—	—
Liquidambar styraciflua	Sweetgum	33	21	—	21
Nyssa aquatica	Tupelo	—	—	71	—
Quercus laurifolia	Laurel oak	—	—	17	27

Macroinvertebrates

The diversity (number of taxa) of the macroinvertebrate community is similar among all four sites (fig. 12, Appendix 8). However, the density of organisms (numbers per unit area) reflects the different habitats available (fig. 13). The similarities of Myers Creek and Cedar Creek near Wise Lake are reflected by the very similar taxa numbers and densities of macroinvertebrates. Likewise, the habitat similarities of Cedar Creek and Toms Creek are reflected by their similar macroinvertebrate densities.

Several measurements (metrics) of stream health or water quality, based on macroinvertebrate community statistics, are available. The metrics and their applications must be adjusted for each type of stream and usually are reported with reference to the geographical location of the stream. For the streams in Congaree Swamp, best professional judgment was used to determine which metrics were applicable. The metrics chosen are a subset of the rapid bioassessment protocols developed by the U.S. EPA (Plafkin and others, 1989). Use of the metrics requires comparison of the macroinvertebrate data with data collected from

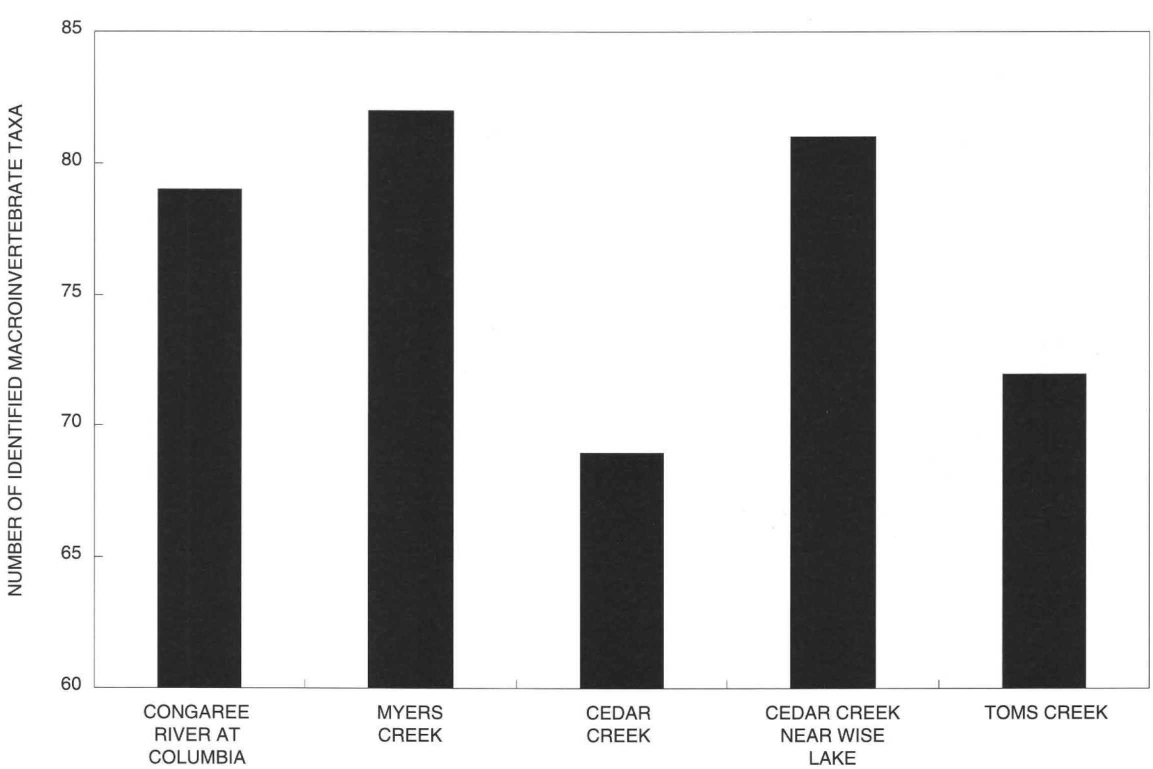

Figure 12. Number of distinct macroinvertebrate taxa identified in streams of Congaree Swamp.

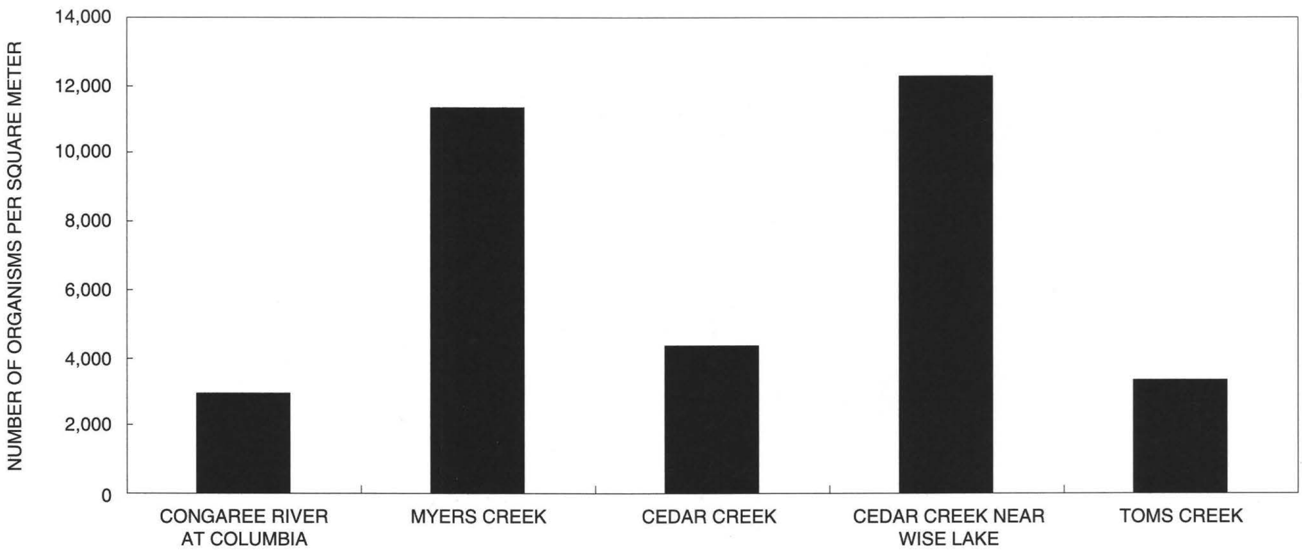

Figure 13. Macroinvertebrate density in streams of Congaree Swamp.

a reference stream. For purposes of this comparison, the Coosawhatchie River, also a blackwater system, was selected as the reference stream because of its similarity to the blackwater streams in Congaree Swamp.

The Coosawhatchie River is a fourth order, highly anastomosing stream in the Lower Coastal Plain of South Carolina. It is an unregulated stream with a drainage basin of 1,036 km^2. The study site on the Coosawhatchie River is approximately 122 km south of Congaree Swamp. Land cover in the Coosawhatchie River Basin is approximately 42 percent agricultural, 30 percent forested, and 24 percent wetlands.

For comparison with a reference stream, the macroinvertebrate data for each metric are assigned a biotic condition score (table 8). Scoring criteria are based on percent comparability to the reference stream, and the scores fall into four broad categories: non-impaired, slightly impaired, moderately impaired, and severely impaired. Results indicate the relative health of the macroinvertebrate community of each stream compared to the reference stream.

Species richness reflects the health of the community based on the total number of species or genera. Species richness generally increases with increasing water quality, habitat suitability, and habitat diversity.

The percentage contribution of the numerically dominant taxon indicates the community balance. The EPT (Ephemeroptera, Plecoptera, Trichoptera) index is the total number of distinct taxa within these three orders of insects. Insects of these orders generally are sensitive to pollution, and the index increases with increasing water quality.

The fourth metric, EPT/Chironomid abundance ratio, uses relative abundance of four indicator groups—Ephemeroptera (mayflies), Plecoptera (stoneflies), Trichoptera (caddisflies), and Chironomids (midges). Fairly even distribution among the four groups, with substantial representation of the three most sensitive groups (mayflies, stoneflies, and caddisflies), is indicative of good biotic conditions. Chironomids tend to become increasingly dominant with increasing enrichment and(or) heavy metals concentrations (Ferrington, 1987).

The biotic condition scores indicate that the water quality of Cedar Creek near Wise Lake is impaired in comparison with the Coosawhatchie River. The biotic condition score is emphasized by the contribution of the numerically dominant taxon. In Cedar Creek near Wise Lake, the numerically dominant taxon is the family Chironomidae, which consists of 64 percent of the macroinvertebrate fauna (numerically), but only 25 percent of the total species. Communities in which the fauna are dominated by relatively few taxa are indicative of some type of environmental stress (Plafkin and others, 1989).

Table 8. Macroinvertebrate biotic condition score computation

[na, not applicable]

Metrics	Congaree River at Columbia[a]	Myers Creek	Cedar Creek	Cedar Creek near Wise Lake	Toms Creek	Coosawhatchie River reference site
Taxa richness (number of macroinvertebrate species)	89	82	68	81	72	77
Contribution (percent of total organisms) of the numerically dominant taxon	40	40	50	64	39	49
EPT index (species)	21	20	13	17	19	14
EPT/Chironomid abundance ratio	.38	1.37	.18	.04	.81	.35
Biotic condition scores						
Taxa richness (number of macroinvertebrate species)[b]	na	6	6	6	6	6
Contribution (percent of total organisms) of the numerically dominant taxon[c]	na	0	0	0	0	0
EPT index (species)[d]	na	6	6	6	6	6
EPT/Chironomid abundance ratio[e]	na	6	3	0	6	6
Biotic condition score	na	18	15	12	18	18
Percent of reference stream	na	100	83	67	100	100
Biotic condition category[f] compared with reference stream	na	non-impaired	non-impaired	slightly impaired	non-impaired	reference

[a]The Congaree River data are included here because it is one of the streams in the study area and affects the hydrology of Congaree Swamp. These data should not be compared to data from the other streams because the Congaree River is not a blackwater stream.

[b]The biotic condition score for taxa richness is based on the ratio of the study site to the reference site times 100. If the result is greater than 80 percent, the assigned score is 6; if the ratio is 40–80 percent, the assigned score is 3; if the ratio is less than 40 percent, the assigned score is 0.

[c]The biotic condition score for the contribution of the numerically dominant taxon is based on the ratio of the study site to the reference site times 100. If the result is less than 30 percent, the assigned score is 6; if 30–50 percent, the assigned score is 3; if greater than 50 percent, the assigned score is 0.

[d]The biotic condition score for the EPT index is based on the ratio of the study site to the reference site times 100. If the result is greater than 90 percent, the assigned score is 6; if 70–90 percent, the assigned score is 3; if less than 70 percent, the assigned score is 0.

[e]The biotic condition score for the EPT/Chironomid ratio is based on the ratio of the study site to the reference site times 100. If the result is greater than 75 percent, the assigned score is 6; if 25–75 percent, the assigned score is 3; if less than 25 percent, the assigned score is 0.

[f]The biotic condition scores for each site are summed. The biotic condition category is determined by direct percentage comparison of the biotic condition score with those of the reference stream. The following apply: If the biotic condition score for a stream is greater than 79 percent of that of the reference stream, a biotic condition category of "non-impaired" is assigned; if 54–79 percent, the condition category is "slightly impaired;" 21–50 percent is assigned "moderately impaired;" and less than 17 percent is assigned "severely impaired" (Plafkin and others, 1989). Gaps between categories allow subjective assignment of biotic condition.

Results of the macroinvertebrate density calculations clearly indicate similarities in habitat structure between Myers Creek and Cedar Creek near Wise Lake, and between Cedar Creek and Toms Creek. The high densities in Cedar Creek near Wise Lake and Myers Creek are indicative of the availability of habitat (many woody snags and leaf packs) combined with an organically rich benthic material. The relatively lower densities in Cedar Creek and Toms Creek indicate much less available habitat and reflect the sandy, shifting bottom-material characteristics.

Fishes

Forty-four species of fishes were collected from five sites in the study area. Cedar Creek is the most diverse stream, with 24 of the 44 species (table 9). The three other small streams are similar to each other in numbers of species: Myers Creek has 15, Toms Creek has 14, and Cedar Creek near Wise Lake has 16 species (Appendix 9). In comparison, the Congaree River at Columbia has 20 species, 14 of which were not collected in any of the other four sites (table 9). Of those 14 species collected only from the Congaree

Table 9. Fish species identified in streams of Congaree Swamp

[An "X" indicates the species was collected in the stream; species names in bold print were not previously listed as found in streams in the study area]

Scientific name	Common name	Congaree River at Columbia	Myers Creek	Cedar Creek	Cedar Creek near Wise Lake	Toms Creek
Ameiurus natalis	yellow bullhead		X	X		X
Ameiurus nebulosus	**brown bullhead**			X		
Amia calva	bowfin	X			X	
Aphredoderus sayanus	pirate perch		X		X	
Carpiodes carpio	river carpsucker	X				
Carpiodes cyprinus	quillback	X				
Ctenopharyngodon idella	grass carp	X				
Cyprinella nivea	whitefin shiner	X				
Cyprinus carpio	common carp	X				
Dorosoma cepedianum	gizzard shad	X				
Dorosoma petenense	threadfin shad	X				
Enneacanthus chaetodon	blackbanded sunfish		X	X		
Enneacanthus gloriosus	bluespotted sunfish			X		
Erimyzon oblongus	creek chubsucker					X
Esox americanus	redfin pickerel		X			X
Esox niger	chain pickerel			X	X	X
Etheostoma olmstedi	tessellated darter		X	X	X	
Gambusia holbrooki	eastern mosquito fish		X	X		X
Ictalurus furcatus	blue catfish	X				
Ictalurus punctatus	channel catfish	X				
Labidesthes sicculus	brook silverside		X	X	X	
Lepisosteus osseus	longnose gar	X				
Lepomis auritus	redbreast sunfish	X	X	X	X	X
Lepomis gulosus	warmouth		X	X	X	X
Lepomis macrochirus	bluegill	X	X	X	X	X
Lepomis marginatus	dollar sunfish		X	X	X	X
Lepomis microlophus	redear sunfish				X	
Lepomis punctatus	spotted sunfish		X	X		X
Lepomis sp.	sunfish hybrid			X		
Micropterus salmoides	largemouth bass	X		X	X	
Minytrema melanops	spotted sucker	X	X	X	X	X
Morone americana	white perch	X				
Morone saxatilis	striped bass	X				
Moxostoma anisurum	silver redhorse	X				
Notropis cummingsae	dusky shiner			X		X
Notropis petersoni	coastal shiner		X	X	X	
Noturus gyrinus	tadpole madtom			X		
Noturus insignis	margined madtom			X	X	
Noturus leptacanthus	**speckled madtom**			X		
Perca flavescens	yellow perch	X	X	X	X	X
Percina crassa	**piedmont darter**			X		
Pomoxis annularis	white crappie	X				
Pomoxis nigromaculatis	black crappie				X	
Pteronotropis hypselopterus	**sailfin shiner**			X		X
Total species		20	15	24	16	14

River, some are fish that are generally adapted to open, deep water and would not fare well in the shallow water of the smaller streams. One might expect the common carp and the longnose gar to occasionally travel to the smaller streams, but none were collected in this survey.

The collection made during this study includes four species not previously listed as inhabitants of Congaree Swamp National Monument streams (National Park Service, 1996; Bulak and others, 1997). These species are the brown bullhead (*Ameiurus nebulosus*), the speckled madtom (*Noturus leptacanthus*), the piedmont darter (*Percina crassa*), and the sailfin shiner (*Pteronotropis hypselopterus*; table 9).

Cedar Creek has the highest density of fish fauna of the four streams (fig. 14). The catch per unit effort (CUE) in Cedar Creek was 20 fishes per 5 minutes of electric-power application to the water. Toms Creek yielded the next highest CUE with 17 fishes per 5 minutes, and Myers Creek and Cedar Creek near Wise Lake yielded 8 and 3, respectively, per 5 minutes of electric-power application.

The relatively low yield from Cedar Creek near Wise Lake most likely was the result of low specific conductance and deeper water. When specific conductance is low, the efficiency of power fishing also is low. In combination with deeper water (allowing less light penetration and poor visibility), the CUE is expected to be low. Boat shocking, barge shocking, and backpack shocking efforts yielded equally poor results. Attempts to collect fishes with a seine were unsuccessful because of the large number of woody snags in the stream. Other collection methods, such as the application of rotenone, were not within the scope of the collection permit. It is likely that more species are in Cedar Creek near Wise Lake than were collected in this study.

The Congaree River presented a collection challenge. An 18-foot electrofishing boat and a chase boat were used for collecting fish. Water depth and current were impediments to fish collection. Efforts were made to collect fish as thoroughly as possible, consistent with crew safety. However, the assessment of water quality based on fish in the Congaree River at

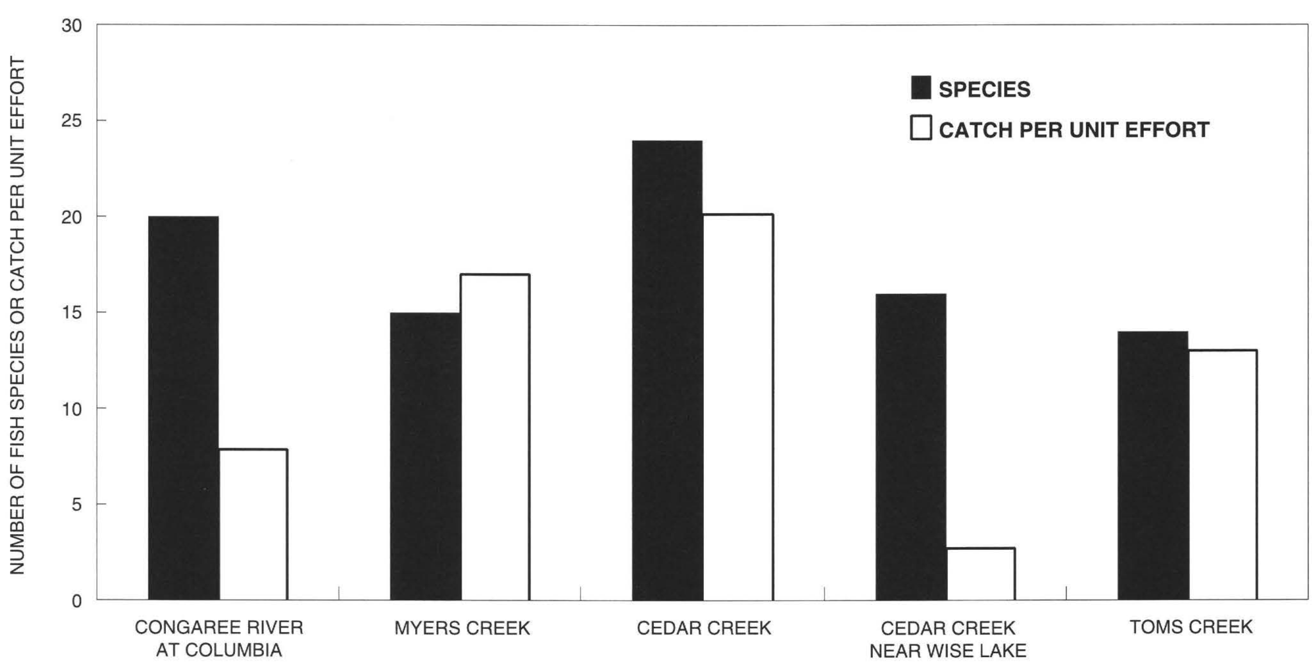

Figure 14. Fish species diversity and catch per unit effort in streams of Congaree Swamp.

Columbia should be considered tentative at this time. A seine was employed as a backup collection device, but yielded no fish. Fish fauna in Myers Creek, Cedar Creek, and Toms Creek are believed to have been adequately represented.

An index of biotic integrity (IBI) was calculated for each of the streams. The IBI is a fish community assessment procedure developed by Karr (1981) and modified to reflect regional differences in fish communities. The formulas used in this study were patterned after work conducted in South Carolina (South Carolina Department of Health and Environmental Control, 1993). The IBI calculations are based on the perspectives of zoogeography, ecosystem, population, community, taxonomy, and trophic level. Each stream is assigned a score based on the metrics (quantitative and qualitative measures) determined from the results of the fish collections. A general description of water quality, ranging from "very poor" to "excellent," is assigned within a range of metric scores. The fish IBI scores for Congaree Swamp streams are listed in table 10. Computations of the IBI scores are in Appendix 10.

Table 10. Fish indices of biotic integrity (IBI) in streams of Congaree Swamp

[Range of descriptors for IBI score: 12–28, very poor; 29–40, poor; 41–48, fair; 49–58, good; greater than 58, excellent]

Stream	Fish IBI score	Water-quality description
Congaree River at Columbia	34	Poor
Myers Creek	38	Poor
Cedar Creek	44	Fair
Cedar Creek near Wise Lake	34	Poor
Toms Creek	40	Poor

The results of the fish IBI are comparable with the results of the macroinvertebrate biotic condition scores. Both scoring methods evaluate the water quality in Cedar Creek near Wise Lake as being somewhat impaired. The macroinvertebrate scores single out Cedar Creek near Wise Lake as the only impaired stream compared to the Coosawhatchie River, the reference site. The fish scores evaluate Cedar Creek near Wise Lake as "poor," but also include the Congaree River, Myers Creek, and Toms Creek in the "poor" category. Cedar Creek is indicated as "fair," based on the fish IBI, and as "non-impaired," based on the macroinvertebrate biotic condition score. The differences in sensitivity and results between the two methods reflect the need for fine-tuning based on the characteristics of the streams. Both measurements failed to identify Myers Creek as being impaired, which might have been the conclusion based solely on the chemical evidence, specifically the organic compounds.

Although pesticides were detected most often in Myers Creek (28 detections), it should not be deduced solely from the chemical evidence that harmful biological effects would be detected at that site. A basic principle of environmental toxicology states that the bioavailability of toxic substances, not merely their concentration, is the cause of toxicity. As long as pesticide concentrations in Myers Creek do not reach toxic threshold levels, they should not cause toxic effects to aquatic organisms. Only through toxicological and other biological investigations can toxic effects be asserted. Because of the complementary/supplementary roles of chemical and biological analyses, it is a tremendous advantage to employ both for complex aquatic environmental assessment.

Ecology and Water Quality

The water-quality constituents that have the greatest relation to the macroinvertebrate community in streams of the study area, as determined by a Pearson correlation analysis, are dissolved oxygen concentration, water temperature, and chloride concentrations. The correlations are significant at $\alpha = 0.05$. Macroinvertebrate community diversity is positively correlated with the concentration of chloride dissolved in the water column ($r^2 = 0.78$). The EPT index is negatively correlated with temperature ($r^2 = 0.83$), and the density of Chironomids is negatively correlated with dissolved oxygen ($r^2 = 0.93$). Water column pesticide concentrations in Myers Creek, Cedar Creek, Cedar Creek near Wise Lake, and Toms Creek have no discernible detrimental effects on the aquatic communities in these streams.

Tissue

Tissue samples were collected using NAWQA protocols. Samples were collected in an effort to characterize the distribution and magnitude of organochlorine pesticides and certain trace elements in aquatic biota.

Pesticides in Fish

Redbreast sunfish (*Lepomis auritus*) was the organism chosen for tissue pesticide analysis in Myers Creek, Cedar Creek, and Toms Creek. Fishes were collected by power-fishing techniques. After several attempts, no redbreast sunfish were caught at Cedar Creek near Wise Lake.

The only organochlorine pesticide detected in the tissues of sunfish collected for this study was *p,p'*-DDE, a metabolic derivative of DDT. This compound is less toxic than DDT but is highly recalcitrant, lingering in the environment for many years. The highest concentration (16 micrograms per kilogram [μg/kg]) was in fishes from Cedar Creek. Tissues from sunfishes in Toms Creek had a concentration of 10 μg/kg, and Myers Creek sunfish tissues had a concentration of 5.1 μg/kg (fig. 15). The effect, if any, of the presence of these pesticides on the fish is not known.

Fish tissue at the Congaree River at Columbia site consisted of whole-body carp. Several pesticides were detected in carp that were not detected in the redbreast sunfish in the other streams. In addition to *p,p'*-DDD and *p,p'*-DDE, Congaree River carp tissue contained concentrations of chlordane and nonachlor compounds and dieldrin. Chlordane is a persistent, manmade pesticide that is highly toxic to fish and invertebrates. Chlordane has not been used legally in the United States since 1988. Nonachlor is a metabolite of chlordane. Dieldrin was widely used in the 1960's and early 1970's as a soil and seed treatment. It has not been used legally in the United States since 1974. Concentrations of organochlorine pesticides detected in all fish tissue samples are listed in Appendix 11. A direct comparison between carp and redbreast sunfish cannot be made because of differences in species, behavior, and habitat.

Pesticides in Clams

Native clams were collected from only one of the six sites; a sandbar downstream from the confluence of Cedar and Myers Creeks yielded several specimens of

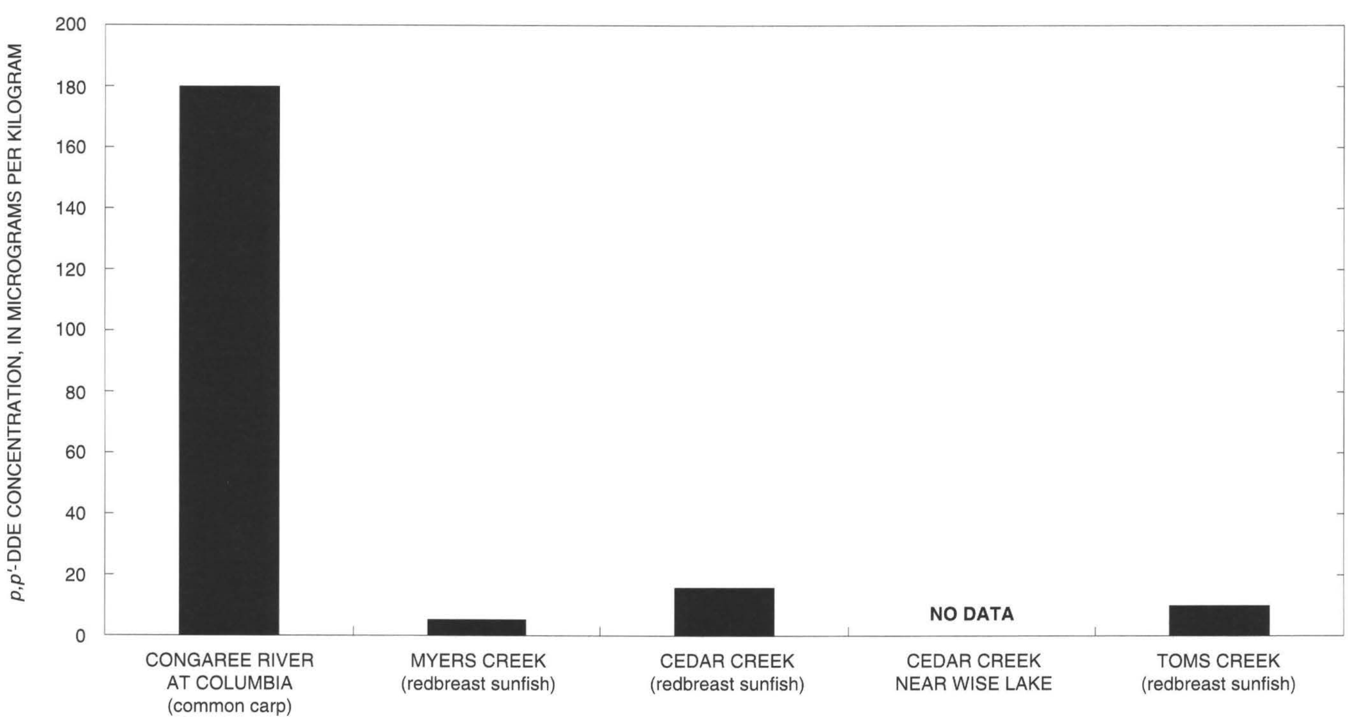

Figure 15. ***p,p'*–DDE detected in fish tissue collected in streams of Congaree Swamp.**

Elliptio sp. No pesticides were detected in the tissues of these native clams. Pesticides in Asiatic clams collected from the Congaree River sites were *p,p'*-DDE and *cis*-Chlordane. Appendix 11 provides a complete list of the 26 pesticides for which clam (and fish) tissues were analyzed.

Trace and Major Elements in Fish

Fishes were not a viable source for the analysis of elements in tissue from any of the streams except the Congaree River. The NAWQA protocols stipulate the use of fish livers for element analysis. No fishes were collected that were large enough to enable extracting an adequate amount of liver tissue for analysis. Attempts to capture the common carp (*Cyprinus carpio*) were unsuccessful, although it has been included in the species listing for Congaree Swamp (National Park Service, 1996). Congaree River carp liver tissue was analyzed for trace and major elements. Of the nine trace-element priority pollutants, zinc was detected in the highest concentration. The data indicate that carp have accumulated zinc to a concentration almost six times that of the sediments, and copper to a concentration more than twice that in sediments. The full data set is provided in Appendix 12.

Trace and Major Elements in Clams

Native bivalve clams (*Elliptio* sp.) were collected in Cedar Creek immediately downstream from the confluence with Myers Creek. Clam tissue was analyzed for 21 elements. Among the nine trace-element priority pollutants, zinc (62 µg/g), lead (22 µg/g), and cadmium (5 µg/g) were present in the highest concentrations. No criteria currently exist for the protection of aquatic life that are based on trace-element concentrations in clam tissue.

Bed Sediments

Bed-sediment samples were collected from the top few centimeters of sediment at several sites in each stream in the study area in order to determine the magnitude and extent of the distribution of organic compounds, and trace and major elements in the study area. Sediment-bound pesticides appeared to have no significant effect on the macroinvertebrate and fish communities in these streams.

Organochlorine Pesticides

Mirex was the only non-DDT pesticide detected in samples collected from the four streams in the study area, and was detected only in Myers Creek (1.2 µg/kg). Mirex had been used to control fire ants in the Southeastern United States and as a fire-retardant in polymers. Mirex has low chemical reactivity, is resistant to biodegradation, and is strongly sorbed onto bacteria, algae, and sediments.

The pesticide DDT and its metabolites were the only other organochlorine pesticides detected in the sediments of the four streams (fig. 16; table 11; Appendix 13). DDT is an extremely effective, long-lasting pesticide that was officially banned from use in the United States in January 1973 (Laws, 1993). Myers Creek contained the highest concentrations of DDT and its metabolites (in sum, 14.7 µg/kg), with *p,p'*-DDE accounting for 66 percent of that amount. In contrast, the bed-sediment sample from the right bank of the Congaree River at Columbia contained traces of chlordane, dieldrin, and nonachlor. Chlordane and dieldrin belong to the same class of organic compounds and have been widely used to control termites and a variety of food crop pests.

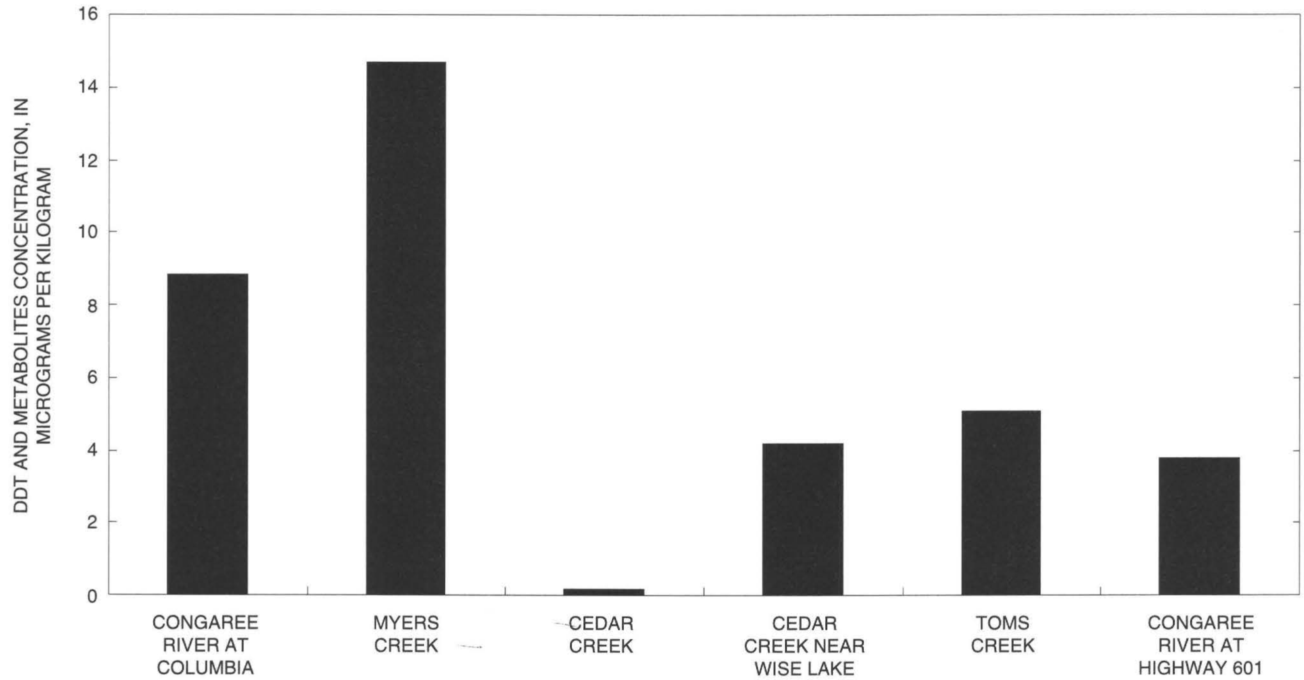

Figure 16. DDT and metabolites detected in bed sediments of streams of Congaree Swamp. (Concentration shown for Congaree River at Columbia is median value from left bank and right bank collection sites.)

Table 11. Bed-sediment organochlorine pesticides

[Units in micrograms per kilogram; nd, not detected]

Pesticide	Congaree River at Columbia (left bank)	Congaree River at Columbia (right bank)	Myers Creek	Cedar Creek	Cedar Creek near Wise Lake	Toms Creek	Congaree River at Highway 601
DDT and metabolites	9.3	8.4	14.7	0.17	4.2	5.1	3.8
trans-Chlordane	nd	.62	nd	nd	nd	nd	nd
cis-Chlordane	nd	.64	nd	nd	nd	nd	nd
Dieldrin	nd	.51	nd	nd	nd	nd	nd
Mirex	nd	nd	1.2	nd	nd	nd	nd
trans-Nonachlor	nd	.47	nd	nd	nd	nd	nd

Non-Pesticide Organic Compounds

Forty-one non-pesticide organic compounds were detected in sediment samples from the six sites. The most common compounds detected were semivolatile organic compounds, phthalate compounds, fluoranthene, and pyrene compounds (Appendix 14). The sum of all non-pesticide organic compounds was highest in Myers Creek with four to five times as much as was detected in Cedar Creek, Cedar Creek near Wise Lake, or Toms Creek. A summation of the non-pesticide organic compounds detected in the sediments of each of the six streams is shown in figure 17.

The major components of non-pesticide organic compounds in Myers Creek were benzo[*a*]pyrene (570 µg/kg), fluoranthene (340 µg/kg), *p*-cresol (260 µg/kg), bis(2-ethylhexyl) phthalate (260 µg/kg), and pyrene (200 µg/kg; table 12). Benzo[*a*]pyrene, a polycyclic aromatic hydrocarbon (PAH), is a ubiquitous contaminant that is generated by the incomplete combustion of many substances, such as gasoline in internal combustion engines. Its effect, if any, on the aquatic life in Myers and Cedar Creeks is unknown. The other PAH's detected were fluoranthene and pyrene (fig. 18).

Para-cresol (*p*-cresol) is representative of the general class of phenolic compounds. It enters the environment as a by-product of the petroleum and coking industry and as a result of the use of creosote as a wood preservative, such as creosote-soaked pilings used for bridge structures. It is a relatively nonhazardous, easily biodegradable material and poses little threat to aquatic life at the concentrations detected in Myers Creek.

Bis(2-ethylhexyl) phthalate is used as a plasticizer in polyvinyl chloride resins (PVC) used in the manufacture of a wide range of vinyl products, such as enclosures for food containers, children's toys, teething rings, and pacifiers. Bis(2-ethylhexyl) phthalate is used as an ink solvent, an inert ingredient in pesticides, and in cosmetic products (National Safety Council, 1999). Phthalates are ubiquitous in the environment. The concentrations detected in Myers Creek sediments are well within the estimated range of daily per capita human consumption (U.S. Environmental Protection Agency, 1998).

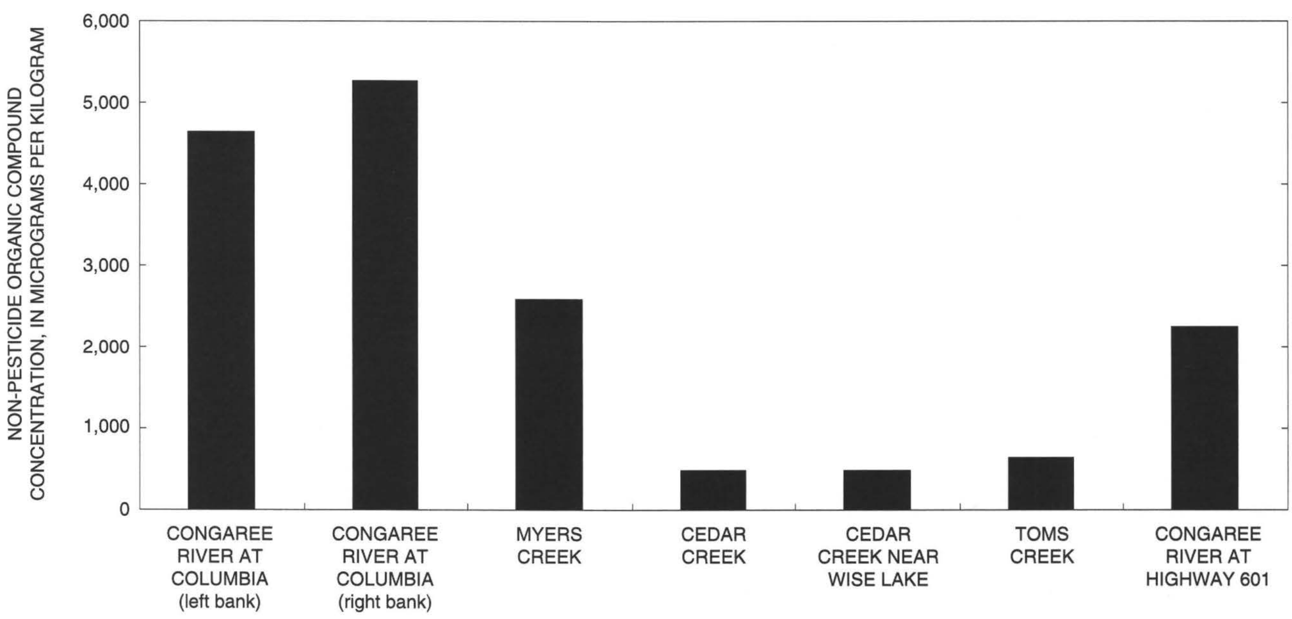

Figure 17. Summation of non-pesticide organic compounds detected in bed sediments of streams of Congaree Swamp.

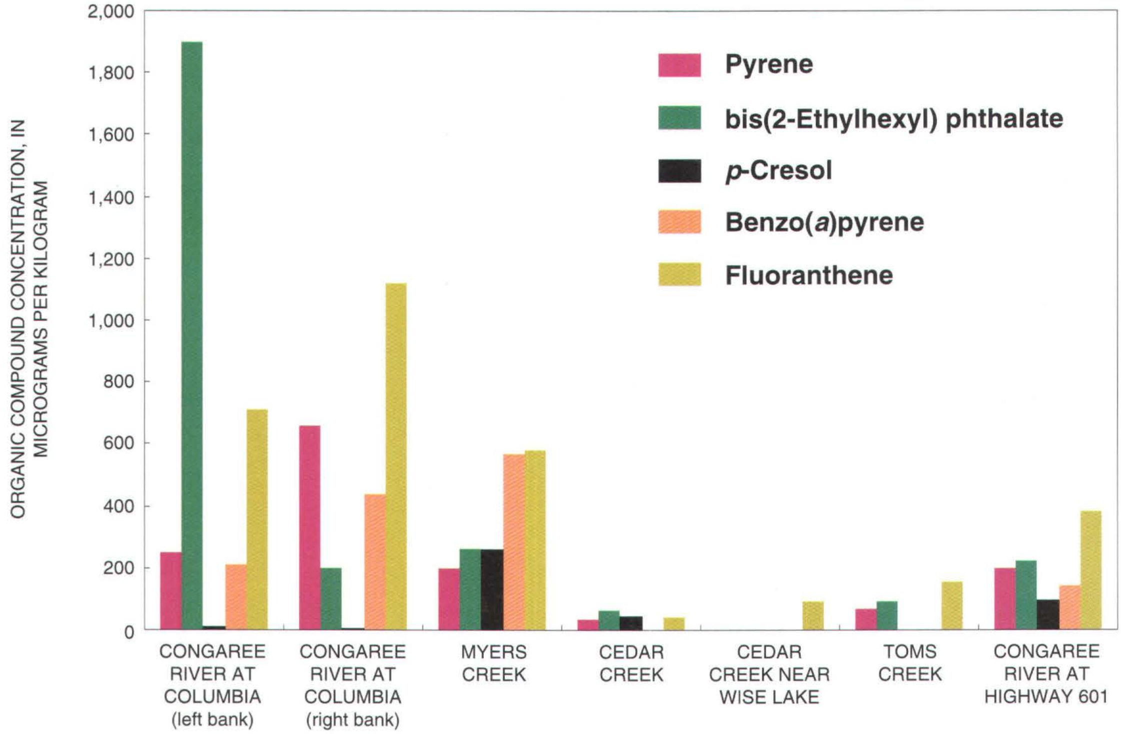

Figure 18. Selected non-pesticide organic compounds in bed sediments of streams of Congaree Swamp.

The relatively high concentrations of the five compounds (listed above) in Myers Creek sediments may be indicative of the greater urbanization of the Myers Creek Basin compared to Cedar Creek or Toms Creek. These five compounds were among the most frequently detected in other studies around the country. Table 12 shows the comparison of concentrations of the five compounds in Myers Creek bed sediments with mean, median, and maximum values from sediments collected by NAWQA studies throughout the country (Lopes and others, 1998).

Analyses of the data and correlation with ecological information indicate that none of the non-pesticide organic compounds detected in sediments has a discernible detrimental effect on the aquatic communities of the streams. Two compounds are positively correlated with the diversity of the macroinvertebrate community (1-methylphenanthrene

Table 12. Semivolatile organic compounds in Myers Creek bed sediments compared to the national data base

[Concentrations in microgram per kilogram; PAH, polycyclic aromatic hydrocarbon]

Compound	Class of compound	National mean concentration[a]	National median concentration[a]	National maximum concentration[a]	Myers Creek concentration
Pyrene	PAH	501	77	1,095	200
bis(2-Ethylhexyl) phthalate	Phthalate	304	75	17,000	260
p-Cresol	Phenol	199	51	3,500	260
Benzo[*a*]pyrene	PAH	357	96	9,900	570
Fluoranthene	PAH	531	49	9,000	340

[a]Lopes and others, 1998.

and 4H-cyclopenta[*d,e,f*]phenanthrene), but the reason is not known.

Trace and Major Elements

Bed sediments were analyzed for 43 trace and major elements (Appendixes 15, 16). Trace elements are defined as those that usually occur in concentrations less than 1,000 micrograms per gram (µg/g; Forstner and Wittmann, 1979). The concentrations of major elements usually are depicted in terms of percent. Among the four smallest Congaree Swamp streams, the major elements present in the highest percentages of concentrations in sediments included aluminum (7 to 12 percent) and iron (2.5 to 4.0 percent). Trace elements present in the highest concentrations included manganese (580 to 1,900 µg/g), barium (320 to 560 µg/g), cerium (81 to 140 µg/g), and zinc (59 to 140 µg/g).

Trace Element Priority Pollutants

Nine of 43 trace and major elements for which sediment samples were analyzed in Congaree Swamp streams have been designated as priority pollutants by the U.S. EPA (1996; fig. 19). Sediment concentrations of trace element priority pollutants were not significantly different ($\alpha = 0.05$) from those in sediments from six other South Carolina Coastal Plain or geographically proximate streams of similar size (Abrahamsen, 1999). Adjusted bed-sediment concentrations in the streams are listed in table 13 along with Canadian Government-derived threshold effect levels (TEL's). These TEL's are based on the fraction of the bed-sediment sample that is less than

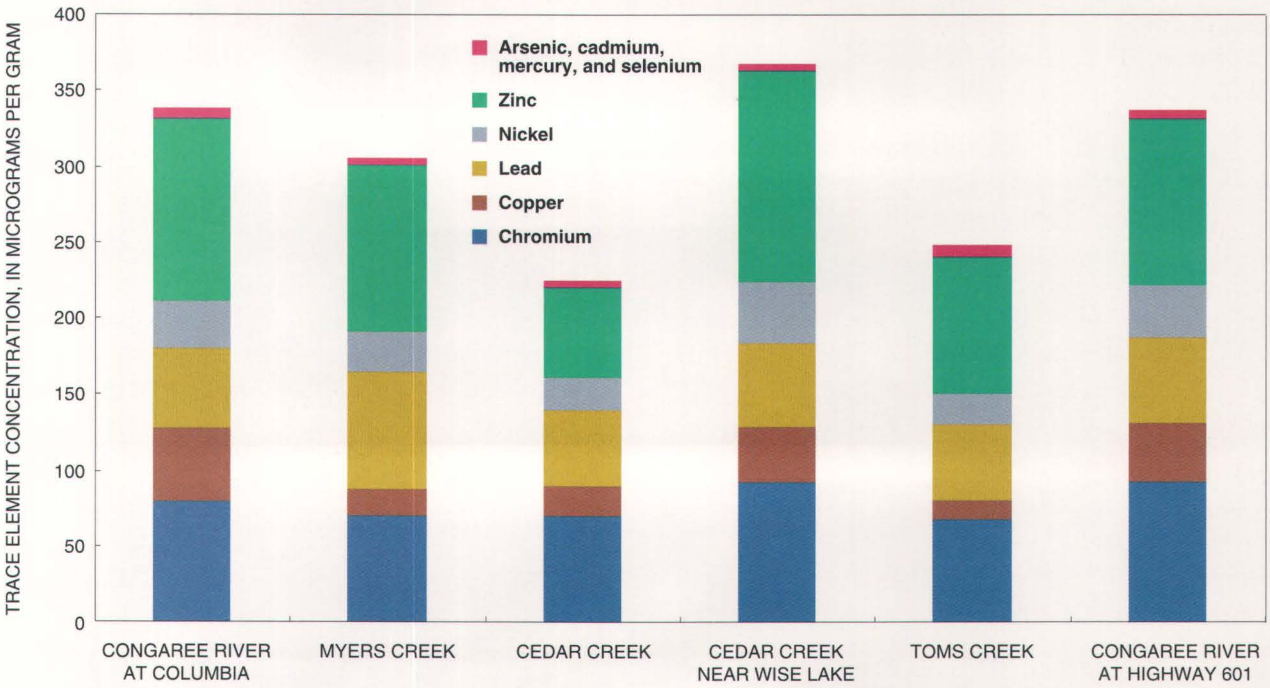

Figure 19. Trace element priority pollutants in bed sediments of streams of Congaree Swamp.

Table 13. Trace element priority pollutant concentrations in bed sediments of streams of Congaree Swamp and Canadian threshold effect levels for the protection of aquatic life

[Adjusted by percentage of suspended sediment less than 0.062 millimeters in diameter; concentrations in micrograms per gram; —, not established; data on suspended sediment in Congaree River at Highway 601 are not available]

Element	Canadian threshold effect level	Congaree River at Columbia (adjusted)	Myers Creek (adjusted)	Cedar Creek (adjusted)	Cedar Creek near Wise Lake (adjusted)	Toms Creek (adjusted)
Arsenic	5.9	1.1	2.5	2.5	2.8	4.3
Cadmium	.596	.08	.48	.21	.39	.26
Chromium	37	15	56	50	72	45
Copper	36	9	14	14	29	9
Lead	35	14	61	35	42	33
Mercury	.174	.02	.13	.08	.08	.08
Nickel	18	6	22	16	31	13
Selenium	—	.18	.72	.78	.55	.59
Zinc	123	26	88	42	110	58

63 μm in diameter. The table contains worst-case scenarios developed from data collected pertaining to the diameter of suspended sediment in the water column. The reported trace element priority pollutant concentrations are based on the percentage of suspended sediment reported as less than 0.062 mm in diameter. The resultant adjusted concentrations are artificial and can only indicate potential threat to aquatic biota. They are presented here only for comparative purposes. Among the four smallest Congaree Swamp streams (after adjustment), bed sediments in Toms Creek had the highest concentration of arsenic (4.3 μg/g; table 13). Bed sediments in Cedar Creek near Wise Lake contained the highest concentrations of chromium (72 μg/g), nickel (31 μg/g), and zinc (110 μg/g). Myers Creek bed sediments had the highest concentrations of cadmium (0.48 μg/g), lead (61 μg/g), and mercury (0.13 μg/g).

Among the nine trace element priority pollutants in the sediments and native clam tissues of Cedar Creek, only cadmium was found in a significantly higher concentration in clam tissues (5.1 μg/g) than in sediments (0.21 μg/g; fig. 20). These findings suggest that native clams are bioconcentrating cadmium. Higher concentrations of cadmium, selenium, and zinc were detected in Asiatic clams in the Congaree River at Columbia and the Congaree River at Highway 601 than were detected in bed sediments. Criteria are not available for the protection of aquatic life based on the concentration of elements in clam tissue.

The overall summation of the trace element priority pollutants in bed sediments indicated no correlation with the macroinvertebrate community or fish community measurements of the streams. None of the individual trace element priority pollutants correlated significantly with fish community diversity in any stream. However, zinc correlated slightly with macroinvertebrate community diversity ($r^2 = 0.77$), and mercury correlated with the EPT/Chironomid ratio ($r^2 = 0.85$).

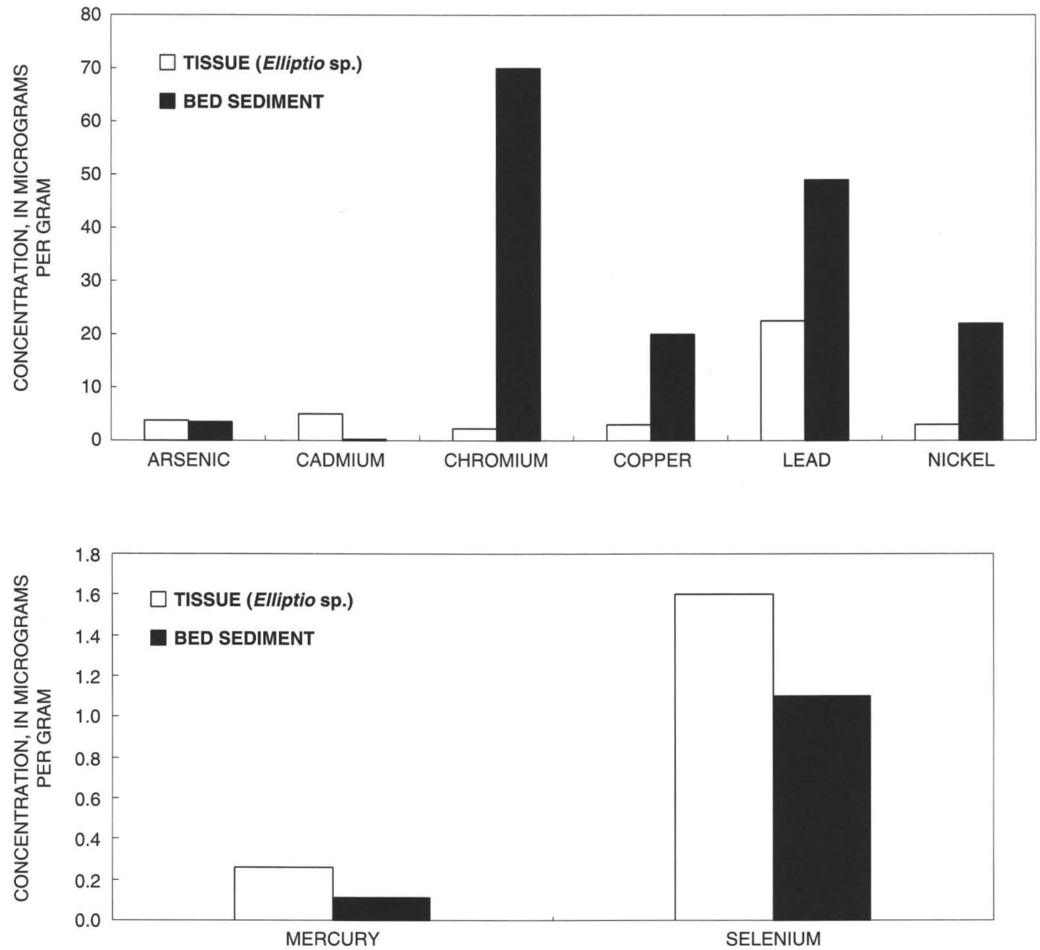

Figure 20. Trace element priority pollutants in clams and bed sediments of Cedar Creek.

SUMMARY

A study was conducted by the U.S. Geological Survey as part of the National Water-Quality Assessment Program in cooperation with the National Park Service to assess the water quality and ecology of selected streams of Congaree Swamp, South Carolina. Surface-water samples were collected quarterly from January 1996 through September 1998 at four sites—Myers Creek, Cedar Creek, Cedar Creek near Wise Lake, and Toms Creek. In addition, monthly surface-water samples were collected from October 1995 through September 1997 at a site on the Congaree River about 40 km upstream from Congaree Swamp National Monument. Surface-water samples were analyzed for major ions, nutrients, organic carbon, pesticides, and field-measured constituents (specific conductance, pH, temperature, and dissolved oxygen). Streamflow measurements were made at the time of sampling at the four sites without continuous streamflow gages.

Bed-sediment and tissue samples and aquatic community and habitat data were collected at five of six sites between 1995 and 1998. At a sixth site, Congaree River at Highway 601, only bed-sediment and tissue samples were collected. Samples of bed sediment and tissue were analyzed for organochlorine pesticides and trace and major elements. Sediments also were analyzed for non-pesticide organic compounds. Aquatic community structure and habitat were assessed by the collection of fish, macroinvertebrate fauna, and algae, and the determination of habitat properties, such as stream width, depth, and flow, riparian vegetation, bank stability and structure, and bed substrate composition.

Concentrations of some major ions (calcium, chloride, magnesium, potassium, silica, sodium, and

sulfate) were significantly higher, whereas other major ions (iron and manganese) were significantly lower in the Congaree River at Columbia than in Myers Creek, Cedar Creek, Cedar Creek near Wise Lake, or Toms Creek. Secondary drinking-water standards for iron (300 micrograms per liter [μg/L]) and manganese (50 μg/L) were exceeded in at least one sample at each site. Cedar Creek generally had the lowest and least variable major ion concentrations.

Nutrient concentrations were generally low. Ammonia nitrogen concentrations all were below 0.15 milligrams per liter (mg/L), and no significant differences in concentrations were detected among sites. The Congaree River at Columbia had significantly higher concentrations of nitrite-plus-nitrate nitrogen than did the other sites, but concentrations were all below 0.5 mg/L. Phosphorus concentrations generally were low, with more variable concentrations in the Congaree River at Columbia than in the other streams. Organic carbon concentrations generally were lower in the Congaree River at Columbia than in the other streams.

Twelve pesticides were detected in the streams of Congaree Swamp. Concentrations ranged from below the method detection limit to a high of 0.084 μg/L for tebuthiuron at Toms Creek. No pesticide exceeded the criteria for the protection of aquatic life or human health.

The Congaree River at Columbia had significantly higher concentrations of suspended sediment than the other streams, and concentrations ranged from 1 to 248 mg/L. Suspended-sediment concentrations in Myers Creek, Cedar Creek, Cedar Creek near Wise Lake, and Toms Creek were all below 30 mg/L. The median percentage of suspended sediment finer than 0.062 millimeters (mm) ranged from about 65 percent to less than 80 percent at all the streams. Specific conductance, alkalinity, and pH were significantly higher in the Congaree River at Columbia than in the other streams.

Indices of biotic integrity based on fish community diversity and fish density yielded water-quality determinations of "poor" to "fair" for the five sites in which fish were collected. The site with the greatest fish diversity and best water quality ("fair") was Cedar Creek, which supported 24 of the 44 species of fishes collected. Toms Creek had the lowest fish diversity and a water-quality designation of "poor," but the Congaree River at Columbia, Myers Creek, and Cedar Creek near Wise Lake also were determined to have poor water quality based on fish IBI's.

Determination of biotic condition based on macroinvertebrate community diversity and density indicated that, of the five sites, only Cedar Creek near Wise Lake had impaired water quality when compared with a reference stream (Coosawhatchie River). The density of the macroinvertebrate communities clearly reflected similarities in habitat structure between Myers Creek and Cedar Creek near Wise Lake, and between Cedar Creek and Toms Creek. The biological components of the study failed to single out Myers Creek as an impaired stream even though it may have appeared to be impaired, based solely on the interpretation of the potential effects of the concentrations of organic compounds detected in bed sediments.

Organochlorine pesticides and non-pesticide organic compounds in bed sediments had no discernible detrimental effect on the macroinvertebrate or fish communities in the streams. The sum of the concentrations of trace element priority pollutants in bed sediments did not have a discernible effect on macroinvertebrate diversity, the appearance of a dominant taxon, or the standard indicators of water quality—mayflies, caddisflies, and stoneflies (EPT index). However, the EPT/Chironomid ratio was positively correlated with the concentration of mercury in the sediments ($r^2 = 0.85$). A comparison of bed-sediment concentrations of the trace element priority pollutants with the Canadian Government threshold effect levels for the protection of aquatic life indicates that lead and nickel in bed sediments could be elements of concern in the Congaree River at Columbia, Myers Creek, and Cedar Creek near Wise Lake. Chromium concentrations in the bed sediments of all streams in the study exceeded the Canadian threshold effect levels. However, the presence of chromium in bed sediments had no discernible deleterious effect on the macroinvertebrate biota of the streams.

Native clams in Cedar Creek, and Asiatic clams in Congaree River at Columbia and in Congaree River at Highway 601 accumulated cadmium and zinc to concentrations greater than those detected in the sediments, but the clams did not accumulate chromium, copper, lead, or nickel.

Comparison of water-quality parameters with ecological data suggests that Chironomid densities are negatively correlated with dissolved oxygen concentrations in the water column. The EPT index was positively correlated with the concentration of chlorides in the water column and negatively correlated with water temperature. No correlation was apparent with concentrations of pesticides detected in the water column, and these pesticides had no apparent effect on the aquatic community.

From an ecological view, the character and health of the aquatic communities of the streams of Congaree Swamp appear to be driven and affected more by habitat, dissolved oxygen, and water temperature than by the chemical products and by-products of human land-use activities.

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APPENDIXES

Appendix 1. Major ion concentrations in streams of Congaree Swamp
[mg/L, milligrams per liter; µg/L, micrograms per liter; —, no data]

CONGAREE RIVER AT COLUMBIA

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Iron (µg/L)	Manganese (µg/L)
10/23/95	4.3	1.7	8.3	2.2	3.9	6.5	0.20	12	250	260
11/30/95	4.0	1.7	7.6	2.4	5.1	6.2	<.10	13	220	16
12/12/95	4.4	1.8	9.3	2.2	5.0	7.2	.20	14	200	9.0
1/10/96	3.9	1.8	7.8	1.9	4.0	6.6	.20	12	160	7.0
2/7/96	3.0	1.5	5.6	2.0	4.5	4.8	<.10	10	130	11
3/4/96	3.9	1.7	7.7	1.9	4.2	6.5	.10	12	180	9.0
3/8/96	3.5	1.5	5.1	1.8	3.8	4.5	<.10	9.7	74	10
4/23/96	4.4	1.7	8.4	2.0	5.2	6.9	<.10	12	300	11
5/15/96	4.1	1.7	8.6	1.8	5.8	6.8	<.10	12	170	8.0
6/5/96	3.9	1.7	7.9	2.1	4.8	6.6	<.10	12	120	9.0
7/3/96	3.4	1.6	8.0	2.0	5.7	7.1	.10	11	94	6.0
8/12/96	3.5	1.7	10	1.9	6.7	7.9	.10	10	120	8.0
9/4/96	3.5	1.7	7.2	2.2	5.8	6.2	<.10	10	70	64
10/21/96	4.2	1.8	10	2.4	6.6	8.7	.10	13	86	14
11/12/96	4.0	1.7	9.5	2.4	6.7	7.6	.10	12	110	5.0
12/5/96	3.7	1.5	5.6	2.3	4.7	5.0	<.10	11	77	15
1/31/97	4.3	1.7	8.1	2.0	6.3	6.8	.10	13	170	6.0
2/27/97	3.7	1.7	8.0	2.2	6.0	6.4	.11	11	39	8.0
3/2/97	3.5	1.4	4.5	1.8	5.5	3.7	<.10	9.6	320	9.0
3/10/97	4.1	1.7	7.9	2.1	6.4	6.3	<.10	12	130	9.0
4/7/97	4.0	1.7	8.2	2.0	5.9	6.5	.11	11	88	7.0
5/5/97	3.9	1.7	6.6	1.9	5.5	5.5	<.10	12	74	6.8
6/9/97	3.6	1.6	7.7	1.9	5.3	6.2	<.10	12	71	6.4
7/1/97	3.9	1.7	8.6	2.1	5.5	7.1	.11	10	62	9.6
8/6/97	3.7	1.7	7.8	2.2	5.2	6.4	.11	9.6	86	13
9/9/97	3.8	1.8	11	2.3	7.4	8.4	.11	8.4	82	19

MYERS CREEK

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Iron (µg/L)	Manganese (µg/L)
1/18/96	0.92	0.61	3.2	0.80	1.1	4.9	<0.10	7.3	450	28
3/27/96	1.1	.63	3.2	.90	1.2	4.7	<.10	4.6	550	50
6/24/96	.92	.61	3.2	1.1	1.5	3.9	<.10	10	180	33
9/12/96	1.0	.71	3.4	1.3	2.5	4.1	<.10	10	310	71
12/16/96	.90	.62	3.9	1.0	2.7	5.4	<.10	11	440	42
3/17/97	1.1	.62	3.4	1.0	2.6	5.0	<.10	6.2	590	82
6/30/97	1.2	.66	3.3	.80	2.8	4.0	<.10	11	750	110
9/29/97	2.5	1.6	4.7	1.4	17	4.9	<.10	14	350	374
12/10/97	.93	.62	3.1	1.1	2.5	4.9	<.10	8.4	360	62
3/5/98	1.2	.62	2.5	1.2	1.8	4.2	<.10	2.0	480	39
6/8/98	1.2	.76	3.1	1.0	1.8	4.3	<.10	9.7	710	52
9/1/98	.90	.62	3.2	1.5	2.3	3.8	<.10	9.4	400	41

[mg/L, milligrams per liter; µg/L, micrograms per liter; —, no data]

CEDAR CREEK

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Iron (µg/L)	Manganese (µg/L)
1/18/96	0.63	0.44	1.8	0.40	0.70	3.1	0.10	4.9	170	16
3/27/96	.74	.43	2.2	.50	.90	3.5	<.10	2.6	320	27
6/24/96	.64	.39	1.8	.40	.50	2.5	<.10	2.1	210	16
9/12/96	.63	.44	2.0	.50	.60	3.0	<.10	3.5	210	25
12/16/96	.71	.41	1.9	.50	.70	2.8	<.10	4.5	240	21
3/17/97	.84	.45	1.9	.50	.90	3.4	<.10	2.5	430	42
6/30/97	.81	.46	2.0	.41	.97	2.7	<.10	2.4	470	42
9/29/97	.83	.59	1.9	.75	2.1	2.8	<.10	5.3	370	32
12/10/97	.91	.51	2.2	.50	1.2	3.8	<.10	4.3	250	14
3/5/98	.93	.47	1.9	.51	1.5	3.5	<.10	.55	330	29
6/8/98	.73	.42	1.7	.48	.43	2.7	<.10	1.4	380	50
9/1/98	.69	.42	1.8	.44	.47	2.6	<.10	2.8	310	65

CEDAR CREEK NEAR WISE LAKE

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Iron (µg/L)	Manganese (µg/L)
1/18/96	0.88	0.55	2.5	0.60	0.80	3.7	<0.10	6.1	290	20
3/26/96	2.0	.93	3.8	1.1	1.7	4.5	<.10	5.3	580	37
6/25/96	.72	.47	2.0	.50	.50	2.9	<.10	3.5	54	76
9/12/96	.93	.59	2.9	.60	1.0	4.3	<.10	4.7	88	95
12/16/96	.79	.53	2.4	.60	1.3	3.4	<.10	6.2	210	21
3/17/97	1.5	.70	2.8	.90	2.0	4.2	<.10	4.9	500	46
6/30/97	1.1	.58	2.6	.61	1.9	3.3	<.10	6.4	650	78
9/29/97	1.7	1.0	3.1	1.0	7.8	3.7	<.10	8.7	320	149
12/11/97	1.0	.60	2.6	.80	2.0	4.4	<.10	6.8	410	36
3/4/98	1.9	.88	2.8	.94	2.0	3.6	<.10	2.2	530	40
6/9/98	.94	.49	2.3	.60	.76	3.1	<.10	3.1	550	60
9/2/98	.76	.46	1.9	.50	.62	2.7	<.10	3.3	440	61

Appendix 1. Major ion concentrations in streams of Congaree Swamp—Continued
[mg/L, milligrams per liter; µg/L, micrograms per liter; —, no data]

TOMS CREEK

Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Sulfate (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Iron (µg/L)	Manganese (µg/L)
3/26/96	0.77	0.64	2.5	0.60	0.80	3.9	<0.10	3.4	550	26
6/25/96	.82	.83	2.5	3.3	.60	3.7	<.10	4.4	540	44
9/12/96	1.1	1.0	2.7	.90	4.8	3.7	<.10	7.2	220	170
12/16/96	.75	.76	2.8	.60	1.6	4.4	<.10	5.3	460	22
3/17/97	.92	.71	2.6	.80	1.7	4.7	<.10	4.0	680	59
6/30/97	.88	.79	2.3	.52	.95	3.4	<.10	4.0	690	41
9/29/97	1.3	1.2	3.0	1.1	6.1	4.5	<.10	8.4	330	107
12/10/97[a]	—	—	—	—	—	—	—	—	—	—
3/4/98	.98	.69	2.0	.67	1.6	3.4	.11	.86	510	32
6/9/98	1.1	.94	2.5	.59	.90	3.8	<.10	5.0	960	24
9/2/98	.93	.93	2.7	.81	1.1	3.8	<.10	4.7	490	27

[a]Site inaccessible.

Appendix 2. Nutrient concentrations in streams of Congaree Swamp
[Concentrations in milligrams per liter; —, no data]

CONGAREE RIVER AT COLUMBIA

Date	Ammonia nitrogen	Total ammonia-plus-organic nitrogen	Dissolved ammonia-plus-organic nitrogen	Nitrite nitrogen	Nitrite-plus-nitrate nitrogen	Dissolved phos-phorus	Total phos-phorus	Ortho-phos-phorus	Dis-solved organic carbon	Sus-pended organic carbon
10/23/95	0.040	0.20	0.20	0.010	0.290	0.020	0.303	0.020	2.3	0.40
11/30/95	.020	.20	<.20	<.010	.290	.020	<.010	.020	3.5	.50
12/12/95	<.015	<.20	<.20	<.010	.380	.020	.040	.020	2.7	.20
1/10/96	<.015	.20	<.20	<.010	.330	.020	.050	.020	3.2	.30
2/7/96	.020	<.20	<.20	<.010	.240	<.010	.030	<.010	3.4	.30
3/4/96	<.015	<.20	<.20	<.010	.410	.010	.040	.010	1.6	.30
3/8/96	.040	.50	.40	<.010	.260	.020	.140	.020	6.0	2.4
4/23/96	<.015	.20	<.20	<.010	.320	<.010	.030	<.010	2.0	.30
5/15/96	.120	<.20	<.20	.010	.310	<.010	.050	<.010	2.8	.30
6/5/96	.020	.30	.20	<.010	.390	.030	.060	.020	2.3	.30
7/3/96	.030	<.20	<.20	.010	.320	.020	.020	.020	3.4	.20
8/12/96	.030	<.20	<.20	.010	.420	<.010	.020	.020	2.5	.30
9/4/96	<.015	.20	<.20	<.010	.260	<.010	.020	<.010	3.1	.30
10/21/96	<.015	.40	<.20	.020	.400	.040	.220	.020	2.8	.30
11/12/96	.040	.20	<.20	.020	.320	.030	.050	.020	3.5	.30
12/5/96	.050	.40	<.20	<.010	.350	.020	.100	.030	3.8	.90
1/31/97	<.015	.20	<.20	.010	.400	<.010	.020	<.010	3.1	.30
2/27/97	<.015	.20	<.20	<.010	.270	<.010	.030	<.010	2.8	.30
3/2/97	.020	1.0	.20	<.010	.270	<.010	.350	.010	5.8	4.8
3/10/97	<.015	<.20	<.20	<.010	.340	<.010	.020	.010	3.2	.20
4/7/97	<.015	<.20	<.20	<.010	.330	<.010	.020	.010	3.2	—
5/5/97	<.015	.30	<.20	<.010	.422	<.010	.076	.015	2.9	.40
6/9/97	.019	<.20	<.20	<.010	.422	<.010	.016	.020	2.3	.30
7/1/97	<.015	.21	<.20	<.010	.391	<.010	.016	.017	3.3	.10
8/6/97	.017	.62	<.20	<.010	.270	<.010	.088	.010	3.0	.30
9/9/97	<.015	.21	<.20	<.010	.249	<.010	.012	<.010	2.8	.20

Appendix 2. Nutrient concentrations in streams of Congaree Swamp—Continued
[Concentrations in milligrams per liter; —, no data]

MYERS CREEK

Date	Ammonia nitrogen	Total ammonia-plus-organic nitrogen	Dissolved ammonia-plus-organic nitrogen	Nitrite nitrogen	Nitrite-plus-nitrate nitrogen	Dissolved phos-phorus	Total phos-phorus	Ortho-phos-phorus	Dis-solved organic carbon	Sus-pended organic carbon
1/18/96	<0.015	0.60	0.20	<0.010	0.220	<0.010	0.060	<0.010	5.2	0.1
3/27/96	.020	.40	.30	<.010	.130	<.010	<.010	.010	7.3	2.0
6/24/96	.060	.40	<.20	<.010	.340	<.010	.020	.010	5.7	1.4
9/12/96	<.020	.30	.20	<.010	.240	<.010	.020	<.010	3.8	1.6
12/16/96	<.015	.30	.20	<.010	.200	<.010	.090	<.010	4.6	1.1
3/17/97	<.015	.40	.40	<.010	.050	<.010	.020	<.010	11	1.2
6/30/97	.019	.41	.51	<.010	.050	<.010	.016	<.010	16	.90
9/29/97	<.015	.41	.27	<.010	<.050	<.010	.011	<.010	8.2	.80
12/10/97	<.020	.27	.24	<.010	<.050	<.010	<.010	.018	7.6	.50
3/5/98	<.020	<.10	.34	<.010	.090	<.010	<.050	.015	8.6	1.2
6/8/98	.043	.38	.42	.016	.232	<.010	.015	.016	6.3	1.7
9/1/98	<.020	.31	.19	<.010	.217	<.010	.017	.013	3.5	1.7

CEDAR CREEK

Date	Ammonia nitrogen	Total ammonia-plus-organic nitrogen	Dissolved ammonia-plus-organic nitrogen	Nitrite nitrogen	Nitrite-plus-nitrate nitrogen	Dissolved phos-phorus	Total phos-phorus	Ortho-phos-phorus	Dis-solved organic carbon	Sus-pended organic carbon
1/18/96	<0.015	0.30	<0.20	<0.010	0.290	<0.010	0.020	0.010	1.5	0.60
3/27/96	.030	.20	.20	<.010	.110	.010	<.010	<.010	3.6	1.0
6/24/96	.060	.30	<.20	<.010	<.050	<.010	.020	<.010	3.9	.30
9/12/96	.020	.30	<.20	<.010	.080	<.010	.020	<.010	2.4	1.5
12/16/96	.030	<.20	<.20	<.010	.240	<.010	<.010	<.010	1.4	1.0
3/17/97	<.015	.30	<.20	<.010	.100	<.010	<.010	<.010	3.6	.80
6/30/97	.017	<.20	<.20	<.010	<.050	<.010	<.010	<.010	4.4	—
9/29/97	<.015	.27	<.20	<.010	<.050	<.010	<.010	<.010	5.1	.80
12/10/97	<.020	.18	<.10	<.010	.064	<.010	<.010	.015	3.5	.60
3/5/98	<.020	<.10	.20	<.010	<.050	<.010	<.050	.011	4.9	.70
6/8/98	.050	.36	.23	.013	<.050	<.010	<.010	.012	3.0	1.9
9/1/98	.029	.36	.24	<.010	<.050	<.010	.024	<.010	3.0	1.0

Appendix 2. Nutrient concentrations in streams of Congaree Swamp—Continued
[Concentrations in milligrams per liter; —, no data]

CEDAR CREEK NEAR WISE LAKE

Date	Ammonia nitrogen	Total ammonia-plus-organic nitrogen	Dissolved ammonia-plus-organic nitrogen	Nitrite nitrogen	Nitrite-plus-nitrate nitrogen	Dissolved phos-phorus	Total phos-phorus	Ortho-phos-phorus	Dis-solved organic carbon	Sus-pended organic carbon
1/18/96	<0.015	0.20	<0.20	<0.010	0.250	<0.010	0.020	<0.010	2.5	0.80
3/26/96	<.015	.30	.20	<.010	.100	.020	.020	.010	5.0	1.3
6/25/96	.070	.20	<.20	<.010	.110	<.010	<.010	<.010	3.7	.60
9/12/96	.020	.30	.20	<.010	.090	<.010	.040	<.010	3.9	1.5
12/16/96	.020	.20	<.20	<.010	.200	<.010	<.010	<.010	4.3	.80
3/17/97	<.015	.40	.40	<.010	.060	<.010	<.010	<.010	7.7	1.1
6/30/97	.026	.32	.27	<.010	<.050	<.010	.012	<.010	8.4	.90
9/29/97	<.015	.29	.20	<.010	<.050	<.010	<.010	<.010	5.9	.70
12/11/97	<.020	.29	.14	<.010	<.050	<.010	.012	.012	5.4	1.2
3/4/98	<.020	.37	.29	<.010	<.050	<.010	.016	<.010	6.9	.60
6/9/98	.048	.37	.26	.011	.070	<.010	.080	.012	3.6	2.4
9/2/98	.040	.35	.21	<.010	<.050	<.010	.021	.011	3.2	1.4

TOMS CREEK

Date	Ammonia nitrogen	Total ammonia-plus-organic nitrogen	Dissolved ammonia-plus-organic nitrogen	Nitrite nitrogen	Nitrite-plus-nitrate nitrogen	Dissolved phos-phorus	Total phos-phorus	Ortho-phos-phorus	Dis-solved organic carbon	Sus-pended organic carbon
3/26/96	<0.015	0.30	0.20	<0.010	0.210	0.010	0.010	0.010	5.3	1.1
6/25/96	.060	.40	.20	<.010	.140	<.010	.020	<.010	5.9	.40
9/12/96	.020	.40	.30	<.010	.110	<.010	.050	.010	6.7	1.2
12/16/96	.020	.30	<.20	<.010	.190	<.010	<.010	.010	3.8	.70
3/17/97	<.015	.40	.40	<.010	<.050	<.010	<.010	<.010	11	1.0
6/30/97	.025	.32	.28	<.010	<.050	<.010	<.010	<.010	8.3	1.1
9/29/97	<.015	.38	.29	<.010	<.050	<.010	<.010	<.010	9.6	.80
12/10/97[a]	—	—	—	—	—	—	—	—	—	—
3/4/98	<.020	.33	.31	<.010	<.050	<.010	<.010	<.010	8.0	.60
6/9/98	.051	.36	.30	.013	.164	<.010	.020	.011	5.2	1.7
9/2/98	.042	.29	.23	<.010	.212	<.010	<.010	.013	3.1	.60

[a]Site inaccessible.

Appendix 3. Parameter codes and method detection limits for pesticides analyzed in samples from streams of Congaree Swamp

[Units in micrograms per liter]

Constituent	Parameter code	Method detection limit
2,6-Diethylaniline	82660	0.003
Acetochlor	49260	.002
Alachlor	46342	.002
Atrazine	39632	.001
Azinphos-methyl	82686	.001
Benfluralin	82673	.002
Butylate	04028	.002
Carbaryl	82680	.003
Carbofuran	82674	.003
Chlorpyrifos	38933	.004
Cyanazine	04041	.004
DCPA	82682	.002
Deethylatrazine	04040	.002
Diazinon	39572	.002
Dieldrin	39381	.001
Disulfoton	82677	.017
EPTC	82668	.002
Ethalfluralin	82663	.004
Ethoprophos	82672	.003
Fonofos	04095	.003
Lindane	39341	.004
Linuron	82666	.002
Malathion	39532	.005
Metolachlor	39415	.002
Metribuzin	82630	.004
Molinate	82671	.004
Napropamide	82684	.003
Parathion	39542	.004
Parathion-methyl	82667	.006
Pebulate	82669	.004
Pendimethalin	82683	.004
Phorate	82664	.002
Prometon	04037	.018
Propachlor	04024	.007
Propanil	82679	.004
Propargite	82685	.013
Pronamide	82676	.003
Simazine	04035	.005
Tebuthiuron	82670	.010
Terbacil	82665	.007
Terbufos	82675	.013
Thiobencarb	82681	.002
Tri-allate	82678	.001
Trifluralin	82661	.002
alpha-HCH	34253	.002
cis-Permethrin	82687	.005
p,p'-DDE	34653	.006

Appendix 4. Pesticide concentrations in streams of Congaree Swamp
[Concentrations in micrograms per liter; E, estimated value]

CONGAREE RIVER AT COLUMBIA

Date	Deethylatrazine	Atrazine	DCPA	Diazinon	Metolachlor	Prometon	Pronamide	Simazine	Tebuthiuron
2/7/96	E0.0020	0.013	E0.0010		E0.003	E0.0040		0.0530	E0.0070
5/15/96	E.0020	.015			.010	E.0040		.0160	E.0100
9/4/96	E.0023	.020	E.0014	E0.003	.004	E.0094	0.0057	.0226	.0120

MYERS CREEK

Date	Deethylatrazine	Atrazine	Chlorpyrifos	Metolachlor	Prometon	Simazine	Tebuthiuron
3/27/96	E0.0040	0.058		0.038	E0.002	0.0110	E0.0100
6/24/96		.005		.006			.0140
9/12/96	E.0023	.005		.006			.0195
12/16/96	E.0010						E.0081
3/17/97		.005		.006			E.0327
9/29/97			E0.0037				
12/10/97							E.0128
3/5/98		E.003		.004			.0114
6/8/98		.011		.011			.0200
9/1/98				.006			E.0090

CEDAR CREEK

Date	Alachlor	Deethylatrazine	Atrazine	Metolachlor	Tebuthiuron
3/27/96		E0.003	0.009	0.005	0.0130
6/24/96	E0.002		.005	E.004	.0110
9/12/96			E.004		.0250
12/16/96					.0193
3/17/97			.009	.005	E.0392
9/29/97					
12/10/97					E.0205
3/5/98					.0150
6/8/98			.008		.0200
9/1/98					.0140

Appendix 4. Pesticide concentrations in streams of Congaree Swamp—Continued
[Concentrations in micrograms per liter; E, estimated value]

CEDAR CREEK NEAR WISE LAKE

Date	Deethylatrazine	Atrazine	Metolachlor	Prometon	Simazine	Tebuthiuron
3/26/96	E0.0040	0.030	0.019	E0.0020	0.0100	E0.0100
6/25/96	E.0010	.004	.004			.0230
9/12/96	E.0014	.004				.0173
12/16/96						.0200
3/17/97		.008	.005			.0194
9/29/97						
12/11/97						E.0198
3/4/98		E.004	E.003			.0124
6/9/98		.005	E.003			.0165
9/2/98						

TOMS CREEK

Date	Deethylatrazine	Atrazine	Carbaryl	Metolachlor	Tebuthiuron
3/26/96	E0.0030	0.004		E0.003	0.0240
6/25/96	E.0020	.005		.007	.0680
9/12/96	E.0023	.005	E0.0064	E.004	.0844
12/16/96	E.0021				.0495
3/17/97	E.0018	E.004		.004	E.0166
9/29/97					.0124
12/10/97[a]					
3/4/98					.0189
6/9/98	E.0043	.007		E.002	.0385
9/2/98					.0462

[a]Site inaccessible.

Appendix 5. Suspended sediment in streams of Congaree Swamp
[mg/L, milligrams per liter; mm, millimeters; —, no data]

CONGAREE RIVER AT COLUMBIA

Date	Suspended sediment (mg/L)	Percent finer than 0.062 mm
10/23/95	7	88
11/30/95	12	90
12/12/95	13	80
1/10/96	5	74
2/7/96	35	76
3/4/96	5	81
3/8/96	136	77
4/23/96	22	36
5/15/96	6	93
6/5/96	10	89
7/3/96	8	96
8/12/96	62	14
9/4/96	13	63
10/21/96	6	74
11/12/96	12	92
12/5/96	248	24
1/31/97	15	91
2/27/97	36	22
3/2/97	248	90
3/10/97	14	62
4/7/97	6	93
5/5/97	47	89
6/9/97	16	77
7/1/97	6	72
8/6/97	7	81
9/9/97	3	62

MYERS CREEK

Date	Suspended sediment (mg/L)	Percent finer than 0.062 mm
3/27/96	12	84
6/24/96	9	86
9/12/96	7	54
12/16/96	2	80
3/17/97	4	90
6/30/97	8	60
9/29/97	5	30
12/10/97	11	36
3/5/98	13	85
6/8/98	7	69
9/1/98	6	82

CEDAR CREEK

Date	Suspended sediment (mg/L)	Percent finer than 0.062 mm
1/18/96	2	71
3/27/96	9	74
6/24/96	7	70
9/12/96	5	52
12/16/96	4	86
3/17/97	3	90
6/30/97	6	71
9/29/97	3	25
12/10/97	2	20
3/5/98	6	76
6/8/98	4	72
9/1/98	7	64

Appendix 5. Suspended sediment in streams of Congaree Swamp—Continued
[mg/L, milligrams per liter; mm, millimeters; —, no data]

CEDAR CREEK NEAR WISE LAKE

Date	Suspended sediment (mg/L)	Percent finer than 0.062 mm
1/18/96	3	78
3/26/96	10	82
6/25/96	7	86
9/12/96	7	74
12/16/96	3	88
3/17/97	7	90
6/30/97	9	76
9/29/97	7	38
12/11/97	3	73
3/4/98	7	95
6/9/98	7	59
9/2/98	7	79

TOMS CREEK

Date	Suspended sediment (mg/L)	Percent finer than 0.062 mm
3/26/96	11	59
6/25/96	5	79
9/12/96	6	74
12/16/96	2	72
3/17/97	1	40
6/30/97	11	79
9/29/97	4	50
12/10/97[a]	—	—
3/4/98	7	78
6/9/98	21	24
9/2/98	5	59

[a]Site inaccessible.

Appendix 6. Field-measured constituents in streams of Congaree Swamp

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; °C, degrees Celsius; su, standard units; mg/L, milligrams per liter; %, percent; —, no data]

CONGAREE RIVER AT COLUMBIA

Date	Streamflow (ft^3/s)	Specific conductance (µS/cm)	Temperature (°C)	pH (su)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (%)	Alkalinity (mg/L)
10/23/95	6,330	85	18.5	7.3	8.4	90	21
11/30/95	16,200	73	13.0	7.0	8.4	81	20
12/12/95	10,500	84	10.0	7.2	10.0	82	24
1/10/96	9,430	80	6.0	7.2	10.0	79	21
2/7/96	14,800	60	6.0	7.1	12.5	97	15
3/4/96	8,260	81	11.0	7.4	6.9	62	18
3/8/96	53,600	39	11.5	7.1	9.7	88	14
4/23/96	7,820	84	19.0	7.7	6.4	69	21
5/15/96	6,420	79	17.0	7.2	7.2	77	22
6/5/96	6,640	79	20.2	6.9	7.2	82	20
7/3/96	6,030	101	25.0	5.5	7.6	89	18
8/12/96	4,710	86	26.0	7.2	6.9	85	20
9/4/96	17,100	69	16.5	6.6	5.8	59	17
10/21/96	2,460	92	17.5	7.2	9.1	91	22
11/12/96	7,760	92	13.0	7.0	9.2	88	22
12/5/96	7,820	64	9.5	6.8	10.3	90	13
1/31/97	12,200	83	9.0	7.2	10.4	90	36
2/27/97	16,900	78	10.5	7.1	10.7	95	18
3/2/97	40,400	51	14.0	6.3	8.3	80	19
3/10/97	9,190	80	12.5	7.1	10.0	97	19
4/7/97	8,920	80	15.5	7.1	9.5	95	26
5/5/97	15,200	73	17.0	6.4	8.7	90	18
6/9/97	5,710	75	19.0	6.8	6.2	65	22
7/1/97	8,920	85	22.0	7.0	8.2	90	21
8/6/97	6,390	81	22.5	7.0	7.2	87	20
9/9/97	2,940	100	22.5	6.4	7.2	83	22

Appendix 6. Field-measured constituents in streams of Congaree Swamp—Continued

[ft³/s, cubic feet per second; µS/cm, microsiemens per centimeter; °C, degrees Celsius; su, standard units; mg/L, milligrams per liter; %, percent; —, no data]

MYERS CREEK

Date	Streamflow (ft³/s)	Specific conductance (µS/cm)	Temperature (°C)	pH (su)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (%)	Alkalinity (mg/L)
1/18/96	19	28	9.5	4.7	9.9	91	3
3/27/96	26	29	14.0	5.6	8.6	83	7
6/24/96	3.9	28	24.0	5.7	5.8	71	4
9/12/96	2.5	32	22.0	5.9	7.4	86	5
12/16/96	7.2	28	6.0	5.3	10.7	86	3
3/17/97	3.0	32	9.0	5.2	9.1	78	4
6/30/97	30	33	21.5	5.1	6.0	68	1
9/29/97	38	68	19.5	4.4	5.0	54	2
12/10/97	32	28	7.0	5.1	8.8	77	2
3/5/98	52	25	9.0	5.4	8.8	76	2
6/8/98	9.7	28	17.5	5.7	7.1	74	5
9/1/98	1.4	28	23.0	5.5	6.3	76	4

CEDAR CREEK

Date	Streamflow (ft³/s)	Specific conductance (µS/cm)	Temperature (°C)	pH (su)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (%)	Alkalinity (mg/L)
1/18/96	38	17	9.5	5.4	10.6	93	2
3/27/96	39	20	15.5	5.8	9.2	93	2
6/24/96	27	15	29.5	5.0	6.3	82	4
9/12/96	22	18	26.5	5.9	6.6	83	3
12/16/96	30	14	7.0	5.7	11.4	94	3
3/17/97	40	20	15.5	5.7	9.3	94	3
6/30/97	36	19	26.5	5.9	7.2	90	2
9/29/97	56	20	20.5	5.1	7.4	82	3
12/10/97	43	19	7.5	5.4	10.5	87	2
3/5/98	61	18	11.5	5.5	10.1	93	3
6/8/98	37	16	24.5	5.6	7.1	86	3
9/1/98	24	16	28.0	5.6	6.6	84	4

Appendix 6. Field-measured constituents in streams of Congaree Swamp—Continued

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter; °C, degrees Celsius; su, standard units; mg/L, milligrams per liter; %, percent; —, no data]

CEDAR CREEK NEAR WISE LAKE

Date	Streamflow (ft^3/s)	Specific conductance (µS/cm)	Temperature (°C)	pH (su)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (%)	Alkalinity (mg/L)
1/18/96	48	20	10.0	5.6	10.3	92	2
3/26/96	86	39	14.0	6.1	7.6	74	13
6/25/96	24	20	28.0	5.6	4.7	61	4
9/12/96	16	24	25.0	5.8	4.2	51	3
12/16/96	34	22	7.5	5.9	10.0	83	3
3/17/97	72	31	13.0	5.7	8.4	79	6
6/30/97	56	25	24.5	5.5	6.4	77	2
9/29/97	95	32	20.0	5.0	6.4	71	1
12/11/97	89	24	7.5	5.6	9.7	81	2
3/4/98	160	27	9.5	6.4	8.4	74	6
6/9/98	44	11	23.0	6.1	6.0	70	3
9/2/98	27	18	26.5	5.7	5.9	73	3

TOMS CREEK

Date	Streamflow (ft^3/s)	Specific conductance (µS/cm)	Temperature (°C)	pH (su)	Dissolved oxygen (mg/L)	Dissolved oxygen saturation (%)	Alkalinity (mg/L)
3/26/96	33	24	16.5	5.6	8.6	87	4
6/25/96	8.9	25	26.5	6.3	5.3	71	4
9/12/96	8.5	32	24.0	5.5	5.1	60	2
12/16/96	11	26	8.0	6.1	10.2	85	3
3/17/97	48	27	11.5	5.4	9.6	89	3
6/30/97	29	23	25.0	5.6	6.2	72	3
9/29/97	53	39	20.0	4.9	5.7	63	2
12/10/97[a]	—	—	—	—	—	—	—
3/4/98	103	18	9.0	5.4	9.5	83	4
6/9/98	23	24	20.5	5.3	6.7	74	4
9/2/98	5.9	27	25.0	6.1	6.8	80	4

[a]Site inaccessible.

MYERS CREEK

[T-n, transect number; m, meters; >, greater than; OD, organic detritus; MU, muck; SA, sand; SI, silt; I, island; Y, yes; NO, none; NA, not applicable. Referring to bank shape: LN, linear; CC, concave; CV, convex. Referring to bank erosion: CB, undercut bank; SL, slab failure; RO rotational failure]

Habitat characteristic	T-1	T-2	T-3	T-4	T-5	T-6
Distance to reach boundary closest to reference location (m)	0	30	63.8	99.8	128.8	157.8
Channel width at bank full (m)	9.7	7.2	10.5	9.7	8.5	10.2
Left bank width (m)	0	0	0	2.0	0	0
Right bank width (m)	2.3	0	2.5	1.0	3.0	2.2
Left bank flood plain width (m)	>50	>50	>50	>50	>50	>50
Right bank flood plain width (m)	>50	>50	>50	>50	>50	>50
Depth at thalweg (m)						
Point 1	0.80	1.35	1.00	0.60	0.80	0.68
Point 2	.70	1.37	1.20	.65	.75	.62
Point 3	.70	1.04	.90	.67	.52	.60
Distance from left bank (m)						
Point 1	1.7	1.3	2.7	2.5	1.3	2.8
Point 2	4.3	2.6	4.8	4.5	3.5	4.8
Point 3	6.6	4.7	7.2	6.6	5.0	6.4
Dominant bed substrate (point 1)	SA	OD	OD	OD	SI	OD
Subdominant (point 1)	SI	SI	MU	SA	SA	SA
Silt (point 1)	Y	Y	Y	Y	Y	Y
Dominant (point 2)	OD	OD	OD	SA	SA	SA
Subdominant (point 2)	SI	SI	MU	OD	SI	OD
Silt (point 2)	Y	Y	Y	NO	Y	N
Dominant (point 3)	OD	OD	OD	OD	OD	MU
Subdominant (point 3)	SA	SI	MU	MU	MU	OD
Silt (point 3)	Y	Y	Y	Y	Y	Y
Embeddedness[a]						
Point 1	0	0	0	0	0	0
Point 2	0	0	0	0	0	0
Point 3	0	0	0	0	0	0
Left bank canopy (degrees)	90	90	90	90	90	90
Right bank canopy (degrees)	90	90	77	90	90	90
Canopy angle (degrees)	0	0	13	0	0	0
Aspect[b] (degrees)	210	190	173	171	190	160
Habitat features (type and percent of transect)						
Woody snags	50	0	10	25	25	15
Overhanging vegetation (terrestrial)	0	35	5	25	25	0
Undercut banks	0	0	0	0	0	0
Boulders	0	0	0	0	0	0
Sloughs	0	0	0	0	0	0
Macrophytes-emergent	0	0	0	0	0	50
Macrophytes-submerged	0	0	0	0	0	0
Macrophytes-floating	0	0	0	0	0	0
Rubbish	0	0	0	0	0	0
Other	0	0	0	0	0	0

[a]Embeddedness is a numerical rating that describes the extent to which coarse material, such as boulders, cobbles, and bedrock, is covered by fine material (sand, silt, fine particulate organic matter). An embeddedness rating of zero (0) indicates that no coarse material is visible.

[b]Aspect is the direction of streamflow at the center of the transect (degrees, magnetic).

MYERS CREEK (Continued)

[T-n, transect number; m, meters; >, greater than; OD, organic detritus; MU, muck; SA, sand; SI, silt; I, island; Y, yes; NO, none; NA, not applicable. Referring to bank shape: LN, linear; CC, concave; CV, convex. Referring to bank erosion: CB, undercut bank; SL, slab failure; RO rotational failure]

Habitat characteristic	T-1	T-2	T-3	T-4	T-5	T-6
Bar/Shelf/Island						
Type point 1	NO	NO	NO	NO	NO	I
Width at point 1 (m)	NA	NA	NA	NA	NA	2.5
Substrate (dominant) point 1	NA	NA	NA	NA	NA	SI
Substrate (subdominant) point 1	NA	NA	NA	NA	NA	SA
Woody vegetation cover point 1 (percent)	NA	NA	NA	NA	NA	0
Herbaceous vegetation cover point 1 (percent)	NA	NA	NA	NA	NA	100
Type point 2	NO	NO	NO	NO	NO	NO
Type point 3	NO	NO	NO	NO	NO	NO
Bank parameters						
Left bank height (m)	1.0	1.40	1.5	0.72	0.96	0.79
Right bank height (m)	.6	1.40	1.4	.73	.93	.77
Left bank vegetation stability	3	3	3	2	3	3
Left bank shape	LN	LN	LN	CC	LN	LN
Left bank erosion	NO	NO	NO	NO	NO	NO
Right bank vegetation stability	1	1	1	2	2	4
Right bank shape	CC	CC	CC	CC	CC	CC
Right bank erosion	NO	CB	NO	NO	NO	NO
Left bank dominant substrate	SI	SA	SA	SA	SA	SA
Left bank subdominant substrate	SA	SI	SI	SI	SI	SI
Right bank dominant substrate	SI	SI	SI	SA	SA	SI
Right bank subdominant substrate	SA	NO	SA	SI	SI	SA

CEDAR CREEK

[T-n, transect number; m, meters; >, greater than; OD, organic detritus; MU, muck; SA, sand; SI, silt; I, island; Y, yes; NO, none; NA, not applicable. Referring to bank shape: LN, linear; CC, concave; CV, convex. Referring to bank erosion: CB, undercut bank; SL, slab failure; RO rotational failure]

Habitat characteristic	T-1	T-2	T-3	T-4	T-5	T-6
Distance to reach boundary closest to reference location (m)	0	35	74	103	137	168
Channel width at bank full (m)	6.4	7.8	6.8	7.1	8.0	6.6
Left bank width (m)	0	0	0	0	0	0
Right bank width (m)	0	0	0	1.6	1.0	0
Left bank flood plain width (m)	>50	>50	>50	>50	>50	>50
Right bank flood plain width (m)	>50	>50	>50	>50	>50	>50
Depth at thalweg (m)						
Point 1	1.28	0.92	0.94	01.62	0.90	1.12
Point 2	1.36	1.34	1.24	1.20	1.30	1.50
Point 3	1.06	.74	1.34	.82	1.62	1.16
Distance from left bank (m)						
Point 1	1.6	1.9	2.3	2.3	2.8	2.0
Point 2	3.0	4.3	4.3	3.4	5.0	3.6
Point 3	4.5	6.0	6.2	4.9	6.4	4.6
Dominant bed substrate (point 1)	SA	SA	SA	SA	SA	SA
Subdominant (point 1)	NO	NO	OD	OD	OD	OD
Silt (point 1)	NO	NO	NO	NO	NO	NO
Dominant (point 2)	SA	SA	SA	SA	SA	SA
Subdominant (point 2)	NO	NO	OD	OD	OD	OD
Silt (point 2)	NO	NO	NO	NO	NO	NO
Dominant (point 3)	SA	SA	SA	SA	SA	SA
Subdominant (point 3)	NO	NO	OD	OD	OD	OD
Silt (point 3)	NO	NO	NO	NO	NO	NO
Embeddedness[a]						
Point 1	0	0	0	0	0	0
Point 2	0	0	0	0	0	0
Point 3	0	0	0	0	0	0
Left bank canopy (degrees)	70	90	85	90	75	90
Right bank canopy (degrees)	90	90	63	90	80	90
Canopy angle (degrees)	20	0	32	0	25	0
Aspect[b] (degrees)	240	260	280	300	187	330
Habitat features (type and percent of transect)						
Woody snags	0	20	50	20	20	25
Overhanging vegetation (terrestrial)	50	75	25	75	25	100
Undercut banks	0	0	0	0	0	0
Boulders	0	0	0	0	0	0
Sloughs	0	0	0	0	0	0
Macrophytes-emergent	0	0	0	0	0	0
Macrophytes-submerged	0	0	0	0	0	0
Macrophytes-floating	0	0	0	0	0	0
Rubbish	0	0	0	0	0	0
Other	0	0	0	0	0	0

[a]Embeddedness is a numerical rating that describes the extent to which coarse material, such as boulders, cobbles, and bedrock, is covered by fine material (sand, silt, fine particulate organic matter). An embeddedness rating of zero (0) indicates that no coarse material is visible.

[b]Aspect is the direction of streamflow at the center of the transect (degrees, magnetic).

CEDAR CREEK (Continued)

[T-n, transect number; m, meters; >, greater than; OD, organic detritus; MU, muck; SA, sand; SI, silt; I, island; Y, yes; NO, none; NA, not applicable. Referring to bank shape: LN, linear; CC, concave; CV, convex. Referring to bank erosion: CB, undercut bank; SL, slab failure; RO rotational failure]

Habitat characteristic	T-1	T-2	T-3	T-4	T-5	T-6
Bank parameters						
Left bank height (m)	1.44	1.36	1.40	1.82	1.64	1.78
Right bank height (m)	1.46	1.2	1.41	1.80	1.66	1.64
Left bank vegetation stability	4	4	4	4	3	4
Left bank shape	LN	LN	LN	LN	LN	LN
Left bank erosion	NO	NO	NO	NO	NO	NO
Right bank vegetation stability	4	4	4	4	4	4
Right bank shape	LN	LN	LN	LN	LN	LN
Right bank erosion	NO	NO	NO	NO	NO	NO
Left bank dominant substrate	SA	SA	SA	SA	SA	SA
Left bank subdominant substrate	OD	OD	OD	OD	OD	OD
Right bank dominant substrate	SA	SA	SA	SA	SA	SA
Right bank subdominant substrate	OD	OD	OD	OD	OD	OD

CEDAR CREEK NEAR WISE LAKE

[T-n, transect number; m, meters; >, greater than; OD, organic detritus; MU, muck; SA, sand; SI, silt; I, island; Y, yes; NO, none; NA, not applicable. Referring to bank shape: LN, linear; CC, concave; CV, convex. Referring to bank erosion: CB, undercut bank; SL, slab failure; RO rotational failure]

Habitat characteristic	T-1	T-2	T-3	T-4	T-5	T-6
Distance to reach boundary closest to reference location (m)	0	47.00	99.70	144.70	219.70	271.20
Channel width at bank full (m)	36.00	36.00	36.60	40.00	43.00	37.00
Left bank width (m)	.00	3.90	3.20	9.00	7.00	8.00
Right bank width (m)	5.30	3.50	.60	.00	21.30	.00
Left bank flood plain width (m)	>50	>50	>50	>50	>50	>50
Right bank flood plain width (m)	>50	>50	>50	>50	>50	>50
Depth at thalweg (m)						
Point 1	1.64	0.20	0.40	0.06	0.37	0.20
Point 2	1.46	.82	.38	.14	.96	.48
Point 3	.58	1.60	1.52	1.70	1.78	1.60
Distance from left bank (m)						
Point 1	4.0	9.0	10.0	10.0	7.5	15.0
Point 2	7.0	18.0	20.0	20.0	11.0	23.0
Point 3	26.0	24.0	30.0	33.0	17.0	31.0
Dominant bed substrate (point 1)	OD	OD	OD	OD	OD	OD
Subdominant (point 1)	SA	NO	SI	SI	SI	SI
Silt (point 1)	Y	Y	Y	Y	Y	Y
Dominant (point 2)	OD	OD	OD	OD	OD	OD
Subdominant (point 2)	SA	NO	SI	SI	SI	SI
Silt (point 2)	Y	Y	Y	Y	Y	Y
Dominant (point 3)	OD	OD	OD	OD	OD	OD
Subdominant (point 3)	SA	NO	SI	SI	SI	SI
Silt (point 3)	Y	Y	Y	Y	Y	Y
Embeddedness[a]						
Point 1	0	0	0	0	0	0
Point 2	0	0	0	0	0	0
Point 3	0	0	0	0	0	0
Left bank canopy (degrees)	90	80	90	60	60	80
Right bank canopy (degrees)	80	90	55	90	70	75
Canopy angle (degrees)	10	10	35	30	50	25
Aspect[b] (degrees)	205	115	110	85	200	87
Habitat features (type and percent of transect)						
Woody snags	0	10	40	10	50	20
Overhanging vegetation (terrestrial)	50	10	10	0	20	10
Undercut banks	0	0	0	0	0	0
Boulders	0	0	0	0	0	0
Sloughs	0	0	0	0	0	0
Macrophytes-emergent	0	0	0	0	0	0
Macrophytes-submerged	0	0	0	0	0	0
Macrophytes-floating	0	0	0	0	0	0
Rubbish	0	0	0	0	0	0
Other	0	0	0	0	0	0

[a]Embeddedness is a numerical rating that describes the extent to which coarse material, such as boulders, cobbles, and bedrock, is covered by fine material (sand, silt, fine particulate organic matter). An embeddedness rating of zero (0) indicates that no coarse material is visible.

[b]Aspect is the direction of streamflow at the center of the transect (degrees, magnetic).

CEDAR CREEK NEAR WISE LAKE (Continued)

[T-n, transect number; m, meters; >, greater than; OD, organic detritus; MU, muck; SA, sand; SI, silt; I, island; Y, yes; NO, none; NA, not applicable. Referring to bank shape: LN, linear; CC, concave; CV, convex. Referring to bank erosion: CB, undercut bank; SL, slab failure; RO rotational failure]

Habitat characteristic	T-1	T-2	T-3	T-4	T-5	T-6
Bar/Shelf/Island						
Type point 1	I	NO	NO	NO	NO	NO
Width point 1 (m)	9.5	NA	NA	NA	NA	NA
Substrate (dominant) point 1	SI	NA	NA	NA	NA	NA
Substrate (subdominant) point 1	SI	NA	NA	NA	NA	NA
Woody vegetation cover point 1 (percent)	80	NA	NA	NA	NA	NA
Herbaceous vegetation cover point 1 (percent)	80	NA	NA	NA	NA	NA
Bank parameters						
Left bank angle (degrees)	90	19	22	5	7	11
Right bank angle (degrees)	23	23	90	90	8	90
Left bank height (m)	2.89	2.69	2.28	2.19	2.64	2.56
Right bank height (m)	1.99	2.32	2.7	2.38	1.93	3.00
Left bank vegetation stability	3	4	3	4	3	3
Left bank shape	LN	CC	CC	CC	CC	CC
Left bank erosion	CB	NO	NO	NO	NO	NO
Right bank vegetation stability	2	3	2	1	4	1
Right bank shape	CC	CC	LN	LN	CC	LN
Right bank erosion	NO	NO	SL	SL	NO	SL
Left bank dominant substrate	SI	SI	SI	SI	SI	SI
Left bank subdominant substrate	NO	NO	NO	NO	NO	NO
Right bank dominant substrate	SA	SI	SI	SI	SI	SI
Right bank subdominant substrate	SI	NO	NO	NO	NO	NO

TOMS CREEK

[T-n, transect number; m, meters; >, greater than; OD, organic detritus; MU, muck; SA, sand; SI, silt; I, island; Y, yes; NO, none; NA, not applicable. Referring to bank shape: LN, linear; CC, concave; CV, convex. Referring to bank erosion: CB, undercut bank; SL, slab failure; RO rotational failure]

Habitat characteristic	T-1	T-2	T-3	T-4	T-5	T-6
Distance to reach boundary closest to reference location (m)	0	30.3	65.9	97.0	124.0	155.0
Channel width at bank full (m)	6.7	6.0	5.6	6.6	8.3	7.0
Left bank width (m)	0	0	0	0	0	0
Right bank width (m)	0	0	0	0	0	0
Left bank flood plain width (m)	>50	>50	>50	>50	>50	>50
Right bank flood plain width (m)	>50	>50	>50	>50	>50	>50
Depth at thalweg (m)						
Point 1	0.64	1.00	0.64	0.74	0.38	0.88
Point 2	.6	.50	.76	.58	.48	.74
Point 3	.52	.40	.54	.30	.64	.40
Distance from left bank (m)						
Point 1	1.4	2	1.6	2.2	2.3	2.2
Point 2	3.0	3.5	2.8	3.5	4.5	3.5
Point 3	4.6	4.7	4.2	4.7	7.1	5.0
Dominant bed substrate (point 1)	SA	SA	SA	SA	SA	SA
Subdominant (point 1)	SI	SI	SI	SI	NO	NO
Silt (point 1)	Y	Y	Y	Y	Y	NO
Dominant (point 2)	SA	SA	SA	SA	SA	SA
Subdominant (point 2)	SI	SI	SI	SI	NO	NO
Silt (point 2)	Y	Y	Y	Y	Y	NO
Dominant (point 3)	SA	SA	SA	SA	SA	SA
Subdominant (point 3)	SI	SI	SI	SI	NO	NO
Silt (point 3)	Y	Y	Y	Y	Y	NO
Embeddedness[a]						
Point 1	0	0	0	0	0	0
Point 2	0	0	0	0	0	0
Point 3	0	0	0	0	0	0
Left bank canopy (degrees)	90	90	90	90	90	90
Right bank canopy (degrees)	90	75	70	80	85	90
Canopy angle (degrees)	0	15	20	10	5	0
Aspect[b] (degrees)	120	177	187	190	230	255
Habitat features (type and percent of transect)						
Woody snags	20	35	50	10	30	10
Overhanging vegetation (terrestrial)	0	0	0	0	0	0
Undercut banks	0	0	0	0	0	0
Boulders	0	0	0	0	0	0
Sloughs	0	0	0	0	0	0
Macrophytes-emergent	0	0	0	0	0	0
Macrophytes-submerged	0	0	0	0	0	0
Macrophytes-floating	0	0	0	0	0	0
Rubbish	0	0	0	0	0	0
Other	0	0	0	0	0	0

[a]Embeddedness is a numerical rating that describes the extent to which coarse material, such as boulders, cobbles, and bedrock, is covered by fine material (sand, silt, fine particulate organic matter). An embeddedness rating of zero (0) indicates that no coarse material is visible.

[b]Aspect is the direction of streamflow at the center of the transect (degrees, magnetic).

TOMS CREEK (Continued)

[T-n, transect number; m, meters; >, greater than; OD, organic detritus; MU, muck; SA, sand; SI, silt; I, island; Y, yes; NO, none; NA, not applicable. Referring to bank shape: LN, linear; CC, concave; CV, convex. Referring to bank erosion: CB, undercut bank; SL, slab failure; RO rotational failure]

Habitat characteristic	T-1	T-2	T-3	T-4	T-5	T-6
Bank parameters						
Left bank height (m)	0.99	1.39	0.87	1.11	0.99	1.60
Right bank height (m)	.86	1.14	.96	.87	.87	1.15
Left bank vegetation stability	3	4	4	4	4	5
Left bank shape	CC	LN	LN	LN	LN	LN
Left bank erosion	NO	NO	CB	CB	CB	CB
Right bank vegetation stability	3	3	3	3	4	5
Right bank shape	CC	CC	CC	CC	CC	CC
Right bank erosion	NO	NO	NO	NO	NO	NO
Left bank dominant substrate	SI	SI	SI	SI	SA	SA
Left bank subdominant substrate	SA	SA	SA	SA	SI	SI
Right bank dominant substrate	SI	SI	SI	SI	SA	SA
Right bank subdominant substrate	SA	SA	SA	SA	SI	SI

Site descriptions

[m, meters]

CONGAREE RIVER AT COLUMBIA

USGS downstream order number: 02169500

The bed-sediment and tissue collections were conducted at the confluence of the Saluda and the Broad Rivers at the Gervais Street Bridge in Columbia. Fish collections and algae/macroinvertebrate collections were accomplished within a designated reach of the river, commencing at the Barney Jordan Public Boat Landing and extending to the Blossom Street Bridge. The reach is 2,896 m in length along the right bank and 3,050 m long along the left bank, and 130 to 190 m in width. Macroinvertebrates and algae were collected from submerged logs along the banks, from rocks in a wadeable section downstream of the railroad bridge along the left bank, and from willow (*Salix* sp.) branches trailing in the water. The habitat presented by tree branches in the Congaree River has been documented by Patrick (1996). Two impoundments in the Saluda River upstream of the site, Lakes Murray and Greenwood, and an impoundment on the Broad River (Monticello Reservoir) eliminate stable shallow water habitats by causing unpredictable daily changes in river stage. The changes in river stage periodically flush the reach and remove woody snags and debris dams. In addition, sediments transported by the Broad River tend to smother benthic habitats during periods of low flow.

MYERS CREEK

USGS downstream order number: 02169660

This site is located upstream of the bridge on Secondary State Route (SSR) 734 near Hopkins, S.C. It is at the northwestern boundary of the Congaree Swamp National Monument. The reach begins 40 m upstream of the bridge and extends for 158 m upstream.

Approximate position of start of reach is latitude 33°50'27", longitude 80°51'36".

Transect 1 (T-1) is the beginning of the reach and is marked with a spike driven into the inboard side of the trunk of a sweet gum (*Liriodendron styraciflua*) tree, about 3 feet up from the bank-full point, on the left bank. Bank-full channel width is 9.7 m.

Transect 2 (T-2) is 30 m upstream of T-1. It is marked with a "2" on the inboard side of the trunk of a *Liriodendron styraciflua* on the left bank. The channel width (bank full to bank full) is 7.2 m.

Transect 3 (T-3) is 33.8 m upstream of T-2. A red maple (*Acer rubrum*) has here been marked with a "3" on the inboard side of its trunk at breast height. At this site, a large, blown down tree (blowdown) bridges the stream (bridging blowdown) just upstream of the transect. Channel width is 10.5 m.

Transect 4 (T-4) is 36 m upstream of T-3 (99.8 m upstream of T-1). It is marked with the number "4" painted on the inboard side of the largest of three *Acer rubrum* trees growing in a close clump on the left bank. Immediately upstream of T-4 are two bridging blowdowns. Directly opposite the marked *A. rubrum*, are three Tupelos (*Nyssa aquatica*) growing side by side on the right bank.

Transect 5 (T-5), marked with the number "5" painted on the inboard side of a dual-trunk sweetgum, *Liriodendron styraciflua*, on the left bank, is 29 m upstream of T-4. At this site there is a small bed of aquatic macrophytes. On the right side of the stream is a slough that becomes a channel during high water and creates a small island. Another blowdown extends from the left bank to the downstream tip of the island.

Transect 6 (T-6) is 29 m upstream of T-5 and 157.8 m upstream of T-1. The marker for this transect is a multi-trunk *Acer rubrum* with a "6" painted on the inboard side and a spike driven into the trunk below the number. The spike has a piece of orange tree-tape tied around it. There is a large bed of aquatic macrophytes within the transect.

CEDAR CREEK, RICHLAND COUNTY, S.C.

USGS downstream order number: 02169670

This site is located just upstream of the bridge on SSR 734 near Hopkins, S.C., and is at the northwest corner of the Congaree Swamp National Monument. Latitude 33°50'23", longitude 80°51'38".

The reach commences 37 m upstream of the bridge and extends for a total length of 168 m. This is a second order stream resulting from the confluence of Cedar Creek and Reedy Branch about 550 m upstream of the beginning of the study reach. On Cedar Creek about 50 m upstream of the confluence is Duffies Pond. This impoundment of approximately 20 acres (0.083 km^2) is the result of damming Cedar Creek and provides a steady flow to Cedar Creek.

The first of 6 transects (T-1) coincides with the beginning (downstream end) of the reach. It is marked by a spike driven into the inboard side of the trunk of a sweet gum tree (*Liquidambar styraciflua*) on the right bank.

Transect 2 (T-2) is 35 m upstream of T-1 (72 m from the bridge) and is marked with a painted “2” on the trunk of a sweet gum tree (*L. styraciflua*) on the left bank, and a white blotch on the trunk of an overhanging red bay (*Persea borbonia*) inboard of the gum tree.

Transect 3 (T-3) is 39 m upstream from T-2 (111 m from the bridge). Marked with a painted “3” on the downstream side of a bridging *L. styraciflua* on the right bank.

Transect 4 (T-4) is 29 m upstream of T-3 (140 m from the bridge). Marked by a painted “4” on the inboard side of a red maple (*Acer rubrum*) that overhangs the stream from the left bank.

Transect 5 (T-5) is 34 m upstream of T-4 (174 m from the bridge). Marked by a painted number “5”on a maple (*Acer* sp.) tree on the left bank.

Transect 6 (T-6) is 31 m upstream of T-5 (205 m from the bridge). Marked with a painted “6” on the trunk of a *L. styraciflua* on the right bank and a spike in the inboard side of the trunk.

CEDAR CREEK NEAR WISE LAKE

USGS downstream order number: 02169672

The site is located inside the Congaree Swamp National Monument at the Hunt Club. The study reach commences at the USGS gage (latitude 33°48'58", longitude 80°49'39") and extends upstream for 271.2 m.

Transect 1 (T-1) commences approximately 2 m upstream of the USGS gage on the left bank. A red tree flag marks the right bank, tied about a tree stump with the number "1" painted in white on the inboard side.

Transect 2 (T-2) is 47 m upstream of T-1. Right bank marker is an ironwood tree (*Carpinus caroliniana*) with orange flagging and the number "2" painted on the inboard side of the trunk.

Transect 3 (T-3) is 52.7 m upstream of T-2. Right bank marker is orange flagging on an ironwood tree (*C. caroliniana*) with the number "3" painted in white on the inboard side of the tree trunk.

Transect 4 (T-4) is 45.0 m upstream of T-3. Right bank marker is orange flagging around an oak tree (*Quercus* sp.) with the number "4" painted in white on inboard side of the tree trunk.

Transect 5 (T-5) is 75 m upstream of T-4. Right bank marker is dead tree with orange flagging and the number "5" painted in white on inboard side.

Transect 6 (T-6) is 51.5 m upstream of T-5. Orange flagging around *Carpinus caroliniana* on right bank, and the number "6" is painted in white on inboard side. Left bank marker is a spike in downstream side of a gum (*L. styraciflua*) at breast height.

TOMS CREEK NEAR GADSDEN, S.C.

USGS downstream order number: 021696966

The Toms Creek site is located in Richland County, S.C. Take S.C. 48 southeast of Columbia toward the Wateree River. Turn right on SSR 489. Proceed for approximately 2.6 mi., turn right on dirt road, cross railroad tracks. Go straight at road split until you cross the stream. Bridge is dirt road over three drainage culverts. The bridge is the permanent reference point for this site, at latitude 33°48'42", longitude 80°43'31". The 150 m-long study site commences approximately 59 m upstream of the bridge.

The reach commences at transect 1 (T-1) 59 m upstream of the reference point. Marked with a spike in the inboard side of a red maple (*A. rubrum*) on the left bank.

Transect 2 (T-2) is located 30.3 m upstream of T-1, marked by blue tree tape on a small red maple (*Acer rubrum*) on the right bank, and a spray-painted white blotch and the number "2" on the trunk.

Transect 3 (T-3) is 35.6 m upstream of T-2, marked by a twin tupelo on the left bank, with "T3" painted on the trunk and blue tape tied to trunk.

Transect 4 (T-4) is 31.1 m upstream of T-3, with "T4" painted on trunk of a tupelo (*N. aquatica*) on left bank and blue tree tape tied around trunk.

Transect 5 (T-5) is 27 m upstream of T-4, with "T5" painted on small gum tree (*L. styraciflua)* on the right bank and blue tape around the tree trunk.

Transect 6 (T-6) is 31 m upstream of T-5, with "T6" painted on the trunk of a tupelo (*N. aquatica*) on the right bank. This is the end of the reach; also marked with a white-painted spike driven into the inboard side of the trunk.

Appendix 8. Macroinvertebrate fauna density
[Organsims per square meter of substrate —, not found]

Macroinvertebrate taxa	Congaree River at Columbia	Myers Creek	Cedar Creek	Cedar Creek near Wise Lake	Toms Creek
Acari	—	118	94	115	70
Amphipoda	—	—	2	—	—
Bryozoa	—	—	2	—	—
Collembola	—	—	11	—	—
Hemiptera	—		—	325	—
Hirudinea	—	—	—	29	—
Insecta - Coleoptera - Elmidae	53	118	177	10	427
Insecta - Coleoptera - Gyrinidae	—	94	109	5	4
Insecta - Coleoptera - Hydrophilidae	—	—	—	5	—
Insecta - Diptera - Ceratopogonidae	11	25	—	115	18
Insecta - Diptera - Chironomidae	1,188	4,055	2,149	7,855	1,293
Insecta - Diptera - Empididae	53	262	77	—	95
Insecta - Diptera - Simuliidae	11	104	324	—	43
Insecta - Diptera - Tipulidae	32	—	—	—	—
Insecta - Ephemeroptera	64	941	315	—	150
Insecta - Lepidoptera	—	—	—	—	2
Insecta - Megaloptera	—	—	2	29	4
Insecta - Odonata - Anisoptera	—	5	28	57	—
Insecta - Odonata - Zygoptera	—	5	4	—	7
Insecta - Plecoptera	—	123	70	—	77
Insecta - Trichoptera	389	4,483	11	296	819
Isopoda	—	—	—	817	—
Malacostraca	—	108	—	—	—
Mollusca - Gastropoda	48	5	—	583	—
Mollusca - Pelycypoda	—	—	20	568	—
Nematoda	85	310	33	430	15
Nemertia	—	—	—	29	—
Oligochaeta	1,041	571	855	860	308
Platyhelminthes - Turbellaria	—	—	46	182	9
Porifera	—	—	—	—	2
Total organisms per square meter substrate	2,975	11,327	4,329	12,310	3,343
Significant taxonomic groups	11	16	19	18	17

Appendix 9. Fish fauna
[g, grams]

MYERS CREEK

Scientific name	Common name	Total weight (g)	Number collected
Ameiurus natalis	yellow bullhead	194.4	2
Aphredoderus sayanus	pirate perch	4.2	2
Enneacanthus chaetodon	blackbanded sunfish	8.2	4
Esox americanus	redfin pickerel	10.3	2
Etheostoma olmstedi	tessellated darter	7.7	8
Gambusia holbrooki	eastern mosquitofish	.8	4
Labidesthes sicculus	brook silverside	2.1	3
Lepomis auritus	redbreast sunfish	478.8	7
Lepomis gulosus	warmouth	156.8	4
Lepomis macrochirus	bluegill	174.0	56
Lepomis marginatus	dollar sunfish	40.4	7
Lepomis punctatus	spotted sunfish	119.5	6
Minytrema melanops	spotted sucker	6,400.0	7
Notropis petersoni	coastal shiner	6.1	10
Perca flavescens	yellow perch	610.3	17

CEDAR CREEK

Scientific name	Common name	Total weight (g)	Number collected
Ameiurus natalis	yellow bullhead	108.2	2
Ameiurus nebulosus	brown bullhead	29.9	2
Enneacanthus chaetodon	blackbanded sunfish	34.7	12
Enneacanthus gloriosus	bluespotted sunfish	51.4	4
Esox niger	chain pickerel	258.4	5
Etheostoma olmstedi	tessellated darter	2.2	1
Gambusia holbrooki	eastern mosquitofish	4.1	9
Labidesthes sicculus	brook silverside	1.8	3
Lepomis auritus	redbreast sunfish	260.4	3
Lepomis gulosus	warmouth	270.9	9
Lepomis macrochirus	bluegill	22.3	4
Lepomis marginatus	dollar sunfish	213.1	8
Lepomis punctatus	spotted sunfish	94.5	3
Lepomis sp.	sunfish species	22.5	14
Micropterus salmoides	largemouth bass	29.0	2
Minytrema melanops	spotted sucker	845.5	3
Notropis cummingsae	dusky shiner	16.0	32
Notropis petersoni	coastal shiner	.5	1
Noturus gyrinus	tadpole madtom	2.6	1
Noturus insignis	margined madtom	79.8	13
Noturus leptacanthus	speckled madtom	4.9	1
Perca flavescens	yellow perch	93.8	5
Percina crassa	piedmont darter	1.6	1
Pteronotropis hypselopterus	sailfin shiner	.6	15

Appendix 9. Fish fauna—Continued
[g, grams]

CEDAR CREEK NEAR WISE LAKE

Scientific name	Common name	Total weight (g)	Number collected
Amia calva	bowfin	[a]	1
Aphredoderus sayanus	pirate perch	[b]	1
Esox niger	chain pickerel	[b]	1
Etheostoma olmstedi	tessellated darter	1.0	1
Labidesthes sicculus	brook silversides	1.6	1
Lepomis auritus	redbreast sunfish	961.9	9
Lepomis gulosus	warmouth	319.6	5
Lepomis macrochirus	bluegill	128.4	3
Lepomis marginatus	dollar sunfish	[b]	1
Lepomis microlophus	redear sunfish	730.4	9
Micropterus salmoides	largemouth bass	4,323.4	9
Minytrema melanops	spotted sucker	2,585.4	6
Notropis petersoni	coastal shiner	3.0	1
Noturus insignis	margined madform	[b]	1
Perca flavescens	yellow perch	622.4	13
Pomoxis nigromaculatis	black crappie	136.5	1

[a]Fish escaped before it could be weighed.
[b]No weight data available.

TOMS CREEK

Scientific name	Common name	Total weight (g)	Number collected
Ameiurus natalis	yellow bullhead	229.8	5
Erimyzon oblongus	creek chubsucker	14.4	1
Esox americanus	redfin pickerel	282.8	10
Esox niger	chain pickerel	219.5	4
Gambusia holbrooki	eastern mosquitofish	3.7	14
Lepomis auritus	redbreast sunfish	805.0	13
Lepomis gulosus	warmouth	75.3	4
Lepomis macrochirus	bluegill	61.3	1
Lepomis marginatus	dollar sunfish	116.6	13
Lepomis punctatus	spotted sunfish	360.3	15
Minytrema melanops	spotted sucker	800.0	1
Notropis cummingsae	dusky shiner	25.1	51
Perca flavescens	yellow perch	115.3	3
Pteronotropis hypselopterus	sailfin shiner	47.8	81

Appendix 10. Fish indices of biotic integrity (IBI)

[#, number; %, percent; <, less than; >, greater than; IBI score: 12–28, very poor; 29–40, poor; 41–48, fair; 49–58, good; >58 excellent]

	Congaree River at Columbia			Myers Creek			Cedar Creek			Cedar Creek near Wise Lake			Toms Creek		
Metric	#	%	Score[a]	#	%	Score[a]	#	%	Score[a]	#	%	Score[a]	#	%	Score[a]
Native species	15		3	14		3	23		5	16		5	13		3
Open-water species	7		5												
Benthic insectivorous species				3		1	5		3	1		1	2		1
Sunfish species	2		1	5		3	6		5	5		3	5		3
Cyprinid species	2		1	1		1	3		1	1		1	3		1
Intolerant species	2		3	3		3	4		5	3		3	0		1
Tolerant individuals	89	94	1	107	78	1	144	94	1	49	82	1	216	100	1
Omnivorous individuals	41	43	3	17	13	5	33	21	3	23	38	3	0	0	5
Insectivorous or invertivorous individuals	11	12	1	118	86	5	111	72	5	39	65	5	199	92	5
Piscivorous individuals	10	11	5	2	15	3	10	6	5	2	3	3	17	8	5
Hybrid individuals	0	0	5	0	0	5	14	9	5	0	0	5	0	0	5
Anomalies	18	19	1	10	7	3	8	5	1	46	77	1	1	<1	5
Total fish	95		5	137		5	154		5	60		3	216		5
Total species	20			15			24			16			14		
IBI score			**34**			**38**			**44**			**34**			**40**
Water-quality designation			**Poor**			**Poor**			**Fair**			**Poor[b]**			**Poor**

[a]The metric scores are applied as follows:

	Metric score criteria		
Metric	1	3	5
Native species	<9	9–15	>15
Open-water species	<4	4–6	>6
Benthic insectivorous species	<4	4–6	>6
Sunfish species	<4	4–5	>5
Cyprinid species	<4	4–6	>6
Intolerant species	<2	2–3	>3
Tolerant individuals	>45%	20–45%	<20%
Omnivorous individuals	>45%	20–45%	<20%
Insectivorous or invertivorous individuals	<25%	25–50%	>50%
Piscivorous individuals	<2	2–5	>5
Hybrid individuals	>1	1	0
Anomalies	>5	2–5	<2

[b]The designation "poor" for this stream should be viewed with caution. Fish collection was hampered by low conductivity, deep bed sediment, dark water, and unsafe conditions for shocking. Seining was not feasible because of numerous woody snags. Four additional species were collected in subsequent trips but are not included in the shocking data because they were not collected as part of the standard procedure. They are included in the species list and are added to the IBI after the fish collected in the standard run.

Appendix 11. Tissue pesticides

[nd, not detected; concentrations in micrograms per kilogram]

Analyte	Congaree River at Columbia (Left bank)	Congaree River at Columbia (Right bank)	Congaree River at Columbia	Myers Creek	Cedar Creek	Cedar Creek	Toms Creek	Congaree River at Highway 601
	Test organism							
	Asiatic clam	Asiatic clam	Common carp	Red-breast sunfish	Native clam (*Elliptio* sp.)	Redbreast sunfish	Red-breast sunfish	Asiatic clam
Aldrin	nd	nd	nd	nd	nd	nd	nd	nd
Dacthal	nd	nd	nd	nd	nd	nd	nd	nd
alpha-HCH	nd	nd	nd	nd	nd	nd	nd	nd
Endrin	nd	nd	nd	nd	nd	nd	nd	nd
gamma-HCH (Lindane)	nd	nd	nd	nd	nd	nd	nd	nd
Heptachlor	nd	nd	nd	nd	nd	nd	nd	nd
Mirex	nd	nd	nd	nd	nd	nd	nd	nd
o,p'-DDE	nd	nd	nd	nd	nd	nd	nd	nd
o,p'-DDD	nd	nd	nd	nd	nd	nd	nd	nd
o,p'-DDT	nd	nd	nd	nd	nd	nd	nd	nd
o,p'-Methoxychlor	nd	nd	nd	nd	nd	nd	nd	nd
Oxychlordane	nd	nd	nd	nd	nd	nd	nd	nd
p,p'-DDT	nd	nd	nd	nd	nd	nd	nd	nd
p,p'-Methoxychlor	nd	nd	nd	nd	nd	nd	nd	nd
Pentachloroanisole	nd	nd	nd	nd	nd	nd	nd	nd
Total PCB	nd	nd	nd	nd	nd	nd	nd	nd
Toxaphene	nd	nd	nd	nd	nd	nd	nd	nd
beta-BHC	nd	nd	nd	nd	nd	nd	nd	nd
cis-Nonachlor	nd	nd	6.7	nd	nd	nd	nd	nd
Dieldrin	nd	nd	7.6	nd	nd	nd	nd	nd
Heptachlor epoxide	nd	nd	nd	nd	nd	nd	nd	nd
p,p'-DDD	nd	nd	27	nd	nd	nd	nd	nd
trans-Chlordane	nd	nd	10	nd	nd	nd	nd	nd
trans-Nonachlor	nd	nd	21	nd	nd	nd	nd	nd
cis-Chlordane	nd	5.2	15	nd	nd	nd	nd	nd
p,p'-DDE	16	16	180	5.1	nd	16	10	6.2

Appendix 12. Elements in carp liver tissue from the Congareee River at Columbia

[Concentrations in micrograms per gram, dry weight]

Element	Concentration
Aluminum	13.8
Antimony	0
Arsenic	.29
Barium	.144
Beryllium	0
Boron	0
Cadmium	10.1
Chromium	0
Cobalt	.18
Copper	110.61
Iron	1,430
Lead	.23
Manganese	3.72
Mercury	.31
Molybdenum	.87
Nickel	0
Selenium	5.23
Silver	.86
Strontium	.767
Uranium	0
Vanadium	1.92
Zinc	657

Appendix 13. Sediment organochlorine pesticides

[nd, not detected; concentrations in micrograms per kilogram]

Analyte	Congaree River at Columbia (Left bank)	Congaree River at Columbia (Right bank)	Myers Creek	Cedar Creek	Cedar Creek near Wise Lake	Toms Creek	Congaree River at Highway 601
Aldrin	nd	nd	nd	nd	nd	nd	nd
alpha-HCH	nd	nd	nd	nd	nd	nd	nd
beta-HCH	nd	nd	nd	nd	nd	nd	nd
Chlorneb	nd	nd	nd	nd	nd	nd	nd
cis-Chlordane	nd	0.64	nd	nd	nd	nd	nd
cis-Nonachlor	nd	nd	nd	nd	nd	nd	nd
cis-Permethrin	nd	nd	nd	nd	nd	nd	nd
DCPA (Dacthal)	nd	nd	nd	nd	nd	nd	nd
Dieldrin	nd	.51	nd	nd	nd	nd	nd
Endosulfan	nd	nd	nd	nd	nd	nd	nd
Endrin	nd	nd	nd	nd	nd	nd	nd
gamma-HCH (Lindane)	nd	nd	nd	nd	nd	nd	nd
Heptachlor	nd	nd	nd	nd	nd	nd	nd
Heptachlor epoxide	nd	nd	nd	nd	nd	nd	nd
Isodrin	nd	nd	nd	nd	nd	nd	nd
Mirex	nd	nd	1.2	nd	nd	nd	nd
o,p'-DDE	nd	nd	nd	nd	nd	nd	nd
o,p'-DDD	nd	2.7	nd	nd	nd	nd	nd
o,p'-DDT	1.5	nd	nd	nd	nd	nd	nd
o,p'-Methoxychlor	nd	nd	nd	nd	nd	nd	nd
Oxychlordane	nd	nd	nd	nd	nd	nd	nd
p,p'-DDD	1.6	2.4	5.0	nd	nd	1.9	nd
p,p'-DDE	3.7	1.2	9.7	0.17	4.2	3.2	3.8
p,p' DDT	2.5	2.1	nd	nd	nd	nd	nd
p,p'-Methoxychlor	nd	nd	nd	nd	nd	nd	nd
Pentachloroanisole	nd	nd	nd	nd	nd	nd	nd
Total PCB	nd	nd	nd	nd	nd	nd	nd
Toxaphene	nd	nd	nd	nd	nd	nd	nd
trans-Chlordane	nd	.62	nd	nd	nd	nd	nd
trans-Nonachlor	nd	.47	nd	nd	nd	nd	nd
trans-Permethrin	nd	nd	nd	nd	nd	nd	nd
Sum	9.3	10.64	15.9	0.17	4.2	5.1	3.8

Appendix 14. Sediment non-pesticide organic compounds

[nd, not detected; concentrations in micrograms per kilogram unless otherwise indicated]

Analyte	Congaree River at Columbia (Left bank)	Congaree River at Columbia (Right bank)	Myers Creek	Cedar Creek	Cedar Creek near Wise Lake	Toms Creek	Congaree River at Highway 601
1-Methyl-9H-fluorene	nd	31	nd	nd	nd	nd	19
1,2-Dimethylnapthalene	8	12	nd	nd	nd	nd	6
1,2,4-Trichlorobenzene	nd	nd	nd	nd	nd	nd	nd
1,6-Dimethylnapthalene	20	29	nd	nd	23	16	6
1-Methylphenanthrene	27	110	41	nd	27	15	37
1-Methylpyrene	41	120	nd	nd	nd	nd	49
2,2-Biquinoline	nd	nd	nd	nd	nd	nd	nd
2,3,6-Trimethylnapthalene	12	20	nd	nd	nd	nd	17
2,4-Dinitrotoluene	nd	nd	nd	nd	nd	nd	nd
2,6-Dimethylnapthalene	17	33	44	nd	36	27	22
2,6-Dinitrotoluene	nd	nd	nd	nd	nd	nd	nd
2-Chloronaphthalene	nd	nd	nd	nd	nd	nd	nd
2-Chlorophenol	nd	nd	nd	nd	nd	nd	nd
2-Ethylnaphthalene	nd	nd	nd	nd	nd	nd	nd
2-Methylanthracene	31	81	nd	nd	nd	nd	30
4-Bromophenylphenylether	nd	nd	nd	nd	nd	nd	nd
4-Chlorophenyl phenyl ether	nd	nd	nd	nd	nd	nd	nd
4H-cyclopenta(*d,e,f*)phenanthrene	29	110	53	nd	5	11	35
9H-Fluorene	18	33	nd	nd	nd	nd	13
Acenaphthene	14	37	nd	nd	nd	nd	7
Acenaphthylene	25	95	21	nd	nd	13	33
Acridine	40	29	nd	nd	nd	nd	9
Anthracene	28	140	nd	26	nd	12	27
Anthroquinone	69	52	nd	nd	nd	nd	27
Azobenzene	nd	nd	nd	nd	nd	nd	nd
Benzene, p-Dichloro	12	12	nd	nd	nd	nd	nd
Benzo(*a*)anthracene	150	370	120	35	52	42	120
Benzo(*a*)pyrene	210	440	570	nd	nd	nd	140
Benzo(*b*)fluoranthene	230	350	140	nd	21	25	140
Benzo(*c*)quinoline	nd	nd	nd	nd	nd	nd	nd
Benzo(*g,h,i*)perylene	97	140	nd	nd	nd	nd	95
Benzo(*k*)fluoranthene	150	240	98	nd	15	31	80
bis(2-Chloroethoxy) methane	nd	nd	nd	nd	nd	nd	nd
bis(2-Ethylhexyl) phthalate	1,900	200	260	60	nd	93	220
Butylbenzyl phthalate	42	45	nd	47	51	nd	87
C8-Alkylphenols	nd	nd	nd	nd	nd	nd	nd
Carbazole	46	25	nd	nd	nd	nd	11
Carbon, total (g/kg)	7.2	19	nd	5.7	nd	nd	nd
Carbon, inorganic (g/kg)	0.5	0.1	nd	nd	nd	nd	nd
Carbon, organic (g/kg)	6.7	19	nd	5.7	nd	nd	nd
Chrysene	210	340	70	25	48	56	120
Di-*n*-butyl phthalate	56	48	160	76	85	49	76
Di-*n*-octyl phthalate	45	43	nd	nd	nd	39	98
Dibenzo(*a,h*)anthracene	59	79	nd	nd	nd	nd	69

Appendix 14. Sediment non-pesticide organic compounds—Continued

[nd, not detected; concentrations in micrograms per kilogram unless otherwise indicated]

Analyte	Congaree River at Columbia (Left bank)	Congaree River at Columbia (Right bank)	Myers Creek	Cedar Creek	Cedar Creek near Wise Lake	Toms Creek	Congaree River at Highway 601
Dibenzothiophene	16	50	19	nd	nd	nd	14
Diethyl phthalate	25	24	47	29	nd	nd	20
Dimethyl phthalate	14	11	nd	21	51	nd	nd
Fluoranthene	330	530	340	39	55	96	160
Hexachlorobenzene	nd	nd	nd	nd	nd	nd	nd
Indeno(1,2,3-cd)pyrene	230	310	nd	nd	nd	nd	66
Isophorone	nd	nd	nd	nd	nd	nd	nd
Isoquinoline	12	13	nd	nd	nd	nd	nd
N-Nitroso-diphenylamine	nd	nd	nd	nd	6	nd	nd
N-Nitrosodi-n-propylamine	nd	nd	nd	nd	nd	nd	nd
Naphthalene	22	48	nd	nd	nd	nd	17
Nitrobenzene	nd	nd	nd	nd	nd	nd	nd
p-Cresol	14	8	260	44	nd	nd	96
Pentachloronitrobenzene	nd	nd	nd	nd	nd	nd	nd
Phenanthrene	120	320	130	15	50	47	67
Phenanthridine	23	21	nd	nd	nd	nd	nd
Phenol	8	7	54	31	nd	nd	19
Pyrene	250	660	200	36	nd	71	200
Quinoline	nd	nd	nd	nd	nd	nd	nd
Sum[a]	4,664.4	5,304.1	2,580	495.4	497	643	2,110

[a]Sum allows quick comparison among streams. Note that Myers Creek sum is 4 to 5 times that of Cedar Creek, Cedar Creek near Wise Lake, and Toms Creek.

Appendix 15. Sediment trace elements

[As reported by laboratory, unadjusted for less than 63 micrometer fraction; concentrations in micrograms per gram; nd, not detected]

Element	Congaree River at Columbia (Left bank)	Congaree River at Columbia (Right bank)	Myers Creek	Cedar Creek	Cedar Creek near Wise Lake	Toms Creek	Congaree River at Highway 601
Antimony	0.8	0.7	0.5	0.3	0.4	0.5	0.6
Arsenic	5.7	5.7	3.1	3.5	3.6	6.6	5.4
Barium	620	670	460	360	560	320	650
Beryllium	2	3	2	2	3	2	3
Cadmium	.4	.3	.6	.3	.5	.4	.3
Cerium	120	160	81	140	100	96	130
Chromium	74	85	70	70	92	68	92
Cobalt	18	22	43	20	32	33	24
Copper	46	50	18	20	37	13	39
Europium	nd	nd	nd	nd	nd	nd	nd
Gallium	23	27	23	21	29	17	27
Gold	nd	nd	nd	nd	nd	nd	nd
Holmium	nd	nd	nd	nd	nd	nd	nd
Lanthanum	62	80	40	70	54	44	70
Lead	68	36	76	49	54	50	55
Lithium	30	40	30	30	50	20	40
Manganese	3,100	1,100	1,800	580	890	1,900	1,300
Mercury	.1	.08	.16	.11	.10	.12	.08
Molybdenum	2	nd	nd	nd	nd	nd	nd
Neodymium	49	65	31	54	42	35	58
Nickel	28	35	27	22	40	20	35
Niobium	18	21	26	19	27	21	24
Scandium	16	18	10	10	17	9	19
Selenium	.9	.8	.9	1.1	.7	.9	.7
Silver	.3	.2	.2	.2	.2	.2	.4
Strontium	140	160	58	56	93	46	150
Sulfur	.06	nd	.18	.13	.11	.16	nd
Thorium	21	22	16	34	14	17	16
Uranium	6.6	7.3	4.95	11.4	5.66	7.63	7.39
Vanadium	110	130	90	97	120	75	130
Ytterbium	3	3	1	2	2	2	3
Yttrium	28	30	22	19	29	25	36
Zinc	130	110	110	59	140	89	110

Appendix 16. Sediment major elements
[Concentrations in percent]

Element	Congaree River at Columbia (Left bank)	Congaree River at Columbia (Right bank)	Myers Creek	Cedar Creek	Cedar Creek near Wise Lake	Toms Creek	Congaree River at Highway 601
Aluminum	9.1	11	8.1	8.7	12	6.7	11
Calcium	.57	.59	.17	.1	.23	.12	.54
Inorganic carbon	2.53	2.07	.02	.03	.01	.03	.02
Iron	4.7	5	2.4	3.2	4	3.1	5.2
Magnesium	.43	.47	.17	.14	.44	.13	.49
Organic carbon	.03	.03	11.2	6.81	6.7	10.1	1.86
Phosphorus	.12	.12	.12	.1	.13	.1	.13
Potassium	1.4	1.5	.61	.7	1.1	.42	1.5
Sodium	.47	.46	.07	.09	.2	.05	.5
Titanium	.66	.79	.73	.69	.86	.64	.79
Organic and inorganic carbon	2.56	2.04	11.2	6.84	6.71	10.1	1.88

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