



OCCURRENCE OF INVERTEBRATES AT 38 STREAM SITES IN THE MISSISSIPPI EMBAYMENT STUDY UNIT, 1996–99

**U.S. GEOLOGICAL SURVEY
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Occurrence of Invertebrates at 38 Stream Sites in the Mississippi Embayment Study Unit, 1996–99

By B.J. Caskey, B.G. Justus, and Humbert Zappia

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For additional information write to:

District Chief
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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
<i>Length</i>		
micrometer (μm)	0.00003937	inch (in.)
millimeter (mm)	0.03937	inch (in.)
centimeter (cm)	0.3937	inch (in.)
meter (m)	3.2808	foot (ft)
kilometer (km)	0.6214	mile (mi)
<i>Volume</i>		
liter (L)	1.057	quart (qt)
liter (L)	0.2642	gallon (gal)
milliliter (mL)	0.00338	ounce, fluid
<i>Area</i>		
square kilometer (km ²)	247.105	acre
<i>Flow</i>		
cubic meter per second (m ³ /s)	0.02832	cubic foot per second (ft ³ /s)
meter per second (m/s)	3.28	foot per second (ft/s)

Temperature Conversion

Degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) by using the following equations:

$$^{\circ}\text{F} = 1.8(^{\circ}\text{C}) + 32$$

The following abbreviations and acronyms are used in this report:

MAP	Mississippi Alluvial Plain
MISE	Mississippi Embayment Study Unit
NAWQA	National Water-Quality Assessment
NWQL	National Water-Quality Laboratory
USGS	U.S. Geological Survey
RTH	richest targeted habitat
QMH	qualitative multihabitat

FOREWORD

The U.S. Geological Survey (USGS) is committed to serve the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life, and facilitates effective management of water, biological, energy, and mineral resources. Information on the quality of the Nation's water resources is of critical interest to the USGS because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for the multiple water uses make water availability, now measured in terms of quantity *and* quality, even more critical to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are the conditions changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues. NAWQA results can contribute to informed decisions that result in practical and effective water-resource management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in more than 50 of the Nation's most important river basins and aquifers, referred to as Study Units. Collectively, these Study Units account for more than 60 percent of the overall water use and population served by public water supply, and are representative of the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multi-scale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments on pesticides, nutrients, volatile organic compounds, trace metals, and aquatic ecology are developed at the national scale through comparative analysis of the Study-Unit findings.

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The Program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, Tribal, and local agencies, non-government organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Associate Director for Water

Occurrence of Invertebrates at 38 Stream Sites in the Mississippi Embayment Study Unit, 1996–99

By B.J. Caskey, B.G. Justus, and Humbert Zappia

ABSTRACT

A total of 88 invertebrate species and 178 genera representing 59 families, 8 orders, 6 classes, and 3 phyla was identified at 38 stream sites in the Mississippi Embayment Study Unit from 1996 through 1999 as part of the National Water-Quality Assessment Program. Sites were selected based on land use within the drainage basins and the availability of long-term streamflow data. Invertebrates were sampled as part of an overall sampling design to provide information related to the status and trends in water quality in the Mississippi Embayment Study Unit, which includes parts of Arkansas, Kentucky, Louisiana, Mississippi, Missouri, and Tennessee.

Invertebrate sampling and processing was conducted using nationally standardized techniques developed for the National Water-Quality Assessment Program. These techniques included both a semi-quantitative method, which targeted habitats where invertebrate diversity is expected to be highest, and a qualitative multihabitat method, which samples all available habitat types possible within a sampling reach. All invertebrate samples were shipped to the USGS National Water-Quality Laboratory (NWQL) where they were processed.

Of the 365 taxa identified, 156 were identified with the semi-quantitative method that involved sampling a known quantity of what was expected to be the richest habitat, woody debris. The qualitative method, which involved sampling all available habitats, identified 345 taxa. The number of organisms identified in the semi-quantitative samples ranged from 74 to 3,295, whereas the number of taxa identified ranged from 9 to 54. The number of organisms identified in the qualitative samples ranged from 42 to 29,634, whereas the number of taxa ranged from 18 to 81. From all the organisms identified, chironomid taxa were the most frequently identified, and plecopteran taxa were among the least frequently identified.

INTRODUCTION

In 1994, the U.S. Geological Survey (USGS) began studies in the Mississippi Embayment (MISE) Study Unit as part of the National Water-Quality Assessment (NAWQA) Program (Leahy and others, 1990). The primary goals of the NAWQA Program are to assess the status and trends in the quality of the Nation's water resources and to determine the natural and human factors affecting these resources (Hirsch and others, 1988). Some of the preliminary findings of the NAWQA Program have shown that streams in basins with significant agriculture or urban concentration almost always

contain complex mixtures of nutrients and pesticides (Fuhrer, 1999). Angermeier and others (1993) reported that streams with complex mixtures of nutrients and pesticides often have altered biological communities. Increasingly, invertebrate communities have been used in studies that develop relations between biological organisms and human perturbation.

The USGS NAWQA Program is using invertebrate community-structure data as part of an overall assessment of water-quality conditions, which is only one aspect of the biological component of the NAWQA Program (Cuffney and others, 1993b; Hirsch and others, 1988). In general, life spans of invertebrates are considered intermediate to those of other organisms such as algae, which may live only a few days--or fish, which may live from a few years to decades. Because of the intermediate life spans of invertebrates, biologists gain insights into relatively recent impacts to water quality (Cuffney and others, 1993b). Such understandings can help managers and policy makers to better anticipate, prioritize, and manage water quality in different hydrologic and land-use settings.

Purpose and Scope

This report documents the occurrence of invertebrate taxa at 38 sites in the MISE Study Unit from 1996 to 1999. This report also documents the methods and materials used for site selection, habitat characterization, and data collection. Finally, this report briefly summarizes the MISE invertebrate data.

Description of Study Unit

The MISE Study Unit lies within eight Level III Ecoregions: Arkansas Valley, Boston Mountains, Ozark Highlands, Interior River Lowlands, Mississippi Alluvial Plain, South Central Plains, Southeastern Plains, and Mississippi Valley Loess Plains (Omernik, 1986). Thirty-six of the sites sampled lie within the Mississippi Alluvial Plain (MAP) Ecoregion; of the two remaining sites, one is located in the Mississippi Valley Loess Plains Ecoregion and the other is in the Southeastern Plains Ecoregion (fig. 1). The MAP Ecoregion has been extensively altered by human activity. About 75 percent (or about 16 million acres) of the original forested wetlands has been cleared and drained (Nature Conservancy, 1992), and most streams in the MAP Ecoregion have some degree of channel and hydrological modifications.

Typical of lowland streams, many of the streams in the MAP can be characterized as having low relief and velocities (table 1) with relatively high turbidities. The climate of the MISE Study Unit is humid, with the southern part being more subtropical and the northern part being more temperate. Mean annual temperatures range from about 64 °F in the south to about 57 °F in the north. The mean annual precipitation ranges from about 56 inches in the south to about 48 inches in the north (U.S. Department of Commerce, 1995). Land use is dominated by agriculture, with most (approximately 85 percent) of the study area devoted to growing row crops such as cotton, corn, and soybeans, and small grains such as rice and wheat (Justus and Caskey, 1999).

Acknowledgments

The authors would like to acknowledge personnel from Mississippi Department of Environmental Quality and the MISE NAWQA staff who assisted in data collection; M. Brian Gregory and Allison R. Brigham for serving as colleague reviewers; and the Mississippi District Editor and Illustrator for their contributions to the final report.

SAMPLING STRATEGIES AND SITE SELECTION

In 1995, prior to sampling, eight sites in the MISE Study Unit (fig. 1) were selected for annual invertebrate sampling from 1996 through 1998 during low-flow periods to determine if invertebrate communities differ from year to year. At two of these sites (Bogue Phlia near Leland, MS, and Cache River near Cotton Plant, AR), multiple reaches were sampled to determine if the invertebrate communities showed variability associated with samples from different reaches within the same stream segment; consequently, invertebrates were sampled from 12 stream reaches in 1996. The eight sites were on seven streams within the MISE Study Unity boundary and located in five states: Arkansas, Louisiana, Mississippi, Missouri, and Tennessee. Considerations for site selection included land use, spatial coverage, and the availability of long-term streamflow data. Six of the eight sites and five of the seven streams are located in the MAP Ecoregion; of the two remaining sites, one is in the Mississippi Valley Loess Plains Ecoregion and the other is in the Southeastern Plains Ecoregion. All eight sites were sampled from 1996 to 1998; then, in addition, three of the eight sites (Bogue Phalia near Leland, MS; Tensas River at Tendal, LA; and Yazoo River below Steele Bayou near Long Lake, MS) were sampled in 1999.

Invertebrates also were sampled in 1997 at an additional 30 sites on 27 streams (table 2). Ten of these sites were selected because they represented a range of crop intensity for each of three major crops grown in the MAP Ecoregion—corn, rice, and cotton. The remaining 20 sites represented various land uses, increased spatial coverage of the MAP Ecoregion, and had availability of long-term streamflow data. Photographs and topographic maps of the 38 sites can be viewed at:
< http://ms.water.usgs.gov/ms_proj/nawqa/index.html > (U.S. Geological Survey, 2000).

At the eight sites sampled annually from 1996 to 1998 and three sites sampled in 1999, two types of samples were collected: richest targeted habitat (RTH) samples and qualitative multi-habitat (QMH) samples (table 2). The RTH samples are semi-quantitative; this type of sample cannot be used to quantify absolute abundance of invertebrates in the selected habitat, but can be used to describe the types of invertebrates present and their abundances relative to each other. The QMH samples are qualitative; this type of sample cannot be used to quantify abundances in a sampling reach, but can be used to determine the presence or absence of invertebrate taxa. At the 30 sites sampled in 1997, only QMH samples were collected (table 2).

After the sites were selected and prior to collection of invertebrate samples, a habitat assessment of the sampling reach was conducted at each site following protocols designed by the NAWQA Program (Meador and others, 1994). Following the NAWQA habitat protocols (Meador and others, 1994) for non-wadeable streams, a 500 m length of stream was measured and marked to indicate where the invertebrate samples would be collected. In general, the selected reaches (sites) were found to be channelized runs that consisted of sand and fine clay substrates and were seldom wadeable (table 1).

METHODS OF SAMPLE COLLECTION AND PROCESSING

Because the majority of the selected streams in the MISE Study Unit had low velocities, did not contain rocky substrates, and were non-wadeable, it was determined that sticks submerged for extended periods of time (seasoned) likely would be the invertebrate habitat with the greatest diversity. Consequently, the RTH samples were collected by cutting five seasoned sticks about 12 inches long by 1 inch in diameter (30.5 cm by 2.5 cm) and placing them into a 5-gallon bucket. The instantaneous velocity was measured at the point where each stick was collected and the mean velocity was calculated for each composite sample (table 1).

After five sticks were collected, the sample was taken to the stream bank where they were visually examined and picked of noticeable invertebrates, then brushed with a soft-bristled toothbrush, and gently sprayed with a pressure sprayer over a 425- μ m sieve. The material remaining in the sieve was washed with the pressure sprayer until it was free of unwanted debris and sediment. The large or rare organisms picked from the sample were placed into a 50-mL plastic bottle; all other organisms removed from the sticks were placed into a 1-L plastic bottle. The material and organisms remaining in the sieve were placed into the 1-L plastic bottle, and 10-percent formalin was used to preserve samples in both bottles.

The QMH sample was collected from all available habitat types present in the sampling reach (sticks, depositional habitats, exposed fine roots of riparian trees, macrophytes, leaf packs, and coarse woody debris). Collection and processing of sticks followed the same procedures as with the RTH samples. The depositional habitats were sampled by lowering a mechanical sampler (Young grab) to the stream bottom. Once the Young grab was retrieved, the material from the top of the grab was placed in a 5-gallon bucket. The remaining habitats were sampled by using a D-frame net with a 210- μ m mesh net and all habitats were composited into a 5-gallon bucket. The sample was then gently sprayed with a pressure sprayer over a 212- μ m seive until the entire sample was free of unwanted debris and sediment. Large or rare organisms were picked from the sample and were placed into a 50-mL bottle. The material and organisms remaining in the sieve were then placed into a 1-L plastic bottle and 10-percent formalin was used to preserve samples in both bottles. Before sampling crews left each site, a discharge measurement was made following USGS protocols (Rantz, 1982).

Samples were shipped to the USGS National Water-Quality Laboratory (NWQL) in Denver, CO, for identification, enumeration, and quality assurance/quality control. In general, processing of the invertebrate samples followed the protocols set by the NAWQA Program (Moulton and others, 2000) with the following exceptions: all of the MISE samples were subsampled by using a 500-organism count instead of the 300-organism count as described in the protocols, and all of the QMH samples collected from 1996 to 1998 were processed as if they were RTH samples, meaning the data can be expressed as percent relative abundances or presence/absence instead of only presence/absence.

DATA SUMMARY

Basic characteristics of each site and its drainage basin are described in table 1. The drainage areas of the 38 sites sampled range from 47.9 km² at Silver Creek near Bayland, MS, to 34,850 km² at Yazoo River below Steele Bayou near Long Lake, MS (mean 2,573 km²). Agriculture within each basin ranged from 14 percent at Wolf River at LaGrange, TN, to 96 percent at Cockle Burr Slough Ditch near Monette, AR (mean 69 percent). The discharge measured prior to sampling ranged from 0 m³/s at Bayou Meto near Bayou Meto, AR, Deer Creek near Holandale, MS, and Silver Creek near Bayland, MS, to 405 m³/s at Yazoo River below Steele Bayou near Long Lake, MS, and the mean instantaneous velocity (measurement taken at the point where sticks were collected) ranged from 0 m³/s at LaGrue Bayou near Dewitt, AR, Bayou Meto near Bayou Meto, AR, Deer Creek near Holandale, MS, and Silver Creek near Bayland, MS, to 0.56 m/s at Big Sunflower River at Sunflower, MS. Earlier habitat assessments showed that the channel widths ranged from 8.1 m at LaGrue Bayou near Dewitt, AR, to 115.8 m at Village Creek near Swifton, AR, and the mean channel depth ranged from 0.13 m at Silver Creek near Bayland, MS, to 5.92 m at Yazoo River below Steele Bayou near Long Lake, MS.

A total of 88 species and 178 genera were identified representing 59 families, 8 orders, 6 classes and 3 phyla at the 38 sites from 1996 to 1999 (table 3). Taxa identified in samples collected from 1996 to 1999 are listed in table 3. In many cases, invertebrates were identified to a relatively high taxonomic resolution, such as family, and at other times classification to lower taxa within the same group was possible (table 3).

Data from the RTH samples (table 4) show the number of individuals identified and number of taxa recorded for each sample. A total of 156 taxa were identified from the RTH samples. The number of individuals ranged from 74 at Skuna River at Bruce, MS, 1996, reach A, to 3,295 at Little River Ditch no. 1 near Morehouse, MO, 1996, reach A. The number of taxa identified ranged from 9 at Bogue Phalia near Leland, MS, 1996, reach B, to 54 at Cache River at Cotton Plant, AR, 1998, reach C. The sample area for the RTH samples ranged from 831.8 cm² at Little River Ditch no. 1 near Morehouse, MO, 1998, to 5,419.4 cm² at Skuna River at Bruce, MS, 1996 (mean 1,599.4 cm²). Invertebrate samples were collected from plant material at the Wolf River at LaGrange, MS, in 1996; therefore, no sample area was recorded.

Data from the QMH samples (table 5) show the number of individuals and number of taxa recorded for each sample. A total of 345 taxa were identified from the QMH samples. The number of individuals ranged from 42 at Yazoo River below Steele Bayou near Long Lake, MS, 1998, reach A, to 29,603 at Second Creek near Palestine, AR, 1997, reach A. The number of taxa identified ranged from 18 at Yazoo River below Steele Bayou near Long Lake, MS, 1999, reach A, to 81 at Cache River near Cotton Plant, AR, 1996, reach A.

Table 6 lists the presence or absence of a particular taxon from all sites, years, and sample reaches. The total number of taxa per site ranged from 35 at Bayou Macon near Delhi, LA, to 122 at Cache River near Cotton Plant, AR.

Of the 88 invertebrate species identified, 24 were reported at only one site each. *Palaemonetes kadiakeusis*, a Decapod, was the only species identified at all 38 sites. This species was identified only in the QMH samples (table 4). In this study, sites in the northern half of the MISE Study Unit tended to have higher taxa richness, while the southern sites tended to have lower richness. Within the class insecta, chironomid taxa were the most frequently collected in samples from the MISE Study Unit. Plecopteran taxa were among the least frequently collected. It is not surprising that chironomids were identified most frequently, because chironomids, as a group, are considered to be tolerant of degraded water-quality conditions often associated with agriculture. Alternatively, plecopteran taxa are relatively intolerant of degraded water quality and would not be expected to be collected frequently (Lenat, 1993).

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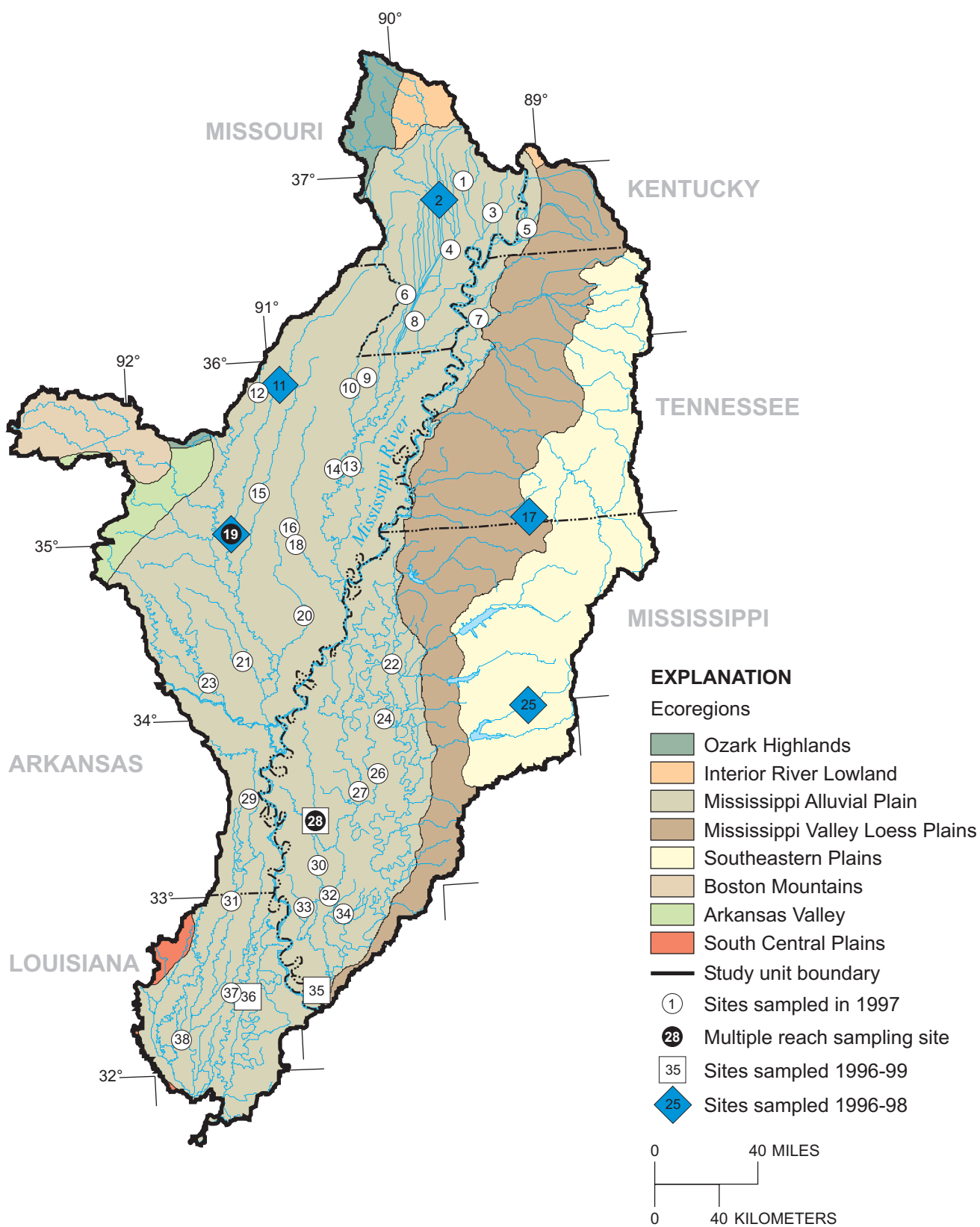


Figure 1. Ecoregions and locations of 38 sites sampled in the Mississippi Embayment Study Unit during 1996–99.