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Water-Quality Assessment of the Lower Illinois River Basin: Environmental Setting

By KELLY L. WARNER

Water-Resources Investigations Report 97–4165

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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 specific contamination problems; 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 U.S. 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

Robert M. Hirsch
Chief Hydrologist

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CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
square mile (mi^2)	2.590	square kilometer
	Flow rate	
inch per year (in/yr)	25.4	millimeter per year
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
cubic foot per second per square mile [$(ft^3/s)/mi^2$]	0.01093	cubic meter per second per square kilometer
million gallons per day (Mgal/d)	0.04381	cubic meter per second
	Mass	
ton, long (2,240 lb)	1.016	megagram
	Specific capacity	
gallon per minute per foot [(gal/min)/ft)]	0.2070	liter per second per meter
	Hydraulic gradient	
foot per mile (ft/mi)	0.1894	meter per kilometer
	Hydraulic conductivity	
gallon per day per square foot [$(gal/d)/ft^2$)]	4.720×10^{-7}	meter per second
	Transmissivity	
gallon per day per foot [(gal/d)/ft)]	1.438×10^{-7}	square meter per second

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

$$°C = (°F - 32) / 1.8$$

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Abbreviated water-quality units:

µg/L	micrograms per liter
mg/L	milligrams per liter

Water-Quality Assessment of the Lower Illinois River Basin: Environmental Setting

by Kelly L. Warner

ABSTRACT

The lower Illinois River Basin (LIRB) encompasses 18,000 square miles of central and western Illinois. Historical and recent information from Federal, State, and local agencies describing the physiography, population, land use, soils, climate, geology, streamflow, habitat, ground water, water use, and aquatic biology is summarized to describe the environmental setting of the LIRB. The LIRB is in the Till Plains Section of the Central Lowland physiographic province. The basin is characterized by flat topography, which is dissected by the Illinois River. The drainage pattern of the LIRB has been shaped by many bedrock and glacial geologic processes. Erosion prior to and during Pleistocene time created wide and deep bedrock valleys. The thickest deposits and most major aquifers are in buried bedrock valleys. The Wisconsinan glaciation, which bisects the northern half of the LIRB, affects the distribution and characteristics of glacial deposits in the basin.

Agriculture is the largest land use and forested land is the second largest land use in the LIRB. The major urban areas are near Peoria, Springfield, Decatur, and Bloomington-Normal. Soil type and distribution affect the amount of soil erosion, which results in sedimentation of lakes and reservoirs in the basin. Rates of soil erosion of up to 2 percent per year of farmland soil have been measured. Many of the 300 reservoirs, lakes, and wetlands are disappearing because of sedimentation resulting from agriculture activities, levee building, and urbanization. Sedimentation and the destruction of habitat appreciably affect the ecosystem. The Illinois River is a large river-flood-plain ecosystem where biological productivity is enhanced by annual flood pulses that advance and retreat over the flood plain and temporarily expand backwater and flood-plain lakes.

Ground-water discharge to streams affects the flow and water quality of the streams. The water budget of several subbasins show variability in ground-water contribution from runoff and storage. More than half of the drinking water, including domestic and public-supply use, in the LIRB is from ground water. Fifty-two percent of the public-supply water is from surface water. Ground-water withdrawals mostly are from glacial sand and gravel aquifers. Structural features, such as monoclines, synclines, and anticlines, in the buried bedrock affect the water quality of the aquifers.

There are five natural environmental divisions in the LIRB. The Grand Prairie covers most of the northeastern half of the basin, and the Western Forest-Prairie covers most of the southwestern half. Implications of environmental setting for water quality in the LIRB are related primarily to land use. The balanced fish community indicates that the lower Illinois River is affected less from urban and industrial waste than the upper Illinois River. A decrease in dissolved oxygen concentrations and turbidity in the lower reaches of the basin in 1993 have resulted from the recent influx of European zebra mussels to the LIRB. Many factors affect water quality in the LIRB. Bedrock and surface topography, type of

glacial material, and land use most directly affect water quality in the basin.

INTRODUCTION

The lower Illinois River Basin (LIRB) encompasses 18,000 mi^2 of central and western Illinois (fig. 1). The basin extends from the confluence of the Illinois and Fox Rivers near Ottawa, Ill., down to the confluence of the Illinois and Mississippi Rivers at Grafton, Ill. Major rivers in the basin include the Sangamon (5,420 mi^2), Spoon (1,860 mi^2), La Moine (1,350 mi^2), Vermilion (1,330 mi^2), and Mackinaw (1,140 mi^2) Rivers. The LIRB is 1 of 60 study units in the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) program, which began full-scale implementation in 1991 with 20 studies (Warner and Schmidt, 1994). A second set of 15 studies began in 1994, which includes the study of the LIRB. The NAWQA studies are intended to assess long-term water-quality changes. Each set of 15 to 20 studies will be active for 7 years and then a 3-year period of minimal data collection before the study becomes active again. The goals of the NAWQA program are to (1) describe the status and trends in the quality of a representative part of the Nation's streams and ground water and (2) provide a sound scientific understanding of the natural and human factors affecting water quality (Leahy and Wilber, 1991). Design of a water-quality assessment generally considers the characteristics of the hydrologic system because components of the system and their interaction determine the similarities and differences in water-quality conditions throughout a basin. An effective regional water-quality assessment strategy is based on environmental setting, which incorporates many interrelated features (for example, physiography, geology, land use, climate, and hydrology).

Purpose and Scope

This report describes the environmental setting for the LIRB. The environmental setting will serve as the basis for the sampling design and strategy of the water-quality assessment of the basin. Historical and recent information from Federal, State, and local agencies describing the physiography, geology, soils, population, land use, climate, streamflow, habitat, ground water, water use, and aquatic biology is included in this report, and the effect of these characteristics on water quality is summarized.

Previous Studies

Three previous studies in the basin include the hydrology of the western region interior coal province (Zuehls, 1987; Zuehls and others, 1981 and 1984) and a report on the waters of the upper and lower Illinois River (Talkington, 1991). The seven-volume report by the Illinois Department of Energy and Natural Resources and The Nature of Illinois Foundation (1994) describes the changing environment and critical trends for the State of Illinois. Data and publications from the Long Term Resource Monitoring Program (LTRMP) as elements of the U.S. Army Corps of Engineers Environmental Management Plan provide insight to habitat, flow, and sediment transport in the Illinois River Basin.

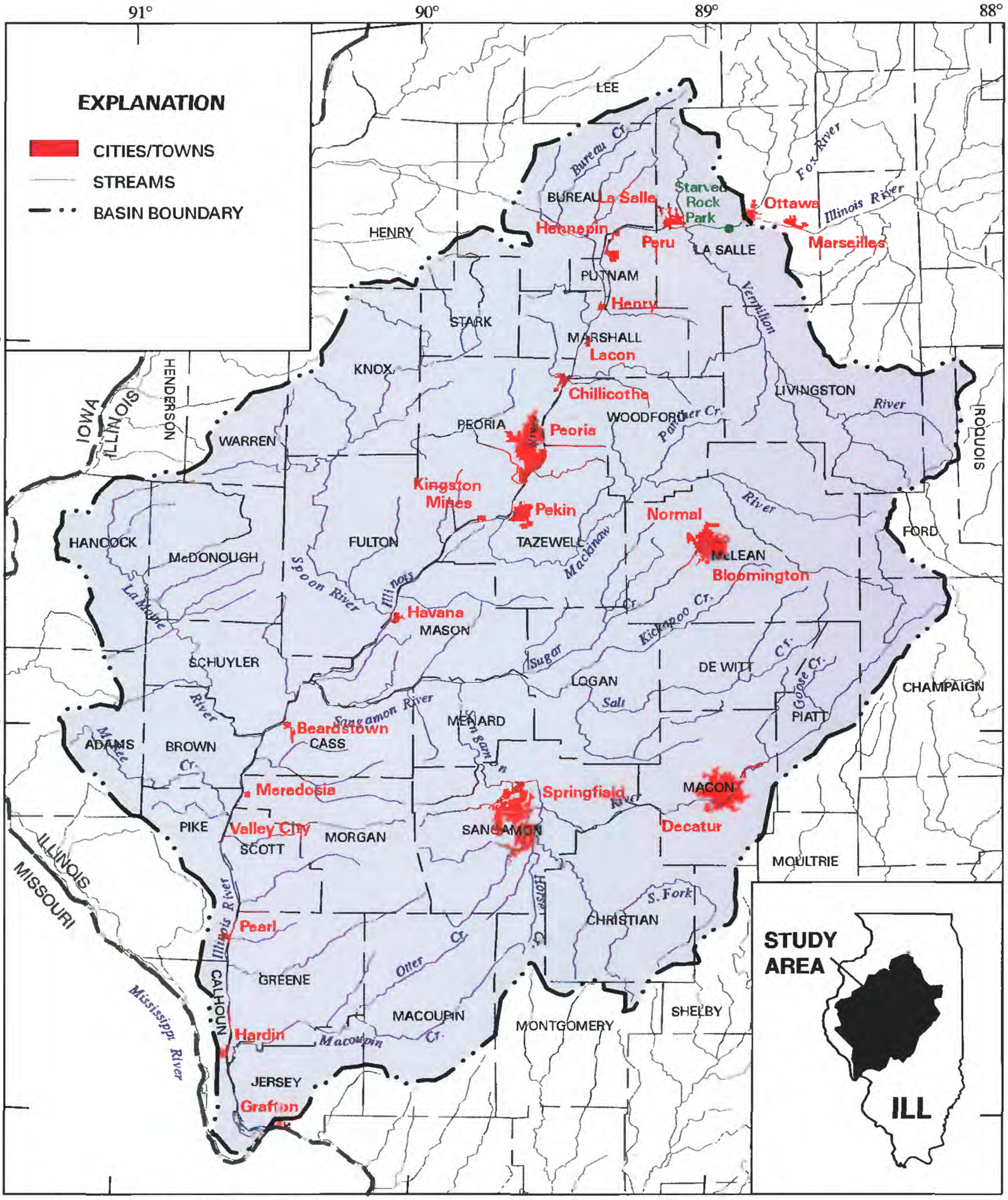
Acknowledgments

The assistance provided to the author by members of the lower Illinois River NAWQA Liaison Committee and agencies they represent is recognized. Liaison Committee members represent Federal, State, local, and private agencies in Illinois. The dedicated and creative work of David Fazio, U.S. Geological Survey, in designing and creating digital illustrations is greatly appreciated.

ENVIRONMENTAL SETTING

Physiography

The flat topography of the LIRB in central Illinois is dissected by the Illinois River. Glacial features are the major landforms. The LIRB is in the Till Plains Section of the Central Lowland physiographic province (Willman and others, 1975). The Galesburg Plain, Springfield Plain, and Bloomington Ridged Plain are subsections within the Till Plain (fig. 2). The Galesburg Plain and Springfield Plain are largely in the Illinoian drift, but prominent glacial topography are only local features. The Bloomington Ridge Plain includes the Wisconsinan glacial moraines and associated glacial topography. A small area near



Base from U.S. Geological Survey
1:2,000,000 and 1:100,000 Digital Data
Albers Equal-Area Conic Projection
Standard Parallels 33° and 45°, central meridian -89°

0 10 20 30 40 50 MILES
0 10 20 30 40 50 KILOMETERS

Figure 1. Location of the study area.

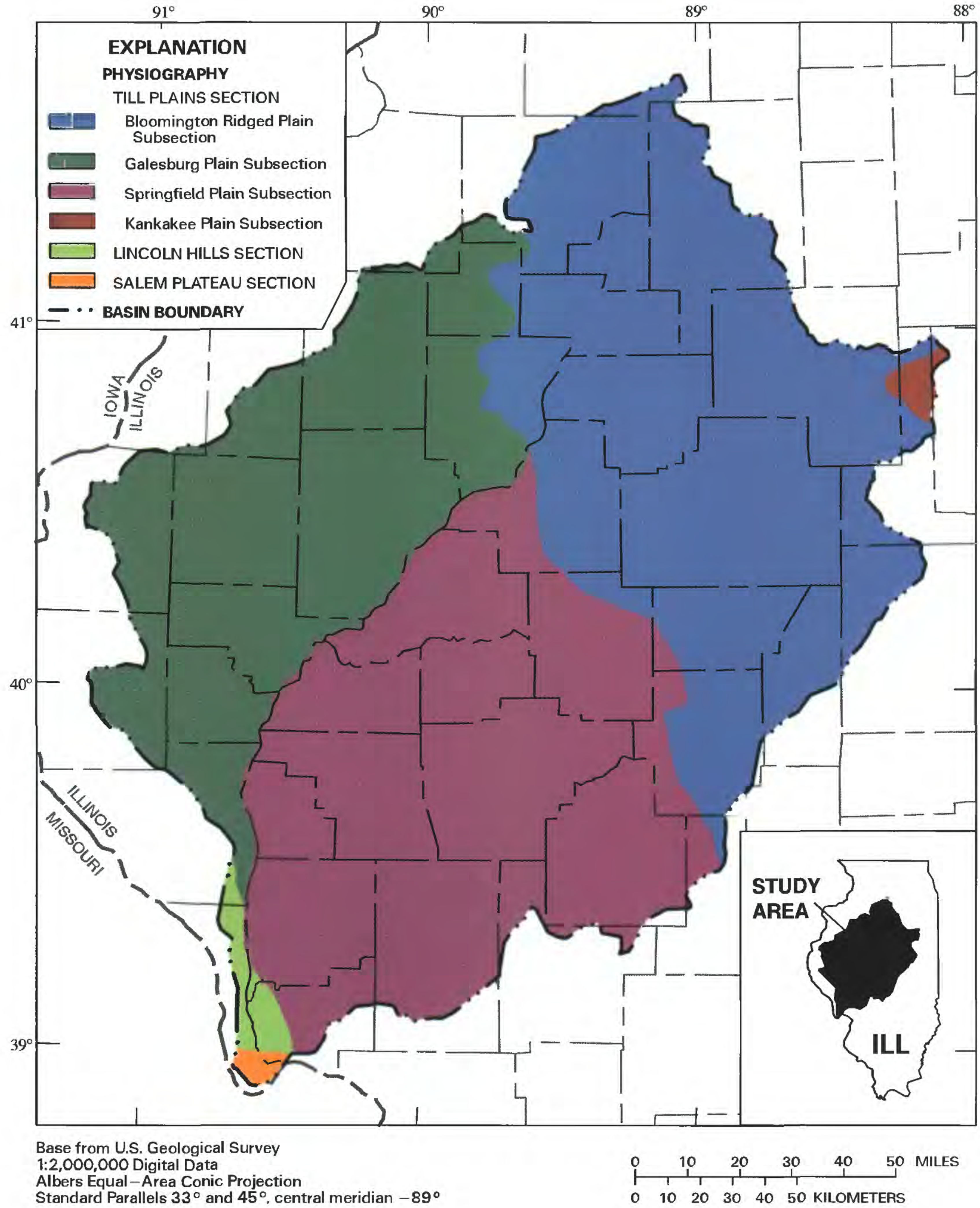


Figure 2. Physiography in the lower Illinois River Basin (modified from Willman and others, 1975).

the confluence of the Illinois and Mississippi Rivers is in the Lincoln Hills Section of the Central Lowland. The Lincoln Hills Section is part of the Ozark Plateau Province including deeply dissected flat-lying rocks.

The altitude of land surface in the LIRB is generally from 600 to 800 ft above sea level. The area of greatest topographic relief is along the river valley, where topographic relief can range from 200 to 400 ft. Relief reaches 400 ft locally in Calhoun and Jersey Counties near the confluence of the Illinois and Mississippi Rivers at Grafton (fig. 1).

The majority of the basin is extremely flat with less than 20 ft of relief. The distinction in topography between the older Illinoian drift (Galesburg and Springfield Plains) and the Wisconsinan drift (Bloomington Ridged Plain) is the morainic ridges in the Wisconsinan drift areas. The morainic ridges are generally from 50 to 100 ft high, 1 to 2 mi wide, and 100 to 500 mi long. The moraines are separated by areas with more subdued, undulating topography or "rolling" topography.

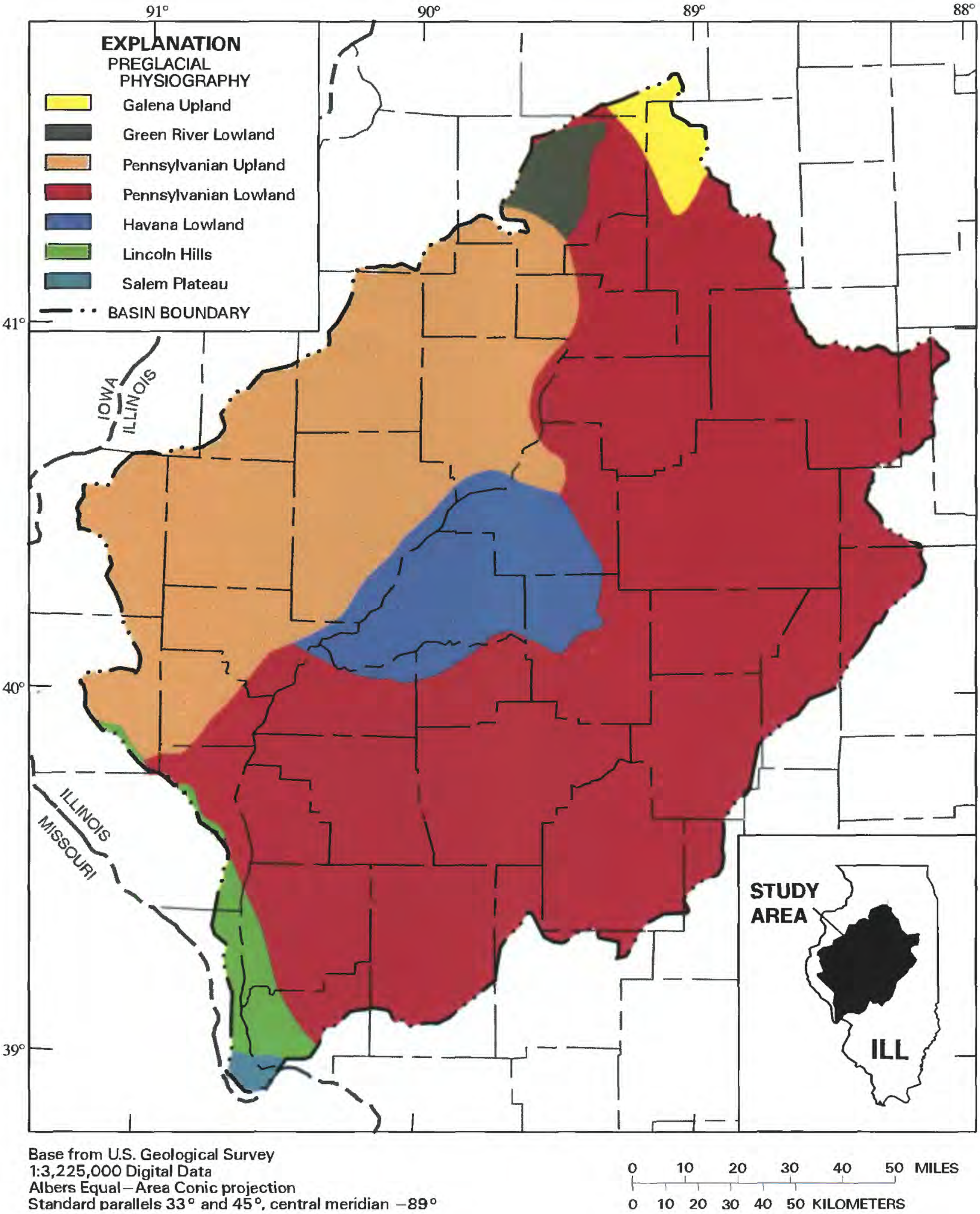
The preglacial physiographic provinces are divided by the type of bedrock (fig. 3). Subsequent glacial deposits also are controlled by bedrock lithology and structure (Horberg and Anderson, 1956: Kempton and others, 1991). The LIRB is part of the Pennsylvanian Upland, Pennsylvanian Lowland, and Havana Lowland. The Pennsylvanian Upland is structurally situated along the northwest flank of the Illinois Basin just west of the axis of the uplift that separates the Illinois structural basin from the structural basin in Iowa. The Havana Lowland borders the Illinois River in the center of the basin, and the Pennsylvanian Lowland lies in the western part of the LIRB. In the areas where the Pennsylvanian Upland and Lowland are covered by the Illinoian drift, the surface topography reflects bedrock surface: The area covered by Wisconsinan drift reflects glacial depositional features (Horberg, 1950). The various glacial advances were responsible for numerous drainage changes, which can be related in part to features of the bedrock topography (Horberg, 1950). The lowlands are areas where bedrock surface has been eroded below the surrounding area. The broad Havana Lowland was developed at the junction of three important ancient drainage areas and just above the point where the massive Mississippian limestone crosses the valley (Horberg, 1950). The Havana Lowland area is hydrologically unique in the LIRB because of the low elevation of bedrock and thick sequence of overlying sand.

Population and Land Use

The 1990 population in the LIRB was 1.3 million (U.S. Department of Commerce, 1992). Over 50 percent of the population lives in the Counties of Macon, McLean, Peoria, Sangamon, and Tazewell. The four most populated cities in the basin in 1990 are as follows: Peoria (113,504), Springfield (105,227), Decatur (83,885), and Bloomington (51,972). The basin population increased approximately 5 percent from 1970 to 1980 and peaked at 1.4 million in 1980 (fig. 4). Several counties had increases in population from 1980 to 1990, but the total basin population decreased approximately 7 percent from 1980 to 1990 (fig. 5).

The population distribution reflects the extent of rural areas in the LIRB. Agriculture is the predominant land use (fig. 6). In 1990, about 87 percent of the land use in the LIRB was agricultural (Hitt, 1994). The major agriculture use is cropland, typically corn and soybean. The sandy soils in Mason and Tazewell Counties are used for specialty crops, such as pumpkin, watermelon, sunflower, pea, cucumber, sweet corn, lima and green beans, and popcorn (Walker, Bergstrom, and Walton, 1965). Mason County has the largest harvested acreage of watermelon (925 acres); Cass County has the largest harvested acreage of sunflower (2,244 acres); Tazewell County has the largest harvested acreage of pumpkin (5,320 acres); and McLean County has the largest harvested acreage of lima bean (2,536 acres) (Neely and Heister, 1987). This area in Mason and Tazewell Counties commonly is irrigated with shallow ground water (less than 200-ft deep) to keep the crops healthy in the extremely well-drained soil. The remaining 13 percent of the land area in the basin is forests (8 percent), urban areas (2 percent), water and wetlands (2 percent), and miscellaneous land-use areas (1 percent). Miscellaneous land use includes at least 39 nature areas that are mostly tallgrass prairie, but less than 0.01 percent of the original prairie remains (Illinois Department of Conservation, 1991) (table 1). Illinois ranks 49th among states remaining in its original vegetation type—only Iowa ranks lower (Iverson and others, 1991).

The second largest land use is forest. Forest land prevents deterioration of the quality of water by reducing soil erosion, sustaining natural plant and animal communities, and maintaining biological diversity. Many counties have forest lands that have the capability and are potentially available to produce commercially valuable trees (Iverson and others, 1991).



Base from U.S. Geological Survey
1:3,225,000 Digital Data
Albers Equal–Area Conic projection
Standard parallels 33° and 45°, central meridian –89°

Figure 3. Preglacial physiographic divisions of the lower Illinois River Basin (modified from Horberg, 1950).

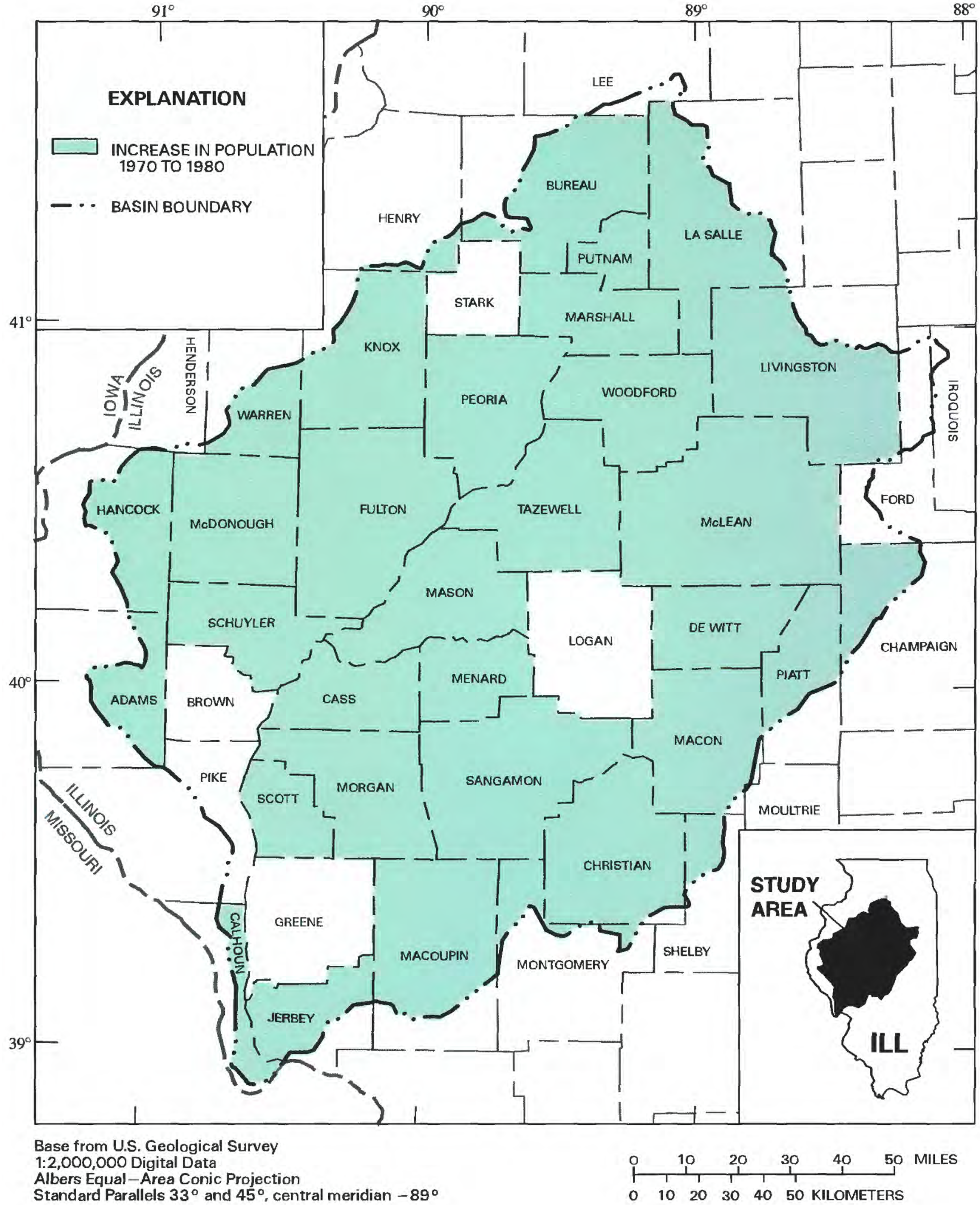


Figure 4. Counties with a population increase from 1970 to 1980 in the lower Illinois River Basin (modified from U.S. Department of Commerce, 1971 and 1982).

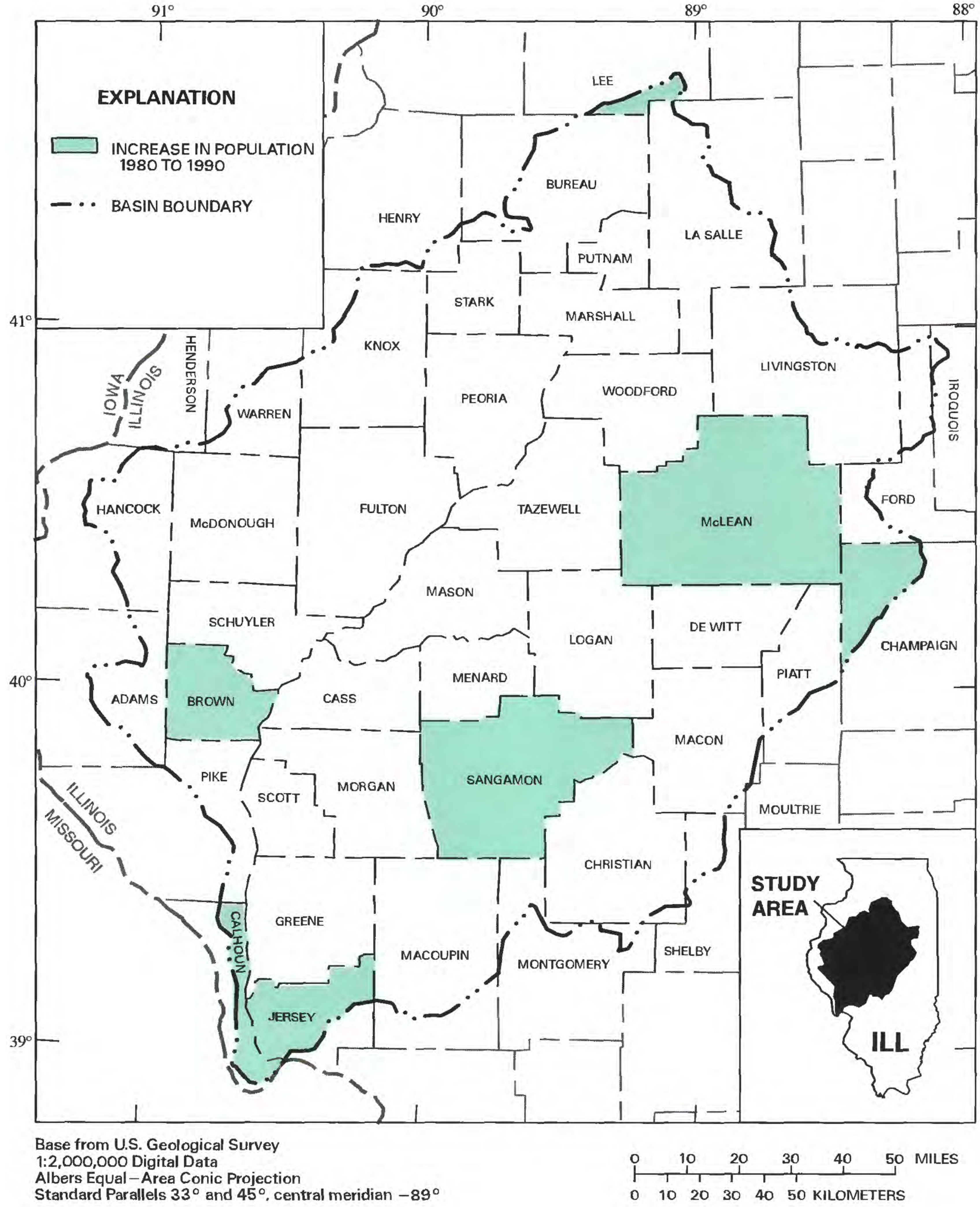


Figure 5. Counties with a population increase from 1980 to 1990 in the lower Illinois River Basin (modified from U.S. Department of Commerce, 1982 and 1992).

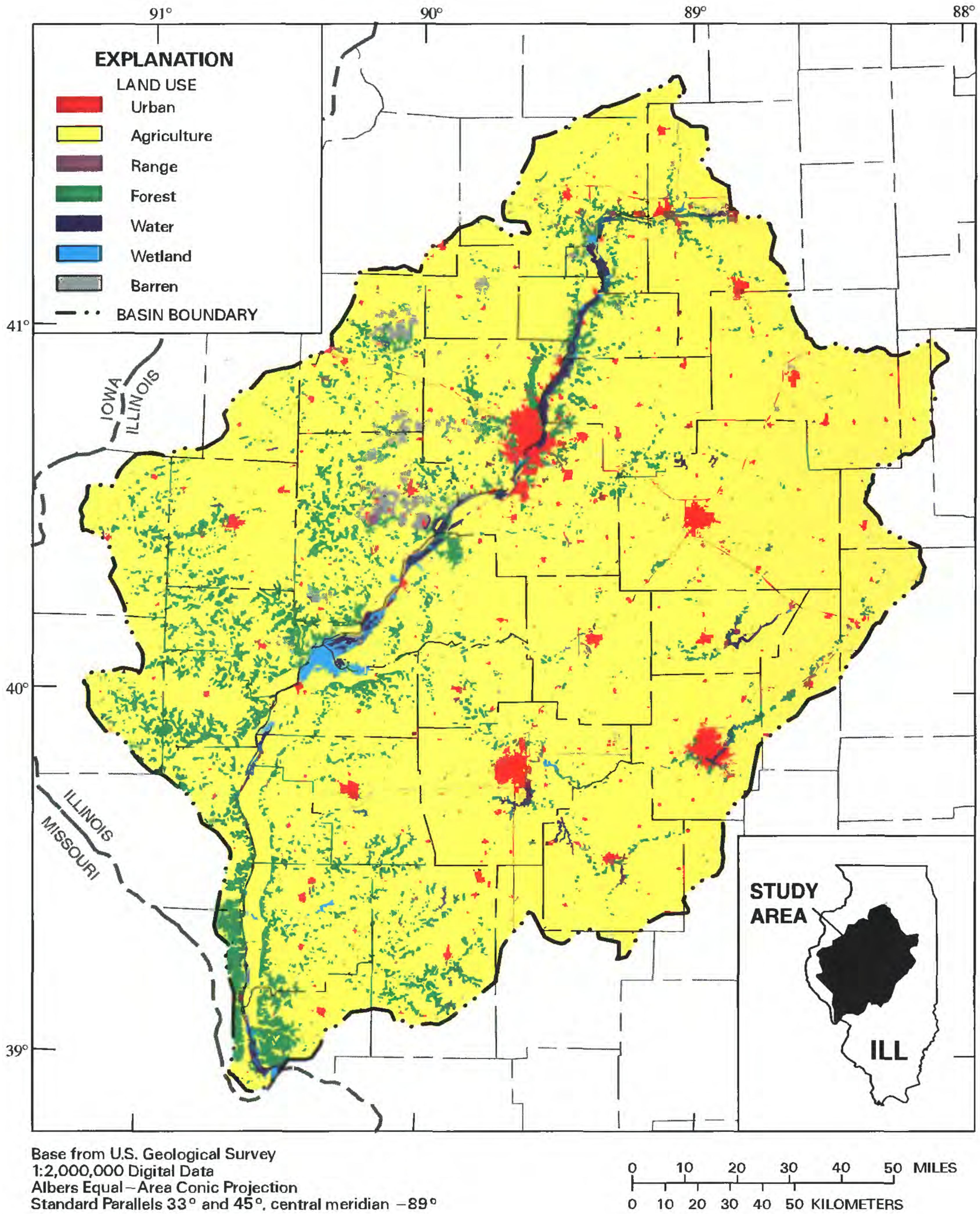


Figure 6. Major land-use classifications, 1970–80, for the lower Illinois River Basin (modified from Hitt, 1994).

Table 1. Changes in area of prairie land from 1820 to 1976, by county, in the lower Illinois River Basin (Illinois Natural History Survey, 1994)

County	Prairie in 1820 (acres)	Prairie in 1976 (acres)
Adams	249,000	3.0
Brown	37,700	4.9
Bureau	435,600	1.3
Calhoun	18,900	20.0
Cass	149,500	44.0
Champaign	592,300	.0
Christian	398,300	.0
De Witt	206,900	.0
Ford	297,100	6.4
Fulton	201,100	.0
Greene	170,700	12.0
Hancock	349,000	1.9
Henderson	174,200	176.0
Henry	428,700	9.7
Jersey	91,200	51.0
Knox	317,900	.5
La Salle	612,800	1.3
Lee	415,300	8.8
Livingston	633,400	2.4
Logan	336,500	.0
Macon	322,700	.0
Macoupin	401,300	8.5
Marshall	178,200	5.7
Mason	260,500	186.0
McDonough	262,100	.0
McLean	669,800	5.0
Menard	136,700	3.6
Montgomery	350,700	1.1
Morgan	235,100	11.0
Peoria	208,700	14.0
Piatt	254,000	.0
Pike	162,200	22.0
Putnam	58,900	1.3
Sangamon	431,400	1.1
Schuyler	78,400	.0
Scott	61,000	.0
Shelby	343,600	.0
Stark	140,000	.0
Tazewell	281,900	4.7
Warren	277,400	5.4
Woodford	240,000	1.6
Total	11,470,700	614.2

Forty percent of the land use in Calhoun County is forest land. Oak-hickory forests account for about half of the acres of Illinois forests and a majority of these are older than 60 years (Iverson and others, 1991). Maple-beech forests also are found in western Illinois, but white pine is most common in the western part of the State where it has been planted extensively (Iverson and others, 1989). The number of tree species varies from 38 in Warren County to 88 in Peoria County (fig. 7). Rare plants are found in abundance in forests. Forty-six percent of the threatened and endangered plants of Illinois are found in forests (Iverson and others, 1989).

Soils

The development of soils is determined by parent materials, climate, plants and animals, topographic relief, and time. The soils in the LIRB developed mostly in thick loess with some loess thicknesses greater than 60 in. Thin loess (10–40 in.) soil is found in the northeastern part of the LIRB (Neely and Heister, 1987). Soils developed on sandy to clayey alluvial sediments are found near major streams. A multicounty area south of Peoria, along the Illinois River, has sandy soil with a high permeability (fig. 8); therefore, the aquifer is vulnerable to contamination (Berg and others, 1984). The potential for contamination is affected by the infiltration or attenuation rate of the soil.

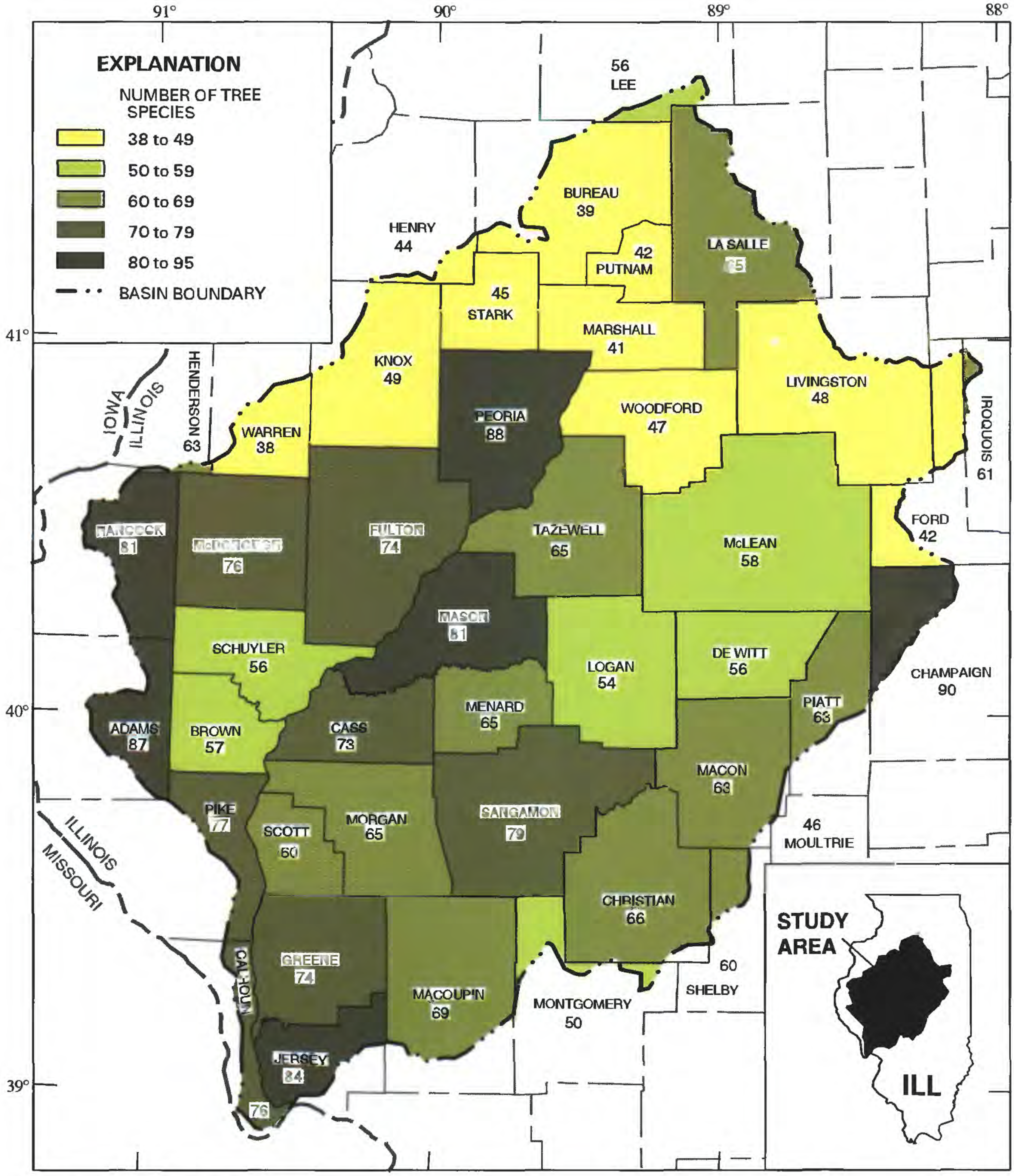
The humid, temperate climate of Illinois is conducive to the weathering of soil, formation of clay, and movement of leached chemical constituents downward in the soil profile. Tills commonly weather to depths of 5 ft and sometimes to a maximum depth of 15 ft along soil discontinuities (Panno and others, 1994). Most soils in the basin are mollisols, which are dark-colored soils formed under grass vegetation (Fehrenbacher and others, 1967). Mollisols average more than 1 percent organic matter. The native prairie vegetation under which soils form contributed to the high accumulation of organic materials, which is valuable to agriculture because of the capacity to store water and nutrients. The areas that are not mollisols are along stream valleys where the light-colored alfisols formed under forest vegetation. A small area in Mason County has entisol, which is a sandy, well-drained soil (Fehrenbacher and others, 1967).

Soil type and distribution are two factors that affect the amount of soil erosion that results in sedimentation of lakes and reservoirs in the LIRB. Sedimentation is one of the most important water-quality problems in the LIRB. Rates of soil erosion of up to 2 percent per year of farmland soil has been measured (Stout and Korab, 1993). Sedimentation from soil erosion is particularly serious in Illinois for three reasons: (1) The loess materials blanketing a large part of the State are highly erodible by water, even on the gently sloping land that covers most of the State; (2) Under conventional tillage practices for corn and soybeans, the primary crops leave little residue on the surface for much of the year; and (3) Rainfall in Illinois is fairly high in the spring when little vegetative cover is present on cropland (Neely and Heister, 1987, p. 22).

Climate

The climate in the LIRB is humid continental, with cold, relatively dry winters and warm, wet summers. Three air masses affect the climate in Illinois. The coldest, driest air mass is from Canada and most frequently covers Illinois in the winter. The warmest, most humid air mass and source of most of the precipitation originates from the Gulf of Mexico and is most frequent in the summer. The third air mass originates over the Pacific Ocean and tends to bring mild, dry air to Illinois. Any of the three air masses can be found over Illinois during a given season; thus, accounting for large day-to-day temperature and humidity variations (Neely and Heister, 1987, p. 120). The mean annual temperature in the LIRB ranges from 50°F in the north to 55°F in the south. Variations in precipitation and temperature may occur in any year because the basin is far from large physical features, such as oceans or mountain ranges that modify regional weather patterns.

Precipitation is normally 35–38 in/yr (fig. 9). In 1993, many States in the Midwest set records for annual precipitation, which resulted in massive flooding. Heavy, sustained precipitation in early spring through October contributed to the wettest year on record for Illinois with 50 in. as the statewide average precipitation for the year. The previous record was 49.5 in., which was set in 1927. Precipitation ranged from 50 to 70 percent above the long-term average across the State (Wendland and Dennison, 1993).



Base from U.S. Geological Survey
1:2,000,000 Digital Data
Albers Equal–Area Conic Projection
Standard Parallels 33° and 45°, central meridian –89°

0 10 20 30 40 50 MILES
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Figure 7. Number of tree species by county in the lower Illinois River Basin (modified from Iverson and others, 1989).

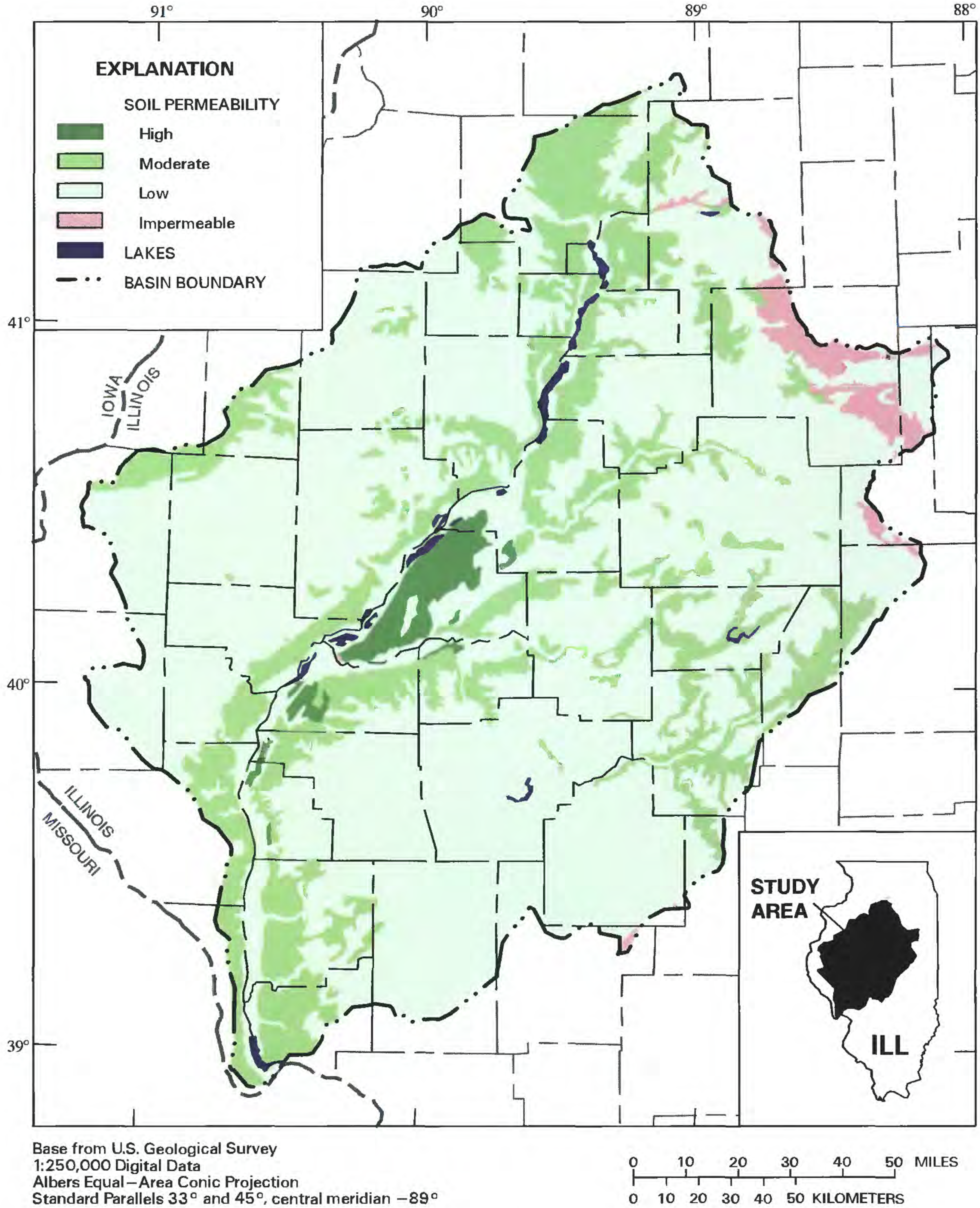

Figure 8. Permeability of soil in the lower Illinois River Basin (Soil Conservation Service, 1993, modified by Barbara Ruddy, U.S. Geological Survey, written commun., 1996).

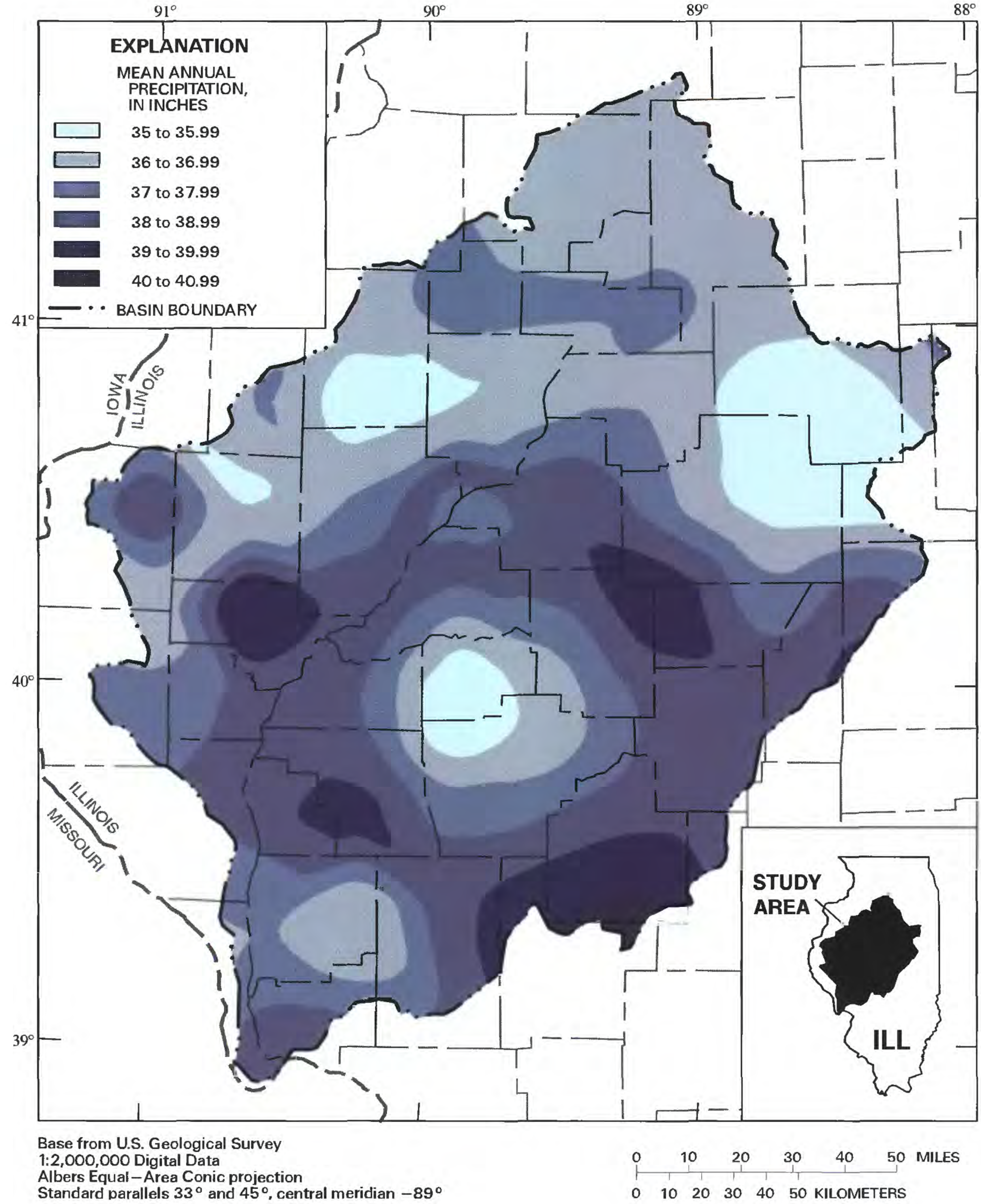

Figure 9. Mean annual precipitation in the lower Illinois River Basin (modified from Midwestern Climate Center, data referenced at http://mcc.sws.uiuc.edu/introduction/data.html).

Geology

An understanding of the geology is critical to understanding the location, movement, and natural quality of surface and ground water in the LIRB. The drainage pattern of the LIRB has been shaped by many geologic processes. The bedrock distribution and topography affected subsequent glacial depositional processes. Glacial processes have strongly affected the hydrology of the LIRB. For example, at the beginning of the Pleistocene Epoch, the rivers and streams in Illinois were not deeply entrenched in bedrock, but Pleistocene glaciation diverted the Mississippi River to its present position and scoured the bedrock surface (Horberg, 1950). Below Peoria the present Illinois River occupies the valley of the Ancient Mississippi River, and above Peoria the Illinois River became established in its present position during Woodfordian glaciation (Willman, 1973).

Bedrock Geology

The uppermost bedrock is mostly carbonate rocks of Mississippian and Pennsylvanian age (fig. 10). Mississippian and Pennsylvanian bedrock are present throughout the LIRB, but in most areas it is concealed by Quaternary deposits up to 500-ft thick. Many of the Mississippian- and Pennsylvanian-aged formations are made of cyclic beds of sandstone, siltstone, shale, limestone, coal, and clay. These rocks contain 1–2 percent of coal by volume. There are 75 identified coal beds in Illinois (Willman and others, 1975). The Herrin (Number 6) Coal Member of the Pennsylvanian Carbondale Formation (fig. 11), mined at two active underground mines in Illinois, ranges from 200 ft below land surface in the northern and western part of the basin to 800 ft in Shelby County (southeastern part of the basin) and is mostly from 28- to 42-in. thick. Coal beds range from 0- to 150-ft thick. The Mississippian bedrock is mostly shale and limestone.

The Mississippian and Silurian rocks near the confluence of the Illinois and Mississippi Rivers contain fracture and dissolution features, including karst. Many caves are present in this area (Panno and Weibel, 1993). The uppermost bedrock surface in parts of Bureau, La Salle, and Lee Counties at the northernmost part of the LIRB includes Silurian, Cambrian, and Ordovician carbonates (fig. 10). The uppermost bedrock surface along the lower reach, south of Valley City, of the Illinois River includes Devonian, Silurian, and Ordovician carbonates. The altitude of the bedrock surface changes as much as 600 ft across the basin (fig. 12).

Erosion, prior to and during glaciation, from large rivers and tributaries cut two major bedrock valleys that dominate the bedrock topography—the Mahomet system from the east and the Ancient Mississippi system from the north (Wilson and others, 1994) (fig. 13). The bedrock valleys are filled by overlying glacial drift. The time of formation of the bedrock valleys is not well defined (Melhorn and Kempton, 1991). The glacial materials in these valleys are some of the most productive aquifers in the LIRB; so an understanding of the configuration and distribution of the valleys is important. The Illinois and Mackinaw Buried Bedrock Valleys underlie the present Illinois River. The preglacial Illinois Valley was part of the ancient Mississippi River (Horberg, 1950). The Mahomet Buried Bedrock Valley is a large, bedrock valley that connects to the Illinois Buried Bedrock Valley from the east through Champaign, De Witt, Logan, Macon, Mason, McLean, Piatt, and Tazewell Counties (fig. 13). Several small, buried bedrock valleys connect to the present Illinois River Valley from the west: lower Spoon, Crooked Creek, and Wyoming. The Princeton Buried Bedrock Valley is a large, bedrock valley that connects to the Illinois River Valley in the northern part of the LIRB in and near Bureau County. The Mahomet Buried Bedrock Valley is part of the ancient Teays drainage system, which was thought to originate in southeastern West Virginia (Kempton and others, 1991), but new evidence indicates that the Teays drainage system may not be one connected valley and that the Mahomet Buried Bedrock Valley had headwaters in western Indiana (John Kempton, Illinois State Geological Survey, oral commun., 1996).

The LIRB is on the northwest edge of the subsurface structural Illinois Basin. Five major tectonic structures (Glasford Structure, Peru Monocline, Downs Anticline, Pittsfield Anticline, and Cap au Gres Faulted Flexure) and many minor tectonic structures affect local geology (fig. 14). Several structures, such as the Osman Monocline and Colfax Syncline, which intersect the western Mahomet Buried Bedrock Valley, may have an effect on the water chemistry as a result of ground-water flow through structural pathways (Panno and others, 1994).

Glacial Geology

The Wisconsinan glacial deposits cover approximately half of the LIRB to the east and northeast. The

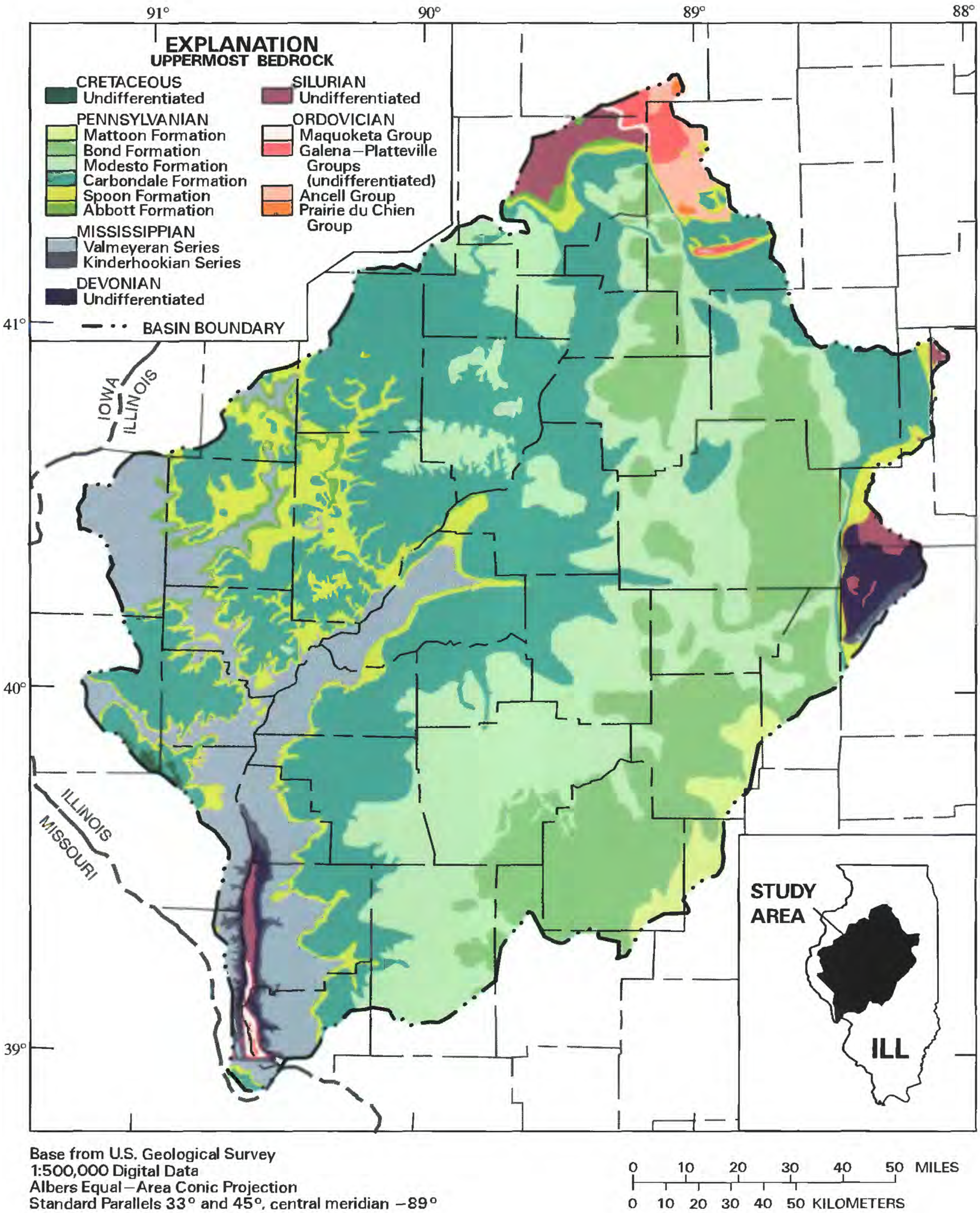

Figure 10. Uppermost bedrock of the lower Illinois River Basin (modified from Willman and others, 1967).

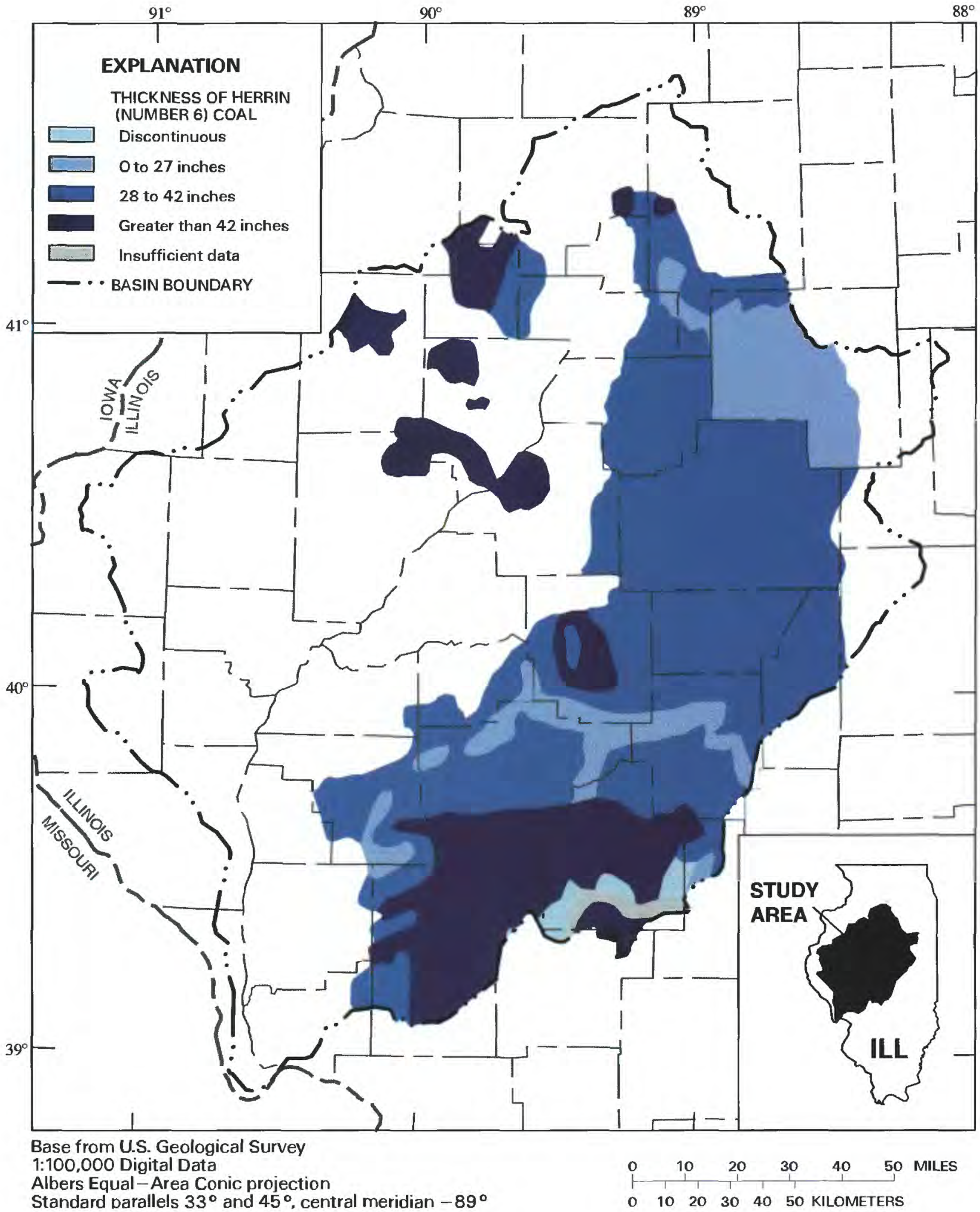

Figure 11. Generalized thickness of Herrin (Number 6) Coal (modified from Neely and Heister, 1987).

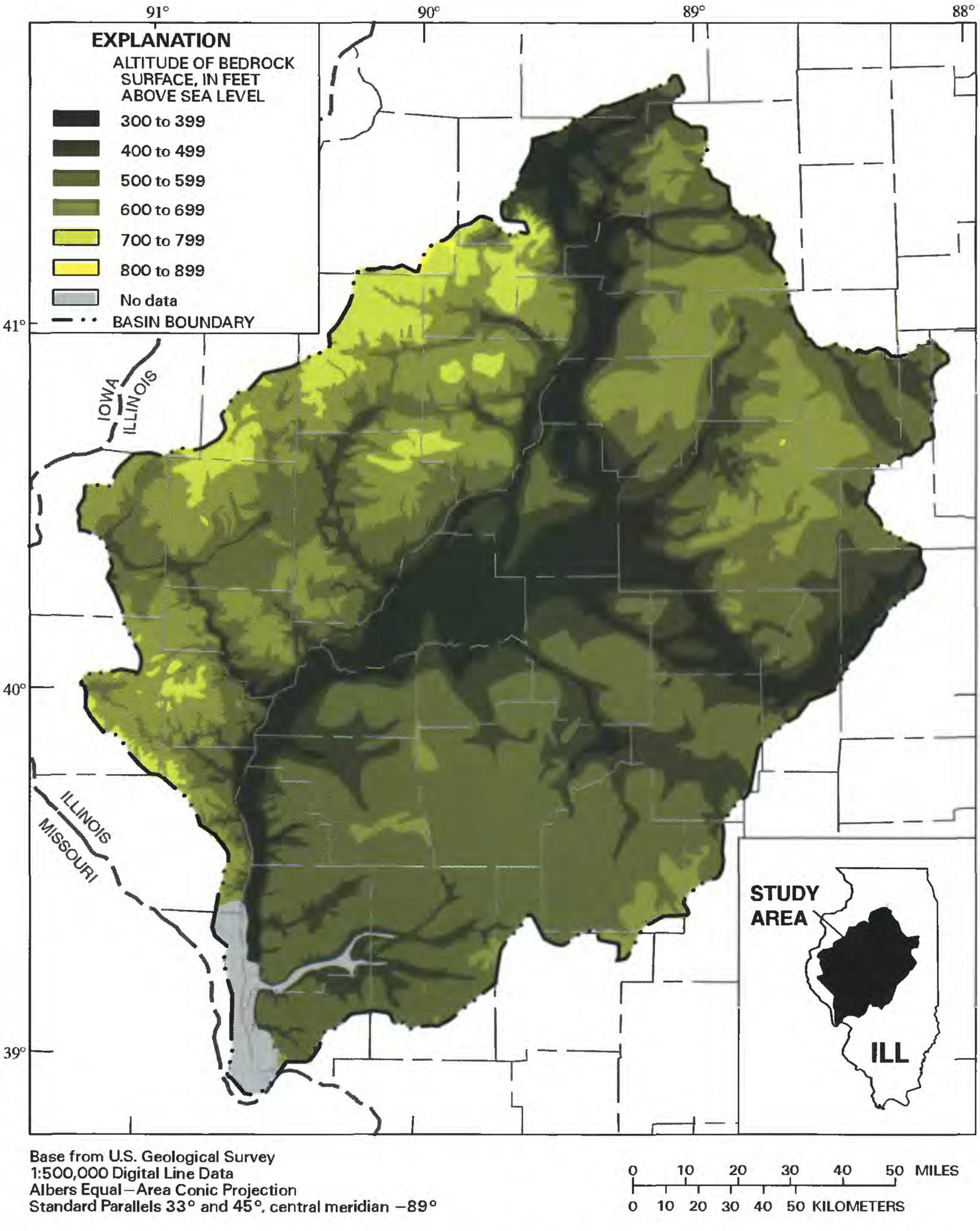

Figure 12. Altitude of the bedrock surface in the lower Illinois River Basin (modified from Herzog and others, 1994).

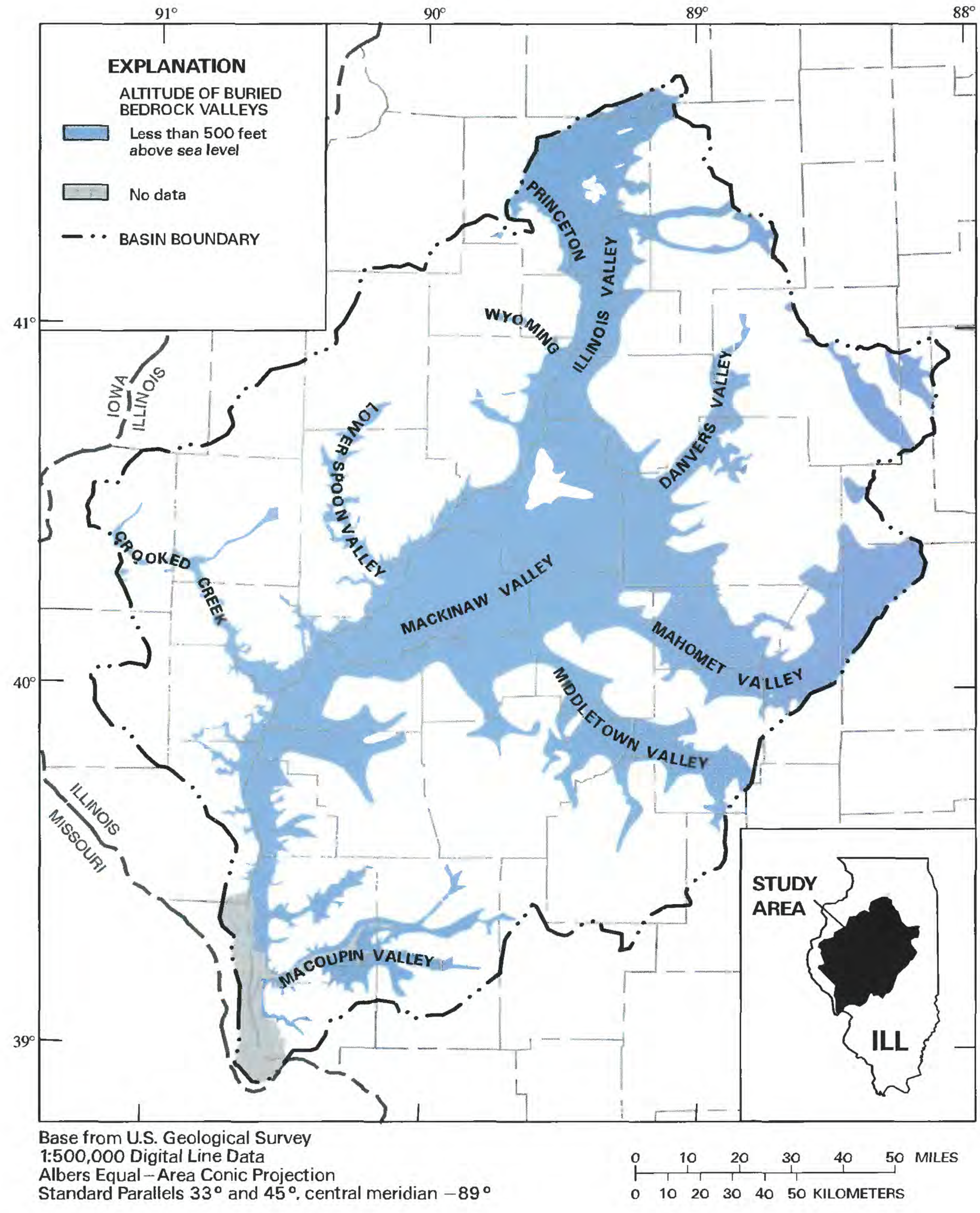

Figure 13. Altitude of the major buried bedrock valleys in the lower Illinois River Basin (modified from Herzog and others, 1994).

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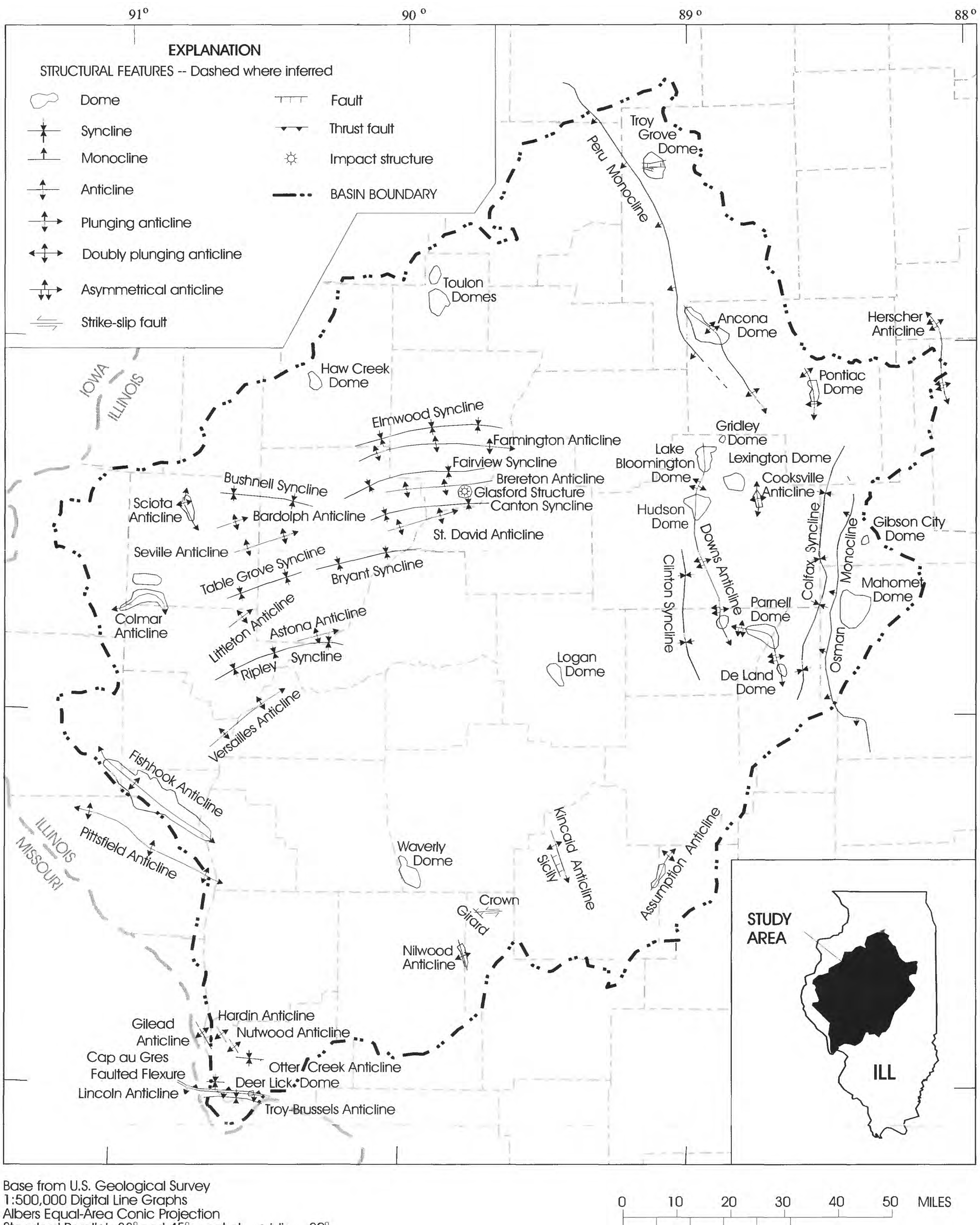

Figure 14. Bedrock structures in the lower Illinois River Basin (modified from Nelson, 1995).

- PAGE 23 FOLLOWS -

concentric band of Wisconsinan deposits intersects the Illinois River near Peoria and is thicker than older Illinoian deposits in the southern half of the basin. The Wisconsinan deposits are characterized by concentric bands of moraines that were deposited during the retreat of glacial ice lobes that formed Lakes Michigan and Erie. These moraines are the dominant landform in the northeastern part of the LIRB.

The glacial deposits range from 50- to 500-ft thick and are thickest in buried bedrock valleys. The thick, sand and gravel deposits in the east-west trending Mahomet Buried Bedrock Valley are major aquifers for public supply in central Illinois. The sands and gravels deposited by glacial streams are thick aquifers near the bottom of the valley. The overlying fine-grained tills deposited by glaciers restrict potential contamination from reaching the aquifers. Sand and gravel deposits within the Glasford Formation are laterally extensive where they are associated with the Vandalia Till Member and constitute a locally productive aquifer (Panno and others, 1994).

The mineral composition of glacial deposits indirectly reflects the source or age of the sediments. Carbonate materials are local bedrock, but heavy minerals, such as hornblende, in the sands commonly are derived from crystalline rocks of southern Canada. The older pre-Illinoian tills have a higher calcite to dolomite ratio than younger deposits, which is an indication of an eastern source for the deposits. The Wisconsinan tills have more dolomite than calcite, more than 50 percent less calcite in fine sediment than the pre-Illinoian tills, indicating a northern source for the deposits. Johnson and others (1986) studied the heavy mineral composition of sediments to determine the source for the tills. The tills in the eastern part of the LIRB were considered part of the Lake Erie glacial lobe deposits, however, the mineral composition is similar to glacial deposits from a Lake Michigan or Lake Huron source. Therefore, the tills in the eastern part of the LIRB are likely derived from the Lake Michigan source. Garnet, epidote, and pyrite are abundant in tills in central Illinois and have a low mean ratio of garnet-to-epidote (Johnson and others, 1986).

Soller (1993) mapped the lithology of surficial deposits in the eastern United States, which are mostly glacial in origin for the LIRB. The coarse-grained deposits are along streams and alluvial valleys, but thick till is found over buried bedrock valleys (fig. 15). The type of surficial deposits and thickness are the primary factors affecting ground-water contamination; therefore, the sand deposits in the center of the LIRB and along streams have a higher potential for contamination.

The stratigraphic relation of glacial deposits is complex because of different modes of deposition, multiple sources, and lack of regional continuity (fig. 16A). Areal distribution of formations and members within formations is generalized because boundaries are intertongued and often indistinct (fig. 16B). The boundaries between formations are similar to facies changes. The Wedron Group is the most extensive till unit of Wisconsinan age in the LIRB, and the type section is largely till with numerous interbedded deposits of outwash gravel, sand, and silt. Other formations with type sections within the LIRB include the Morton and Peoria Loess, which are silty and sandy formations of Wisconsinan age (Willman and others, 1975). Major deposits of loess were formed during Wisconsinan glaciations as silt and fine sand was blown from the bottomlands and deposited on adjacent bluffs and uplands. On the bluffs, southeast of the broad lowlands in the Havana area, loess accumulated to nearly 100-ft thick, but elsewhere it is not as thick (Willman, 1973). Two distinct lithostratigraphic units—the Sankoty Sand Member and Mahomet Sand Member—include major aquifers found in the northern and western parts of the LIRB.

Hydrology

Streamflow

The Illinois River is part of the upper Mississippi River drainage basin. The Illinois River accounts for at least 22 percent of the flow in the Mississippi River just below the confluence of the Illinois and Mississippi Rivers. A low gradient is characteristic of the lower Illinois River and is the principal difference between the lower and upper Illinois River (fig. 17). Less than 10 mi downstream from the beginning of the lower Illinois River near Ottawa, the Starved Rock Lock and Dam regulate the flow from the Starved Rock Pool to the Peoria Pool of the Illinois River. Downstream from the dam, the gradient of the river is low (0.2 ft/mi) relative to the gradient upstream from the dam (1.1 ft/mi).

Locks and dams regulate the flow of the Illinois River. The Alton, La Grange, Peoria, and Starved Rock Pools are the reaches of stream (navigation pools) between the lock and dams from Grafton to Ottawa.

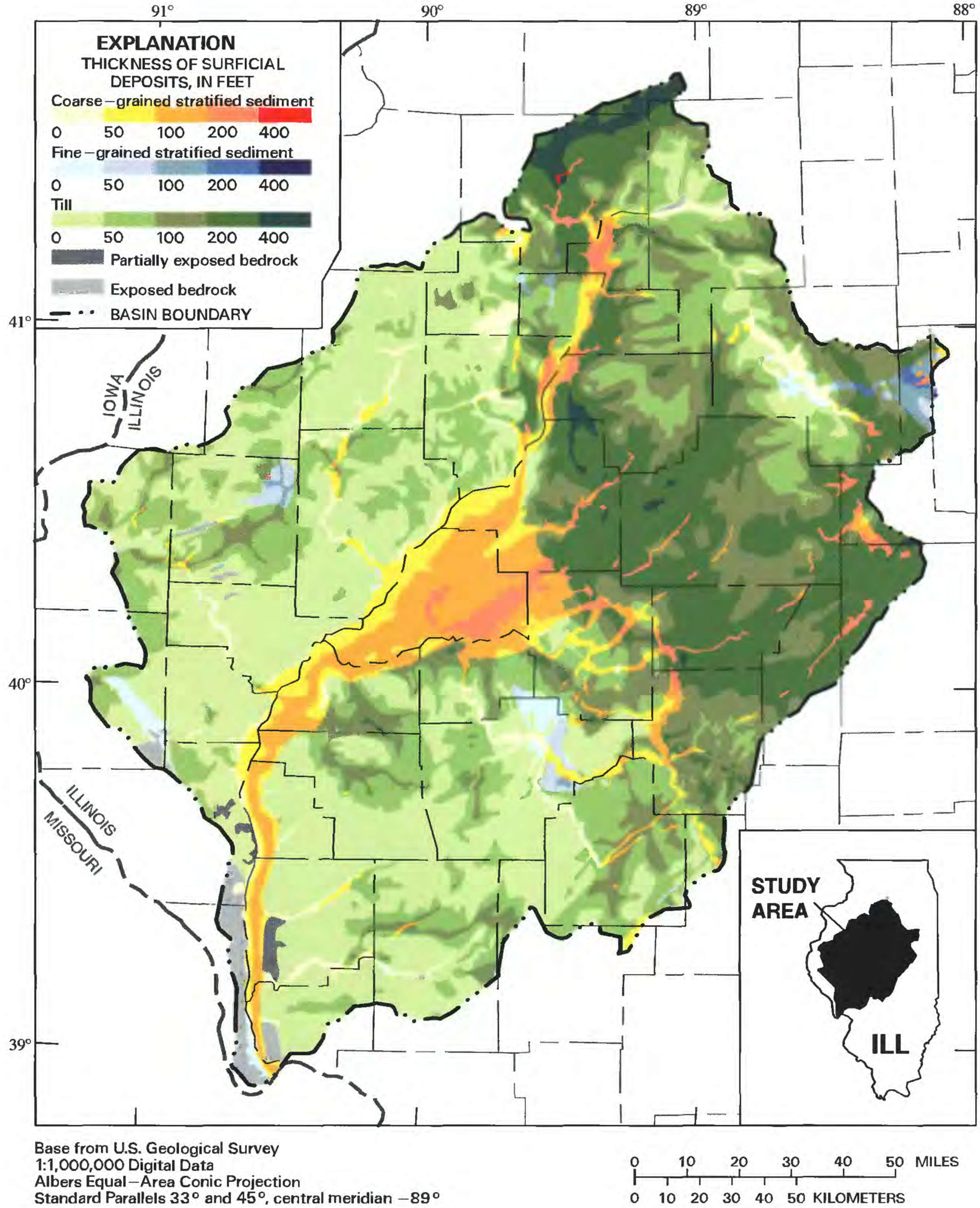

Figure 15. Type and thickness of surficial deposits in the lower Illinois River Basin (modified from Soller, 1993).

QUATERNARY SYSTEM / PLEISTOCENE SERIES	West-Central Illinois (Walker, Bergstrom, and Walton, 1965) — Valley Deposits	West-Central Illinois (Walker, Bergstrom, and Walton, 1965) — Upland Deposits	East-Central Illinois (Kempton, Morse, and Visocky, 1982)	Central and Northern Illinois (Hansel and Johnson, 1996)
WISCONSINAN STAGE **Valderan Substage** **Two Creekan Substage**	Beardstown Terrace	Alluvium, Colluvium	Cahokia Alluvium	NOT MAPPED
Woodfordian Substage	Bath Terrace Havana Terrace Manito Terrace Bloomington Outwash Terrace	Peoria Loess: Richland Loess; Morton Loess	Richland Loess Henry and Wedron Formation: Batestown Till Member, Piatt Till Member, Fairgrange Till Member, Oakland Till Member, Ashmore Aquifer Morton Loess	Wedron Group: Kewaunee Formation: Two Rivers Member, Manitowac Member, Shorewood Member Wadsworth Formation Lemont Formation Undivided: Haegar Member, Yorkville Member, Batestown Member Tiskilwa Formation Undivided: Piatt Member, Delevan Member
Farmdalian Substage	Undifferentiated	Farmdale Silt	Robein Silt	NOT MAPPED
Altonian Substage	Undifferentiated	Roxanna Silt	Roxanna Silt	
YARMOUTHIAN STAGE	Undifferentiated	Till/Silt/Sand/Gravel	Glasford Formation: Berry Clay Member	
ILLINOIAN STAGE **Jubileean Substage**	Undifferentiated	Till/Silt/Sand/Gravel	Glasford Formation: Radnor Till Member, Roby Silt Member	
Monican Substage	Undifferentiated	Till/Silt/Sand/Gravel	Glasford Formation: Vandalia Till Member, Hulick Till Member, Mulberry Grove Member	
Liman Substage	Undifferentiated	Till/Silt/Sand/Gravel	Glasford Formation: Smithboro Till Member	
SANGOMONIAN STAGE	Undifferentiated	Till/Silt/Sand/Gravel	Banner Formation: Lierle Clay Member	
PRE-ILLINOIAN STAGE	Sankoty-Mahomet Sand (Sankoty Sand in central Illinois)	Till/Silt/Sand/Gravel	Banner Formation: Mahomet Sand Member; Tilton Clay Member, Hillery Till Member, Harmattan Till Member, Undifferentiated	
	Undifferentiated	Till and Sand	Undifferentiated older deposits	

Figure 16. (A) Stratigraphic *relation of* Quaternary-aged deposits (modified from Walker, Bergstrom, and Walton, 1965; Kempton, Morse, and Visocky, 1982; Hansel and Johnson, 1996).

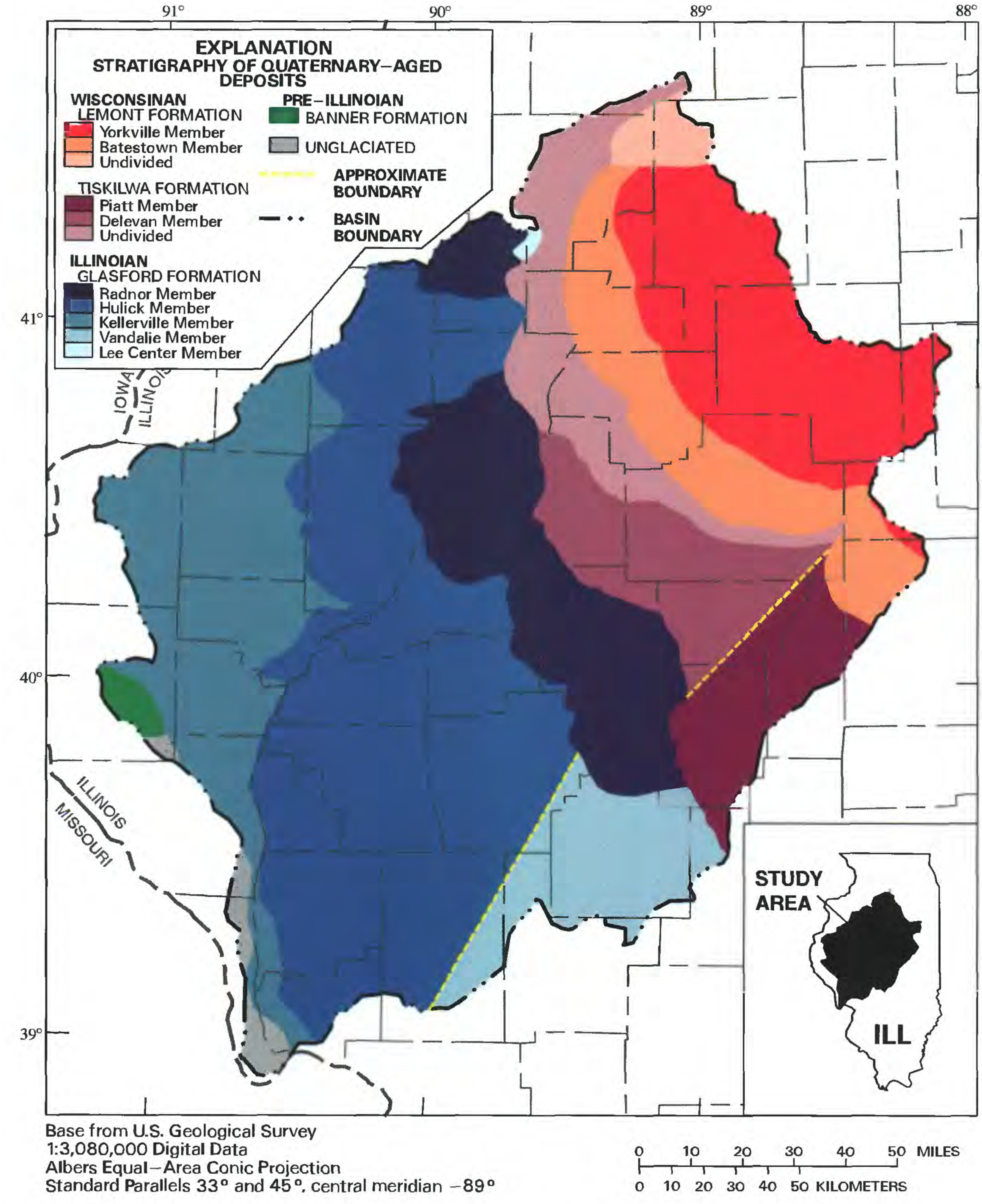

Figure 16. (B) Generalized distribution of Quaternary formations and members.

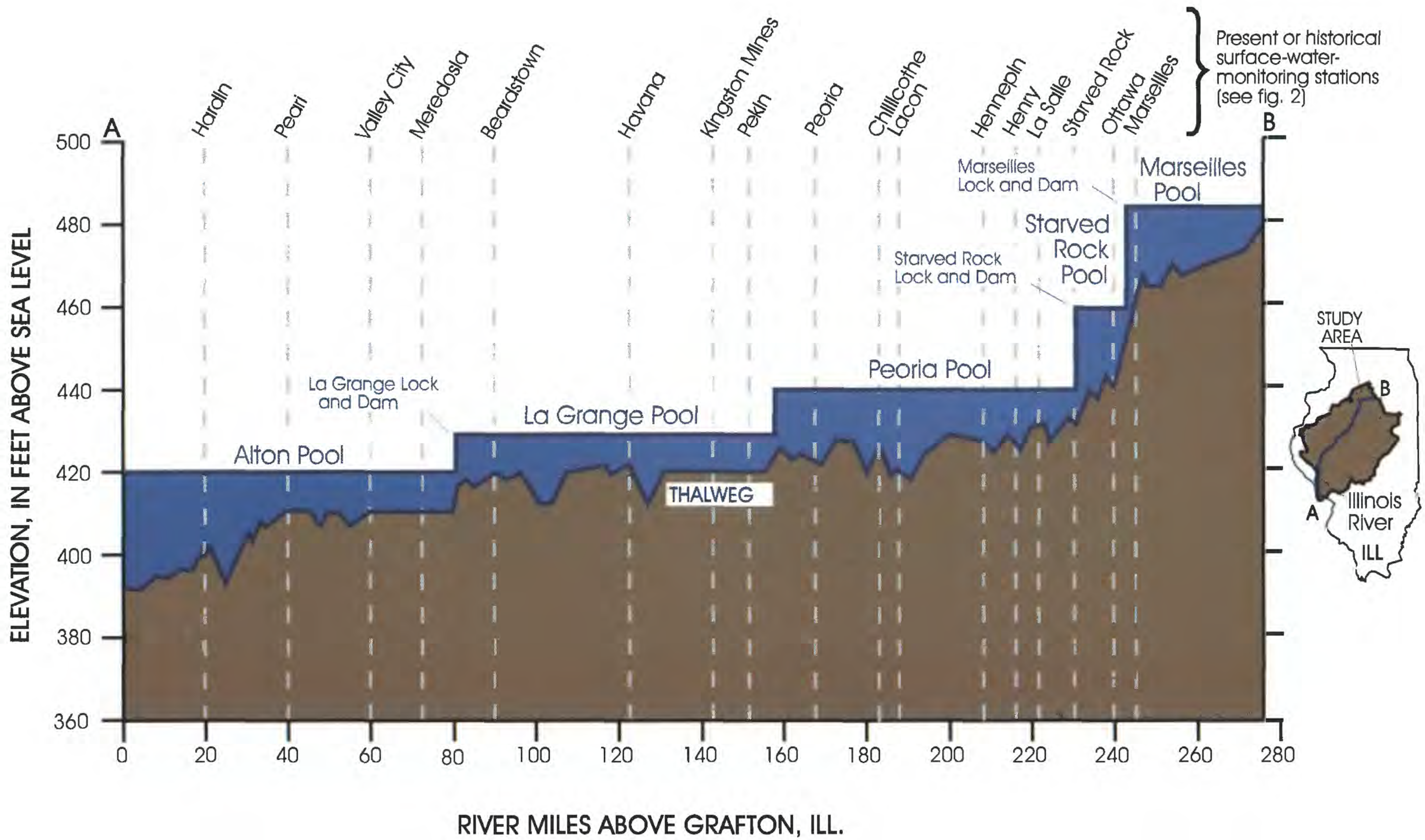

Figure 17. The elevation of the lower Illinois River Basin and location of the U.S. Geological Survey surface-water-monitoring stations (modified from U.S. Army Corps of Engineers, 1974).

The general change in stream elevation between lock and dams is 20 ft, and each pool is named for the dam immediately downstream. The Alton Lock and Dam is on the Mississippi River and may regulate flow on the Illinois River. During the floods in 1993, backwater from the Mississippi River could be measured on the Illinois River as far north as Valley City.

The U.S. Geological Survey (USGS) has operated 17 surface-water-monitoring stations on the Illinois River from Ottawa to Hardin, Ill., since 1903, and only three of these stations on the Illinois River were active in 1996. There were 26 active surface-water-monitoring stations across the basin in 1995 (fig. 18). Measurements include:

- discharge at 26 stations,
- sediment at 7 stations, and
- gage height at 1 station.

Surface-water flow had been measured for more than 20 years at 22 of the historical stations.

The mean annual flow from the upper Illinois and Fox Rivers to the lower Illinois River is 12,600 ft^3/s near Ottawa, Ill. The flow in the Illinois River increases approximately 10,000 ft^3/s across the basin from Ottawa to Valley City. The mean annual flow of the Illinois River at Valley City (61 mi upstream from the river mouth) is 22,600 ft^3/s.

Precipitation (80 percent) and discharge from the upper Illinois River Basin (20 percent) account for most of the inflow of water to the LIRB, but many changes occur across the basin. Discharge to the lower Illinois River across the basin consists of return flow, surface runoff, and ground-water discharge. Return flow is water that has been released from some facility. Typical examples of return flow are discharges from industrial and municipal wastewater-treatment facilities. The combined return flow, which is from sewage-treatment facilities and overland runoff, has an appreciable effect on the water budget of the basin. The combined return flow, based on average annual discharge for all facilities, was 4,400 Mgal/d in 1991. The return flow has increased over 100 percent from 1986 to 1991. The median of the average annual flow per facility was 0.26 Mgal/d in 1991, but there is a large standard deviation of 123 Mgal/d. The 1991 average per facility was 17 Mgal/d. An annual average of over 600 Mgal/d was discharged by three facilities in 1991.

The principal source of surface runoff is precipitation that enters the stream as overland flow, which is rainwater or snowmelt that flows over the land surface toward stream channels. In urban areas there is less infiltration and much more overland flow.

Ground-water discharge, which is ground water that discharges into a stream channel from a spring or as seepage, varies across the basin (Berg and others, 1997). Berg and others (1997) characterize low-flow conditions by basin for the State. Basins in the LIRB less than 36 mi^2 appear to have the most ground-water contribution as a percentage of the total inflow.

Although the largest discharge from a tributary to the lower Illinois River is from the Sangamon River, the largest tributary sediment load is from the Spoon River (fig. 19). The discharge of the Illinois River increases gradually downstream, but the sediment load increases dramatically in the La Grange Pool (Demissie and others, 1992). The Spoon River and Sangamon River are the largest tributary sources of sediment to the La Grange Pool. The sediment load is notably greater for the lower compared to the upper Illinois River. The major sources of sediment are watershed, streambank, and bluff erosion, which result, in part, from agricultural land-use practices (Demissie and others, 1992). In backwater lakes, sedimentation causes infilling and loss of habitat.

Floods

Precipitation has the greatest effect on floods or droughts in central and western Illinois. The floods of 1927, 1943, 1970, 1974, 1982, and 1993 are the largest recorded based on 30-day and 183-day high mean value for discharge measured at Illinois River at Valley City and Spoon River at Seville (Zuehls, 1991). The severe flooding of the Mississippi River in 1993 resulted from unusually intense and persistent rains and high soil moisture. Backwater from the Mississippi River affected the Illinois River over 60 mi upstream from the confluence. Some tributaries of the Illinois River (Big Bureau, La Moine, Macoupin, Sangamon, and Vermilion) had annual mean discharge exceeding 200 percent of the normal, whereas annual mean discharge for the Mackinaw and Spoon Rivers exceeded 300 percent (Zuehls and others, 1994). The 1993 flooding along the Illinois River inundated large areas of farmland and many urban areas in Peoria and other cities.

Lakes and Reservoirs

The flood plain of the Illinois River is lined with dozens of backwater lakes that are remnants of

Figure 18. Surface-water-monitoring and sediment stations in the lower Illinois River Basin (modified from Wicker and others, 1995).

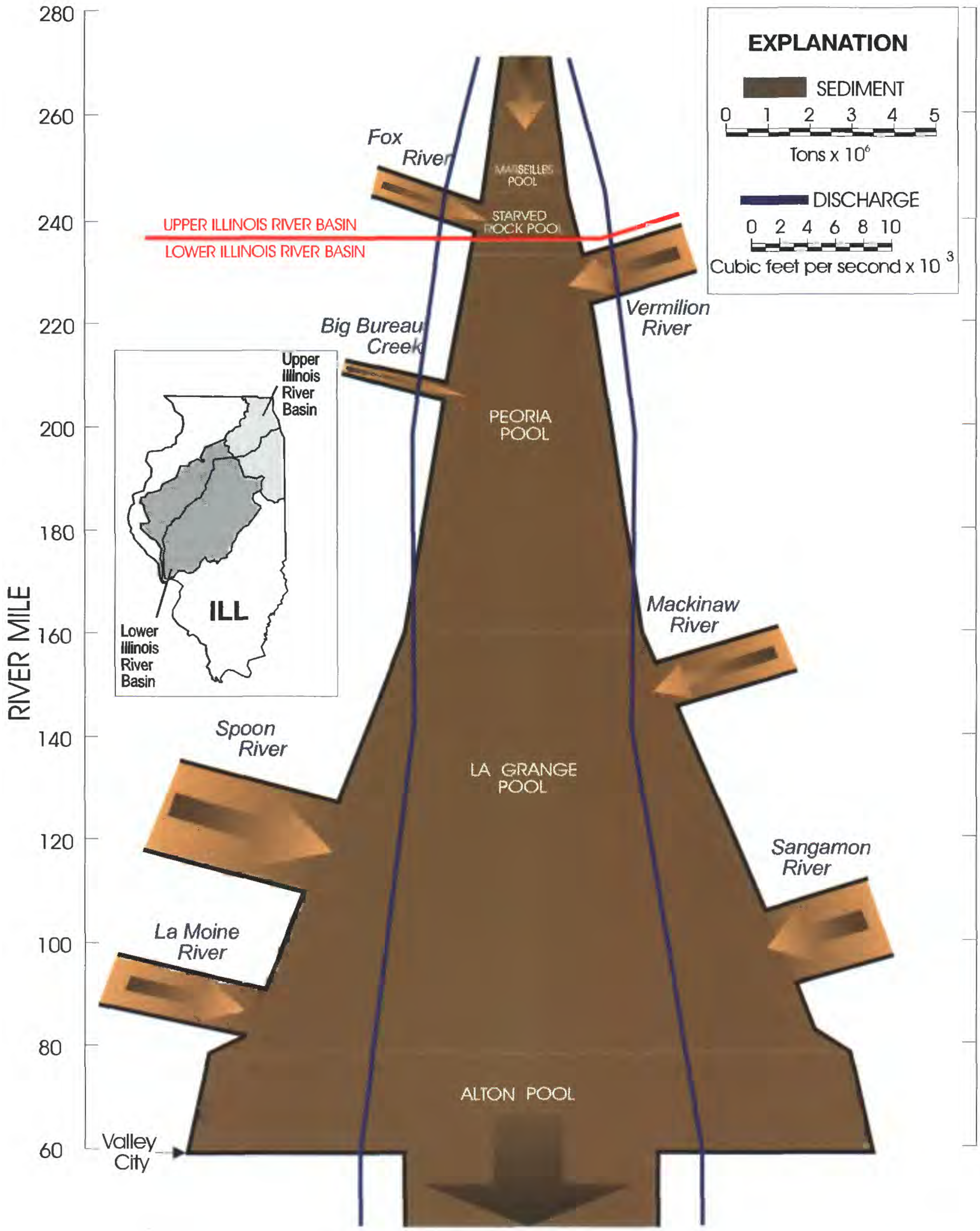

Figure 19. Sediment budget for the lower Illinois River Basin for the period from 1981 to 1990 (modified from Demisse and others, 1992).

marsh that covered the Illinois River Valley after glaciation. Sediment filled much of the marsh area, but there are still more than 300 backwater or bottomland lakes, in the LIRB (Talkington, 1991). The Illinois Environmental Protection Agency (IEPA) investigated the need for protection, restoration, and management of 67 lakes in the LIRB in 1984 and 1994. The following discussion is based on data from the 1984 and 1994 IEPA study (Sefton and Little, 1984). The lakes are inland lakes classified as State or public with surface areas of 20 acres or more. Two lakes in the LIRB are valuable public natural resources according to the IEPA—Lake of the Woods, Champaign County, and Siloam Springs, Adams County.

Thirty-nine percent of the lakes (26) evaluated in the LIRB had a decrease in overall water quality, and 18 percent of the lakes (12) had improved water quality from 1984 to 1994 (Gregg Good, Illinois Environmental Protection Agency, written commun., 1994). In 1994, 76 percent of the lakes in the LIRB were moderately or substantially affected by sediment, which is a 5-percent decrease since 1984. Twenty-two percent of the lakes (22) were moderately or substantially affected by macrophytes in 1994. The trophic state index (TSI) increased for 56 percent of the lakes (38) from 1984 to 1994, which indicates reduced water clarity and/or increasing eutrophication for over half of the lakes.

Thirty-four percent of the lakes (23) evaluated by IEPA in the LIRB in 1994 were primary or alternate public-water supplies. The general water quality of public-supply lakes is better than for other lakes in the basin. Forty-three percent of the public-water supplies (10) indicated poorer water quality from 1984 to 1994, and 26 percent (6) indicated improved water quality. The median changes in water quality were negligible from 1984 to 1994.

Many of the lakes and wetlands are disappearing because of sedimentation resulting from agriculture activities, levee building, and urbanization. Seventy-six percent of the lakes in the LIRB assessed by the IEPA are substantially or moderately affected by sediment input. The median depth for lakes in the LIRB is 5.1 ft (Gregg Good, Illinois Environmental Protection Agency, written commun., 1994).

Wetlands

Many wetland or formerly wetland areas in the LIRB are glacial in origin. Blocks of ice, from retreating continental glaciers, were left buried in hills of gravel that the glaciers had pushed forward. Warmer temperatures melted the blocks of ice to form lakes. Plants grew around the lakes and eventually filled in the lakes, transforming open water to wet soil and marsh (Bell, 1981). Wetlands are important as natural filters for excess nutrients, such as nitrogen and phosphorus, suspended solids, and other constituents (Bell, 1981).

Wetlands provide a sink for nutrients and sediment that filters water. Wetlands also reduce the biological oxygen demand (BOD) of the water without serious water-quality degradation (Bell, 1981). Presettlement wetlands were widespread throughout the Illinois River Valley and counties bordering the Illinois River. Wetlands covered as much as 20–40 percent of the land in counties bordering the Illinois River (Suloway and Hubbel, 1994). By 1987, the total area in most counties was less than 2 percent wetlands (fig. 20).

Three of the five nationally recognized types of wetland systems are present in Illinois—palustrine (marshes, bogs, swamps, bottomland forests, and small ponds), lacustrine (lakes, rivers, and streams), and riverine (free-flowing rivers and streams) (Suloway and Hubbell, 1994). Palustrine wetlands are found mostly in southern Illinois but are present from Peoria to Beardstown along the Illinois River. Lacustrine wetlands are found in small areas along the Illinois River from Peoria to Beardstown. The riverine wetlands are the most abundant wetland system in the LIRB, especially west of the lower Illinois River. The riverine wetlands are abundant but are much smaller individually than palustrine or lacustrine wetlands. The National Wetland Inventory and Illinois Wetland Inventory contains one area in Cass County that was classified as swamp (Suloway and Hubbell, 1994). The natural wetland distribution, by river basin, shows the Illinois River Basin to contain the most wetlands followed by the La Moine and Sangamon River Basins. The Illinois River south of Beardstown contains the greatest number of natural wetlands—wetlands that are not diked, impounded, or excavated. The Spoon River has more open-water palustrine wetlands than other river basins in the LIRB because of dikes, impoundments, or excavations of abandoned mining pits and associated haulage roads (Zuehls and others, 1981).

Little study has been completed on the hydrology of wetlands in central Illinois. The Illinois State Geological and Water Surveys are presently (1996) collecting data for the Illinois Department of Transportation to characterize the hydrology of selected wetlands (Mike Miller, Illinois State

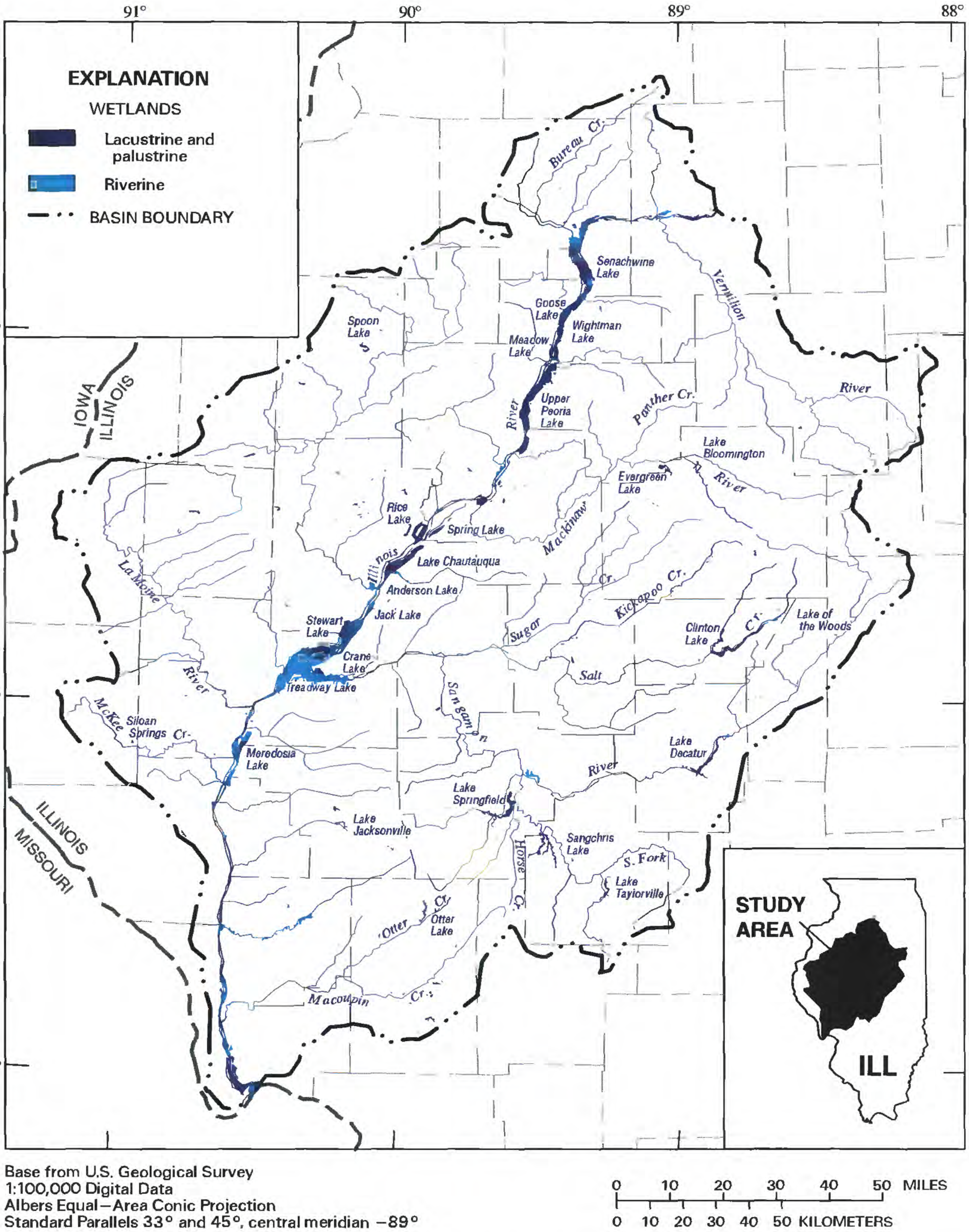

Figure 20. Wetlands, lakes, and reservoirs in the lower Illinois River Basin (modified from Anderson and others, 1978).

Geological Survey, written commun., 1995). Most wetlands in central Illinois are surface-water depressions recharged from overland flow. The organic-rich material blanketing the wetlands has a low permeability, which increases the overland flow. Water tables may be a few feet below wetland elevations, but the impermeable surface retains water rather than recharging aquifers. Areas of ground-water seeps in east-central Illinois may contain ground-water depression wetlands recharged from overland flow and ground-water inflow.

Habitats

The Illinois River is a large, river-flood-plain ecosystem where biological productivity is enhanced by annual flood pulses that advance and retreat over the flood plain and temporarily expand backwater lakes (Sparks and Lerczak, 1993). The expanded aquatic habitats are utilized as feeding areas by migratory birds and as breeding areas and nurseries by fish and other aquatic life (Sparks and Lerczak, 1993).

Wetland areas are habitats that provide nesting, food, and cover for fish, waterfowl, and wildlife. The Illinois River was once one of the most productive fishing and duck hunting areas in the country, but the wetland habitat upon which fish and wildlife depend for food and breeding was either converted to agricultural land or covered in silt (Bell, 1981). By 1937, 50 percent of the Illinois River flood plain had been converted from wetland to agricultural land by drainage and levee districts (Bell, 1981). Small-fish species, such as shiners and minnows, were less consistently collected from the La Grange to Alton Pools than upstream, which could indicate differences in habitat conditions or other undetermined factors (Sparks and Lercsak, 1993).

Turbidity and siltation have further degraded the wetland habitat of the Illinois River. Aquatic wetland plants are more sensitive to fluctuation in water levels than plants rooted in moist soil. Turbidity reduces light penetration through water, thus, inhibiting growth of aquatic wetland plants.

Ground Water

The presence and extent of aquifers varies across Illinois from areas such as Mason County, where the aquifer is present within a few feet of the land surface, to areas such as Champaign County, where aquifers are more than 100 ft below land surface and are protected by overlying materials of low permeability. Most shallow aquifers, less than 200 ft below land surface, are composed of unconsolidated glacial material, and bedrock aquifers commonly are the Mississippian-Pennsylvanian-aged formations.

Aquifer properties of unconsolidated glacial material vary greatly over short distances and by depth (Kempton and others, 1982). Variability of aquifer properties is greater for younger formations and less variable for older formations (table 2) (Kempton and Visocky, 1992). The till is almost impervious where it is composed of primarily clay and yields very little water to wells; a sandy till is relatively more porous and permeable.

The nature of unconsolidated glacial deposits makes it difficult to correlate or compare these aquifer systems across the LIRB. Lithic discontinuities, genetic associations, and stratigraphic position of the deposits often have been the basis for aquifer nomenclature of the Quaternary deposits. An understanding

Table 2. Aquifer properties from selected locations in McLean and Tazewell Counties (from Kempton and Visocky, 1992)
[(gal/d)/ft, gallons per day per foot; (gal/d)/ft^2, gallons per day per square feet; (gal/min)/ft, gallons per minute per foot]

Aquifer	Aquifer properties						
	Transmissivity [(gal/d)/ft]		Hydraulic conductivity [(gal/d)/ft^2]		Storage coefficient (dimensionless)	Specific capacity [(gal/min)/ft]	
	Range	Median	Range	Median	Value or Range	Range	Median
Henry or Wedron	35-105,000	15,000	12-8,300	1,000	0.0002-0.0005	0.1-105.7	12.6
Glasford	880-96,000	16,300	110-9,600	1,000	.0001	.7-117.6	8
Banner	2,400-546,000	140,000	200-4,778	1,705	.0002-0.09	1.0-155.0	16.2

of these characteristics is needed to interpret the hydrostratigraphy and the relation of aquifer properties to water quality. The processes of deposition of materials derived from glaciers generally are local, such as lacustrine deposits or end moraine deposits. Some Quaternary deposits form sheets over an area or fill an older bedrock valley. The basal units in the buried bedrock valleys are often continuous or spatially connected. Various references in Illinois literature use genetic terms to define aquifers, such as glacial drift aquifers or glacial till aquifers. These aquifer names define the depositional origin of material composing the aquifer.

Stratigraphic position is a method of designating an aquifer. Aquifers in the Quaternary System, which have been associated with rock-stratigraphic units, consist of one or more members of the same formation. Two distinct rock-stratigraphic units that are hydrostratigraphic units are members of the Banner Formation—the Sankoty and Mahomet Sands. The Sankoty Sand Member and the Mahomet Sand Member are in the same stratigraphic position, but the Mahomet Sand Member consists of about equal amounts of sand and gravel, contains many silt beds, and lacks the polished pink quartz grains that distinguish the Sankoty Sand Member (Willman and Frye, 1970). The Mahomet Sand Member is found in the eastern part of the basin, and the Sankoty Sand Member is found in the central and west-central parts of the basin.

The variety of ways that an aquifer has been named is a source of confusion in the nomenclature, especially for aquifers that are composed of glacial sand and gravel deposits. The following are examples of nomenclature with references to the use of aquifer names in Illinois literature:

1. Time stratigraphic—An example is Quaternary aquifer (Bergstrom and others, 1968; Piskin and others, 1981).
2. Relative position—An example is upper, middle, or lower aquifer (U.S. Department of the Air Force, 1989).
3. Alphanumeric designations—An example is A1 aquifer and C3 aquifer. This nomenclature is often used in ground-water-flow models.
4. Depositional environment—An example is glacial drift aquifer (Suter and others, 1959; Schicht and others, 1976; Zeizel and others, 1962).
5. Depth of occurrence—An example is less than 50 ft aquifer or greater than 50 ft aquifer (Gibb and O'Hearn, 1980).
6. Synonyms for aquifer—An example is hydrofer, aquiformation, or aquigroup (Curry and Seaber, 1990).

Different nomenclature among reports for aquifers in the sand and gravel deposits make it difficult to compare aquifer properties.

A study of regional ground-water resources in McLean and Tazewell Counties shows that most water wells are open to the Sankoty Sand Member of the Banner Formation or the lower sands of the Glasford Formation (Kempton and Visocky, 1992). The altitude of the top of the Sankoty Sand Member in McLean and Tazewell Counties ranges from 400 to 500 ft. The altitude to the top of the sands and gravels of the lower Glasford Formation generally is about 550 ft within the bedrock valleys but is higher where it lies over the bedrock uplands (Kempton and Visocky, 1992). Results of aquifer tests performed in McLean and Tazewell Counties have shown no evidence of appreciable vertical leakage between the Banner and Glasford Formation (Kempton and Visocky, 1992). The Sankoty Sand Member in the Mackinaw Bedrock Valley is contiguous with the Mahomet Sand Member of the Banner Formation in the Mahomet Bedrock Valley. The mixing of waters from each aquifer in the two sand members constitutes a water-chemistry confluence area (Panno and others, 1994). Ground water in the glacial materials of the buried bedrock valleys is mostly confined. Till or other fine-grained deposits overlie the bedrock valley aquifers, impede vertical movement, and confine water in the aquifer in most areas. Aquifers in the northern half of the LIRB under unconfined (water table) conditions consist of shallow, sand and gravel deposits of the Henry and Wedron Formations (Kempton and Visocky, 1992). The water table is in direct connection with streams and lakes.

The water table usually follows land-surface topography rising under the uplands and intersecting the land surface near perennial streams, lakes, swamps, and springs (McKenna and Keefer, 1991). Ground water flows from recharge areas to nearby streams. The shallow, sand and gravel aquifers are recharged from precipitation, but the deeper aquifers in the buried bedrock valleys, the Sankoty and Mahomet Sands, receive approximately 9.5 percent of the recharge from the bedrock (Panno and others, 1994). The potential for aquifer recharge is a function of depth to the aquifer, occurrence of adjacent major aquifers, and potential infiltration rate of soil. The potential for aquifer recharge is highest along the Illinois River, especially in Mason and Tazewell Counties where there is sandy aquifer material at the surface (Keefer and Berg, 1990).

The geometry of the buried bedrock valleys affects the configuration of the embedded glacial drift aquifers and flow patterns. Near the Illinois River, in eastern Mason and Tazewell Counties, is the intersection of two major buried bedrock valleys—the Mahomet and Mackinaw (fig. 13). Based on the chloride concentrations and mass-balance calculations of selected constituents, only about 17 percent of the ground water at the area of intersection is derived from the Mahomet Bedrock Valley (Panno and others, 1994). Most of the water at the confluence of the buried Mahomet and Mackinaw Valleys is from recharge because it is a ground-water divide (Wilson and others, 1994). At the confluence, the water in the Sankoty Sand of the buried Mackinaw Valley flows north and discharges to the Mackinaw River, and the Mahomet Sand of the buried Mahomet Valley flows southwest and discharges to the Illinois River.

Discharge to streams from shallow aquifers is affected by precipitation. Annual ground-water discharge to streams for a year of normal precipitation is from 0.09 to 0.36 $(ft^3/s)/mi^2$ for most of the basin, except for a small portion of the eastern LIRB where ground-water discharge is 0–0.1 $(ft^3/s)/mi^2$ (Walton, 1965) (table 3).

The bedrock aquifers are in Mississippian- and Pennsylvanian-aged formations. The Pennsylvanian-age rocks, which underlie the glacial drift, are mostly shale with alternating carbonate beds. These rocks have a low permeability and porosity, and yield small amounts of water to wells from interconnected fractures, joints, and bedding planes. The relatively low permeability restricts deep percolation. In the southern and western part of the basin, the bedrock surface lies within 50 ft of land surface (fig. 21). Regional flow in the deeper bedrock aquifers is toward the southeast in the direction of the axis of the structural Illinois Basin. Recharge to the bedrock aquifers is limited by low permeability loess, clayey silts, and glacial till. Hydraulic properties of the bedrock aquifers vary less than the sand and gravel aquifers.

Water Use

More than half of the drinking water, that water supplied for domestic use, in the LIRB is from ground water. Forty-eight percent of the public-supply or municipal water is drawn from ground water and 52 percent from surface water. In 1988, the total public-supply deliveries was 190 Mgal/d of which 108 Mgal/d, or 57 percent, was for domestic use (Avery, 1995). In addition to public supplies, 25 percent of the population in counties in the LIRB are self-supplied. Fourteen percent of the total domestic water is estimated to be self-supplied. If the self-supplied population obtains the water from wells, then the percentage of water for domestic use is 55 percent from ground water and 45 percent from surface water. In large parts of western and southern Illinois, where shallow aquifers are not present or the ground water in aquifers is naturally of poor quality, homeowners rely primarily on cisterns or large-diameter dug or bored wells (fig. 22) (McKenna and Keefer, 1991). These large-diameter wells are highly susceptible to contamination from surface-water runoff and shallow ground water.

Ground-water withdrawals in the LIRB are mostly from sand and gravel aquifers and Mississippian-Pennsylvanian-aged aquifers (Kirk, 1987). The primary uses of water from sand and gravel aquifers is public supply, industry and mining, and domestic and commercial. The primary use (65 percent) of water from Mississippian-Pennsylvanian-aged aquifers is for domestic and commercial use.

Water-use data are collected by the Illinois State Water Survey (ISWS) for site specific information. Aggregated information by county and hydrologic basin is available from the USGS (Avery, 1995). Surface water is withdrawn from reservoirs and streams. There are 12 subbasins in the LIRB that have been coded with an eight-digit hydrologic unit code (HUC) (Seaber and others, 1984). These include: Senachwine Lake (07130001), Vermilion River (07130002), Lake Chautauqua (07130003), Mackinaw River (07130004), Spoon River (07130005), upper Sangamon River (07130006), South Fork of the Sangamon River (07130007), lower Sangamon River (07130008), Salt River (07130009), La Moine River (07130010), lower Illinois River (07130011), and Macoupin Creek (07130012) (fig. 23). In the Lake Chautauqua Basin and South Fork Sangamon River, substantially more water was used than in the

Table 3. Estimated ground-water discharge to streams near selected streamflow-gaging stations for years of near, below, and above normal precipitation and for years of low flow for the entire period of record as of 1994 in the lower Illinois River Basin (Walton, 1965; Berg, Keefer, Demissie, and Ramamurthy, 1997)

[$(ft^3/s)/mi^2$, cubic feet per second per square mile; in/yr, inches per year; --, no data]

Streamflow-gaging station	Annual ground-water discharge $[(ft^3/s)/mi^2]$ Near	Below	Above	Low flow (in/yr)
North Fork Vermilion River near Charlotte, Ill.	0.09	0.02	0.28	0.0001
Vermilion River at Pontiac, Ill.	.10	.03	.27	.0004
Vermilion River at Lowell, Ill.	.15	.05	.37	.0004
Crow Creek near Washburn, Ill.	.20	.06	.40	.0000
Mackinaw River near Congerville, Ill.	.24	.05	.46	.0006
Hickory Creek above Lake Bloomington, Ill.	.30	.01	.59	.0000
Money Creek at Lake Bloomington, Ill.	.28	.03	.56	.0000
Mackinaw River near Green Valley, Ill.	.26	.10	.45	.0015
Farm Creek at East Peoria, Ill.	.11	.06	.26	.0007
Kickapoo Creek at Peoria, Ill.	.16	.07	.36	.0009
Kickapoo Creek near Kickapoo, Ill.	.18	.07	.36	.0009
Big Bureau Creek at Bureau, Ill.	.25	.17	.45	.0034
East Bureau Creek near Bureau, Ill.	.12	.04	.32	.0000
Bureau Creek at Princeton, Ill.	.20	.08	.48	.0006
West Bureau Creek at Wyanet, Ill.	.16	.07	.39	.0001
Spoon River at London Mills, Ill.	.22	.08	.40	.0014
Spoon River at Seville, Ill.	.28	.14	.45	.0014
La Moine River at Colmar, Ill.	.29	.14	.46	.0005
La Moine River at Ripley, Ill.	.22	.09	.38	.0007
Macoupin Creek near Kane, Ill.	.14	.07	.19	.0003
South Fork Sangamon River at Kincaid, Ill.	.30	.12	.58	.0004
South Fork Sangamon River near Taylorville, Ill.	.36	.17	.60	.0002
Sangamon River at Riverton, Ill.	.30	.13	.44	.0007
Sangamon River near Oakford, Ill.	.34	.15	.55	.0023
Salt Creek near Greenview, Ill.	.38	.17	.59	.0025
Kickapoo Creek near Lincoln, Ill.	.28	.10	.46	.0007
Sugar Creek near Hartsburg, Ill.	.32	.08	.50	.0015
Kickapoo Creek near Heyworth, Ill.	.19	.08	.35	--
Salt Creek near Rowell, Ill.	.36	.13	.58	.0012
Sangamon River at Monticello, Ill.	.33	.14	.58	.0008
Average	.24	.09	.44	--

other subbasins in 1988. Peoria is in the Lake Chautauqua Basin, and Springfield is in the South Fork Sangamon Basin. The thermoelectric use is substantial in these basins. Over 50 percent of the water was used for thermoelectric power in the subbasins: South Fork Sangamon River, Salt River, Lake Chautauqua, lower Illinois River, and Senachwine Lake. The majority of water used in the Vermilion, La Moine, upper Sangamon, Spoon, and Macoupin Basins is for public supply. The major use of water in the lower Sangamon River and Mackinaw River is irrigation.

The largest freshwater withdrawals in Illinois, excluding the Chicago area, are in the LIRB. The total freshwater withdrawals in 1988 for the LIRB is 4,050 Mgal/d (table 4). Eighty-six percent of this water was used for thermoelectric power. Agricultural use (for livestock and irrigation) and public supply are the next largest water uses with 4–5 percent of the total, each. Industrial and commercial use are 2 percent of the total, each. Mining accounts for 1 percent of the total water use.

The 1986 water use for Standard Metropolitan Statistical Areas (SMSA), which include the largest cities in the LIRB, is summarized in Kirk (1987). Peoria and Normal use ground water for most of their water supplies. Decatur, Bloomington, and Springfield withdraw mostly surface water. Bloomington withdraws water from Lake Bloomington on Money Creek

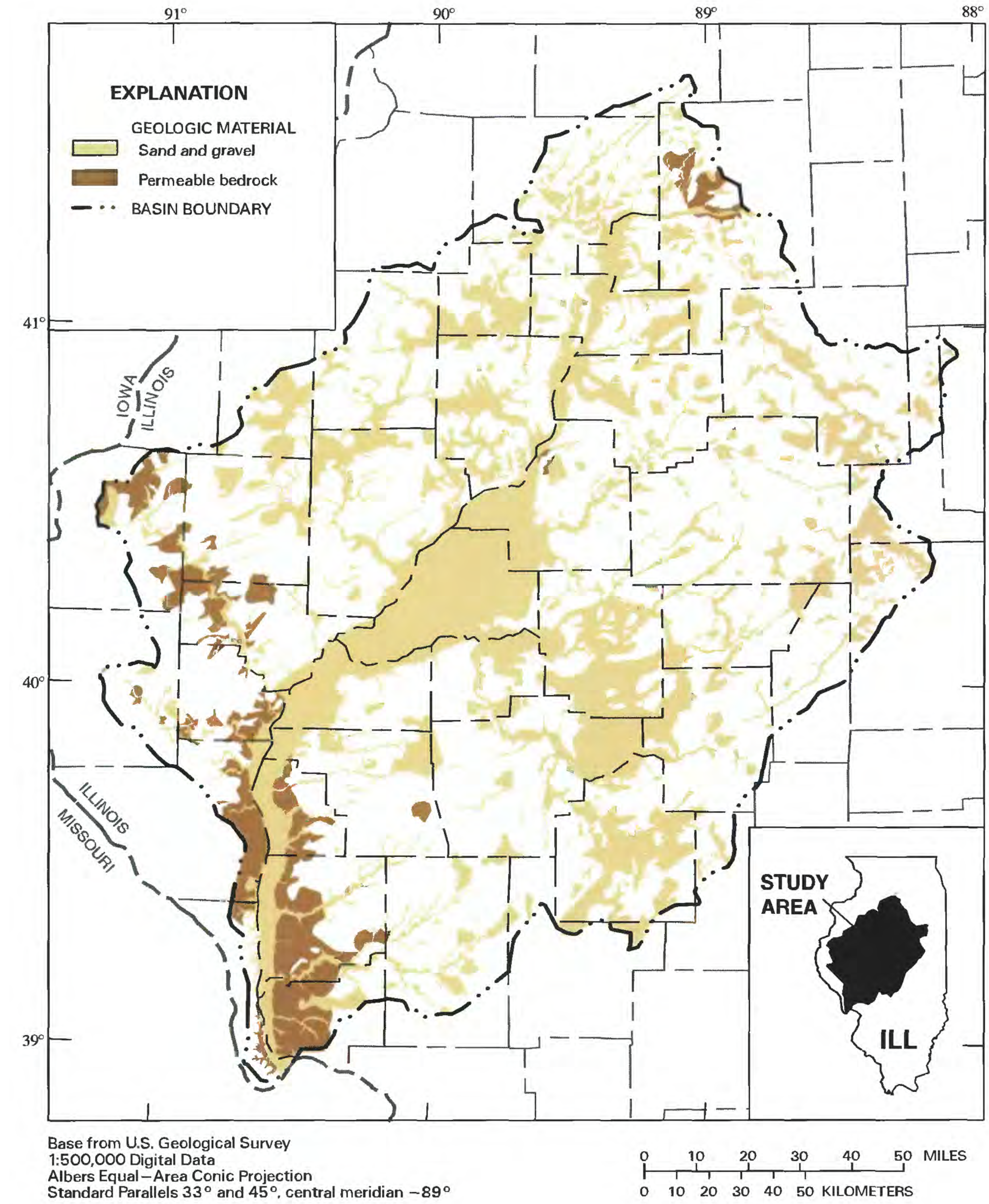

Figure 21. Geologic material within 50 feet of the land surface (modified from Berg and others, 1984).

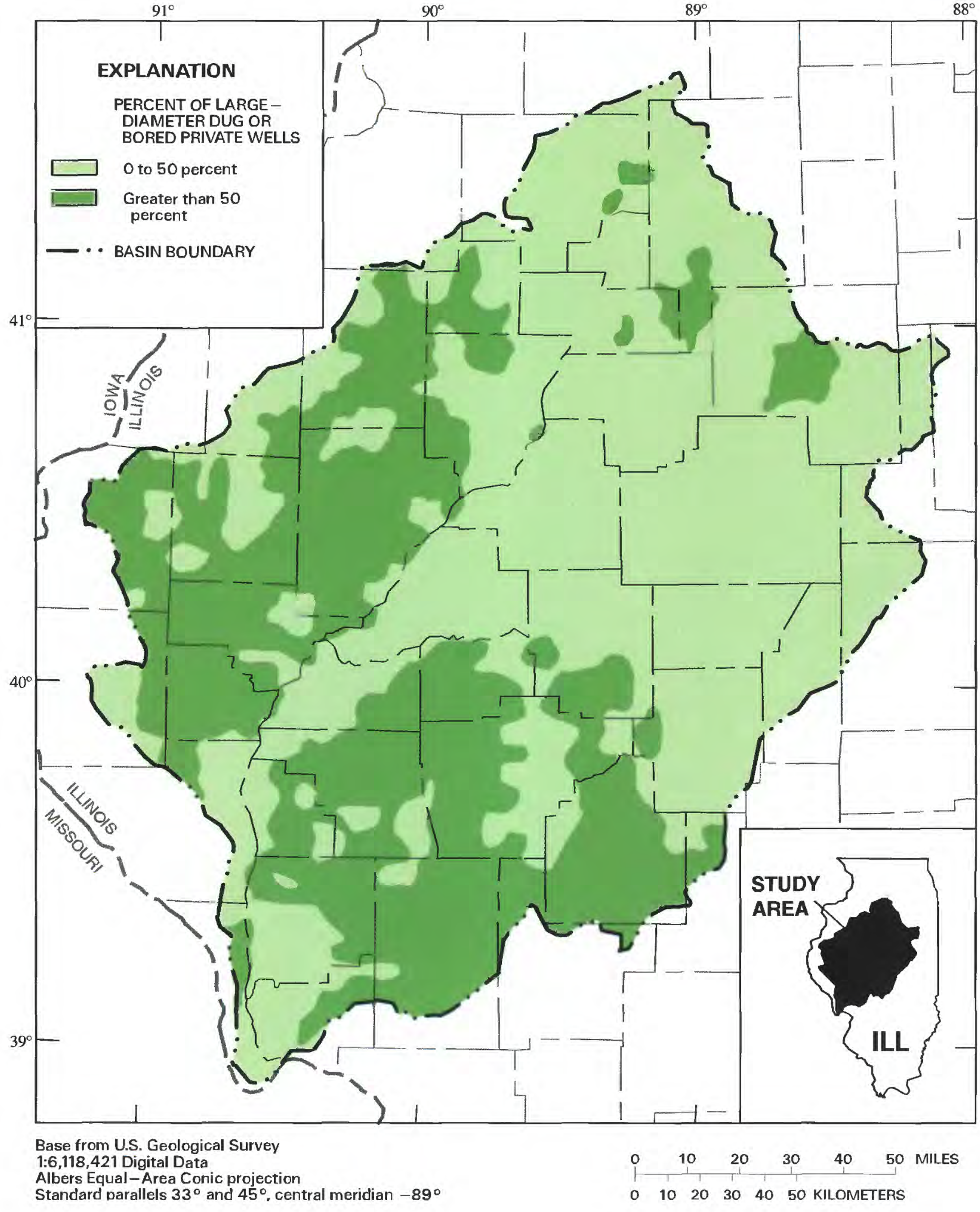

Figure 22. Percentage of private wells that are large-diameter dug or bored wells (modified from McKenna and Keefer, 1991).

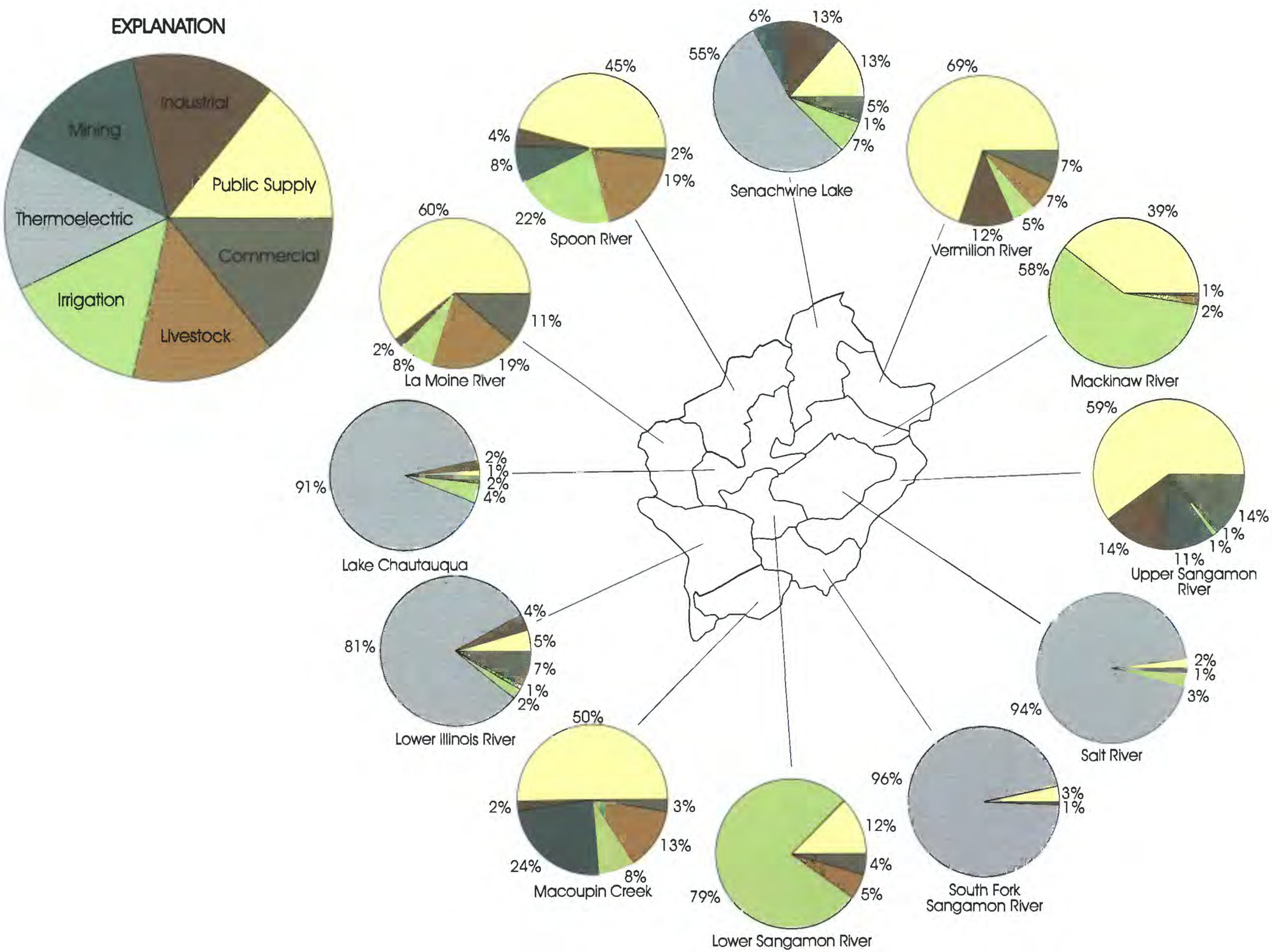

Figure 23. Water use by subbasin in the lower Illinois River Basin (Avery, 1995).

Table 4. Total withdrawals and water use, by hydrologic unit, for Illinois, 1988 (Avery, 1995)
[Water-use values in millions of gallons per day]

Basin	Hydrologic unit code	Ground water Fresh	Ground water Saline	Ground water Total	Surface water	Total
Senachwine Lake	07130001	55.7	0	55.7	183	238
Vermilion River	07130002	4.86	0	4.86	5.88	10.7
Lake Chautauqua	07130003	117	0	117	1,540	1,660
Mackinaw River	07130004	29.6	0	29.6	10.7	40.4
Spoon River	07130005	10.4	0	10.4	.73	11.2
Upper Sangamon River	07130006	13.6	.01	13.7	48.6	62.3
South Fork Sangmon River	07130007	3.92	.45	4.37	1,140	1,140
Lower Sangamon River	07130008	18.0	0	18.0	.09	18.1
Salt River	07130009	33.8	0	33.8	606	640
La Moine River	07130010	4.16	0	4.16	2.51	6.67
Lower Illinois River	07130011	24.2	0	24.2	193	217
Macoupin Creek	07130012	2.02	0	2.02	4.59	6.61
Total		317	0.46	318	3,730	4,050

and Lake Evergreen on the Mackinaw River. Because of the rapid population growth and recent droughts in these areas, there is interest in developing a regional ground-water supply (Wilson and others, 1994). Lake Decatur, which supplies the city of Decatur, is on the Big Creek, Friends Creek, Long Creek, Sana Creek, and Sangamon River. Near Decatur, wells open to the sand and gravel deposits supply ground water to Friends Creek when needed to replenish the lake. Lake Springfield is on Lake Creek and Sugar Creek, but water is pumped from the South Fork of the Sangamon River when the lake contains an insufficient volume of water for public supply.

Stream-Aquifer Interactions

Ground-water discharge to streams affects streamflow and water quality. Ground-water discharge is precipitation that infiltrates into the soil and to the water table, and then flows into the stream channel. The estimated average annual ground-water discharge in 30 subbasins of the LIRB is 0.09, 0.24, and 0.44 $(ft^3/s)/mi^2$ for years with below normal, near normal, and above normal precipitation, respectively (Walton, 1965).

Ground-water discharge is least from basins with surficial lakebed sediments and/or underlain by impermeable bedrock. Ground-water discharge is greatest from basins having considerable surficial sand and gravel, and underlain by permeable bedrock. Ground-water discharge during a year of near normal precipitation ranges from 0.09 to 0.36 $(ft^3/s)/mi^2$ for basins in the LIRB (Walton, 1965). Maximum ground-water discharge occurs during spring and early summer, and minimum ground-water discharge occurs in late summer and fall but is affected by antecedent moisture conditions and the amount and distribution of annual precipitation. The sand and gravel aquifers in glacial deposits contribute an estimated 17 percent of the total surface-water flow in the LIRB. This estimate is derived from the amount of water entering and leaving the basin and subtracting out the return flows during the driest month of 1992–93. During the driest month of the year, it is assumed that most surface-water flow is from return flows of industry and public works and ground-water discharge.

Water Budget

Water budgets are hard to estimate, especially the ground-water component, which is often the residue. Schicht and Walton (1961) estimated the water budget of two small headwater basins in the LIRB, Goose and Panther Creeks, based on the assumption that water entering the basin is equal to water leaving the basin, plus or minus changes in basin storage. These two basins have similar geology, land use, soils, temperature, and depth to the water table. The water budgets of these two basins were determined as

$$P = R + ET \pm \Delta S_g,$$

where,

P is the precipitation,

R is the surface-water and ground-water discharge,

ET is evapotranspiration, and

ΔS is the change in ground-water storage.

Schicht and Walton (1961) assumed both constant soil and subsurface interbasin flow. Ground-water flow is 40 and 73 percent of the total outflow for Goose Creek and Panther Creek, respectively. An important factor of the ground-water component in the water budget is the change in ground-water storage, which depends on the porosity of deposits. Three to five days after precipitation ceases in these basins, there is no surface-water runoff, and streamflow is derived entirely from ground-water discharge. Areas where thick sequences of sand and gravel deposits are in buried bedrock valleys that traverse a tributary have large contributions from ground water.

A similar approach used for estimating the water budget of the LIRB was based on precipitation, surface-water discharge, and evaporation data previously referenced. The entire inflow and outflow budget for the LIRB is difficult to estimate because many factors that affect the flow of water in and out of the basin are affected by intrabasin characteristics and changes among basins. The input of water from the upper Illinois River Basin to the LIRB is about 20 percent of the total water input to the basin (fig. 24). The output of water is mostly evaporation, but surface-water flow is a substantial output of water. There is very little ground-water flow from outside the basin because the shallow aquifers follow the surface topography; thus, ground-water divides are assumed to follow surface-water drainage divides. Deep ground-water flow does not discharge in the basin but moves to the southeast toward the center of the structural Illinois Basin. Recent work indicates that some deep buried bedrock valley aquifers may be recharged locally from adjacent bedrock aquifers (Panno and others, 1994). The hydrologic budget for a small stream or small watershed may have a substantial input from ground-water flow from adjacent basins because small watershed drainage divides are less likely to follow local ground-water divides.

Determining the hydrologic budget for an aquifer under unconfined conditions, such as in some areas in the LIRB, may require even more detailed information, such as recharge from precipitation or artificial recharge, subsurface inflow, inflow from deeper aquifers, ground-water evaporation, subsurface outflow, and a thorough understanding of the connection between shallow and deep aquifers. The sand and gravel glacial aquifers are not spatially continuous, and aquifer properties vary over short distances. A water budget of the shallow aquifer would need to be done for several small areas that are representative of the major aquifers in the basin. Recent work by Berg and others (1997) summarizes areas of the State where ground- and surface-water interactions are important. This work can be used to target areas where ground water is significant in a water-budget analysis.

Natural Environmental Divisions and Aquatic Biology

Many approaches are available for determining natural environmental divisions in the LIRB. Omernick (1987) includes two divisions or ecoregions in the LIRB—Central Cornbelt Plains and Interior River Lowlands. A detailed approach is the natural divisions defined by Schwegman (1973). The natural divisions in the LIRB are distinguished by bedrock, glacial history, topography, soils, and the distribution of plants and animals (fig. 25). The five divisions are the Grand Prairie, Western Forest-Prairie, Illinois River Bottomlands, Illinois River Sand Area, and Middle Mississippi Border. The Grand Prairie had the largest percentage of original undisturbed prairie area. The Illinois River Bottomlands encompass rivers, bottomlands, and associated backwater lakes along the main stem of the Illinois River that were originally forested and contained some prairie and marsh. The Illinois River Sands Area contains sand and dunes in the bottomlands of the Illinois River, which are naturally vegetated by scrub oak forest and dry sand prairie. The Illinois chorus frog is a threatened species and restricted to this area along the Illinois River. The Western Forest-Prairie is a dissected till plain with forests and prairie on the uplands. The Middle Mississippi Border is a narrow band of river bluffs, limestone cliffs, and rugged terrain bordering the flood plain. The dark-sided salamander, western worm snake, and wintering bald eagles are found in the part of the Middle Mississippi Border without overlying glacial deposits.

The Illinois Natural History Survey (INHS) collects data at 21 long-term electrofishing sites in the LIRB where fish populations have been surveyed annually (except for a few years of no funding or high

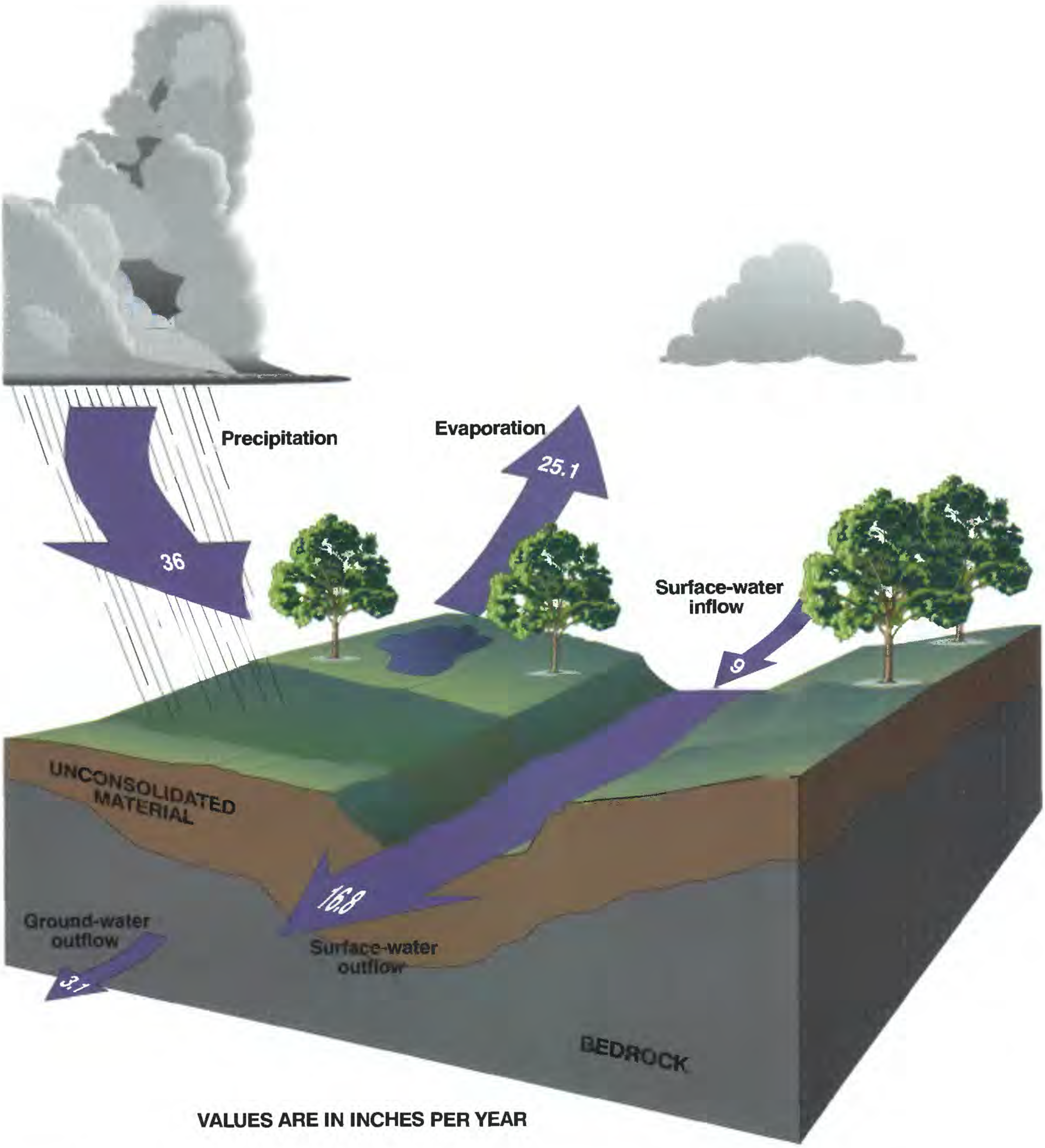

Figure 24. Estimated mean annual water budget of the lower Illinois River Basin.

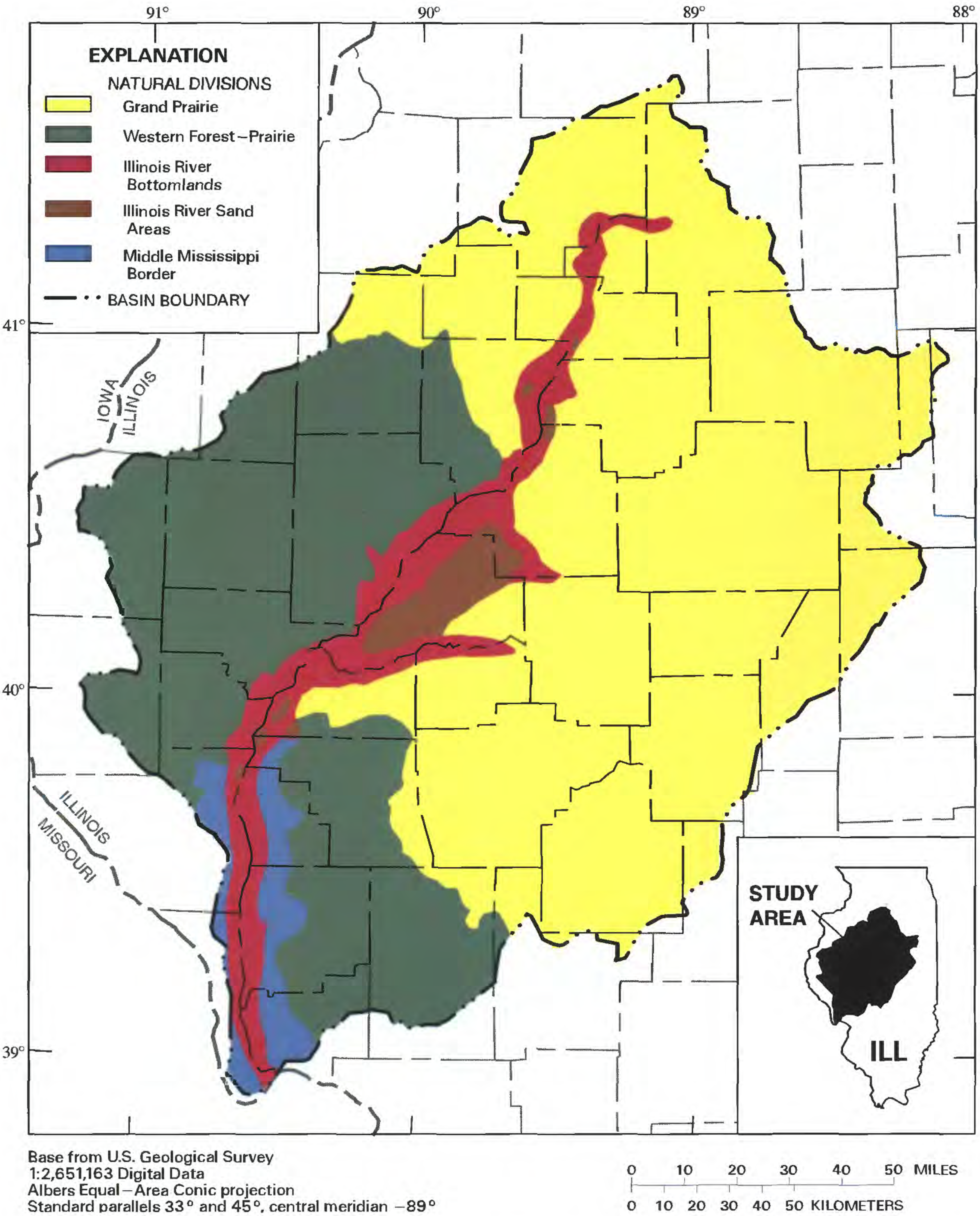

Figure 25. Natural divisions in the lower Illinois River Basin distinguished by bedrock, glacial history, topography, soils, and distribution of plants and animals (modified from Schwegman, 1973).

flood water) from 1957 to 1992 (Sparks and Lerczak, 1993). The Illinois River is divided into upper, middle and lower river for evaluation by the INHS. Twelve species of fish were consistently collected in 90 percent or more of all years (over 30 years of data collection) in the middle Illinois River, which includes a number of pollution-sensitive centrarchid species, as follows:

Gizzard shad	Largemouth bass
Common carp	Bluegill
Emerald shiner	Black crappie
Bigmouth buffalo	White crappie
Smallmouth buffalo	Green sunfish
Channel catfish	Freshwater drum

The middle Illinois River, as defined by the INHS, is between Starved Rock Lock and Dam, and La Grange Lock and Dam. The consistent collection of bigmouth buffalo, a native fish that requires backwaters for spawning, is related to the large backwater habitat areas along the middle Illinois River.

The lower reach contained similar species, except bigmouth buffalo, smallmouth buffalo, and green sunfish were not present in 90 percent of all years sampled. White bass were present 90 percent of all years sampled. In sharp contrast to the other sections of the river, goldfish and carp or goldfish hybrids, nonnative pollution-tolerant fish, were present in only a few years.

Improvements in water quality of rivers and waterways in the Chicago area have allowed nonnative species to invade the Illinois River by a manmade link to Lake Michigan. Nonnative species from the Great Lakes include the white perch fish and European zebra mussel, which was first reported in the Illinois River in 1991 (Sparks and Lerczak, 1993). Zebra mussels were carried from Lake Michigan to St. Louis in the Illinois River. Nonnative species that have invaded the LIRB from the Mississippi River include the Asian clam, *Corbicula*, which arrived in 1971 (Sparks and Lerczak, 1993).

Deterioration of backwater habitat in the LIRB is mostly from heavy sediment loads, which have not significantly changed in the last 15–20 years (Sparks and Lerczak, 1993). Suspended sediment reduces visibility for sight predators, their ability to find food, and the amount of food. Centrarchid fish have complex reproductive and social behavior that depend on visual cues, and their eggs and larvae are susceptible to smothering with sediment or predation if the guardian male cannot see and defend them (Sparks and Lerczak, 1993). The diversity in aquatic biology continues to increase as initiatives help to improve the water quality of the Illinois River.

EFFECT OF ENVIRONMENTAL SETTING ON WATER QUALITY

A particular environmental setting is defined by specific combinations of physiographic, geologic, land-use, hydrologic, and water-use characteristics that may affect water quality (Huntzinger and Ellis, 1993). Environmental setting is a broad categorization of an area that may be affected by diverse local conditions and heterogeneity within a setting. Many variables that affect water quality are not independent; therefore, the entire environmental framework must be considered when assessing the water quality. For example, physiography is one variable that is often dependent on geology, so both variables need to be studied.

Work by Panno and others (1994) have shown that the geology appreciably affects the water quality of aquifers in buried bedrock valleys in the LIRB. Structural features, such as monoclines, synclines, and anticlines in the buried bedrock (fig. 14), affect the water quality of the aquifers. In the western part of the Mahomet Bedrock Valley, west of the Champaign and Piatt County border, concentrations of sodium, chloride, carbonate, arsenic, and dissolved solids increase, probably because of leakage of saline ground water from Pennsylvanian bedrock into the deepest bedrock valley aquifers (Panno and others, 1994).

Land use and population have a major effect on water quality in the LIRB. Studies in the Midwest have described the occurrence and distribution of nitrogen and agricultural chemicals, and concentrations in surface and ground water (Scribner and others, 1994; Kolpin and others, 1994; Schideman and Blanchard, 1995). Nitrogen and nitrate concentrations exceeding Maximum Contaminant Levels (MCL's) have been detected in public-supply and private wells in the LIRB (Goetsch and others, 1992). Atrazine and alachlor have been detected in the Sangamon River Basin and many other midwestern streams (Scribner and others, 1994). Many of the pesticides and nitrogen concentrations are associated with land use and anthropogenic effects. Volatile organic compounds have been detected in ground water near the major metropolitan areas. Public-supply facilities near Peoria have had detectable concentrations of bromoform and bromodichloromethane in water from wells. A complete and accurate map of land use and associated activities was not available in time to be included in this report but is now available (Illinois Department of Natural Resources, 1996).

Fish populations and diversity are key indicators of changes in water quality. The change from the upper to the lower Illinois River to a more balanced fish community dominated by native species indicates improvements in water quality in the LIRB (Sparks and Lerczak, 1993). Carp and goldfish are more tolerant than most native species of low oxygen levels and toxic materials associated with heavy sediment and pollution loads, and species populations often expand in the absence of these pollution-tolerant predators (Lubinski and Sparks, 1981). The incidence of external abnormalities (eroded fins, sores) in fish has declined from 1963 to 1992. However, abnormalities are found more frequently in fishes that contact bottom sediments (catfish, carp) than in fish that occupy the water column, (bass, bluegill) indicating that there are pollutants or pathogens associated with the sediments (Sparks and Lerczak, 1993) (fig. 26).

Nonnative species affect the water quality in the LIRB. A decrease in dissolved oxygen concentrations and turbidity have resulted from the recent influx of European zebra mussels to the LIRB. The zebra mussels are attacking rare native mussels and threatening extinction within a few years (Wendland and Dennison, 1993).

Other characteristics of the environmental setting of the LIRB affect the sources and sinks of pollutants. The organic content of soils and rate of infiltration of soils are two soil properties that directly affect the leaching of pesticides into surface or ground water. Some pesticides may be sorbed to the organic material in the soils, thus, preventing transport of pesticides to ground water. A high infiltration rate will increase the leaching of pesticides and other constituents to the water table. A low infiltration rate will restrict the transport of water and constituents to the water table but will increase discharge to surface water. The ISGS has mapped the potential for contamination of shallow aquifers from agricultural compounds (Keefer, 1995). Potential contamination is strongly affected by soil type. Different types of soils are more easily eroded and, thus, transported and deposited in aquatic environments.

Climate affects the amount of precipitation and evapotranspiration. Precipitation has a direct effect on the hydrologic system—amount of streamflow, flooding and droughts, lake levels, wetland distribution, and ground-water recharge. High precipitation resulted in severe flooding in 1993 and low precipitation resulted in droughts in the late 1980's. Precipitation accounts for 80 percent of water inflow to the LIRB.

There are many factors affecting the environmental setting of the LIRB, such as physiography and environmental divisions. Physiography is affected by geology and topography. Environmental divisions are affected by bedrock, glacial history, topography, soils, and the distribution of plants and animals. These factors are interdependent. For example, the distribution of glacial deposits is partially dependent on bedrock topography. Soils are dependent on the source materials, which are glacial deposits. Factors that most directly or indirectly affect water quality in the LIRB are bedrock and surface topography, type of glacial material, and land use. Information on factors affecting the environmental setting is important and considered when designing and interpreting data from the National Water-Quality Assessment of the lower Illinois River Basin.

SUMMARY

The goals of the National Water-Quality Assessment (NAWQA) program of the U.S. Geological Survey (USGS) are to describe the status and trends in the quality of a representative part of the Nation's streams and ground water, and provide an understanding of factors affecting the water quality. The lower Illinois River Basin (LIRB), which encompasses 18,000 mi^2 of central and western Illinois, is one of 60 study units throughout the Nation selected for water-quality assessment. Information about the environmental setting provides a framework of the basin characteristics and includes natural and human factors that determine the similarities and differences in water-quality conditions throughout the basin.

The LIRB includes the drainage area of the Illinois River south of Ottawa, Ill., to the confluence with the Mississippi. The altitude of land surface generally is from 600 to 800 ft above sea level. The flat topography of the basin is a result of the glacial tills that cover the basin. The major surficial features are the moraines of the Wisconsinan glacial deposits in the northeastern half of the basin. A population of 1.3 million in 1990 has remained relatively constant since 1970 with the major population center near Peoria. Approximately 87 percent of the land use in the basin is agricultural. Most of the agriculture is cropland

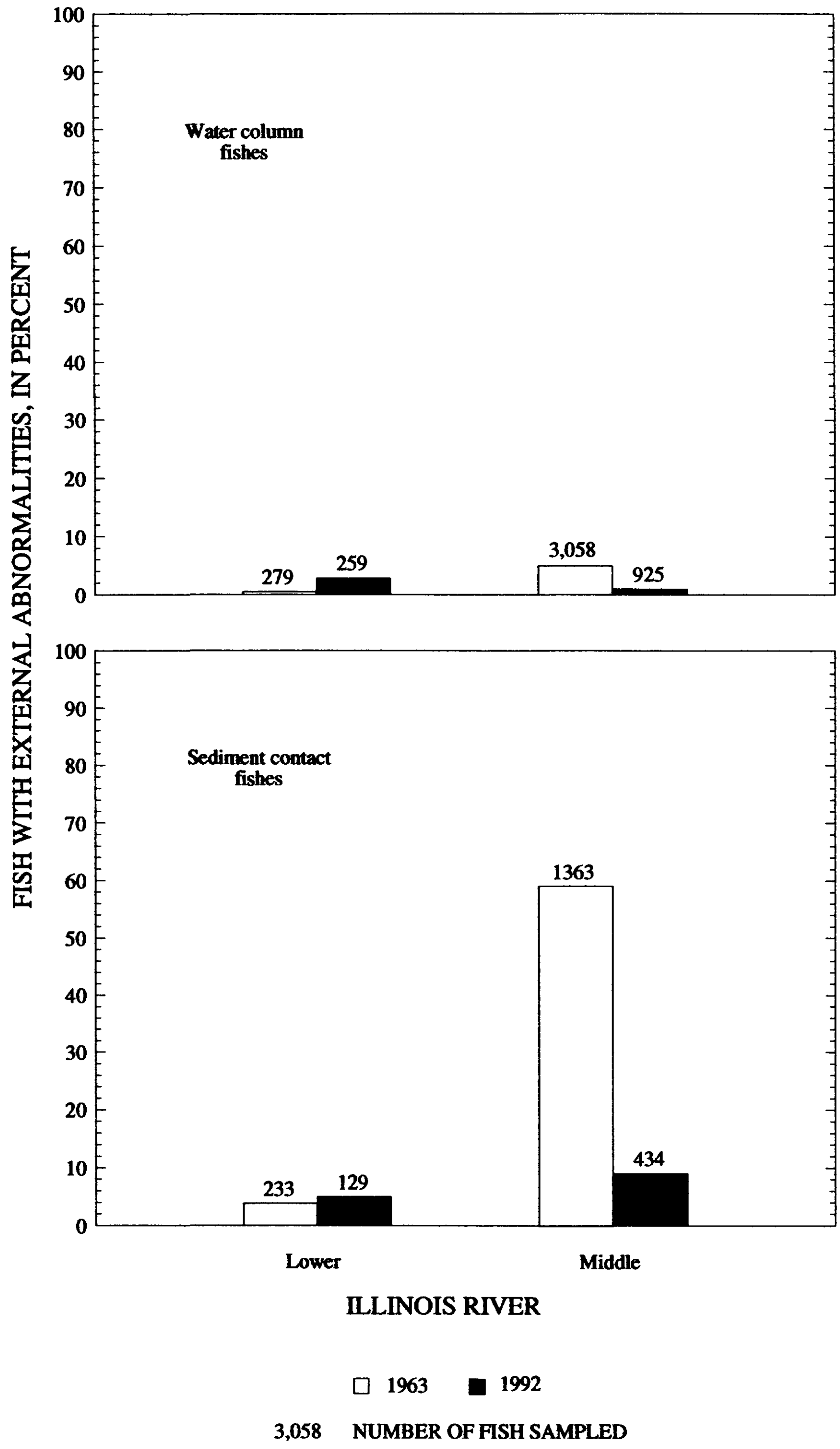

Figure 26. Percent abnormalities in fish in the water column and fish in contact with sediment (modified from Sparks and Lerczak, 1993).

for growing corn and soybean, and there is very little remaining original prairie vegetation. The native prairie vegetation under which soils form contributed to the high accumulation of organic materials, which is valuable to agriculture because of the capacity to store water and nutrients. The climate includes cold, relatively dry winters and warm, wet summers with normal precipitation from 35 to 38 inches per year.

The hydrology of the LIRB has been most affected by glacial processes and deposits that cover the basin. Bedrock is mostly carbonate rocks that include some coal deposits. Five major tectonic features (Glasford Structure, Peru Monocline, Downs Anticline, Pittsfield Anticline, and Cap au Gres Faulted Flexure) and many minor features affect local geology and may affect water chemistry. Erosion of the bedrock, prior to and during glaciation, cut large bedrock valleys that have been filled with over 500 ft of glacial deposits. Two of the major buried bedrock valleys, the Mahomet and Mackinaw, contain thick sand and gravel at the bottom of the valleys that are overlain by hundreds of feet of till. The sand and gravel in these buried bedrock valleys are major aquifers, and the overlying tills are thick confining units. The stratigraphic relation of glacial deposits is complex because of the limited aerial extent of many deposits.

The Illinois River accounts for at least 22 percent of the flow in the Mississippi River just below the confluence of the Illinois and Mississippi Rivers. The Illinois River has a low gradient, and the flow is regulated by five lock and dams from Grafton to Ottawa and on the Mississippi River at Alton. Major tributaries to the Illinois River are the La Moine, Mackinaw, Sangamon, Spoon, and Vermilion Rivers, but the upper Illinois River accounts for most of the inflow of water to the LIRB. The Spoon River contributes the largest sediment load to the Illinois River. Lakes and reservoirs line the banks of the Illinois River, and many backwater lakes and wetlands are in the surrounding area. Presettlement wetlands covered as much as 40 percent of the land in counties bordering the Illinois River, but most of these wetlands have been filled by sediment. The wetlands provide an expanded aquatic habitat that is utilized by many birds, fish, and other aquatic life.

Glacial deposits from 200 to 500 ft below land surface include the major sand and gravel aquifers. Aquifer properties vary greatly over short distances and by depth. The nature of the glacial deposits make it difficult to correlate and compare aquifers across the LIRB, but two aquifers are composed of distinctive rock-stratigraphic units—the Sankoty and Mahomet Sands. The Sankoty and Mahomet Sands are present in the Mackinaw and Mahomet buried bedrock valleys and are major water supplies. These aquifers are confined by thick tills. The water table in the LIRB is in the till and in direct connection with streams and lakes. The shallow aquifers (less than 200-ft deep) are recharged from precipitation, but the deeper confined aquifers, such as in the Sankoty and Mahomet Sands, also have recharge from the bedrock. Bedrock aquifers are in the Mississippian- and Pennsylvanian-aged formations that yield small amounts of water to wells from interconnected fractures, joints, and bedding planes.

Forty-eight percent of the public-supply or municipal water in the LIRB is drawn from ground water and 52 percent from surface water. Most ground-water withdrawals are from glacial sand and gravel, but in the southern part of the LIRB, private well owners rely primarily on ground water from cisterns or large-diameter dug or bored wells. In small basins with thermoelectric facilities, over 50 percent of the surface water withdrawn is used for thermoelectric power.

The water budget of the LIRB was estimated based on precipitation, surface-water discharge, and evaporation data. The inflow and outflow budget for the LIRB is difficult to estimate because many factors affect the flow of water in and out of the basin. The input of water from the upper Illinois River Basin to the LIRB is about 20 percent of the total inflow to the basin. Total outflow from the LIRB is mostly by evaporation, but surface-water flow is a substantial output.

There are five natural environmental divisions in the LIRB (Grand Prairie, Western Forest-Prairie, Illinois River Bottomlands, Illinois River Sand Area, and Middle Mississippi Border). The two natural environmental divisions that cover the most area are the Grand Prairie in the northeastern half of the basin and the Western Forest-Prairie in the southwestern half of the basin. The Grand Prairie had the largest percentage of original undisturbed prairie vegetation, and the Western Forest-Prairie is a dissected till plain with forests and prairie on the uplands. The fish in the Illinois River include a number of pollution-sensitive species. The improvement in water quality in the Chicago waterways have allowed nonnative species, such as the zebra mussel, to invade the Illinois River from Lake Michigan.

Natural and human factors affect the physical, chemical, and biological characteristics in the LIRB, which then affect the water quality. For example, diversity and balance in fish population in the LIRB compared with the upper Illinois River Basin indicate improved water quality in the LIRB. Soils and wetlands help prevent or filter contaminants moving to the ground water. Bedrock structural features also affect the water quality of deep glacial aquifers. Bedrock and surface topography, type of glacial material, and land use most directly affect water quality in the LIRB.

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