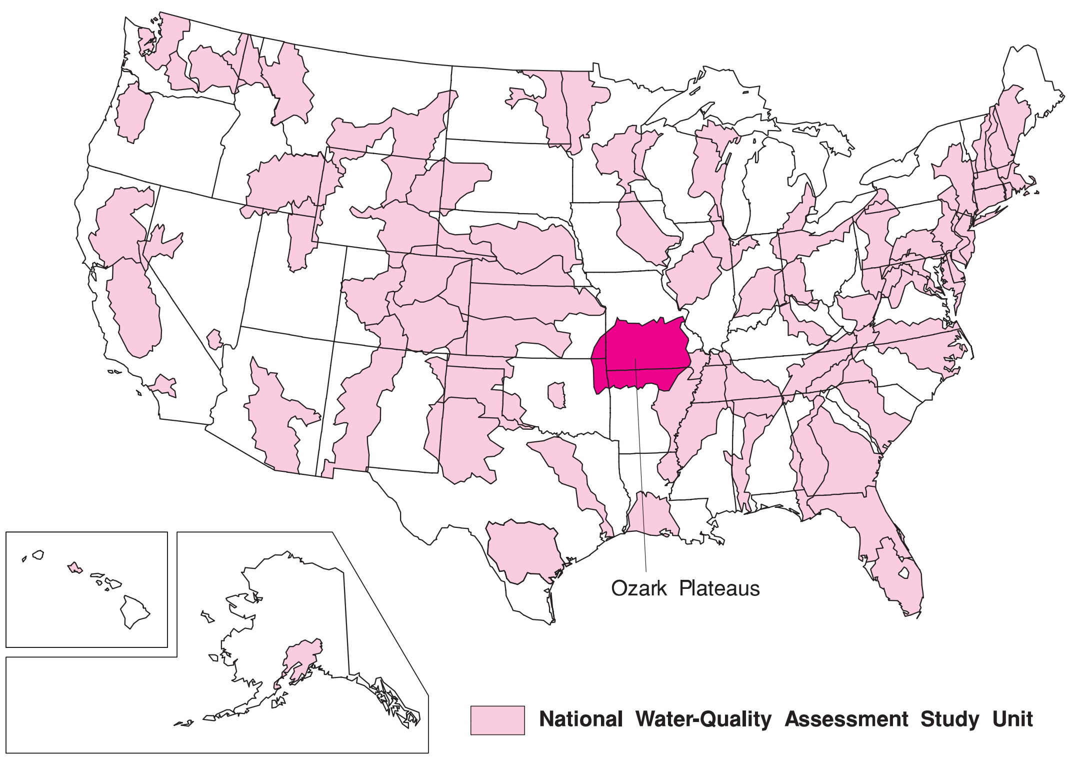
National Water-Quality Assessment Program

Water-Quality Assessment of the Ozark Plateaus Study Unit, Arkansas, Kansas, Missouri, and Oklahoma—Nutrients, Bacteria, Organic Carbon, and Suspended Sediment in Surface Water, 1993–95

Water-Resources Investigations Report 98–4164



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By JERRI V. DAVIS *and* RICHARD W. BELL

Water-Resources Investigations Report 98–4164

Little Rock, Arkansas
1998

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

CONTENTS

FIGURES

TABLES

Water-Quality Assessment of the Ozark Plateaus Study Unit, Arkansas, Kansas, Missouri, and Oklahoma—Nutrients, Bacteria, Organic Carbon, and Suspended Sediment in Surface Water, 1993–95

By Jerri V. Davis *and* Richard W. Bell

ABSTRACT

Nutrient, bacteria, organic carbon, and suspended-sediment samples were collected from 1993–95 at 43 surface-water-quality sampling sites within the Ozark Plateaus National Water-Quality Assessment Program study unit. Most surface-water-quality sites have small or medium drainage basins, near-homogenous land uses (primarily agricultural or forest), and are located predominantly in the Springfield and Salem Plateaus. The water-quality data were analyzed using selected descriptive and statistical methods to determine factors affecting occurrence in streams in the study unit.

Nitrogen and phosphorus fertilizer use increased in the Ozark Plateaus study unit for the period 1965–85, but the application rates are well below the national median. Fertilizer use differed substantially among the major river basins and physiographic areas in the study unit. Livestock and poultry waste is a major source of nutrient loading in parts of the study unit. The quantity of nitrogen and phosphorus from livestock and poultry wastes differed substantially among the river basins of the study unit's sampling network. Eighty six municipal sewage-treatment plants in the study unit have effluents of 0.5 million gallons per day or more (for the years 1985–91).

Statistically significant differences existed in surface-water quality that can be attributed to land use, physiography, and drainage basin size. Dissolved nitrite plus nitrate, total phosphorus, fecal coliform bacteria, and dissolved organic carbon concentrations generally were larger at sites associated with agricultural basins than at sites associated with forested basins. A large difference in dissolved nitrite plus nitrate concentrations occurred between streams draining basins with agricultural land use in the Springfield and Salem Plateaus. Streams draining both small and medium agricultural basins in the Springfield Plateau had much larger concentrations than their counterparts in the Salem Plateau. Drainage basin size was not a significant factor in affecting total phosphorus, fecal coliform bacteria, or dissolved organic carbon concentrations. Suspended-sediment concentrations generally were small and indicative of the clear water in streams in the Ozark Plateaus.

A comparison of the dissolved nitrite plus nitrate, total phosphorus, and fecal coliform data collected at the fixed and synoptic sites indicates that generally the data for streams draining basins of similar physiography, land-use setting, and drainage basin size group together. Many of the variations are most likely the result of differences in percent agricultural land use between the sites being compared or are discharge related. The relation of dissolved nitrite plus nitrate, total phosphorus, and fecal coliform concentration to percent agricultural land use has a strong positive

correlation, with percent agricultural land use accounting for between 42 and 60 percent of the variation in the observed concentrations.

INTRODUCTION

In 1991, the U.S. Geological Survey (USGS) began full implementation of the National Water-Quality Assessment (NAWQA) Program to provide a nationally consistent description of water-quality conditions for a large part of the Nation's water resources. The long-term goals of the NAWQA Program are to describe the status and trends in the quality of the Nation's surface- and ground-water resources and to provide a better understanding of the natural and human factors that affect the quality of these resources (Leahy and others, 1990). Investigations will be conducted on a rotational basis in 60 river basins or aquifer systems (referred to as study units) throughout the Nation.

The Ozark Plateaus NAWQA study unit was among the first 20 study units selected in 1991 for assessment under the full implementation plan. The study unit investigation consists of five years (1991–95) of intensive assessment, followed by five years (1996–2000) of low-level monitoring, and then the cycle is to be repeated. Each 5-year assessment period will include about 2 years of retrospective analysis and planning and 3 years of intensive data collection.

The purpose of this report is to summarize nutrient, indicator bacteria, organic carbon, and suspended-sediment information for surface water in the study unit. The information summarized includes fertilizer-use data, animal and municipal sources of nutrients, description of the sampling network, and an assessment of recent (1993–95) conditions. Information provided in this report 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. This information also will contribute to national synthesis activities that compare and contrast water quality in similar and different environments throughout the Nation (Leahy and others, 1990).

This report includes (1) a brief overview of the environmental setting of the study unit; (2) a summary of fertilizer-use data for 1965 and 1985; (3) a summary of animal and municipal sources of nutrients; (4) a description of the surface-water-quality sampling network; and (5) an assessment of conditions using statistical summaries of nutrient, indicator bacteria, organic carbon, and suspended-sediment data collected from 1993–95.

DESCRIPTION OF THE OZARK PLATEAUS STUDY UNIT

This section of the report provides a brief description of the environmental setting of the Ozark Plateaus study unit. For more detail, the reader is referred to the environmental setting report for the study unit (Adamski and others, 1995).

The Ozark Plateaus study unit area encompasses approximately 48,000 mi^2 (square miles) and includes parts of northern Arkansas, southeastern Kansas, southern Missouri, and northeastern Oklahoma (fig. 1). The study unit includes most of the Ozark Plateaus Province as well as part of the surrounding Central Lowland Province known as the Osage Plains section, and a small portion of the Mississippi Alluvial Plain section of the Coastal Plain Province (Fenneman, 1938).

The Ozark Plateaus Province consists of a structural dome of sedimentary and igneous rocks. Sedimentary rocks gently dip away from the igneous core of the St. Francois Mountains in southeastern Missouri to form three distinct physiographic sections (Fenneman, 1938)—the Salem Plateau (includes the St. Francois Mountains), the Springfield Plateau, and the Boston Mountains (fig. 1). Topography varies from mostly gently rolling hills in the Springfield Plateau, to rugged with relief up to 500 ft (feet) in the Salem Plateau, to extremely rugged with relief as much as 1,000 ft in the Boston Mountains. The Osage Plains of the Central Lowland Province in the west-northwestern part of the study unit has gently rolling topography with relief rarely exceeding 250 ft. The Mississippi Alluvial Plain of the Coastal Plain Province along the extreme southeastern boundary of the study unit has flat to gently rolling topography with little relief.

The St. Francois Mountains area is not a separate physiographic section as defined by Fenneman (1938), but will be discussed in this report separately because of its unique hydrogeologic features. For the purposes of this report, the physiographic sections described above and the St. Francois Mountains will hereinafter be referred to as physiographic areas.

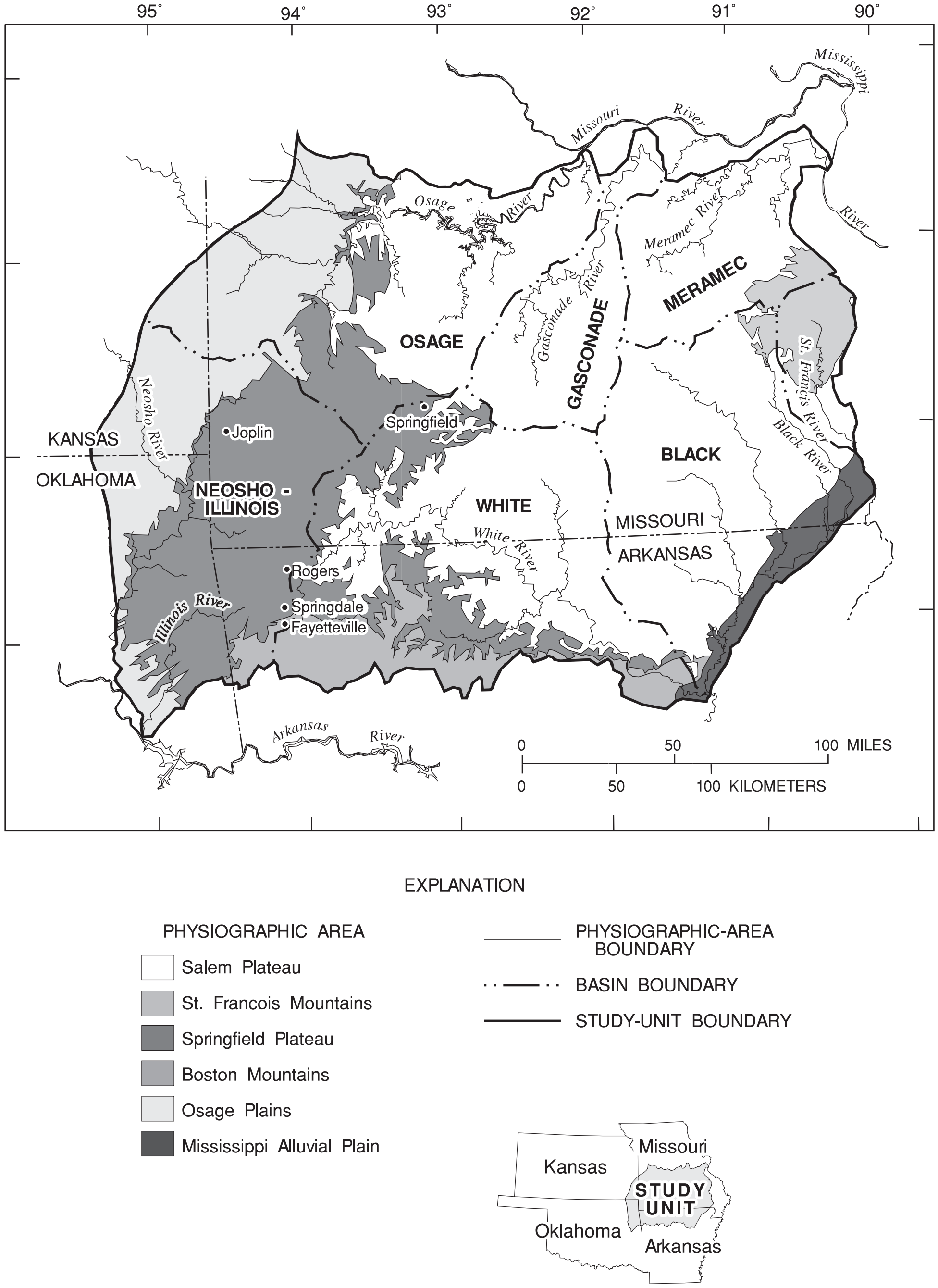

Figure 1. Location of Ozark Plateaus study unit, major river basins, and physiographic areas (modified from Fenneman, 1938).

Hydrology

The Ozark Plateaus study unit is drained by seven major rivers—the White, Neosho-Illinois, Osage, Gasconade, Meramec, Black, and St. Francis Rivers (fig. 1)—which flow directly or indirectly into the Mississippi River. Many large reservoirs have been constructed on the White, Osage, and Neosho Rivers.

Stream gradients are steepest in the Boston and St. Francois Mountains and flattest in the Osage Plains and Mississippi Alluvial Plain. Channel-bed material ranges from clay and silt in the Osage Plains to sand, gravel, boulders, and bedrock in most of the Ozark Plateaus Province. Streams in the Osage Plains are turbid, with long pools separated by poorly defined riffles. Streams in the Ozark Plateaus Province are mostly clear, with pools separated by riffles, and in places, cascading waterfalls.

Mean annual runoff generally increases from the north to the south (Gebert and others, 1985). Mean annual runoff is least in the northern Osage Plains, ranging from 9 to 10 in. (inches); increases in the Springfield and Salem Plateaus, ranging from 10 to 16 in.; and is greatest in the Boston Mountains, ranging from 14 to 20 in.

Minimum monthly streamflows generally occur in the summer and early fall and maximum monthly streamflows typically occur in the late winter and spring. Maximum monthly streamflows generally coincide with the period of maximum precipitation and minimum evapotranspiration.

Climate, Population, Land Use, and Water Use

The Ozark Plateaus study unit has a temperate climate with average annual precipitation ranging from about 38 in/yr (inches per year) in the north to about 48 in/yr near the southern edge of the study unit (Dugan and Peckenpaugh, 1985). Average monthly precipitation is greatest in the spring, about 3 to 5 in/mo (inches per month), and least in the late fall and winter, about 1 to 3 in/mo. Precipitation was above average for water years 1993–95; the average annual precipitation was exceeded by 16.5 in., 1.3 in., and 7.6 in. for water years 1993–95, respectively (National Oceanic and Atmospheric Administration, 1993–95a; 1993–95b; 1993–95c). Mean annual air temperature ranges from about 56 °F (degrees Fahrenheit) in the northeastern part of the study unit to about 60 °F in the southwestern part of the study unit (Dugan and Peckenpaugh, 1985). Estimated mean annual evapotranspiration in the study unit is 30 to 35 in. (Hanson, 1991).

Population within the study unit in 1990 was approximately 2.3 million people (U.S. Department of Commerce, Bureau of Census, 1990). Population increased by about 28 percent between 1970 and 1990 with the largest increases occurring in northwestern Arkansas and southwestern Missouri. Springfield, Missouri, with a population of about 140,000 residents (1990), is the largest city in the study unit. Joplin, Missouri, and Fayetteville, Rogers, and Springdale, Arkansas, are the only other cities within the study unit with populations exceeding 20,000 (1990).

Table 1. Land-use percentage by physiographic area

[<, less than; 1978–83 land-use data from U.S. Geological Survey, 1990]

Physiographic area	Percent land use				
	Agriculture[1]	Forest	Urban	Water	Barren[2]
Osage Plains	82	14	1	1	2
Springfield Plateau	58	38	3	1	<1
Salem Plateau	27	71	1	1	<1
Boston Mountains	29	70	1	<1	<1
Mississippi Alluvial Plain	83	8	1	[3]8	<1

[1]Includes pasture and cropland.
[2]Includes mining.
[3]Includes approximately 7 percent wetland.

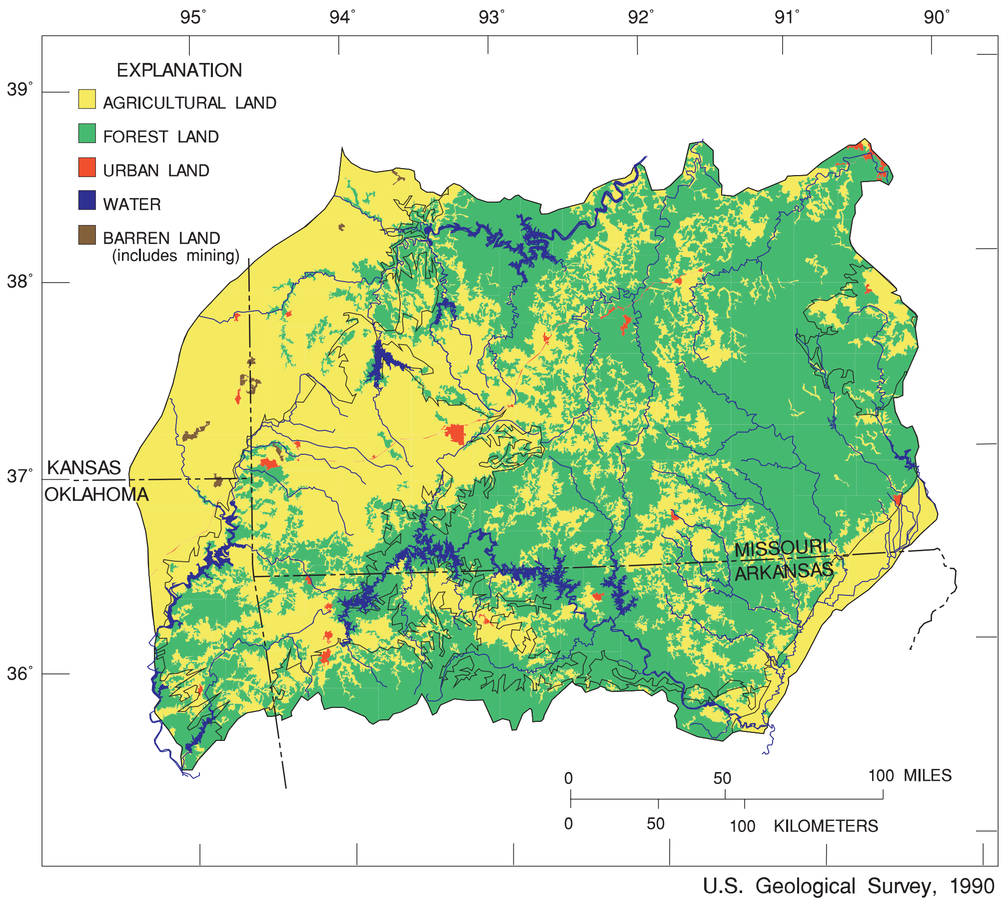

Figure 2. Land use in the Ozark Plateaus study unit.

Land use in the study unit (table 1; fig. 2) is predominantly forest and agriculture (includes pasture and cropland; U.S. Geological Survey, 1990). Deciduous forest is predominant in the Salem Plateau and Boston Mountains, although this is commonly mixed with evergreen forest. Some pasture also occurs in the Salem Plateau where livestock (beef and dairy cattle) are raised, mostly in the southern part. The Springfield Plateau is predominantly pasture, although this is mixed with cropland in the north and forest in the south. Intensive poultry farming occurs in pastures of the Springfield Plateau in northwestern Arkansas, southwestern Missouri, and northeastern Oklahoma. Cropland dominates in the Osage Plains and Mississippi Alluvial Plain. Major crops grown in the Osage Plains are soybeans and sorghum with some corn, wheat, grains, and other field crops. Rice is the dominant crop grown in the Mississippi Alluvial Plain.

Total water use from both surface- and ground-water sources in the study unit was 1,053 Mgal/d (million gallons per day) in 1990 (Adamski and others, 1995). Of this, 614 Mgal/d was from ground-water sources and 439 Mgal/d was from surface-water sources. About 67 percent of the total ground-water use is for irrigation; most of this use is in counties along the extreme southeastern part of the study unit in the Mississippi Alluvial Plain. Domestic and public supply accounts for about 22 percent of the ground-water use. About 47 percent of the total surface-water use is for public supply and almost 30 percent is for commercial and industrial use. About 6 percent of the total water used in the study unit is for nonirrigation agricultural purposes.

Nitrogen and Phosphorus Fertilizer Use

Fertilizer use in the Ozark Plateaus study unit increased substantially for the period 1965–85. Nitrogen and phosphorus fertilizer use increased 152 percent and 55 percent, respectively, during this period based on fertilizer use estimates (Alexander and Smith, 1990).

Although the application rates for nitrogen and phosphorus fertilizer in the Ozark Plateaus study unit have increased in recent years, these rates are well below the national median. Estimates of county nitrogen and phosphorus fertilizer application rates for 1982 were expressed as a ratio of fertilizer sold in the county to county area. The national median of nitrogen fertilizer application rate is 28 tons/mi^2 (tons per square mile) with median application rates by State ranging from 14 to 64 tons/mi^2. Nitrogen fertilizer application rates (1982) for the counties within the study unit ranged from an estimated 0 to 35 tons/mi^2. Application rates generally were largest in counties in Arkansas and Kansas. The national median of phosphorus fertilizer application rate is 6 tons/mi^2 with median application rates by State ranging from 3 to 17 tons/mi^2. Phosphorus fertilizer application rates (1982) for the counties within the study unit ranged from an estimated 0 to 5 tons/mi^2 (Alexander and Smith, 1990).

Fertilizer use differed substantially among the study unit's major river basins (table 2). Annual nitrogen fertilizer use in 1965 ranged from 0.53 tons/mi^2 in the St. Francis River Basin to 2.41 tons/mi^2 in the Osage River Basin. In 1985, annual nitrogen fertilizer use ranged from 1.30 tons/mi^2 in the St. Francis River Basin to 5.09 tons/mi^2 in the Osage and Neosho-Illinois River Basins. Nitrogen fertilizer use in the Osage and the Neosho-Illinois River Basins nearly equals the combined total nitrogen fertilizer use in the rest of the study unit. Annual phosphorus fertilizer use in 1965 ranged from 0.14 tons/mi^2 in the St. Francis River Basin to 0.64 tons/mi^2 in the Osage River Basin. In 1985, annual phosphorus fertilizer use ranged from 0.23 tons/mi^2 in the St. Francis River Basin to 0.87 tons/mi^2 in the Osage River Basin. As with nitrogen fertilizer use, nearly one-half of the total phosphorus

Table 2. Annual nitrogen and phosphorus fertilizer use by major river basins, 1965 and 1985

[mi^2, square miles; tons/mi^2/yr, tons per square mile per year; Fertilizer use data from U.S. Department of Agriculture *in* Alexander and Smith, 1990]

Basin	Drainage area (mi^2)	Nitrogen fertilizer (tons/mi^2/yr)		Percent difference	Phosphorus fertilizer (tons/mi^2/yr)		Percent difference
		1965	1985		1965	1985	
Black	8,560	1.33	3.17	139	0.34	0.49	42
Gasconade	3,600	1.28	3.22	152	.34	.56	65
Meramec	3,980	.77	1.85	141	.20	.32	58
Neosho-Illinois	9,230	1.67	5.09	206	.45	.78	73
Osage	10,500	2.41	5.09	111	.64	.87	36
St. Francis	1,310	.53	1.30	144	.14	.23	59
White	11,300	.81	2.43	200	.21	.37	77

fertilizer used was applied in the Osage and Neosho-Illinois River Basins.

The physiographic area with the largest nitrogen fertilizer use within the study unit in 1985 was the Mississippi Alluvial Plain (8.0 tons/mi^2) followed by the Osage Plains (7.1 tons/mi^2), Springfield Plateau (3.4 tons/mi^2), Salem Plateau (3.0 tons/mi^2), and the Boston Mountains (1.8 tons/mi^2). The largest phosphorus fertilizer use in 1985 occurred in the Mississippi Alluvial Plain and the Osage Plains (each 0.99 tons/mi^2) followed by the Springfield Plateau (0.52 tons/mi^2), Salem Plateau (0.49 tons/mi^2), and the Boston Mountains (0.23 tons/mi^2).

Animal and Municipal Sources of Nutrients

Livestock and poultry waste is a major source of nutrient loading in parts of the study unit. Estimated livestock and poultry populations within the study unit were used to calculate total nutrient contribution to the study unit by animal waste (table 3). An estimated 154,600 tons of wet weight manure are produced daily in the study unit, from which about 358,300 tons of nitrogen and 123,400 tons of phosphorus are available annually.

The quantity of nitrogen and phosphorus from livestock and poultry wastes differed substantially among selected river basins of the study unit's sampling network (table 4). Estimates of the quantity of nitrogen from livestock and poultry waste in 1992 ranged from 0.7 tons/mi^2 in the drainage basin of the Black River below Annapolis, Missouri, to 15 tons/mi^2 in the drainage basin of the Illinois River near Tahlequah, Oklahoma (L. Puckett, U.S. Geological Survey, written commun., 1995). Estimates of the quantity of phosphorus from livestock and poultry waste in 1992 ranged from 0.2 tons/mi^2 in the drainage basin of the Black River below Annapolis, Missouri, to 4.9 tons/mi^2 in the drainage basin of the Illinois River near Tahlequah, Oklahoma (L. Puckett, written commun., 1995). Application of animal waste (manure) and litter to pasturelands for fertilizer is a widespread practice, particularly in the southwest part of the study unit where intensive poultry farming occurs.

Table 3. Animal waste nutrient contribution to the study unit

[tons/d, tons per day; tons/yr, tons per year]

Animal species	Annual animal population[1]	Manure production[2] (tons/d)	Nitrogen (tons/yr)	Phosphorus (tons/yr)
Beef cattle	4,264,000	127,900	264,400	85,300
Dairy cattle	231,000	9,500	17,300	3,100
Swine	1,087,000	8,800	22,400	7,500
Chickens	[3]498,325,000	4,400	29,200	12,400
Turkeys	[3]25,178,000	[4]4,000	25,000	15,100
Totals		154,600	358,300	123,400

[1]Kansas State Board of Agriculture, 1991; Missouri Agriculture Statistics Office, 1991; Arkansas Agricultural Statistics Service, 1992; Oklahoma Department of Agriculture, 1992; Jerry Barker, Oklahoma Department of Agriculture, oral commun., 1992; Ken Arnold, Missouri Department of Natural Resources, oral commun., 1993.

[2]University of Missouri, Columbia Extension Division and Missouri Department of Natural Resources, 1979 (animal waste production based on wet weight pounds of manure per day per 1,000 pounds of animal).

[3]Chicken and turkey populations are totals produced during a year. Manure production and nutrient contribution (tons per year) values have been adjusted based on the average number of chickens and turkeys being produced on a single day. Multiple flocks of chickens (6) and turkeys (2.25) are produced per year (Fulhage, 1989).

[4]Van Dyne and Gilbertson, 1978.

Table 4. Estimated contributions of nitrogen and phosphorus in animal waste to selected sampling sites within the study unit surface-water sampling network

[mi^2, square mile; tons/mi^2, tons per square mile]

Site number (fig. 4)	River basin[1]	Drainage area (mi^2)	Nitrogen[2] (tons/mi^2)	Phosphorus[2] (tons/mi^2)
4	Illinois River near Tahlequah, Okla.	959	15.0	4.9
5	Buffalo River near Boxley, Ark.	57.4	[3]1.5	.5
10	Buffalo River near St. Joe, Ark.	829	1.7	.6
11	North Sylamore Creek near Fifty Six, Ark.	58.1	[3]3.4	1.0
16	Kings River near Berryville, Ark.	527	10.1	3.2
17	Yocum Creek near Oak Grove, Ark.	52.8	13.2	4.1
19	Elk River near Tiff City, Mo.	872	11.5	3.7
23	Current River at Van Buren, Mo.	1,667	1.8	.5
26	Jacks Fork River at Alley Spring, Mo.	305	[3]2.9	.8
27	Center Creek near Smithfield, Mo.	294	6.2	1.8
30	Black River below Annapolis, Mo.	495	.7	.2
33	Paddy Creek above Slabtown Spring, Mo.	30.5	[3]3.9	1.0
35	Dousinbury Creek near Wall Street, Mo.	40.9	5.0	1.3
38	Niangua River at Windyville, Mo.	338	6.0	1.6

[1]See figure 4 for the location of sampling sites within the study unit and table 5 for additional site and basin characteristics.

[2]Larry Puckett, U.S. Geological Survey, written commun., 1995.

[3]Nitrogen and phosphorus values for river basins were calculated using county-level estimates that were adjusted for the percentage of the county that is located within the basin. The accuracy of the estimated values are influenced by the representativeness of land use within the basin as compared to land use throughout the county. For example, values for small forested basins, such as North Sylamore Creek near Fifty Six, Ark., are higher than expected because the parts of the two counties which are drained by the stream basin have land uses which contribute minor amounts of nitrogen and phosphorus in comparison to the parts of the counties located outside of the drainage basin.

Municipal sewage-treatment plant (STPs) that have effluents of 0.5 Mgal/d or more (for the years 1985–91) are shown in figure 3. Municipalities commonly upgrade and change their STPs, and therefore, in some instances, these data have been superseded. Many additional sources (less than 0.5 Mgal/d from municipalities, private homes, recreational areas, businesses, and public offices) were excluded from this analysis.

The upper White, lower Meramec, Illinois, and Spring River Basins have the highest occurrence of municipal STPs (fig. 3). The Southwest wastewater-treatment plant in Springfield, Missouri, discharges effluent into a tributary of the White River and has the largest single discharge capability (42.5 Mgal/d) in the study unit. The Metropolitan Sewer District of St. Louis has five STPs that discharge to the lower Meramec River. These five plants have the capability of collectively discharging as much as 36 Mgal/d. The cities of Springdale, Fayetteville, and Rogers, Arkansas, discharge their effluent into tributaries of the Illinois River, although Fayetteville also discharges some

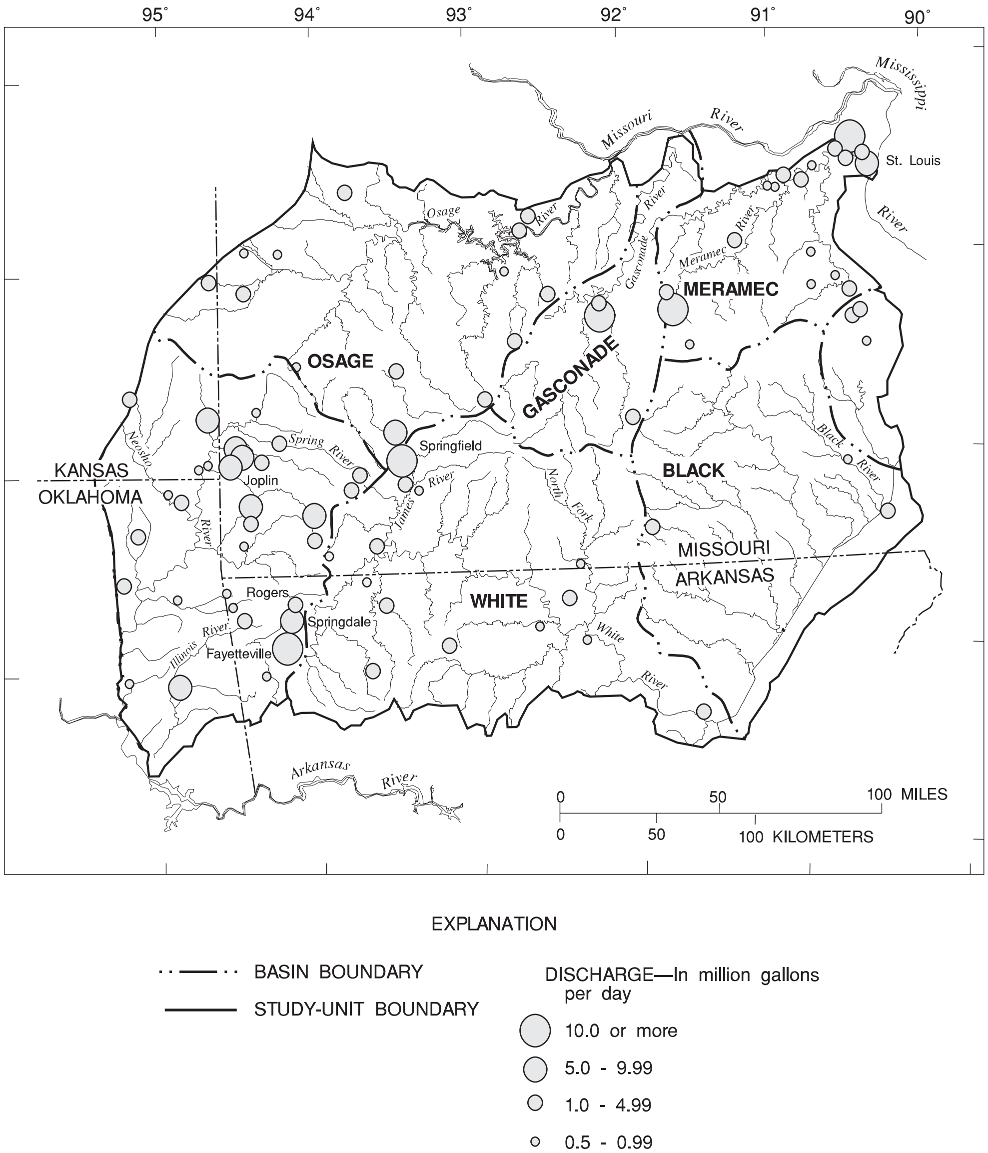

Figure 3. Municipal sewage-treatment plant point-source discharges greater than 0.5 million gallons per day.

effluent into a tributary of the White River. These three cities have the ability to collectively discharge as much as 34 Mgal/d. Joplin, Missouri, discharges about 21 Mgal/d into tributaries of the Spring River.

Most municipalities in the study unit treat their raw sewage with a combination of two or more treatment methods. The most common method of sewage treatment appears to be the use of oxidation ditches or ponds. Trickling filters, aerated lagoons, extended aeration, and lagoons in series also are common methods of treatment. Sewage water that has undergone tertiary treatment contains nitrogen mostly as nitrate, whereas the nitrogen in secondary treated wastewater is mostly in the form of ammonia, which rapidly oxidizes in most stream environments. Chlorination is frequently used in the disinfectant process. Nationwide, the average STP generally has a daily discharge of 0.479 Mgal/d of effluent with an average total nitrogen concentration of 8.4 mg/L (milligrams per liter) and an average total phosphorus concentration of 5.2 mg/L (National Oceanic and Atmospheric Administration, 1993).

DESCRIPTION OF SURFACE-WATER-QUALITY SAMPLING NETWORK

Forty-three sampling sites (basic-fixed, intensive-fixed, and synoptic) comprise the surface-water-quality sampling network within the study unit (fig. 4; table 5). The sampling network was designed based on factors including physiography, land use, and drainage area. The drainage basins of most sites are located in the Salem (19 sites) and Springfield (15 sites) Plateaus; drainage basins of fewer sites are located in the Boston Mountains (4 sites). The drainage basins of five sites cover parts of two or more physiographic areas. The predominant land use of basins in the sampling network is agricultural (19 sites) and forest (19 sites); fewer sites are designated as multiple land uses (5 sites). The drainage basins of six sites have a specialized land use (urban or mining) that represents a small part of the basin drainage area but substantially effects water quality at the sampling site.

The surface-water sampling network is comprised of 12 basic-fixed, 2 intensive-fixed, and 29 synoptic sites. The sampling network was established, from a list of about 60 potential sites, to monitor water quality in the study unit on a long-term basis and to assess the occurrence and temporal distribution of nutrients, bacteria, organic carbon, and suspended sediment.

Basic-Fixed and Intensive-Fixed Sites

The network of basic-fixed and intensive-fixed sites (fig. 4; table 5) was established to monitor water quality of sites representative of basins with several combinations of land use, basin size, and physiography within the study unit on a long-term basis. Basic-fixed and intensive-fixed sites are located in small (30.5 to 58.1 mi^2) and medium (294 to 959 mi^2) size drainage basins with near-homogenous land use (indicator sites) and one drainage basin (527 mi^2) that integrates forest and agricultural land uses, instream gravel mining, and discharge from an upstream wastewater-treatment facility, and several physiographic areas. An additional site (site 23; Current River at Van Buren, Missouri) located in a large drainage basin (1,667 mi^2) was added to the basic-fixed site network in 1995. The basic-fixed and intensive-fixed site networks will be referred to collectively as the fixed-site network.

The 14 fixed sites have drainage basins in the Boston Mountains (1 site), Salem Plateau (5 sites), and Springfield Plateau (5 sites) physiographic areas. Three fixed sites have drainage basins that cover parts of two or more physiographic areas. The fixed sites include agricultural (pasture and confined animal; 6 sites), forest (7 sites), and multiple (1 site) land uses. Water-quality samples were collected at the fixed sites monthly from April 1993 through September 1995.

The intensive-fixed site network was established to assess the occurrence and temporal distribution of nutrients and bacteria (also pesticides; see Bell and others, 1997) in small agricultural land-use basins in the Springfield and Salem Plateaus. The intensive-fixed sites (fig. 4; table 5), Yocum Creek near Oak Grove, Arkansas (site 17), and Dousinbury Creek near Wall Street, Missouri (site 35), had an increased sample-collection frequency to evaluate variations in the concentrations of nutrients and fecal indicator bacteria during the time of most intense nutrient application and runoff. The drainage basin of site 17 is located in the White River Basin in the Springfield Plateau; land use in the basin is about 75 percent agricultural, predominantly poultry and beef cattle operations. The drainage basin of site 35 is located in the Osage River Basin in the Salem Plateau; the land use in the basin is about 60 percent agricultural, predominantly dairy operations and pasture. The animal waste (manure) and litter from these operations are used to fertilize pasturelands. Crops such as alfalfa, corn, soybean, and milo also are grown in these basins. Water-quality samples were collected on a monthly basis at the two intensive-fixed sites for most months from April 1993 through September 1995. In addition to the regular monthly sampling schedule, biweekly samples were collected at the two intensive-fixed sites in February, March, and July 1994; weekly samples were collected in April, May, and June 1994 (to coincide with the application of manure, commercial fertilizer, and pesticides to pasturelands and crops).

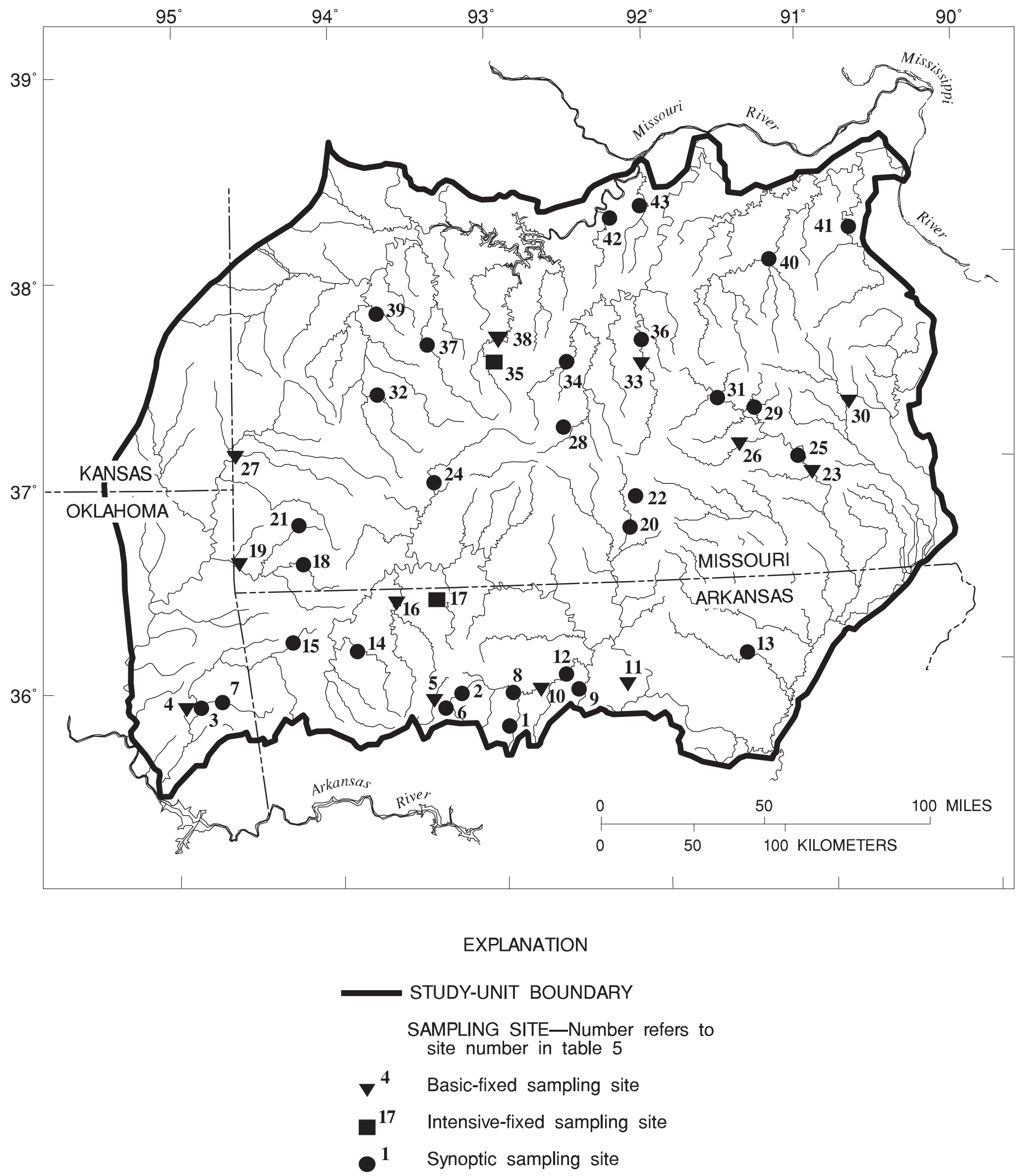

Figure 4. Location of sampling sites comprising the surface-water sampling network.

Synoptic Sites

The 29-site synoptic network was established to increase the spatial coverage of the basic-fixed and intensive-fixed site networks and to determine if the fixed sites adequately represent surface-water-quality conditions in the Ozark Plateaus. The basin characteristics (basin size, physiography, and land use) for each site in the synoptic network are similar to the basin characteristics of a basic-fixed or intensive-fixed site. The synoptic sites (fig. 4; table 5) are located in small (17.9 to 89.5 mi^2) and medium (186 to 735 mi^2) size drainage basins in the Boston Mountains (3 sites), Salem Plateau (14 sites), and Springfield Plateau (10 sites) physiographic areas. The drainage basins of two synoptic sites cover parts of two physiographic areas.

Table 5. Site and basin characteristics of sampling sites within the sampling network

[mi^2, square mile; SYN, Synoptic; <, less than; --, no land use in the category; BF, Basic Fixed; INT, Intensive; Sampling-network land use shown in parenthesis indicates a specialized land use that represents a small part of the basin drainage area but substantially effects water quality at the sampling site]

Site number (fig. 4)	Site name	Latitude	Longitude	Drainage area (mi^2)	Sampling network	Physiographic area	Predominant land use in the sampling network	Percent land use in basin			
								Forest	Agriculture	Urban	Other
1	Richland Creek near Witts Springs, Ark.	354749	925543	67.4	SYN	Boston Mountains	Forest	96.6	3.2	<1	--
2	Little Buffalo River at Murray, Ark.	355509	931916	45.2	SYN	Boston Mountains	Forest	94.6	5.0	<1	--
3	Baron Fork at Eldon, Okla.	355516	945018	312	SYN	Springfield	Agriculture	52.3	46.4	1.3	--
4	Illinois River near Tahlequah, Okla.	355522	945524	959	BF	Springfield	Agriculture	35.9	58.9	4.9	<1
5	Buffalo River near Boxley, Ark.	355643	932412	57.4	BF	Boston Mountains	Forest	96.1	3.9	--	--
6	Shop Creek at Parthenon, Ark.	355709	931435	25.4	SYN	Boston Mountains	Forest	91.6	8.4	--	--
7	Peacheater Creek at Christie, Okla.	355717	944146	23.6	SYN	Springfield	Agriculture	42.3	57.1	<1	--
8	Buffalo River near Eula, Ark.	355811	925310	603	SYN	Boston Mountains and Springfield	Forest	87.8	11.6	<1	<1
9	Big Creek near Big Flat, Ark.	355843	922853	89.5	SYN	Springfield	Forest and agriculture	64.1	35.7	<1	--
10	Buffalo River near St. Joe, Ark.	355902	924444	829	BF	Boston Mountains and Springfield	Forest	86.3	13.1	<1	<1
11	North Sylamore Creek near Fifty Six, Ark.	355943	921245	58.1	BF	Springfield	Forest	97.3	2.7	--	--
12	Water Creek near Evening Star, Ark.	360259	923434	38.6	SYN	Springfield	Forest	72.3	27.7	--	--
13	Strawberry River near Poughkeepsie, Ark.	360637	912659	473	SYN	Salem	Agriculture	57.2	41.2	1.2	<1
14	War Eagle Creek near Hindsville, Ark.	361202	935120	266	SYN	Springfield	Forest and agriculture	61.2	38.1	<1	--
15	Little Osage Creek at Healing Springs, Ark.	361513	941612	39.3	SYN	Springfield	Agriculture	5.6	91.3	3.1	--

Table 5. Site and basin characteristics of sampling sites within the sampling network—Continued

Site number (fig. 4)	Site name	Latitude	Longitude	Drainage area (mi^2)	Sampling network	Physiographic area	Predominant land use in the sampling network	Percent land use in basin			
								Forest	Agriculture	Urban	Other
16	Kings River near Berryville, Ark.	362536	933715	527	BF	Springfield, Salem, and Boston Mountains	Forest and agriculture (urban)	67.5	31.9	<1	<1
17	Yocum Creek near Oak Grove, Ark.	362714	932123	52.8	INT	Springfield	Agriculture	22.1	76.2	1.7	--
18	Mikes Creek at Powell, Mo.	363735	941052	64.4	SYN	Springfield	Forest	71.9	28.1	--	--
19	Elk River near Tiff City, Mo.	363750	943512	872	BF	Springfield	Agriculture	50.8	46.7	1.9	<1
20	North Fork White River near Dora, Mo.	364535	920912	404	SYN	Salem	Forest	70.9	29.0	<1	--
21	North Indian Creek near Wanda, Mo.	364840	941236	46.6	SYN	Springfield	Agriculture	4.7	94.1	1.2	--
22	Noblett Creek near Willow Springs, Mo.	365516	920544	20.6	SYN	Salem	Forest	90.7	9.3	--	--
23	Current River at Van Buren, Mo.	365929	910053	1,667	BF	Salem	Forest	82.6	17.1	<1	--
24	James River near Boaz, Mo.	370025	932150	464	SYN	Springfield	Agriculture (urban)	21.4	68.2	9.7	<1
25	Rogers Creek near Van Buren, Mo.	370257	910418	17.9	SYN	Salem	Forest	99.5	<1	--	--
26	Jacks Fork River at Alley Spring, Mo.	370840	912727	305	BF	Salem	Forest	77.9	21.7	<1	<1
27	Center Creek near Smithfield, Mo.	370920	943610	294	BF	Springfield	Agriculture (urban and mining)	17.4	76.8	3.4	2.4
28	Woods Fork near Hartville, Mo.	371443	923404	45.6	SYN	Salem	Agriculture	42.9	57.1	--	--
29	Big Creek at Mauser Mill, Mo.	371847	911900	41.6	SYN	Salem	Forest	94.7	4.9	<1	--
30	Black River below Annapolis, Mo.	371930	904550	495	BF	Salem and St. Francois Mountains	Forest (mining)	93.2	6.2	<1	<1

Table 5. Site and basin characteristics of sampling sites within the sampling network—Continued

Site number (fig. 4)	Site name	Latitude	Longitude	Drainage area (mi^2)	Sampling network	Physiographic area	Predominant land use in the sampling network	Percent land use in basin			
								Forest	Agriculture	Urban	Other
31	Current River below Akers, Mo.	372235	913251	294	SYN	Salem	Forest	73.9	26.0	<1	--
32	Sac River near Dadeville, Mo.	372635	934105	257	SYN	Springfield	Agriculture	14.9	82.6	2.4	<1
33	Paddy Creek above Slabtown Spring, Mo.	373329	920255	30.5	BF	Salem	Forest	90.1	9.6	<1	--
34	Osage Fork near Russ, Mo.	373518	923054	351	SYN	Salem	Agriculture	48.3	51.3	<1	--
35	Dousinbury Creek near Wall Street, Mo.	373540	925800	40.9	INT	Salem	Agriculture	40.1	59.4	<1	--
36	Big Piney River near Big Piney, Mo.	373958	920302	551	SYN	Salem	Forest and agriculture	63.5	35.7	<1	<1
37	Pomme de Terre River near Polk, Mo.	374056	932212	276	SYN	Salem	Agriculture	28.0	71.2	<1	--
38	Niangua River at Windyville, Mo.	374103	925527	338	BF	Salem	Agriculture	42.2	56.3	1.4	<1
39	Brush Creek above Collins, Mo.	375005	934022	55.1	SYN	Salem	Agriculture	36.6	61.7	1.7	--
40	Huzzah Creek near Scotia, Mo.	380144	911248	486	SYN	Salem	Forest (mining)	86.5	12.1	<1	1.2
41	Big River near Richwoods, Mo.	380934	904222	735	SYN	Salem and St. Francois Mountains	Forest and agriculture (mining)	64.3	31.0	1.4	3.3
42	Little Tavern Creek near St. Elizabeth, Mo.	381608	921250	47.8	SYN	Salem	Agriculture	49.7	50.3	--	--
43	Maries River near Free-burg, Mo.	382001	915934	186	SYN	Salem	Agriculture	58.9	40.5	<1	<1

The synoptic sites include agricultural (pasture and confined animal; 13 sites), forest (12 sites), and multiple (4 sites) land uses. Samples were collected at the synoptic sites during high-flow periods (May) in 1994 and 1995 and a low-flow period (August or September) in 1994.

ASSESSMENT OF CONDITIONS

The following sections provide an assessment of the conditions of nutrients (nitrite plus nitrate, ammonia, ammonia plus organic nitrogen, orthophosphate, and phosphorus), indicator bacteria (fecal coliform, fecal streptococcus, and *Escherichia coli*), organic carbon (dissolved and suspended), and suspended sediment in surface water in the Ozark Plateaus study unit. The discussion includes a description of the study approach used for sample collection and summaries of the results of the nutrient, indicator bacteria, organic carbon, and suspended-sediment sampling program. For an assessment of the conditions of nutrients in ground water in the study unit, the reader is referred to Adamski (1997).

Study Approach

Water samples analyzed for nutrients, indicator bacteria, organic carbon, and suspended sediment in surface water were collected at the 14 fixed sites in the study unit from April 1993 through September 1995 (from January 1995 through September 1995 at site 24) and at 29 synoptic sites in May 1994 and 1995 and August or September 1994. Representative samples (composites of depth-integrated samples from multiple verticals in the stream cross section) were collected and split into subsamples for nutrients and suspended-sediment analysis. Indicator bacteria and organic carbon samples were collected at the centroid of flow in a sterile 250-mL (milliliter) polyethylene bottle and a baked, 1-L (liter) amber glass bottle, respectively. The surface-water collection strategy and methods are described in Shelton (1994). The nutrient and organic carbon samples were analyzed by the USGS, National Water-Quality Laboratory (NWQL) in Denver, Colorado, the indicator bacteria were analyzed in the field, and the suspended-sediment samples were analyzed by the USGS, Missouri District Sediment Laboratory.

Forty-two quality-assurance samples were collected at 2 intensive-fixed sites, 10 basic-fixed sites, and 5 synoptic sites. The quality-assurance samples included 25 field equipment blanks (FEB) collected to monitor for contamination and carryover between environmental samples and 17 replicate environmental samples collected to monitor analytical precision. Nutrients and organic carbon were analyzed in the FEB and replicate samples. Most constituent concentrations were below the method detection limit (MDL) in the 25 FEB with the following exceptions: (1) dissolved nitrite plus nitrate detected in 1 FEB (MDL 0.05 mg/L; detected concentration 0.10 mg/L); (2) dissolved phosphorus detected in 1 FEB (MDL 0.01 mg/L; detected concentration 0.01 mg/L); (3) dissolved ammonia detected in 15 FEB (MDL 0.01 mg/L; detected concentrations ranged from 0.01 to 0.05 mg/L with a median of 0.02 mg/L); (4) dissolved organic carbon (DOC) detected in 20 FEB (MDL 0.10 mg/L; detected concentrations ranged from 0.10 to 1.1 mg/L with a median of 0.20 mg/L); and suspended organic carbon (SOC) detected in 11 FEB (MDL 0.10 mg/L; detected concentrations ranged from 0.10 to 0.20 mg/L with a median of 0.10 mg/L). Nutrient and organic carbon concentrations in the replicate environmental samples were comparable in most cases and well within laboratory analytical error.

In addition to the analyses for nutrients, indicator bacteria, organic carbon, and suspended sediment, water samples from all the sites were analyzed for major ions (calcium, magnesium, sodium, potassium, chloride, fluoride, bromide, and silica), selected trace elements, and pesticides. For an assessment of the conditions of pesticides in surface water in the study unit, the reader is referred to Bell and others (1997). Field measurements at each site included water and air temperatures, alkalinity, dissolved oxygen, pH, and specific conductance.Water-quality data collected during water years 1993–95 at the 43 basic-fixed, intensive-fixed, and synoptic sites are available in the Arkansas, Missouri, or Oklahoma annual data reports (U.S. Geological Survey, 1994–96a; 1994–96b; 1994–96c).

The nutrient, indicator bacteria, organic carbon, and suspended-sediment data were evaluated to determine factors affecting their occurrence in streams in the study unit. Data were grouped according to physiographic area (Boston Mountains, Springfield Plateau, or Salem Plateau), land use (forest, agricultural, urban, or mix), and drainage area (small, medium, or large).

Descriptive statistics were used to show the central tendency and variation in the water-quality data. The minimum and maximum and the values at the 10th, 25th, 50th (median), 75th, and 90th percentiles were calculated. Summary statistics for each of the 14 fixed sites are listed in table 6, at the back of this report.

The distribution of selected nutrient, indicator bacteria, organic carbon, and suspended-sediment concentrations at the 2 intensive-fixed sites and 11 of the basic-fixed sites (not enough data were available for site 23, Current River at Van Buren, Missouri, to include in the analysis) was graphically displayed using truncated, side-by-side boxplots (Helsel and Hirsch, 1992, p. 26). The plots show five percentiles of the data distribution: 10th, 25th, 50th (median), 75th, and 90th. Boxplots constructed for sites with censored data were modified by making the lower limit of the box equal to the MDL. The nonparametric Kruskal-Wallis analysis-of-variance test (Helsel and Hirsch, 1992, p. 163) was used to test for differences in the distributions of the data from the 13 fixed sites. The distributions were considered significantly different from one another if the probability (p-value) is less than 5 percent (less than 0.05) that the observed difference occurs by chance. If a statistically significant difference was detected between the sites, individual differences were evaluated by applying Tukey's multiple comparison test to the rank-transformed data (Helsel and Hirsch, 1992, p. 196). In addition, selected constituent concentrations in streams at the fixed sites were compared to concentrations in streams at the synoptic sites, and the relation of selected constituent concentrations to percent agricultural land use and stream discharge was considered.

Streamflow conditions frequently affect the concentration of constituents in streams. To accurately represent water-quality conditions at a particular location, water-quality samples should be collected during a variety of streamflow conditions. The number of samples of a representative constituent, total phosphorus, collected under different discharge conditions at the fixed sites during water years 1993–95, is shown in figure 5. The sites shown in figure 5 generally were sampled throughout the complete range of discharge conditions, although specific deciles for some sites might have fewer samples than expected for an ideal statistical distribution.

Nutrients

The fixation of atmospheric nitrogen by plants and animals, the dissolution of phosphorus-bearing rocks or minerals in the soil, and organic matter, including soil organic matter and decaying plants and animals, are natural sources for nitrogen and phosphorus in streams. Anthropogenic sources include sewage discharges, fertilizers, animal waste, and septic tanks. Atmospheric deposition is another source of nitrogen in natural waters (Hem, 1985). Background concentrations in streams generally are small, because the dissolved forms of the two elements are assimilated rapidly by plants and bacteria. Aquatic vegetation, particularly algae, depend on nitrogen and phosphorus for their food supply. Nitrogen or phosphorus concentrations greater than normal, ambient levels can contribute to the dense growth of algae (algal blooms). Bacterial decomposition of dead algal cells after an algal bloom can cause the depletion of dissolved oxygen, causing fish kills and other negative effects on aquatic life.

Nitrogen occurs in surface water as nitrite (NO_2^-), nitrate (NO_3^-), and ammonium (NH_4^+) ions and at intermediate oxidation states in organic solutes (Hem, 1985). The ammonium ion is in chemical equilibrium with un-ionized ammonia, a nitrogen species that is toxic to aquatic life under certain conditions. Ammonium ions predominate at pH values of less than 9.2, which is larger than the pH of most natural water (Hem, 1985). Nitrite and organic species are unstable in aerated water, nitrate is highly soluble in water and is stable over a wide range of conditions, and ammonium cations tend to adsorb on mineral surfaces. The reduced forms of nitrogen (nitrite, ammonium, and organic species) are oxidized to nitrate in most aerobic environments, but in contaminated streams and aquifers, a substantial part of the total nitrogen concentration may be these reduced species. Large nitrate concentrations are undesirable in a domestic or public water supply because of potential health hazards, particularly for infants. Because of the potential health risks associated with nitrate, the U.S. Environmental Protection Agency (USEPA) has established a Maximum Contaminant Level (MCL) of 10 mg/L of nitrate as nitrogen in public-drinking water supplies (U.S. Environmental Protection Agency, 1986). No dissolved nitrite plus nitrate concentrations in surface-water samples from the Ozark Plateau study unit exceeded the MCL of 10 mg/L as nitrogen.

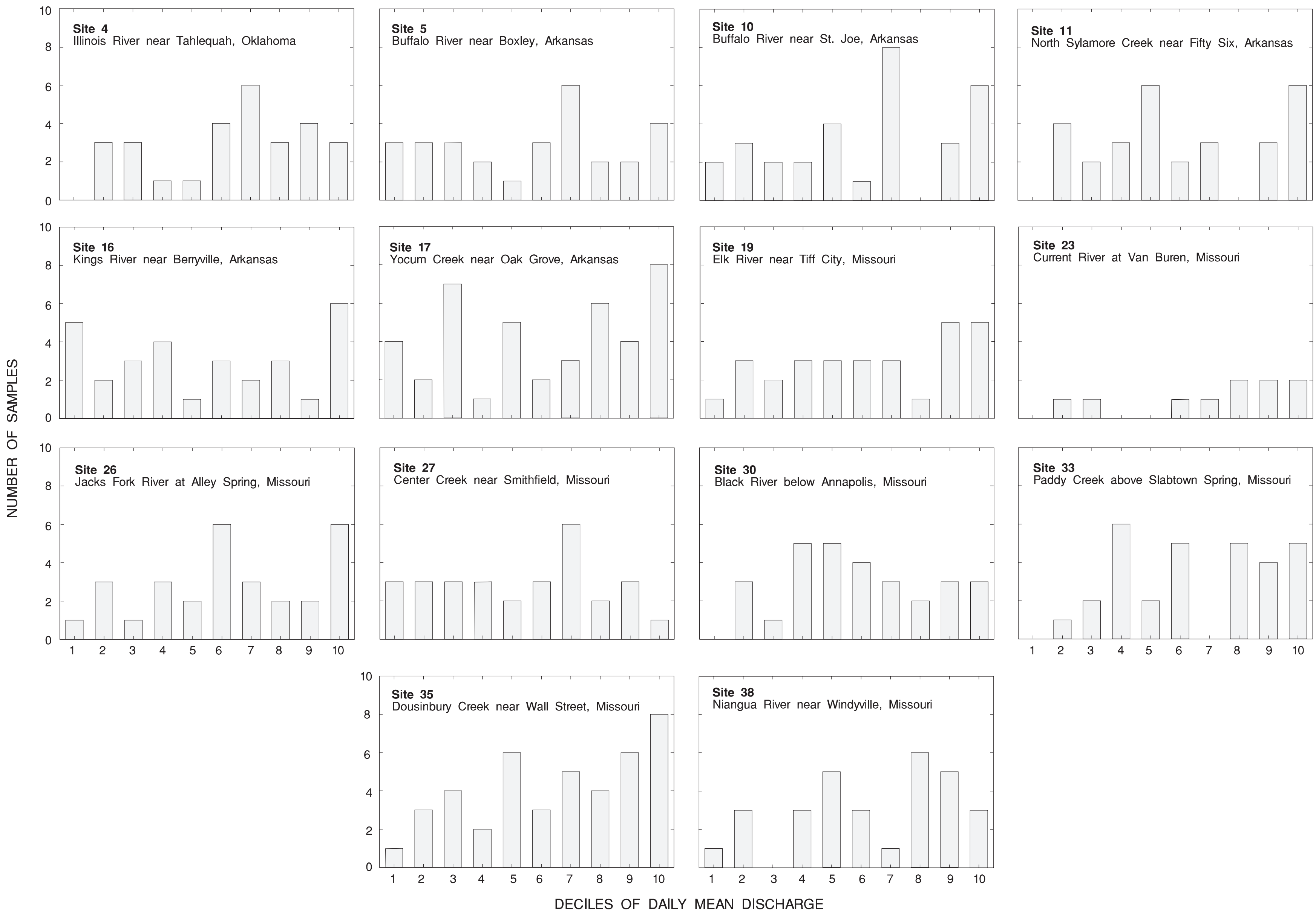

Figure 5. Number of samples for total phosphorus within deciles of daily mean discharge for water years 1993–95.

The most common dissolved, inorganic phosphorus species in water are the orthophosphates ($H_2PO_4^-$ and HPO_4^{2-}), but organic phosphate species synthesized by plants and animals also constitute a substantial part of the phosphorus in natural waters (Hem, 1985). The orthophosphate ion is the phosphorus species most readily available for use by aquatic plants. Most phosphorus-containing compounds are relatively insoluble, and thus the chemistry of the element favors precipitation or adsorption onto sediments. Total phosphorus concentrations include inorganic phosphorus (in solution, complexed with iron or other trace elements, or adsorbed to sediment particles) and organic phosphorus.

The nutrient species analyzed included dissolved nitrite plus nitrate, dissolved ammonia, total and dissolved ammonia plus organic nitrogen, total and dissolved phosphorus, and dissolved orthophosphate. Summary statistics of the nutrient data for the 14 fixed sites are listed in table 6. The dissolved nitrite plus nitrate and total phosphorus data will be discussed in detail in the following sections. Other nutrient species did not have enough variation in concentrations in streams with different physiography, land-use setting, or basin size to warrant additional discussion.

Dissolved Nitrite Plus Nitrate

Dissolved nitrite plus nitrate concentrations differed significantly ($p < 0.05$) among samples for streams draining basins of different size and with forest or agricultural land-use settings within the Springfield and Salem Plateaus (fig. 6; table 6). Similar

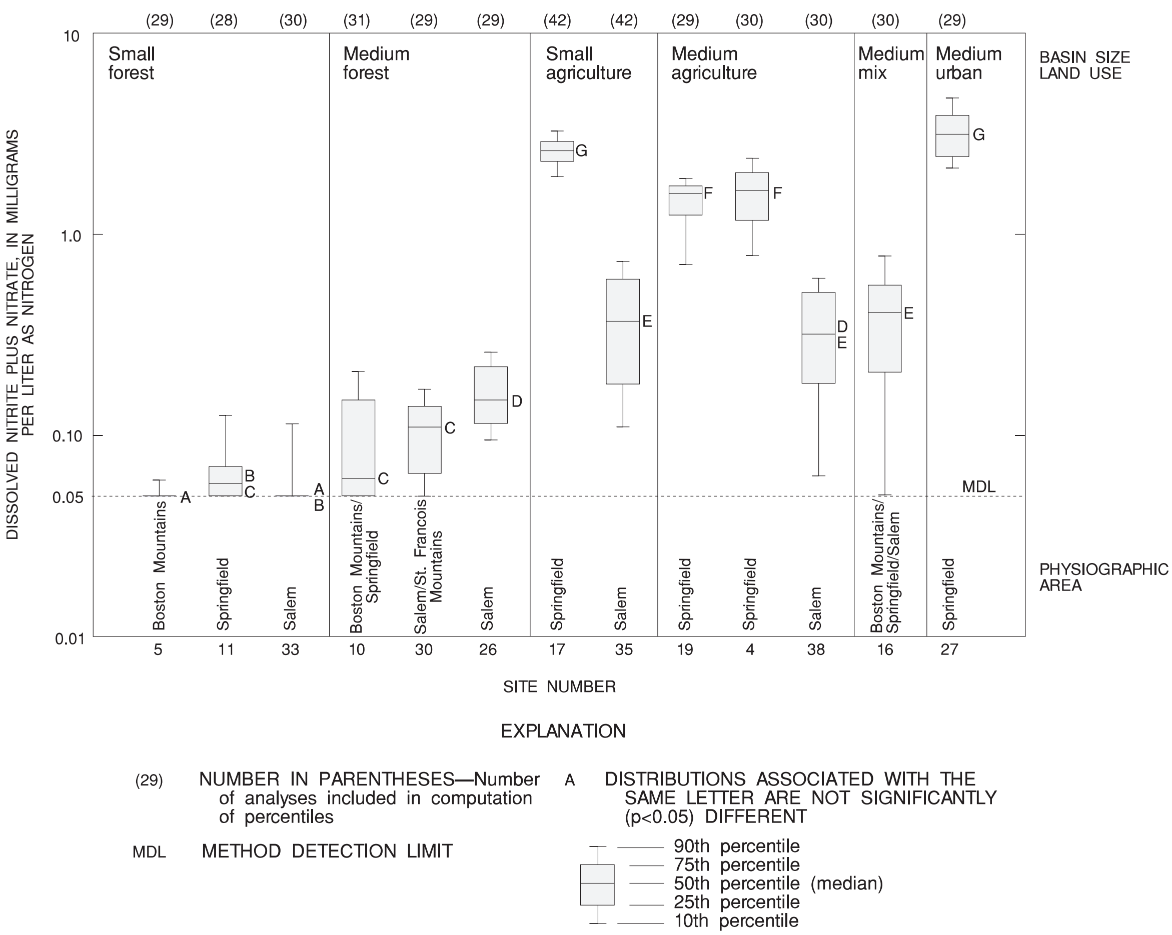

Figure 6. Statistical distribution of dissolved nitrite plus nitrate concentrations at selected surface-water fixed sites for water years 1993–95.

results were seen in an analysis of historical nitrite plus nitrate data for the Ozark Plateaus done prior to this data collection (Davis and others, 1995). The stream draining a small, forest basin in the Salem Plateau had smaller concentrations (median of less than 0.05 mg/L as nitrogen for site 33, Paddy Creek above Slabtown Spring, Missouri) than two streams draining medium, forest basins (median of 0.15 mg/L for site 26, Jacks Fork River at Alley Spring, Missouri, and 0.11 mg/L for site 30, Black River below Annapolis, Missouri). The difference probably is related to more extensive silvicultural and recreational activities in the larger basins. Dissolved nitrite plus nitrate concentrations did not differ significantly among samples for forest basins in the Springfield Plateau, median of 0.06 mg/L for both small (site 11, North Sylamore Creek near Fifty Six, Arkansas) and medium (site 10, Buffalo River near St. Joe, Arkansas) basins.

A stream draining a small, agricultural basin in the Springfield Plateau had larger dissolved nitrite plus nitrate concentrations (median of 2.6 mg/L as nitrogen for site 17, Yocum Creek near Oak Grove, Arkansas) than streams draining medium, agricultural basins (median of 1.6 mg/L for site 4, Illinois River near Tahlequah, Oklahoma, and site 19, Elk River near Tiff City, Missouri). The Yocum Creek basin has a larger percentage of agricultural land use than either the Elk or Illinois River Basins. A similar relation with drainage-basin size did not exist for agricultural basins in the Salem Plateau (median of 0.37 mg/L for site 35, Dousinbury Creek near Wall Street, Missouri, and 0.31 mg/L for site 38, Niangua River at Windyville, Missouri). The Dousinbury Creek and Niangua River basins both have about 40 percent agricultural land use.

A large difference in dissolved nitrite plus nitrate concentrations occurred between streams draining basins with agricultural land use in the Springfield and Salem Plateaus (figs. 6, 7). Streams draining both small and medium agricultural basins in the Springfield Plateau had much larger concentrations than their counterparts in the Salem Plateau. This result probably is related to the type of agricultural activity in the Springfield Plateau (intensive poultry farming and subsequent application of poultry wastes to pastures) rather than percent agricultural land use in the basin because the three medium basins have similar percentages of agricultural land use (table 5).

Dissolved nitrite plus nitrate concentrations at fixed and synoptic sites of similar physiography, basin size, and land-use setting are generally within the same order of magnitude. The dissolved nitrite plus nitrate data collected at 13 fixed sites (site 23, Current River at Van Buren, Missouri, was not included in this analysis) and 29 synoptic sites during the synoptic sampling in May 1994 and 1995 and August or September 1994 are compared in figure 7. Overall, the data for streams in basins of similar physiography, basin size, and land-use setting group together, suggesting that the fixed sites are relatively representative of other sites in a physiographic-area/basin-size/land-use category. Two notable exceptions are the three synoptic sites representing small, Springfield Plateau forest basins (sites 9, 12, and 18; table 5) and three of the four synoptic sites representing medium, Salem forest basins (sites 20, 31, and 36; table 5). Agricultural land use in the three Springfield Plateau synoptic site basins ranges from 28 to 36 percent as compared to only 3 percent in the North Sylamore Creek Basin (site 11). In the three Salem Plateau synoptic site basins agricultural land use ranges from about 26 to 36 percent as compared to about 6 percent in the Black River Basin (site 30), 22 percent in the Jacks Fork River Basin (site 26), and 12 percent in the Huzzah Creek Basin (site 40).

Dissolved nitrite plus nitrate concentration correlated strongly with percent agricultural land use. A plot of dissolved nitrite plus nitrate versus percent agricultural land use is shown in figure 8 for 13 fixed sites and 29 synoptic sites. The relation of dissolved nitrite plus nitrate concentration to percent agricultural land use has a strong positive correlation (Spearman correlation coefficient of 0.74), with percent agricultural land use accounting for almost 60 percent of the variation in the dissolved nitrite plus nitrate concentrations (multiple R^2 of 0.60). Most of the Salem Plateau sites plot below the regression line, whereas most of the Springfield Plateau sites plot above the line. This indicates that factors other than land-use percentage (most likely land-use practices) also affect dissolved nitrite plus nitrate concentration. The areal distribution of median dissolved nitrite plus nitrate concentrations at the fixed and synoptic sites is shown in figure 9. This figure illustrates that streams draining agricultural and mixed land-use basins in the Springfield Plateau in southwest Missouri, northwest Arkansas, and northeast Oklahoma have the largest dissolved nitrite plus nitrate concentrations.

Also apparent from the comparison of dissolved nitrite plus nitrate concentrations at fixed and

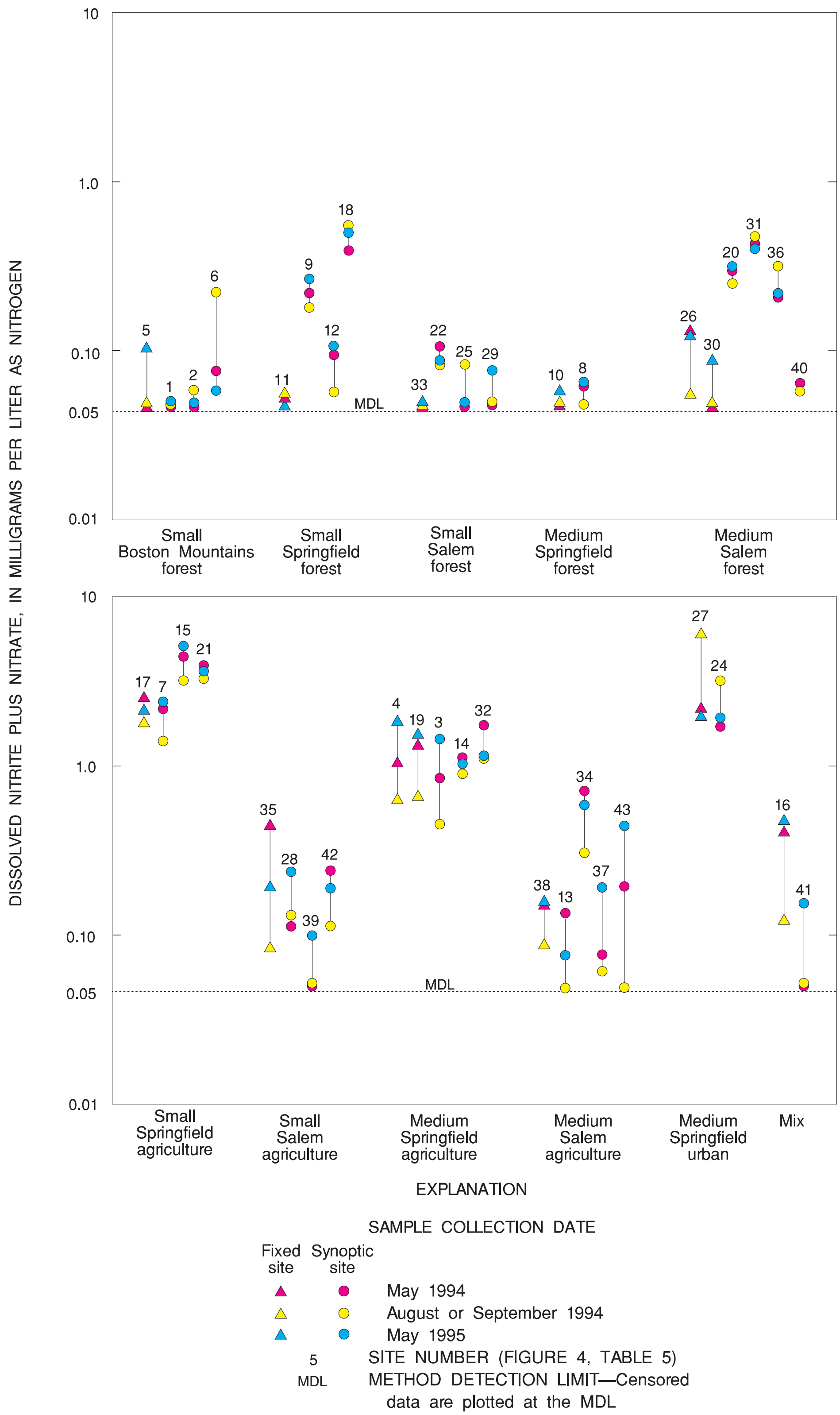

Figure 7. Comparison of dissolved nitrite plus nitrate data collected at fixed and synoptic sites May 1994 and 1995 and August or September 1994.

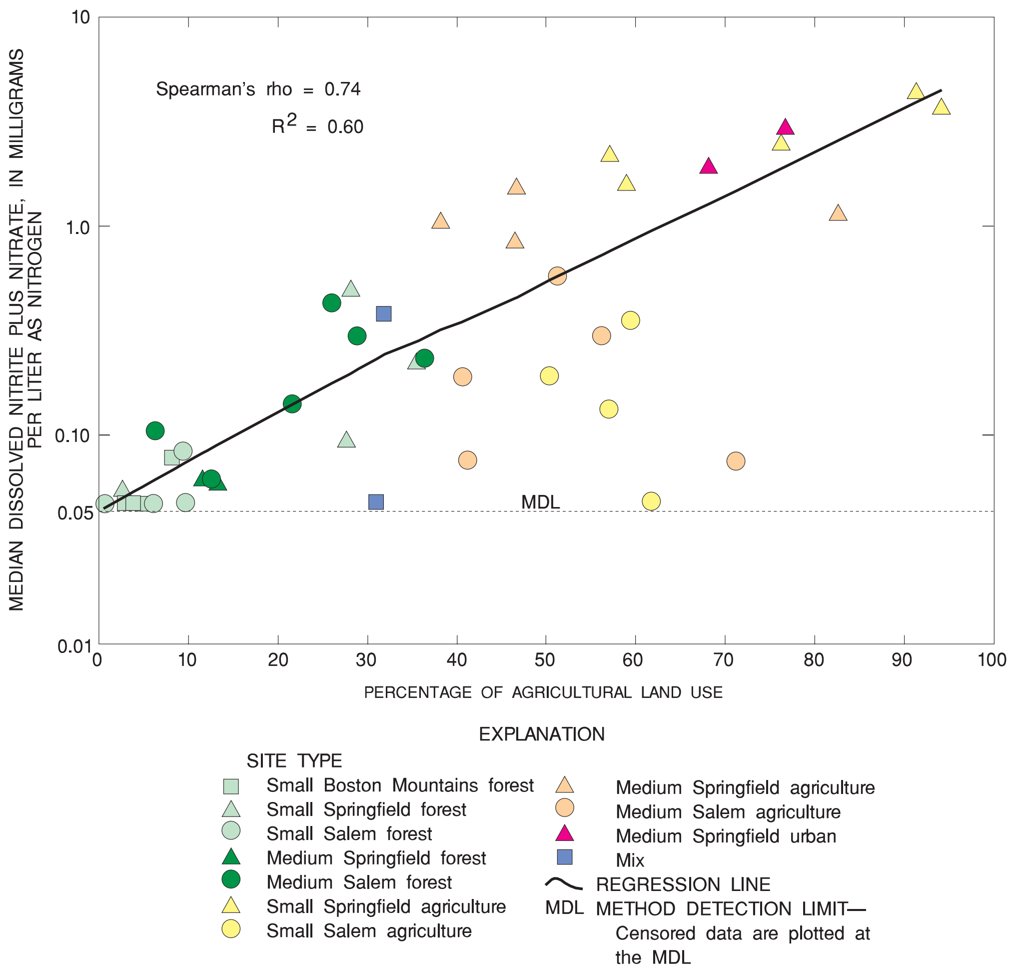

Figure 8. Relation of dissolved nitrite plus nitrate concentrations to the percentage of agricultural land use.

synoptic sites (fig. 7) is that in streams primarily affected by nonpoint sources of nitrogen (primarily agricultural sites), the largest dissolved nitrite plus nitrate concentrations generally occurred during periods of increased runoff in May 1994 and 1995, whereas the smallest concentrations generally occurred during the low-flow period in August or September 1994. The opposite situation is observed at the two sites representing medium, Springfield Plateau urban basins. Site 27, Center Creek near Smithfield, Missouri, is affected by small municipal and industrial point-source discharges; site 24, James River near Boaz, Missouri, is located downstream from a municipal wastewater-treatment discharge in Springfield, Missouri (fig. 4; table 5). During low-flow periods, these streams are affected primarily by point sources of nitrogen. The relation between dissolved nitrite plus nitrate concentration and discharge is primarily a function of the source (point or nonpoint) and the land use in the basin (fig. 10). Increases in discharge caused by precipitation runoff in basins with primarily nonpoint sources of nitrite and nitrate generally caused increases in concentration up to some threshold, which implies a nitrate source related to surface runoff. The magnitude of the concentrations depends on the

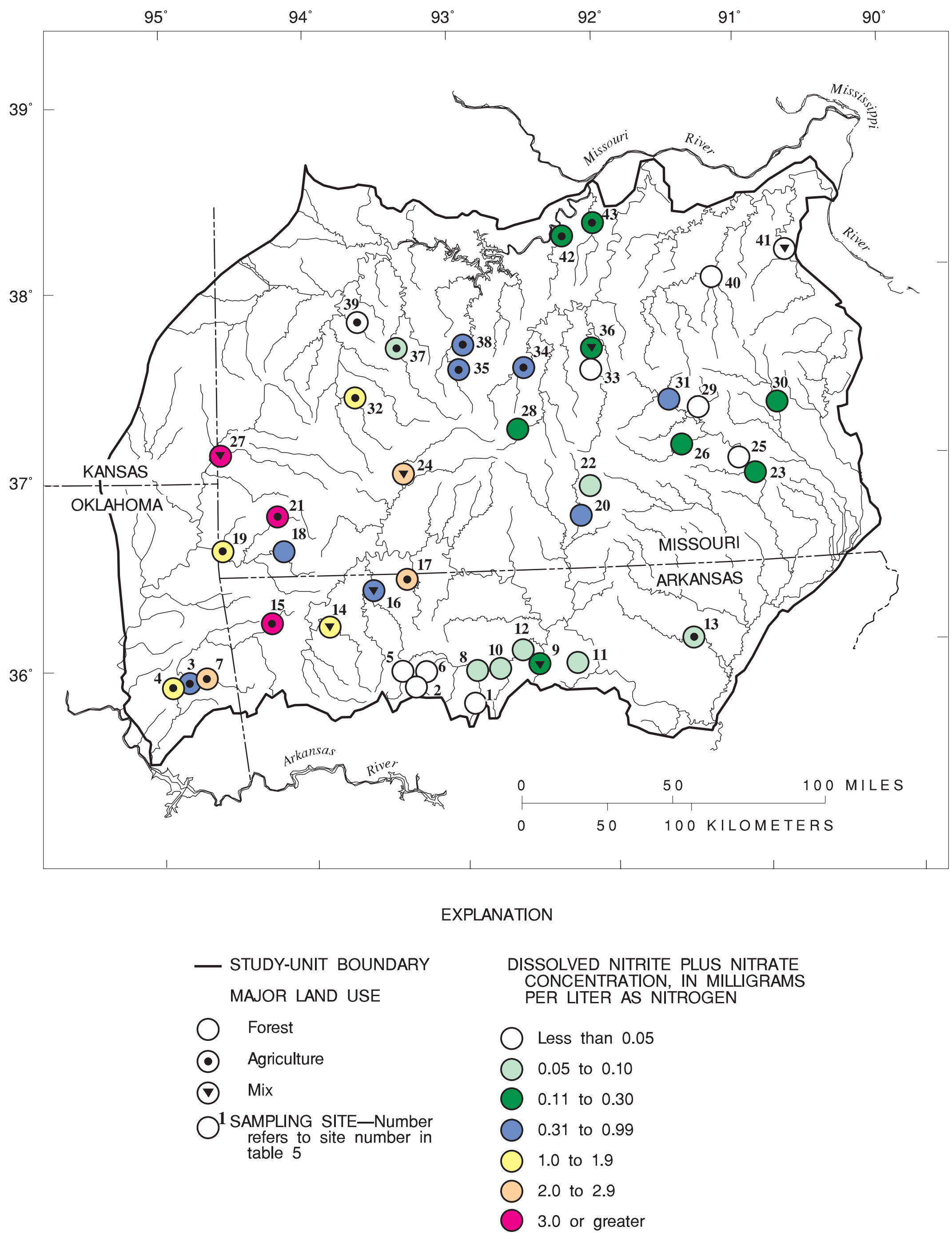

Figure 9. Areal distribution of median dissolved nitrite plus nitrate concentrations at fixed and synoptic sites for water years 1993–95.

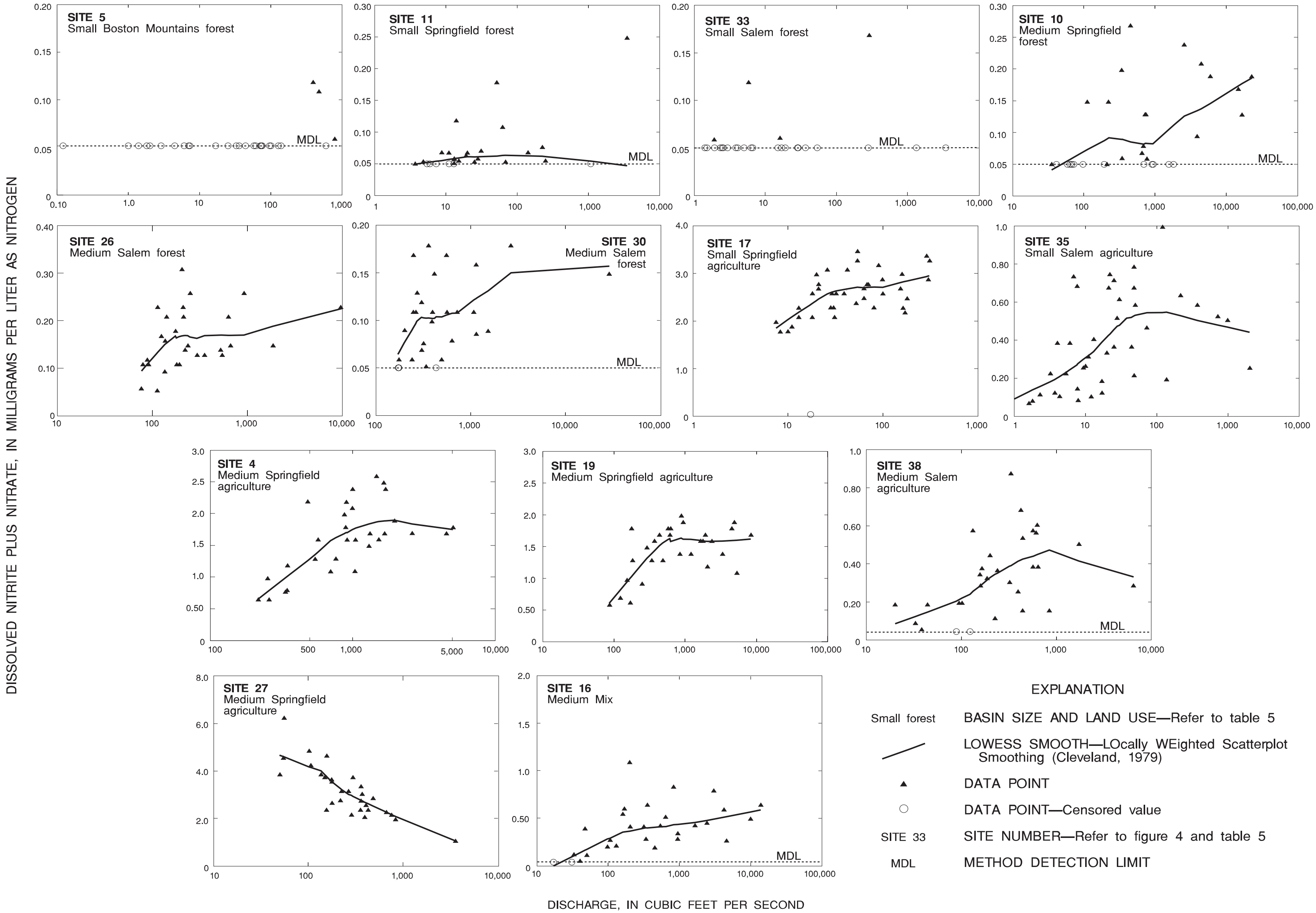

Figure 10. Relation of dissolved nitrite plus nitrate concentrations to discharge at fixed sites for water years 1993–95.

availability of nitrate in the basin, which is directly related to land use. The sites representing small, forest basins in the Boston Mountains, Springfield Plateau, and Salem Plateau (sites 5, 11, and 33; fig. 4; table 5) had little to no increase in dissolved nitrite plus nitrate concentrations with increasing discharge. In contrast, the sites representing agricultural land use (sites 4, 16, 17, 19, 35, and 38) had increases in concentration with increasing discharge (fig. 10). At Center Creek near Smithfield, Missouri (site 27), where dissolved nitrite plus nitrate concentrations primarily are affected by point sources, concentrations were largest at low flows and then decreased in response to increases in discharge caused by precipitation runoff. Similar results were seen in an analysis of historical nitrite plus nitrate data for the Ozark Plateaus done prior to this data collection (Davis and others, 1995).

Total Phosphorus

Total phosphorus concentrations differed significantly among samples for streams draining basins with forest or agricultural land-use settings within the Springfield and Salem Plateaus (fig. 11; table 6). Sites on streams representing agricultural land use had larger total phosphorus concentrations in all cases. Similar results were previously described in Davis and others (1995). Basin drainage size was not a significant factor in affecting total phosphorus concentrations. No significant differences in total phosphorus

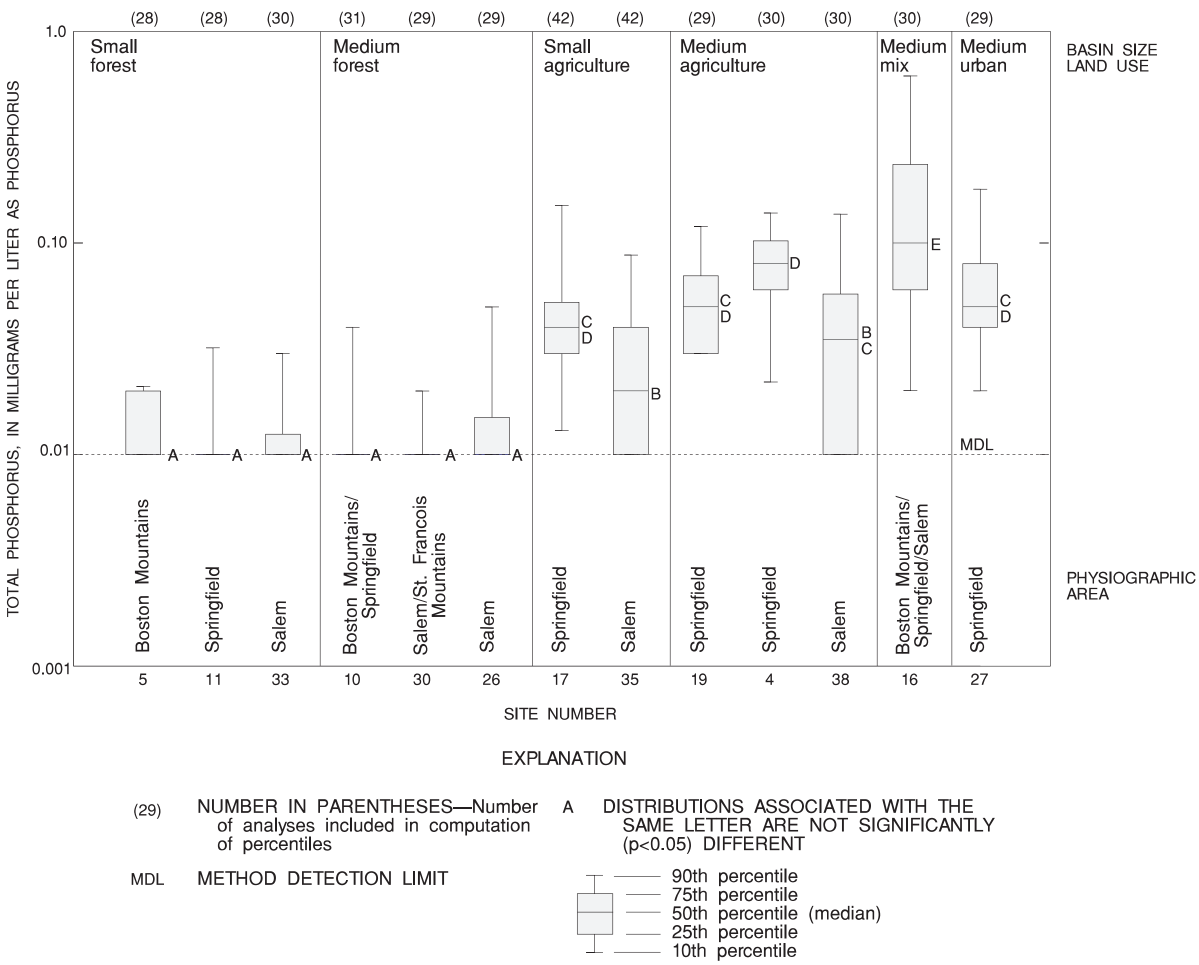

Figure 11. Statistical distribution of total phosphorus concentrations at selected surface-water fixed sites for water years 1993–95.

concentrations occurred between small and medium basins with forest or agricultural land use in either the Springfield or Salem Plateaus or between any of the streams in forest basins in the Boston Mountains, Springfield Plateau, or Salem Plateau (median of less than 0.01 mg/L for all forest basins). As with dissolved nitrite plus nitrate, differences in total phosphorus concentrations occurred between streams draining basins with agricultural land use in the Springfield Plateau and those in the Salem Plateau (fig. 11). Streams in both small and medium agricultural basins in the Springfield Plateau (median of 0.04 mg/L for site 17, 0.05 mg/L for site 19, and 0.08 mg/L for site 4) had larger concentrations than their counterparts in the Salem Plateau (median of 0.02 mg/L for site 35 and 0.03 mg/L for site 38), again indicating a relation to the type of agricultural land use rather than the percent agricultural land use. The largest total phosphorus concentrations were observed at site 16, Kings River near Berryville, Arkansas, which is located about 10 mi (miles) downstream from a municipal wastewater-treatment discharge.

The total phosphorus data collected at 13 fixed sites and 29 synoptic sites during the synoptic sampling in May 1994 and 1995 and August or September 1994 are compared in figure 12. Overall, the data for streams in basins of similar size and land-use setting group together, although the variation in concentrations is greater than with dissolved nitrite plus nitrate concentrations (fig. 7). Many of the exceptions (for example, sites 11, 17, 35, and 37) appear to be discharge related (fig. 13). For example, the May 1995 sample collected at site 37, representing medium, Salem Plateau agricultural basins, had a much larger total phosphorus concentration than other samples from comparable sites (sites 13, 34, 38, and 43). The stream discharge for the May 1995 sample collected at site 37 (fig. 13) was an order of magnitude larger than the discharges at the other sites.

In streams primarily affected by nonpoint sources of phosphorus (primarily agricultural sites), the largest total phosphorus concentrations did not necessarily occur during periods of increased runoff in May 1994 and 1995 but often were measured in the low-flow samples collected in August or September of 1994 (fig. 12). At the two sites representing medium, Springfield Plateau urban basins (sites 24 and 27), the largest concentrations were observed in the August and September samples as expected. The same is true at site 16, Kings River near Berryville, Arkansas, which is downstream from a point-source discharge. The variation among sites primarily affected by nonpoint sources may be attributed to the relation between phosphorus concentrations and discharge. Because phosphorus species tend to sorb to sediments, total phosphorus concentrations decrease with initial increases in streamflow until sediment is mobilized causing an increase in total phosphorus concentrations (fig. 14). Depending on when a sample is collected in relation to the streamflow hydrograph, a larger discharge may have a smaller or larger total phosphorus concentration.

Total phosphorus concentrations also increase with increasing percent agricultural land use. A plot of total phosphorus versus percent agricultural land use is shown in figure 15 for 13 fixed sites and the 29 synoptic sites. The relation of total phosphorus to percent agricultural land use has a positive correlation (Spearman correlation coefficient of 0.74), with percent agricultural land use accounting for about 42 percent of the variation in the total phosphorus concentrations (multiple R^2 of 0.42).

Fecal Indicator Bacteria

Fecal indicator bacteria are measures of the sanitary quality of water. The concentration of these bacteria is one indicator of whether water is safe for whole-body-contact recreation, safe for consumption, or free from disease-causing organisms. Indicator bacteria are not typically disease causing but are correlated to the presence of water-borne pathogens. Sources of fecal indicator bacteria include undisinfected municipal wastewater-treatment effluents; combined-sewer overflows; septic tanks; animal wastes from feedlots, barnyards, and pastures; manure application areas; and stormwater. The fecal indicator bacteria species used in this study are bacteria of the fecal coliform and fecal streptococci groups and *Escherichia coli* (*E. coli*), all of which are restricted to the intestinal tracts of warm-blooded animals. *E. coli* is strictly an inhabitant of the gastrointestinal tract of warm-blooded animals and its presence in water is direct evidence of fecal contamination from warm-blooded animals and the possible presence of pathogens (Dufour, 1977). The fecal coliform test is not as specific for fecal coliform bacteria but tends to test positive for soil bacteria as well.

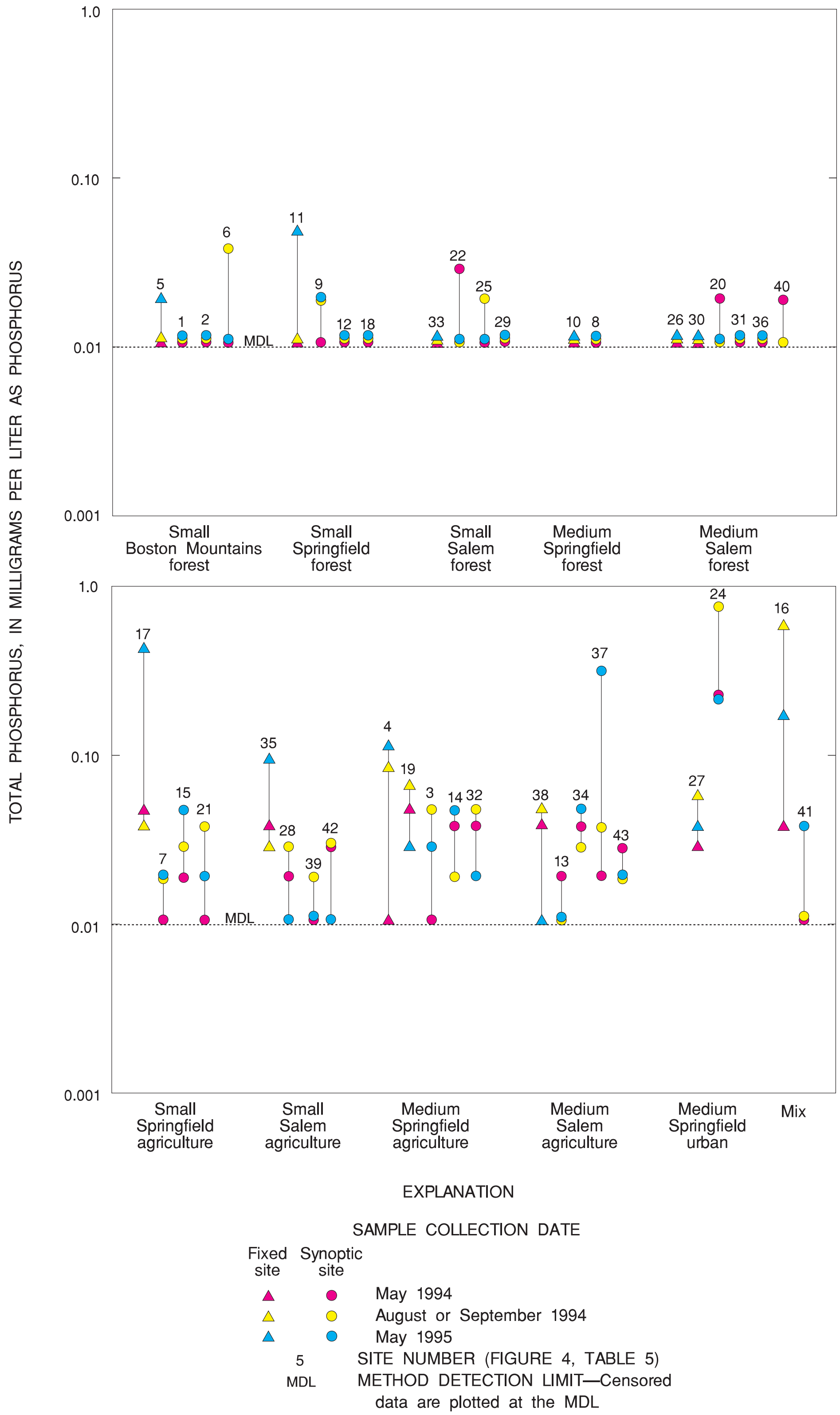

Figure 12. Comparison of total phosphorus data collected at fixed and synoptic sites May 1994 and 1995 and August or September 1994.

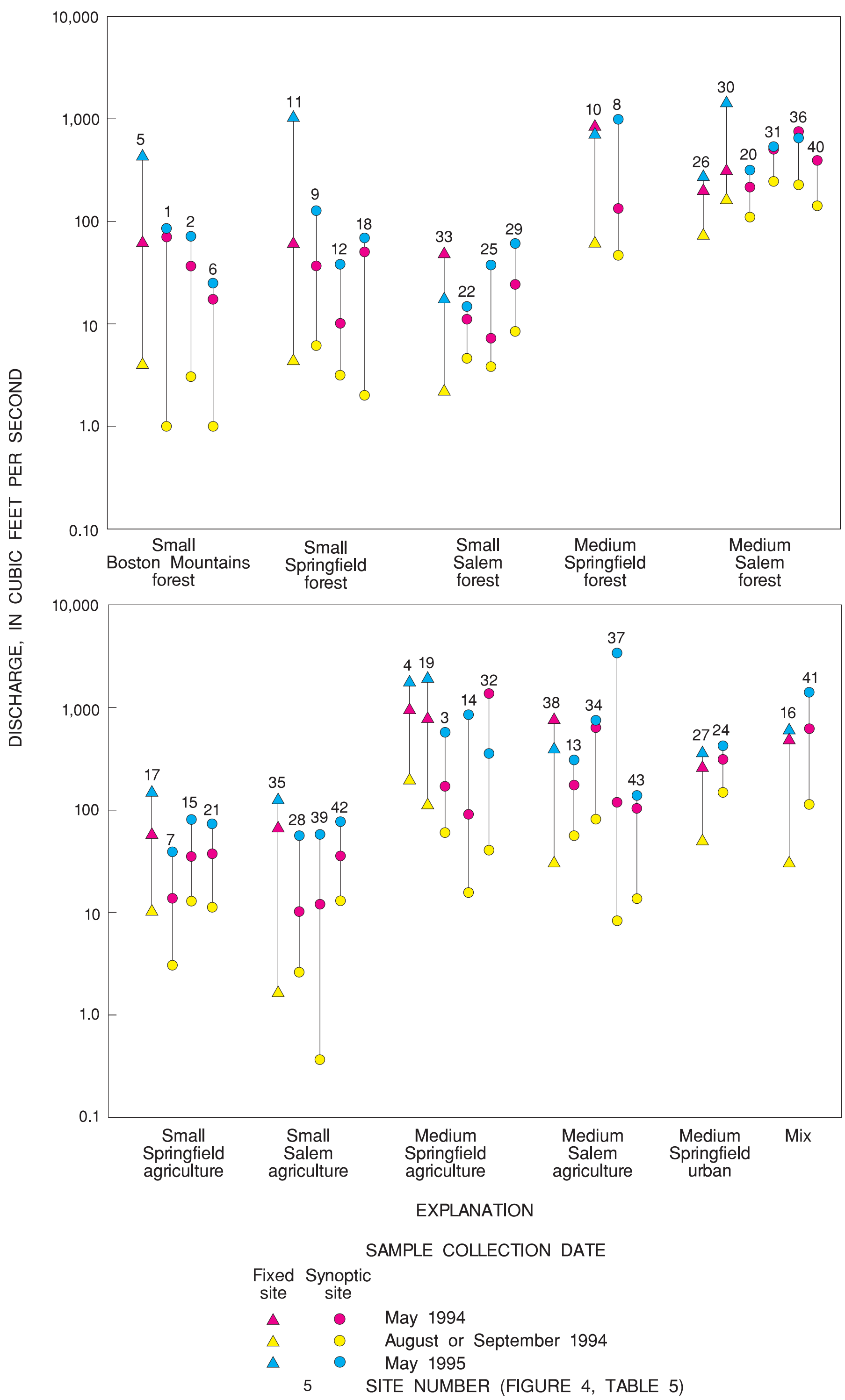

Figure 13. Comparison of instantaneous discharge at fixed and synoptic sites May 1994 and 1995 and August or September 1994.

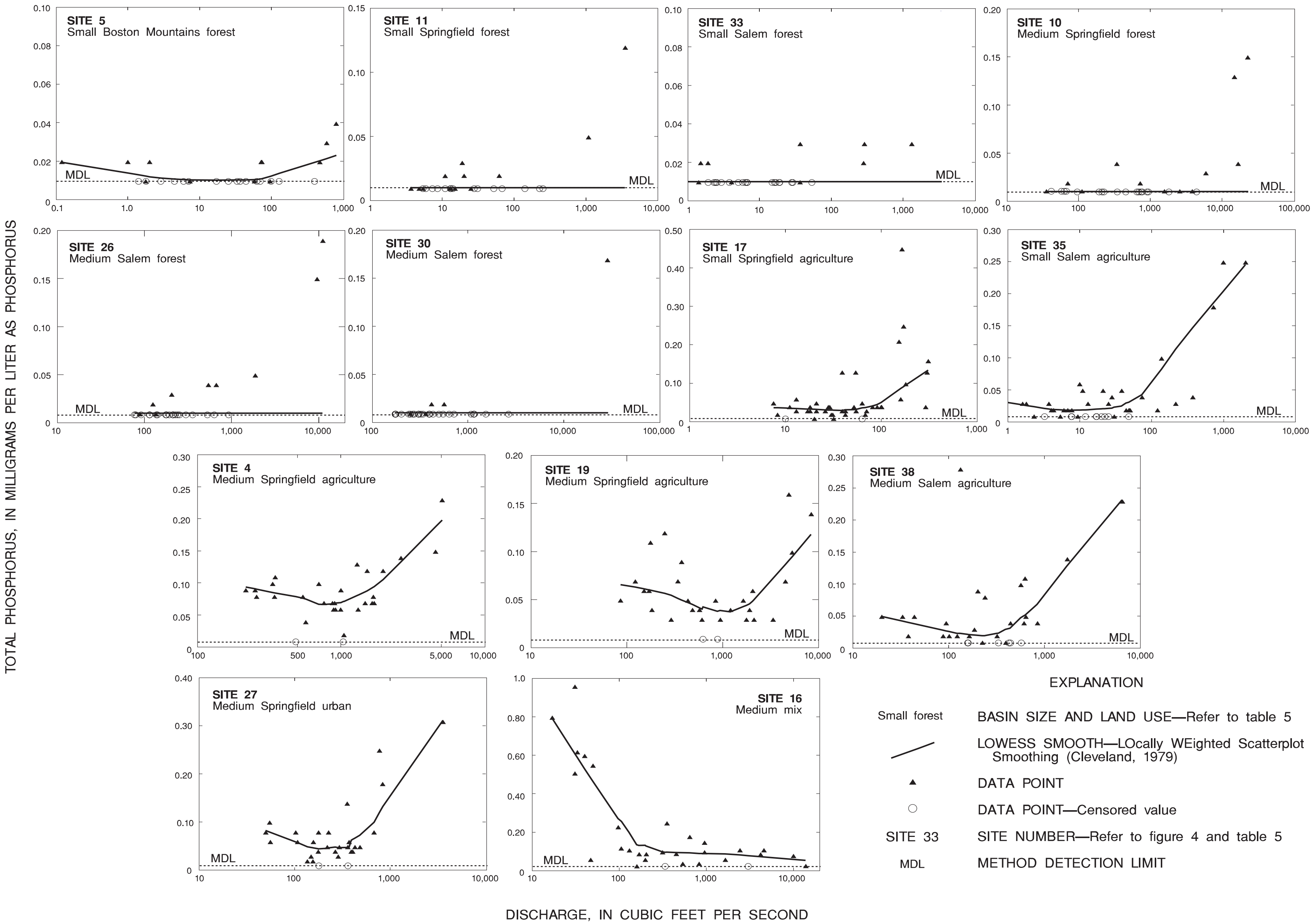

Figure 14. Relation of total phosphorus concentrations to discharge at fixed sites for water years 1993–95.

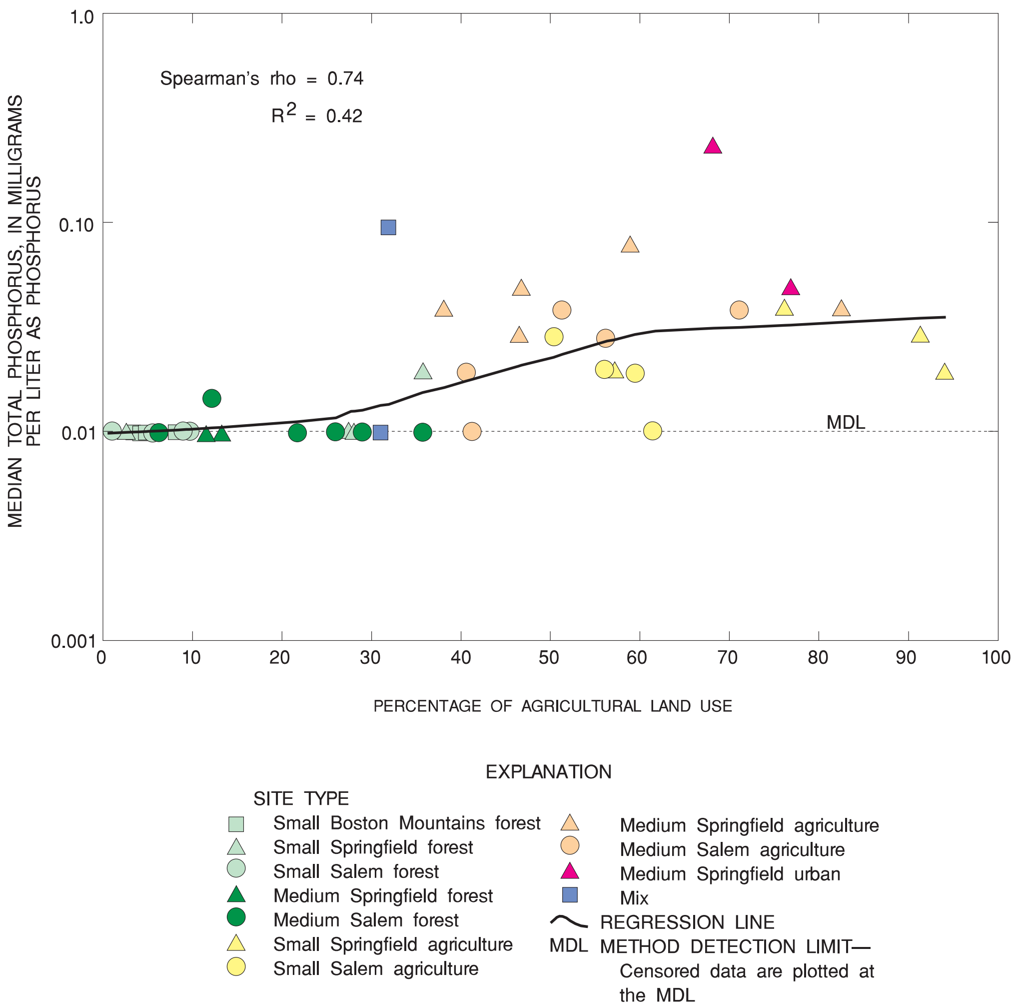

Figure 15. Relation of total phosphorus concentrations to the percentage of agricultural land use.

The fecal coliform bacteria data were evaluated for this report because the data were available for the entire period of record whereas *E. coli* data collection did not begin until May 1994. Also, a comparison to historical data is possible for fecal coliform bacteria. For those samples where both *E. coli* and fecal coliform counts were determined, the fecal coliform to *E. coli* ratio would be expected to be equal to or greater than 1.0 because *E. coli* are a subset of the fecal coliform group. The median fecal coliform to *E. coli* ratio for the fixed sites ranged from 1.0 to 1.8 (table 7).

Fecal coliform bacteria counts differed significantly ($p < 0.05$) among samples for streams draining basins with forest or agricultural land-use settings within the Springfield and Salem Plateaus (fig. 16; table 6). With the exception of site 33 (Paddy Creek above Slabtown Spring, Missouri), all sites on streams representing forest land use had significantly smaller fecal coliform counts than sites on streams representing agricultural land use. Significant differences were not observed between site 33 and streams draining other forested basins or streams draining small and medium agricultural basins in the Springfield Plateau.

Table 7. Median fecal coliform to *Escherichia coli* ratios at fixed sites for water years 1993–95

[FC, fecal coliform; EC, *Escherichia coli*]

Site number (fig. 4)	Station name (table 5)	Median FC/EC ratio
4	Illinois River near Tahlequah, Okla.	1.0
5	Buffalo River near Boxley, Ark.	1.0
10	Buffalo River near St. Joe, Ark.	1.3
11	North Sylamore Creek near Fifty Six, Ark.	1.4
16	Kings River near Berryville, Ark.	1.5
17	Yocum Creek near Oak Grove, Ark.	1.1
19	Elk River near Tiff City, Mo.	1.2
26	Jacks Fork River at Alley Spring, Mo.	1.8
27	Center Creek near Smithfield, Mo.	1.2
30	Black River below Annapolis, Mo.	1.2
33	Paddy Creek above Slabtown Spring, Mo.	1.3
35	Dousinbury Creek near Wall Street, Mo.	1.2
38	Niangua River near Windyville, Mo.	1.2

The reason for the slightly elevated bacteria counts at site 33 [median 24 col/100 mL (colonies per 100 mL) of sample] as compared to other small, fixed-site forest basins has not been identified, but a campground near the sampling site, hiking and horse trails, and numerous small springs could be sources. Similar bacteria counts were observed in other small, Salem Plateau forest basins (fig. 17). No significant differences in fecal coliform bacteria counts occurred between small and medium basins with agricultural land use in either the Springfield or Salem Plateaus or between any of the streams in forest basins in the Boston Mountains, Springfield Plateau, or Salem Plateau (median ranged from 6 to 24 col/100 mL sample, table 6). The largest fecal coliform bacteria counts were measured at site 35 (Dousinbury Creek near Wall Street, Missouri; median 570 col/100 mL sample).

The fecal coliform bacteria data collected at 13 fixed sites and 29 synoptic sites during the synoptic sampling in May 1994 and 1995 and August or September 1994 are compared in figure 17. The data for streams in basins of similar size and land-use setting generally group together, and as with total phosphorus, the exceptions (for example, sites 11, 17, 35, and 37) appear to be discharge related. The largest counts generally were in the May 1995 samples and the smallest counts generally were in the August or September 1994 samples. Fecal coliform bacteria have a similar concentration-to-discharge relation as total phosphorus (figs. 14, 18). Site 24, representing medium, Springfield Plateau streams with urban land use, did not have an unusually large fecal coliform count, and the largest count did not occur during low-flow conditions (fig. 17). This result suggests that the municipal wastewater-treatment plant located upstream from the sampling site on the James River provides adequate disinfection of municipal wastewater prior to release,

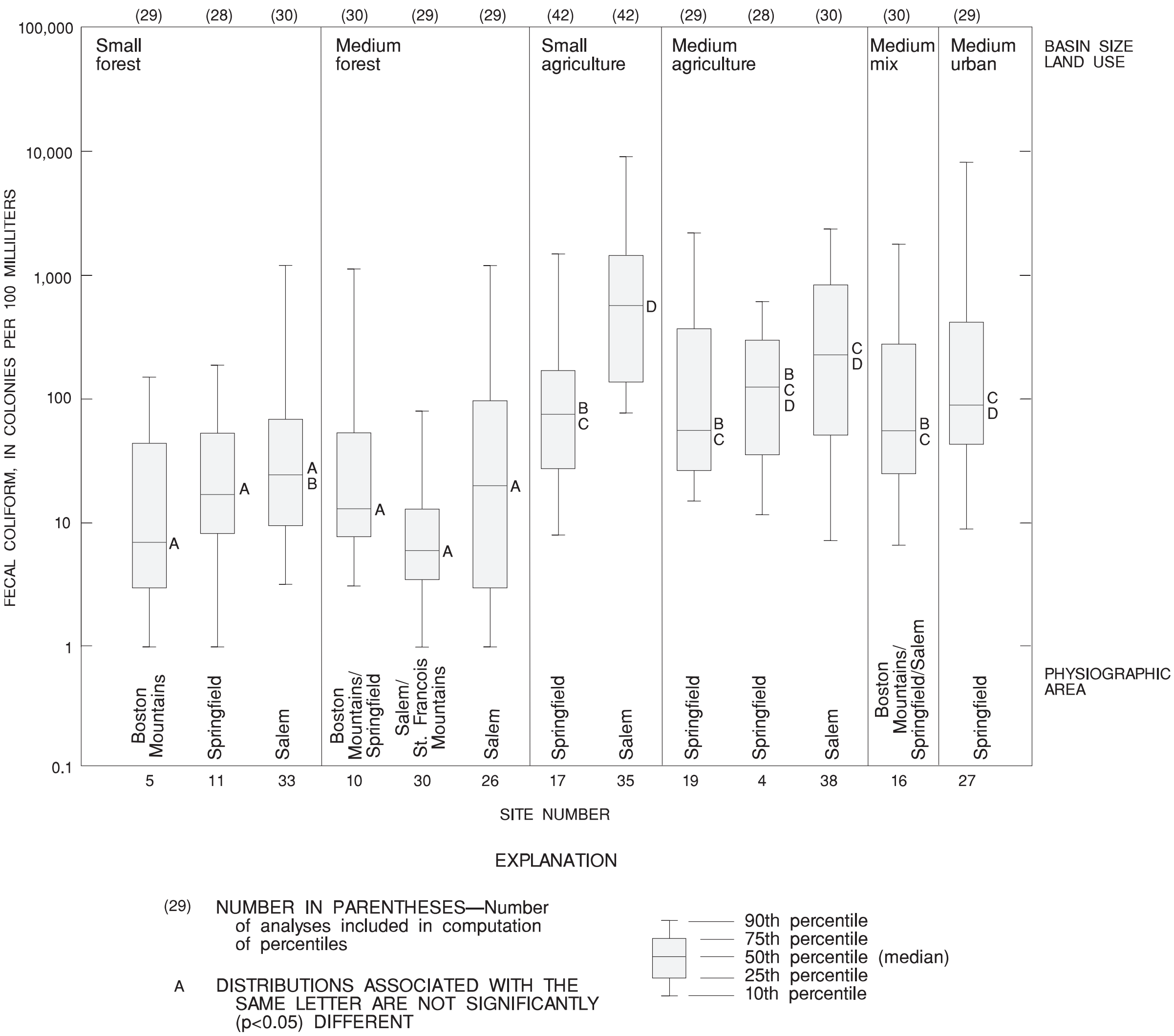

Figure 16. Statistical distribution of fecal coliform counts at selected surface-water fixed sites for water years 1993–95.

and that bacteria in the stream may originate from other sources.

Fecal coliform bacteria counts increase with increasing percent agricultural land use. A plot of fecal coliform counts versus percent agricultural land use is shown in figure 19 for 13 fixed sites and 29 synoptic sites. The relation of fecal coliform to percent agricultural land use has a positive correlation (Spearman correlation coefficient of 0.78), with percent agricultural land use accounting for about 42 percent of the variation in the fecal coliform counts (multiple R^2 of 0.42).

Organic Carbon

Organic carbon in streams consists of DOC and SOC, with the ratio of DOC to SOC generally between 6 and 10 (Wetzel, 1975). The median DOC-to-SOC ratio for the fixed sites ranged from 4.2 to 9.5 (table 8). Ratios for small forest, medium forest, and small

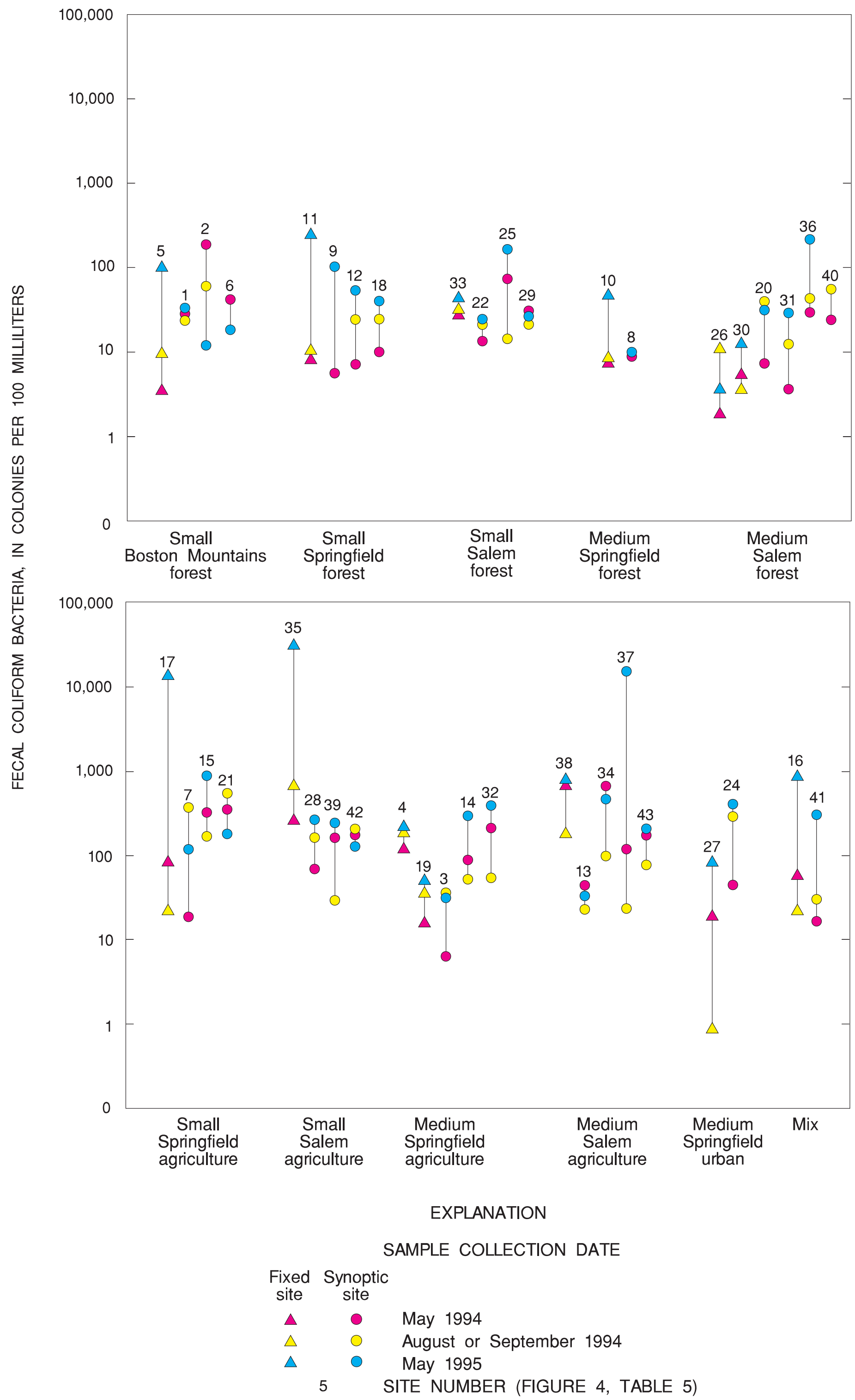

Figure 17. Comparison of fecal coliform data collected at fixed and synoptic sites May 1994 and 1995 and August or September 1994.

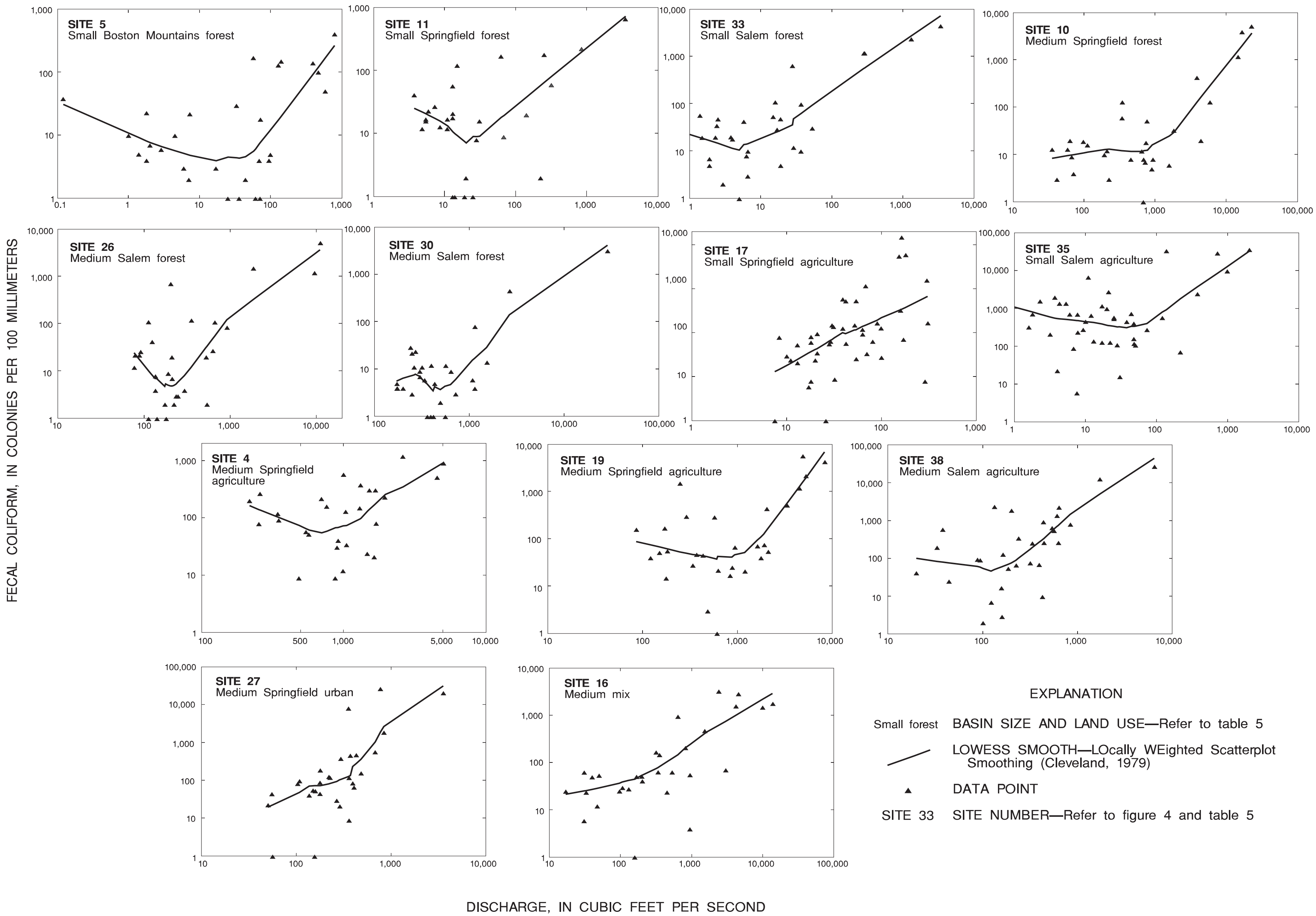

Figure 18. Relation of fecal coliform counts to discharge at fixed sites for water years 1993–95.

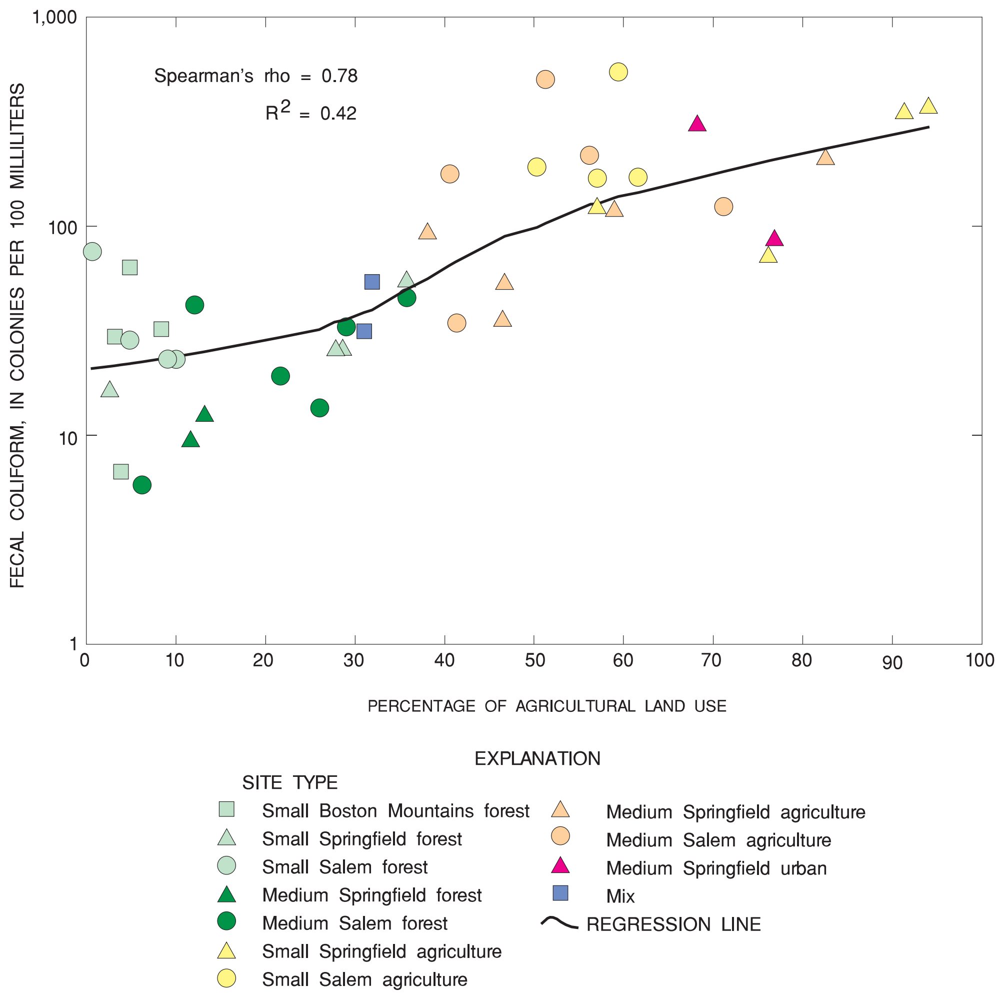

Figure 19. Relation of fecal coliform counts to the percentage of agricultural land use.

agricultural sites (sites 5, 10, 11, 17, 26, 30, 33, and 35) generally were 7.0 or greater. Ratios for medium agricultural, medium mix, medium urban, and large forest generally were equal to or less than 6.0. The biochemical transformations of DOC and SOC by microbial metabolism are fundamental to the dynamics of nutrient cycling and energy flux within aquatic ecosystems. The compounds that make up DOC and SOC include carbohydrates, proteins, peptides, amino acids, fats, waxes, resins, and humic substances, which generally constitute 40 to 60 percent of the DOC and are the largest fraction of natural organic matter in water (Thurman, 1985). Natural sources of organic carbon include those outside the aquatic system (allochthonous) such as from soil and from plants and those within the aquatic system (autochthonous) such as excretion from actively growing algae or the decomposition of dead algae and macrophytes. Terrestrial sources are the major inputs of DOC and SOC into streams. Anthropogenic sources include municipal wastewater-treatment effluents, animal waste, and septic tanks. Activities that cause land disturbance such as row-crop agriculture, animal grazing, timber harvesting, mining, highway construction and maintenance, and urbanization can result in increased stream concentrations of DOC and SOC.

Table 8. Median dissolved organic carbon to suspended organic carbon ratios at fixed sites for water years 1993–95

[DOC, dissolved organic carbon; SOC, suspended organic carbon]

Site number (fig. 4)	Station name (table 5)	Median DOC/SOC ratio
4	Illinois River near Tahlequah, Okla.	4.2
5	Buffalo River near Boxley, Ark.	6.0
10	Buffalo River near St. Joe, Ark.	5.5
11	North Sylamore Creek near Fifty Six, Ark.	9.0
16	Kings River near Berryville, Ark.	6.0
17	Yocum Creek near Oak Grove, Ark.	7.3
19	Elk River near Tiff City, Mo.	4.8
23	Current River at Van Buren, Mo.	4.8
26	Jacks Fork River at Alley Spring, Mo.	8.0
27	Center Creek near Smithfield, Mo.	4.5
30	Black River below Annapolis, Mo.	7.0
33	Paddy Creek above Slabtown Spring, Mo.	9.5
35	Dousinbury Creek near Wall Street, Mo.	9.0
38	Niangua River near Windyville, Mo.	6.0

The DOC data were analyzed for this report because there was only slight variation in SOC concentrations between the fixed sites (table 6). The DOC concentrations differed significantly ($p < 0.05$) among samples for streams draining basins with forest or agricultural land-use settings within the Salem Plateau (fig. 20; table 6). Although some variation is observed between forested basins in all physiographic areas (median ranged from 0.7 mg/L at sites 5 and 30 to 1.1 mg/L at site 33), these differences do not relate to basin size or percent forest land use. In agricultural basins in the Springfield and Salem Plateaus, significant differences in DOC concentrations also were not observed between median and small basins. The largest DOC concentrations generally occurred in streams draining basins with agricultural land use in the Salem Plateau (sites 35 and 38; median 1.6 and 1.8 mg/L, respectively).

Suspended Sediment

Suspended sediment in water is the particulate matter that consists of soil and rock particles eroded from land. Sediment can be transported in the water column or can settle to the streambed. The movement of suspended sediment in streams is an important factor in the transport and fate of chemicals in the environment, because the particles can sorb nutrients, trace elements, and organic compounds. Fecal bacteria also can be associated with suspended sediment. Large suspended-sediment concentrations often are associated with intense storms that increase stream discharge,

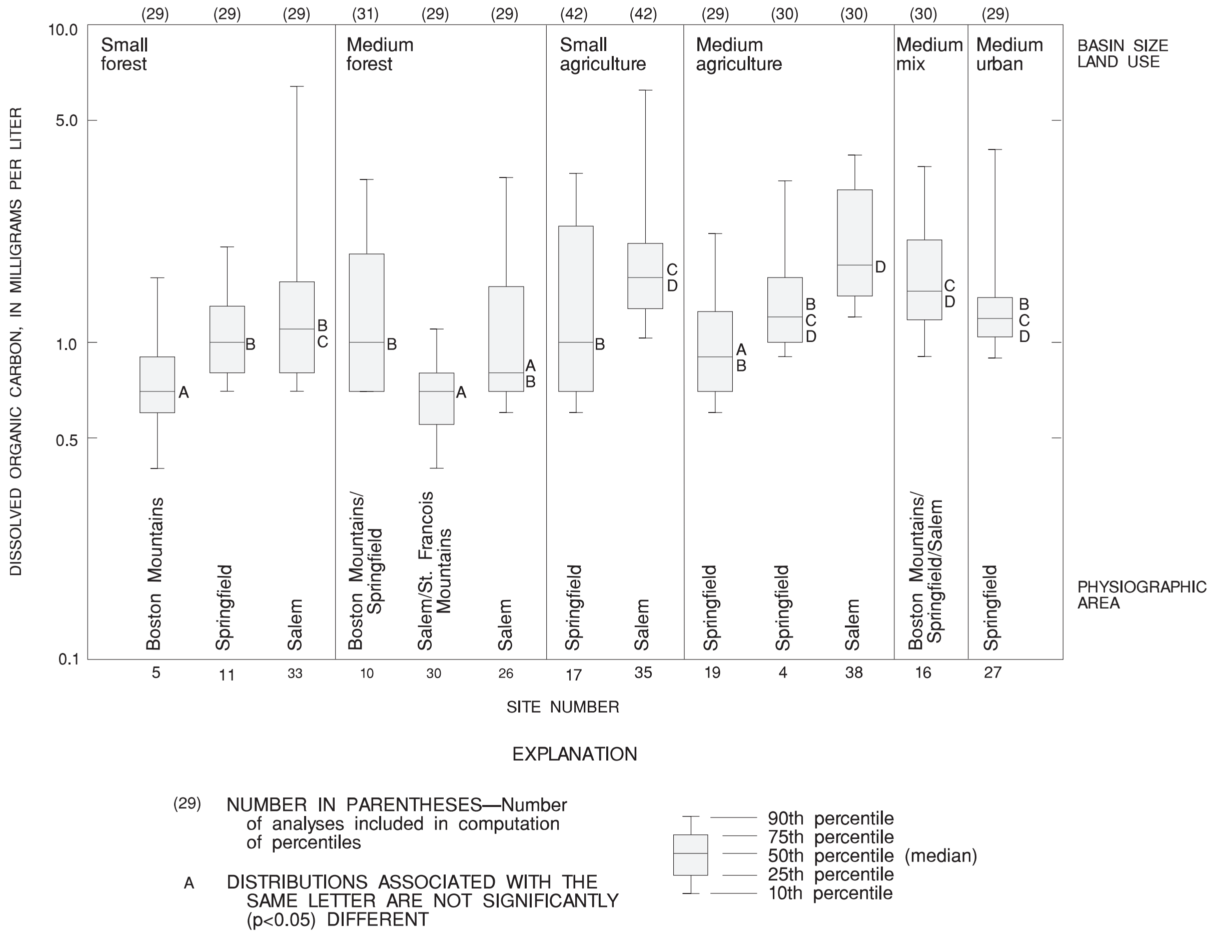

Figure 20. Statistical distribution of dissolved organic carbon concentrations at selected surface-water fixed sites for water years 1993–95.

erosion, and resuspension of bed sediments. Row-crop agriculture, animal grazing, timber harvesting, mining, highway construction and maintenance, and urbanization can cause increased erosion resulting in increased stream sediment concentrations and degradation of stream water quality.

Stream water in the Ozark Plateaus is usually quite clear as evidenced by the median suspended-sediment concentrations of the fixed sites which range from 3 mg/L at site 30 to 28 mg/L at site 4 (table 6). Suspended-sediment concentrations increase with increasing discharge at most of the fixed sites, with the largest concentrations occurring during periods of greatest runoff even in primarily forested basins. Suspended-sediment concentrations differed significantly in only a few cases (fig. 21) and did not appear to be as closely related to land use, physiography, or basin size as were the dissolved nitrite plus nitrate, total phosphorus, and fecal coliform bacteria concentrations. Analysis of historical data (Davis and others, 1995) indicated that suspended-sediment concentrations were significantly higher downstream from more intense land use, but the sample sizes from that historical data were larger and encompassed a wider range of flow conditions.

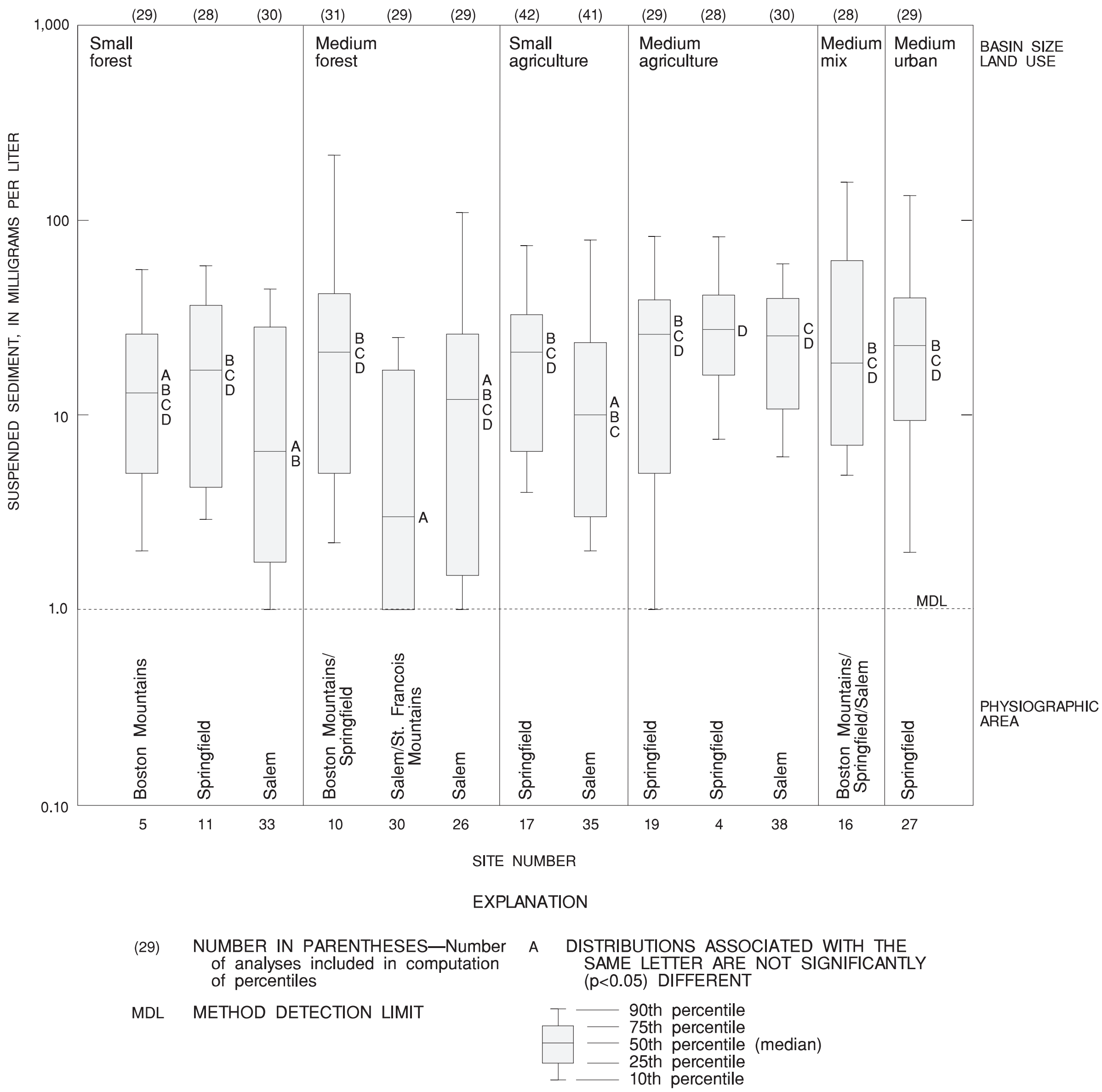

Figure 21. Statistical distribution of suspended-sediment concentrations at selected surface-water fixed sites for water years 1993–95.

SUMMARY

Nitrogen and phosphorus fertilizer use increased substantially in the Ozark Plateaus National Water-Quality Assessment Program study unit for the period 1965–85, but the application rates are well below the national median. Fertilizer use differed among the major river basins in the study unit. In 1985, annual nitrogen fertilizer use ranged from 1.30 to 5.09 tons/mi^2 (tons per square mile), and phosphorus fertilizer use ranged from 0.23 to 0.87 tons/mi^2. Physiographic areas with the largest fertilizer use in 1985 were the Mississippi Alluvial Plain and Osage Plains.

Livestock and poultry waste is a major source of nutrient loading in parts of the study unit. The quantity of nitrogen and phosphorus from livestock and poultry wastes differed substantially among the river basins of the study unit's sampling network. Estimates of the quantity of nitrogen from livestock and poultry waste in 1992 ranged from 0.7 to 15 tons/mi^2; estimates of the quantity of phosphorus from livestock and poultry waste in 1992 ranged from 0.2 to 4.9 tons/mi^2.

Eighty six municipal sewage-treatment plants (STPs) in the study unit have effluents of 0.5 million gallons per day or more (for the years 1985–91), with the upper White, lower Meramec, Illinois, and Spring River Basins having the highest number of municipal STPs. The largest single discharge capability in the study unit is in the upper White River Basin from a plant in Springfield, Missouri.

The surface-water-quality sampling network (basic-fixed, intensive-fixed, and synoptic) is represented by 43 sites. The basic-fixed site network consists of 12 sites located primarily in small and medium drainage basins with near-homogenous land uses (primarily agricultural or forest). Water-quality samples were collected at the basic-fixed sites monthly from April 1993 through September 1995. The intensive-fixed site network consists of two sites in small agricultural land-use basins in the Springfield and Salem Plateaus. The intensive-fixed sites had an increased sample-collection frequency in comparison with the basic-fixed network. In addition to the regular monthly sampling schedule, biweekly samples were collected in February, March, and July 1994; weekly samples were collected in April, May, and June 1994. The synoptic network consists of 29 sites located primarily in small and medium drainage basins with near-homogenous land uses (primarily agricultural or forest). Water-quality samples were collected at the synoptic sites during high-flow periods (May) in 1994 and 1995 and a low-flow period (August or September) in 1994.

Surface-water-quality samples were analyzed for nutrients (dissolved nitrite plus nitrate, dissolved ammonia, total and dissolved ammonia plus organic nitrogen, total and dissolved phosphorus, and dissolved orthophosphate), indicator bacteria (fecal coliform, *Escherichia coli*, and fecal streptococcus), organic carbon (dissolved and suspended), and suspended sediment. The nutrient, indicator bacteria, organic carbon, and suspended-sediment data were grouped according to physiographic area (Boston Mountains, Springfield Plateau, or Salem Plateau), land use (forest, agricultural, urban, or mix), and drainage area (small, medium, or large) and then analyzed using selected descriptive and statistical methods to determine factors affecting occurrence in streams in the study unit. In addition, selected constituent concentrations in streams at the fixed sites were compared to concentrations in streams at the synoptic sites, and the relation of selected constituent concentrations to percent agricultural land use and stream discharge was considered.

Dissolved nitrite plus nitrate concentrations differed significantly among samples for streams draining basins of different size and with forest or agricultural land-use settings within the Springfield and Salem Plateaus. One stream draining a small, forest basin in the Salem Plateau had smaller concentrations [median of less than 0.05 mg/L (milligrams per liter)] than two streams draining medium, forest basins in the Salem Plateau (medians of 0.15 and 0.11 mg/L); a similar relation did not exist for forest basins in the Springfield Plateau.

A stream draining a small, agricultural basin in the Springfield Plateau had larger dissolved nitrite plus nitrate concentrations (median of 2.6 mg/L) than streams draining medium, agricultural basins (median of 1.6 mg/L for two sites); a similar relation did not exist for agricultural basins in the Salem Plateau. A large difference in dissolved nitrite plus nitrate concentrations occurred between streams draining basins with agricultural land use in the Springfield and Salem Plateaus. Streams draining both small and medium agricultural basins in the Springfield Plateau had much larger concentrations than their counterparts in the Salem Plateau (medians of 0.31 and 0.37 mg/L).

Total phosphorus concentrations differed significantly among samples for streams draining basins with forest or agricultural land-use settings within the Springfield and Salem Plateaus. Sites on streams representing agricultural land use had larger total phosphorus concentrations in all cases. Basin drainage size was not a significant factor in affecting total phosphorus concentrations. As with dissolved nitrite plus nitrate, streams draining both small and medium agricultural basins in the Springfield Plateau had larger total phosphorus concentrations (medians of 0.04, 0.05, and 0.08 mg/L) than their counterparts in the Salem Plateau (medians of 0.02 and 0.03 mg/L).

Fecal coliform bacteria counts also differed significantly among samples for streams draining basins with forest or agricultural land-use settings within the Springfield and Salem Plateaus. Basin drainage size was not a significant factor in determining fecal coliform bacteria counts. With only one exception, sites on streams representing agricultural land use had the largest fecal coliform counts. The largest fecal coliform counts were measured at Dousinbury Creek near Wall Street, Missouri (median of 570 colonies per 100 milliliters of sample).

A comparison of the dissolved nitrite plus nitrate, total phosphorus, and fecal coliform data collected at the fixed sites and synoptic sites indicates that generally the data for streams in basins of similar physiography, basin size, and land-use setting group together. Many of the variations are most likely the result of differences in percent agricultural land use between the sites being compared or are discharge related. The relation of dissolved nitrite plus nitrate, total phosphorus, and fecal coliform concentration to percent agricultural land use has a strong positive correlation, with percent agricultural land use accounting for between 42 and 60 percent of the variation in the observed concentrations.

The relation between dissolved nitrite plus nitrate, total phosphorus, and fecal coliform concentrations and discharge is primarily a function of the source (point or nonpoint) and the land use in the basin. Increases in discharge caused by precipitation runoff in basins with primarily nonpoint sources of nitrite and nitrate generally caused increases in concentration up to some threshold. Because phosphorus species tend to sorb to sediments, total phosphorus concentrations decrease with initial increases in streamflow until sediment is mobilized causing an increase in total phosphorus concentrations. Fecal coliform bacteria have a similar concentration-to-discharge relation as total phosphorus. The sites representing small, forest basins had little to no increase in dissolved nitrite plus nitrate or total phosphorus concentrations with increasing discharge. At sites primarily affected by point sources, concentrations of dissolved nitrite plus nitrate and total phosphorus were generally largest at low flows and decreased in response to precipitation.

Dissolved organic carbon concentrations differed significantly among samples for streams draining basins with forest or agricultural land-use settings within the Salem Plateau. Although some variation is observed between forested basins in all physiographic areas (median ranged from 0.7 to 1.1 mg/L), the differences do not relate to basin size or percent forest land use. The largest dissolved organic carbon concentrations generally occurred in streams draining basins with agricultural land use in the Salem Plateau.

Median suspended-sediment concentrations at the fixed sites ranged from 3 to 28 mg/L and are indicative of the clear water in streams in the Ozark Plateaus. Suspended-sediment concentrations differed significantly in only a few cases and did not appear to be as closely related to land use, physiography, or basin size as were the dissolved nitrite plus nitrate, total phosphorus, and fecal coliform bacteria concentrations.

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TABLE

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95

[<, less than]

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
	Discharge, instantaneous, in cubic feet per second								
4	Illinois River near Tahlequah, Okla.	30	217	5,050	267	530	953	1,550	2,540
5	Buffalo River near Boxley, Ark.	29	.12	787	1.4	3.7	36	97	467
10	Buffalo River near St. Joe, Ark.	31	35	22,700	59	112	683	1,820	12,900
11	North Sylamore Creek near Fifty Six, Ark.	29	3.7	3,490	5.4	9.8	15	65	319
16	Kings River near Berryville, Ark.	30	17	13,800	31	85	325	1,120	4,510
17	Yocum Creek near Oak Grove, Ark.	42	7.5	308	12	20	40	92	176
19	Elk River near Tiff City, Mo.	29	86	8,350	151	270	626	1,980	4,900
23	Current River at Van Buren, Mo.	10	969	18,500	993	1,760	2,850	4,680	17,200
26	Jacks Fork River at Alley Spring, Mo.	29	77	11,100	88	130	210	532	1,860
27	Center Creek near Smithfield, Mo.	29	50	3,550	56	153	267	400	771
30	Black River below Annapolis, Mo.	29	171	28,800	174	256	391	678	1,530
33	Paddy Creek above Slabtown Spring, Mo.	30	.68	3,400	1.5	2.5	6.6	31	286
35	Dousinbury Creek near Wall Street, Mo.	42	.62	2,020	2.6	6.6	18	48	325
38	Niangua River at Windyville, Mo.	30	20	6,480	39	118	232	566	820

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
	Nitrite plus nitrate, dissolved, in milligrams per liter, as nitrogen								
4	Illinois River near Tahlequah, Okla.	30	0.66	2.6	0.78	1.2	1.6	2.0	2.4
5	Buffalo River near Boxley, Ark.	29	<.05	.12	<.05	<.05	<.05	<.05	.06
10	Buffalo River near St. Joe, Ark.	31	<.05	.27	<.05	<.05	.06	.15	.20
11	North Sylamore Creek near Fifty Six, Ark.	28	<.05	.25	<.05	.05	.06	.07	.12
16	Kings River near Berryville, Ark.	30	<.05	1.1	.05	.21	.40	.55	.65
17	Yocum Creek near Oak Grove, Ark.	42	.05	3.5	1.9	2.3	2.6	2.9	3.3
19	Elk River near Tiff City, Mo.	29	.60	2.0	.71	1.2	1.6	1.8	1.9
23	Current River at Van Buren, Mo.	10	.14	.33	.14	.20	.23	.31	.33
26	Jacks Fork River at Alley Spring, Mo.	29	.06	.31	.10	.12	.15	.22	.26
27	Center Creek near Smithfield, Mo.	29	1.1	6.3	2.1	2.4	3.1	3.8	4.7
30	Black River below Annapolis, Mo.	29	<.05	.18	<.05	.07	.11	.13	.17
33	Paddy Creek above Slabtown Spring, Mo.	30	<.05	.17	<.05	<.05	<.05	<.05	.06
35	Dousinbury Creek near Wall Street, Mo.	42	.07	1.0	.11	.18	.37	.60	.73
38	Niangua River at Windyville, Mo.	30	<.05	.88	.06	.19	.31	.51	.58

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
	Ammonia, dissolved, in milligrams per liter, as nitrogen								
4	Illinois River near Tahlequah, Okla.	30	<0.01	0.04	<0.015	<0.015	0.01	0.02	0.03
5	Buffalo River near Boxley, Ark.	28	<.01	.04	<.01	<.015	.01	.02	.02
10	Buffalo River near St. Joe, Ark.	31	<.01	.05	<.015	<.015	.01	.02	.03
11	North Sylamore Creek near Fifty Six, Ark.	28	<.01	.03	<.015	<.015	.02	.02	.02
16	Kings River near Berryville, Ark.	30	<.01	.06	<.015	.01	.02	.03	.04
17	Yocum Creek near Oak Grove, Ark.	42	<.01	.10	<.015	.01	.02	.03	.04
19	Elk River near Tiff City, Mo.	29	<.01	.08	<.015	.01	.02	.03	.03
23	Current River at Van Buren, Mo.	10	<.015	.03	<.015	<.015	<.015	.02	.02
26	Jacks Fork River at Alley Spring, Mo.	29	<.01	.05	<.01	<.015	.02	.02	.03
27	Center Creek near Smithfield, Mo.	29	<.01	.18	<.015	<.015	.02	.03	.06
30	Black River below Annapolis, Mo.	29	<.01	.04	<.01	<.015	<.015	.02	.04
33	Paddy Creek above Slabtown Spring, Mo.	30	<.01	.07	<.01	<.015	.01	.02	.03
35	Dousinbury Creek near Wall Street, Mo.	42	<.01	.11	<.015	.01	.02	.03	.05
38	Niangua River at Windyville, Mo.	30	<.01	.12	<.015	<.015	.02	.03	.04

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
	Ammonia plus organic nitrogen, total, in milligrams per liter, as nitrogen								
4	Illinois River near Tahlequah, Okla.	30	<0.2	0.5	<0.2	<0.2	<0.2	0.2	0.4
5	Buffalo River near Boxley, Ark.	28	<.2	<.2	<.2	<.2	<.2	<.2	<.2
10	Buffalo River near St. Joe, Ark.	31	<.2	.7	<.2	<.2	<.2	<.2	<.2
11	North Sylamore Creek near Fifty Six, Ark.	28	<.2	.7	<.2	<.2	<.2	<.2	.2
16	Kings River near Berryville, Ark.	30	<.2	.6	<.2	<.2	<.2	.3	.4
17	Yocum Creek near Oak Grove, Ark.	42	<.2	.8	<.2	<.2	<.2	.2	.4
19	Elk River near Tiff City, Mo.	29	<.2	.4	<.2	<.2	<.2	<.2	.3
23	Current River at Van Buren, Mo.	10	<.2	.5	<.2	<.2	<.2	<.2	.2
26	Jacks Fork River at Alley Spring, Mo.	29	<.2	.9	<.2	<.2	<.2	<.2	.5
27	Center Creek near Smithfield, Mo.	29	<.2	1.1	<.2	<.2	<.2	.2	.5
30	Black River below Annapolis, Mo.	29	<.2	.7	<.2	<.2	<.2	<.2	<.2
33	Paddy Creek above Slabtown Spring, Mo.	30	<.2	.8	<.2	<.2	<.2	<.2	.3
35	Dousinbury Creek near Wall Street, Mo.	42	<.2	1.4	<.2	<.2	<.2	<.2	.4
38	Niangua River at Windyville, Mo.	30	<.2	.6	<.2	<.2	<.2	.3	.4

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile: 10	25	50 (median)	75	90
Ammonia plus organic nitrogen, dissolved, in milligrams per liter, as nitrogen									
4	Illinois River near Tahlequah, Okla.	30	<0.2	0.3	<0.2	<0.2	<0.2	<0.2	0.2
5	Buffalo River near Boxley, Ark.	28	<.2	.3	<.2	<.2	<.2	<.2	<.2
10	Buffalo River near St. Joe, Ark.	31	<.2	.2	<.2	<.2	<.2	<.2	<.2
11	North Sylamore Creek near Fifty Six, Ark.	24	<.2	.2	<.2	<.2	<.2	<.2	<.2
16	Kings River near Berryville, Ark.	30	<.2	.6	<.2	<.2	<.2	<.2	<.2
17	Yocum Creek near Oak Grove, Ark.	42	<.2	.5	<.2	<.2	<.2	.2	.3
19	Elk River near Tiff City, Mo.	29	<.2	.2	<.2	<.2	<.2	<.2	.2
23	Current River at Van Buren, Mo.	10	<.2	.4	<.2	<.2	<.2	<.2	<.2
26	Jacks Fork River at Alley Spring, Mo.	29	<.2	.3	<.2	<.2	<.2	<.2	<.2
27	Center Creek near Smithfield, Mo.	29	<.2	.5	<.2	<.2	<.2	<.2	.4
30	Black River below Annapolis, Mo.	29	<.2	<.2	<.2	<.2	<.2	<.2	<.2
33	Paddy Creek above Slabtown Spring, Mo.	30	<.2	.4	<.2	<.2	<.2	<.2	<.2
35	Dousinbury Creek near Wall Street, Mo.	42	<.2	.6	<.2	<.2	<.2	<.2	.4
38	Niangua River at Windyville, Mo.	30	<.2	.5	<.2	<.2	<.2	<.2	.3

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
	Phosphorus, total, in milligrams per liter, as phosphorus								
4	Illinois River near Tahlequah, Okla.	30	<0.01	0.23	0.02	0.06	0.08	0.10	0.13
5	Buffalo River near Boxley, Ark.	28	<.01	.04	<.01	<.01	<.01	.02	.02
10	Buffalo River near St. Joe, Ark.	31	<.01	.02	<.01	<.01	<.01	.01	.04
11	North Sylamore Creek near Fifty Six, Ark.	28	<.01	.12	<.01	<.01	<.01	.01	.03
16	Kings River near Berryville, Ark.	30	<.01	.96	.02	.06	.10	.23	.60
17	Yocum Creek near Oak Grove, Ark.	42	.01	.45	.01	.03	.04	.05	.15
19	Elk River near Tiff City, Mo.	29	<.01	.16	.03	.03	.05	.07	.12
23	Current River at Van Buren, Mo.	10	<.01	.09	<.01	<.01	<.01	.02	.02
26	Jacks Fork River at Alley Spring, Mo.	29	<.01	.19	<.01	<.01	<.01	.01	.05
27	Center Creek near Smithfield, Mo.	29	<.01	.31	.02	.04	.05	.08	.18
30	Black River below Annapolis, Mo.	29	<.01	.17	<.01	<.01	<.01	<.01	.02
33	Paddy Creek above Slabtown Spring, Mo.	30	<.01	.10	<.01	<.01	<.01	.01	.03
35	Dousinbury Creek near Wall Street, Mo.	42	<.01	.25	<.01	.01	.02	.04	.06
38	Niangua River at Windyville, Mo.	30	<.01	.28	<.01	.01	.03	.05	.11

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
Phosphorus, dissolved, in milligrams per liter, as phosphorus									
4	Illinois River near Tahlequah, Okla.	30	0.01	0.15	0.03	0.06	0.06	0.09	0.11
5	Buffalo River near Boxley, Ark.	28	<.01	.03	<.01	<.01	<.01	<.01	.02
10	Buffalo River near St. Joe, Ark.	31	<.01	.03	<.01	<.01	<.01	.01	.02
11	North Sylamore Creek near Fifty Six, Ark.	28	<.01	.01	<.01	<.01	<.01	<.01	<.01
16	Kings River near Berryville, Ark.	30	.01	.89	.02	.03	.06	.21	.61
17	Yocum Creek near Oak Grove, Ark.	42	<.01	.38	<.01	.02	.03	.05	.12
19	Elk River near Tiff City, Mo.	29	.01	.14	.02	.04	.05	.06	.12
23	Current River at Van Buren, Mo.	10	<.01	.03	<.01	<.01	<.01	<.01	.01
26	Jacks Fork River at Alley Spring, Mo.	29	<.01	.03	<.01	<.01	<.01	<.01	.01
27	Center Creek near Smithfield, Mo.	29	.01	.22	.02	.03	.05	.06	.11
30	Black River below Annapolis, Mo.	29	<.01	.02	<.01	<.01	<.01	<.01	<.01
33	Paddy Creek above Slabtown Spring, Mo.	30	<.01	.02	<.01	<.01	<.01	<.01	.01
35	Dousinbury Creek near Wall Street, Mo.	42	<.01	.16	<.01	<.01	.01	.03	.04
38	Niangua River at Windyville, Mo.	30	<.01	.27	<.01	.01	.02	.04	.08

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
	Orthophosphate, dissolved, in milligrams per liter, as phosphorus								
4	Illinois River near Tahlequah, Okla.	30	0.01	0.14	0.03	0.06	0.07	0.09	0.11
5	Buffalo River near Boxley, Ark.	28	<.01	.02	<.01	<.01	<.01	<.01	.01
10	Buffalo River near St. Joe, Ark.	31	<.01	.02	<.01	<.01	<.01	<.01	.02
11	North Sylamore Creek near Fifty Six, Ark.	28	<.01	.02	<.01	<.01	<.01	<.01	.01
16	Kings River near Berryville, Ark.	30	<.01	1.0	.02	.03	.06	.20	.59
17	Yocum Creek near Oak Grove, Ark.	42	.01	.40	.02	.02	.03	.05	.12
19	Elk River near Tiff City, Mo.	29	.02	.12	.02	.03	.05	.06	.09
23	Current River at Van Buren, Mo.	10	<.01	.02	<.01	<.01	<.01	<.01	.02
26	Jacks Fork River at Alley Spring, Mo.	29	<.01	.03	<.01	<.01	<.01	<.01	.02
27	Center Creek near Smithfield, Mo.	29	.01	.19	.02	.03	.04	.06	.12
30	Black River below Annapolis, Mo.	29	<.01	.01	<.01	<.01	<.01	<.01	<.01
33	Paddy Creek above Slabtown Spring, Mo.	30	<.01	.03	<.01	<.01	<.01	<.01	<.01
35	Dousinbury Creek near Wall Street, Mo.	42	<.01	.13	<.01	<.01	.01	.02	.03
38	Niangua River at Windyville, Mo.	30	<.01	.27	<.01	<.01	.02	.03	.07

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile 10	25	50 (median)	75	90
	Fecal coliform bacteria, in colonies per 100 milliliters of sample								
4	Illinois River near Tahlequah, Okla.	28	9	1,200	12	36	120	300	610
5	Buffalo River near Boxley, Ark.	29	1	410	1	3	7	44	150
10	Buffalo River near St. Joe, Ark.	30	1	5,300	3	8	13	53	1,100
11	North Sylamore Creek near Fifty Six, Ark.	28	1	660	1	8	17	53	190
16	Kings River near Berryville, Ark.	30	1	3,300	7	25	56	280	1,800
17	Yocum Creek near Oak Grove, Ark.	42	1	15,000	8	28	76	170	1,500
19	Elk River near Tiff City, Mo.	29	1	5,800	15	26	56	370	2,200
23	Current River at Van Buren, Mo.	10	2	1,600	2	4	24	130	1,500
26	Jacks Fork River at Alley Spring, Mo.	29	<1	5,200	<1	3	20	84	1,200
27	Center Creek near Smithfield, Mo.	29	1	27,000	9	44	90	420	8,200
30	Black River below Annapolis, Mo.	29	1	3,200	1	4	6	13	80
33	Paddy Creek above Slabtown Spring, Mo.	30	1	4,500	3	10	24	68	1,200
35	Dousinbury Creek near Wall Street, Mo.	42	6	37,000	77	140	570	1,400	9,000
38	Niangua River at Windyville, Mo.	30	2	28,000	7	52	230	840	2,400

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
	Escherichia coli **bacteria, in colonies per 100 milliliters of sample**								
4	Illinois River near Tahlequah, Okla.	15	4	7,700	14	23	150	270	4,200
5	Buffalo River near Boxley, Ark.	16	1	540	2	3	8	26	220
10	Buffalo River near St. Joe, Ark.	17	1	4,000	2	4	10	88	2,700
11	North Sylamore Creek near Fifty Six, Ark.	16	<1	420	1	6	8	18	140
16	Kings River near Berryville, Ark.	17	6	6,900	7	19	41	810	2,500
17	Yocum Creek near Oak Grove, Ark.	25	7	9,700	15	32	69	440	4,300
19	Elk River near Tiff City, Mo.	16	2	1,100	9	15	28	110	520
23	Current River at Van Buren, Mo.	10	<1	2,000	<1	1	16	42	190
26	Jacks Fork River at Alley Spring, Mo.	16	<1	810	<1	1	9	37	400
27	Center Creek near Smithfield, Mo.	16	<1	500	<	11	48	97	160
30	Black River below Annapolis, Mo.	17	<1	62	<1	1	5	9	41
33	Paddy Creek above Slabtown Spring, Mo.	17	<1	2,400	<1	4	25	71	690
35	Dousinbury Creek near Wall Street, Mo.	23	16	33,000	38	130	340	1,200	2,000
38	Niangua River at Windyville, Mo.	17	2	1,800	8	22	98	540	940

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
Fecal streptococci bacteria, in colonies per 100 milliliters of sample									
4	Illinois River near Tahlequah, Okla.	28	5	3,700	10	25	220	520	1,200
5	Buffalo River near Boxley, Ark.	29	1	2,700	3	10	29	180	1,500
10	Buffalo River near St. Joe, Ark.	31	2	13,000	4	17	37	270	2,600
11	North Sylamore Creek near Fifty Six, Ark.	29	1	5,000	2	7	47	180	500
16	Kings River near Berryville, Ark.	30	4	10,000	10	31	93	420	5,600
17	Yocum Creek near Oak Grove, Ark.	42	3	10,000	11	40	84	580	7,400
19	Elk River near Tiff City, Mo.	29	2	13,000	7	22	86	400	7,400
23	Current River at Van Buren, Mo.	10	<1	4,500	<1	3	4	120	480
26	Jacks Fork River at Alley Spring, Mo.	29	1	5,500	2	9	25	87	1,000
27	Center Creek near Smithfield, Mo.	29	6	50,000	7	28	70	160	8,200
30	Black River below Annapolis, Mo.	29	1	6,000	1	4	7	26	82
33	Paddy Creek above Slabtown Spring, Mo.	30	1	5,200	2	18	48	160	2,800
35	Dousinbury Creek near Wall Street, Mo.	41	7	120,000	21	55	130	440	3,300
38	Niangua River at Windyville, Mo.	30	2	75,000	23	33	120	700	2,300

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
	Organic carbon, dissolved, in milligrams per liter, as carbon								
4	Illinois River near Tahlequah, Okla.	30	0.8	3.6	0.9	1.0	1.2	1.6	3.2
5	Buffalo River near Boxley, Ark.	29	.4	2.9	.4	.6	.7	.9	1.6
10	Buffalo River near St. Joe, Ark.	31	.6	5.1	.7	.7	1.0	1.9	3.3
11	North Sylamore Creek near Fifty Six, Ark.	29	.6	4.1	.7	.8	1.0	1.3	2.0
16	Kings River near Berryville, Ark.	30	.8	4.6	.9	1.2	1.4	2.1	3.6
17	Yocum Creek near Oak Grove, Ark.	42	.5	11	.6	.7	1.0	2.3	3.4
19	Elk River near Tiff City, Mo.	29	.6	2.8	.6	.7	.9	1.2	2.2
23	Current River at Van Buren, Mo.	10	.4	3.9	.4	.6	1.0	1.2	3.6
26	Jacks Fork River at Alley Spring, Mo.	29	.5	7.2	.6	.7	.8	1.5	3.3
27	Center Creek near Smithfield, Mo.	29	.8	6.3	.9	1.0	1.2	1.4	4.1
30	Black River below Annapolis, Mo.	29	.4	3.8	.4	.6	.7	.8	1.1
33	Paddy Creek above Slabtown Spring, Mo.	29	.7	12	.7	.8	1.1	1.6	6.4
35	Dousinbury Creek near Wall Street, Mo.	42	.9	26	1.0	1.3	1.6	2.0	6.2
38	Niangua River at Windyville, Mo.	30	.9	8.5	1.2	1.4	1.8	3.0	3.9

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
Organic carbon, suspended, in milligrams per liter, as carbon									
4	Illinois River near Tahlequah, Okla.	30	0.1	1.4	0.2	0.2	0.3	0.4	0.9
5	Buffalo River near Boxley, Ark.	29	.1	.5	.1	.1	.1	.2	.3
10	Buffalo River near St. Joe, Ark.	29	.1	2.7	.1	.1	.2	.2	1.0
11	North Sylamore Creek near Fifty Six, Ark.	29	.1	3.4	.1	.1	.1	.1	.2
16	Kings River near Berryville, Ark.	30	.1	1.2	.1	.2	.2	.4	.8
17	Yocum Creek near Oak Grove, Ark.	41	.1	1.5	.1	.1	.1	.2	.5
19	Elk River near Tiff City, Mo.	28	.1	1.4	.1	.1	.2	.3	.8
23	Current River at Van Buren, Mo.	10	.1	3.6	.1	.2	.2	.9	3.5
26	Jacks Fork River at Alley Spring, Mo.	29	.1	5.0	.1	.1	.1	.2	.6
27	Center Creek near Smithfield, Mo.	28	.1	2.5	.1	.2	.2	.4	1.2
30	Black River below Annapolis, Mo.	29	.1	3.2	.1	.1	.1	.1	.1
33	Paddy Creek above Slabtown Spring, Mo.	29	.1	2.8	.1	.1	.1	.1	1.3
35	Dousinbury Creek near Wall Street, Mo.	42	.1	5.0	.1	.1	.2	.2	.8
38	Niangua River at Windyville, Mo.	29	.1	2.5	.1	.2	.3	.6	1.7

Table 6. Statistical summary of discharge, nutrient, indicator bacteria, dissolved and suspended organic carbon, and suspended-sediment data for surface-water fixed sites in the Ozark Plateaus study unit for water years 1993–95—Continued

Site number (fig. 4)	Station name (table 5)	Number of samples	Minimum	Maximum	Value at indicated percentile				
					10	25	50 (median)	75	90
	Suspended sediment, in milligrams per liter								
4	Illinois River near Tahlequah, Okla.	28	2	106	8	16	28	41	82
5	Buffalo River near Boxley, Ark.	29	1	93	2	5	13	26	56
10	Buffalo River near St. Joe, Ark.	31	1	298	2	5	21	42	216
11	North Sylamore Creek near Fifty Six, Ark.	28	2	198	3	4	17	36	59
16	Kings River near Berryville, Ark.	28	3	258	5	7	18	62	157
17	Yocum Creek near Oak Grove, Ark.	42	2	181	4	6	21	33	74
19	Elk River near Tiff City, Mo.	29	1	138	1	5	26	39	83
23	Current River at Van Buren, Mo.	10	2	180	2	2	28	33	165
26	Jacks Fork River at Alley Spring, Mo.	29	1	176	1	2	12	26	110
27	Center Creek near Smithfield, Mo.	29	1	294	2	10	23	40	136
30	Black River below Annapolis, Mo.	29	1	270	1	1	3	17	25
33	Paddy Creek above Slabtown Spring, Mo.	30	1	106	1	2	6	28	44
35	Dousinbury Creek near Wall Street, Mo.	41	1	655	2	3	10	24	79
38	Niangua River at Windyville, Mo.	30	4	343	6	11	26	40	60