Volume 1

Land Cover Inventory ■ Geology
Water Resources ■ Living Resources

MACKINAW RIVER AREA ASSESSMENT

ILLINOIS DEPARTMENT OF NATURAL RESOURCES

MACKINAW RIVER AREA ASSESSMENT

VOLUME 1

Part I: Land Cover Inventory
Illinois Department of Natural Resources
Office of Scientific Research and Analysis
Natural History Survey Division, 607 East Peabody Drive, and
State Geological Survey Division, 615 East Peabody Drive
Champaign, Illinois 61820

Part II: Geology
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Other CTAP Publications

The Changing Illinois Environment: Critical Trends
- *Summary Report*
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- *Volume 2: Water Resources*
- *Volume 3: Ecological Resources*
- *Volume 4: Earth Resources*
- *Volume 5: Waste Generation and Management*
- *Volume 6: Sources of Environmental Stress*
- *Volume 7: Bibliography*

Rock River Area Assessment, technical report
The Rock River Country: An Inventory of the Region's Resources, general report
Cache River Area Assessment, technical report
The Cache River Basin: An Inventory of the Region's Resources, general report
Annual Report 1995, Illinois RiverWatch
Stream Monitoring Manual, Illinois RiverWatch
PLAN-IT EARTH, Flowing Waters Module
PLAN-IT EARTH, Forest Module
Forest Monitoring Manual, Illinois ForestWatch
Illinois Land Cover, An Atlas, plus CD-ROM
Inventory of Ecologically Resource-Rich Areas in Illinois
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For more information about CTAP, call (217) 524-0500 or e-mail at ctap2@dnrmail.state.il.us; for information on the Ecosystems Program call (217) 78l1-7940 or e-mail at ecoprog@dnrmail.state.il.us.

About This Report

The Mackinaw River Area Assessment examines an area situated along the Mackinaw River in the central part of Illinois. Because significant natural community and species diversity is found in the area, it has been designated a state Resource Rich Area.

This report is part of a series of reports on Illinois Resource Rich Areas where a public-private partnership has been formed. These assessments provide information on the natural and human resources of the areas as a basis for managing and improving their ecosystems. The determination of resource rich areas and development of ecosystem-based information and management programs in Illinois are the result of three processes -- the Critical Trends Assessment Program, the Conservation Congress, and the Water Resources and Land Use Priorities Task Force.

Background

The Critical Trends Assessment Program (CTAP) documents changes in ecological conditions. In 1994, using existing information, the program provided a baseline of ecological conditions.[1] Three conclusions were drawn from the baseline investigation:

1. the emission and discharge of regulated pollutants over the past 20 years has declined, in some cases dramatically,
2. existing data suggest that the condition of natural ecosystems in Illinois is rapidly declining as a result of fragmentation and continued stress, and
3. data designed to monitor compliance with environmental regulations or the status of individual species are not sufficient to assess ecosystem health statewide.

Based on these findings, CTAP has begun to develop methods to systematically monitor ecological conditions and provide information for ecosystem-based management. Five components make up this effort:

1. identify resource rich areas,
2. conduct regional assessments,
3. publish an atlas and inventory of Illinois landcover,
4. train volunteers to collect ecological indicator data, and
5. develop an educational science curriculum which incorporates data collection

[1] See *The Changing Illinois Environment: Critical Trends*, summary report and volumes 1-7.

At the same time that CTAP was publishing its baseline findings, the Illinois Conservation Congress and the Water Resources and Land Use Priorities Task Force were presenting their respective findings. These groups agreed with the CTAP conclusion that the state's ecosystems were declining. Better stewardship was needed, and they determined that a voluntary, incentive-based, grassroots approach would be the most appropriate, one that recognized the inter-relatedness of economic development and natural resource protection and enhancement.

From the three initiatives was born Conservation 2000, a six-year program to begin reversing ecosystem degradation, primarily through the Ecosystems Program, a cooperative process of public-private partnerships that are intended to merge natural resource stewardship with economic and recreational development. To achieve this goal, the program will provide financial incentives and technical assistance to private landowners. The Rock River and Cache River were designated as the first Ecosystem Partnership areas.

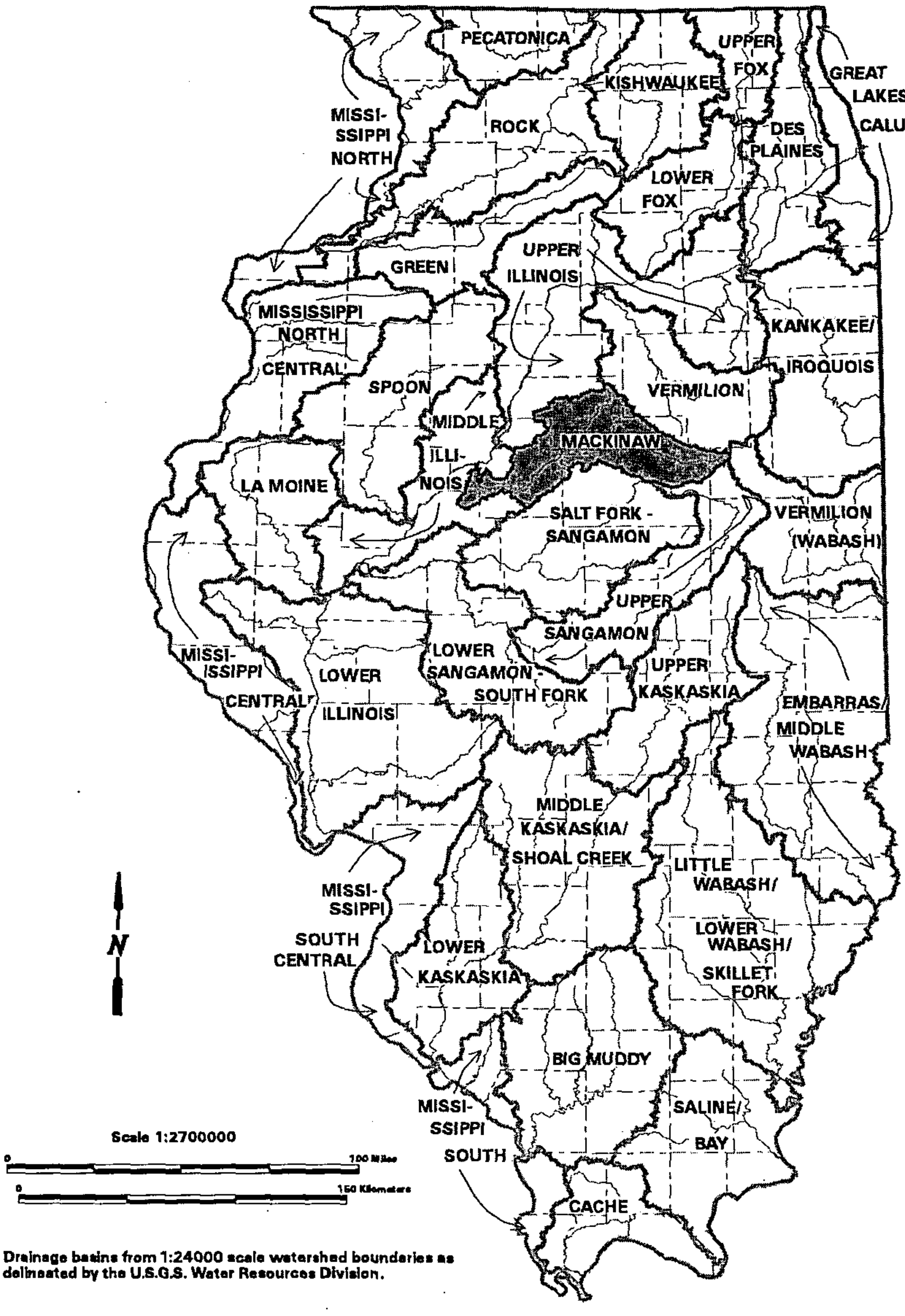
At the same time, CTAP identified 30 Resource Rich Areas (RRAs) throughout the state. In RRAs where Ecosystem Partnerships have been formed, CTAP is providing an assessment of the area, drawing from ecological and socio-economic databases to give an overview of the region's resources -- geologic, edaphic, hydrologic, biotic, and socio-economic. Although several of the analyses are somewhat restricted by spatial and/or temporal limitations of the data, they help to identify information gaps and additional opportunities and constraints to establishing long-term monitoring programs in the partnership areas.

The Mackinaw River Assessment

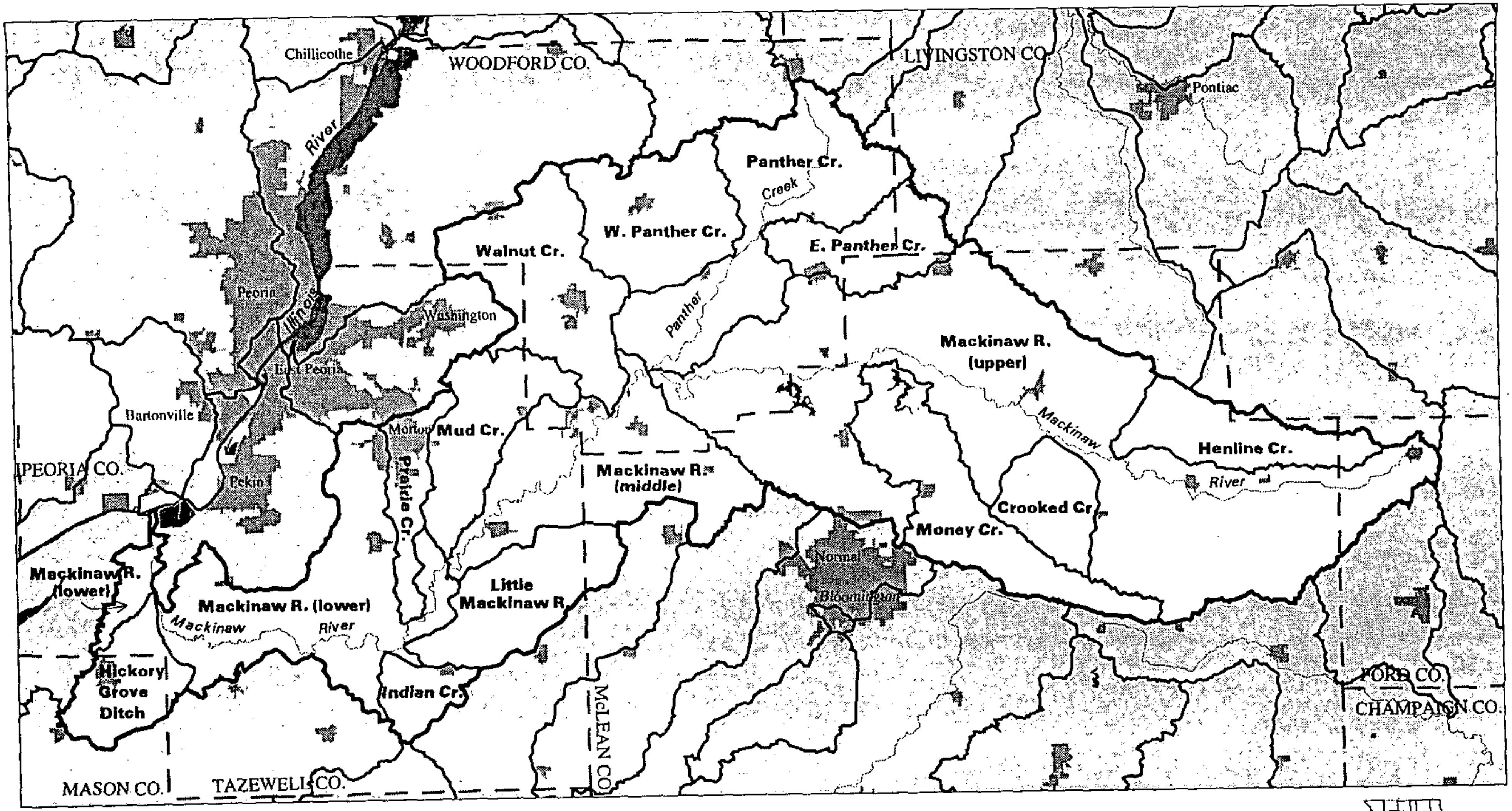
The Mackinaw River begins near Sibley in Ford County and runs west to meet the Illinois River south of Pekin, Illinois. The boundaries of the Mackinaw River Area Assessment, as well as the Mackinaw River Ecosystem Partnership area, coincide with the boundaries of the Mackinaw River Basin. This area is situated along the roughly 125-mile river in the counties of Tazewell, McLean, and Woodford, with small sections in Mason, Livingston, and Ford counties. The Basin has 15 subbasins (identified by the Illinois Environmental Protection Agency) which cover approximately 1,138 mi^2 (728,495 acres). The land in the Panther Creek and the "middle" Mackinaw River subbasins, an area totaling 124,740 acres, was designated a state "Resource Rich Area" because it contains significant natural community diversity. The Mackinaw River Ecosystem Partnership was subsequently formed around this core area of high quality ecological resources.

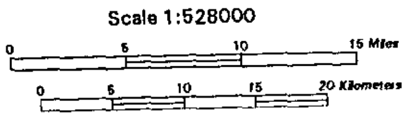
This assessment is comprised of two volumes. In Volume 1, *Land Cover Inventory* provides an overview of the land cover in the region; *Geology* discusses the geology, soils, and minerals in the assessment area; *Water Resources* discusses the surface and groundwater resources; and *Living Resources* describes the natural vegetation communities and the fauna of the region.

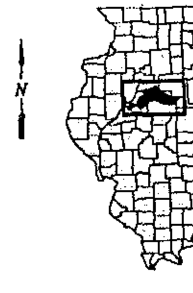
In Volume 2, the *Socio-Economic Profile* discusses the demographics, infrastructure, and economy of the area, focusing on the three counties with the greatest amount of land in



Major Drainage Basins of Illinois and Location of the Mackinaw River Basin







Subbasins in the Mackinaw River Basin. Subbasin boundaries depicted are those determined by the Illinois Environmental Protection Agency.

the watershed area -- McLean, Tazewell and Woodford counties; *Environmental Quality* discusses air and water quality, and hazardous and toxic waste generation and management in the area; *Archaeological Resources* identifies and assesses the archaeological sites, ranging from the Paleoindian Prehistoric (B.C. 10,000) to the Historic (A.D. 1650), known in the assessment watershed; and *Early Accounts of the Ecology of the Mackinaw River Area* describes the ecology of the area as recorded by historical writings of explorers, pioneers, early visitors and early historians.

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PART I

LAND COVER INVENTORY

Contributors

Introduction ....Donald E. Luman

Land Cover Inventory ....Donald E. Luman
with contributions by Lisa R. Smith
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Land Cover Inventory

Introduction

Land is the "raw material" of Illinois. Current and detailed information regarding this fundamental natural resource is essential for making wise decisions affecting the land and ensuring good stewardship. Land can be described in terms of a number of biological, geological, and hydrological characteristics. Part 1 of this report focuses on *land cover,* a principal factor of a region's land resource. The following paragraphs introduce and explain some basic concepts.

Land use refers to human activities on the land and emphasizes the principal role of land in describing a region's economic activities. Since the concept describes human activity, land use is not always directly observable; that is, we often cannot "see" the specific use of a parcel of land. For example, the presence of forested land in an aerial photograph or satellite image does not convey the possible multiple uses of that land, which may include recreation, wildlife refuge, timber production, or residential development.

Land cover refers to the vegetation and manmade features covering the land surface, all of which can be directly observed using remote sensing imagery.[1] Whereas land use is abstract, land cover is tangible and can be determined by direct inspection of the land surface; it is the visible evidence of land use (Campbell, 1987).

Land cover can be a readily obtainable and reliable indicator of ecosystems (Scott, 1993) because vegetation effectively integrates biological, geological, and hydrologic factors in a geographic area. Moreover, land cover can be determined by remote sensing methods, which afford greater spatial and temporal sampling than do traditional sampling methods (Stoms and Estes, 1993), and remotely sensed data can estimate factors of biodiversity associated with resource quality, richness, and quantity.

For assessments at the site level (*e.g.*, sampling sites or plots) or for small regions (*e.g.*, at the county level), land cover information is typically derived by interpreting aerial photography. At the statewide level, land cover information is usually derived from the analysis of satellite imagery and offers accurate information regarding regional surface cover characteristics. In 1996, the Illinois Department of Natural Resources published *Illinois Land Cover, An Atlas*, the most recent and comprehensive inventory of the state's surface cover. Multitemporal, Landsat Thematic Mapper satellite imagery acquired during 1991–1995 was the principal data source for the atlas. The land cover information used for the present report is derived from *Illinois Land Cover, An Atlas.*

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[1]Remote sensing is the science of deriving information about an object or phenomenon at or near the surface or the earth through the analysis of data acquired by a camera or sensor system located in an aircraft or orbiting satellite

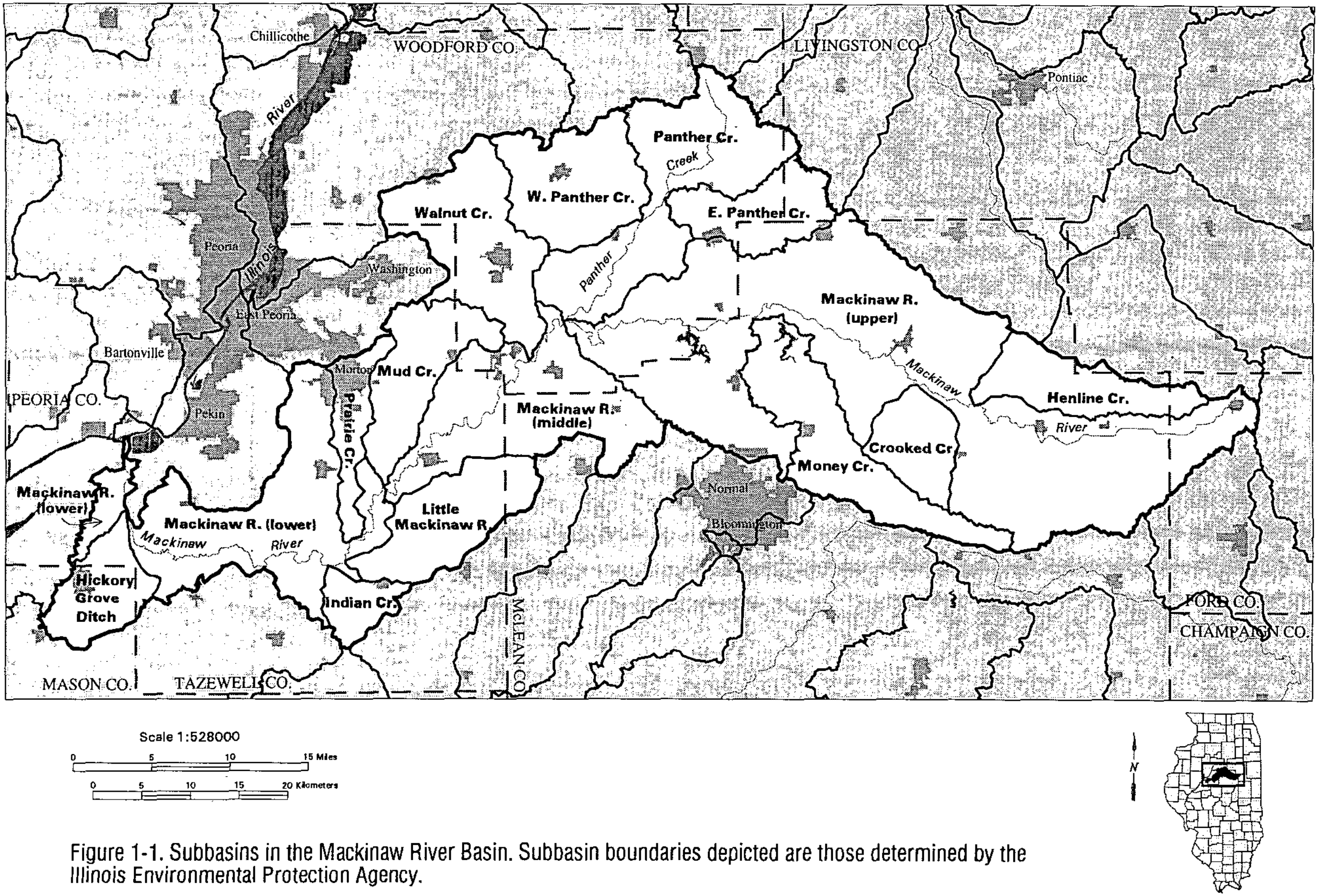


Figure 1-1. Subbasins in the Mackinaw River Basin. Subbasin boundaries depicted are those determined by the Illinois Environmental Protection Agency.

Land Cover Inventory

The Mackinaw River Basin comprises 15 subbasins and covers approximately 1,138 square miles, or 728,495 acres (Figure 1-1). The major land cover categories in the basin and their areal extent are given in Table 1-1. For purposes of comparison, a statewide summary of the major land cover categories is given in Table 1-2. Appendix A summarizes the land cover for each subbasin. For conciseness, the 20 individual land cover categories (only 17 are present in the basin) are consolidated into 9 principal land cover categories in Table 1-3.

To better visualize the spatial relations between land cover and its distribution in the Mackinaw basin, Figures 1-2 through 1-7 are maps of these nine principal land cover categories. It should be noted that for the purposes of this report, the map scale is significantly reduced to 1:600,000. Increased detail is available in the statewide land cover inventory, as shown in Figure 1-8, a composite land cover map of the Mackinaw River (middle) subbasin.

Approximately three-fourths (77.5%) of Illinois' surface is devoted to agriculture, of which cropland (row crops, small grains) accounts for over one-half (59.9%) of all the land cover in the state (Table 1-2). In contrast, slightly over 90% of the land cover in the basin is classified as agricultural, with cropland accounting for slightly more than three-fourths of all surface cover (Table 1-1). For the individual subbasins, the percentage of land devoted to cropland ranges from 52.1% in the deeply incised Mackinaw River (lower) subbasin (see Figure 2-10, Part 2) to 93.0% in the Henline Creek subbasin (Appendix A). Figure 1-6 shows not only how widespread cropland is in the basin but, with the exception of the Illinois River Valley, how pervasive cropland is in the adjoining regions.

Because they appear very similar to remote sensing devices, natural and planted grasses and other grass-like vegetation cannot be consistently differentiated using satellite imagery. As a result, the rural grassland category is necessarily a composite of cover types including pasture, hay, "old" fields, set-aside acreage, road rights-of-way, and remnant prairies (Figure 1-4). With the exception of orchards and nurseries (none present in the basin), the rural grassland category represents all remaining agricultural land that is not included under the cropland category. Because of the deeply incised drainage network and steeply sloping land, which results in the lowest percentage of cropland in the entire basin, the greatest concentration of rural grassland is found in the Mackinaw River (lower) subbasin. Rural grassland accounts for nearly one-fourth (23.7%) of all land cover in that subbasin (see Figure 1-8). Conversely, the Henline Creek subbasin, which contains the highest percentage of cropland in the basin (93.0%), also possesses the smallest concentration of rural grassland—only 5.5%, representing just 0.2% of all rural grassland cover in the basin. Whereas the relative amount of cropland in the basin is almost

Table 1-1. Land Cover of the Mackinaw River Basin (IDNR 1996)

Category	Sq. Mi.*	Acres	Basin %*
Agricultural Land	**1,027.7**	**657,744**	**90.3**
Row Crops	847.6	542,449	74.5
Small Grains	26.9	17,243	2.4
Rural Grassland	153.2	98,051	13.5
Forest & Woodland	**56.0**	**35,851**	**4.9**
Deciduous Closed Canopy	40.3	25,799	3.5
Deciduous Open Canopy	15.4	9,863	1.4
Coniferous	0.3	189	0.0
Urban & Built-Up Land	**26.7**	**17,081**	**2.4**
High Density	2.9	1,867	0.3
Medium Density	4.4	2,811	0.4
Low Density	3.8	2,459	0.3
Transportation	8.7	5,549	0.8
Urban Grassland	6.9	4,396	0.6
Wetland	**13.3**	**8,515**	**1.2**
Shallow Marsh	1.3	810	0.1
Deep Marsh	0.1	36	0.0
Forested	9.4	6,005	0.8
Open Water Shallow	2.6	1,663	0.2
Other Land	**14.5**	**9,305**	**1.3**
Open Water Deep	14.5	9,304	1.3
Barren & Exposed	0.0	0	0.0
Basin Totals	**1,138.3**	**728,496**	**100.0**

*Small differences in statistical tables may be due to rounding.

30% higher than the statewide proportion, the percentage of rural grassland in the entire basin (13.5%) is quite similar to the statewide percentage of 17.5%.

Upland forests and forested wetlands (*e.g.*, bottomland forest) cover 13.6% of Illinois, compared with 5.7% in the Mackinaw River Basin (Figure 1-2); this comparison again emphasizes the position of the basin in a dominantly agricultural portion of the state. Forest and woodland areas are clustered along the valley of the Mackinaw River where stream incision is the greatest and steeper slopes predominate (compare Figures 2-10 and 1-2). Note also the extensive amount of forested land cover associated with the steep bluffs adjoining the Illinois River Valley. In the basin, the greatest concentration of both

Table 1-2. Land Cover of Illinois (IDNR 1996)

Category	Sq. Mi.*	Acres	State %
Agricultural Land	**43,638.8**	**27,928,797**	**77.5**
Row Crops	30,600.4	19,584,247	54.3
Small Grains	3,166.0	2,026,268	5.6
Rural Grassland	9,847.5	6,302,371	17.5
Orchards & Nurseries	24.9	15,911	0.0
Forest & Woodland	**6,388.5**	**4,088,623**	**11.3**
Deciduous Closed Canopy	5,618.0	3,595,538	10.0
Deciduous Open Canopy	657.8	421,013	1.2
Coniferous	112.6	72,072	0.2
Urban & Built-Up Land	**3,261.6**	**2,087,396**	**5.8**
High Density	476.7	305,065	0.8
Medium/High Density	186.5	119,352	0.3
Medium Density	729.5	466,894	1.3
Low Density	392.5	251,180	0.7
Transportation	492.0	314,866	0.9
Urban Grassland	984.4	630,038	1.8
Wetland	**1,829.0**	**1,170,550**	**3.2**
Shallow Marsh/W. Meadow	219.8	140,664	0.4
Deep Marsh	54.5	34,855	0.1
Swamp	18.3	11,726	0.0
Forested	1,264.0	808,987	2.2
Open Water Shallow	272.4	174,318	0.5
Other Land	**1,228.7**	**786,361**	**2.2**
Open Water Deep	1,203.4	770,183	2.1
Barren & Exposed	25.3	16,178	0.0
State Totals	**56,346.5**	**36,061,727**	**100.0**

*Small differences in statistical tables may be due to rounding.

upland and bottomland forest is found in the Mackinaw River (lower) subbasin, comprising 18.7% of the subbasin.

Small but significant amounts of nonforested wetland land cover (including shallow marsh/wet meadow, deep marsh, and shallow water wetland) and open water (including lakes and streams) are dispersed across the basin and are concentrated in the upper, middle, and lower Mackinaw River subbasins (Figures 1-3 and 1-5). Figure 1-3 shows that the largest area of nonforested wetland (specifically, shallow water wetland) is situated in

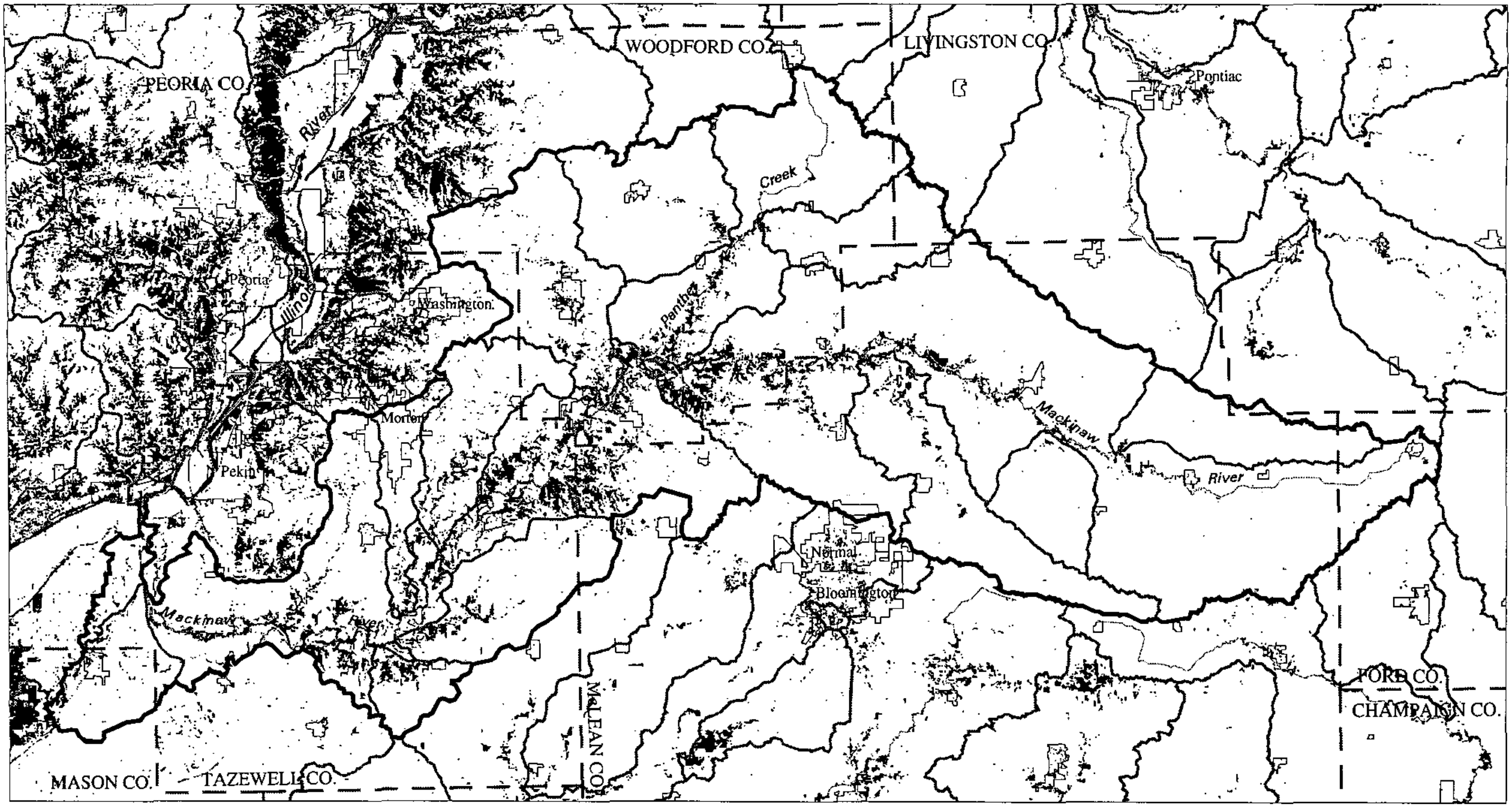
Table 1-3. Principal Land Cover in the Mackinaw River Basin (IDNR 1996)

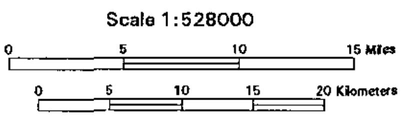
Category	Sq. Mi.*	Acres	Basin %
Agricultural Land	**1,027.7**	**657,744**	**90.3**
Cropland	874.5	559,693	76.8
Rural Grassland	153.2	98,051	13.5
Forest & Woodland	**56.0**	**35,851**	**4.9**
Urban & Built-Up Land	**26.7**	**17,081**	**2.3**
Urban/Built-Up	19.8	12,686	1.7
Urban Grassland	6.9	4,396	0.6
Wetland	**13.3**	**8,515**	**1.2**
Forested	9.4	6,005	0.8
Non-Forested	3.9	2,510	0.3
Other Land	**14.5**	**9,305**	**1.3**
Lakes & Streams	14.5	9,304	1.3
Barren & Exposed	0.0	0	0.0
Basin Totals	**1,138.3**	**728,496**	**100.0**

*Small differences in statistical tables may be due to rounding.

the Illinois River outside the Mackinaw River Basin, at the location of the Upper and Lower Peoria Lakes. Figure 1-8, an enlargement of the Mackinaw River (middle) sub-basin, shows the small and discontinuous nature of wetland habitat in the basin.

Although the Mackinaw River Basin contains only a small amount of urban and built-up land (1.7%), the metropolitan areas of Peoria and Bloomington-Normal adjoin the basin (Figure 1-7). The close proximity of such concentrated areas of urban land poses the potential for point and non-point pollution sources within the basin.





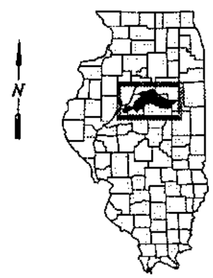


Figure 1-2. Forest in the Mackinaw River Basin. Forest depicted on this map includes upland and bottomland forest from the Land Cover of Illinois database, which is based on Landsat Thematic Mapper (TM) satellite imagery from 1991-1995. Subbasin boundaries depicted are labelled in Figure 1-1.

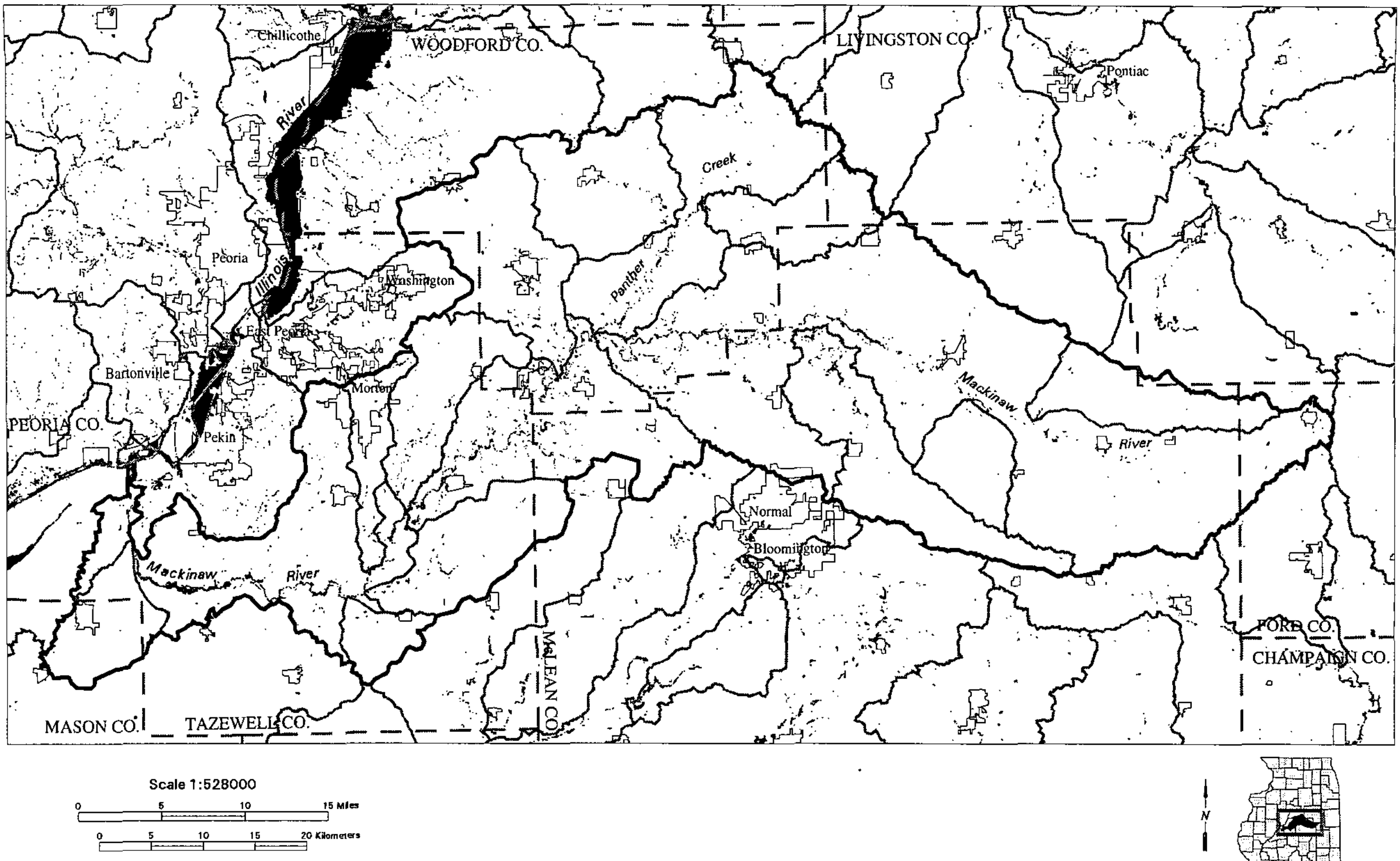
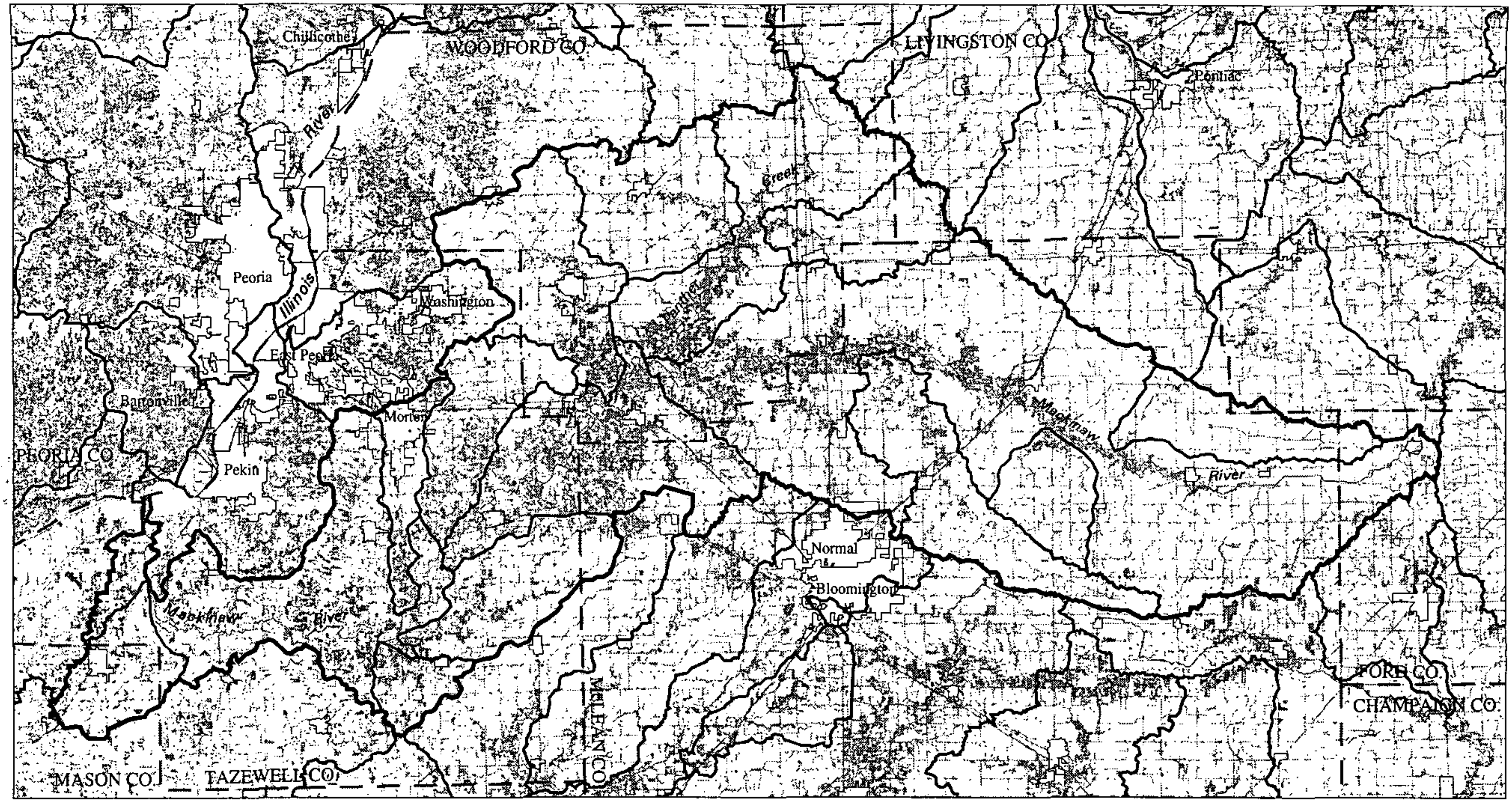


Figure 1-3. Wetlands in the Mackinaw River Basin. Wetlands depicted on this map include nonforested wetlands and bottomland forest from the Land Cover of Illinois database, which is based on Landsat Thematic Mapper (TM) satellite imagery from 1991-1995. Subbasin boundaries depicted are labelled in Figure 1-1.



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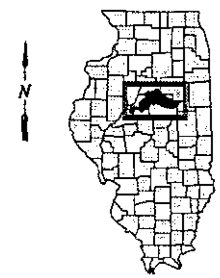


Figure 1-4. Grasslands in the Mackinaw River Basin. Grasslands depicted on this map are nonurban grasslands from the Land Cover of Illinois database, which is based on Landsat Thematic Mapper (TM) satellite imagery from 1991-1995. Subbasin boundaries depicted are labelled in Figure 1-1.

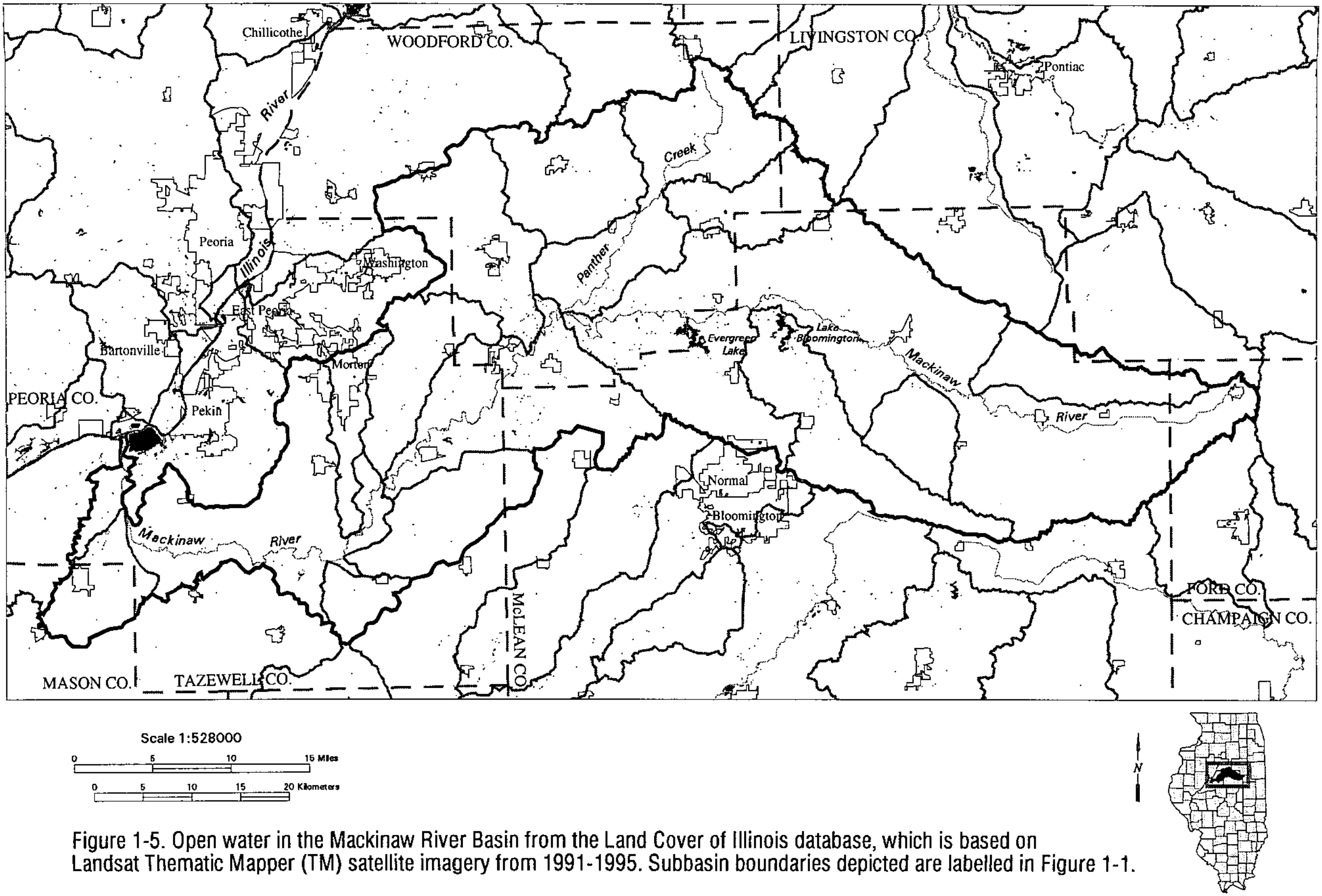
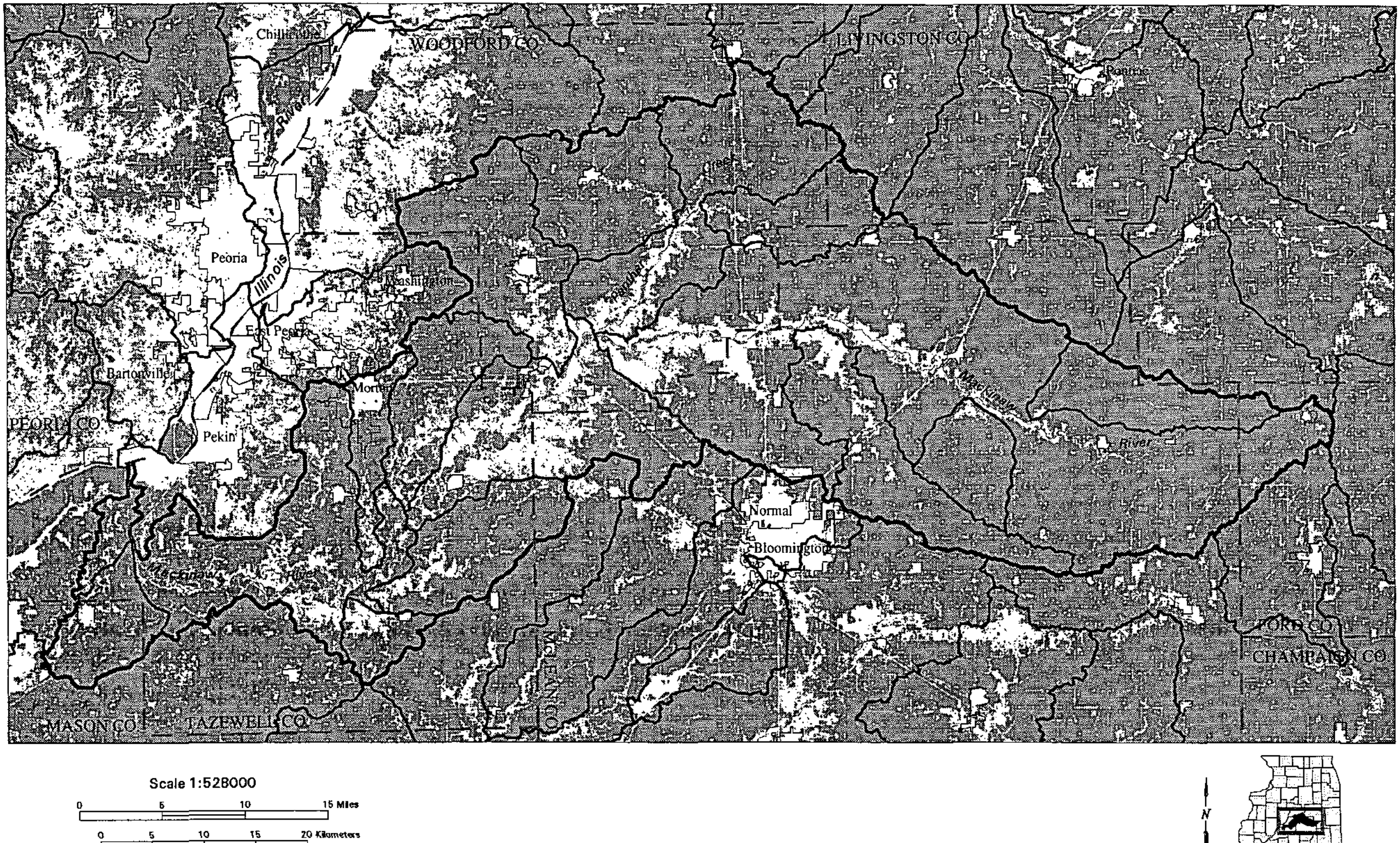


Figure 1-5. Open water in the Mackinaw River Basin from the Land Cover of Illinois database, which is based on Landsat Thematic Mapper (TM) satellite imagery from 1991-1995. Subbasin boundaries depicted are labelled in Figure 1-1.



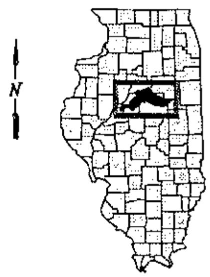


Figure 1-6. Cropland in the Mackinaw River Basin. Cropland depicted on this map includes row crops and small grains from the Land Cover of Illinois database, which is based on Landsat Thematic Mapper (TM) satellite imagery from 1991-1995. Subbasin boundaries depicted are labelled in Figure 1-1.

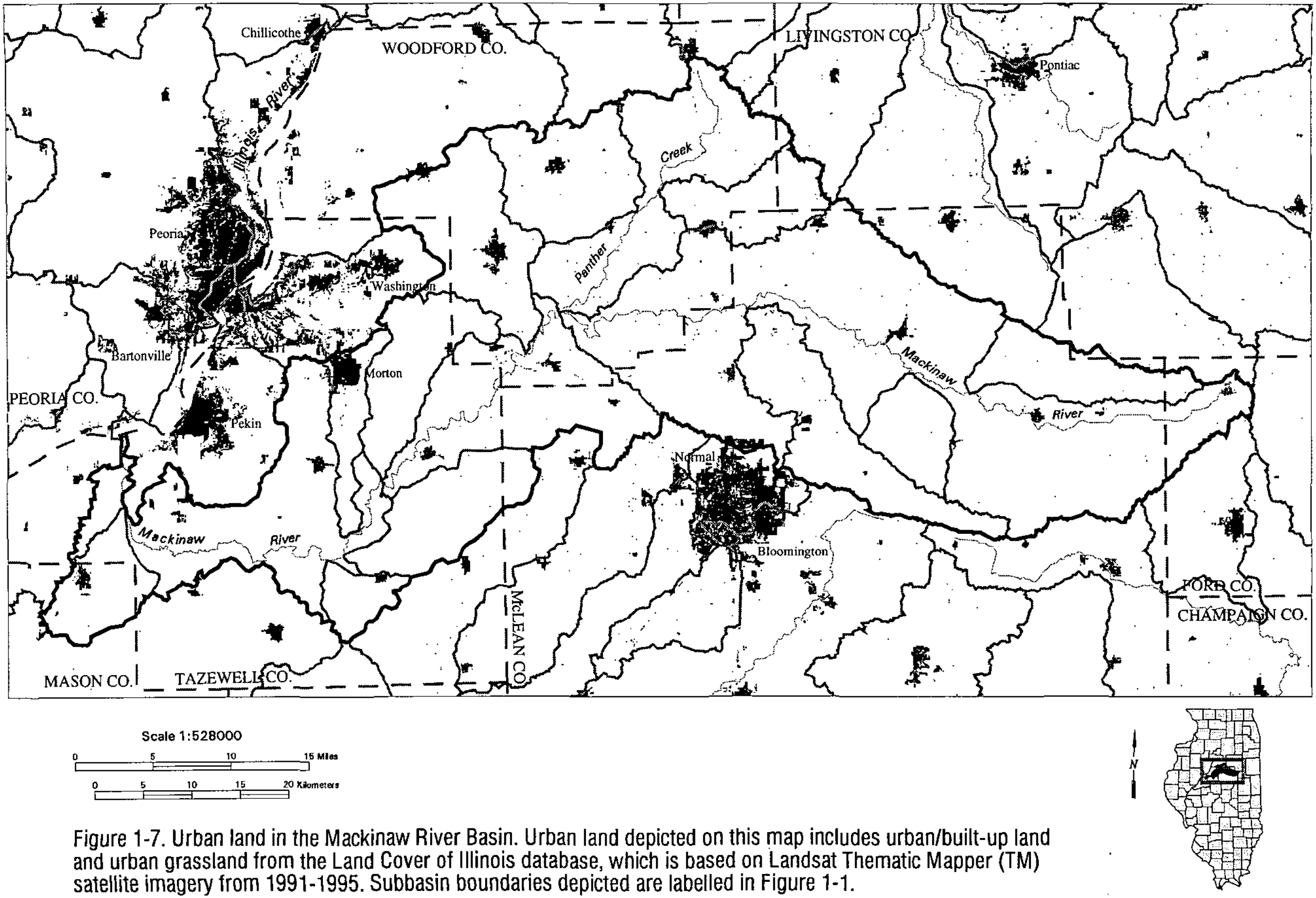


Figure 1-7. Urban land in the Mackinaw River Basin. Urban land depicted on this map includes urban/built-up land and urban grassland from the Land Cover of Illinois database, which is based on Landsat Thematic Mapper (TM) satellite imagery from 1991-1995. Subbasin boundaries depicted are labelled in Figure 1-1.

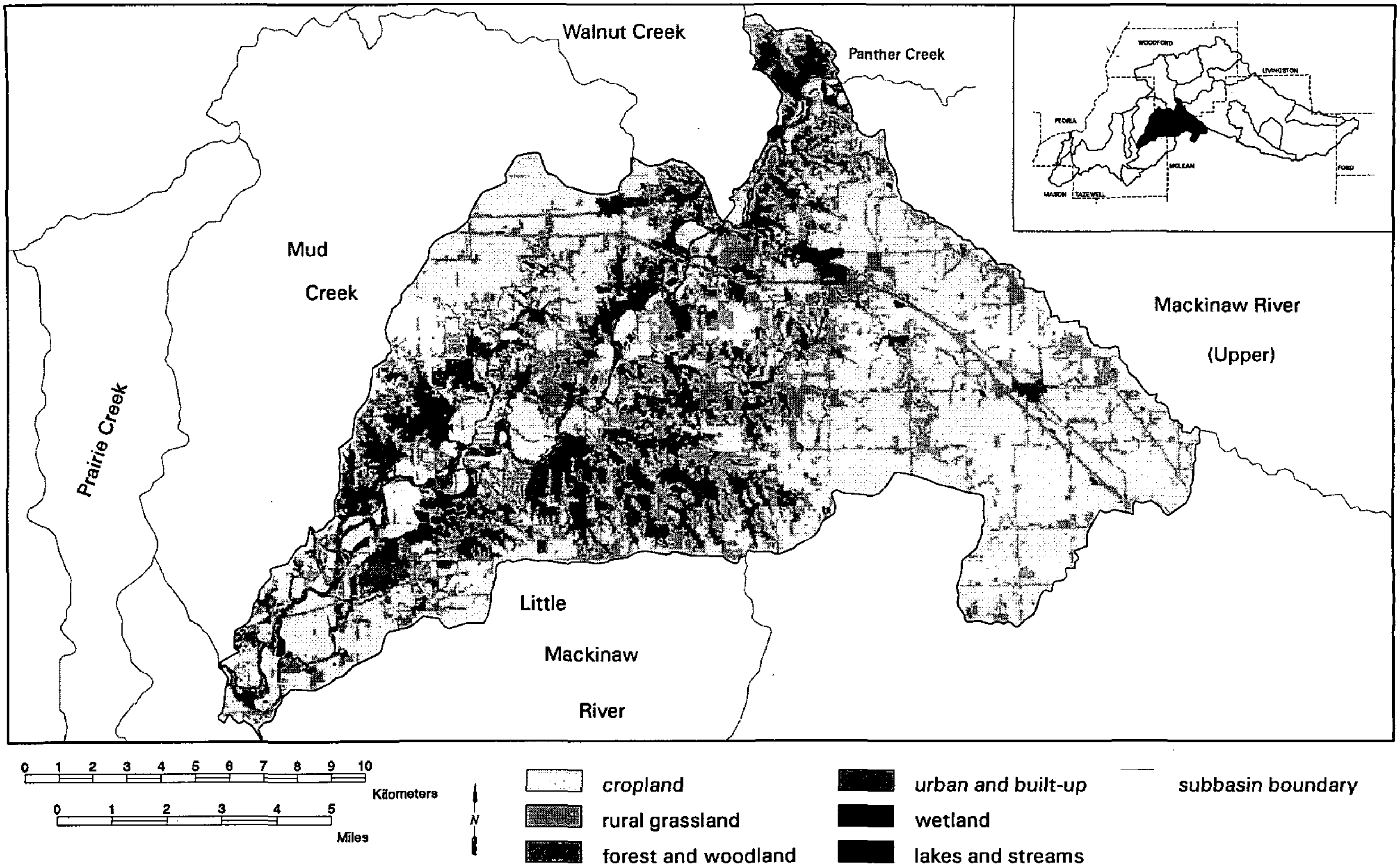


Figure 1- 8. Composite land cover map for the Mackinaw River (middle) subbasin (IDNR 1996).

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Appendix A
Mackinaw River Basin: Land Cover by Subbasin

Category	Acres	% Subbasin	% Basin
	Panther Creek Subbasin		
Agricultural Land	**57,603**	**93.5**	**7.9**
Cropland	48,831	79.3	6.7
Rural Grassland	8,772	14.2	1.2
Forest & Woodland	**2,008**	**3.3**	**0.3**
Urban & Built-Up Land	**833**	**1.4**	**0.1**
Urban/Built-Up	679	1.1	0.1
Urban Grassland	153	0.3	0.0
Wetland	**614**	**1.0**	**0.1**
Forested	404	0.7	0.1
Non-Forested	211	0.3	0.0
Other Land	**559**	**0.9**	**0.1**
Lakes & Streams	559	0.9	0.1
Subbasin Totals	**61,617**	**100.0**	**8.5**
	West Panther Creek Subbasin		
Agricultural Land	**35,852**	**95.3**	**4.9**
Cropland	32,698	86.9	4.5
Rural Grassland	3,154	8.4	0.4
Forest & Woodland	**411**	**1.1**	**0.1**
Urban & Built-Up Land	**853**	**2.3**	**0.1**
Urban/Built-Up	584	1.6	0.1
Urban Grassland	269	0.7	0.0
Wetland	**180**	**0.5**	**0.0**
Forested	89	0.2	0.0
Non-Forested	91	0.3	0.0
Other Land	**334**	**0.9**	**0.0**
Lakes & Streams	334	0.9	0.0
Subbasin Totals	**37,630**	**100.0**	**5.2**

Category	Acres	% Subbasin	% Basin
	Walnut Creek Subbasin		
Agricultural Land	**41,892**	**90.9**	**5.8**
Cropland	36,178	78.5	5.0
Rural Grassland	5,714	12.4	0.8
Forest & Woodland	**1,723**	**3.7**	**0.2**
Urban & Built-Up Land	**1,791**	**3.9**	**0.2**
Urban/Built-Up	1,254	2.7	0.2
Urban Grassland	537	1.2	0.1
Wetland	**360**	**0.8**	**0.1**
Forested	224	0.5	0.0
Non-Forested	136	0.3	0.0
Other Land	**333**	**0.7**	**0.0**
Lakes & Streams	333	0.7	0.0
Subbasin Totals	**46,099**	**100.0**	**6.3**
	East Panther Creek Subbasin		
Agricultural Land	**23,303**	**95.6**	**3.2**
Cropland	21,209	87.0	2.9
Rural Grassland	2,094	8.6	0.3
Forest & Woodland	**107**	**0.4**	**0.0**
Urban & Built-Up Land	729	3.0	0.1
Urban/Built-Up	560	2.3	0.1
Urban Grassland	169	0.7	0.0
Wetland	**76**	**0.3**	**0.0**
Forested	40	0.2	0.0
Non-Forested	36	0.2	0.0
Other Land	**160**	**0.7**	**0.0**
Lakes & Streams	160	0.7	0.0
Subbasin Totals	**24,375**	**100.0**	**3.4**
	Mackinaw River (upper) Subbasin		
Agricultural Land	**202,628**	**91.6**	**27.8**
Cropland	175,741	79.5	24.1
Rural Grassland	26,887	12.2	3.7
Forest & Woodland	**8,824**	**4.0**	**1.2**
Urban & Built-Up Land	**4,475**	**2.0**	**0.6**
Urban/Built-Up	2,936	1.3	0.4
Urban Grassland	1,539	0.7	0.2
Wetland	**72,054**	**0.9**	**0.3**
Forested	71,453	0.7	0.2
Non-Forested	601	0.3	0.1
Other Land	**3,174**	**1.4**	**0.4**
Lakes & Streams	3,174	1.4	0.4
Subbasin Totals	**221,155**	**100.0**	**30.4**

Category	Acres	% Subbasin	% Basin
		Mud Creek Subbasin	
Agricultural Land	**27,389**	**91.9**	**3.8**
Cropland	22,675	76.1	3.1
Rural Grassland	4,714	15.8	0.7
Forest & Woodland	**1,563**	**5.2**	**0.2**
Urban & Built-Up Land	**388**	**1.3**	**0.1**
Urban/Built-Up	357	1.2	0.1
Urban Grassland	32	0.1	0.0
Wetland	**220**	**0.7**	**0.0**
Forested	128	0.4	0.0
Non-Forested	91	0.3	0.0
Other Land	**241**	**0.8**	**0.0**
Lakes & Streams	241	0.8	0.0
Subbasin Totals	**29,801**	**100.0**	**4.1**
		Mackinaw River (lower) Subbasin	
Agricultural Land	**47,048**	**75.7**	**6.5**
Cropland	32,358	52.1	4.4
Rural Grassland	14,690	23.7	2.0
Forest & Woodland	**10,324**	**16.6**	**1.4**
Urban & Built-Up Land	**1,857**	**3.0**	**0.3**
Urban/Built-Up	1,460	2.4	0.2
Urban Grassland	397	0.6	0.1
Wetland	**1,849**	**3.0**	**0.3**
Forested	1,289	2.1	0.2
Non-Forested	560	0.9	0.1
Other Land	**1,045**	**1.7**	**0.1**
Lakes & Streams	1,045	1.7	0.1
Subbasin Totals	**62,123**	**100.0**	**8.5**
		Money Creek Subbasin	
Agricultural Land	**41,012**	**92.6**	**5.6**
Cropland	36,514	82.4	5.0
Rural Grassland	4,498	10.2	0.6
Forest & Woodland	**985**	**2.2**	**0.1**
Urban & Built-Up Land	**676**	**1.5**	**0.1**
Urban/Built-Up	513	1.2	0.1
Urban Grassland	163	0.4	0.0
Wetland	**514**	**1.2**	**0.1**
Forested	383	0.9	0.1
Non-Forested	131	0.3	0.0
Other Land	**1,119**	**2.5**	**0.2**
Lakes & Streams	1,119	2.5	0.2
Subbasin Totals	**44,306**	**100.0**	**6.1**

Category	Acres	% Subbasin	% Basin
		Prairie Creek Subbasin	
Agricultural Land	**11,439**	**77.6**	**1.6**
Cropland	9,300	63.1	1.3
Rural Grassland	2,139	14.5	0.3
Forest & Woodland	**651**	**4.4**	**0.1**
Urban & Built-Up Land	**2,373**	**16.1**	**0.3**
Urban/Built-Up	2,021	13.7	0.3
Urban Grassland	352	2.4	0.1
Wetland	**127**	**0.9**	**0.0**
Forested	42	0.3	0.0
Non-Forested	85	0.6	0.0
Other Land	**146**	**1.0**	**0.0**
Lakes & Streams	146	1.0	0.0
Subbasin Totals	**14,736**	**100.0**	**2.0**
		Henline Creek Subbasin	
Agricultural Land	**25,547**	**98.5**	**3.5**
Cropland	24,121	93.0	3.3
Rural Grassland	1,427	5.5	0.2
Forest & Woodland	**88**	**0.3**	**0.0**
Urban & Built-Up Land	**113**	**0.4**	**0.0**
Urban/Built-Up	113	0.4	0.0
Urban Grassland	1	0.0	0.0
Wetland	**48**	**0.2**	**0.0**
Forested	25	0.1	0.0
Non-Forested	23	0.1	0.0
Other Land	**151**	**0.6**	**0.0**
Lakes & Streams	151	0.6	0.0
Subbasin Totals	**25,947**	**100.0**	**3.6**
		Mackinaw River (middle) Subbasin	
Agricultural Land	**67,081**	**86.4**	**9.2**
Cropland	53,636	69.1	7.4
Rural Grassland	13,445	17.3	1.9
Forest & Woodland	**5,797**	**7.5**	**0.8**
Urban & Built-Up Land	**1,586**	**2.0**	**0.2**
Urban/Built-Up	1,150	1.5	0.2
Urban Grassland	436	0.6	0.1
Wetland	**2,213**	**2.9**	**0.3**
Forested	1,762	2.3	0.2
Non-Forested	451	0.6	0.1
Other Land	**975**	**1.3**	**0.1**
Lakes & Streams	974	1.3	0.1
Barren & Exposed	0	0.0	0.0
Subbasin Totals	**77,653**	**100.0**	**10.7**

Category	Acres	% Subbasin	% Basin
	Crooked Creek Subbasin		
Agricultural Land	**18,348**	**97.9**	**2.5**
Cropland	16,777	89.5	2.3
Rural Grassland	1,571	8.4	0.2
Forest & Woodland	**98**	**0.5**	**0.0**
Urban & Built-Up Land	**137**	**0.7**	**0.0**
Urban/Built-Up	131	0.7	0.0
Urban Grassland	6	0.0	0.0
Wetland	**14**	**0.1**	**0.0**
Forested	13	0.1	0.0
Non-Forested	1	0.0	0.0
Other Land	**152**	**0.8**	**0.0**
Lakes & Streams	152	0.8	0.0
Subbasin Totals	**18,750**	**100.0**	**2.6**
	Little Mackinaw River Subbasin		
Agricultural Land	**30,673**	**93.2**	**4.2**
Cropland	26,097	79.3	3.6
Rural Grassland	4,576	13.9	0.6
Forest & Woodland	**1,333**	**4.1**	**0.2**
Urban & Built-Up Land	**264**	**0.8**	**0.0**
Urban/Built-Up	258	0.8	0.0
Urban Grassland	6	0.0	0.0
Wetland	**190**	**0.6**	**0.0**
Forested	137	0.4	0.0
Non-Forested	53	0.2	0.0
Other Land	**459**	**1.4**	**0.1**
Lakes & Streams	459	1.4	0.1
Subbasin Totals	**32,919**	**100.0**	**4.5**
	Hickory Grove Ditch Subbasin		
Agricultural Land	**18,896**	**90.5**	**2.6**
Cropland	16,439	78.7	2.3
Rural Grassland	2,457	11.8	0.3
Forest & Woodland	**972**	**4.7**	**0.1**
Urban & Built-Up Land	**707**	**3.4**	**0.1**
Urban/Built-Up	430	2.1	0.1
Urban Grassland	276	1.3	0.0
Wetland	**24**	**0.1**	**0.0**
Forested	1	0.0	0.0
Non-Forested	23	0.1	0.0
Other Land	**281**	**1.2**	**0.0**
Lakes & Streams	281	1.2	0.0
Subbasin Totals	**20,879**	**100.0**	**2.9**

Category	Acres	% Subbasin	% Basin
	Indian Creek Subbasin		
Agricultural Land	**9,033**	**86.0**	**1.2**
Cropland	7,119	67.8	1.0
Rural Grassland	1,913	18.2	0.3
Forest & Woodland	**968**	**9.2**	**0.1**
Urban & Built-Up Land	**299**	**2.9**	**0.0**
Urban/Built-Up	239	2.3	0.0
Urban Grassland	61	0.6	0.0
Wetland	**31**	**0.3**	**0.0**
Forested	15	0.2	0.0
Non-Forested	15	0.1	0.0
Other Land	**176**	**1.7**	**0.0**
Lakes & Streams	176	1.7	0.0
Subbasin Totals	**10,507**	**100.0**	**1.4**

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PART II

GEOLOGY

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Coal Mine Subsidence and Acid Drainage .... Daniel C. Barnstable

Appendix: Overview of Databases .... Lisa R. Smith

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Introduction: Influence of Geology and Soils on Ecosystem Development

In the few areas of the earth that have not been modified by human settlement, the patterns of vegetation and the animals that interact with vegetation are directly influenced by geological factors. In fact, in undisturbed areas, surficial geology and to some extent bedrock geology can be mapped using inferences drawn from vegetation patterns observed on air photographs and satellite images and during field observations. For example, in the pristine terrains of northern North America, ecosystem variations were used to infer and eventually map underlying geological conditions. With virtually no change in unit boundaries, many of these maps have been used as base maps for a series of ecosystem maps published by the Lands Directorate of the Canadian Department of the Environment.

The geological characteristics that most influence ecosystem development are soil moisture and composition, topography (including slope angle, slope direction, and local drainage), and texture of the parent material. In some places, geological events such as earthquakes, glacial advances and retreats, and volcanic eruptions exert a strong control over the ecosystem. Even animal activities that are seemingly removed from geological control are influenced by geological factors such as availability of salt for migrating herds, availability of suitable vegetation for food, or—in the case of carnivores—suitable colonies of prey that congregate near geologically controlled food sources.

In uninhabited areas of the glaciated North American Arctic, ridges of gravel (eskers) left behind by retreating glaciers served as transportation routes for early humans and animals alike. The ridges provided ease of footing, vantage points for hunters or the hunted, and protection from ravenous insects that prefer the calmer air of low-lying areas. Even in modern America, roads in New England are often constructed on these ridges. These examples clearly illustrate the dominant role local geologic factors can play in ecosystem development.

Before human settlement, a whole panoply of ecological components was in equilibrium with the geology and climate of an area. The original ecological systems were closely attuned to the variety of near-surface conditions that are generated by spatial variations in bedrock and, especially in Illinois, by glacial geology.

The vegetation patterns and ecosystems of Illinois before human settlement were controlled by geology no less than were other ecosystems on the continent. The glacial moraines in the northeastern part of the state provided well-drained soils for forest growth and refuge for forest-dwelling animals. The low, flat plains are sites where shallow lakes were dammed between moraines and became poorly drained seas of herbaceous plants whose luxuriant growth provided the biomass for the thick organic-rich soils that support so much agriculture. Illinois soils developed on tills that are crushed mixtures of bedrock. These soil parent materials, formed and homogenized by the grinding action of glaciers, supply abundant nutrients vital to crops that are the agricultural basis of our society.

Where glaciers did not cover the Illinois terrain, the topography, soils, and vegetation differed significantly from the glaciated terrain. Where bedrock crops out in these areas, the soils are directly related to the composition of the immediately underlying bedrock from which they were primarily formed by chemical action. The contrasts in our ancient ecosystems can be imagined by observing the ways modern society has adjusted to the variations in the soils of glaciated and unglaciated parts of the state: except on alluvial plains, crops are not a major source of income outside the glacial boundary.

On our modern landscape as altered by human activity, original ecosystems cannot be restored or maintained without appreciating the geologic factors that generated the original complex animal and plant interrelations. For instance, attempting to reestablish a wetland consisting of acid loving plants that require periodic drying will not succeed in depressions actively fed by groundwater passing through alkaline glacial till. Likewise, reestablishing certain types of forest vegetation on an unstable terrain underlain by thick, easily erodible glacial loess is likely to fail.

The geologic foundation of the Mackinaw River watershed is bedrock and glacially derived sediments that lie directly beneath the soils and modern sediments at the land surface. The topography of the bedrock surface partly determined the type and distribution of the overlying glacial deposits. These sediments, in turn, determine the area's groundwater resources, form the parent materials of the region's rich soils, and play a role in the development of the watershed's wetland areas. Glacially derived sand and gravel supports an ongoing industry important to the region's economy. Together, these geologic factors govern the development of the entire range of plant and animal communities within the watershed.

Thus, geology is the foundation for understanding the complex world of plants and animals and the surface processes we see in the Mackinaw River watershed. Geology also plays a fundamental role in human use of the land. For example, more than 90% of the land in the Mackinaw River watershed is devoted to agricultural use (Regional Land Cover Assessment Analysis in Part III) largely because of the abundant fertile soils that developed in the windblown silts that blanket the landscape.

The geologic characteristics of the watershed are a product of continuing interactions between natural processes and materials, from the formation of bedrock to the development of soils in the glacial sediments at the land surface. To provide a logical understanding of the geology of the Mackinaw River watershed, this volume is organized "from the bottom up"—that is, from the bedrock to the soils—to reflect the natural order in which the geologic processes occurred and the geologic materials were laid down.

The following discussions and accompanying maps are generalized for the entire Mackinaw River watershed (Figure 2-1) and cannot be used for site-specific purposes. Users needing more detailed information should contact the authors at the agency address and telephone number listed in the front of this publication.

The fact that Illinois is incorporating geologic data into the Mackinaw River and other watershed reports in the state, is an appropriate recognition of the necessity of integrating geologic and biological data into efforts to preserve our natural heritage.

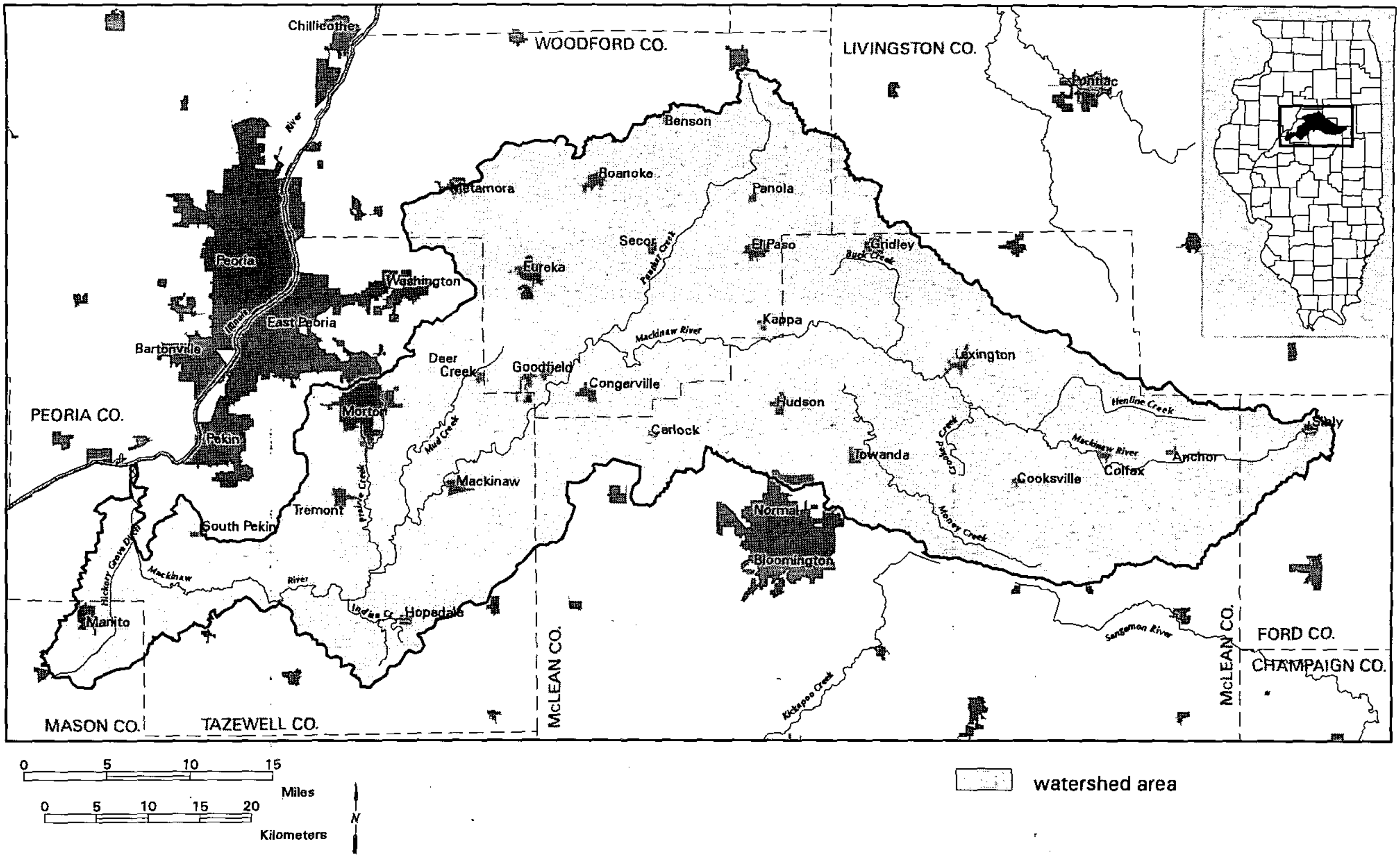

Figure 2- 1. Mackinaw River Watershed

Geology

Bedrock Geology

Description of Materials

Bedrock beneath the Quaternary mantle of unconsolidated glacial material within the Mackinaw River watershed consists of sedimentary rocks of Silurian, Devonian, and Pennsylvanian age (Figure 2-2). Silurian rocks are predominantly dolomite, and the Middle Devonian rocks are predominantly limestone. Pennsylvanian strata consist of many relatively thin layers of sandstone, siltstone, shale, limestone, and coal. Sandstone, siltstone, and shale are the dominant lithologies (rock types).

In the Mackinaw River watershed, Pennsylvanian strata are separated into five formations (Kosanke and others 1960, Willman and others 1967) which are generally similar. Each formation is differentiated by key beds (rock layers with diagnostic features) and is characterized by general lithologic differences between minor lithological components. The oldest and lowermost Pennsylvanian formation is the Tradewater Formation, which

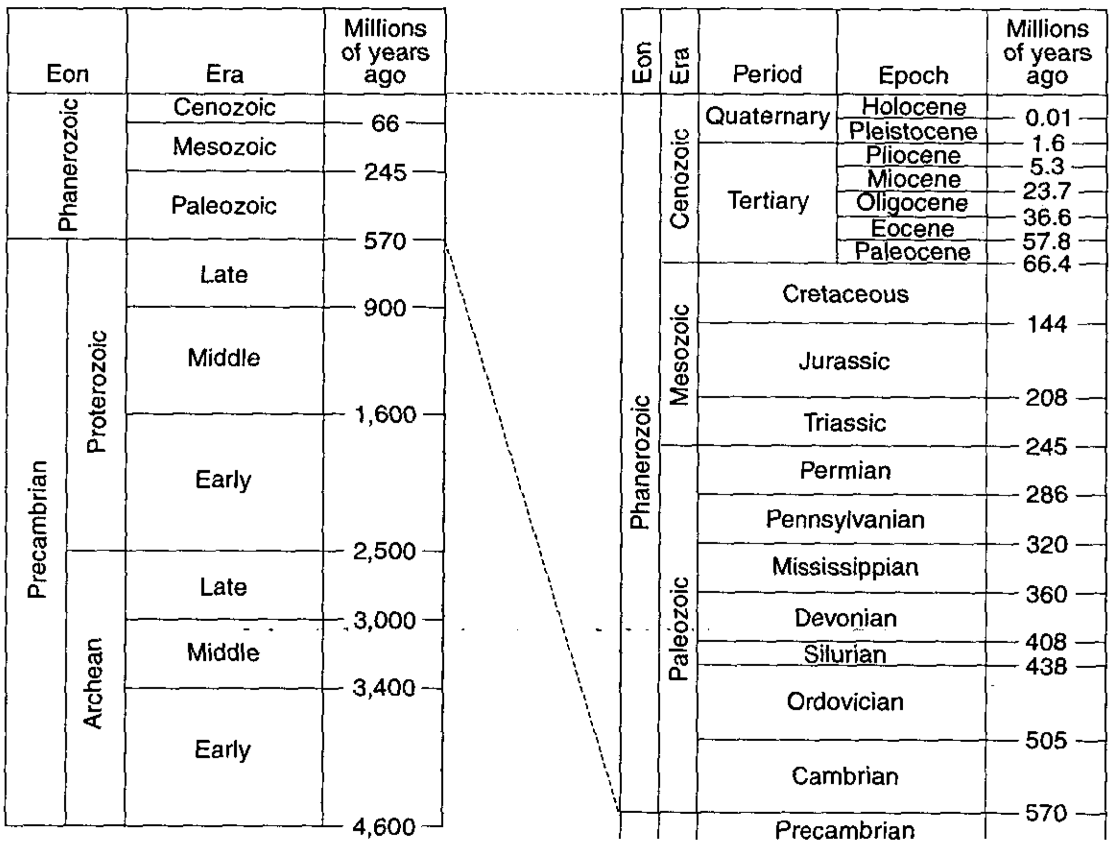

Figure 2-2. Major Subdivisions of Geologic Time

is characterized by thin, widespread limestones and coals. The overlying Carbondale Formation contains the thickest coal beds in Illinois. (The Colchester Coal Member, considered to be one of the most extensive coal beds in the United States, can be found in the Carbondale Formation [Willman and others 1975]; see Coal Mine Subsidence and Acid Mine Drainage section below). The Modesto Formation contains widespread, relatively thicker, argillaceous (clayey) limestones and thin coals, whereas the Bond Formation is characterized by several thick, pure limestones. The youngest and uppermost Pennsylvanian Formation, the Mattoon Formation, is characterized by widespread, thin limestones and discontinuous, thin coals.

Most of the bedrock subcrop (bedrock that occurs directly beneath glacial sediment) within the watershed area is of Pennsylvanian age (Figure 2-3). Older strata form the bedrock surface only near the headwaters of the Mackinaw River watershed in Ford County. Silurian- and Middle Devonian-age dolomite or limestone subcrop in this area because the watershed crosses a regional composite upfold in the bedrock, called the La Salle Anticlinorium (Nelson 1995). To the west, in the downstream direction of the surface drainage, bedrock subcrops consist entirely of Pennsylvanian-age strata that are gently deformed by small north–south-trending folds. The pattern of the Pennsylvanian formation subcrop boundaries reflects these undulations throughout most of the drainage basin. In the northwest corner of Ford County, strata dip steeply westward on the west flank of the La Salle Anticlinorium, and bedrock subcrops are progressively younger in age (from older Tradewater Formation to younger Mattoon Formation) westward to near the center of the Colfax syncline (downfold in the bedrock) (Clegg 1970) in northeastern McLean County. Mattoon Formation strata are the youngest bedrock layers in the Mackinaw River watershed. Continuing westward, the age progression reverses, and the strata gradually are older from the Colfax syncline to the Downs anticline (Heigold and others 1964) in west-central McLean County. The Downs anticline is demarcated by subcrops of the Carbondale Formation in north-central McLean County. To the west, strata dip gently westward toward the axis of an unnamed synclinal fold where first the Modesto Formation subcrops, followed by the younger Bond Formation in the middle of the fold in central Woodford County and far west-northwest McLean County. From here west to the foot of the watershed, the strata dip gently eastward and subcrops become progressively older and consist mostly of the Carbondale Formation.

Bedrock Topography

The top of the bedrock surface in the Mackinaw River watershed is a complex topographic surface containing buried valleys, lowlands, and uplands (Figure 2-4). Buried bedrock valleys generally contain coarse grained sediments (i.e., sands and gravels) that form productive aquifers (Horberg 1945, Kempton and others 1991). The buried bedrock surface formed during the early and middle Pleistocene and was part of a regional fluvial drainage system (Kempton and others 1991). Several large valleys on the bedrock surface traverse the western two-thirds of the watershed area (Horberg 1950). The buried Mackinaw Valley occurs in northeastern and southeastern Tazewell County. Near the eastern Tazewell County line, the buried Danvers Valley, a major tributary to the buried

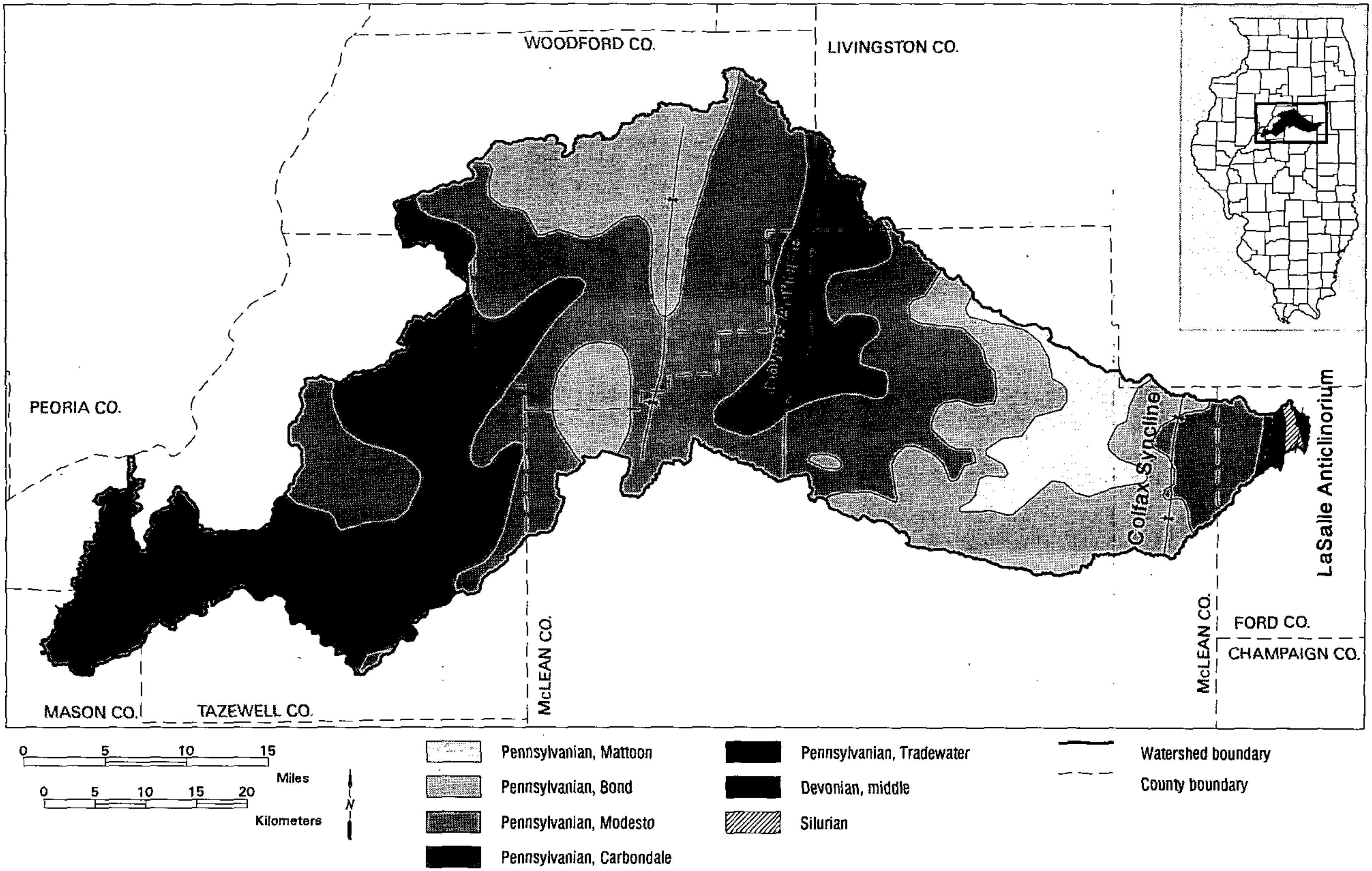

Figure 2-3. Bedrock Geology (modified after Willman et al. 1967).

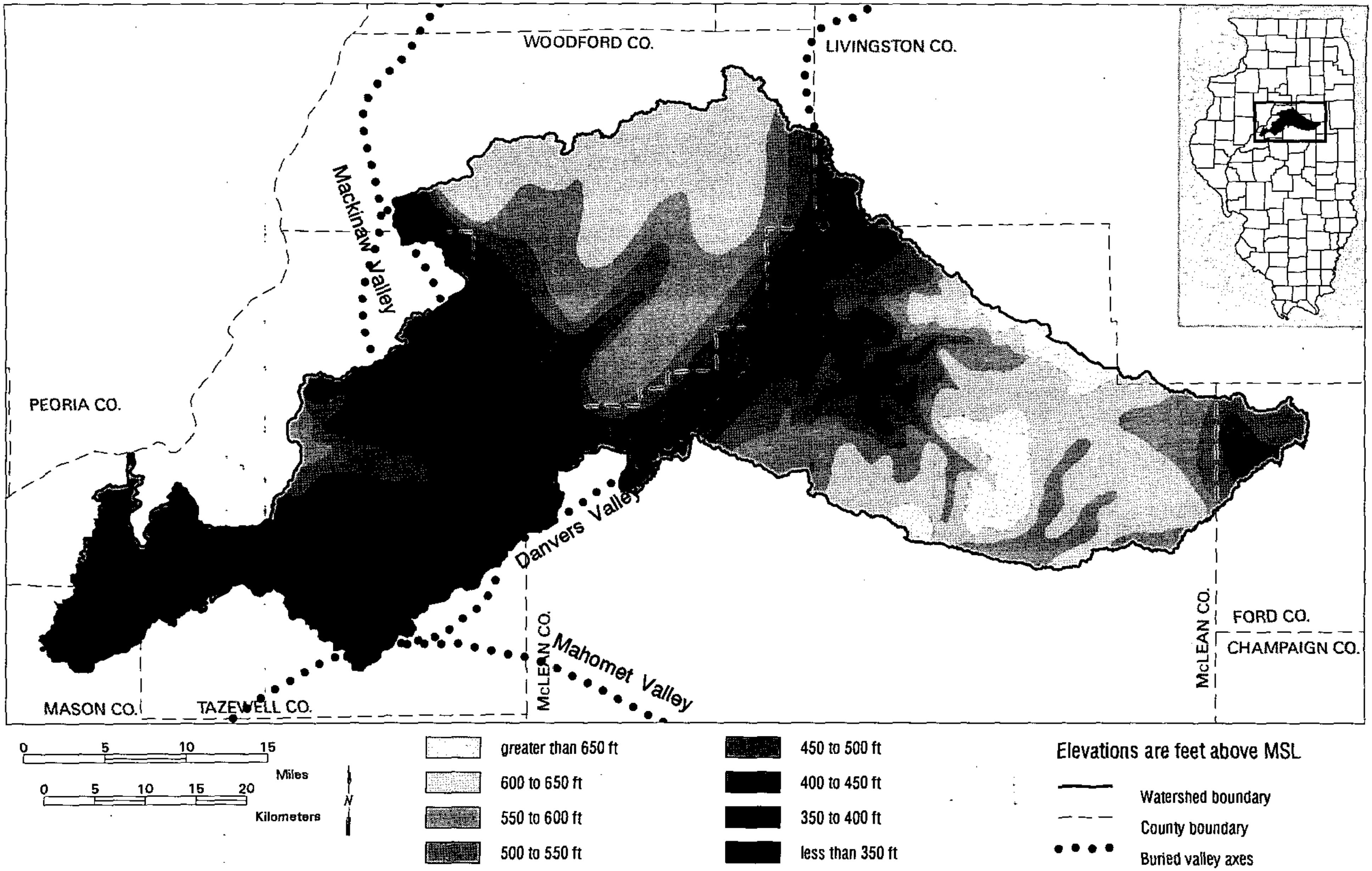

Figure 2-4. Bedrock Topography and Buried Valleys (modified after Herzog et al. 1994).

Mackinaw Valley that traverses the McLean-Woodford County boundary, joins the main channel of the buried Mackinaw Valley where it makes a 90° turn from southeast to southwest. The west end of the modern Mackinaw River watershed in Mason County overlies a major channel that runs from the modern Illinois River Valley to the buried Mahomet Valley. Minor buried bedrock valleys in eastern McLean County and at the headwaters of the modern watershed are also tributaries to the buried Mahomet Valley. Panno and others (1994) concluded that in portions of the buried Mahomet Valley, the bedrock lithology has an influence on the geochemistry of the groundwater. Their study also suggested that bedrock within the buried Mackinaw Valley had little geochemical influence on the contained groundwater.

Glacial and Surficial Geology

Description of Materials

The sediments that overlie bedrock were deposited by a succession of glaciers that advanced across the area during the Pleistocene Epoch, or Great Ice Age. These sediments fall into two major categories: till (usually called diamicton by geologists) and outwash. Minor types of deposits include lacustrine (lake) sediments and organic-rich debris. Overlying the deposits of glacial origin is a windblown silt (loess, pronounced "luss") of late glacial and postglacial age. Collectively, glacial sediments are called glacial drift. Knowledge and understanding of these deposits, described below, is important because the deposits control, in part, use of the land, ecosystem development, landscape processes that can affect ecosystems (see also Soils and Relationship to Habitat Development section below), and, to a certain extent, effects of geologic hazards on the land.

Till is a mixture of all sizes of rocks and ground-up rock debris, ranging from the smallest clay particles to the largest boulders. Most of this sediment is composed of a compact mixture of clay, silt, and sand particles that provides the matrix that surrounds and supports larger grains, such as pebbles, cobbles, and boulders. This dense, compact sediment, when exposed in stream banks, can be involved in slumping and minor landslides. However, during the infrequent earthquakes experienced in the area, the sediment is less likely to enhance seismic energy than the loose, water-saturated sediments found along river floodplains.

Till was deposited across the pre-existing landscape at the base of the glacier as it moved along or flowed as a muddy mass of material off the front of the melting ice sheet or through crevasses (cracks) that developed within the ice. Each layer (or bed) of till represents a particular glacial advance and can be found regionally over large areas. These layers help identify major groups of sediment associated with particular glacial episodes.

Outwash is sand and gravel that literally "washed out" from the ice in meltwater streams along the margin of a glacier. Found at the land surface primarily in the westernmost part of the Mackinaw River watershed, outwash is a potential resource for construction sand and gravel (see Mineral Resources section below). Layers (or beds) of outwash also occur within the glacial sediments between the bedrock surface and today's land surface. Such sand and gravel deposits are generally porous and permeable, and fluids such as water can move easily among the grains. Therefore, when thick enough, these deposits can often serve as excellent aquifers (see Groundwater section below).

Outwash occurs in elongate deposits in the stream valleys that were meltwater outlets in front of or beneath the glacier, in fan-shaped deposits in front of end moraines (arc-shaped ridges of till built up on the landscape where the ice margin temporarily stabilized; Figure 2-5), and occasionally as isolated hillocks and ridges on the landscape where meltwater carrying rock debris plunged through crevasses in the ice. Where extensive beds of outwash are associated with particular tills, the identification of the tills in drillholes helps geologists predict the occurrence of major bodies of outwash that can serve as aquifers.

Lacustrine (lake) deposits are generally fine grained sediments such as silt and clay deposited in temporary lakes that often formed along the margin of the ice as it melted or that were dammed between a moraine and the melting ice front. These sediments are often poorly drained and may cause water problems in construction projects.

Organic-rich debris deposited between layers of glacial sediment can serve as important marker beds that represent major intervals of warmer climate between glaciations during which vegetation could grow. Organic deposits often separate major sequences of glacial sediments and help geologists interpret the sequence of deposits and predict where outwash may occur in the subsurface. The low bearing capacity (weight the ground can safely support) of organic soils can affect construction.

Loess, a windblown silt, blankets much of the landscape in the watershed area. As stated earlier, its importance lies in those properties that make it an excellent parent material for the region's productive soils. Its origin is the floodplain sediments along major valleys, such as the Illinois River Valley, which served as a major meltwater outlet for melting glaciers to the northeast. Prevailing westerly winds picked up the finer sediments—silt, fine sand, and some clay—from the floodplain and blew them across the landscape. Loess is thickest immediately east of the valley and thins rapidly with distance eastward (note loess thickness contours in Figure 2-5).

An outstanding exposure of loess exists in western McLean County at the Danvers Geological Area. The exposure is on private land and generally not accessible to the public. However, loess can be examined in numerous roadcuts throughout the western part of the watershed.

Regional Glacial History

Hundreds of records (logs) and samples of sediments are available from borings drilled throughout the watershed region. These logs and samples are stored and catalogued at

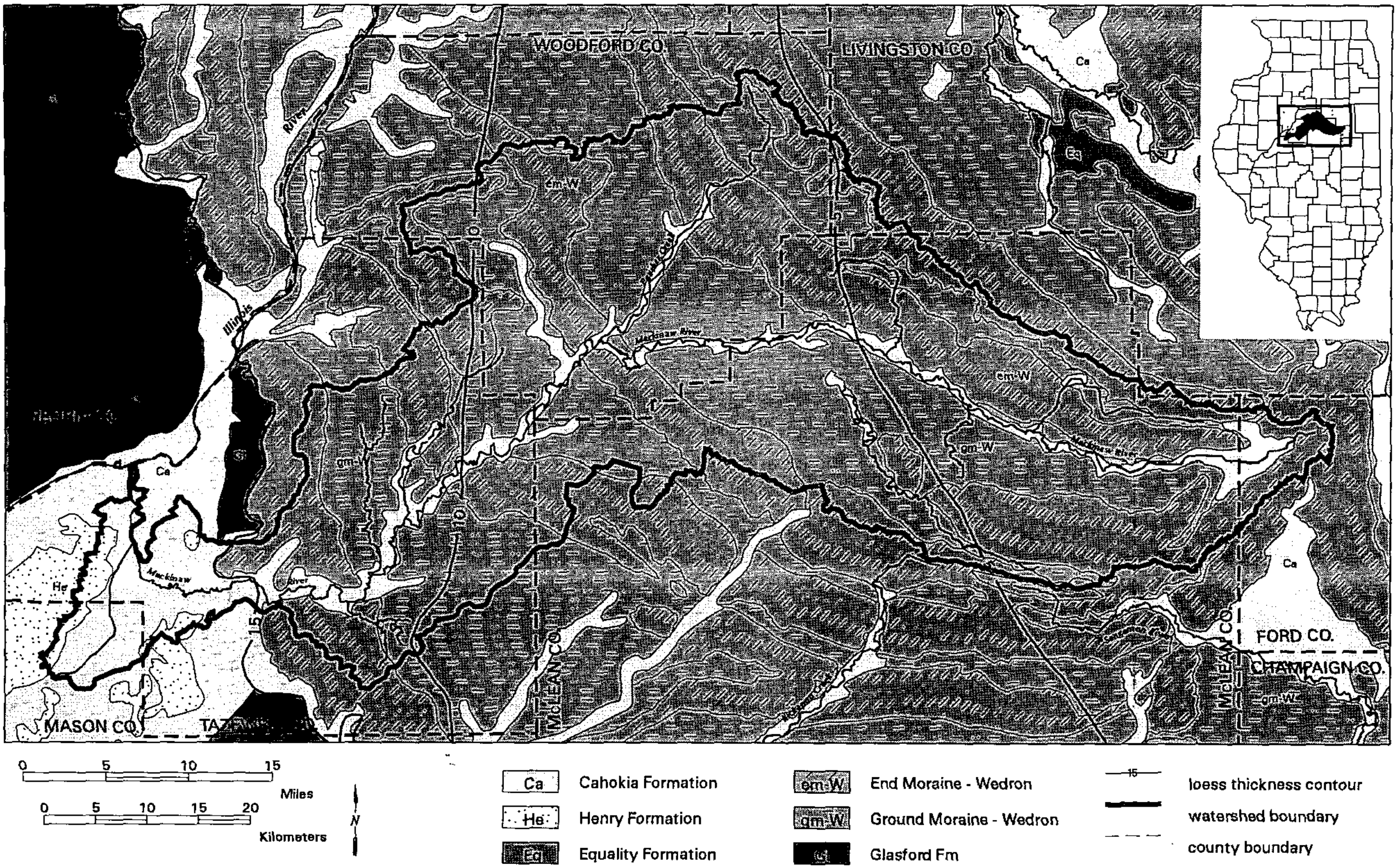

Figure 2- 5. Glacial Geology (modified after Hansel and Johnson 1996)

the Illinois State Geological Survey. Many borings penetrated the entire sequence of glacial sediments overlying bedrock and provide the record from which the general glacial history of the region can be interpreted.

The sediments left by the earliest glaciers in this area are buried or partially eroded away. The early sediment record is therefore less clearly defined than that of the more recent Illinois Episode and the most recent Wisconsin Episode of glaciation (Hansel and Johnson 1996). Tills of several pre-Illinois episodes are collectively named the Banner Formation (Willman and Frye 1970).

Pre-Illinoian glaciers and their meltwaters deepened the pre-existing bedrock valleys by erosion and then partially filled them with outwash and tills. These sediments have been preserved in some of the deeper bedrock valleys (see Bedrock Geology section above), but are not known to occur at the land surface anywhere within the watershed area. A major buried soil, named the Yarmouth Soil, represents a long warm interval between major glacial advances; the soil still exists in places on the upper surface of Banner Formation sediments. Even where the Yarmouth Soil is absent, a weathered surface can sometimes help us trace the physical record of this major time interval between glacial episodes.

Tills deposited by glaciers of the Illinois Episode are named the Glasford Formation (Willman and Frye 1970). Within the watershed area, Glasford sediments are buried beneath younger tills of the Wedron Group, water-laid sediments of the Mason Group (composed of outwash of the Henry Formation and lake sediments of the Equality Formation), or still more recently deposited alluvium of the Cahokia Formation (Figure 2-5) (Hansel and Johnson 1996). Another major buried soil, called the Sangamon Soil, and associated weathering surfaces commonly occur at the top of the Glasford Formation. The Sangamon Soil represents the major interval between the Illinois and Wisconsin Episodes.

Tills deposited during the Wisconsin Episode of glaciation belong to the Wedron Group. They occur at or near the surface over all but the westernmost part of the watershed area. Wedron Group tills compose the landforms seen on the present land surface, primarily end moraines and ground moraines. Ground moraines are the gently rolling land surface between the end moraines.

Loess, called Peoria Silt, blankets nearly all of the land surface except for areas along streams. The loess thins rapidly eastward across the watershed (Figure 2-5). Stream deposits (alluvium) belong to the Cahokia Formation.

Thickness of Materials

Deposits of glacial origin range from less than 100 feet thick to more than 400 feet thick within the watershed (Figure 2-6). Knowledge of the thicknesses of sediments deposited by the various ice sheets that crossed the area can guide drilling to locate water resources. In general, the thickest deposits occur in the bedrock valleys (compare Figure 2-6 with

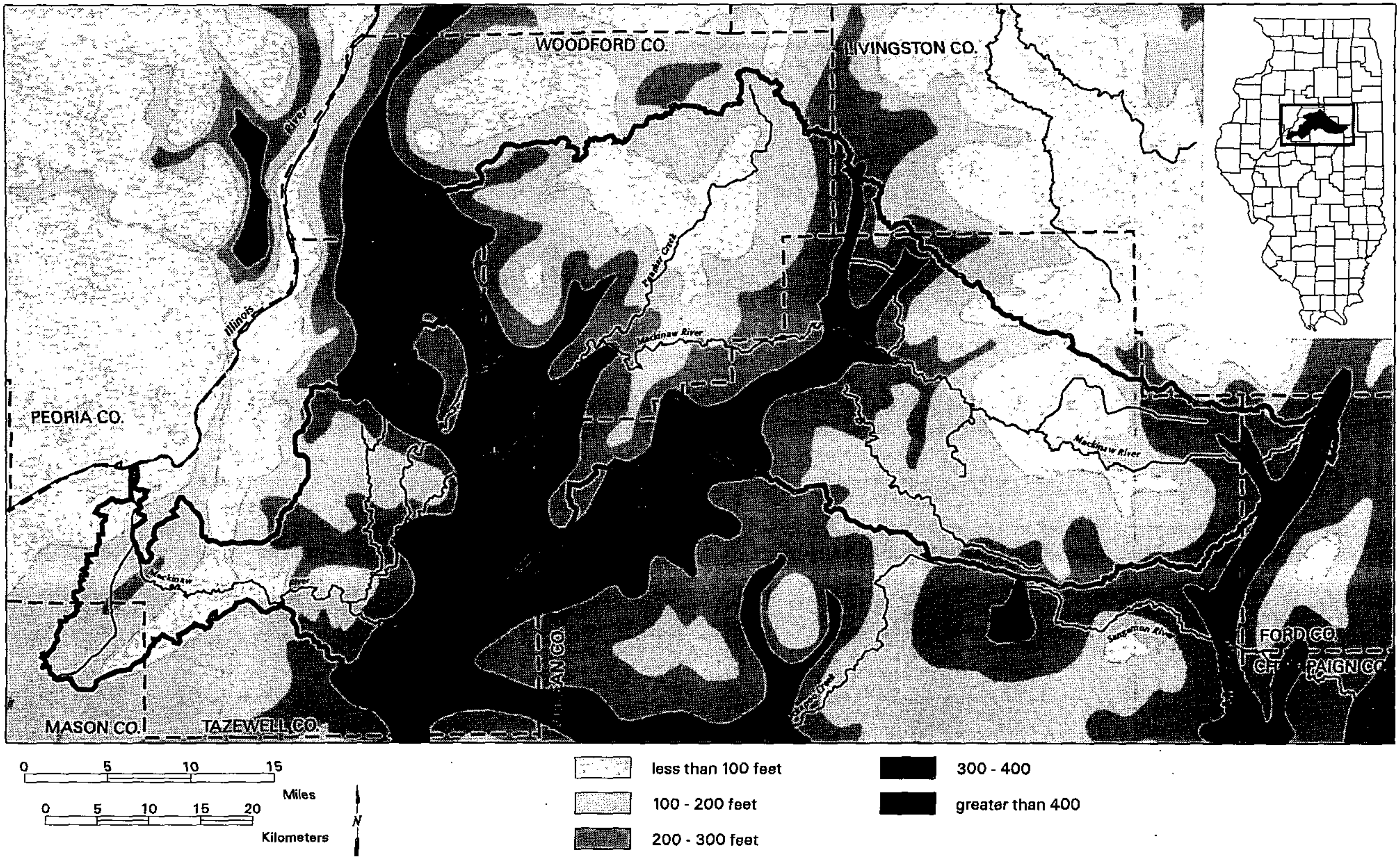

Figure 2- 6. Thickness of Glacial Drift (modified after Piskin and Bergstrom 1975)

Figure 2-4), which cross the central portion of the watershed area and are discussed in the preceding section.

In the bedrock valleys, Banner Formation sediments compose up to 50% of the total drift thickness, with the Glasford Formation and Wedron Group each accounting for approximately 25% (Herzog and others 1995). On the bedrock uplands, the Banner Formation is generally thinner (accounting for one-quarter to one-third of the total drift thickness) or may be absent. Where moraines formed during the Wisconsin Episode, Wedron Group sediments can account for more than 50% of the drift thickness (Herzog and others 1995). Considerable local variability can occur, however, depending on the shape and height of the moraine and the effects of later erosion.

Outwash of the Henry Formation and modern stream alluvium of the Cahokia Formation tend to thin toward their margins. These formations are generally not mapped where they are less than 20 feet thick because the scale of mapping does not make it feasible to show this amount of detail. The Peoria Silt decreases in thickness from about 10 feet in the westernmost part of the watershed area to less than 5 feet in the eastern part.

Mineral Resources

The only mineral produced in the Mackinaw River watershed is construction sand and gravel. There were 30 active pits in 1992 in Tazewell and Woodford Counties of the watershed but none in the other three counties (Figure 2-7) (Samson and Masters 1992). The pits are located in the Mackinaw River valley extending in a northeast–southwest direction between Peoria and Bloomington-Normal, cities that are outside the watershed area.

Production figures or employment data for the pits are not available. The pits, however, play an important role in the economy of both the rural and urban areas in the surrounding region by delivering sand and gravel for various types of construction projects. Material is shipped in and around Peoria and Bloomington-Normal in addition to about 30 communities of varying sizes located in the Mackinaw River watershed area.

Sand and gravel is a mineral commodity of low unit value, sold at about $4 per ton at the pits. Transportation charges can be a significant cost factor in sand and gravel markets, often equaling or exceeding the value of the commodity itself within a few miles from the pits (Bhagwat 1989). Therefore, production sites near the market have a special economic significance.

Significant amounts of sand and gravel occur in the Mackinaw River valley (Figure 2-8) (Lineback 1979). The primary source of sand and gravel is the glacial-age Henry Formation. Additional, but less well-sorted, deposits may be found in the Cahokia Formation along the valley, which may overlie well-sorted glacial sand and gravel.

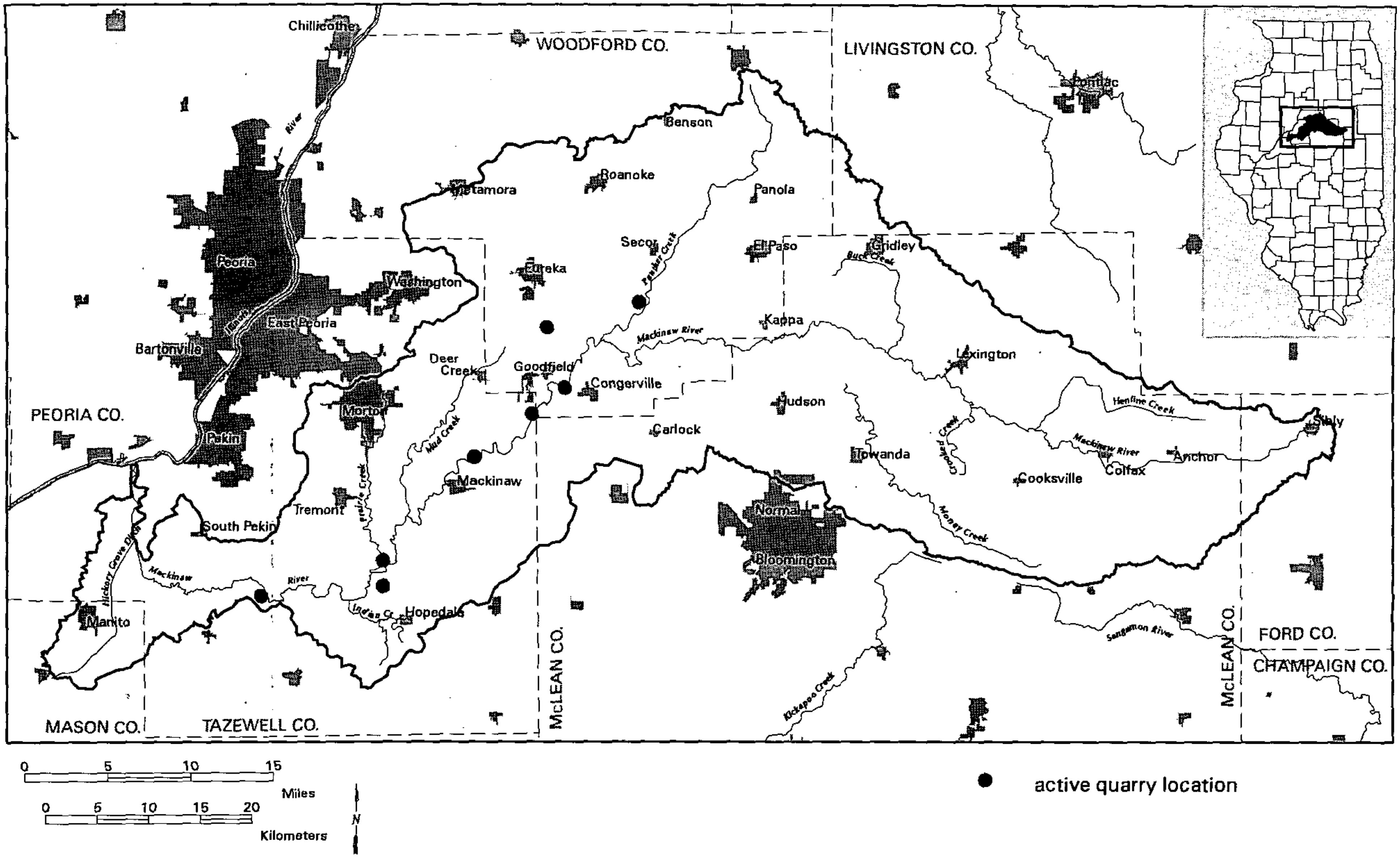

Figure 2- 7. Active Sand and Gravel Pits

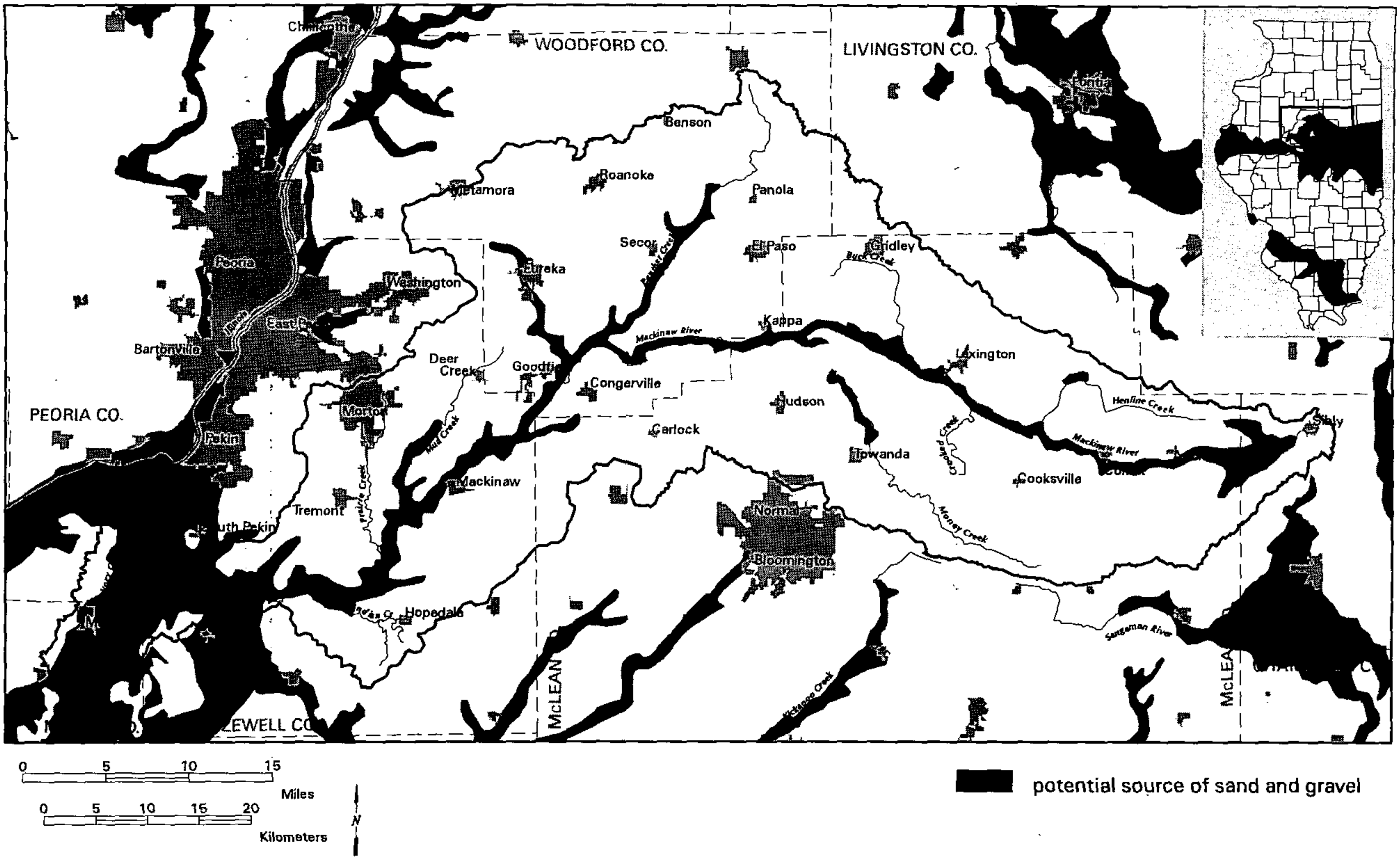

Figure 2- 8. Areas of Significant Sand and Gravel Deposits (modified after Hansel and Johnson 1996)

Groundwater

Aquifer Delineation

An aquifer is a body of water-saturated earth materials that yields sufficient quantities of groundwater to a stream, spring, or a small-diameter well for its intended use. Aquifers in Illinois are composed of saturated sand and gravel, fractured or jointed limestone or dolomite, or permeable sandstone. Fine grained earth materials such as clay, shale, or till (see also Glacial and Surficial Geology section above) may restrict the flow of groundwater through and between aquifers. Aquifers in the Mackinaw River watershed are almost entirely sand and gravel confined and separated by till or clay. Beneath the glacial deposits, either the bedrock yields insufficient quantities of water or the water is too mineralized for many private, agricultural, or municipal uses.

The depth and areal extent of aquifers in the Mackinaw River watershed can best be understood by first knowing the bedrock surface features on which they developed. The configuration of the bedrock topography is of interest because it governs the geometry of the major aquifers in the watershed. Many recent studies conducted by the State Water and Geological Surveys to assess groundwater resources (Kempton and Visocky 1992, Wilson and others 1994, Herzog and others 1995) have produced maps of bedrock topography that roughly delineate aquifer boundaries for most of the watershed. Despite findings that have indicated broader, deeper bedrock valleys in some locations and discovered bedrock highs in others, the configuration of the bedrock topography and the aquifers can only be delineated in a general way.

The uppermost bedrock strata in the Mackinaw River watershed consist primarily of shales and relatively thin lenses or layers of sandstone, limestone, and coal, all of which have been identified as components of the Pennsylvanian-age Tradewater, Carbondale, Modesto, Bond, and Mattoon Formations (Willman and others 1967; see also Clegg 1970, 1972, and Jacobson 1983). These bedrock aquifers have generally not proven to be useful sources of groundwater.

In this relatively soft uppermost bedrock, ancient rivers, such as the Ancestral Mississippi River, carved the channels that now cradle the deepest sand and gravel aquifers in the vicinity of the Mackinaw River watershed (Figure 2-4). The two principal bedrock valleys passing beneath the Mackinaw River watershed are the Mackinaw Bedrock Valley trending southward through Woodford County and into Tazewell County along its eastern and southern borders, and the bedrock valley beneath the Illinois River in the Peoria and Pekin area (see Bedrock Geology section above). The bottoms of these major bedrock valleys may lie as much as 150 feet below the bedrock uplands and reach total depths of more than 300 feet below land surface. Tributary bedrock valleys include the Danvers Bedrock Valley, which traces southeast of the step-like border of northwestern McLean

County and connects with the Mackinaw Bedrock Valley in eastern Tazewell County, and a shallow valley that lies below present-day Panther Creek in southern Woodford County.

In Illinois, the glacial history responsible for our rich soils also provided our most productive aquifers (see Glacial and Surficial Geology section above). Suites of sand and gravel deposits that compose the aquifers in the Mackinaw River watershed have been categorized by hydrogeologists according to their physical characteristics (lithostratigraphy) and the time when they were deposited. The Sankoty-Mahomet Sand Aquifer—the thickest, most widespread, and most productive sand and gravel aquifer in the watershed—belongs to the Banner Formation (Willman and Frye 1970). Most groundwater resources in the Banner Formation are found in the sub-Sankoty-Mahomet sands and in the Sankoty-Mahomet Sand Member. Layers of silty glacial lake (lacustrine) deposits and clayey till are scattered within and along the margins of these sand and gravel units and commonly divide the sub-Sankoty-Mahomet and Sankoty-Mahomet units. The two units are connected hydraulically and behave as one aquifer, known as the Sankoty-Mahomet Sand Aquifer. Collectively, these deposits blanket the base of the major bedrock valleys in the western portion of the watershed, often reaching thicknesses of up to 200 feet. Between Tremont and Hopedale (Tazewell County; see Figure 2-1), where the Mackinaw and Danvers Bedrock Valleys converge, the aquifer is 150 feet thick. Within a 5 mile radius of the bedrock valley walls, the aquifer may thin to 25 feet or less (Herzog and others 1995). In the eastern third of the watershed, where bedrock uplands dominate (bedrock elevations exceed 500 feet, see Figure 2-4), the Sankoty-Mahomet Aquifer sediments give way to more prominent fine grained materials such as backwater and lacustrine silts and clays. Glacially deposited tills occur toward the top of the Banner Formation, and locally significant sand and gravel units occur between these tills and at the top of the Banner Formation.

The next significant geologic unit overlying the Banner Formation is the Glasford Formation (Willman and Frye 1970). With an average thickness of 100 feet, the Glasford Formation is primarily composed of two tills with locally significant medium to fine grained sand and gravel deposits at the base of each member. Locally, the sand and gravel deposits beneath the lower till may directly overlie the Sankoty-Mahomet Sand Member and contribute to the water yield associated with the Sankoty-Mahomet Sand Aquifer. In general, the sand and gravel units of the Glasford Formation are thin and discontinuous throughout the watershed, and commonly have a total thickness of 20 feet or less. Their lack of sufficient thickness and continuity, and their coarse grained texture make the sand and gravel units of the Glasford Formation inadequate sources for large public water supplies in most of the Mackinaw River watershed.

The uppermost geologic units include the Wedron Group and the Henry Formation, deposited during the Wisconsin Episode of glaciation (Hansel and Johnson 1996). The Wedron Group consists primarily of tills and limited sand and gravel deposits. Its thickness is extremely variable, ranging from only a few feet to more than 100 feet, with an average thickness of about 50 feet. The Tiskilwa Formation, a till with a diagnostic reddish color and sandy clay composition, is the dominant unit of the Wedron Group in the watershed area and occurs at the base of the Group. The Henry Formation, predominantly composed of sand and gravel, interbeds with the Tiskilwa and younger Wedron Group tills and is often present along major streams such as the Mackinaw River and Panther Creek. Locally, these sand and gravel deposits may reach depths of 60 feet below land surface and occasionally combine with uppermost Glasford Formation sand and gravel units to provide small to moderate local private water supplies. Not all areas near major waterways within the watershed have shallow, productive aquifers because outwash interbedded with tills is usually not a dependable source of groundwater.

Landscape Features

The region's landscape features were formed by processes associated with multiple glacial advances across the area. Most of the Mackinaw River watershed falls within the physiographic division called the Bloomington Ridged Plain; the western one-quarter of the watershed falls within the Springfield Plain (Figure 2-9). Both are subdivisions of the Till Plains Section of the Central Lowland Province (Leighton and others 1948). The Bloomington Ridged Plain is characterized by a succession of end moraines that cross the land surface in general northwest–southeast-trending arcs. The Springfield Plain refers to the part of the watershed beyond the maximum extent reached by glaciers of the Wisconsin Episode.

The landscape can also be characterized as uplands and lowlands connected by slopes. Uplands are the extensive regions of higher ground, including the area of end moraines and ground moraine in the Mackinaw River watershed. Lowlands are low-lying areas especially along valleys, such as floodplains and similar areas of alluvial deposition.

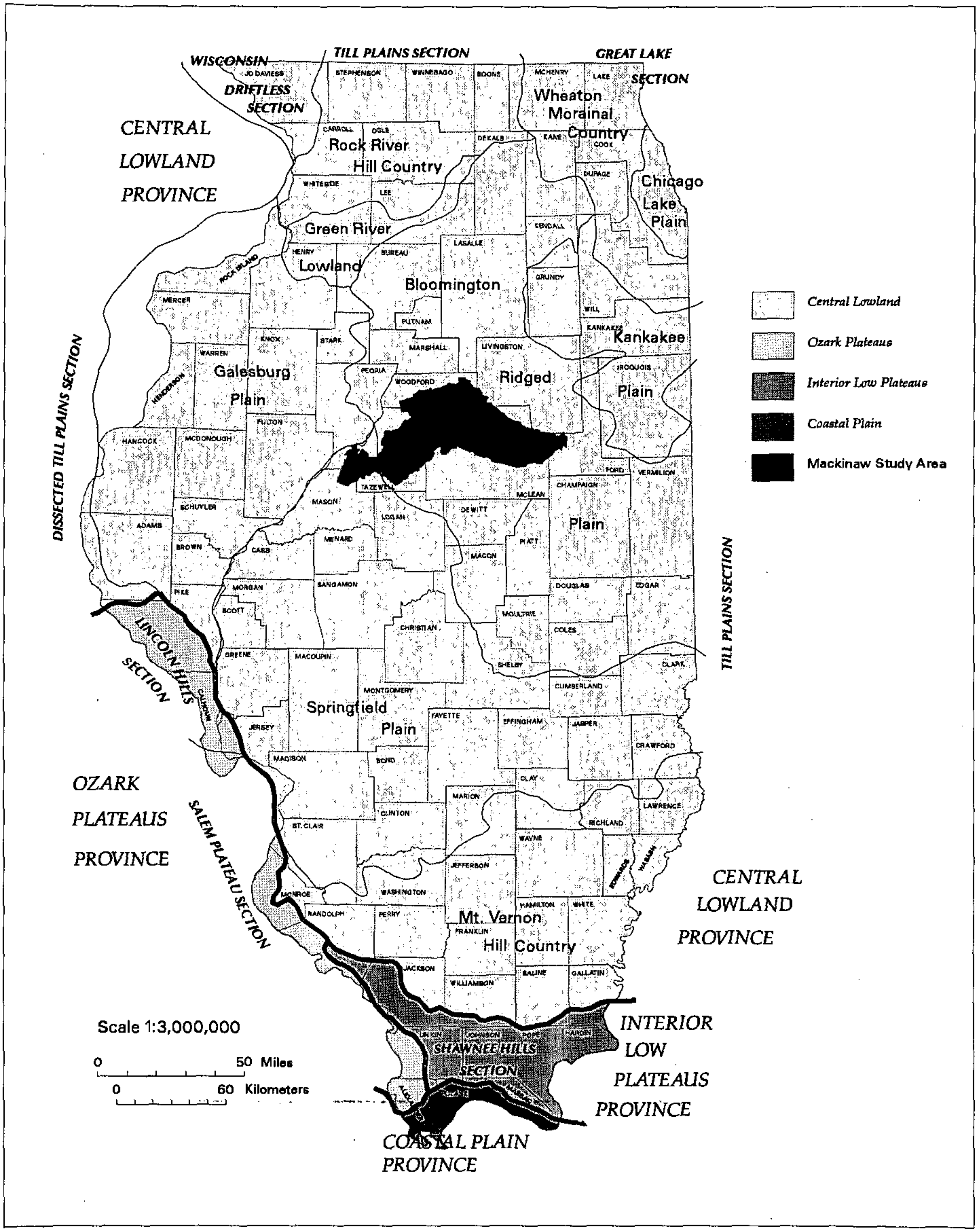

Figure 2- 9. Physiographic Divisions of Illinois (from Leighton, Ekblaw, and Horberg 1948)

Soils and Relationship to Habitat Development

Soil Geomorphology

Factors of Soil Formation

The Mackinaw River watershed contains some of the most productive soils in Illinois, as indicated by the extensive distribution of agricultural land cover **(see Land Cover map, Part III:** Living Resources). Soil development in the Mackinaw River watershed is strongly influenced by topographic, geologic, and biological differences that create habitats conducive to the development and survival of various natural communities. Topographic controls of drainage and erosional and depositional processes are important in the long-term development of the landscape. Differences in the frequency, rate, and magnitude of surficial geologic processes have created many combinations of angle, length, and orientation of slopes that now influence local drainage and erosional and sedimentation processes (Figure 2-10). These variations directly affect local natural communities. Most soils in the area have developed under deciduous forests (alfisols) or prairie grasslands (mollisols). The two types can be differentiated by the organic matter accumulated in the upper soil horizon. Mollisols tend to be more fertile and have a darker soil color (black to dark brown), whereas alfisols are not as organic rich and have thinner upper soil horizons.

The overall thickness of geologic materials (primarily loess) in which soils have developed varies across the basin from the far western part to the east. The loess cover is rather continuously distributed in its physical and chemical characteristics across the landscape. Windblown silt (loess) covers most of the Mackinaw River watershed, generally to a thickness of about 10 feet in the western part of the watershed and thinning quickly eastward to 3–4 feet. The loess overlies medium to fine textured, loamy or sandy loam glacial sediments (till and lacustrine) in the eastern half of the watershed (Figure 2-5). At the mouth of the watershed, thick deposits of outwash and eolian sediments from the Wisconsin Episode dominate the parent materials. The loess, till, and outwash differ significantly in their permeability, erodibility, and physical and chemical characteristics. The predominance of loess as the uppermost parent material creates an erosion hazard in some parts of the watershed due to its erodibility. These differences in characteristics between materials also affect the development of local habitats by influencing water table elevations, erosional and sedimentation patterns, and water chemistry.

Soil Classification

The soils in the Mackinaw River watershed are of two main orders, alfisols and mollisols, with scattered occurrences of entisols on floodplains and sandy outwash areas. In

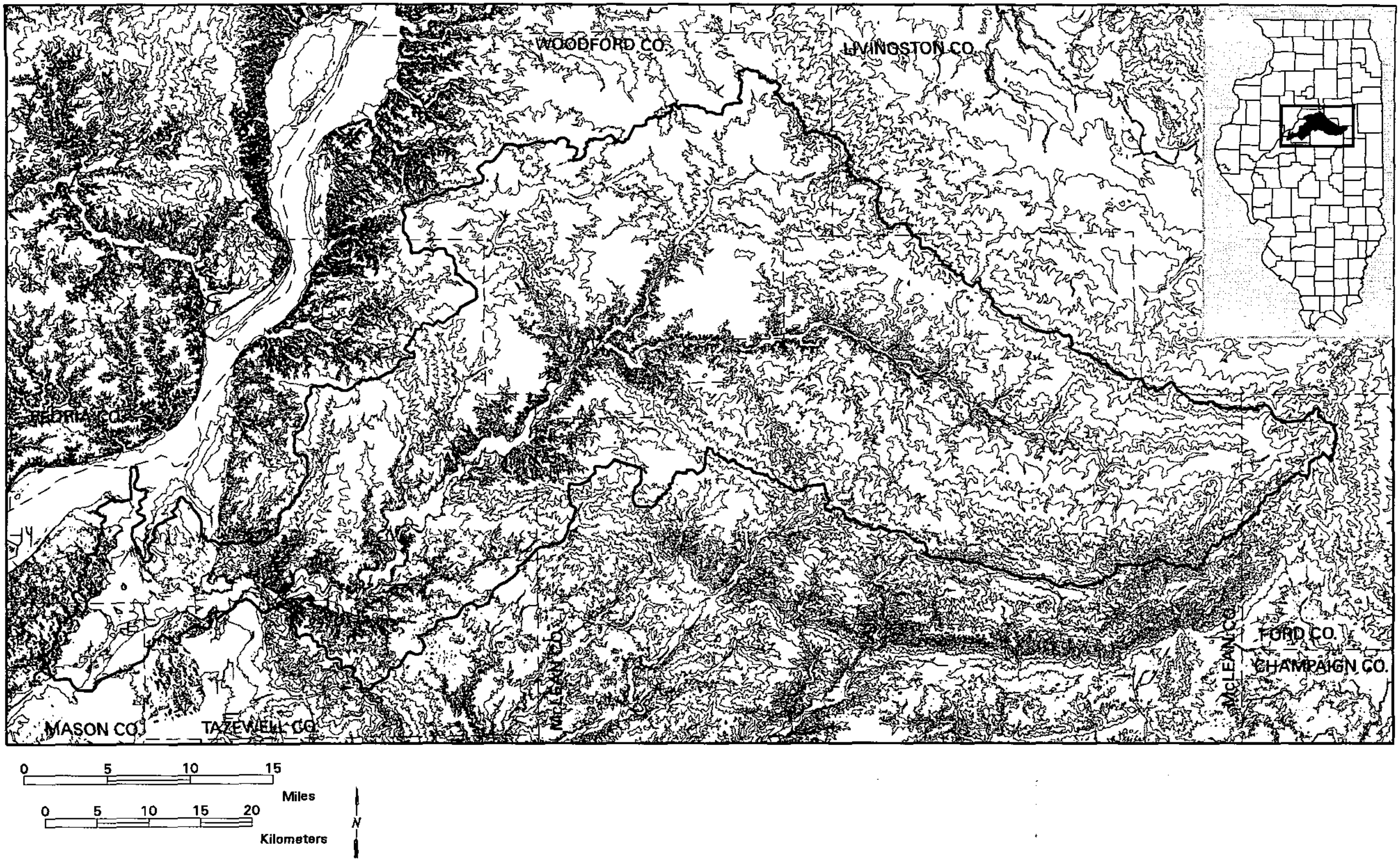

Figure 2- 10. Topography of Land Surface (contour interval 5 meters, or 16.4 feet)

general, alfisols have developed under forest vegetation, while mollisols have developed under natural prairie or marsh vegetation. Entisols (soils with minimal soil horizon development) occupy small acreages in the area but are still significant because, where exceptionally sandy sediments exist, they help create niche communities. Very poorly and poorly drained mollisols and alfisols are common along drainages, floodplains, and flat upland areas and can also play an important role in the development and maintenance of local plant communities.

The soil associations map (Figure 2-11) indicates that soils immediately adjacent to the Mackinaw River are mainly sandy to clayey alluvial soils on bottomlands that are subject to frequent flooding and overbank sediment deposition. High water tables, frequent flooding, and sedimentation create a large variety of habitats and make these areas prime wildlife and wetland areas when they have not been cleared for cultivation. The steeper slopes adjoining the floodplains are often susceptible to severe soil erosion through sheetwash and the development of extensive gully networks. This eroded sediment is often transported into small local channels and ultimately into the larger drainages. Uncontrolled erosion and sedimentation can seriously damage in-channel and streambank biological communities by altering water tables, channel capacity, and channel geometry. The extensive distribution and thickness of loess across the watershed further contributes to the erosion hazard. The upland areas between tributary drainages and in the uppermost parts of the watershed are often level and poorly to somewhat poorly drained. Prime farmland is located in these uplands, as shown by the land cover map **(see Part IV: Living Resources).** More than 75% of the land in these areas is used for row crop agriculture; in some subbasins, such as Henline Creek, Crooked Creek, East and West Panther Creek, and Money Creek, more than 82% of the basin is in row crop agriculture. These subbasins are dominated by Ipava, Tama, Sable, Drummer, Saybrook, and other very productive mollisols (Figure 2-11). The Mackinaw River subbasin has extensive grassland and wooded land, which suggests the difficulty of cultivating the dissected and eroded landscape in this area. The four subbasins farthest downstream in the watershed are less agricultural because of the sandy parent materials.

In general, soils classified within the same association will behave similarly and can be treated as a single unit for general planning purposes (Figure 2-11). Differences in drainage class are often the reason for differences in soil characteristics on a local scale. The large-scale soil maps in the county soil survey report are valuable sources of information regarding local conditions. Tabulated information within the report summarizes the physical and chemical characteristics of each soil series, as well as its capabilities and limitations for various land uses.

Because of their topographic position, lowland wet areas are often the location for accelerated deposition of sediment eroded from adjacent upland areas that have been or are currently in cultivation or transition from undisturbed natural vegetation. The physical load of sediment can accumulate quickly enough to bury part of the modern soil. Evidence of this process can be seen in the vertical soil profiles exposed along stream courses where a dark soil horizon is overlain by recently deposited, lighter colored sediments. Such profiles are evidence of accelerated erosion processes related to human activ-

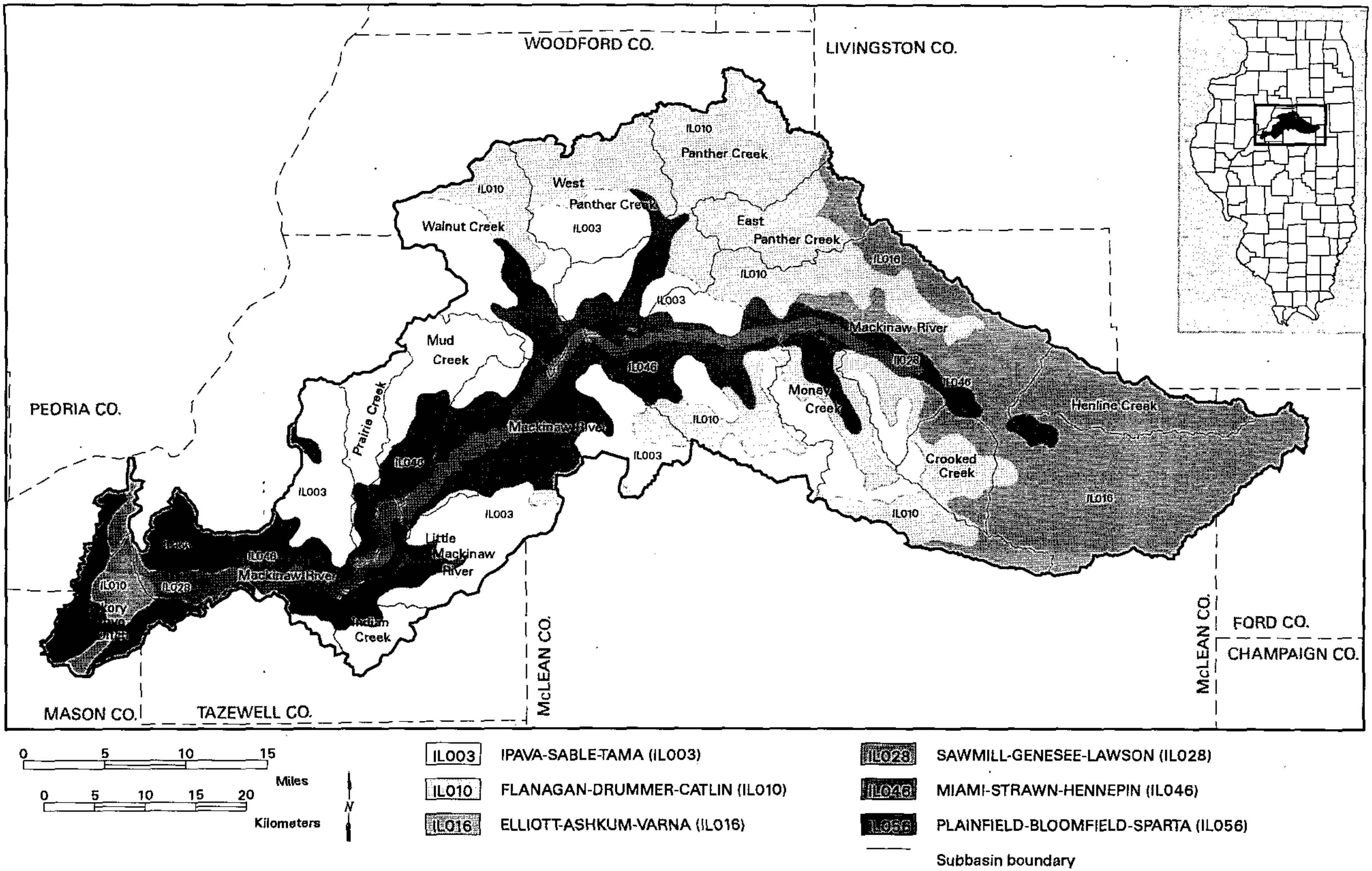

Figure 2- 11. Soil Associations

ity and indicate current and potential problems within the drainage system.

Potential Erosion Hazards

Loess is very erodible. When dry it has the consistency of talcum powder, and if unprotected it is easily moved by wind. When subjected to running water, it is rapidly incised and develops into a dissected landscape characterized by rills and gullies that are difficult to control. A characteristic landscape drainage pattern develops in which the contour lines are highly crenulated; such a landscape occurs just east of the Illinois River and along the Mackinaw River (Figure 2-10). Most of the eroded soils are located on slopes adjacent to stream channels and along the Mackinaw River and moraines. Loess is the uppermost parent material over much of the Mackinaw River watershed and often overlies less permeable geologic materials such as fine textured tills, especially in the eastern two-thirds of the watershed. This contrast in permeability and erodibility creates problems in land management, especially when the overlying loess unit is completely dissected and the less permeable materials are exposed at the land surface.

Silt deposits are particularly susceptible to erosion by running water because of the tendency for piping to develop within the deposits. Piping is common when surface water penetrates the subsurface and flows along macropores, such as channels formerly occupied by roots, or other natural fractures in the ground. Because silt deposits have low shear resistance, they are easily dispersed and carried by water running in the pipes. These natural underground pipes may enlarge and ultimately collapse, causing the ground surface to subside and form small surface drainage channels. These channels then begin to collect and transport sediment and water as they are integrated into the local drainage system.

Sloping, forested soils are especially susceptible to piping, and hillside gullies often begin in them, even when the ground surface has not been disturbed by deforestation or cultivation. Once begun, these small rills and gullies can quickly enlarge and erode upstream, extending the drainage network and directing increased water and sediment into the existing drainage system. The increased water and sediment discharge can initiate streambank erosion and streambed changes that are detrimental to in-channel biological communities. Lowland areas may be inundated with sediment that degrades wildlife food supplies and fills stream channels, decreasing their capacity to transport water and increasing the frequency of overbank discharges. Pools along a stream are especially prone to damage from sedimentation. Pesticides and other agricultural chemicals adsorbed on the sediment particles may also be deposited.

Because most soils in the Mackinaw River watershed have loess as their uppermost parent material, the potential for soil erosion is moderate to high, especially on sloping land along stream valleys and moraines. The sandy loam soils of the lower basin are not as susceptible to erosion because they generally occur on level land. They will, however, erode quickly where water runs off slopes and where water runoff from cultivated land is concentrated. These sandy soils have very high rates of infiltration and are generally well to excessively well drained.

Land use and management practices are especially important in controlling erosion on loessial soils. Damaged land should quickly be remediated and appropriate erosion control measures implemented to prevent additional damage to the landscape. It is unlikely that severe erosion caused by gullying on hillslopes will self-repair quickly enough to prevent extensive damage to adjacent land. Gullies developing in loess can quickly achieve depths too great for farm equipment to cross and eliminate through tillage. Farming along narrow ridgetops is generally not advisable because transition zones do not occur along field edges to trap and hold runoff from the field before it enters hillside drainage channels.

Potential Geologic Hazards

A critical step towards determining proper land uses in the Mackinaw River watershed is understanding the potential geologic hazards in the area. Geologic hazards can develop during interactions between geologic materials and natural forces. Human activity can also contribute to hazards. The following discussion identifies some of the types of geologic hazards, including groundwater contamination, which can occur in the Mackinaw River watershed. They do not characterize all site-specific geologic conditions or hazards. *The Citizens' Guide to Geologic Hazards,* prepared by the American Institute of Professional Geologists, provides a broader survey of geologic hazards and what measures to take when they occur. It covers a range of hazards in terms of geologic materials, such as radon and asbestos, and geologic processes, such as earthquakes, landslides, and flooding. Its appendices list sources of help from professional geologists and insurance professionals. This publication may be ordered from:

American Institute of Professional Geologists
7828 Vance Drive
Suite 103
Arvada, CO 80003
telephone number: (303) 431-0831

Potential for Contamination of Groundwater Resources

Groundwater contamination can occur from many different sources. These sources are of two classes, point or nonpoint, based on the size of the area where waste is disposed or a chemical is applied or spilled on the soil. Point sources of contamination can be many types of facilities and activities, including landfills, chemical storage tanks (both above and below ground surface), pesticide and fertilizer dealers and applicators, individual septic systems, homeowner disposal of unwanted chemicals (e.g., paint, used motor oil), and homeowner overapplication of lawn fertilizers and pesticides.

The primary nonpoint source of potential groundwater contamination in the watershed is the agricultural use of pesticides and fertilizers. Urban and suburban sources of groundwater contamination, such as septic systems and overuse of lawn fertilizers and pesticides, can also become nonpoint sources if a significant concentration of point sources occurs in a subdivision.

It is important to understand that groundwater contamination only occurs when potential contaminants, resulting from application or disposal of chemicals or disposal of wastes, exist in amounts too large for complete degradation or immobilization to occur. Therefore, disposal or application in an area does not always result in groundwater contamination. Responsible chemical use and prompt cleanup of spills can prevent the contamination of groundwater. It can also be helpful to restrict or closely monitor activities that can contribute to groundwater contamination, particularly when they are conducted in or near the setback zone of a water supply well. The Illinois Environmental Protection Agency supplies information on the delineation of setback zones and evaluates activities around water supply wells covered by the Illinois Groundwater Protection Act (Illinois Environmental Protection Agency 1995).

The present landscape, soils, and geologic material sequences in the watershed are the legacy left by the diversity of geologic processes that have affected the surface of Illinois. The potential for groundwater contamination in an area depends on both the properties of the geologic materials in the area and the quantity and nature of the contaminant in question. Important factors that affect the potential for groundwater contamination include:

- the hydraulic conductivity (permeability) of the soil and geologic deposits;
- the depth from ground surface to aquifer materials (sand and gravel, sandstone, or fractured/jointed limestone and dolomite) and the thickness of confining units;
- the amount of clay and organic matter in the soil and geologic deposits;
- the amount and form of the chemical spilled or applied (for example, 2 pounds of dry pesticides as opposed to 200 gallons of gasoline);
- the depth from land surface and the area of land exposed to the chemical (for example, a pesticide applied over 640 acres of land at the land surface as opposed to gasoline leaking from a hole in a storage tank 15 feet below land surface);
- chemical characteristics of the applied compounds (such as water solubility, chemical/microbial degradation rates) and the likelihood of the chemical to cling to clay particles and organic matter; and
- climatic variables (such as rainfall amounts and intensities, temperature, wind speed, and relative humidity).

In addition to these material and chemical factors, several natural processes affect the ultimate fate of chemicals at or below ground surface. These processes include:

- chemical loss through rainfall runoff and soil erosion;
- infiltration through the soil surface;
- percolation through the unsaturated soil and geologic materials;
- leaching through saturated soil and geologic materials;
- volatization of a liquid chemical to its gaseous form;
- sorption (the tendency of a chemical to stick to and detach from clay particles or organic matter); and
- degradation of the chemical into smaller molecules by microbial action or other means.

Groundwater contamination does not always produce contamination of a drinking water source. As discussed in the sections on aquifer delineation and water use, most public and private water supplies are obtained from tubular, drilled wells finished in aquifers. Locations where the top of the aquifer lies at significant depth are less likely to be contaminated from near-surface sources than locations where the top of the aquifer lies at shallow depths (generally less than 50 feet).

The sensitivity of aquifers to contamination from near-surface sources can be evaluated by examining soil and geologic characteristics. From the eastern boundary of the watershed study area, near Sibley in Ford County to south of Goodfield in Woodford County, the Mackinaw River watershed has relatively limited aquifer sensitivity to contamination by agricultural chemicals. This protection is primarily due to the depths to the uppermost aquifers (usually greater than 50 feet) and the fine grained texture of the soils and the underlying tills, which can greatly reduce the mobility of any spilled chemicals. From south of Goodfield to northeastern Mason County, however, the watershed has very shallow aquifers (the top of sand and gravel outwash materials and dune sand is less than 20 feet below land surface). The sensitivity to chemical contamination dramatically increases when shallow aquifers and their well-drained soil counterparts are overlain by porous geologic materials. The Plainfield-Bloomfield, Sparta-Plainfield-Ade, and Onarga-Dakota-Sparta soil associations (see Soils and Relationship to Habitat Development section and Figure 2-11 above) are particularly vulnerable to leaching because they are excessively to well drained, sandy and loamy soils that occur on sloping stream terraces and dunes.

A study of water quality in rural, private water wells conducted by the Illinois State Geological Survey, the Illinois State Water Survey, and the Illinois Department of Agriculture (Schock and others 1992) has shown that the occurrence of agricultural chemicals is most closely related to the presence of an aquifer within 50 feet of the well, the type of well construction, and the total depth of the well. In particular, well depth significantly limited the occurrence of agricultural chemicals in small-diameter, private, rural drinking-water wells. Groundwater wells deeper than 50 feet contained fertilizers and pesticides significantly less frequently than did wells shallower than 50 feet. Dug or bored wells were contaminated more frequently than drilled wells. One potential source of contaminants for large-diameter wells is use or mixing of chemicals near the wellhead. For more information on agricultural contamination studies done in an area, contact the State Water or Geological Surveys. It is not advisable to rely on one study to interpret the potential for contamination. The results may differ from from one study to an other, and geologic and hydrologic conditions generally change from one location to another.

Several publications by DNR agencies address issues related to groundwater contamination potential; these include Keefer 1995, Herzog and others 1995, Risatti and Mehnert 1995, and Schock and others 1992.

Regional Seismic History

PEKIN, ILL. October 31, 1895:
At 5:20 in the morning there was a severe earthquake shock. First came a sudden quick shock like an explosion, accompanied by low rumbling that seemed to come from the

sky. About a minute later there was a second shock, which lasted about a minute and a half. It awoke everybody, rattled windows and pictures. It rolled one man, who was sleeping in the third story of a building, out of bed, and in another part of town caused a bed to roll several inches. It caused much excitement, but did no damage.

The Dubuque, Iowa *Telegraph Herald*

Earthquakes are more an occasional curiosity than a dangerous hazard in the Mackinaw River watershed. Small earthquakes are known to have occurred in the area on rare occasions. Larger, more frequent earthquakes in the more seismically active regions of southern and southwestern Illinois also shake the area. The 1895 quake that so rudely awakened the residents of Pekin is a good example. Located about 10 miles south of Cairo, Illinois, it probably measured about 6.2 on the Richter magnitude scale. Very large earthquakes (magnitudes greater than 8.0) have occurred in the area just south of Illinois. Even the most powerful earthquakes from these southern regions, however, would cause only minor damage in the Mackinaw River watershed. Such very large quakes are not expected to recur in the near future.

A half-dozen small earthquakes have been reported over the last century from the watershed area and surrounding counties (Figure 2-12). All of these small earthquakes occurred before seismometers were installed in the region in the 1960s, so their magnitudes are only estimated as somewhere between 3.0 and 4.2. None of these small earthquakes was known to have caused any damage, and only the ones with estimated magnitudes of 4.0 or greater were even felt more than about 10 miles from their epicenters. These small earthquakes occur about every 20 years and could possibly reach magnitudes as great as 5.0. At that energy, minor damage such as broken chimneys and cracked or broken plaster walls could be expected. So few earthquakes occur in the region that it is difficult to locate the fault or system of faults responsible for them. A regional bedrock feature named the La Salle Anticlinorium, a composite upfold consisting of a series of "ripples" in the crustal rocks beneath much of east-central Illinois (see Bedrock Geology section above), could theoretically produce earthquakes. However, the few earthquakes that have been reported do not appear to be related to this or any other known feature.

The Mackinaw River watershed is more frequently shaken by earthquakes that occur outside the watershed. Magnitude 4.5 to 5.0 earthquakes occur in northern Illinois about every 20 years. The most recent was a magnitude 4.6 earthquake in 1974 that was felt in the watershed area, particularly by people who were indoors at the time. The Wabash Valley Seismic Zone, about 200 miles to the southeast, produces magnitude 5.0 earthquakes about every 10 years. The magnitude 5.0 earthquake of 1987 and the magnitude 5.2 earthquake of 1968 were felt in central Illinois by people indoors but generally not by people outdoors at the time. An earthquake centered in the Wabash Valley region in 1891 shook the ground in Bloomington so much that "some people rushed out into the streets." The Wabash Valley area could produce earthquakes as large as magnitude 6.5. These larger quakes might cause damage to chimneys and older brick structures in the Mackinaw watershed, but the likelihood of their occurring in the near future is very low.

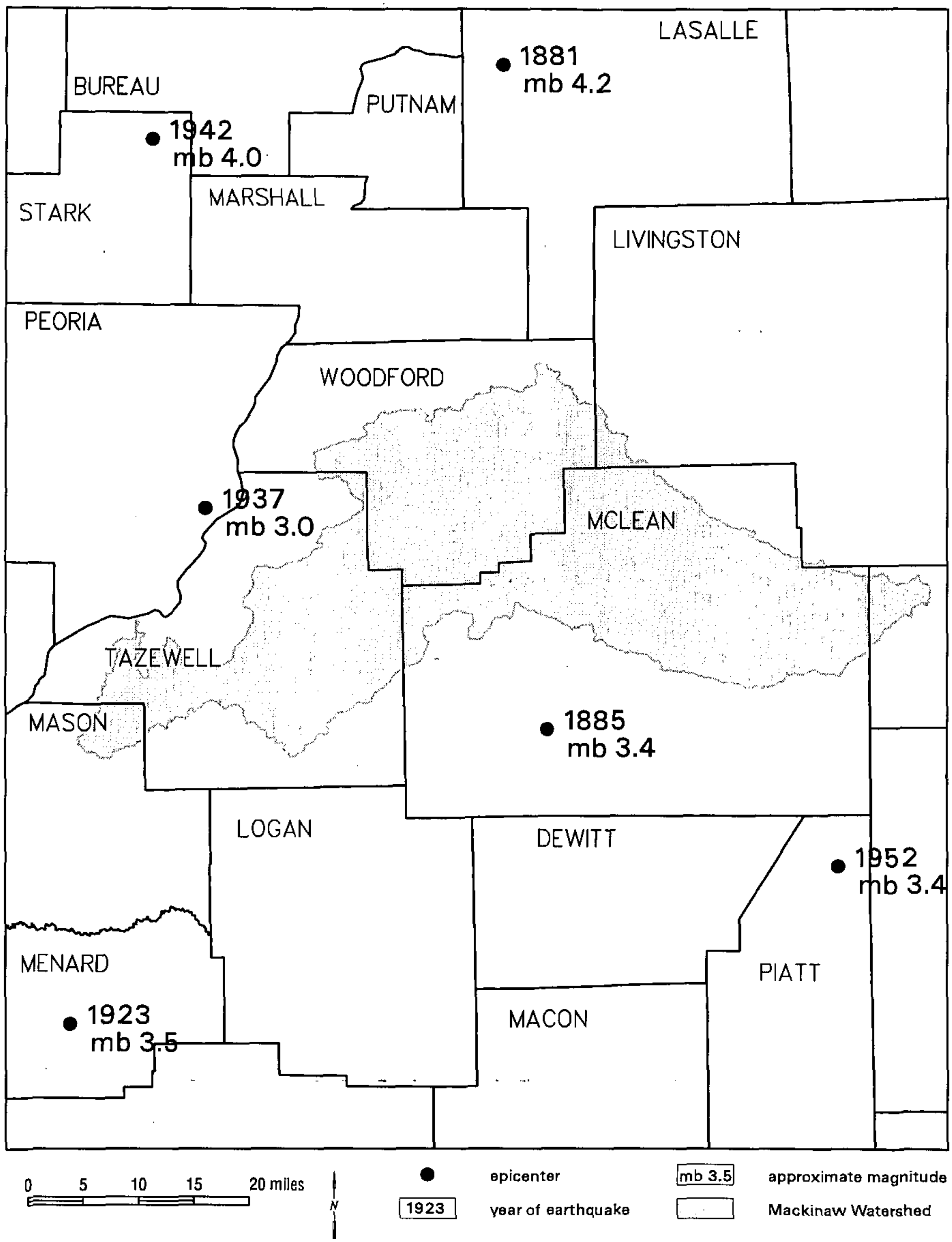

Figure 2- 12. Earthquakes in Vicinity of Mackinaw River Watershed
(St. Louis University Earthquake Center database, 1996)

he New Madrid Seismic Zone in far southern Illinois, Missouri, and Tennessee can produce very powerful earthquakes, but because it is 270 to 350 miles to the south, the resulting ground motions in the Mackinaw River watershed are not expected to be dangerous. The 1895 magnitude 6.2 earthquake that woke people in Pekin occurred in the northern part of the New Madrid Zone and caused severe damage in southern Illinois towns. A similar earthquake, with similar effects, is expected to occur in the New Madrid Seismic Zone sometime in the next 15 years.

An even stronger series of earthquakes occurred in the New Madrid Seismic Zone in 1811–1812. Devastating earthquakes, probably as large as magnitude 8, occurred three times that winter. Ground motions in the Mackinaw River watershed from those earthquakes are not recorded, but the estimated motions would probably have been strong enough to damage masonry structures. Fortunately, such large earthquakes are not expected to recur within the next several hundred years.

Although the Mackinaw River watershed has experienced increases in population, public and private industry, and building construction during the past century, its vulnerability to damaging seismic activity remains relatively low.

Landslides and Soil Erosion

When most people think of landslides they usually envision a massive body of boulders, gravel, sand, and dirt crashing down a hillside, destroying everything in its path. Rightfully so, for that type of "mass wasting," as geologists call it, often occurs on landscapes dominated by steep slopes or frequent seismic activity. Several such landslides have been inventoried for Illinois and have generated millions of dollars in property damage. In the relatively young, low-relief, glacially sculpted landscape common to most of Illinois, however, more subtle mechanisms of mass wasting—which are equally as threatening and costly to engineers, community planners, and landowners as their more visible landslide counterparts—are more likely to occur.

Nearly 60 % of landslides inventoried thus far in Illinois are "slumps" (Killey and others 1985). A slump is a mass of rock or earth that moves down along one or more underground surfaces of slippage within, or between, the mass and the body of rock or earth beneath it. Slump-type landslides can be recognized by one or more of the following characteristics:

- a sharp cliff (also called a "scarp") several inches to several feet high, resulting from the initial downward movement
- one or more additional scarp faces resulting from successive slump movement
- poor drainage (ponding or development of marshy areas) due to disturbance of normal drainage patterns
- dead trees (due to root damage or excess moisture) and tilted trees, fence posts, and utility poles (Killey and others 1985).

Only one landslide has been recorded for the Mackinaw River watershed since all landslides known up to March 1983 were inventoried (Killey and others 1985). This natural landslide occurred near the Mackinaw River, approximately 7 miles south of the town of Secor, Woodford County. The landslide was an earth slump and measured 300 feet long by 150 feet wide. The landslide was caused by stream erosion, and its date of last known movement was September 1980.

Information on landslides in Illinois is contained in *Landslide Inventory of Illinois* (Killey and others 1985), produced by the Illinois State Geological Survey in cooperation with the United States Geological Survey. This publication contains historical photos of landslides that occurred in Illinois and information on landslide classification, factors contributing to landslide potential, and what can be done to stabilize landslides. It may be purchsaed from the Illinois State Geological Survey.

Soil Erosion

Information concerning soil erosion and potential geologic hazards that result from soil erosion can be found in the Potential Erosion Hazards section above.

Coal Mine Subsidence and Acid Drainage

The coal industry has long been an important component of the Illinois economy. Currently, coal generates approximately 40% of the electricity in the state. The coal mining industry directly and indirectly employs about 41,000 people (Bauer and others 1995). Despite its obvious economic contributions, coal production can threaten many natural resources. Mine subsidence (sinking of the land surface over mined-out areas) can damage structures and affect farmland productivity, and unreclaimed mine wastes can pollute air and water resources. Achieving a balance between the advantages and disadvantages of coal production can be aided when citizens are knowledgeable about past and present coal mining methods, and how these methods affect natural resources.

The Mackinaw River watershed has had little mining. One coal mine, just south of Roanoke, in Woodford County, operated from 1883 to 1940. In 1883, a shaft was sunk 276 feet to a 40-inch-thick seam of coal. The coal was of poor quality, so the following year, the shaft was deepened to 480 feet to reach a 30-inch seam of Colchester coal. Because of the coal's very high quality, the mining company wanted to extract as much of it as possible and used the "longwall" method. In this method, which removes all of the coal, the roof of the mined-out area is supported by backfilling the voids with rock from the hallways and from beneath the coal being mined nearby. As the overburden (rock and earth between the mine ceiling and the land surface) subsides, backfilled rock is crushed to about 50% of its original thickness. This subsidence normally occurs days to several weeks after extraction and backfilling, depending on the rate of mining. All settling associated with the Roanoke mine, therefore, would have occurred years ago.

Piles of mining waste, often called "gob piles," can present another potential hazard. Composed of mostly shale (clay-rich rock) and poorer quality coals, the unusable waste often contains sulfur-rich minerals, especially pyrite and marcasite. These minerals react with water and oxygen from the atmosphere to produce sulfuric acid; eventually, precipitation initiates runoff which may transport the sulfuric acid to nearby water resources. The net effect is an increase in acidity of water resources, which can affect aquatic life and weaken concrete structures such as bridge piers, retaining walls, utility pipes, and well casings (Nuhfer and others 1993). At Roanoke, much of the mine refuse was used by a local company to make bricks and clay tiles. However, a large gob pile, covering approximately 8 acres, remains.

Two essential publications for land-use planners and homeowners who want to learn more on coal mine subsidence are *Planned Coal Mine Subsidence in Illinois, A Public Information Booklet* (Bauer and others 1995) and *Mine Subsidence in Illinois: Facts for Homeowners* (Bauer and others 1993). These booklets contain information on coal-mine reserves in Illinois, coal-mining methods, the history of subsidence in Illinois, steps to take if subsidence occurs, and sources for additional information. Contact the Illinois State Geological Survey to purchase these publications.

Appendix: Overview of Databases

Illinois Wetlands Inventory

This digital database contains the location and classification of wetland and deepwater habitats in Illinois. Following U.S. Fish and Wildlife Service definitions, the Illinois Natural History Survey (INHS) compiled the information from interpretations of 1:58,000-scale high-altitude photographs taken between 1980 and 1987. Identifiable wetlands and deepwater habitats were represented by point, line, and polygons on 1:24,000-scale U.S. Geological Survey (USGS) 7.5-minute quadrangle maps. These data were digitized and compiled into the Illinois Wetlands Inventory. Because no wetland or deepwater habitats smaller than 0.01 acre were included, many farmed wetlands are not in the database. This database is appropriate for analysis on a local and regional scale; due to the dynamics of wetland systems, however, boundaries and classifications may change over time. For detailed explanation of wetland classification in Illinois, see *Wetland Resources of Illinois: An Analysis and Atlas* (Suloway and Hubbell 1994).

Quaternary Deposits of Illinois

Originally automated in 1984 , this database is the digital representation of the 1:500,000-scale map *Quaternary Deposits in Illinois* (Lineback 1979). Because these data, modified by Hansel and Johnson (1996), represent a generalization of the glacial sediments that lie at or near the land surface, this database is most appropriate for use at a regional scale. For further information about surface deposits in Illinois, see *Wedron and Mason Groups: Lithostratigraphic Reclassifications of the Wisconsin Episode, Lake Michigan Lobe Area* (Hansel and Johnson 1996).

Thickness of Loess in Illinois

This database contains 5-foot-interval contour lines indicating loess thickness on uneroded upland areas in Illinois. This data was originally automated in 1986 from the 1,1:500,000-scale map in *Glacial Drift in Illinois—Thickness and Character* (Piskin and Bergstrom 1975, plate 1). This database is most appropriate for use at a regional scale.

Thickness of Surficial Deposits

This database contains polygons delineating glacial and stream materials throughout the state, with thicknesses ranging from less than 25 feet to greater than 500 feet. The data were originally automated in 1986 from the 1,1:500,000-scale map in *Glacial Drift in Illinois—Thickness and Character* (Piskin and Bergstrom 1975, plate 1). This database is most appropriate for use at a regional scale.

Noncoal Mineral Industry Database

Compiled by the ISGS from Illinois Office of Mines and Minerals permit data and information from the ISGS Directory of Illinois Mineral Producers, this database contains the locations of mineral extraction operations (other than coal, oil, and gas producers) in Illinois. The database contains both active and inactive sites and is updated every year. The 1996 data include 7 active underground mines and 449 active surface pits and quarries. This is a point database and is appropriate for analysis on a local to regional scale. For more information on the current locations of noncoal mineral extraction sites or on the location of potential noncoal mineral resources, contact the Industrial Minerals Section of the Illinois State Geological Survey.

1:100,000-Scale Topography of Illinois

Depicting the general configuration and relief of the land surface in Illinois, this database was compiled by the ISGS from 1:100,000-scale digital line graph (DLG) format data files, originally automated by the USGS from USGS 1:100,000-scale 30- by 60-minute quadrangle maps. The USGS collected the land surface relief data for Illinois from stable-base manuscripts, photographic reductions, and stable-base composites of the original 1:100,000-scale map separates using manual, semiautomatic, and automatic digitizing systems. The contour interval of this topographic data is 5 meters (16.4 feet). These digital data are useful for the production of intermediate- to regional-scale base maps and for a variety of spatial analyses, such as determining the slope of a geographic area. DLG format topographic data are available from the USGS and can be downloaded on the Internet from

http://edcwww.cr.usgs.gov/glis/hyper/guide/100kdlgfig/states /Il.html

A full description of the DLG format can be found in *Digital Line Graphs from 1:100,000-Scale Maps—Data Users Guide 2* produced by the USGS. These data are also available from the ISGS in ARC format.

State Soil Geographic (STATSGO) Database for Illinois

The Illinois STATSGO was compiled by the USDA Natural Resources Conservation Service (NRCS). The database is the result of generalizing available county-level soil surveys into a general soil association map. If no county survey was available, data on geology, topography, vegetation, and climate were assembled along with Land Remote Sensing Satellite (LANDSAT) images. Soils of like areas were studied, and the probable classification and extent of the soils were determined. The data were compiled at 1:250,000-scale using USGS 1° x 2° quadrangle maps. This database was designed to be used primarily for regional, multistate, state, and river basin resource planning, management, and monitoring. It is not intended to be used at the county level. Illinois STATSGO data are available in DLG, ASCII, or ARC format and can be downloaded on the Internet from

http://www.gis.uiuc.edu/nrcs/soil.html

The data are also available from the ISGS in ARC format. For more information visit the USDA web site or contact the Natural Resources Conservation Service, 1902 Fox Drive, Champaign, IL 61820.

Land Cover Database of Illinois

Compiled for the IDNR Critical Trends Assessment Project by the INHS, the land cover database is intended as a base line for assessment and management of biologic natural resources in Illinois. Six major land cover classes were defined using Thematic Mapper (TM) satellite data. Dates of the imagery range from April 1991 to May 1995. Ancillary data used to interpret the TM imagery include the 1992 Topologically Integrated Geographic Encoding and Referencing System (TIGER) line files, the Illinois Wetlands Inventory, NRCS county crop compliance data, 1988 National Aerial Photography Program (NAPP) photography, and USGS transportation and hydrography data. This database is most appropriate for use at medium and regional scales. For more information on land cover in Illinois see *Illinois Land Cover, An Atlas* (Illinois Department of Natural Resources 1996).

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Part III

Water Resources

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Introduction

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- Lakes .... H. Vernon Knapp
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- Land Use .... Laura Keefer, Susan Shaw

Climate and Trends in Climate .... James Angel, Beth Reinke

Streamflow .... H. Vernon Knapp, Gana Ramamurthy, Kenneth Nichols

Erosion and Sedimentation .... Misganaw Demissie

Water Use and Availability

- Ground-Water Resources .... Kenneth Hlinka, John Blomberg, Kay Charles
- Surface Water Resources .... H. Vernon Knapp

Ground-Water Quality .... Kenneth Hlinka, John Blomberg, Thomas Holm

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Introduction

The Mackinaw River is one of the major tributaries to the Illinois River, draining an area of 1,138 square miles (sq. mi.) in central Illinois. Its watershed covers parts of six central Illinois counties: Ford, Livingston, Woodford, McLean, Tazewell, and Mason. The Mackinaw River originates in Ford County near Sibley and flows in a westerly direction before joining the Illinois River at River Mile 147.7 downstream of Pekin.

The Mackinaw River basin is located within the Bloomington Ridged Plain of the Till Plains section of the Central Lowland Province physiographic division. The Till Plain section is generally characterized by broad till plains, "which are uneroded or in a youthful stage of erosion," and the Bloomington Ridged Plain is further defined by "low broad morainic ridges with intervening wide and flat gently undulating ground moraine" (Leighton et al. 1948). The watershed elevations range from a high of 863 feet (above mean sea level, msl) in the headwater area to a low of 445 feet (msl) at the mouth of the river in the Illinois River valley.

Mean annual precipitation for the river basin is about 38 inches. The corresponding average annual streamflow is about 9.5 inches.

Rivers and Streams

Based on the U.S. Geological Survey's (USGS's) 1:100,000 Digital Line Graphs, there are more than 1,400 river miles in the Mackinaw River basin. (More detailed maps will, of course, show more river miles.) The drainage pattern and location of the stream channels in the basin are shown in Figure 3-1. Major tributaries, their drainage area, and the river miles within each sub-watershed are provided in Table 3-1. Those drainage areas outside of the major tributaries that drain directly to the Mackinaw River are grouped in the category "Main Stem Mackinaw River and Unnamed Tributaries."

Table 3-1. Drainage Areas and River Miles for Tributaries in the Mackinaw River Basin

	Drainage area (sq. mi.)	River miles (miles)
Panther Creek	193.2	182.3
Walnut Creek	72.0	93.3
Money Creek	69.2	92.7
Little Mackinaw River	51.4	68.8
Mud Creek	46.6	85.8
Henline Creek	40.6	38.9
Hickory Grove Ditch	32.6	23.2
Crooked Creek	29.3	38.2
Prairie Creek	23.0	30.5

Figure 3-1.
Stream Network in the
Mackinaw River Basin

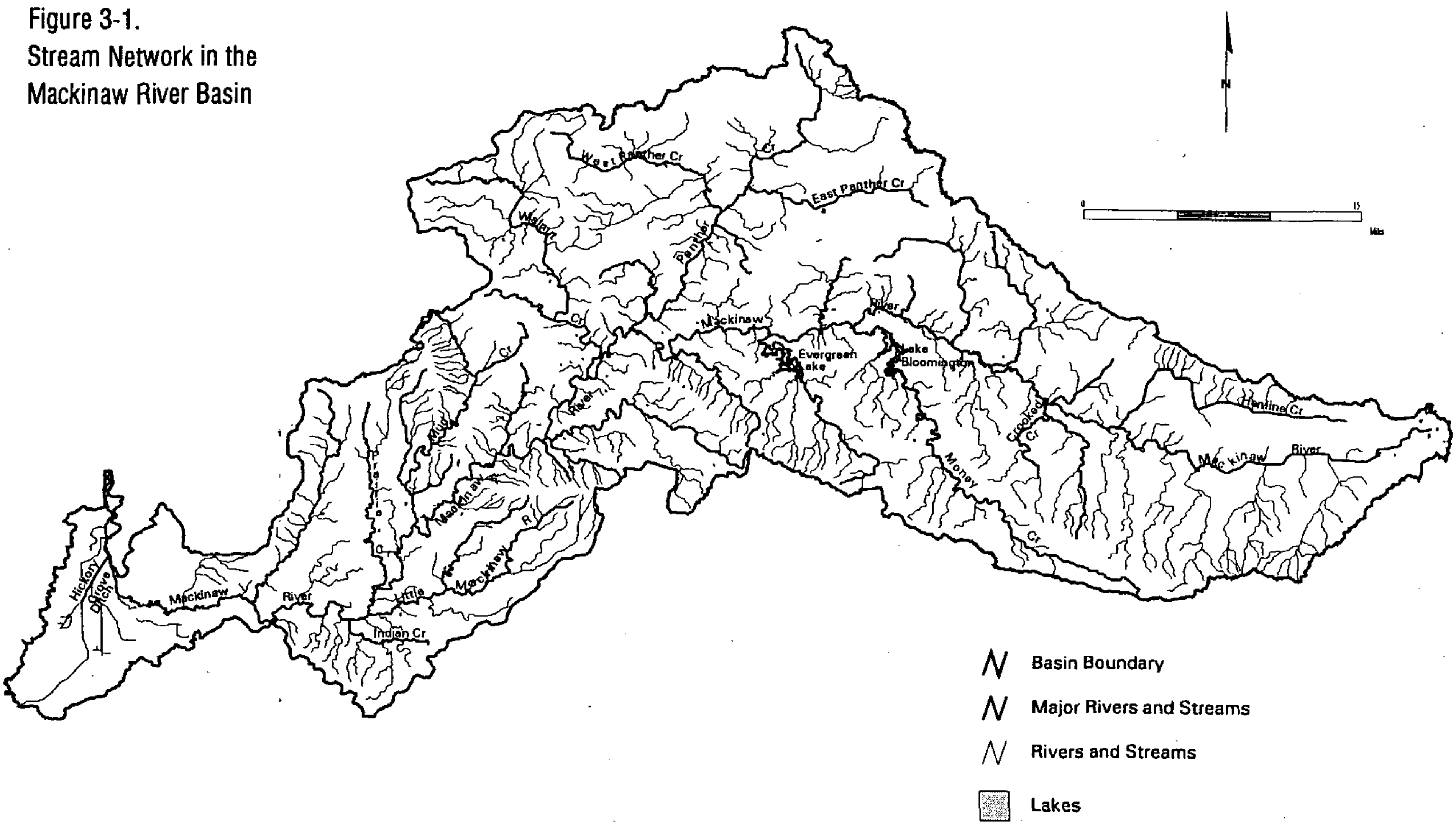


Table 3-1. Concluded

	Drainage area (sq. mi.)	River miles (miles)
Indian Creek	16.4	24.2
Main Stem Mackinaw River and Unnamed Tributaries	563.9	778.2

The largest tributary to the Mackinaw River is Panther Creek, with a drainage area of 193.2 sq. mi., which drains the northern part of the Mackinaw River basin. Other tributaries are relatively smaller, with drainage areas ranging from 16.4 to 72 sq. mi.

Lakes

There are six lakes in the Mackinaw River basin that have a surface area greater than 20 acres. These lakes are listed in Table 3-2. The largest and most notable are Lake Bloomington and Evergreen Lake, the water supply reservoirs for the city of Bloomington. Additional information for these lakes is given in the chapter titled *Water Use and Availability*. Prior to 1995, Lake Eureka was also used for public water supply.

Table 3-2. Significant Lakes and Reservoirs in the Mackinaw River Basin

Name	County	Year built	Surface area (acres)	Primary use
Evergreen Lake	Woodford	1970	700	Water supply
Lake Bloomington	McLean	1930	635	Water supply
Heritage Lake	Tazewell	1968	71	Recreation
Spin Lake	McLean	1972	29	Recreation
Venado Grande Lake	Tazewell	1975	N/A	Recreation
Lake Eureka	Woodford	1941	30	Recreation

Note: N/A = not available

In addition to the lakes listed in Table 3-2, there are numerous smaller lakes in the basin that provide recreation, including fishing and boating. All of the lakes in the basin are man-made reservoirs that have impounded a stream.

Wetlands

Wetlands are an important part of our landscape because they provide critical habitat for many plants and animals and serve an important role in mitigating the effects of storm flow in streams. They are also government-regulated landscape features under Section 404 of the Clean Water Act. In general, wetlands are a transition zone between dry uplands and open water; however, open-water areas in many upland depressional wetlands are dry at the surface for significant portions of the year.

The Mackinaw River basin has only about 1.2% (8,752 acres) of its total area in wetlands (Table 3-3). Approximately 60% (5,250 acres) of these wetlands exist in stream corridors and are classed as bottomland forest or riverine wetlands. (For wetland categories, see the table describing wetland and deepwater habitat in Part IV: Living Resources.)

Table 3-3. Wetlands in the Mackinaw River Basin

	Subbasin		Wetlands		
Subbasin name	Acres	% of basin	Acres	% of subbasin	% of total wetlands
Crooked Cr.	18,760	2.6	25.23	0.1	0.3
E. Panther Cr.	24,380	3.3	89.20	0.4	1.0
Henline Cr.	25,951	3.6	60.94	0.2	0.7
Hickory Grove Ditch	20,877	2.9	36.01	0.2	0.4
Indian Cr.	10,503	1.4	60.01	0.6	0.7
Little Mackinaw R.	32,922	4.5	297.39	0.9	3.4
Mackinaw R. (lower)	77,650	10.7	2,430.26	3.1	27.8
Mackinaw R. (middle)	62,122	8.5	1,765.28	2.8	20.2
Mackinaw R. (upper)	221,141	30.4	1,892.07	0.9	21.6
Money Cr.	44,285	6.1	333.55	0.8	3.8
Mud Cr.	29,801	4.1	333.29	1.1	3.8
Panther Cr.	61,618	8.5	576.52	0.9	6.6
Prairie Cr.	14,735	2.0	193.43	1.3	2.2
W. Panther Cr.	37,631	5.2	224.36	0.6	2.6
Walnut Cr.	46,092	6.3	434.80	0.9	5.0
Total	728,468	100.0	8,752.34	--	100.0

Note: Subbasin locations are depicted in the location map at the beginning of the volume.

The hydrogeology of wetlands allows water to accumulate in them longer than in the surrounding landscape, with far-reaching consequences for the natural environment. Wetland sites become the locus of organisms that require or can tolerate moisture for extended periods of time, and the wetland itself becomes the breeding habitat and nursery for many organisms that require water for early development. Plants that can tolerate moist conditions (hydrophytes) can exist in these areas, whereas upland plants cannot successfully compete for existence. Given the above conditions, the remaining wetlands in our landscape are refuges for many plants and animals that were once widespread but are now restricted to existing wetland areas.

The configuration of wetlands enables them to retain excess rainwater, extending the time the water spends on the upland area. The effect of this retention on the basin is to delay the delivery of water to the main stream. This decreases the peak discharges of storm flow or floods, thus reducing flood damages and the resulting costs. It is important to realize that the destruction of wetland areas has the opposite effect, increasing peak flood flows and thereby increasing flood damages and costs.

The location of wetlands affects many day-to-day decisions because wetlands are considered "Waters of the United States" (Clean Water Act) and are protected by various legislation at the local, state, and federal levels (for example, the Rivers and Harbors Act of 1899, Section 10; the Clean Water Act; and the Illinois Interagency Wetlands Act of 1989). Activities by government, private enterprise, and individual citizens are subject to regulations administered by the U.S. Army Corps of Engineers. Under a Memorandum of Agreement between federal regulatory agencies with jurisdiction over wetlands, the Natural Resources Conservation Service takes the lead in regulating wetland issues for agricultural land, and the U.S. Army Corps of Engineers takes the lead for all nonagricultural lands.

In contexts where wetland resources are an issue, the location and acreage of a wetland will be information required by any regulatory agency, whether local, state, or federal. Currently, there are two general sources of wetland location information for Illinois: the National Wetland Inventory (NWI), completed in 1980, and *Illinois Land Cover, an Atlas (ILCA)* by the Illinois Department of Natural Resources (1996). The State of Illinois used the NWI information to publish the *Wetland Resources of Illinois: An Analysis and Atlas* (Suloway and Hubbell 1994). While this atlas is not of suitable scale for landowners or government agencies to use for individual wetland locations, it can be used by agencies or groups that consider wetlands in an administrative or general government manner and focus on acreage and not individual wetland boundaries.

The NWI program involved identifying wetlands on aerial photographs of 1:58,000 scale and publishing maps of this information using USGS 1:24,000-scale topographic quadrangle maps as the base. NWI quadrangle maps for the Mackinaw River basin are shown in Figure 3-2. Individual quadrangles can be purchased from:

Center for Governmental Studies
Wetland Map Sales
Northern Illinois University
De Kalb, IL 60115
Telephone: (815) 753-1901

Digital data by quadrangle is available from the NWI Web site: http://www.nwi.fws.gov.

The ILCA inventory used Landsat Thematic Mapper satellite data as the primary source for interpretation. National Aerial Photography Program photographs verified the land cover classification and helped ensure consistency from area to area within Illinois. The ILCA and companion compact disc can be purchased from:

Illinois Department of Natural Resources
524 South Second Street
Lincoln Tower Plaza
Springfield, IL 62701-1787
Telephone: (217) 524-0500
E-mail: ctap2@dnrmail.state.il.us
Web site: http://dnr.state.il.us/ctap/ctaphome.htm

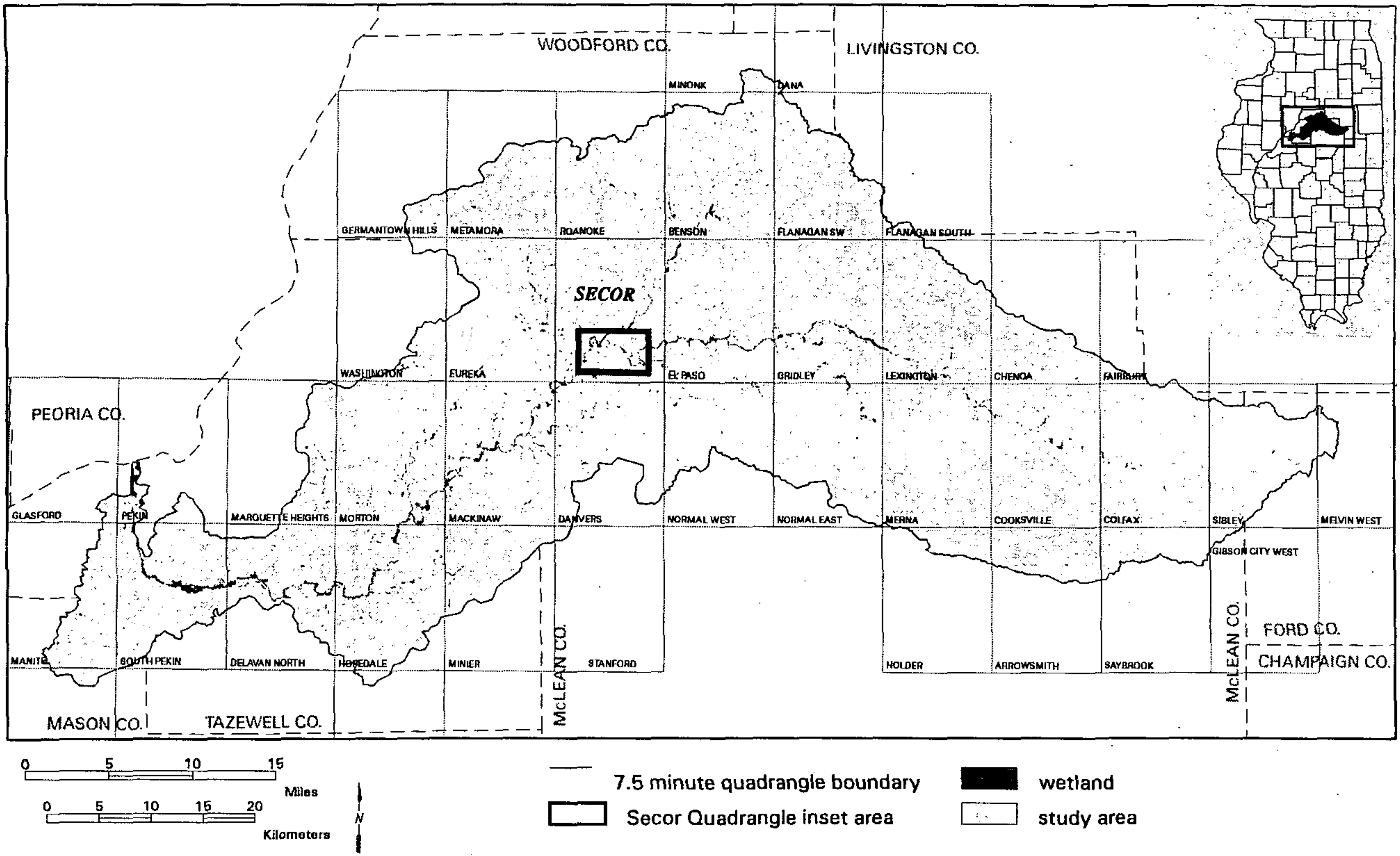


Figure 3-2. National Wetland Inventory Quadrangle Maps

Although the ILCA and NWI programs were not meant for regulatory purposes, they are the only state or regional wetland map resources available and are the logical sources for beginning a wetland assessment. The presence or absence of wetlands as represented by the wetland maps is not certified by either the ILCA or the NWI mapping program. Figure 3-3, taken from the Secor Quadrangle in the Mackinaw River basin, exemplifies the information that can be expected from NWI maps.

In some areas with intense economic development and significant wetland acreage, the NWI maps have been redone or updated for use in designating or locating wetland areas. Whatever the source of wetland map information, the user should be aware that this information is a general indication of wetland locations, and the boundaries and exact locations should be field-verified by persons trained or certified in wetland delineation.

Given the limitations of most existing wetland maps, more complete information can be obtained by comparing mapped wetlands with other regional attributes such as shallow aquifers, subsurface geology, and placement in the landscape. When these comparisons show consistent regional patterns (for example, placement in the landscape or correlation with a particular geologic material), any parcels of land with similar landscape positions or geologic materials can be considered potential wetland sites even if maps do not show them as wet.

Land Use

Agriculture is the dominant land use in the six major counties (Ford, Livingston, McLean, Mason, Tazewell, and Woodford) within the Mackinaw River basin. Illinois Agricultural Statistics (IAS) data indicate that total crop acreage in the basin has not significantly changed over time. However, as shown in Figure 3-4, acreages for selected crops changed drastically from 1925-1995.

The dominant crops in 1925 were corn and grassy crops (wheat, oats, and hay), whereas in 1995 the dominant crops were corn and soybeans. Soybean acreage increased significantly, from 1,300 acres in 1925 to 255,000 acres in 1995. The increase in soybean acreage correlates directly with a decrease in wheat/oats/hay acreage for the same time period: these crops decreased from 248,000 acres in 1925 to only 17,000 acres in 1995. Corn acreage remained fairly steady, increasing only slightly to levels above 300,000 acres from 1965-1982.

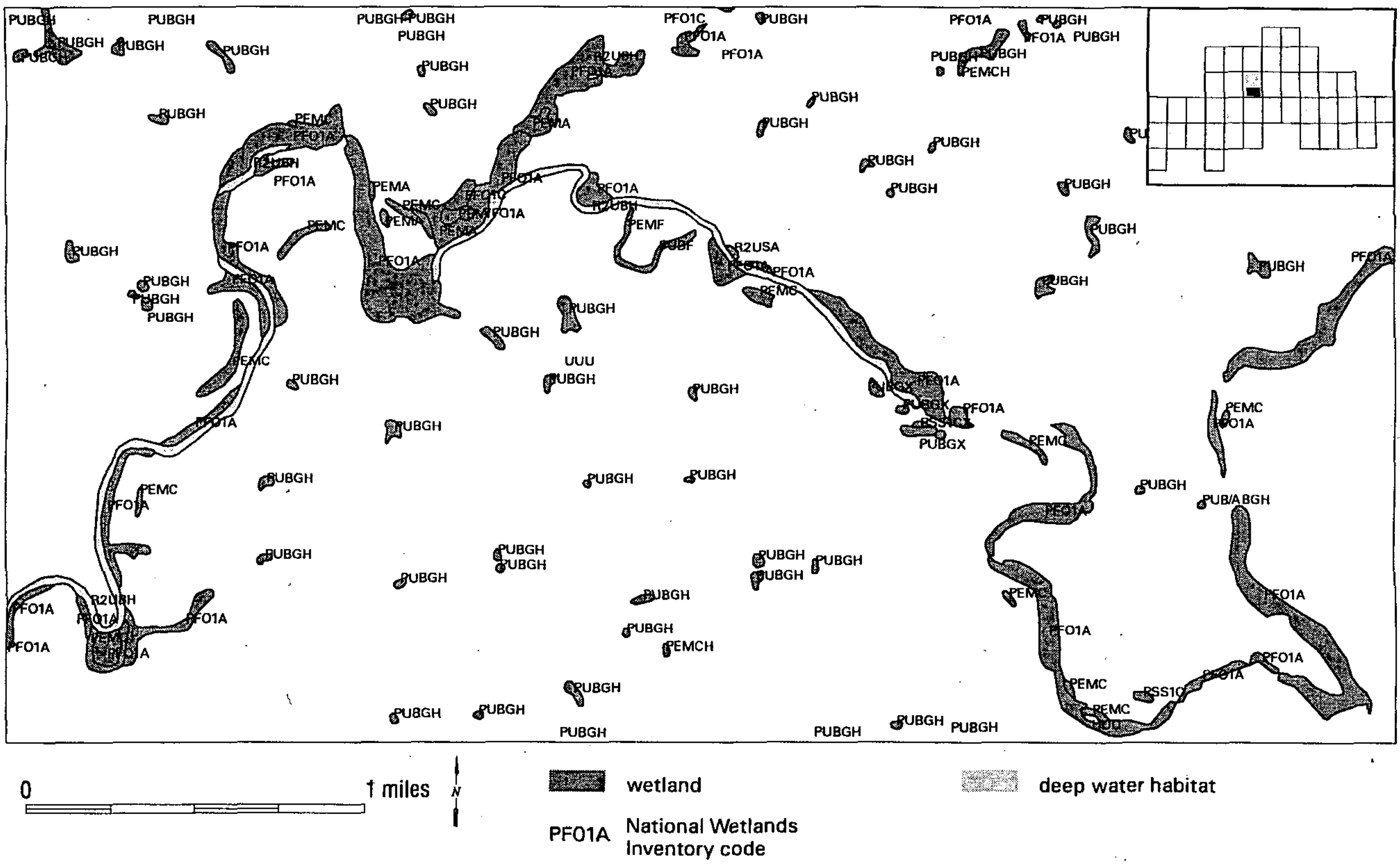


Figure 3-3. National Wetland Inventory information from Secor Quandrangle

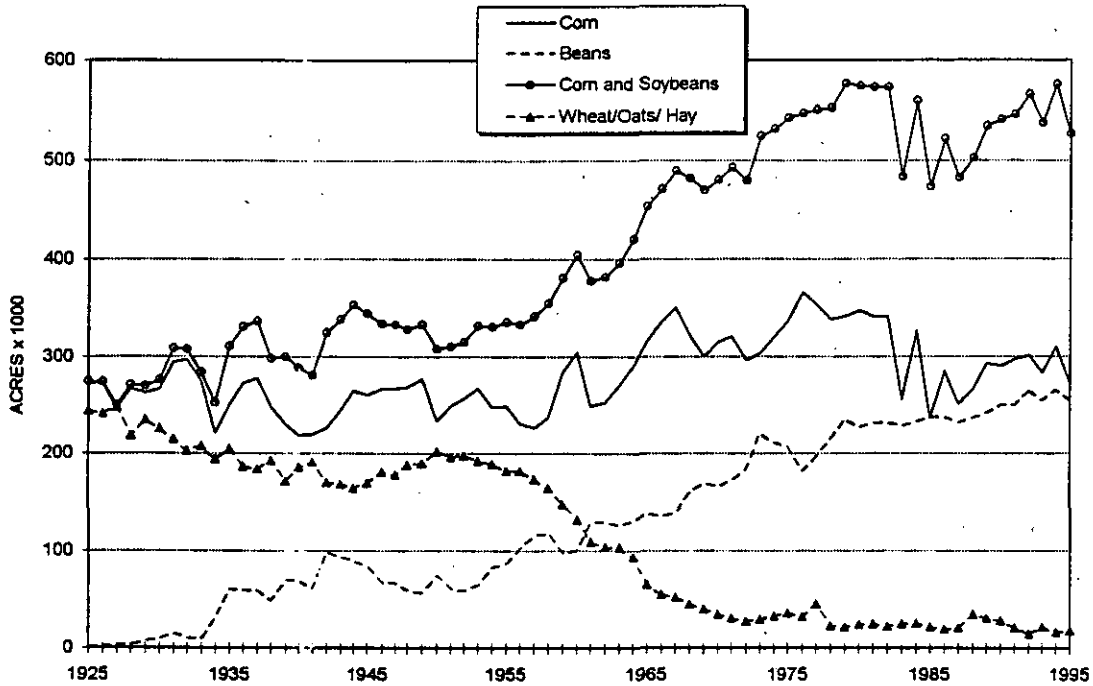


Figure 3-4. Acreages of Selected Crops in the Mackinaw River Basin, Based on IAS Data

The inverse relationship between row crop (corn and soybeans) and grassy crop acreages in the Mackinaw River basin from 1925-1995 can also be seen in Figure 3-4. In 1995, row crops covered approximately 72% of the total watershed area. Row crop acreage more than doubled between 1925 (275,000 acres) and 1979 (577,000 acres), while grassy crops decreased sharply. Between 1979 and 1987, row crop acreage oscillated, with a slightly declining trend and then a rising trend, reaching 576,000 acres in 1994; almost as high as the peak of 1979. Grassy crop acreage has declined steadily.

Climate and Trends in Climate

This chapter reviews trends in climate in and around the Mackinaw River basin since the turn of the century. Climate parameters examined are: annual mean temperature, the number of days with highs above or equal to 90°F, the number of days with lows below or equal to 32°F, the number of days with lows below or equal to 0°F, annual precipitation, the number of days with measurable precipitation, annual snowfall, and the number of days with measurable snowfall. Extreme weather events examined in this report are tornadoes, hail, and thunderstorms.

Overview

The Mackinaw River basin in central Illinois occupies portions of Mason, Tazewell, Woodford, McLean, Livingston, and Ford Counties. The climate of this area is typically continental, as shown by its changeable weather and the wide range of temperature extremes. Summer maximum temperatures are generally in the 80s or 90s, with lows in the 60s or low 70s, while daily high temperatures in winter are generally in the 30s, with lows in the teens or 20s. Based on the latest 20 years of data, the average first occurrence of 32°F is October 10, and the average last occurrence of 32°F is April 23.

Precipitation is normally heaviest during the growing season and lightest in midwinter. Thunderstorms and associated heavy showers are the major source of growing season precipitation, and they can produce gusty winds, hail, and tornadoes. The months with the most snowfall are December, January, and February. However, snowfalls have occurred as early as September and as late as April. Heavy snowfalls have rarely exceeded 12 inches.

The climate data used in the following discussions originate at: 1) Bloomington-Normal, Illinois (McLean County), the National Weather Service (NWS) Coop site with the longest record (1898-1996), located within the south-central portion of the basin; and 2) Peoria, Illinois, a first-order NWS site located 10 miles northwest of the basin. The Bloomington-Normal site was maintained in Bloomington from 1898 until June 1977. The site was then moved to Normal, where it continues to operate at this time. Despite the change in location, Bloomington-Normal represents the best long-term station in the region with little missing data. Supportive data and analyses for nearby Illinois sites can be found in reports by the Illinois Department of Energy and Natural Resources (1994) and Changnon (1984).

Temperature

The mean January maximum temperature is 33°F and the minimum is 16°F, whereas the mean July maximum and minimum temperatures are 87°F and 65°F, respectively (Table 3-4). The mean annual temperature at Bloomington-Normal is 51.8°F. The warmest year of record since 1898 was 1921, with an average of 55.7°F, while the coldest was 1917, with 48.7°F.

Table 3-4. Temperature Summary for Bloomington-Normal
(Averages are from 1976-1995 and extremes are from 1898-1995. Temperatures are in °F)

Month	Average high	Average low	Record high (year)	Record low (year)	# of days with high ≥90°F	# of days with low ≤32°F	# of days with low ≤ 0°F
January	32.5	15.5	69 (1950)	-23 (1918)	0	27	4.7
February	36.7	18.1	71 (1932)	-24 (1905)	0	23	3.5
March	49.5	29.5	88 (1907)	-15 (1943)	0	18	0.1
April	62.9	39.8	95 (1899)	10 (1982)	0.2	6.6	0
May	74.4	51.0	103 (1934)	21 (1966)	1.1	0.4	0
June	84.2	61.2	106 (1934)	35 (1993)	6.8	0	0
July	86.8	65.4	114 (1936)	44 (1904)	9.7	0	0
August	84.9	63.3	105 (1936)	38 (1915)	7.2	0	0
September	78.6	55.2	103 (1899)	26 (1942)	2.4	0.3	0
October	65.9	42.7	93 (1897)	11 (1925)	0	4.9	0
November	50.6	32.4	82 (1950)	-4 (1929)	0	15	0
December	37.5	20.7	70 (1982)	-22 (1989)	0	26	2.7

Although there is a great deal of year-to-year variability, mean annual temperatures at Bloomington-Normal show no strong trends since 1898 (Figure 3-5). The period 1930-1960 was generally warmer than any period before or after. There is some indication of a pattern similar to global trends, with warming until 1940, followed by cooling until the end of the 1970s, and a return to a warming trend. However, the period 1992-1995 was much cooler than the rest of the record and may reflect a change in instrumentation or exposure (Figure 3-5). Wendland and Armstrong (1993) reported that cooler temperatures can be recorded when changing from the traditional liquid-in-glass thermometers to the new electronic sensors.

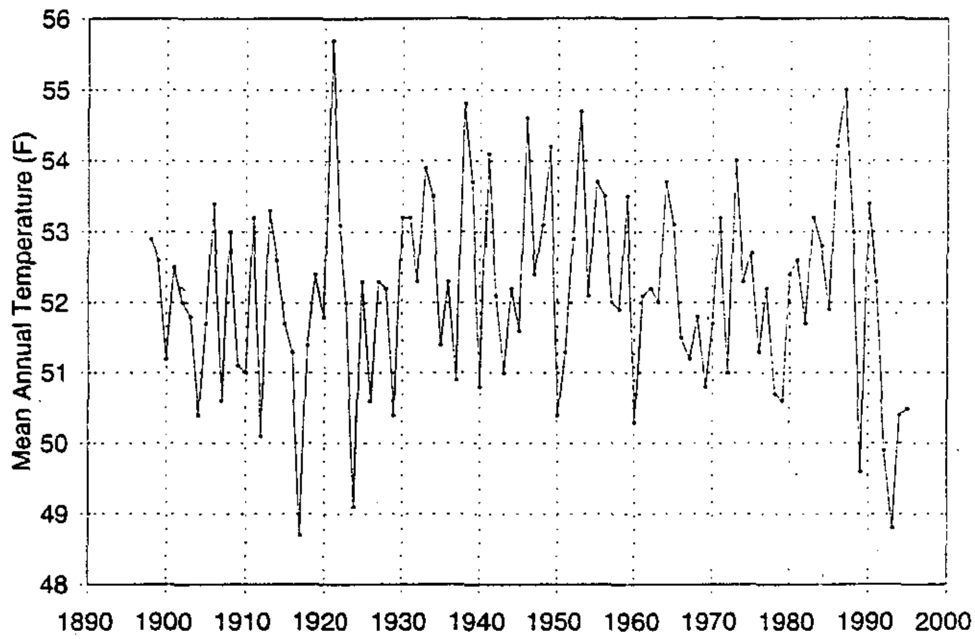


Figure 3-5. Mean Annual Temperature for Bloomington-Normal, Illinois, 1898-1995

Examination of mean temperatures over time is one way to clarify trends. The NWS has adopted 30-year averages, ending at the beginning of the latest new decade, to represent climate "normals." These averages were adopted to filter out some of the smaller scale features and yet retain the character of the longer term trends. Consecutive, overlapping "normals" for the last seven 30-year periods at Bloomington-Normal are presented in Table 3-5. The consecutive means demonstrate the warming trend during the 1931-1960 period, followed by a cooling trend in the 1951-1980 period, with a return to a warming trend during the 1961-1990 period.

Table 3-5. Average Annual Temperature at Bloomington-Normal during Consecutive 30-Year Periods

Averaging period	Average temperature (°F)
1901-1930	51.6
1911-1940	51.9
1921-1950	52.3
1931-1960	52.4
1941-1970	52.2
1951-1980	52.1
1961-1990	52.8

The frequency of extreme events sometimes conveys a clearer picture of trends than mean values. The annual number of days with temperatures equal to or above 90°F is shown in Figure 3-6. Not too surprisingly, the time series bears little resemblance to that of annual temperature (Figure 3-5), because the number of days with temperatures above 90°F represents only the high summer temperature extremes. Figure 3-6 data show a marked downward trend from 1898-1975, followed by a period of high variability.

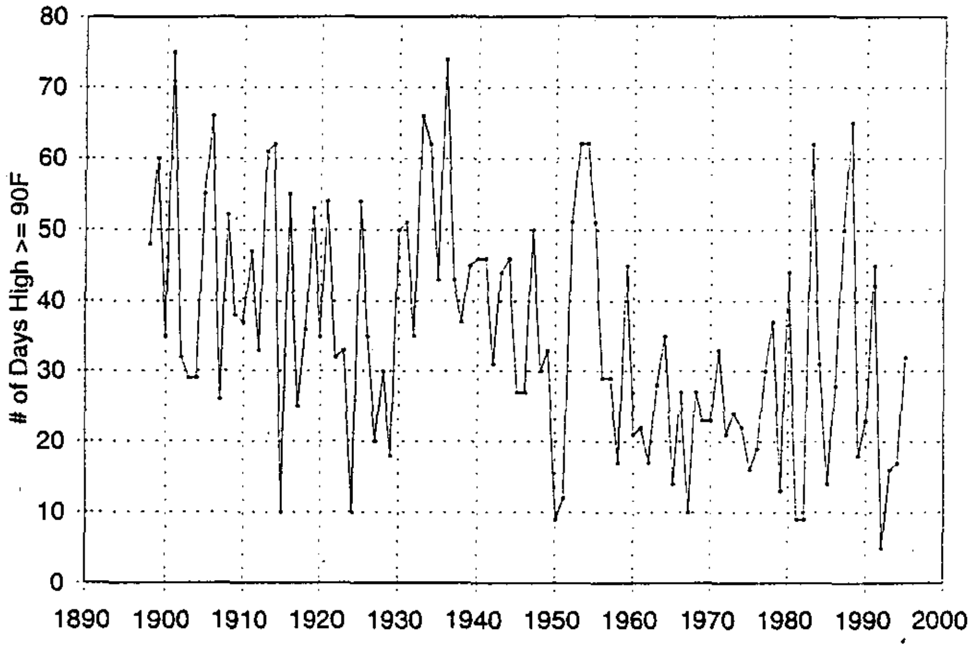


Figure 3-6. Annual Number of Days with Maximum Temperatures Equal to or Above 90°F at Bloomington-Normal, Illinois, 1898-1995

Figure 3-7 shows the winter frequency of daily minimum temperatures equal to or below 32°F. The frequency of such temperatures decreased slightly from 1898-1965, before increasing rapidly in the late 1980s and 1990s. The most recent change may be due to the change in instruments or exposure as noted earlier.

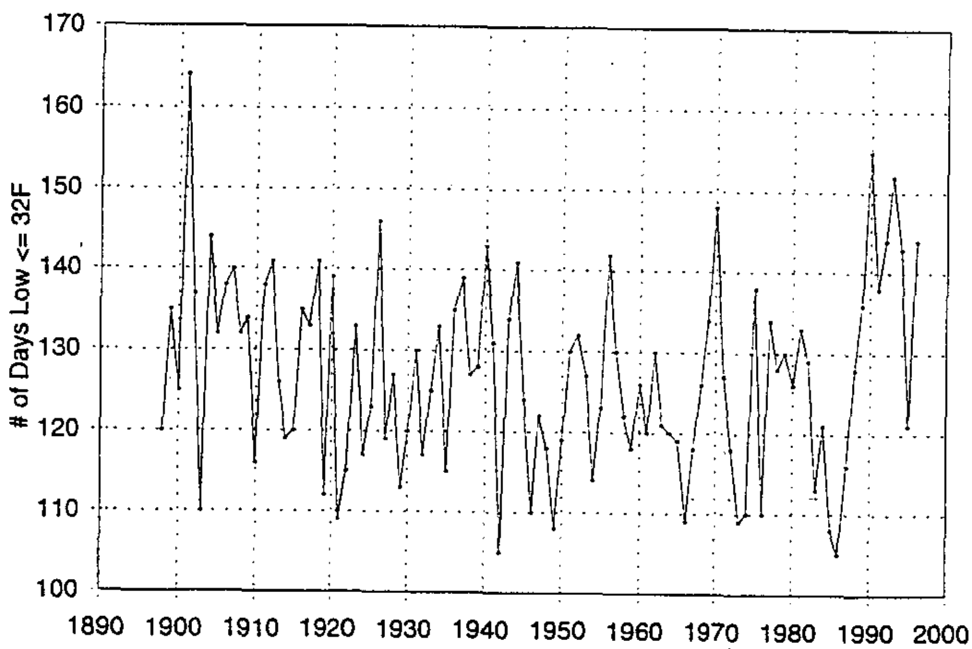


Figure 3-7. Annual Number of Days with Minimum Temperatures Equal to or Below 32°F at Bloomington-Normal, Illinois, Winters 1898-1899 to 1995-1996

Figure 3-8 shows the number of days per year when the minimum temperature was equal to or below 0°F, beginning with the 1897-1898 winter. Such days are not very frequent on average in central Illinois, with a large degree of variability from year to year. No long-term trends are evident.

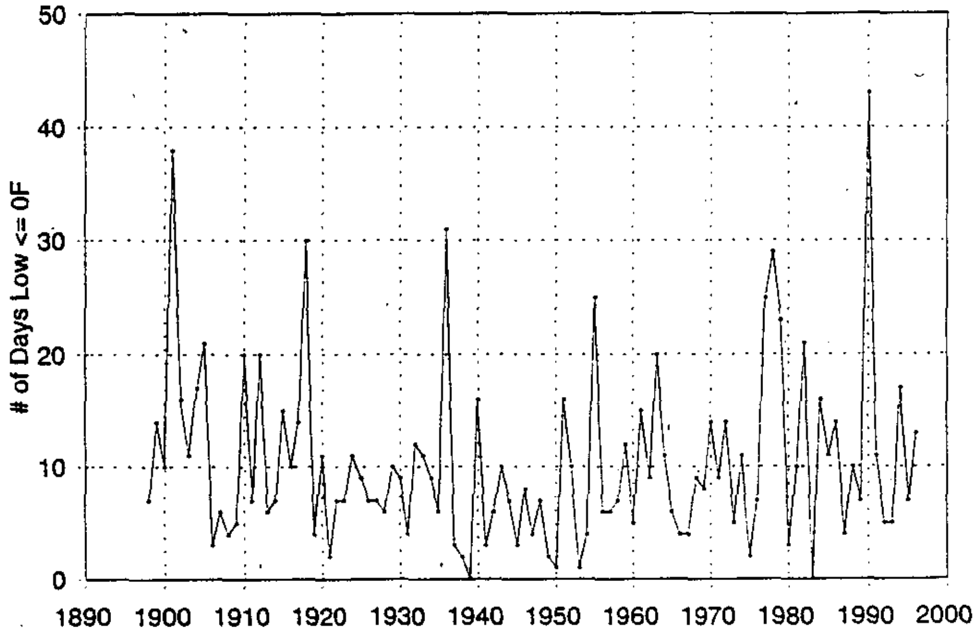


Figure 3-8. Annual Number of Days with Minimum Temperatures Equal to or Below 0°F at Bloomington-Normal, Illinois, Winters 1898-1899 to 1995-1996

Precipitation

Mean annual precipitation is 37.75 inches, with more rainfall in the spring and summer than in fall and winter (Table 3-6). Late spring, summer, and early fall precipitation is primarily convective in nature, often associated with thunderstorms, with a duration of 1 to 2 hours. During the remainder of the year, the precipitation is of longer duration and associated with synoptic-scale weather systems (cold fronts, occluded fronts, and low pressure systems).

The wettest year of record since 1898 at Bloomington-Normal was 1993 (63.35 inches), the year of the great flood along the Mississippi River and its tributaries. The driest year was 1988 (23.22 inches), the year of the great Midwestern drought.

Table 3-6. Precipitation Summary for Bloomington-Normal
(Averages are from 1976-1995 and extremes are from 1898-1995. Precipitation is in inches.)

Month	Avg. precip.	Record high (year)	Record low (year)	Largest one-day amount (year)	Snow-fall	# of days w/ precip.
January	1.61	7.28 (1965)	0.05 (1919)	2.40 (1965)	6.9	8
February	1.56	5.94 (1900)	0.07 (1907)	2.25 (1900)	6.1	8
March	2.70	7.73 (1973)	0.61 (1910)	2.42 (1898)	1.8	11
April	3.69	9.10 (1957)	0.74 (1971)	3.29 (1947)	0.8	12
May	4.21	10.17 (1908)	0.43 (1934)	3.92 (1936)	0	11
June	3.64	12.45 (1902	0.20 (1959)	4.00 (1946)	0	9
July	4.41	13.74 (1992)	0.50 (1916)	3.70 (1992)	0	9
August	4.11	12.76 (1924)	0.70 (1910)	6.10 (1943)	0	9
September	3.28	13.54 (1961)	0.03 (1939)	5.21 (1986)	0	8
October	3.02	10.08 (1941)	0.06 (1964)	3.53 (1986)	0.1	9
November	3.54	9.33 (1985)	0.19 (1904)	3.85 (1936)	0.8	11
December	2.49	7.40 (1971)	0.22 (1976)	3.40 (1949)	4.7	9

Trends in annual precipitation at Bloomington-Normal (Figure 3-9) are not particularly clear until after 1970, when there appears to be a general increase but a larger degree of variability. Overlapping 30-year precipitation averages (not shown) reflect the lack of any long-term trends.

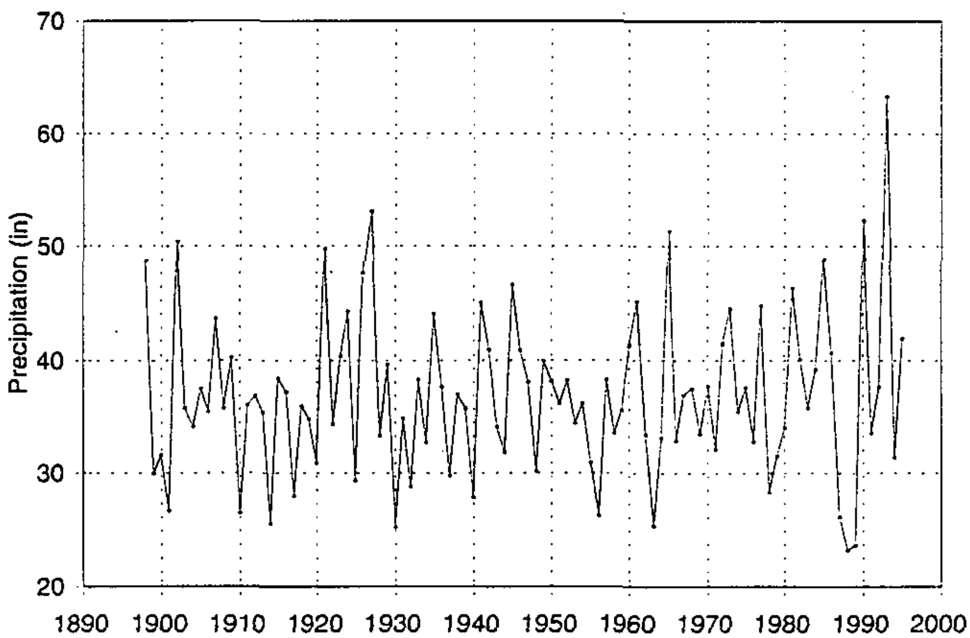


Figure 3-9. Annual Precipitation at Bloomington-Normal, Illinois, 1898-1995

The number of days per year with measurable precipitation (i.e., more than a trace) is shown in Figure 3-10. An upward trend is evident, with a 20% increase--from 100 days per year to 120 days per year--over the period of record. Precipitation in Bloomington-Normal is more frequent during summer months than during winter months, and averages about 105 days per year.

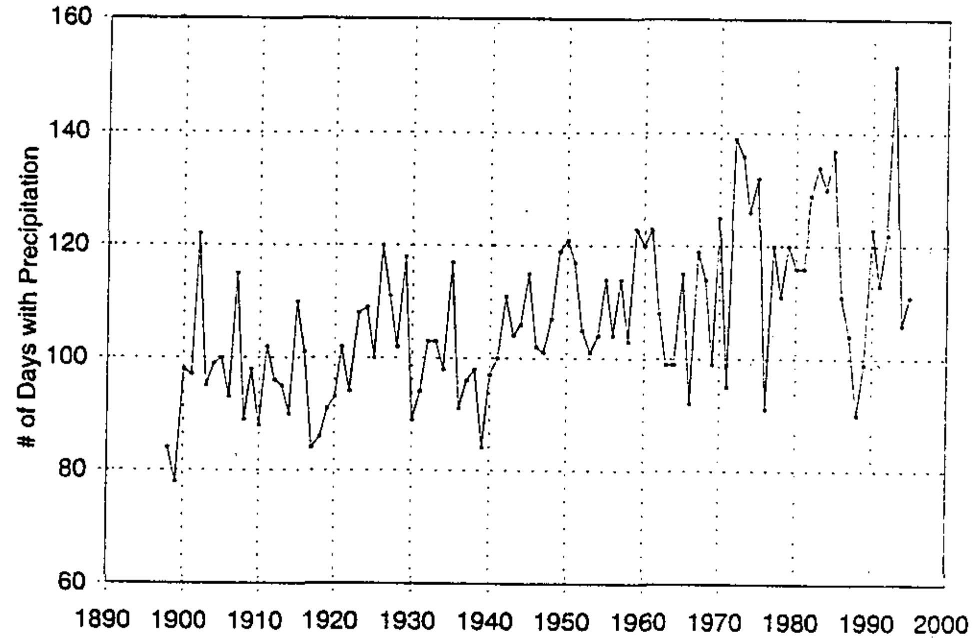


Figure 3-10. Annual Number of Days with Measurable Precipitation at Bloomington-Normal, Illinois, 1898-1995

Average winter snowfall at Bloomington-Normal is 20.9 inches, but there is great year-to-year variability. The most snowfall during any one winter in Bloomington-Normal was 57.8 inches during the 1959-1960 winter, whereas the least was only 5.1 inches during the 1994-1995 winter. Snowfall from the 1901-1902 winter season through the 1995-1996 season is shown in Figure 3-11. There are no long-term trends in snowfall, although the period 1959-1960 to 1964-1965 appears to be much snowier than previous winters. Recent years have shown a steady decline in the amount of snowfall.

Figure 3-12 shows the number of days each winter with snowfall, from 1901-1902 through 1995-1996. Annual frequencies apparently increased regularly from the early 1900s to the 1970s and then declined to the present. A snowfall of more than 6 inches occurs only once every three years. Snow cover is frequently experienced at Bloomington-Normal, typically lasting from a few days at a time to up to two months.

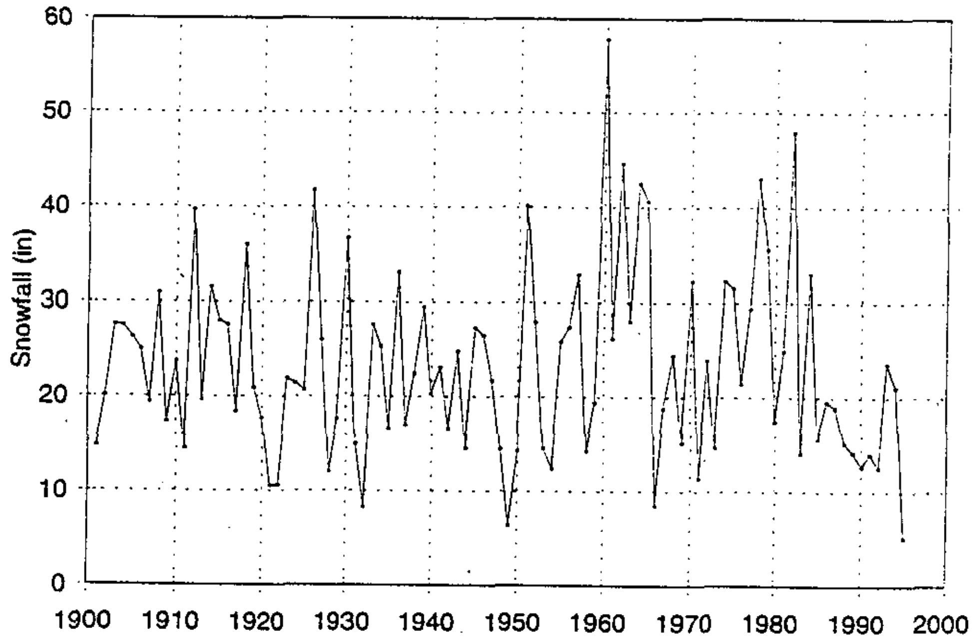


Figure 3-11. Annual Snowfall at Bloomington-Normal, Illinois, Winters 1901-1902 to 1995-1996

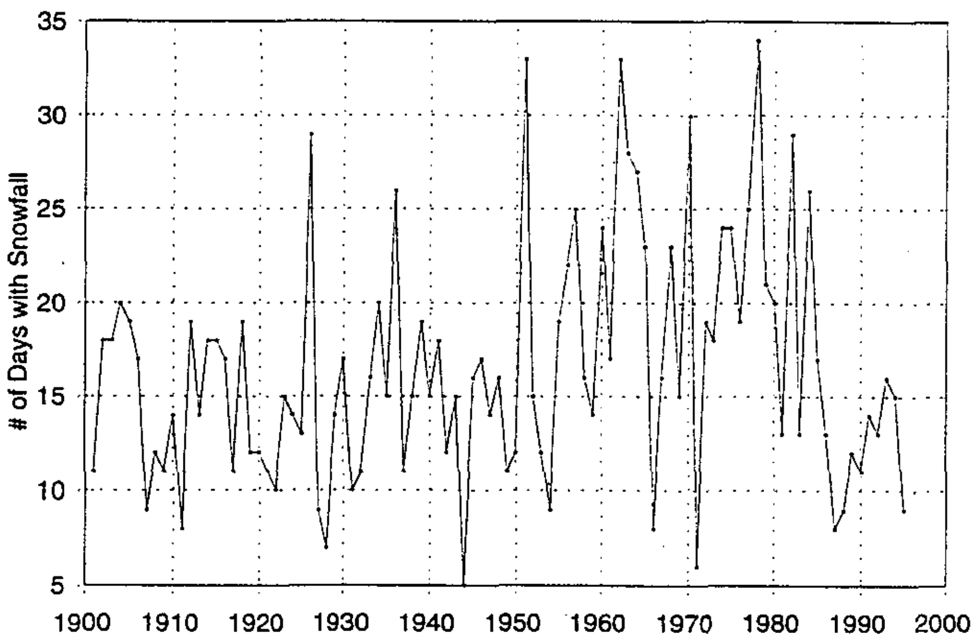


Figure 3-12. Annual Number of Days with Measurable Snowfall at Bloomington-Normal, Illinois, Winters 1901-1902 to 1995-1996

Precipitation Deficits and Excesses

Following are the driest years in the Mackinaw River basin in terms of annual precipitation shortfall, starting with the driest: 1988, 1989, 1930, 1963, 1914, 1987, 1956, 1910, 1901, and 1940. Three of the driest years occurred in the 1980s, a feat unmatched in any other decade. Driest summer seasons in the basin include: 1920, 1988, 1933, 1991, 1908, 1910, 1930, 1900, 1914, and 1936. In this case, the 1930s are well represented in terms of the driest summers. Much above average precipitation fell at Bloomington-Normal in 1993, 1927, 1990, 1965, 1902, 1921, 1985, 1898, 1926, and 1945. No single decade dominated in terms of years with excessive precipitation.

Severe Weather

Tornadoes

Although tornadoes are not uncommon in Illinois, most people do not expect to be affected directly, even if they live in the state for a lifetime. This is because tornadoes are generally only one-quarter mile in diameter, travel at roughly 30 miles per hour for only 15-20 minutes, and then dissipate, directly affecting a total area less than 2 square miles. Since Illinois observes an average of 28 tornadoes a year (though the actual number varies from fewer than ten to about 100 during the last 35 years), the total area directly affected by tornadoes annually is only about 55 square miles, 0.001% the total area of the state. Even with 96 tornadoes reported in Illinois in 1974 (the greatest number reported in the last 30 years), the affected area was only about 0.003% the total area of the state. These numbers do not diminish the effect on those experiencing property damage, injury, or worse, but they demonstrate the extremely low probability of direct impact at any given location.

Regular reporting of tornadoes in Illinois began in 1959. From that time through September 1995, 62 tornadoes were recorded in the Mackinaw River basin with no apparent trend in frequency or intensity. On average, the Mackinaw River basin experiences two tornadoes per year. The maximum number of tornadoes reported per year is six (1975 and 1981), with 16 of the last 37 years experiencing no tornado activity.

Hail

Hail events are somewhat rare and typically affect a very small area (from a single farm field up to a few square miles). Unfortunately, very few NWS Coop sites measure hail. The combination of small, infrequent events being measured by a sparse climate network makes for very few reliable, long-term records of these events, particularly for large areas.

The closest NWS site to the Mackinaw River basin with reliable and regular hail observations is at Peoria, Illinois. This site has records extending back to 1901. On average, Peoria experiences two hail days per year, with the actual number varying greatly from year to year (Changnon, 1995). There are no persistent upward or downward trends lasting over the 1904-1994 period of record at Peoria.

Thunderstorms

On average, the Mackinaw River basin experiences about 48 days with thunderstorms each year, 7-8 each summer month, and 1 each winter month. The annual number of days with thunder over the Mackinaw River valley since 1949 is shown in Figure 3-13, which is composed of data from Peoria (1949-1995). There is substantial year-to-year variation in thunderstorm days, ranging from as many as 60 in 1970 to as few as 35 in 1980. A slight upward trend is evident from 1955-1975, followed by a more marked downward trend from 1976 to the present.

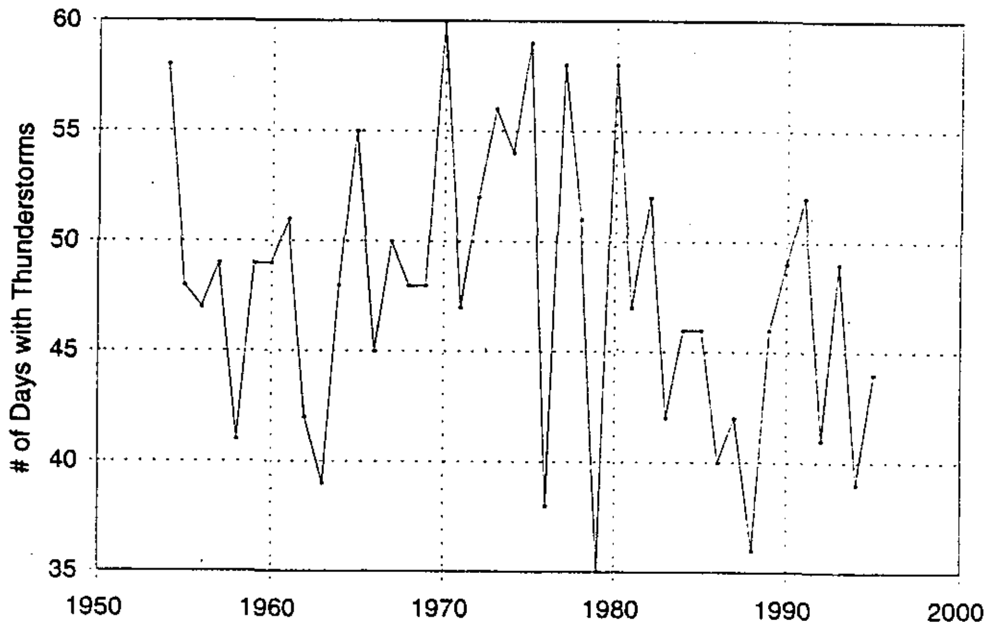


Figure 3-13. Annual Number of Days with Thunderstorms at Peoria, Illinois, 1949-1995

Summary

There are no clear trends in mean annual temperature. However, the number of days with temperatures above or equal to 90°F shows a downward trend until 1975, followed by a period of high variability. The number of days with temperatures below or equal to 32°F shows a downward trend until 1965, followed by an upward trend until the present. The number of days with temperatures below or equal to 0°F shows no trends.

For precipitation, no trend is evident before 1970. An upward trend with increased variability can be observed after 1970. The number of days with measurable precipitation shows a clear upward trend over the period of record. For snowfall, there is no long-term trend. However, the number of days with snow increased regularly from the early 1900s to the 1970s before declining to the present.

Records extending back to the early 1900s show no clear trends in hail events. Similarly, there are no apparent trends in tornado events, although records date only to 1959. The number of days with thunderstorms shows a slight upward trend from 1955-1975, followed by a more marked downward trend from 1976 to the present.

Streamflow

Surface water resources are an essential component of any ecosystem because they provide different types of habitats for aquatic and terrestrial biota. In addition to their natural functions, they are sources of water supply for domestic, industrial, and agricultural use. Changes in natural and human factors, such as climate, land and water use, and hydrologic modifications, can greatly affect the quantity, quality, and distribution (both in space and time) of surface waters in a river basin.

There are at least 1,400 miles of rivers and streams in the Mackinaw River basin. The status of these rivers and streams is generally monitored by stream gaging stations, which measure the flow of water over a period of time, providing information on the amount and distribution of surface water that passes the station. Since it is not feasible to monitor all streams in a river basin, gaging stations are established at selected locations, and the data collected at those stations are transferred to other parts of the watershed by applying hydrologic principles. Streamflow records are used to evaluate the impacts of changes in climate, land use, and other factors on the water resources of a river basin.

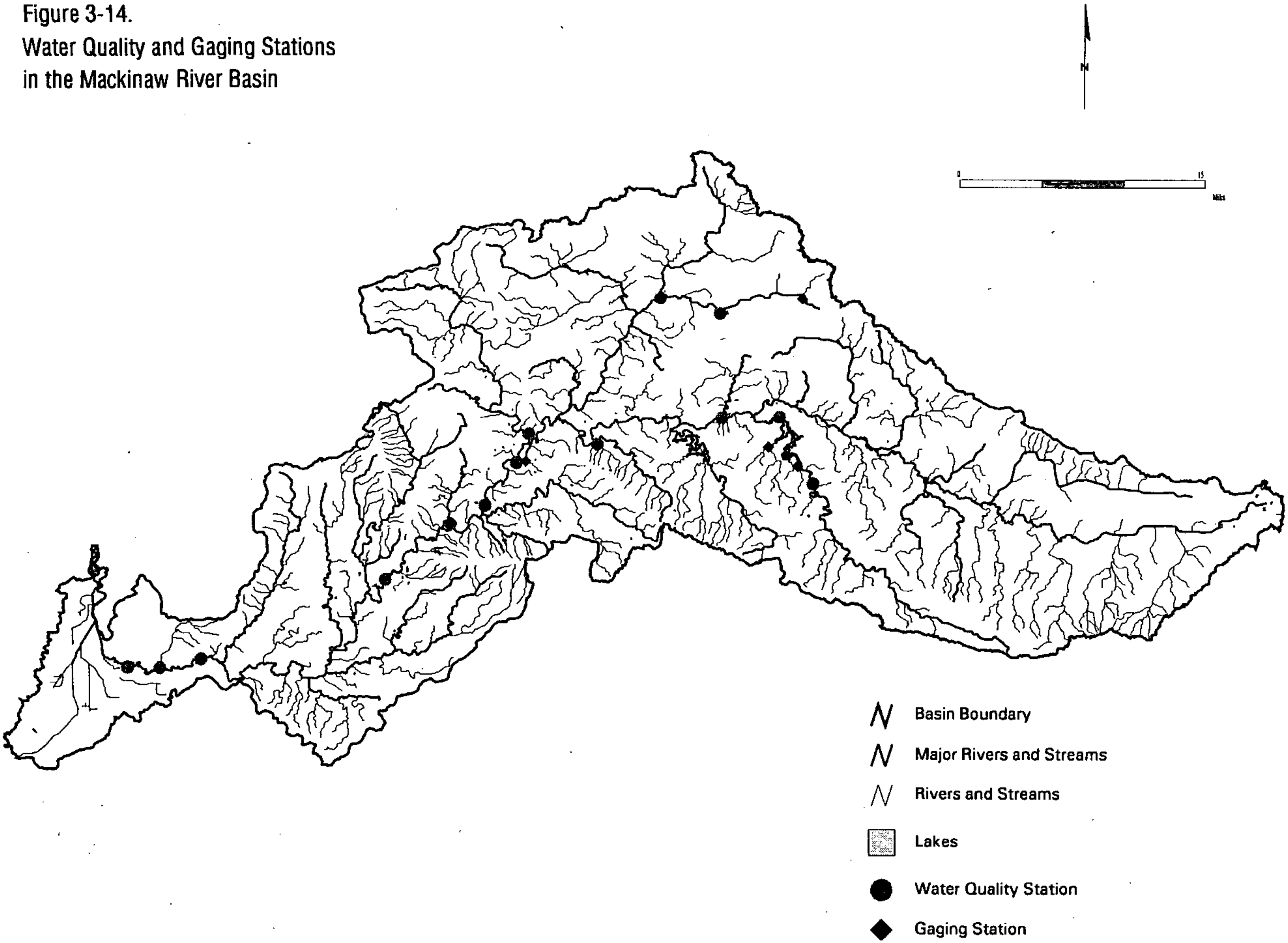
Stream Gaging Records

Eight gaging stations in the Mackinaw River basin have five or more years of continuous daily flow data. These stations are listed in Table 3-7, and their locations are shown in Figure 3-14. The two stations on Money Creek are located near each other, and for the purpose of analyzing streamflow trends are considered to have equivalent records. Only two of the eight stations are currently active, these being on the Mackinaw River near Congerville and near Green Valley. With the exception of the gage at Green Valley, all of the stream gages are located in the central portion of the Mackinaw River basin.

Table 3-7. USGS Stream Gaging Stations with Continuous Discharge Records in the Mackinaw River Basin

USGS ID	Station name	Drainage area (mi^2)	Record length (years)	Period of record
05564400	Money Creek near Towanda	49.0	25	1959-1983
05564500	Money Creek above Lake Bloomington	53.1	25	1934-1958
05565000	Hickory Creek above Lake Bloomington	9.8	20	1939-1958
05566000	East Branch Panther Creek near Gridley	6.3	11	1950-1960
05566500	East Branch Panther Creek at El Paso	30.5	34	1950-1983
05567000	Panther Creek near El Paso	93.9	11	1950-1960
05567500	Mackinaw River near Congerville	767.	51	1945-1995
05568000	Mackinaw River near Green Valley	1070.	42	1922-1956, 1989-1995

Figure 3-14.
Water Quality and Gaging Stations
in the Mackinaw River Basin



Annual and Monthly Water Budget

Of the 37 inches of average annual precipitation that falls over the Mackinaw River basin, approximately 9.5 inches reaches its streams. This represents an average flow of approximately 0.7 cubic feet per second (cfs) per square mile of drainage area. Average annual streamflow is expected to vary across the basin in very much the same distribution as the average precipitation, ranging from 10.5 inches per year in the eastern portion of the basin to 8 inches in the western portion.

As with all other locations in Illinois, streams in the Mackinaw River basin display a well-defined seasonal cycle. As shown in Figure 3-15 for the Mackinaw River, flows are expected to be greatest during the spring months, March-June, while lower flows are more common in late summer and autumn. However, this figure also shows that the average flow in any month can vary considerably from the long-term median condition.

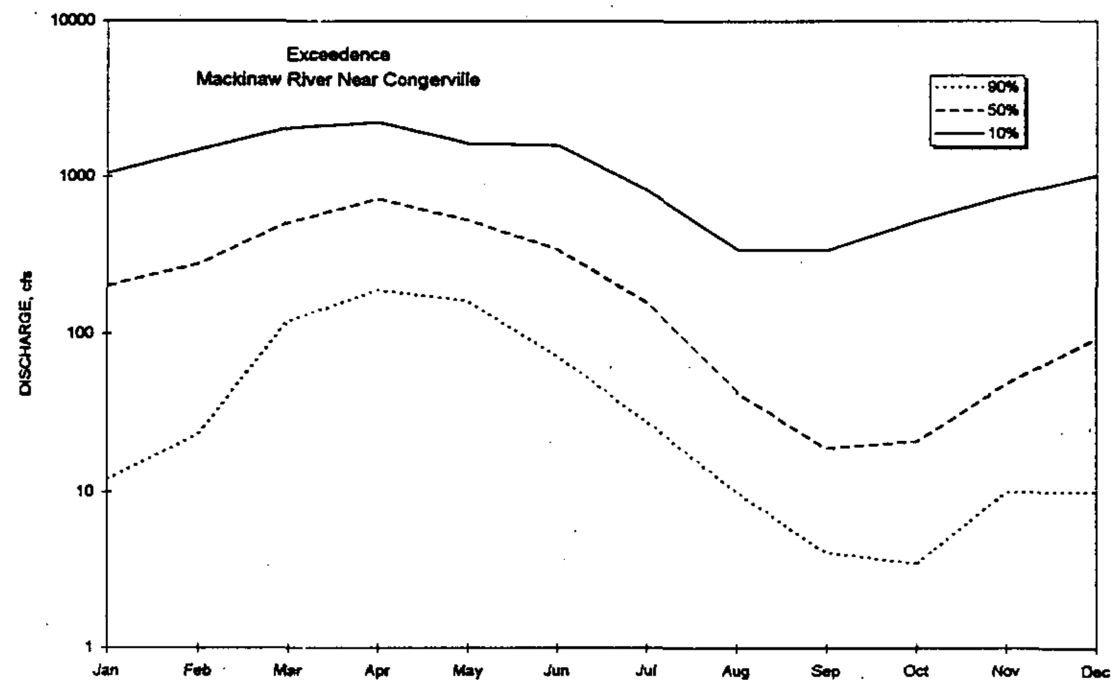


Figure 3-15. Probabilities of Exceedence for Monthly Flows, Mackinaw River near Congerville

Schicht and Walton (1961) investigated the water budget and source of streamflows for Panther Creek, a typical watershed in the basin. Their analysis shows that direct surface runoff and shallow ground water provide roughly equivalent contributions of flow to streams, although their relative contributions vary considerably seasonally and annually. The amount of surface runoff is most variable, being greatest in years with high precipitation amounts, and during the wet portions of most every year (typically March-June).

While shallow ground-water discharge to streams is also greatest during these wet periods, its relative contribution is much greater during dry and average conditions. During late summer and fall, the majority of flow originates from the shallow ground water. The variations in the relative contributions of surface runoff and shallow ground water have a significant impact on the temporal variability of stream water quality.

Variability in Daily Flows

Figure 3-16 plots the flow duration curves for five locations in the Mackinaw River basin. The flow duration curve provides an estimate of the frequency with which the given flows are exceeded. As can be seen in this figure, the flows for all of the streams can vary significantly, ranging in many cases from near zero to well over 20 times a stream's average flow. Variations in the shapes of the flow duration curves can often point to major differences in the hydrology of each stream. But the general shapes of the curves in Figure 3-16 are fairly similar, indicating that the watersheds of these gaging locations have relatively homogeneous physiographic characteristics.

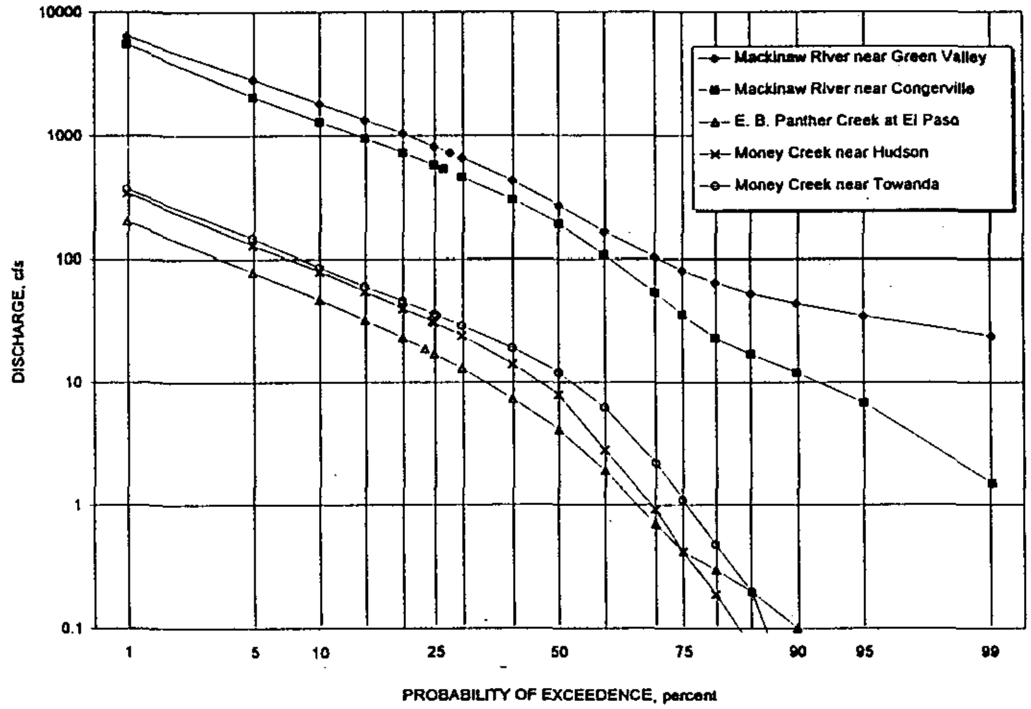


Figure 3-16. Flow Duration Curves (Discharge Versus Probability) for Five Selected Gaging Stations in the Mackinaw River Basin

The major variation in the shape of the curves is for low flow conditions, when the probability of exceedence is greater than 70%. The Mackinaw River near Green Valley has low flows that are significantly greater than at Congerville, and they are accreted to the river after it flows into the Havana Lowlands area in southwestern Tazewell County. Smaller streams in this southwestern region of the basin are expected to have much reduced variability in flows, with significantly greater low flows and reduced high flows.

The two stations on Money Creek are located very close to each other, and the difference in low flows between these two records arises because the gage above Lake Bloomington, near Hudson, was operated during a drier period (1934-1958) than the gage near Towanda (1959-1983). The variability in flows on the East Branch Panther Creek is very similar to the Money Creek locations, except that there is a greater persistence of very low flows during dry conditions.

Variability in Average Streamflow

Average streamflow not only varies greatly from year to year, but can also show sizable variation between decades. Figure 3-17 shows the annual series of average streamflow for seven selected stream gage records in the Mackinaw River basin. As seen in these figures, the average flow during any given year is similar for all stations. Over the 74 years of composite record, the annual flows have ranged from a high of 29.5 inches in 1993 to a low of less than 1 inch in the drought year of 1940.

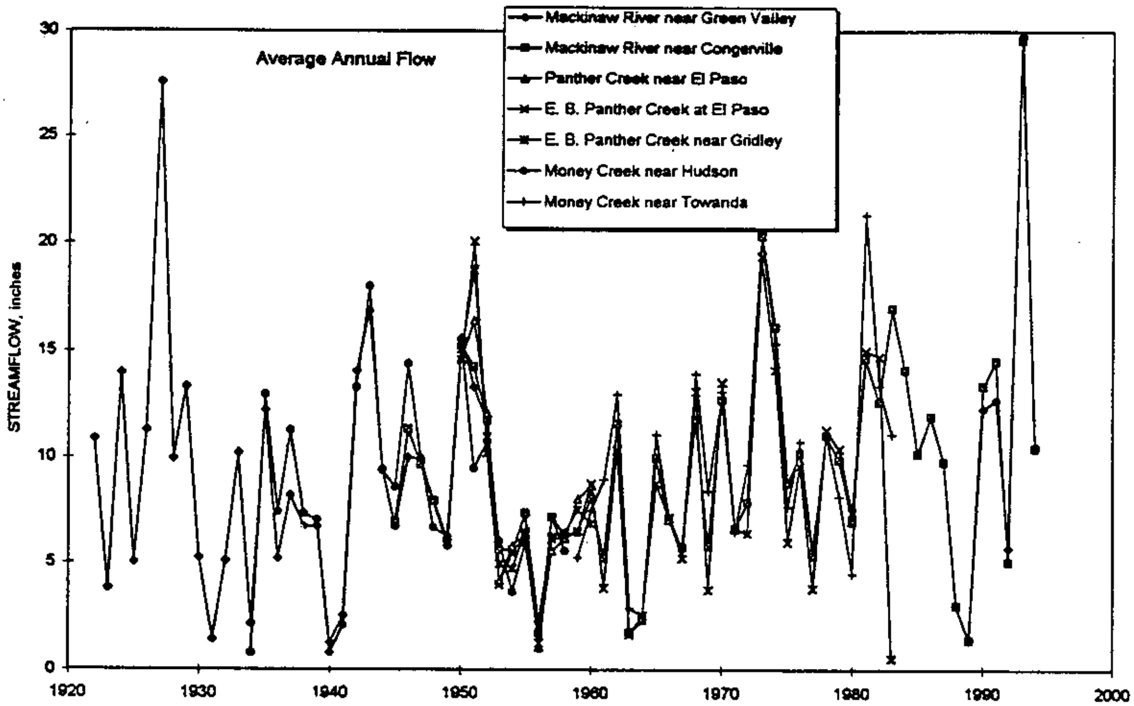


Figure 3-17. Average Annual Streamflow for Seven Gaging Stations in the Mackinaw River Basin

Figure 3-18 shows the 11-year moving averages of streamflow and precipitation in the Mackinaw River basin for the period 1920-1996. The moving average (MA) streamflow is the average flow for 11 consecutive years; for example, the 11-year MA for 1968 is the average flow for the period 1963-1973. The precipitation MA has ranged from 39 inches in 1965-1975 to 32.6 inches in 1930-1940. The streamflow MA has ranged from 12.1 inches in 1973-1983 to 5.5 inches in 1931-1941.

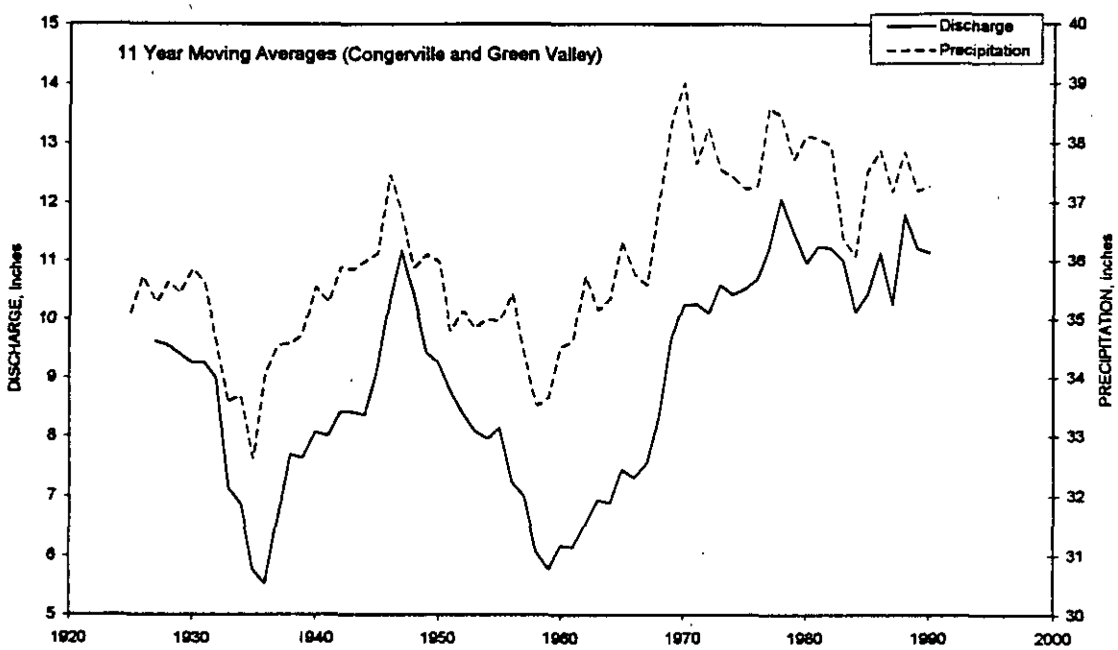


Figure 3-18. Eleven-Year Moving Averages for Streamflow and Precipitation (Calculated for the Period 1920-1995)

As shown in the figure, average streamflow is strongly related to the average precipitation during that time. The correlation coefficient between these two moving averages is 0.905, indicating that most of the variation in average flow over the period of record can be explained by coincident changes in precipitation. Trend analysis indicates that the observed increase in annual streamflow is statistically significant at a confidence level of 90%, whereas the trend in precipitation is close to, but not significant at, that same level.

On average, the difference between precipitation and streamflow is 27 inches per year, equivalent to the average annual rate of evapotranspiration for the Mackinaw River, with a one-year lag between precipitation and streamflow. In the period 1955-1970, the average difference increased to about 28 inches, while in 1984-1994 the difference decreased to about 26 inches. This increase and decrease is probably related to a variation in evapotranspiration, which could be related to changes in average temperature and cloudiness. Another possible factor is a change in land use patterns, although we are not yet aware of any land use change that would have had this alternating effect on the rate of evapotranspiration.

Flooding and High Flows

Figure 3-19 shows the annual series of peak flood discharges for four locations: the Mackinaw River near Green Valley, Panther Creek near El Paso, and Money Creek above Lake Bloomington and near Towanda. The record of peak discharges at the Green Valley gage indicates that flooding was most frequent in the two periods 1942-1951 and 1979-1987, especially during the latter period. A visual examination of Figure 3-19 suggests a possible increasing trend in flooding on the Mackinaw River. This conclusion is greatly influenced by the frequent flooding during 1979-1987. However, the continuation of such a trend has not been exhibited over the subsequent nine years, nor does trend analysis of the record identify a statistically significant trend.

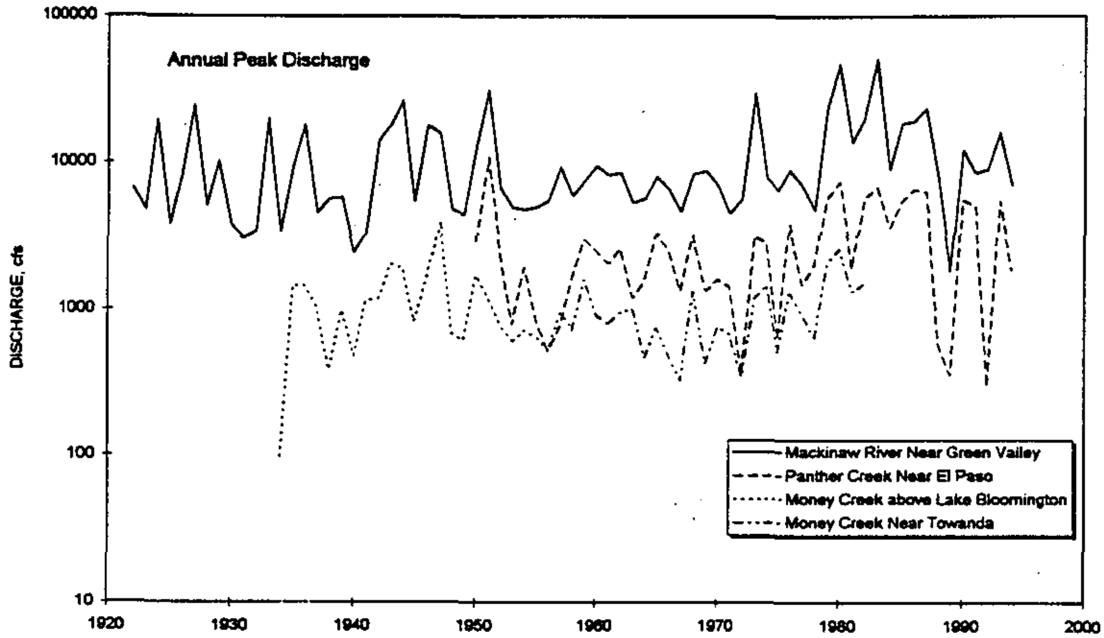


Figure 3-19. Annual Peak Discharges for Four Gaging Stations in the Mackinaw River Basin

Table 3-8 presents the monthly distribution of the top 25 flood events on the Mackinaw River near Green Valley. This table shows that major flooding on the Mackinaw can occur during any season of the year, although spring flooding is most common.

Table 3-8. Monthly Distribution of Top 25 Flood Events, Mackinaw River near Green Valley

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. of events	0	3	3	4	5	2	2	2	1	1	1	1

The primary factor leading to major flooding on the Mackinaw River is the occurrence of heavy, widespread precipitation. Heavy rainstorms are most common during the summer months and are more likely to produce flooding on smaller watersheds (less than 30 square miles in area); however, these storms generally do not have the same widespread areal coverage as the heavy storms in the spring. In addition, the flooding potential is enhanced by wet soils normally present during spring months. The duration of heavy precipitation associated with flooding conditions can range from a few hours for small streams to several days for a stream as large as the Mackinaw River.

The two periods of increased flood frequency, 1942-1951 and 1979-1987, coincide with periods when the average streamflows in the Mackinaw River have been greatest (see Figure 3-18). Analyses by Kunkel et al. (1992) indicate that heavy rainfall events occur more frequently in extended periods of above-normal rainfall. Their analyses also indicate that heavy rainfall events provide a significant portion of the precipitation total during extended wet periods, and in fact are the major distinction between extended wet and dry periods. The frequency of major storm events and major flooding in the Mackinaw River basin can therefore be expected to be higher during periods of above-normal rainfall and streamflow.

Drought and Low Flows

Two flow parameters are used here to describe dry period flows: the 7-day low flow and the 18-month drought flow. The 7-day low flow is representative of the minimum streamflows that are measured during any given year, whereas the 18-month drought flow is specifically estimated for drought periods and is more representative of the persistence of a drought and its resulting impact on reservoir supplies.

Figure 3-20 presents the 7-day low flows computed from the Congerville and Green Valley gage records. Even though the watershed areas at these two stations are reasonably similar, the magnitude of the low flows is considerably different. As described earlier, this significant difference in low flows occurs as a result of baseflow accretion as the river flows downstream through the Havana Lowlands area. While the flows at the two gaging stations are not directly comparable, they each provide a measure of the effect of drought and the variability of low flows from year to year.

The expected 7-day low flow during a 10-year drought (i.e., the 7-day, 10-year low flow), as given by Singh et al. (1988), is zero for most of the tributaries in the Mackinaw River basin. The exceptions are 1) the smaller tributaries in the southwestern portion of the basin in Tazewell County, which typically have low flows less than 1 cfs; and 2) Prairie Creek in Tazewell County, which carries the treated wastewater effluent from the city of Morton. The Morton effluent discharge is the only major discharge in the Mackinaw River basin. Wastewater effluents from the cities of Bloomington and Normal are discharged into Sugar Creek, which eventually flows to the Sangamon River.

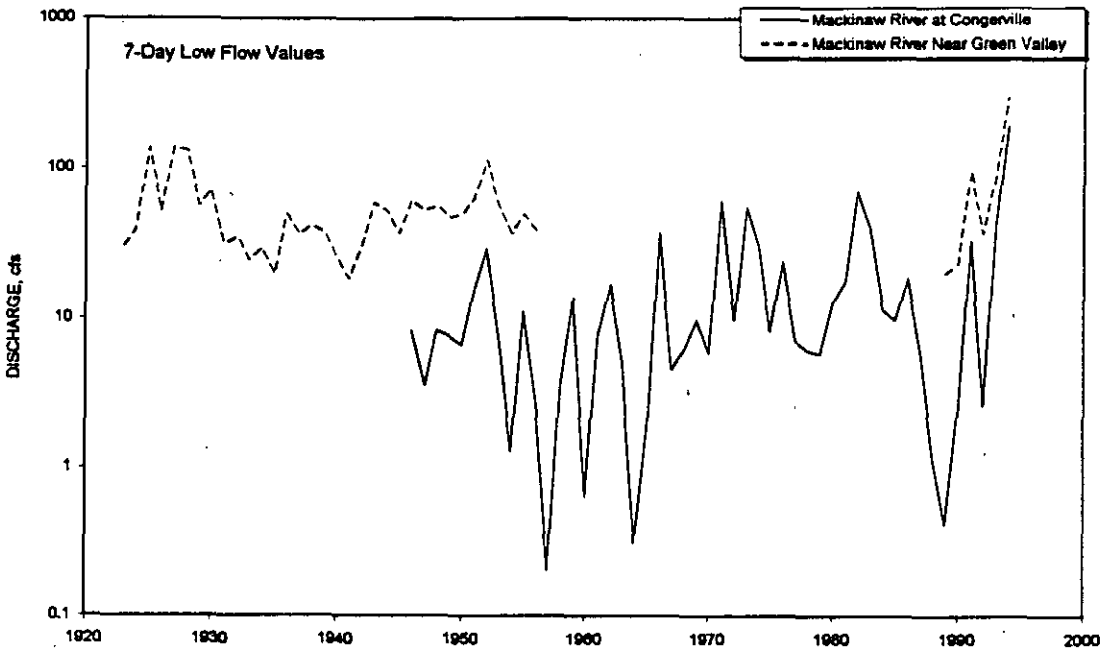


Figure 3-20. Seven-Day Low Flows for the Mackinaw River near Congerville and Green Valley

The 7-day, 10-year low flow for the Mackinaw River ranges from zero in its upstream reaches throughout McLean County to 47 cfs at the river's confluence with the Illinois River. Most of the low flow accreting to the river during dry periods occurs in the most downstream reaches of the river, in western Tazewell County. In the middle reach of the river, near the towns of Congerville and Mackinaw, the 10-year low flow is less than 5 cfs. This amount of low flow typically suggests that the flow across the shallow portions of the river (riffles) is less than 1 foot deep and 10 feet wide.

Table 3-9 lists the 7-day low flow and 18-month flows measured at the Congerville and Green Valley gages for the five worst droughts on record. The minimum 7-day low flows at Congerville and Green Valley were experienced in the 1955-1956 and 1940-1941 droughts, respectively, and have been close to these minimum values during a number of other years on record. However, it is clear from the 18-month flow estimates that the 1988-1989 drought was the worst on record in the Mackinaw River basin, both in terms of the longevity of low flow conditions and their impacts on surface water supplies and, quite probably, the impact on the biotic resources along the river.

Table 3-9. Low Flows and Drought Flows Experienced during Five Major Droughts

	18-month drought flows		7-day low flows	
Drought years	Congerville	Green Valley	Congerville	Green Valley
1930-1931	---	124	---	31.0
1940-1941	---	114	---	18.3
1955-1956	69	168*	0.20	30.1
1963-1964	69	---	0.31	---
1988-1989	57	98*	0.41	20.1

* Note: The Green Valley gage was not operational between October 1956 and September 1988. For the 1955-1956 and 1988-1989 droughts, the values presented are the average flows for the 15-month periods June 1955-September 1956 and October 1988-December 1989, respectively. In both cases, the 15-month flow estimate is expected to be higher than the 18-month minimum flow experienced during the respective droughts.

Trends in Streamflow

As discussed earlier, the Mackinaw River basin streamflow records show increasing trends in average, high, and low flows over the past 50 years. However, only the trend in average flow appears to be statistically significant at a 90% level of confidence, and the trends become less apparent when examining the entire 74 years of gaging on the Mackinaw River. All of the observed flow increases generally correspond to coincident increases in the average precipitation rate and frequency of heavy storms. Given the current level of analysis it is not possible to conclude that there are any other contributing factors to these trends.

Erosion and Sedimentation

Instream Sediment Load

Instream sediment load is the component of soil eroded in the watershed and from the streambanks that is transported to and measured at a gaging station. It indicates the actual amount of soil generated upstream of the gaging station and eventually transported to downstream reaches of the river. Given the complex dynamic process of soil erosion, sediment transport, and deposition, it is very difficult to quantify how much of the soil eroded from uplands and streambanks actually moves to downstream reaches.

The sediment transported by a stream is a relatively small percentage of the total erosion in the watershed. However, the amount of sediment transported by a stream is the most reliable measure of the cumulative results of soil erosion, bank erosion, and sedimentation in the watershed upstream of a monitoring station.

In the Mackinaw River basin, there were only two gaging stations where instream sediment was monitored for some time. As shown in Figure 3-21, these two stations are located on the main stem of the Mackinaw River, at River Miles 17.3 and 58.7. Information about the stations, including duration of the monitoring period and the type of data collected, is summarized in Table 3-10.

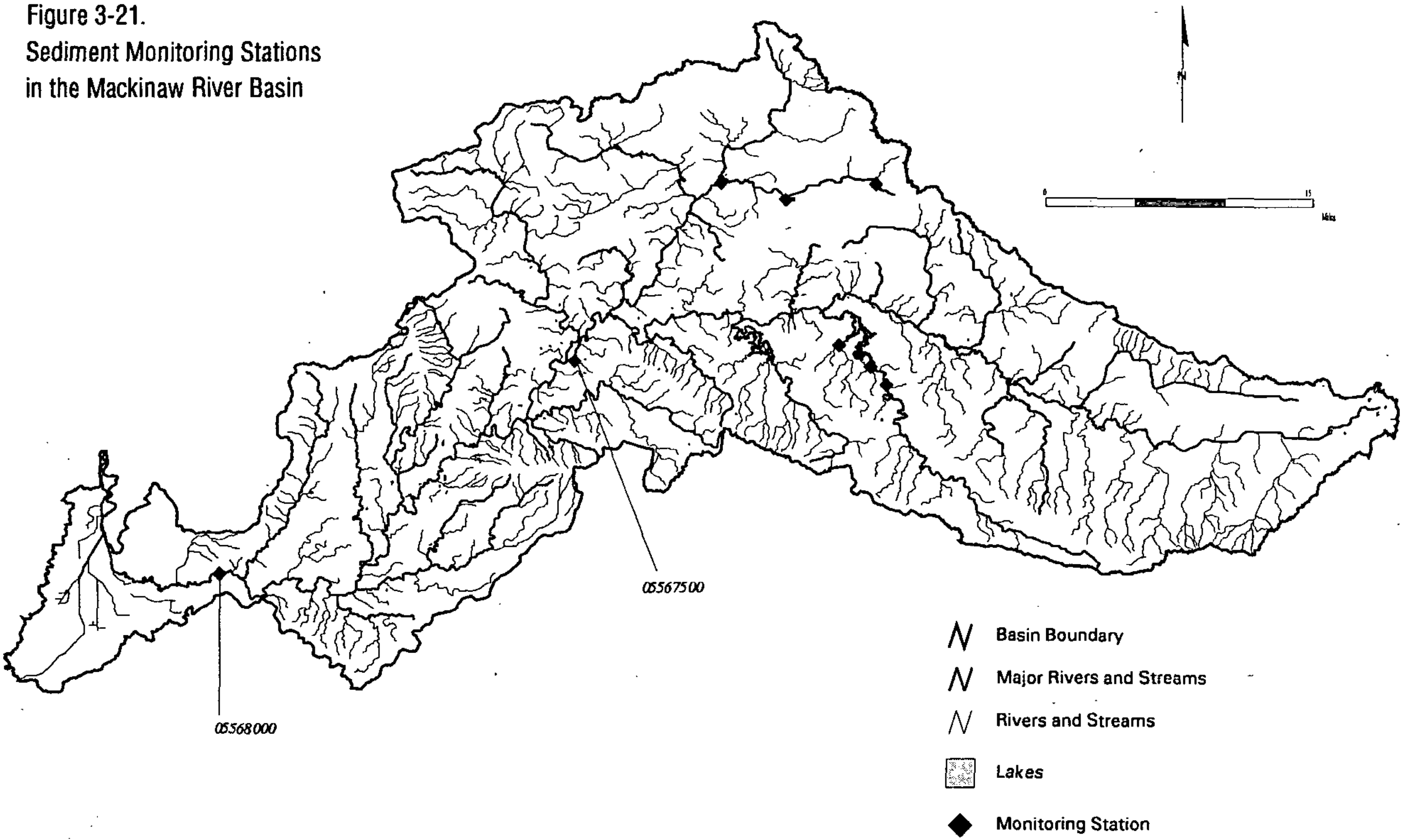
Table 3-10. Suspended Sediment Monitoring Stations within the Mackinaw River Basin

	USGS station number	Drainage area (sq. mi.)	Period of record	Type and frequency of record (collecting agency, years): Mean daily	Instantaneous weekly
Mackinaw River below Congerville	05567500	776	July 1983-1986	July 1983-1986 (USGS)	N/A
Mackinaw River near Green Valley	05568000	1,073	1981, 1995	1995 (USGS)	1981 (ISWS)

At the Congerville station, the U.S. Geological Survey (USGS) monitored the sediment yield from the upper 767 square miles of the Mackinaw River basin. The Green Valley station was used to monitor sediment yield from about 95 percent of the watershed, with data collected by the Illinois State Water Survey (ISWS) in 1981 and by the USGS in 1994-1995. *Because the stations were not monitored concurrently, it is not possible to* compare both the sediment concentrations and yields for the same period.

Data from the three years of data collection at the Congerville station are plotted in Figure 3-22, which shows the variability of streamflow (Q_w), suspended sediment concentration

Figure 3-21.
Sediment Monitoring Stations
in the Mackinaw River Basin



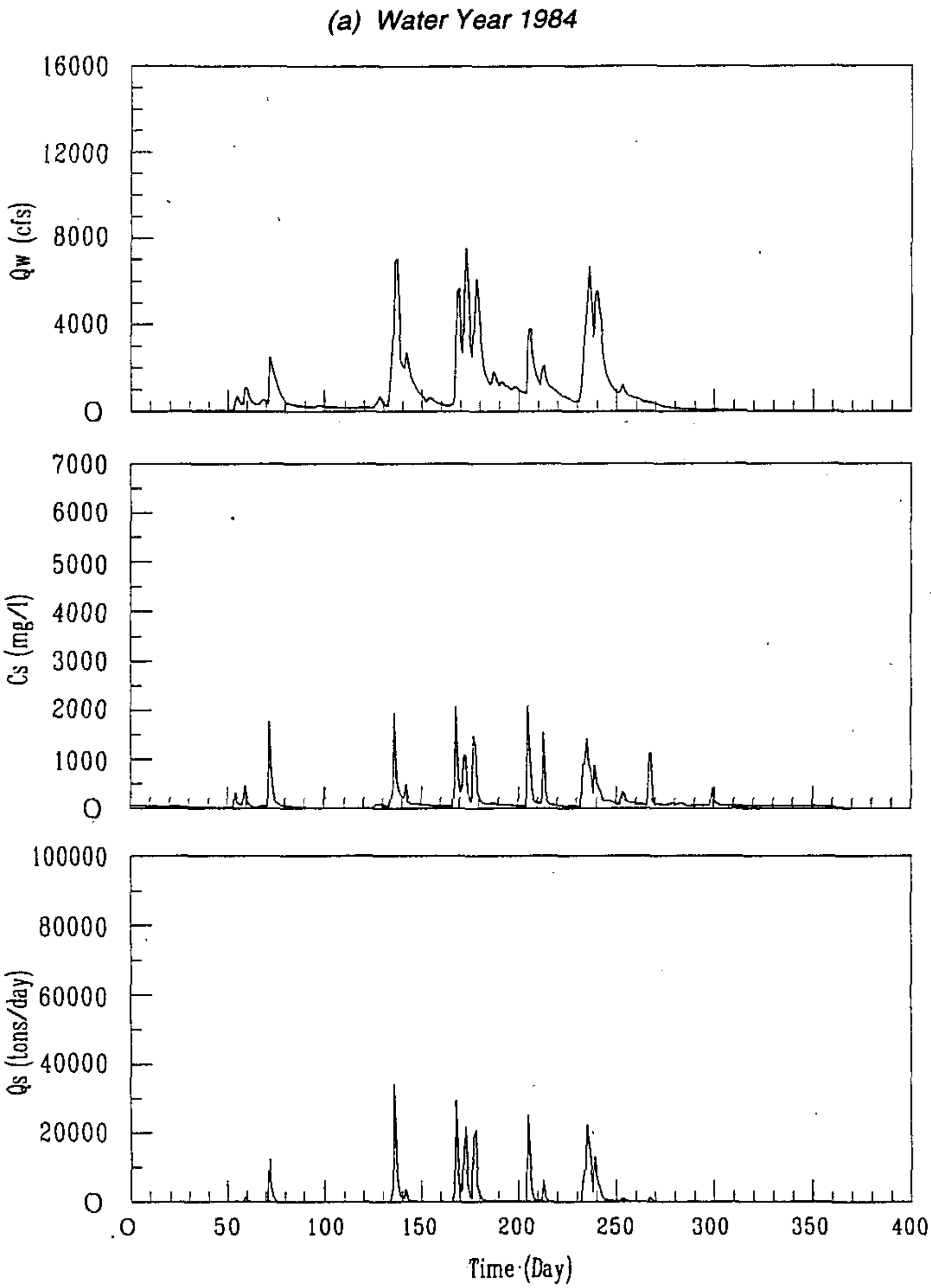


Figure 3-22. Sediment Load for the Mackinaw River below Congerville, (a) Water Year 1984, (b) Water Year 1985, and (c) Water Year 1986

(b) Water Year 1985

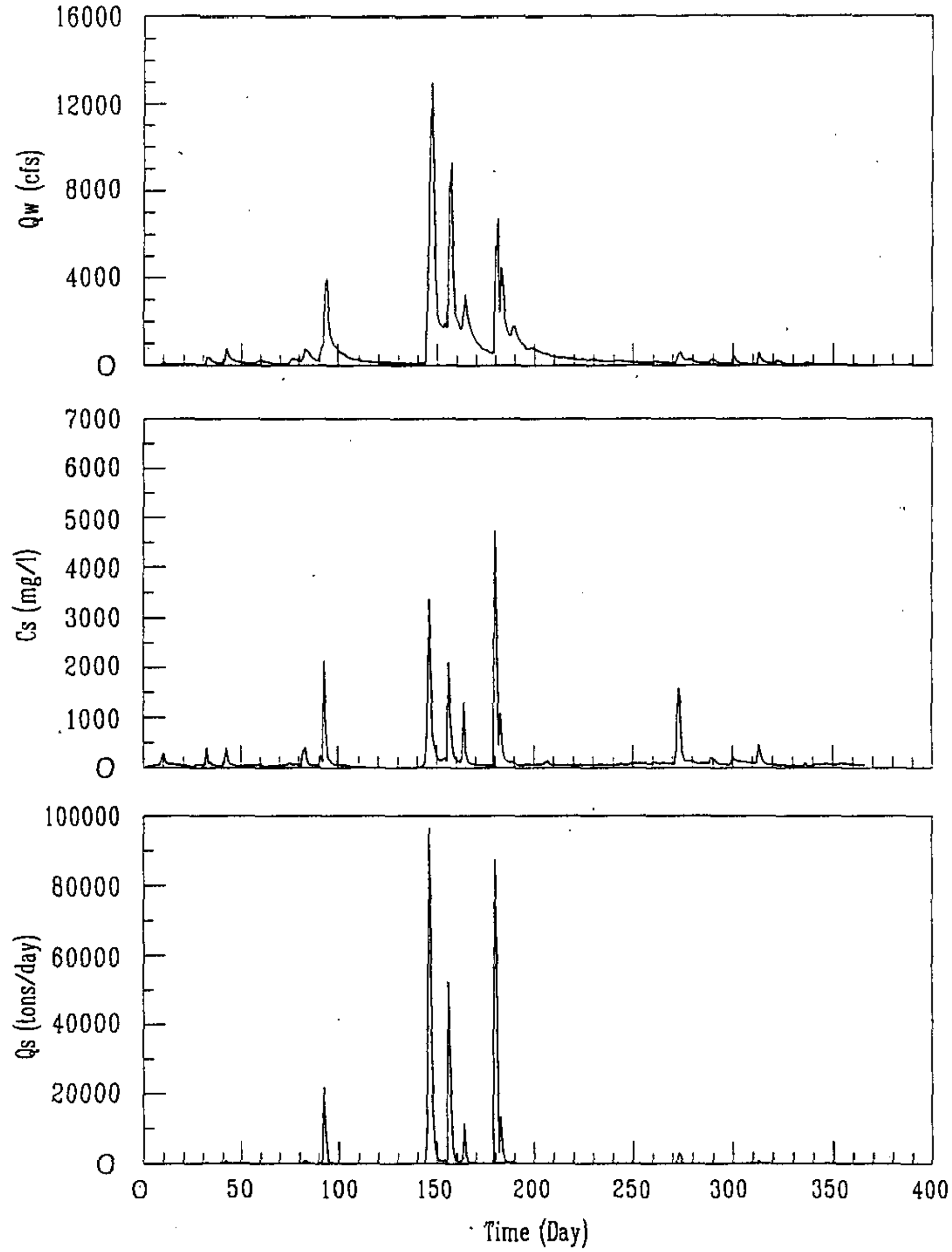


Figure 3-22. Continued

(c) Water Year 1986

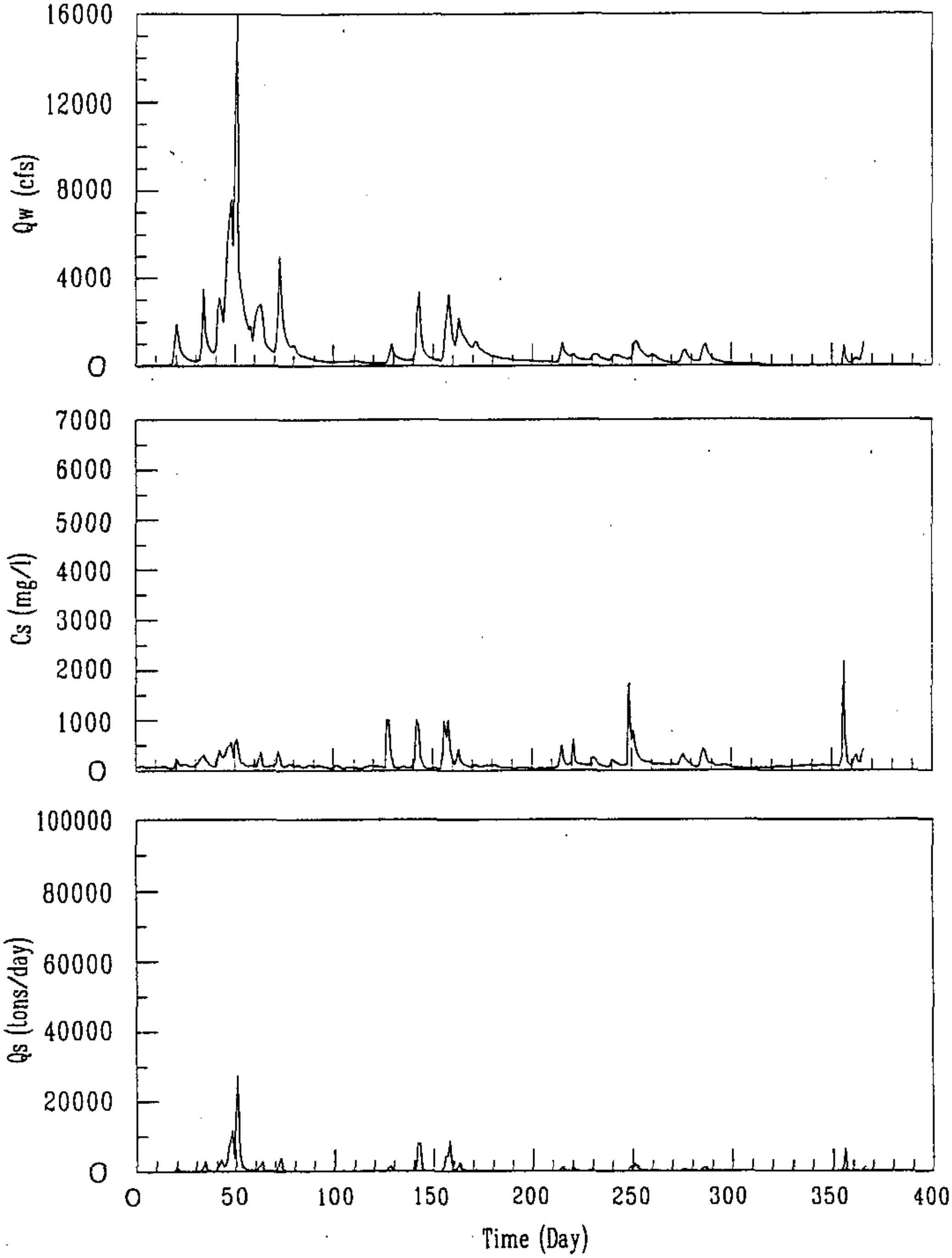


Figure 3-22. Concluded

(C_s), and suspended sediment load (Q_s). Water years start on October 1 and end on September 30. Therefore, day 1 on the time scale is October 1 of the previous year. Sediment load was computed by multiplying the water discharge values by the sediment concentrations and applying proper unit conversion factors.

In general, the data indicate that most of the sediment was transported during flood events that occur for relatively short periods. The annual sediment load for the three years (Table 3-11) varied from a low of 207,427 tons in Water Year 1986 to a high of 522,469 tons in Water Year 1985, with an average of 377,689 tons, or 492 tons per square mile. Even though these data are from a relatively short period, they provide very useful information as to the general soil erosion and sediment transport process in the basin.

Table 3-11. Annual Sediment Load for the Mackinaw River below Congerville

Water Year	Water discharge (cfs)	Sediment load (tons)
1984	291,516	403,172
1985	209,928	522,469
1986	246,217	207,427

Sediment load data for the Mackinaw River near Green Valley for Water Year 1995 are shown in Figure 3-23. As with the Congerville station, the bulk of the annual sediment load was transported during a small number of flood events. The annual sediment load at the Green Valley station was calculated to 618,153 tons, or 576 tons per square mile. The sediment yield at this station was significantly higher than the average annual sediment yield per square mile at the Congerville station. This indicates that the lower portion of the Mackinaw River basin may be experiencing a higher erosion rate than the upper part of the watershed.

Compared to the other major tributaries of the Illinois River, the Mackinaw River basin has one of the highest sediment yield rates in the Illinois River basin (Demissie et al. 1992). The sediment yield in the Mackinaw River is of the same magnitude as that of the Spoon, LaMoine, and Vermilion Rivers.

Sedimentation

Sedimentation is the process by which eroded soil is deposited in stream channels, lakes, wetlands, and floodplains. In natural systems that have achieved dynamic equilibrium, the rates of erosion and sedimentation are in balance over a long period of time. This results in a stable system, at least until disruption by extreme events. However, in ecosystems where there are significant human activities such as farming, construction, and hydraulic modifications, the dynamic equilibrium is disturbed, resulting in increased rates of erosion in some areas and a corresponding increased rate of sedimentation in other areas.

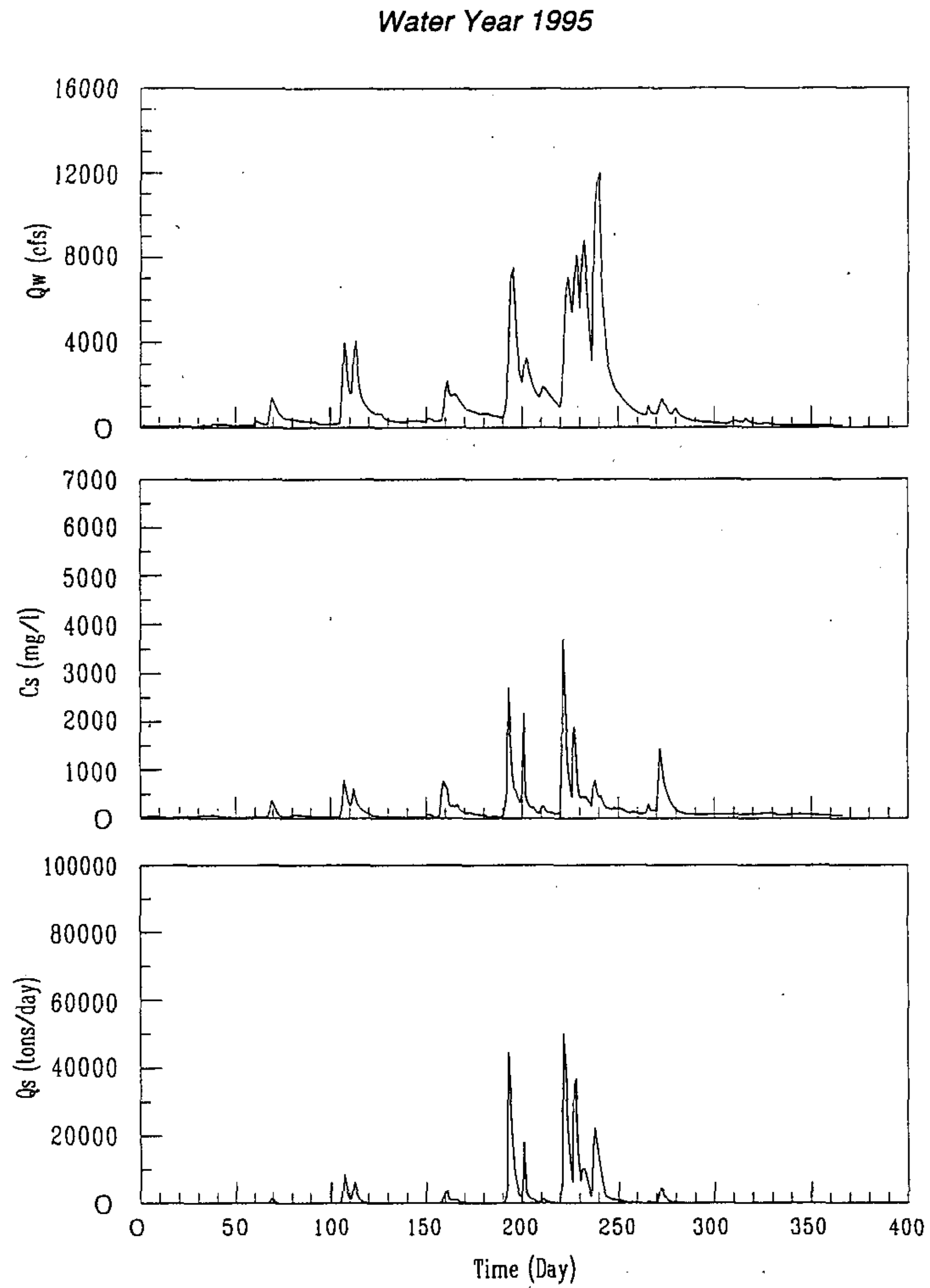


Figure 3-23. Sediment Load for the Mackinaw River near Green Valley, Water Year 1995

Erosion rates are measured by estimating soil loss in upland areas and measuring streambank and bed erosion along drainageways. These measurements are generally not very accurate and thus are estimated indirectly, most often through evaluation of sediment transport rates based on instream sediment measurements and empirical equations.

Similarly, measurement of sedimentation rates in stream channels is very difficult and expensive. Lake sedimentation surveys provide the most reliable sedimentation measurements. Since lakes are typically created by constructing dams across rivers, creating a stagnant or slow-moving body of water, they trap most of the sediment that flows into them. The continuous accumulation of eroded soils in lake beds provides a good measure of how much soil has been eroded in the watershed upstream of the lake.

Within the Mackinaw River basin, Lake Bloomington in McLean County is the only lake for which a detailed sedimentation survey has been conducted. The lake, which supplies water for the City of Bloomington, was created in 1929 by the construction of a dam across Money Creek, one of the main tributaries of the Mackinaw River. The dam and spillway were raised by 5 feet in 1957 to increase the storage capacity of the lake (Raman and Twait 1994; Bogner 1987).

While the ISWS conducted three sedimentation surveys in Lake Bloomington after 1929, all three surveys were conducted prior to the increase in lake capacity. In addition, Lake Evergreen in Woodford County was partially surveyed by students from Illinois State University in Normal in 1974. However, the data cannot be used to assess the total sedimentation rate in the lake.

The results of the three Lake Bloomington surveys (1948, 1952, and 1955) are shown in Tables 3-12 and 3-13 (Bogner 1987; Water Survey files). The lake capacity decreased by a total of 791 acre-feet from 1929 to 1955 due to sediment accumulation. This is equivalent to an average of 19.4 inches of sediment over the lake bed. The average annual sediment accumulation rate was 30.4 acre-feet, or 0.75 inches of sediment.

Table 3-12. Lake Capacity and Volume of Accumulated Sediment for Lake Bloomington

	Survey interval (years)	Reservoir capacity (acre-feet)	Sediment deposited between surveys (acre-feet)
1929	--	6,654	--
1948	19	6,062	592
1952	4	5,905	157
1955	3	5,863	42
1929-1955	26	--	791

Table 3-13. Sedimentation Rates for Lake Bloomington

Period	Sediment deposited (acre-feet)	Sediment deposited per acre of watershed (tons)	Sediment accumulation inches/period	inches/year
1929-1948	31.2	0.74	14.6	0.77
1948-1952	39.3	0.74	3.8	0.96
1952-1955	14.0	0.34	1.0	0.32
1929-1955	30.4	0.61	19.4	0.75

The sediment accumulated can be translated in terms of sediment yield from the watershed. As shown in Table 3-13, the sediment contribution from the watershed averaged 0.61 tons of sediment per acre over the 26 years.

Water Use and Availability

Ground-Water Resources

Ground water provides approximately one-third of Illinois' population with drinking water. The sources of this water can be broken down into three major units: 1) sand and gravel, 2) shallow bedrock, and 3) deep bedrock. Most ground-water resources are centered in the northern two-thirds of Illinois.

Sand-and-gravel aquifers are found along many of the major rivers and streams across the state and also within "buried bedrock valley" systems created by complex glacial and interglacial episodes of surface erosion. There are also many instances of thin sand-and-gravel deposits within the unconsolidated materials above bedrock. These thin deposits are used throughout Illinois to meet the water needs of small towns. Shallow bedrock units are more commonly used in the northern third of Illinois, whereas deep bedrock units are most widely used in the northeastern quarter (in and around the Chicago area).

The variety of uses and the volume of water used vary widely throughout the state. This section of the report describes ground-water availability and use within the Mackinaw River basin.

Data Sources

Private Well Information

The Illinois State Water Survey (ISWS) has maintained well construction reports since the late 1890s. Selected information from these documents has been computerized and is maintained within the Private Well Database. These data are easily queried and summarized for specific needs and form the basis of well distribution studies within the Mackinaw River basin.

Public Well Information

Public Water Supply (PWS) well information has been maintained at the ISWS since the late 1890s. Municipal well books (or files) have been created for virtually all of the reported surface and ground-water PWS facilities in Illinois. Details from these files are assembled within the Public-Industrial-Commercial Database, which was created to house water well and water use information collected by the ISWS.

Ground-Water Use Information

The water use data given in this report come from the records compiled by the ISWS Illinois Water Inventory Program (IWIP). This program was developed to document and facilitate planning and management of existing water resources in Illinois. Information for the program is collected through an annual water use summary mailed directly to each PWS facility.

Data Limitations

Several limitations must be taken into consideration when interpreting these data:

1. Information is reported by drillers and by each PWS facility.
2. Data measuring devices are generally not very accurate.
3. Participation in the IWIP is voluntary.

Information assembled from well construction reports and from the IWIP is considered "reported" information. This means that the data are as accurate as the reliability of the individual reporting or as mechanical devices dictate. The quality of the reported information depends upon the skill or budget of the driller or facility, respectively. Moreover, the ISWS estimates that only one-third to one-half of the wells in the state are on file at the Survey, mainly due to the lack of reporting regulations prior to 1976.

Water use measuring devices, such as the meters used by PWS facilities, are generally not very accurate. In fact, errors of as much as 10% are not uncommon. Much of the reported information in the IWIP is estimated by the water operator or by program staff.

Participation in the program is not required by the State of Illinois, and each facility voluntarily reports its information through a yearly survey. However, not all facilities know of or respond to the water use questionnaire. After several mail and telephone attempts have been made to gather this information, estimates are made using various techniques. To help reduce errors associated with the program, reported water use information is checked against usage from previous years to identify any large-scale reporting errors.

Ground-Water Availability

The Mackinaw River basin encompasses portions of six counties: Ford, Livingston, McLean, Mason, Tazewell, and Woodford. The portions of each county within the basin vary from 1.4% (Livingston County) to 59.2% (Woodford County). This section summarizes ground-water availability within the basin, taking into consideration only those portions of each county that are actually within the basin.

Domestic and Farm Wells

Available regional information indicates that ground water for domestic and farm use in the basin is mostly obtained from two types of wells finished within the unconsolidated materials above the bedrock: large-diameter dug-and-bored wells and small-diameter drilled wells.

Large-diameter wells usually tap strips or lenses of water-bearing silt, sand, or gravel only a few inches thick. The wells are generally finished at depths less than 100 feet. Water levels at any given location may fluctuate seasonally as much as 10 feet in response to variations in precipitation recharge and may decline below the bottom of shallow wells in the uplands in late summer and early fall just before normal ground-water recharge season begins. Wells of this type normally are capable of producing only a few hundred gallons of water each day. However, their large diameter permits storage of several hundred gallons of water (about 53 gallons per foot for a 36-inch-diameter well). Such storage allows large withdrawals during heavy demand periods and is slowly replenished by seepage from the surrounding fine-grained materials during times of little or no pumpage.

Small-diameter drilled wells tap water-bearing sand-and-gravel deposits within the unconsolidated materials above bedrock. These wells range in depth from less than 100 feet to almost 400 feet. Table 3-14 summarizes the number of reported wells within the basin by county and depth. Figure 3-24 shows the locations of these wells and the large-diameter dug-and-bored wells.

Table 3-14. Reported Private Wells within the Mackinaw River Basin
(Source: ISWS Private Well Database)

	Depth range, feet								
County	0-50	51-100	101-150	151-200	201-250	251-300	301-350	351-400	> 400
Ford	19	35	28	8	3	1	2	0	0
Livingston	2	11	2	1	2	5	0	0	0
McLean	638	492	291	207	100	68	18	13	1
Mason	67	62	61	0	0	0	3	0	1
Tazewell	369	323	323	263	152	121	76	17	3
Woodford	164	199	164	108	60	58	24	2	1
Total	1,259	1,122	869	587	317	253	123	32	6

The mineral quality of water from the unconsolidated deposits is discussed in the *Ground-Water Quality* chapter of this volume. Typically the water is hard and contains enough iron to cause staining of porcelain fixtures but can be improved for household uses with commercially available home treatment units.

The underlying bedrock consists principally of nonwater-bearing shale with only a few thin beds of water-yielding sandstone or creviced limestone of Pennsylvanian age. Several wells have been drilled into the bedrock of this area, but we have no records of any of these wells obtaining an adequate supply of good quality water.

Public Water Supply Wells

Information from the ISWS Public-Industrial-Commercial Database indicates that PWS ground-water use in the area comes from small-diameter drilled wells finished within the unconsolidated materials above bedrock. These wells tap water-bearing sand-and-gravel deposits and range in depth from 35 to 408 feet. Water use from each PWS facility within the basin is shown in Table 3-15. A total of 23 PWS facilities provide ground

Figure 3-24.
Ground-Water Wells
in the Mackinaw River Basin

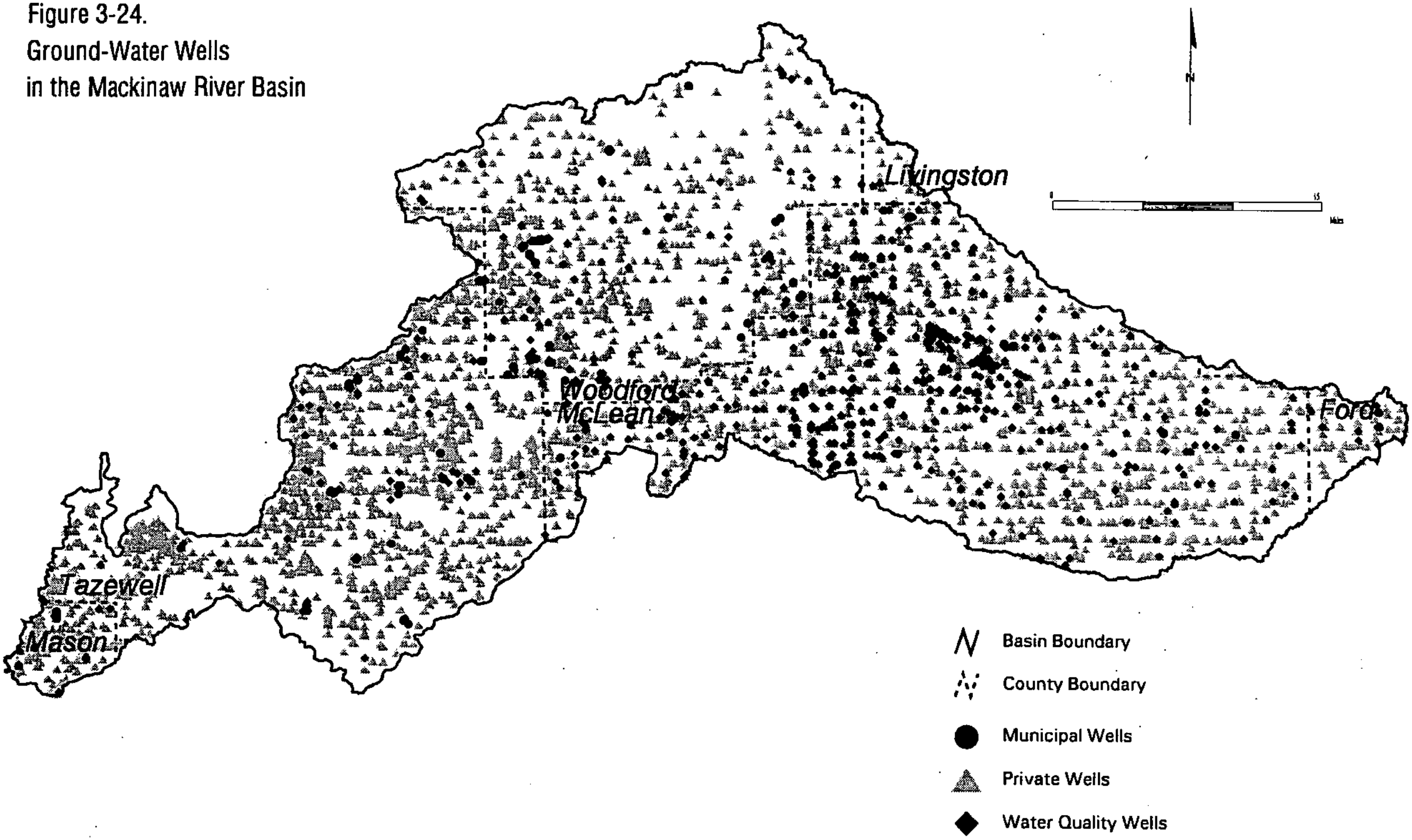


Table 3-15. Water Use Information per Public Water Supply within the Mackinaw River Basin

County	City	Population (reported)	# of services (reported)	Population per service	Water source	# of wells	Well depths (ft)	Formation in which wells were finished	1995 per source water use (gal)	1995 total water use (gal)	Per capita water use (gpd)
Ford	Sibley	380	180	2.1	GW	2	116,170	sand & gravel	9,540,000	9,540,000	68.8
McLean	Anchor	180	71	2.6	GW	1	83	sand & gravel	5,300,000	5,300,000	80.7
	Carlock	404	183	2.2	GW	2	246,250	sand & gravel	12,000,000	12,000,000	81.3
	Colfax	900	431	2.1	GW	2	102,103	sand & gravel	33,248,000	33,248,000	101.2
	Cooksville	275	104	2.6	GW	2	133,135	sand & gravel	8,431,500	8,431,500	84.0
	Gridley	1,310	513	3.1	GW	3	287,294,295	sand & gravel	29,129,300	29,129,300	61.0
	Lexington	1,887	645	2.9	GW	5	130,102,242	sand & gravel	52,100,000	52,100,000	75.6
	Normal	40,500	10,347	3.9	GW	14	35-92,217-364	sand & gravel	821,184,300	821,184,300	55.6
Mason	Manito	1,800	677	2.7	GW	2	147,148	sand & gravel	55,473,149	55,473,149	84.4
Tazewell	Deer Creek	684	264	2.6	GW	1	335	sand & gravel	20,700,000	20,700,000	82.9
	Hopedale	900	328	2.3	GW	2	205,222	sand & gravel	22,521,000	22,521,000	68.6
	Mackinaw	2,100	928	2.3	GW	4	39,40,151,325	sand & gravel	65,600,000	65,600,000	85.6
	Morton	14,200	4,700	3.0	GW	8	254-280	sand & gravel	338,450,000	338,450,000	65.3
	South Pekin	1,200	404	3.0	GW	2	112,117	sand & gravel	29,130,070	29,130,070	66.5
	Tremont	2,100	807	2.6	GW	2	212,201	sand & gravel	61,725,000	61,725,000	80.5
Woodford	Benson	440	198	2.2	GW	1	114	sand & gravel	9,836,000	9,836,000	61.2
	Congerville	500	173	3.0	GW	1	47	sand & gravel	14,300,000	14,300,000	78.4
	El Paso	2,505	860	2.9	GW	3	120,120,103	sand & gravel	88,200,000	88,200,000	96.7
	Eureka	5,000	1,553	3.2	GW	2	338,340	sand & gravel	88,195,200	113,738,900	62.3
					SW	1	(intake)		31,101,900		
	Goodfield	510	230	2.2	GW	2	320,330	sand & gravel	13,400,000	13,400,000	72.0
	Metamora	2,600	1,118	2.3	GW	2	362,408	sand & gravel	77,781,800	77,781;800	82.0
	Roanoke	2,015	750	2.8	GW	3	52,51,121	sand & gravel	83,800,000	83,800,000	113.9
	Secor	393	165	2.4	GW	2	158,156	sand & gravel	20,233,900	20,233,900	141.1

water to almost 83,000 reported residents within the basin. The per capita daily water use of these residents ranges from as little as 56 gallons per day (gpd) to more than 140 gpd. (Note: These statistics were calculated from information reported by each PWS facility.) Locations of the PWS wells and the private domestic wells are shown in Figure 3-24.

1995 Ground-Water Use

Ground water constitutes almost all of the total water used within the Mackinaw River basin. Total ground-water use within the basin during 1995 was estimated to be 6.71 million gallons per day (mgd). PWS facilities withdrew 4.40 mgd, self-supplied industries (SSI) withdrew 0.11 mgd, rural/domestic withdrawals totaled 0.96 mgd, and livestock watering withdrawals totaled 1.24 mgd.

Public Water Supply

In 1995, municipal use for 23 communities using ground water was reported to be 4.40 mgd, serving a combined population of 82,783. The per capita use from these municipalities ranged from 56 to 141 gpd. Water use summaries for each facility are described in Table 3-15.

Self-Supplied Industry

Self-supplied industries are defined as those facilities that meet all or a portion of their water needs from their own sources. Within the Mackinaw River basin, six of these facilities reported ground-water pumpage during 1995 totaling 0.11 mgd.

Rural/Domestic

There is no direct method for determining rural/domestic water use within the basin. To get a rough estimate for the area, several assumptions were made using existing information. The population served and number of services reported by PWS facilities were used to calculate an average population per service for all PWS facilities within the basin. This number was then used as an estimate of population per reported domestic well within the area. The average PWS per capita use was then used as a multiplier to determine the total rural/domestic water use from each well. Since the ISWS Private Well Database shows 4,568 reported wells within the basin, an average of 3.2 people per service (well), and an average of 65.7 gpd per person, the total rural/domestic water use was estimated to be 0.96 mgd.

Livestock Watering

Water withdrawals for livestock use in 1995 were estimated to be 1.24 mgd. Water use estimates for livestock are based on a fixed amount of water use per head for each type of animal. Percentages of the total animal population (Illinois Department of Agriculture 1995) for the major livestock (cattle and hogs) in the counties were calculated based upon the percentage of county acres within the Mackinaw River basin. Daily consumption rates (beef cattle = 12 gpd, all other cattle = 35 gpd, and hogs = 4 gpd) provided the basis for these calculations.

Ground-Water Use Trends

Total ground-water use within the basin has been relatively consistent for the last six years, averaging 4.49 mgd and ranging from 4.08 to 5.00 mgd. PWS use has averaged 4.37 mgd and ranged from 3.97 to 4.85 mgd during this period, and SSI use has averaged 0.12 mgd and ranged from 0.08 to 0.17 mgd. Table 3-16 shows the individual totals per year since 1990. No significant trends are evident for water withdrawals within the basin.

Table 3-16. Ground-Water Use within the Mackinaw River Basin
(in million gallons per day, mgd)

	PWS	SSI	Total
1990	3.97	0.13	4.01
1991	4.62	0.17	4.79
1992	4.39	0.08	4.47
1993	3.99	0.09	4.08
1994	4.85	0.15	5.00
1995	4.40	0.11	4.51
Average	4.37	0.12	4.49

Summary

Statewide, water use has increased a modest 27% since 1965 (Illinois Department of Energy and Natural Resources 1994). Most of that increase is in power generation. Water use for PWS has risen only about 7% during that time, less than the concurrent percentage increase in population. The number of public ground-water supply facilities within Illinois has risen significantly during that time, yet the total amount supplied by ground water remains near 25%.

A dependable, adequate source of water is essential to sustaining existing and potential population demands and industrial uses in Illinois. Modifications to and practical management of both surface and ground-water use have helped make Illinois' water resources reliable. As individual facilities experience increases in water use, innovative alternative approaches to developing adequate water supplies must arise. This is likely to involve conjunctive use of surface and ground waters.

Major metropolitan centers such as the Chicago area, Peoria, and Decatur, as well as smaller communities such as Eureka in the Mackinaw River basin, have already developed surface and ground-water sources to meet their development needs and to sustain growth. The construction of impounding reservoirs has become and will remain economically and environmentally expensive, making it a less common approach.

Proper management of water resources is necessary to ensure a reliable, high quality supply for the population. Water conservation practices will become increasingly important to reduce total demand and to avoid exceeding available supplies. Both our ground-water resources and surface reservoir storage must be preserved to maintain reliable sources for future generations.

Surface Water Resources

The rivers, streams, and lakes of the Mackinaw River basin serve a wide variety of purposes, including uses for 1) public water supply; 2) recreation (boating, fishing, and swimming); and 3) habitat for aquatic life. The primary focus of this section is on water withdrawn from streams for public water supply and the surface water resources available for such use.

Water supply systems generally obtain surface water in one of three manners: 1) direct withdrawal from a stream, 2) impoundment of a stream to create a storage reservoir, and 3) creation of an off-channel (side-channel) storage reservoir into which stream water is pumped. As described below, potential locations for direct withdrawals and impounding reservoirs are somewhat limited geographically. The potential for side-channel storage exists along most streams.

Water Use and Availability

The only user of surface water for water supply in the Mackinaw River basin is the PWS for the city of Bloomington. Prior to February 1995, the Eureka PWS withdrew approximately 0.66 mgd from Lake Eureka, which it supplemented with well water. However, the Eureka PWS has since switched entirely to the use of wells.

The average water use of the Bloomington PWS has grown steadily (Figure 3-25) and is currently about 11.5 mgd.

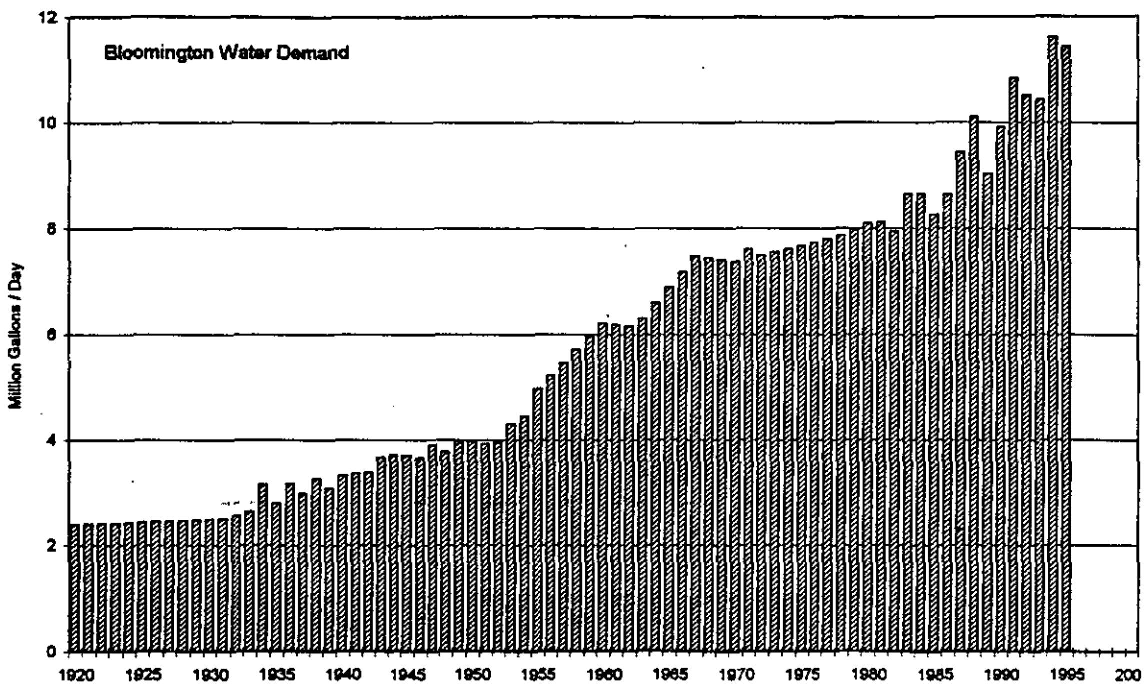


Figure 3-25. Water Use for the City of Bloomington PWS, 1920-1995

As its average use has increased, the city has continued to develop additional water supplies to meet water demands. Two PWS reservoirs, Lake Bloomington and Evergreen Lake, were constructed in 1930 and 1970, respectively. The locations of these reservoirs are shown in Figure 3-26.

Lake Bloomington and Evergreen Lake impound Money Creek and Six Mile Creek, respectively, which collectively drain an area of about 100 square miles. The catchments of these two lakes represent roughly 8% of the entire Mackinaw River basin and 30% of the basin upstream of the Mackinaw River's confluence with Panther Creek. The spillways of the two lakes were raised--in 1959 for Lake Bloomington and 1995 for Evergreen Lake--to increase the available storage.

Water is also withdrawn directly from the Mackinaw River in eastern Woodford County to supply supplemental water to the city of Bloomington during extended droughts. Pumping from this facility is discontinued during low flow conditions when withdrawals might interfere with instream water uses, such as canoeing or fish and aquatic habitats.

Treated wastewater from the city is discharged into Sugar Creek, a tributary to the Sangamon River. The transfer of water to another major basin reduces the average flow in the Mackinaw River in western McLean County by approximately 5%. The percentage change in low flows and high flows on the Mackinaw River resulting from this transfer is expected to be of a similar or smaller magnitude.

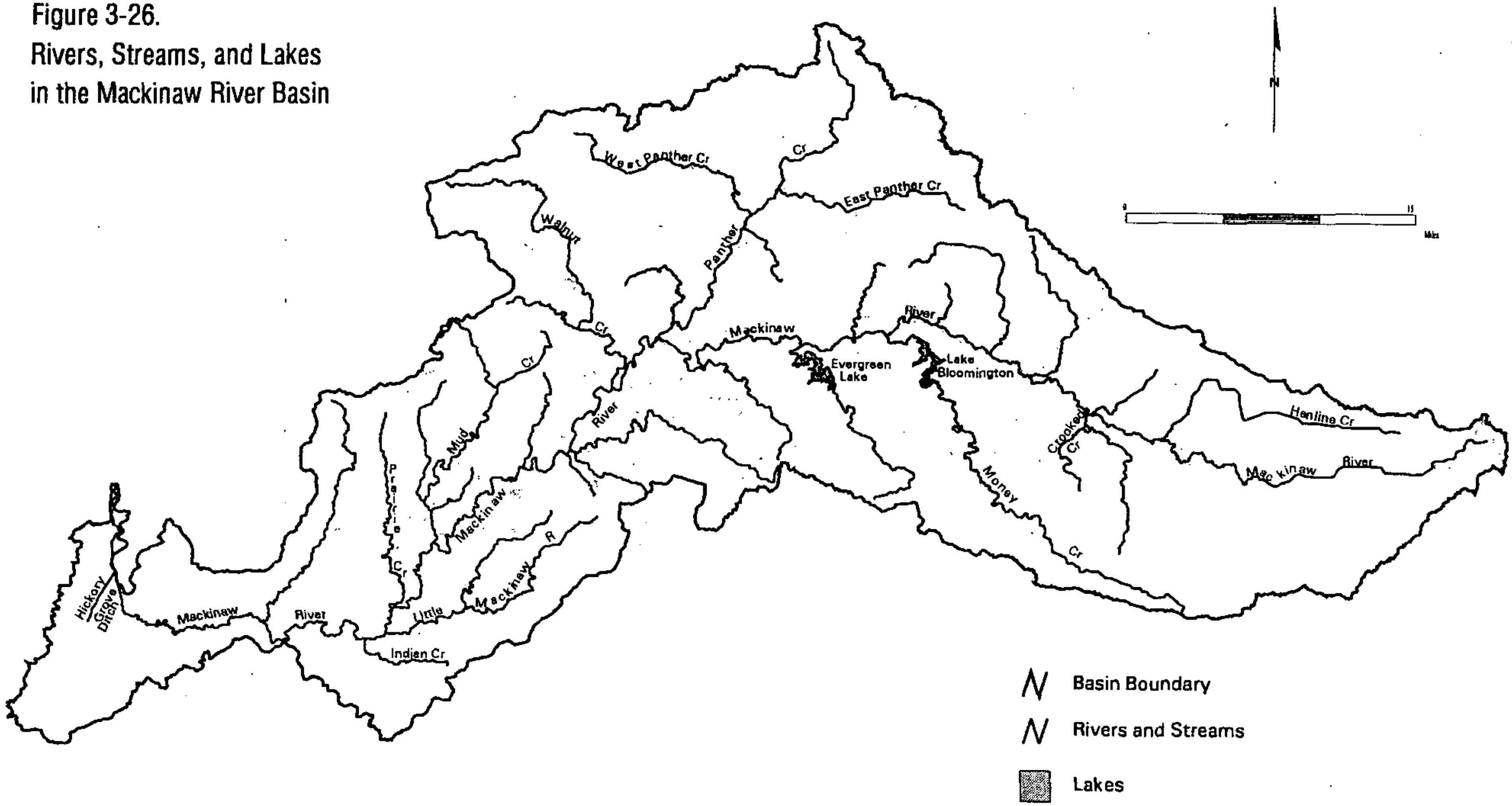
The ability of Bloomington's reservoir supplies to meet increasing water use has been most critically tested in two major droughts, 1953-1956 and 1988-1989. Shortages during the 1988 drought prompted three meaningful actions to expand the city's water supply system: 1) installation of a pumping station on the Mackinaw River with a transmission line to Lake Evergreen, to supplement the lake's storage during drought; 2) raising the spillway elevation of Lake Evergreen to create additional storage; and 3) investigating the use of regional ground-water resources to meet future increases in water use.

Potential for Development of Surface Water Supplies

<u>Direct Withdrawals from Streams</u>

No water supply systems in the Mackinaw River basin use water pumped directly from a stream for their primary water supply. For a stream to be used for this purpose, it is essential that the stream have a continuous flow of water during extreme drought conditions. The Mackinaw River in Tazewell County is the only reach of stream in the basin that has this characteristic. Although the potential exists for the river to support direct withdrawals in this reach, it is not likely that the river will be used in this manner since ground-water resources in the area are generally sufficient to meet present and expected water use needs.

Figure 3-26.
Rivers, Streams, and Lakes
in the Mackinaw River Basin



Impounding Reservoirs

The central portion of the Mackinaw River basin provides a number of possible reservoir sites, primarily because of its steep valley slopes. Figure 3-27 shows the locations of 15 potential reservoir sites in Woodford and eastern Tazewell Counties (Dawes and Terstriep 1966). Only three of these sites would provide a yield equivalent to that presently provided by either of the two existing water supply lakes.

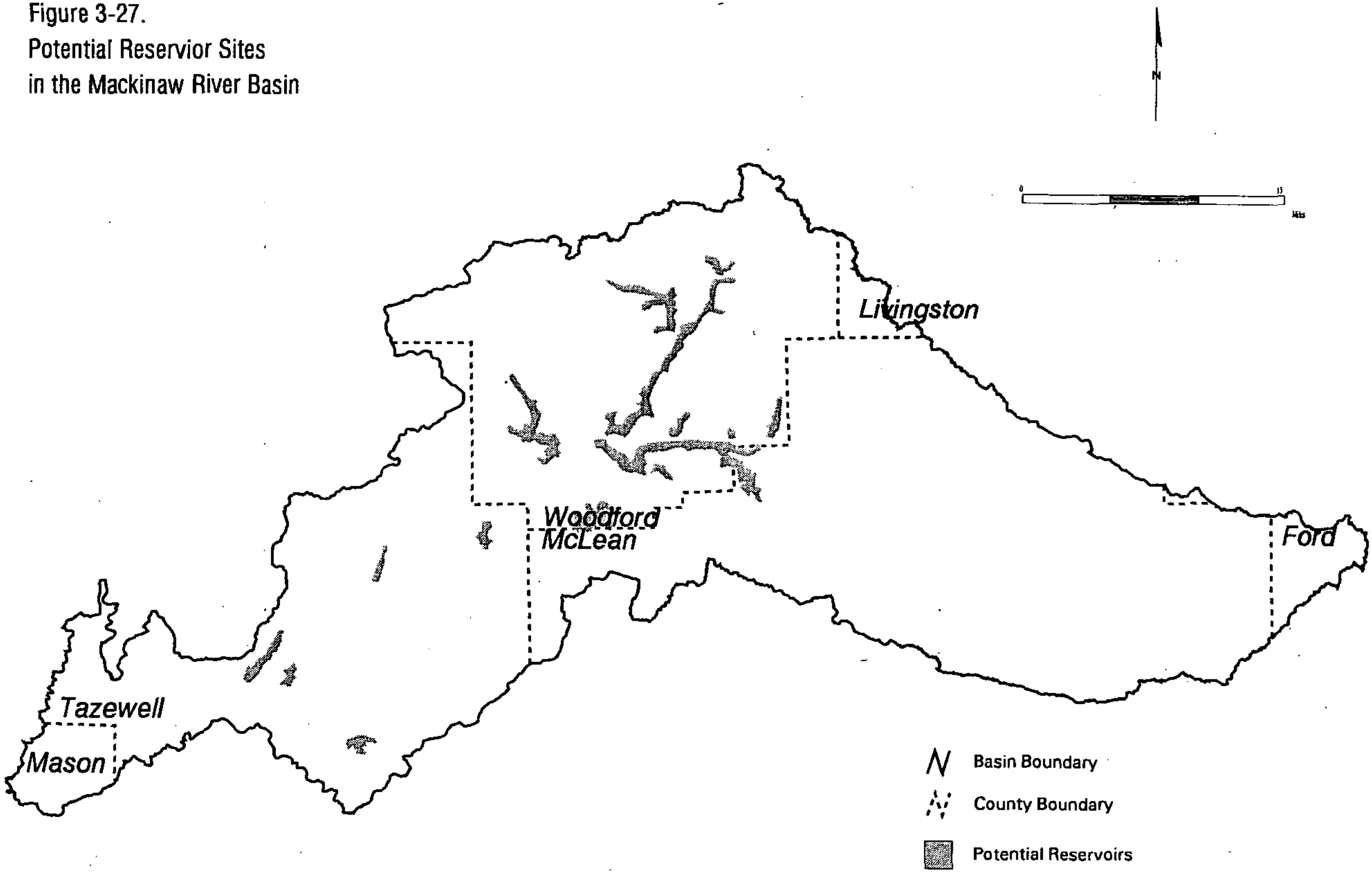
During the 1960s, the construction of a dam at the largest potential lake site, on the Mackinaw River near the town of Congerville, was considered to provide both flood control and water supply for the city of Bloomington. The project was eventually dismissed, however, because of its potential cost and insufficient local funding. In general, the construction of impounding reservoirs has become a less common option for water supply, primarily because of costs and environmental concerns.

Side-Channel Reservoirs

There are no side-channel reservoirs in the Mackinaw River basin. However, during drought years, Evergreen Lake receives water pumped from the Mackinaw River and thus functions partially as a side-channel reservoir. It is estimated that this pump station on the river can provide the equivalent of 4 mgd of water during a drought, or about one-third of Bloomington's current water use.

The construction of side-channel reservoirs is generally not limited by local topography and is a viable water supply option along most streams in the basin. The amount of water supply that off-channel storage can provide is limited primarily by the temporal distribution of flow in the stream and the size of the storage reservoir.

Figure 3-27.
Potential Reservior Sites
in the Mackinaw River Basin



Ground-Water Quality

This section examines ground-water quality records to determine temporal trends and to provide baseline water quality parameters within the Mackinaw River basin. Increasingly, ground-water contamination is discussed in the news media, and it may seem that the entire ground-water resource has been affected. However, these contamination events are often localized and may not represent widespread degradation of the ground-water resource. By examining the temporal trends in ground-water quality within this basin, it may be possible to determine if large-scale degradation of the ground-water resource has occurred.

The general term "ground-water quality" refers to the chemical composition of ground water. Ground water originates as precipitation that filters into the ground. As the water infiltrates the soil, it begins to change chemically due to reactions with air in the soil and with the earth materials through which it flows. Human-induced chemical changes can also occur. In fact, contamination of ground water is generally the result of human-induced chemical changes and not naturally occurring processes.

As a general rule, local ground-water quality tends to remain nearly constant under natural conditions because of long ground-water travel times. Therefore, significant changes in ground-water quality can often indicate degradation of the ground-water resource.

Data Sources

The ground-water quality data that are used in this report come from two sources: private wells and municipal wells. The private well water quality data are compiled by the Chemistry Division of the ISWS as part of its water testing program and are maintained by the Office of Ground-Water Information in a water quality database. The municipal well data come from ISWS analyses and from the Illinois Environmental Protection Agency (IEPA) laboratories.

The combined database now contains more than 50,000 records of chemical analyses from samples analyzed at the ISWS and IEPA laboratories. Some of these analyses date to the early part of the century, but most are from 1970 to the present. Before 1987, most analyses addressed inorganic compounds and physical parameters. Since then, many organic analyses have been added to the database from the IEPA Safe Drinking Water Act compliance monitoring program.

Data Limitations

Several limitations to the data must be understood before any meaningful interpretation can begin:

1. Representativeness of the sample
2. Location information
3. Data quality (checked by charge balance)
4. Extrapolation to larger areas

The private well samples are likely not completely representative of regional ground-water quality. In most cases, private well owners submit samples for analysis only when they believe there may be a problem such as high iron or an odd odor or taste. This suggests that perhaps one or more constituents may not be representative, but in general, the remainder of the chemical information will be accurate and useful. As a result, the composite data may be skewed toward analyses with higher than normal concentrations.

On the other hand, the private well information probably provides a better picture of the spatial distribution of chemical ground-water quality than municipal well information because of the larger number of samples spread over a large area. Recent IEPA data from municipal wells will not be skewed because each well is sampled and analyzed on a regular basis. While this produces a much more representative sample overall, samples are generally limited to specific areas where municipalities are located. Therefore, these data may not be good indicators of regional ground-water quality.

Much of the location information for the private wells is based solely on the location provided by the driller at the time the well was constructed. Generally, locations are given to the nearest 10-acre plot of land. For our purposes in this discussion, that degree of resolution is adequate. However, it is not uncommon for a given location to be in error by as much as 6 miles. To circumvent possible location errors, this report presents results on a watershed basis.

The validity of water quality data was not checked for this report. However, previous charge balance checking of these data was conducted for a similar statewide project (Illinois Department of Energy and Natural Resources 1994). Charge balance is a simple measure of the accuracy of a water quality analysis. It measures the deviation from the constraint of electrical neutrality of the water by comparing total cations (positively charged ions) with total anions (negatively charged ions). Because many of the early analyses were performed for specific chemical constituents, a complete chemical analysis is not always available from which to calculate a charge balance.

The statewide study searched the water quality database for analyses with sufficient chemical constituents to perform an ion balance. The charge balance checking of those data found that more than 98% of the analyses produced acceptable mass balance, which suggests that the chemical analyses are accurate within the database. Using that assumption for this report, we feel confident that most of the analyses used are accurate and give representative water quality parameters in the basin.

The question of extrapolation of point value (a well water sample) to a regional description of ground-water quality is difficult and theoretically beyond the scope of this report. However, none of the data provide a uniform spatial coverage. Therefore, it seems best to summarize the data on a watershed basis to ensure the availability of an adequate number of values. The private well analyses are more numerous and will likely provide better spatial coverage than the municipal well data, which are concentrated in isolated locations. The locations of the water quality analysis sites within the basin are pictured in Figure 3-24 in the chapter on *Water Use and Availability.*

Chemical Components Selected for Trend Analysis

In many cases, ground-water contamination involves the introduction into ground water of industrial or agricultural chemicals such as organic solvents, heavy metals, fertilizers, or pesticides. However, recent evidence suggests that many of these contamination occurrences are localized and form finite plumes that extend down gradient from the source. Much of this information is relatively recent, dating back a few decades, but long-term records at any one site are rare.

As mentioned earlier, changes in the concentrations of naturally occurring chemical elements such as chloride, sulfate, or nitrate also can be indicative of contamination. Increasing chloride concentrations may indicate contamination from road salt or oil field brine. Increasing sulfate concentrations may be from acid wastes such as metal pickling, while increasing nitrate concentrations may result from fertilizer application, feed-lot runoff, or leaking septic tanks. These naturally occurring substances are the major components of mineral quality in ground water and are routinely included in ground-water quality analyses.

Fortunately, the ISWS has maintained records of routine water quality analyses of private and commercial wells that extend as far back as the 1890s. After examination of these records, six chemical constituents were chosen for trend analyses based on the large number of available analyses and because they may be indicators of human-induced degradation of ground-water quality. These components are iron (Fe), total dissolved solids (TDS), sulfate (SO_4), nitrate (NO_3), chloride (Cl), and hardness (as $CaCO_3$).

Aquifer Unit Analysis

Ground water occurs in many types of geological materials and at various depths below the land surface. This variability results in significant differences in natural ground-water quality from one part of Illinois to another and from one aquifer to the next even at the same location. For the purpose of this trend analysis, only wells that were finished within the unconsolidated sand and gravel units are used. These units are by far the most frequently used within the Mackinaw River basin. Of the more than 4,500 private wells in this area (see Figure 3-24 in *Water Use and Availability*), only 50 indicate penetration into the bedrock units. There is no information on whether any of these wells produce usable ground water for domestic supply. Only six water quality analyses in the ISWS water quality database indicate that a water sample came from the bedrock units.

The temporal trends of the six chemical constituents from unconsolidated materials are summarized in this section. Table 3-17 presents the number of data points and the maximum, minimum, mean, and median of the decade analyses for each constituent.

Table 3-17. Chemical Constituent Statistical Values per Decade

	Decade*									
Chemical constituent	0	1	2	3	4	5	6	7	8	9
Iron (Fe)										
Sample size (N)	26	8	6	40	66	32	373	339	184	17
Minimum (mg/L)	0.0	0.3	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Maximum (mg/L)	45.0	2.7	2.0	14.0	50.0	13.0	37.0	23.0	11.2	4.7
Mean (mg/L)	4.1	1.6	1.4	2.6	3.1	2.5	2.5	2.5	2.3	1.8
Median (mg/L)	1.8	1.4	1.5	2.3	2.0	1.7	1.2	1.9	2.0	1.7
TDS										
Sample size (N)	23	11	6	42	64	32	373	372	181	17
Minimum (mg/L)	310.0	308.0	330.0	302.0	291.0	279.0	131.0	223.0	284.0	237.0
Maximum (mg/L)	1480.0	739.0	761.0	793.0	1874.0	1496.0	3336.0	2560.0	3700.0	691.0
Mean (mg/L)	581.7	488.7	462.0	503.7	540.5	573.0	632.5	552.7	515.9	425.5
Median (mg/L)	470.0	467.0	380.0	480.0	470.0	486.0	517.0	497.0	454.0	379.0
Sulfate (SO_4)										
Sample size (N)	24	7	6	41	50	7	9	145	177	17
Minimum (mg/L)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	10.0
Maximum (mg/L)	425.0	67.0	254.0	276.0	289.0	238.0	169.0	555.0	470.0	79.0
Mean (mg/L)	94.7	15.4	49.3	57.3	42.8	55.4	61.1	48.7	39.1	36.3
Median (mg/L)	49.0	6.0	10.0	4.0	4.0	3.0	44.0	10.0	10.0	34.0
Nitrate (NO_3)										
Sample size (N)	21	11	6	38	25	18	227	299	11	N/A
Minimum (mg/L)	0.0	0.4	0.5	0.0	0.0	0.0	0.0	0.0	0.3	N/A
Maximum (mg/L)	27.5	7.4	2.5	47.9	29.1	128.0	323.0	193.0	16.3	N/A
Mean (mg/L)	4.0	2.7	1.3	7.9	5.3	25.4	45.4	5.5	3.0	N/A
Median (mg/L)	0.0	1.3	1.2	2.1	1.3	3.4	12.8	0.9	1.1	N/A
Chloride (Cl)										
Sample size (N)	27	13	6	42	63	32	371	337	183	17
Minimum (mg/L)	2.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.1	1.5
Maximum (mg/L)	310.0	81.0	16.0	73.0	232.0	180.0	510.0	340.0	425.0	64.0
Mean (mg/L)	47.9	21.9	6.8	11.4	30.0	26.3	34.6	20.8	24.4	14.0
Median (mg/L)	12.0	13.0	6.0	7.0	11.0	9.5	14.0	11.0	12.0	3.6
Hardness (as $CaCO_3$)										
Sample size (N)	26	9	6	41	66	32	373	319	123	13
Minimum (mg/L)	212.0	291.0	229.0	47.0	58.0	140.0	32.0	4.0	10.0	213.0
Maximum (mg/L)	1200.0	456.0	640.0	682.0	1156.0	848.0	2400.0	2020.0	938.0	383.0
Mean (mg/L)	419.9	347.7	380.3	354.5	381.7	387.3	426.2	355.2	319.0	306.9
Median (mg/L)	328.0	333.0	315.0	341.0	329.5	334.0	364.0	318.0	305.0	311.0

*Note: Decade 0=1900-1909, decade 1=1910-1919, and so on.

Discussion and Results

The median values for the data are plotted by decade in Figures 3-28–3-33, beginning with 1900-1909 (decade 0), 1910-1919 (decade 1), and so on through the 1990s, which are plotted as decade 9. Each decade covers the corresponding ten-year period, except for the partial decade of the 1990s. The median concentration values are plotted per decade to determine whether temporal trends can be identified within the data set. Median values are the midpoints of a set of data, above which lie half the data points and below which is found the remaining half. These values are used to look at the central tendency of the data set. Although the arithmetic mean would also look at this statistic, it incorporates all data points into its analysis, which can move the mean value in one direction or another based upon maximum or minimum values.

In many data sets, outliers occur. These are extreme values that tend to stand alone from the central values of the data set. They may lead to a false interpretation of the data set, whereas the median values are true values that are central to the data set. By looking at the median we can determine trends in the central portions of the data.

Iron (Fe)

Iron in ground water occurs naturally in the soluble (ferrous) state. However, when exposed to air, iron becomes oxidized into the ferric state and forms fine to fluffy reddish-brown particles that will settle to the bottom of a container if allowed to set long enough. The presence of iron in quantities much greater than 0.1 to 0.3 milligrams per liter (mg/L) usually causes reddish-brown stains on porcelain fixtures and laundry. The drinking water standards recommend a maximum limit of 0.3 mg/L iron to avoid staining (Gibb 1973).

Median iron concentrations for the basin for each decade are graphed in Figure 3-28. Minimum and maximum concentrations for all ten decades are 0.0 and 50.0 mg/L, respectively. The high variability of these concentrations clearly indicates a great deal of spatial variability in iron within the basin. The median values range from 1.2 to 2.3 mg/L for all ten decades (Table 3-17).

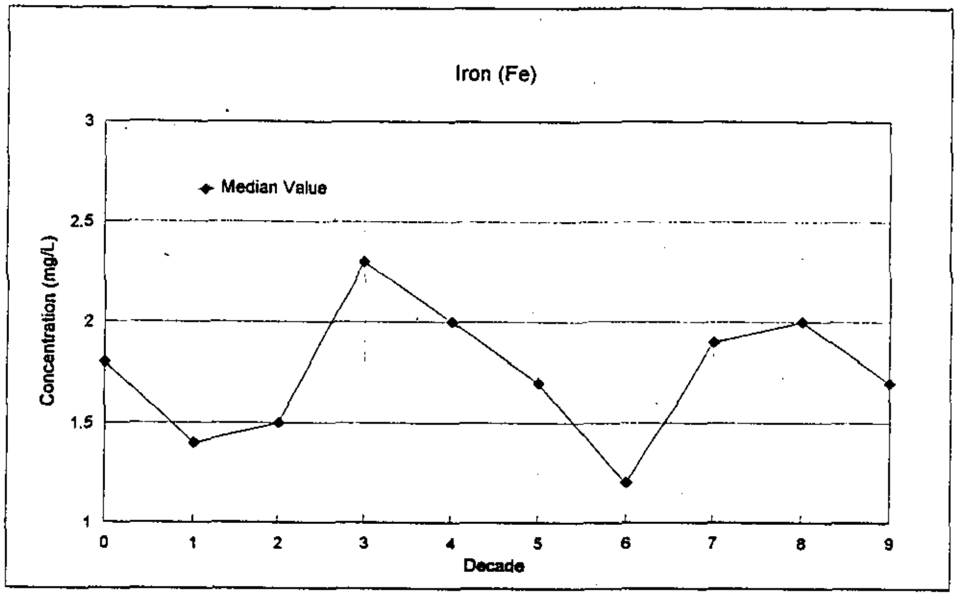


Figure 3-28. Median Iron Concentrations in the Mackinaw River Basin (by decade beginning with decade 0, 1900-1909)

While the plot of these median values shows relatively high concentrations that would cause staining of porcelain fixtures (greater than 0.3 mg/L), they pose no threat to human health and are all well above the class I potable ground-water supply standard of 0.5 mg/L. Figure 3-28 indicates no significant trend in iron concentrations in the basin.

Total Dissolved Solids (TDS)

The TDS content of ground water is a measure of the mineral solutes in the water. Water with a high mineral content may taste salty or brackish depending on the types of minerals in solution and their concentrations. In general, water containing more than 500 mg/L TDS will taste slightly mineralized. However, the general public can become accustomed to the taste of water up to concentrations of 2,000 mg/L. Water containing more than 3,000 mg/L TDS generally is not acceptable for domestic use, and at 5,000 to 6,000 mg/L, livestock may not drink the water. Because TDS concentration is a lumped measure of the total amount of dissolved chemical constituents in the water, it will not be a sensitive indicator of trace-level contamination. However, it is a good indicator of major inputs of ions or cations to ground water.

Median TDS concentrations for the basin for each decade are graphed in Figure 3-29. Minimum and maximum concentrations for all ten decades are 131 and 3,700 mg/L, respectively. The median values range from 379 to 517 mg/L for all ten decades (Table 3-17). Figure 3-29 indicates a slight decline in TDS concentrations over the last 30 years, but this may be due to the limits of the available information.

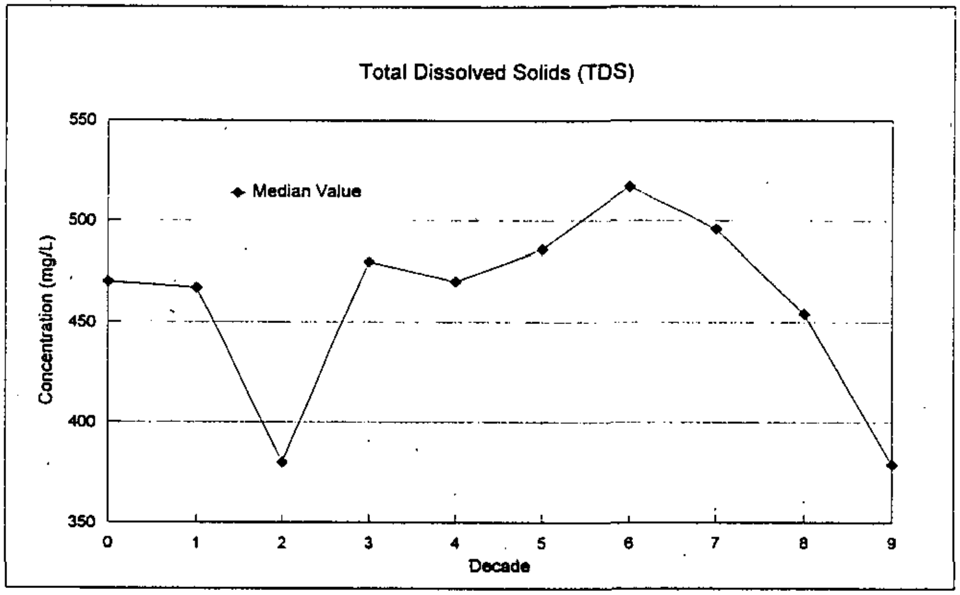


Figure 3-29. Median TDS Concentrations in the Mackinaw River Basin (by decade beginning with decade 0, 1900-1909)

Generally, no significant trend in TDS concentrations is observed in the basin. The fluctuations from one decade to the next are more likely related to data limitations rather than to any inherent changes in ground-water quality.

Sulfate (SO_4)

Water with high sulfate concentrations often has a medicinal taste and a pronounced laxative effect on those not accustomed to it. Sulfates generally are present in aquifer systems in one of three forms: as magnesium sulfate (sometimes called Epsom salt); as sodium sulfate (called Glauber's salt); or as calcium sulfate (called gypsum). They also occur in earth materials in a soluble form that is the source for natural concentrations of this compound. Man-made sources similar to those for chloride also can contribute locally to sulfate concentrations. Coal mining operations particularly are a common source of sulfate pollution, as are industrial wastes. Drinking water standards recommend an upper limit of 250 mg/L for sulfates. Trends in sulfate concentrations can suggest potential ground-water pollution.

Median sulfate concentrations for the basin for each decade are graphed in Figure 3-30. Minimum and maximum concentrations for the ten decades are 0.0 and 555 mg/L, respectively. The median values range from 3 to 49 mg/L for all ten decades (Table 3-17).

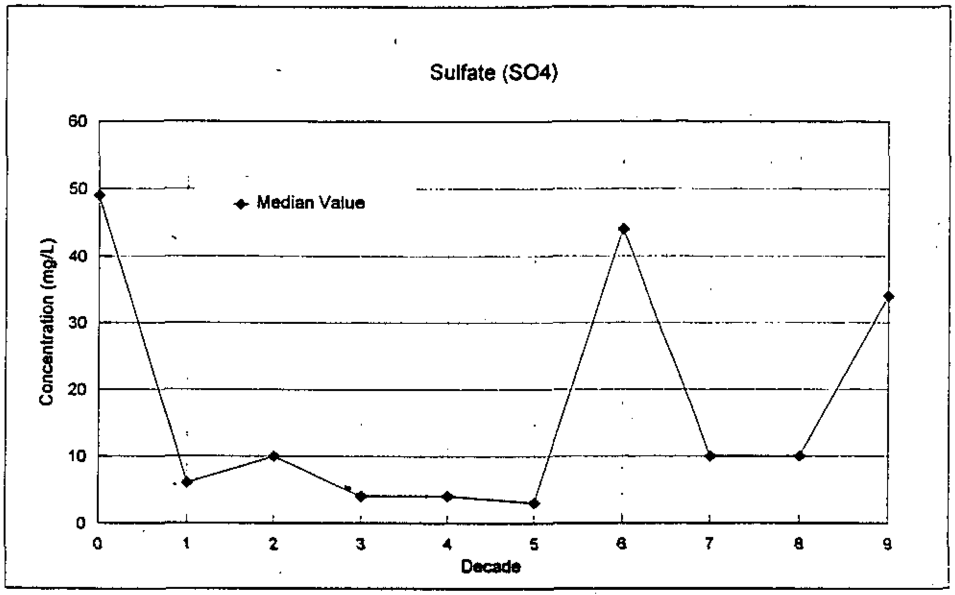


Figure 3-30. Median Sulfate Concentrations in the Mackinaw River Basin (by decade beginning with decade 0, 1900-1909)

Figure 3-30 indicates variability, but no significant trend in sulfate concentrations in the basin. Again, fluctuations from one decade to the next are more likely related to data limitations rather than to any inherent changes in ground-water quality. The median values are all well below the drinking water standard.

Nitrate (NO_3)

Nitrates are considered harmful if present in drinking water supplies in excess of 45 mg/L (as NO_3), or the approximate equivalent of 10 mg/L nitrogen (N). Excessive nitrate concentrations in water may cause "blue babies" (methemoglobiation) when such water is used in the preparation of infant feeding formulas. Inorganic nitrogen fertilizer has proven to be a source of nitrate pollution in some shallow aquifers, and may become an even more significant source in the future as ever increasing quantities are applied to Illinois farmlands. Trends in concentrations of nitrate may be a good indication that farm practices in the basin are affecting the ground-water environment.

Median nitrate concentrations for the basin for each decade are graphed in Figure 3-31. Minimum and maximum concentrations for the ten decades are 0.0 and 323 mg/L, respectively. The median values range from 0.0 to 12.8 mg/L for nine decades (Table 3-17).

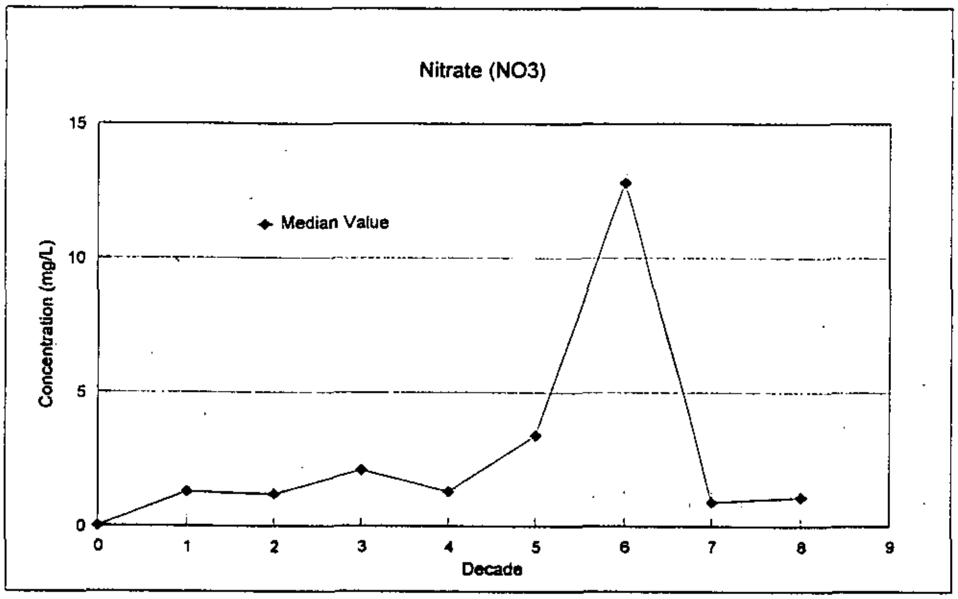


Figure 3-31. Median Nitrate Concentrations in the Mackinaw River Basin (by decade beginning with decade 0, 1900-1909)

While Figure 3-31 indicates a slight increase in nitrate concentrations in the basin over the century, the reported values are well below the drinking water standards for nitrate. On the other hand, the ISWS has documented numerous cases of elevated nitrate levels associated with rural private wells (Wilson et al. 1992). The evidence suggests that rural well contamination is associated more with farmstead contamination of the local ground water or well rather than regional contamination of major portions of an aquifer from the land application of fertilizers. This topic is actively being studied.

Chloride

Chloride is generally present in aquifer systems as sodium chloride or calcium chloride. Concentrations greater than about 250 mg/L usually cause the water to taste "salty." Chloride occurs in earth materials in a soluble form that is the source for normal concentrations of this mineral in water. Of the constituents examined in this report, chloride is one of the most likely to indicate the impacts of anthropogenic activity on ground water. Increasing chloride concentrations may indicate contamination from road salt or oil field brine. The drinking water standards recommend an upper limit of 250 mg/L for chloride. In sand and gravel aquifers throughout most of the state, chloride concentrations are usually less than 10 mg/L.

Median chloride concentrations for the basin for each decade are graphed in Figure 3-32. Minimum and maximum concentrations for the ten decades are 0.0 and 510 mg/L, respectively. The median values range from 3.6 to 14.0 mg/L for all ten decades (Table 3-17).

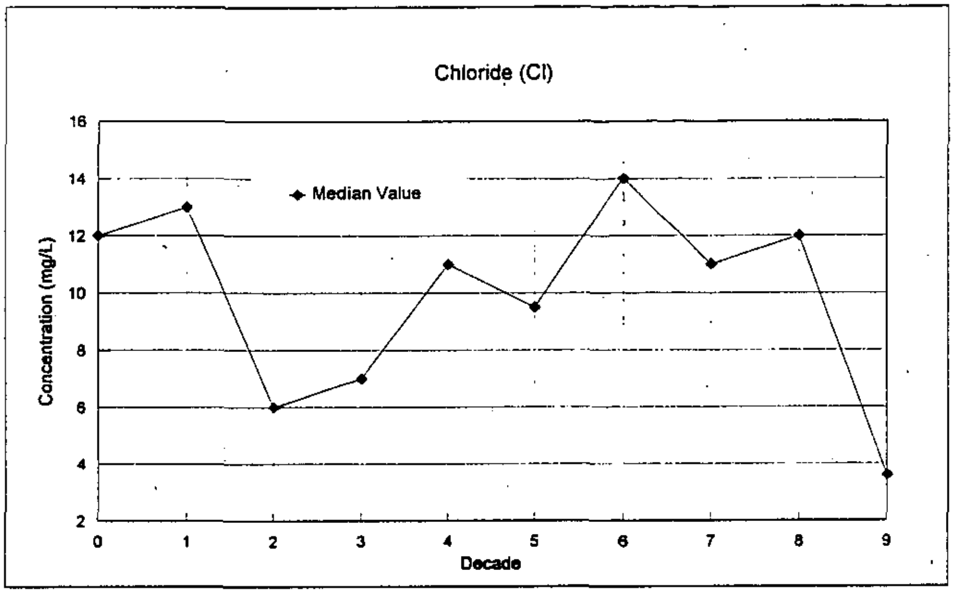


Figure 3-32. Median Chloride Concentrations in the Mackinaw River Basin (by decade beginning with decade 0, 1900-1909)

Figure 3-32 indicates no significant trend in chloride concentrations in the basin. All median values are well below the recommended drinking water standards. The small fluctuations from one decade to the next are more likely related to data limitations than to any inherent changes in ground-water quality.

Hardness (as $CaCO_3$)

Hardness in water is caused by calcium and magnesium. These hardness-forming minerals generally are of major importance to users since they affect the consumption of soap and soap products and produce scale in water heaters, pipes, and other parts of the water system. The drinking water standards do not recommend an upper limit for hardness. The distinction between hard and soft water is relative, depending on the type of water a person is accustomed to. The ISWS categorizes water from 0 to 75 mg/L as soft, 75 to 125 mg/L as fairly soft, 125 to 250 mg/L as moderately hard, 250 to 400 mg/L as hard, and over 400 mg/L as very hard.

Median hardness concentrations for the basin for each decade are graphed in Figure 3-33. Minimum and maximum concentrations for the ten decades are 4.0 and 2,400 mg/L, respectively. The median values range from 305 mg/L to 364 for all ten decades (Table 3-17).

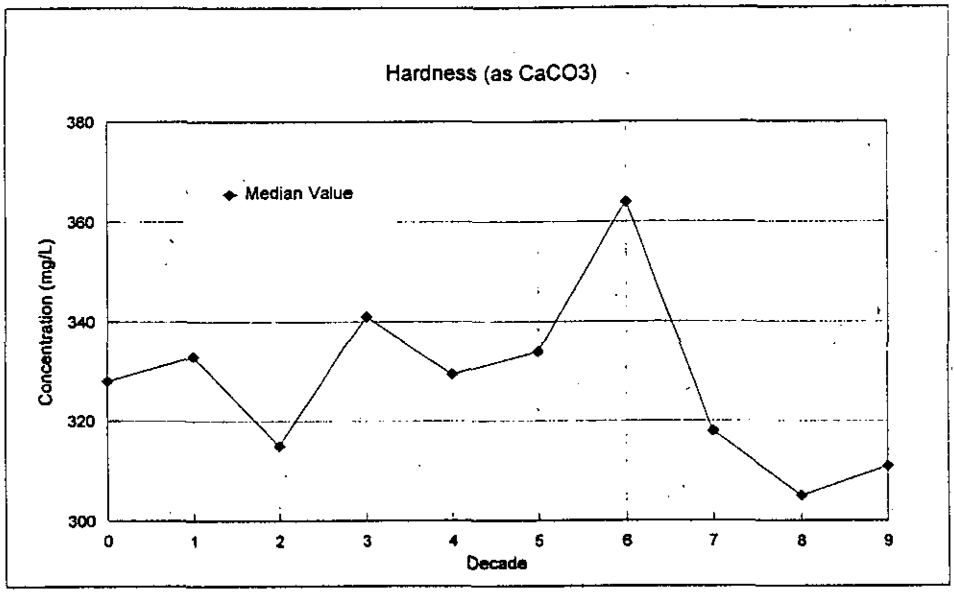


Figure 3-33. Median Hardness Concentrations in the Mackinaw River Basin (by decade beginning with decade 0, 1900-1909)

Figure 3-33 indicates no significant trend in hardness concentrations in the basin. The water is considered hard and is typical for shallow unconsolidated materials within Illinois.

Relevant Ground-Water Studies

Studies focusing on ground-water quality problems within the basin were undertaken at two specific sites where arsenic and ammonium have been a source of concern for ground-water development. The ISWS Office of Environmental Chemistry (Holm 1995) conducted a regional study as an adjunct project to the ground-water investigation conducted for the Joint Steering Committee in this area (Herzog et al. 1995). While the study found that the water quality of the Mahomet aquifer located within the basin was generally good, it also found some localized elevated arsenic concentrations. These elevated concentrations were the result of dissolution of naturally occurring minerals (Panno et al. 1994) and not human-induced contributions.

During the mid-1970s, the ISWS helped analyze the ground-water potential of the Mahomet aquifer for development of a State of Illinois fish hatchery. The study site was located near the village of Lilly. Although the quantity of water may have been sufficient to support this hatchery, the water of these sand and gravel deposits was not of the quality preferred for fish development. Ammonium was detected in some of the samples analyzed for this project.

Both projects help substantiate the fact that ground-water quality is variable within the basin and that chemical components other than those discussed here may be of concern at other locations. Further, the reported values for the six chemical components are spread throughout the basin and may not be totally representative of one specific location.

Summary

This work was undertaken to examine long-term temporal trends in ground-water quality within the Mackinaw River basin. Data from private and municipal wells were the primary source of information used to construct figures showing the trends in six chemical constituents in ground water within the basin. These figures demonstrate that on a watershed scale, ground water has not been degraded with respect to the six chemicals examined.

Much of the contamination of Illinois ground water is localized. Nonetheless, this contamination can render a private or municipal ground-water supply unusable. Once contaminated, ground water is very difficult and expensive to clean, and clean-up may take many years to complete. Clearly it is in the best interests of the people of Illinois to protect their ground-water resource through prevention of contamination.

Although no significant trends in water quality are apparent for these six constituents, the information provided represents the baseline water quality for the Mackinaw River basin. This can be used in future studies of the area as a reference to determine whether the local ground-water quality is degrading.

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PART IV

LIVING RESOURCES

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Introduction

Physiographic Characteristics

The Mackinaw River Basin (hereafter MRB) is an approximately 1,138 mile^2 (728,495 acre), watershed including portions of Ford, Livingston, Mason, McLean, Tazewell, and Woodford counties in central Illinois (Figure 1-1). The basin ranks 24th in size out of 51 basins in Illinois (Suloway and Hubbell 1994). The majority of the basin occurs in the Bloomington Ridged Plain physiographic division, comprised of a series of arched morainal ridges (Willman et al. 1975). Most of the MRB lies within the Grand Prairie Section of the Grand Prairie Natural Division, the single largest natural division in Illinois (Figure 4-1). Near the mouth of the Mackinaw River the basin also includes portions of the Illinois River Section of the Upper Mississippi River and Illinois River Bottomlands Natural Division and the Illinois River Section of the Illinois River and Mississippi River Sand Areas Natural Division (Schwegman et al. 1973). Table 4-1 gives the acreage of the MRB that is in each Natural Division.

Table 4-1. Natural Divisions occurring in the Mackinaw River Basin.

Division & Section	Acres	% of MRB
Grand Prairie/Grand Prairie Section	682,068	93.6
Upper Miss. Riv. & Ill. Riv. Bottomlands/Ill. Riv. Sect.	28,140	3.9
Ill. River & Miss. River Sand Areas/Ill. River Section	18,267	2.5
Total:	728,475	100.0

Elevation within the basin ranges from about 820 ft. above sea level in the upper reaches of the watershed near Sibley to about 430 ft. above sea level at the mouth of the Mackinaw River. Much of the basin is a rather level to gently rolling plain of glacial till. Topographic relief is provided by glacial moraines and by the dissection of the glacial drift by the Mackinaw River and tributaries forming valleys and ravines. The surface geology of the basin lying within the Grand Prairie Section, which includes the headwaters areas and the majority of the watershed, occurs on deep Woodfordian-aged glacial drift, a substage of Wisconsinan glaciation and the most recent Pleistocene glacial episode. Thickness of glacial drift in the basin ranges from 50ft. to over 400 ft. (Lineback 1979). Little if any bedrock is exposed in the basin. Soils in the area, mostly mollisols (formed under grassland vegetation) with a silt-loam texture, are developed largely in loess deposits which cap the glacial till and range in thickness from 36 inches to 200 inches. Soils developed under forest or savanna vegetation are primarily concentrated in

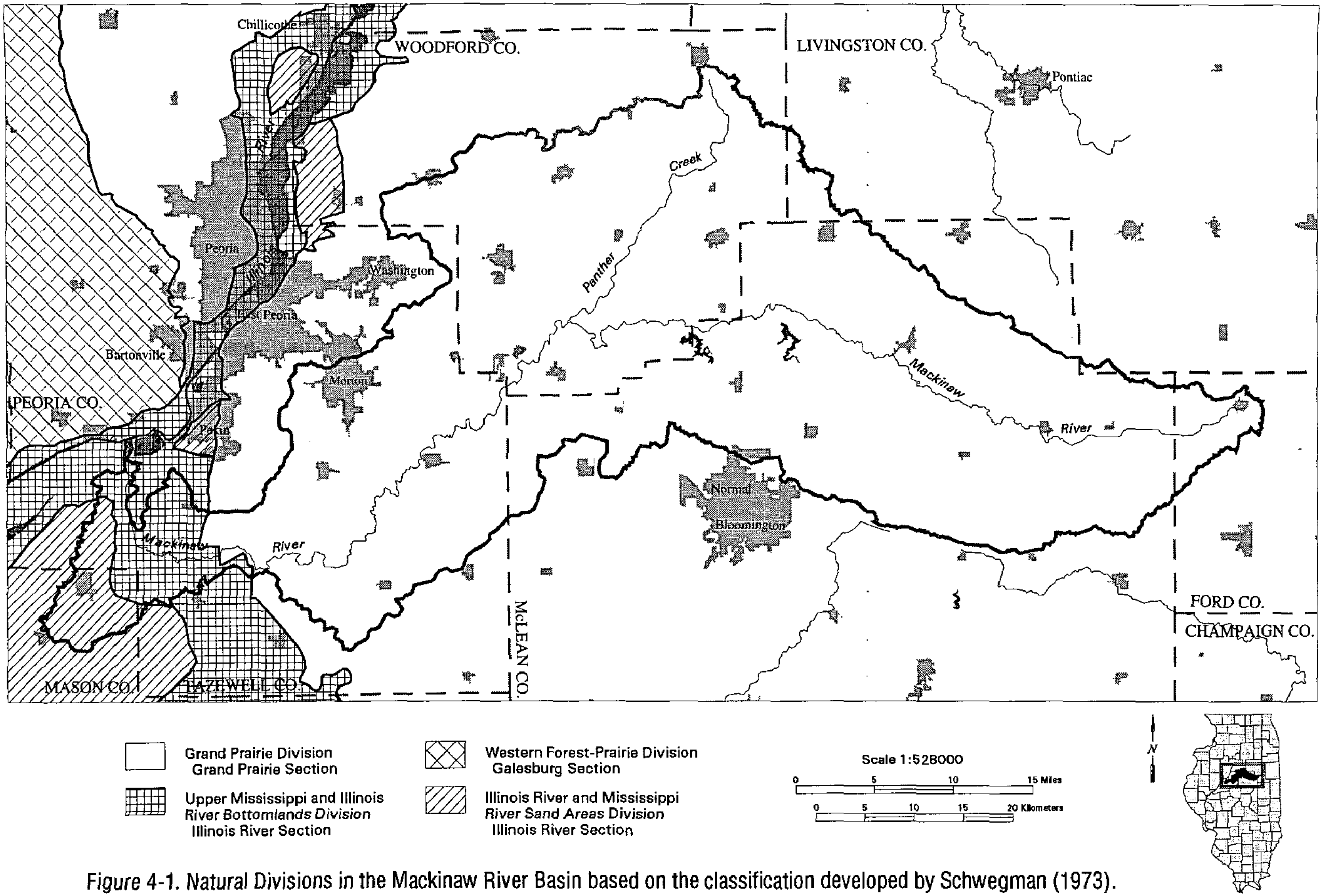

Figure 4-1. Natural Divisions in the Mackinaw River Basin based on the classification developed by Schwegman (1973).

stream valleys and adjacent ravine complexes. Gravelly glacial till is exposed locally, particularly on eroding slopes bordering the Mackinaw River. A full description of the geology of the MRB is given in Part II of this volume.

Soils associated with the Illinois River sections of the Illinois River and Mississippi River Sand Areas Natural Division include sandy glacial outwash. Just east of Manito in Mason County is an area that was characterized as containing deep peat deposits (Smith et al. 1924). This area was described briefly by Vestal (1931) as a former river channel filled with deep peat deposits. Some of these peat deposits included deposits of sand (Smith et al. 1924). No description of the vegetation was made. It is not clear if any of these organic soils remain undisturbed. Organic soils with a sand content support unique plant communities and many rare species in other parts of Illinois. Soils in the Illinois Section of the Upper Mississippi River and Illinois River Bottomlands Natural Division near the Illinois River are alluvial and typically high in clay and/or sand content. More information on the soils of the MRB is given in Part II of this volume.

The Mackinaw River rises near Sibley in Ford County and flows westerly for 125 miles before emptying into the Illinois River 3.5 miles south of Pekin (Figure 1-1). Principal tributaries of the Mackinaw are Panther, Walnut, and Money creeks. The Mackinaw River is a series of pools and fast flowing riffles with the substrate predominantly of sand with considerable gravel, some silt, and rubble. Gravel bars, undercut banks, overhanging trees, and brush piles are common along the river. The banks are largely forested except for some sections where the land has been cultivated to the waters edge. The stream varies in depth to six feet and has an average width of 70 feet. The Mackinaw River fluctuates greatly in depth due to its compact drift beds and the near absence of headwater marshes and other natural impoundments (Forbes and Richardson 1908). The upper 11 miles in Ford and McLean counties have been dredged and straightened; levees have been constructed along the channel of the lower Mackinaw River.

Tributaries vary from headwaters to creeks as large as Panther Creek. Substrates vary from gravel and rubble found in the shallow riffles to sandy runs and pools such as those found in the lower Mackinaw River. Over 90% of the watershed is either cropland (Table 1-3, Figure 1-6) or (mostly agricultural) rural grassland (Table 1-3, Figure 1-4) and, in some areas, silt has covered much of the natural grassland and sand substrate. Agricultural pollution, including sedimentation resulting from poor land use, is the major source of stream degradation. Several small municipalities discharge untreated effluents into tributaries. Impoundments on Money Creek (Lake Bloomington) and Six Mile Creek (Evergreen Lake) provide Bloomington and Normal with their water suppies (Figure 1-5). No springs or caves are known to occur in the Mackinaw River Basin.

Vegetation History

The pre-European settlement vegetation of the area has been described by Rogers and Anderson (1979) and Thomas and Anderson (1990), and was summarized by Reber

(1997) and White (Volume 2 of this report). Prairie dominated the level to gently rolling till plain while a complex mosaic of forest, savanna, and prairie was associated with moraines and the stream valleys, terraces, slopes and ravines associated with the Mackinaw River. Some estimates of trends in the amounts of these communities since European settlement time can be inferred from county-wide data. The counties containing the largest area of the MRB (McLean, Tazewell, and Woodford) were approximately 10.5%, 31%, and 27% forested, respectively, in the 1820s at the time of the Government Land Office survey (Rogers and Anderson 1979; Iverson et al. 1989). Tazewell and Woodford counties were characterized by 1.3 and 3.0%, respectively, of open water. Prairie totaled approximately 89.5, 67.6, and 69.9%, respectively, for McLean, Tazewell, and Woodford counties. Total area of savanna at that time is unclear. The MRB is within the transition zone of prairie and forest (Anderson 1983) and supported areas of tall-grass savanna (Rogers and Anderson 1979; Nuzzo 1986; Thomas and Anderson 1990). However, savannas typically were spatially dynamic and their total area and distribution varied on the presettlement landscape depending on several factors including local conditions of climate and fire frequency and intensity (Taft 1997). Fire is generally considered to have been a major ecological factor in the maintenance of tall-grass prairie, savanna, and open woodland vegetation in the Midwest (Anderson 1970, 1983, 1990; Axelrod 1985; Taft et al. 1995). Fire, drought, and grazing animal herds collectively are considered to have had important impacts on vegetation community structure and species composition within McLean County including much of the MRB (Rogers and Anderson 1979).

The prairie-dominated upland plains of the MRB were characterized by scattered prairie pothole ponds (Reber 1997) particularly in the upper portions of the watershed (Rogers and Anderson 1979). Total area of presettlement wetlands in the McLean, Tazewell, and Woodford counties is estimated, judging from amounts of hydric soils, at 26, 24, and 20%, respectively (Havera et al. 1994). Most of this was wet prairie, prairie potholes, and floodplain forest. The mouth of the Mackinaw in the 1770s was described as a large marshland with numerous small islands (Reber 1997).

Currently the landscape of the MRB is dominated by cropland (77% of the total area). Grassland occupies over 13% of the land area and includes pastures, hay, idle fields, roads and railroad rights-of-way, and remnant prairies. Forest, which accounts for less than 6% of the total area, is comprised mostly of upland forest (4.9%) and a relatively small amount of forested wetlands (0.8%). Nonforested wetlands such as marshes, wet meadows, and ponds occupy 0.3% of the MRB with the vast majority being shallow marsh or wet meadows (Table 4-2). The largest concentrations of open water (0.5%) are two impoundment lakes on tributaries to the Mackinaw River. Urban land (2.34%) is distri-buted among several small towns, with Morton being the largest in the MRB. The distributions of these land cover types are illustrated in Figures 1-2 through 1-7.

Though formerly the dominant vegetation type in the MRB, no areas of high-quality mesic prairie are known presently. A total of about 1.5 acres of high quality hill prairie is found at three different sites. This amount of prairie is 0.0002% of the MRB compared with presettlement estimates for the three major counties of 89.5, 67.6, and 69.9%. An

Table 4-2. Wetland and Deepwater Habitat of the Mackinaw River Basin (MRB) (Suloway and Hubbell 1994). Total acreage in the MRB = 728,475.00 acres.

Category	Acreage	% of Wetland Area	% of MRB Area
Shallow Water Wetlands			
Palustrine Wetlands			
Shrub-Scrub Wetlands	236.7	2.7	0.0
Forested Wetlands			
Bottomland Forest	5250.3	60.0	0.7
Swamp	0.0	0.0	0.0
Emergent Wetlands			
Shallow Marsh/Wet Meadow	1180.0	13.5	0.2
Deep Marsh	50.4	0.6	0.0
Open Water Wetlands	1405.0	16.1	0.2
Subtotal Palustrine[1]	**8122.3**	**92.9**	**1.1**
Lacustrine Wetlands			
Shallow Lake	38.0	0.4	0.0
Lake Shore	0.0	0.0	0.0
Emergent Lake	0.0	0.0	0.0
Subtotal Lacustrine	**37.0**	**0.4**	**0.0**
Riverine Wetlands			
Perennial Riverine	137.0	1.5	0.0
Intermittent Riverine	460.1	5.3	0.1
Subtotal Riverine	**597.1**	**6.8**	**0.1**
Total Wetlands	**8757.3**	**100.1**	**1.2**
Deepwater Habitat			
Deepwater Lake	1516.1		0.2
Deepwater River	2832.1		0.4
Total Deepwater	**4348.1**		**0.6**

[1]Subtotal of shrub-scrub, forested, emergent, and open water wetlands.

unknown quantity of degraded prairie, including mesic tall-grass prairie, may persist. Degraded prairie often can be found along railroad rights-of-way. Wetlands also have declined in area. As in the presettlement landscape, forests are concentrated on the slopes and bottomlands bordering the Mackinaw River and associated tributaries. Much of the riparian zone throughout the MRB has at least a narrow forested strip (Gough 1994). This forested buffer is considered a primary reason for the relatively good ecological integrity of the river compared with other central Illinois streams (Reber 1997). Though wetlands occupied about 20-to-26% of the three counties containing the MRB (McLean, Tazewell, and Woodford), a contemporary estimate of wetland area for the MRB is about 1% (Suloway and Hubbell 1994).

Biologically Significant Features of Natural Communities

Natural Areas, Nature Preserves, and Biologically Significant Streams

In 1978, an inventory of "natural areas" in Illinois was completed by the University of Illinois and the Natural Land Institute under contract with the Illinois Department of Conservation (now the Illinois Department of Natural Resources). The original inventory was a three year project that consisted of surveys to find, evaluate, describe, and classify natural areas of statewide significance (White 1978). The Illinois Natural Areas Inventory (INAI) is an ongoing process. The methods and criterea established during the original inventory are still used today to continually update the INAI by re-evaluating the previously defined natural areas or finding new sites that qualify.

The INAI established seven categories of natural areas based on significant features. The categories are: I - High Quality Natural Communities; II - Habitat for Endangered Species; III - Habitat for Relict Species; IV - Outstanding Geological Areas; V - Approved Natural Areas and Restoration Sites; VI - Unique Natural Areas; and VII - Outstanding Aquatic Areas. The INAI established a grading system to designate natural quality (White 1978). The natural quality of a community or area was graded from A (relatively stable or undisturbed) to E (very early successional or severely disturbed). In general only A and B communities are designated as significant or exceptional features.

The purpose of the INAI was, and is, to identify high quality natural areas and other significant features in the state. Identification, however, does not automatically ensure that an area is protected. Once an area is selected, further action is required to protect the natural conditions. The highest level of protection offered is for the area to be designated as an Illinois Nature Preserve. This means that the area has been formally protected in perpetuity by the landowner through the state. The majority of the Nature Preserves in Illinois are publicly owned, but many are maintained in private ownership. Almost every Nature Preserve falls within a natural area.

The community types and acreage's of all INAI natural areas and nature preserves within the MRB and in the surrounding areas are summarized in Table 4-3 and 4-4 respectively, and their locations are shown in Figure 4-2. Five sites within the MRB qualify as Category I natural areas for the INAI (Table 4-5). These include remnants of glacial drift hill prairie (Grades A and B), loess hill prairie (Grade B), dry-mesic barrens (Grade B), mesic upland forest (Grade B), and wet floodplain forest (Grade A). One of these natural areas, the Ridgetop Hill Prairie, occurs within a state nature preserve. Two other nature preserves are also present in the MRB (Table 4-4). The Parklands Nature Preserve contains populations of two plant species (heart leaved plantain [state endangered - SE] and spreading sedge [state threatened - ST] listed as threatened or endangered by the Illinois Endangered Species Protection Board (IESPB). The combined area for the Category I natural areas is approximately 43 acres, or about 0.006% of the MRB. This contrasts with the statewide results from the INAI that indicated a total of 0.07% of the total land and water area in Illinois remained in a high-quality, relatively undisturbed condition (White 1978). All INAI natural areas, including Categories II and IV and Grade C buffer lands, total about 758.5 acres, or about 0.015% of the basin. Comparisons of the area of Category I natural communities in the MRB in relation to the total remaining in Illinois is described under each community type in the section on "Natural Vegetation Communities" below.

Table 4-3. Natural Areas in the Mackinaw River Basin (MRB) and surrounding area.[1]

NA#[2]	County	Acres	Acres in MRB	Name
109	Mason	96.8		Henry Allan Gleason
117	Peoria	44.0		Jubilee College State Park
123	Mason	197.9		Quiver Prairies
129	**Tazewell**	**7.3**	**7.3**	**Log Cabin Hill Prairie**
130	**Tazewell**	**29.4**	**29.4**	**Indian Creek Woods**
131	Tazewell	13.0		Manito Prairie
132	**Tazewell**	**39.8**	**39.8**	**McCoy Woods**
133	Tazewell	3.7		Fort Creve Coeur Hill Prairie
134	Woodford	9.7		Caterpillar Hill Prairies
142	Peoria	13.2		Dickison Run Hill Prairie
143	Peoria	7.2		Mossville Road Hill Prairie
204	Peoria	119.4		Rocky Glen
205	Peoria	59.0		Grandview Woods
206	Peoria	2.0		St. Mary's Cemetery
207	Peoria	496.5		Forest Park
208	Peoria	347.8		Detweiller Park
209	Peoria	63.2		Boyds Hollow Woods
210	Peoria	250.2		Springdale Cemetery
212	Peoria	33.3		Wokanda Camp
213	Peoria	82.6		County Line Hill Prairie
233	Peorial	48.7		Robinson Park Hill Prairie
249	**Woodford**	**17.7**	**17.7**	**Ridgetop Hill Prairie**
250	**Woodford**	**7.4**	**7.4**	**Mackinaw River Hill Prairie**
305	Marshall	46.8		Crow Creek Marsh
364	Mason	57.6		Sand Ridge Savanna
697	Livingston	9.6		Ocoya Geological Area
698	Livingston	2.3		English Prairie
721	McLean	883.8		Funks Grove
722	**McLean**	**2.2**	**2.2**	**Danvers Geological Area**
733	Mason	4.8		Sand Ridge State Forest IL Mud Turtle Site
776	Peoria	5.5		Trivoli Northwest Geological Area

Table 4-3. Continued

NA#	County	Acres	Acres in MRB	Name
788	**McLean**	**1,690.1**	**1,690.1**	**Mackinaw River**
850	Tazewell	183.8		Spring Lake Seeps
851	Tazewell	15.5		Fondulac Seep
852	Tazewell	2.4		Farm Creek Geological Area
928	Woodford	56.4		Spring Bay Fen
929	Woodford	5.3		Partridge Creek Marsh
995	McLean	4.8		Weston Cemetery Prairie
1064	Tazewell	1,389.0		Clear Lake Heron Colony
1121	Fulton	438.5		Rice Lake Eagle Roost
1122	Fulton	6.9		Duck Club Road
1131	Peoria	21.1		Hancher Woods
1136	**Tazewell**	**774.9**	**114.2**	**Green Valley Site**
1137	Tazewell	147.5		Worley Lake Heron Colony
1138	**Tazewell**	**638.8**	**638.8**	**Parklands Site**
1139	Tazewell	5.2		Cooper Park North
1143	Woodford	9.6		Blalock Creek Site
1341	**Mason**	**860.56**	**35.7**	**Sparks Ponds**
1347	Mason	58.6		Burns Sand Prairie
1419	Peoria	4.7		Rock Island Trail Prairie
1447	Livingston	1,492.9		Vermilion River
1449	Piatt	1,441.7		Sangamon River
1494	Peoria	1.4		Root Cemetery
1497	Ford	0.0		Don Gardner's Prairie Restoration
		Total in MRB:	**3,182.6**	

[1] Bold type indicates Natural Areas within the MRB.
[2] The number of the natural area (NA#) refers to the number designated in the IDNR Natural Heritage database and in Figure 4-2.

Table 4-4. Nature Preserves in the Mackinaw River Basin (MRB) and surrounding area.[1]

NP#[2]	Corr.-NA[3]	County	Acres	Name
13	207	Peoria	90.0	Forest Park
29	109	Mason	110.0	Henry Allen Gleason Nature Preserve
35	995	McLean	5.0	Weston Cemetery Prairie
76	928	Woodford	31.3	Spring Bay Fen
85	133	Tazewell	23.0	Crevecoeur
123	**249**	**Woodford**	**17.4**	**Ridgetop Hill Prairie**
136	721	McLean	18.6	Funks Grove
137	131	Tazewell	19.6	Manito Prairie
148	117	Peoria	64.0	Jubilee College Forest
170	234	Peoria	135.2	Robinson Park Hill Prairies
171	**1138**	**Tazewell**	**27.2**	**Mehl's Bluff**
187	**1138**	**Tazewell**	**39.7**	**Parklands**
190	851	Tazewell	2.5	Bennett's Terraqueous Gardens
226	1419	Peoria	5.1	Rock Island Trail Prairie
230	208	Peoria	246.0	Detweiller Woods
232	721	McLean	30.0	Thaddeus Stubblefield Grove
238	1494	Peoria	2.5	Root Cemetery Savanna
		Total in MRB:	**84.3**	

[1] Bold type designates Nature Preserves within the MRB.
[2] The Nature preserve number (NP#) refers to the number designated in the IDNR Natural Heritage database and in Figure 4-2.
[3] Each of the Nature Preserves is associated with a corresponding Natural Area (Corr.-NA) referred to in Table 4-3.

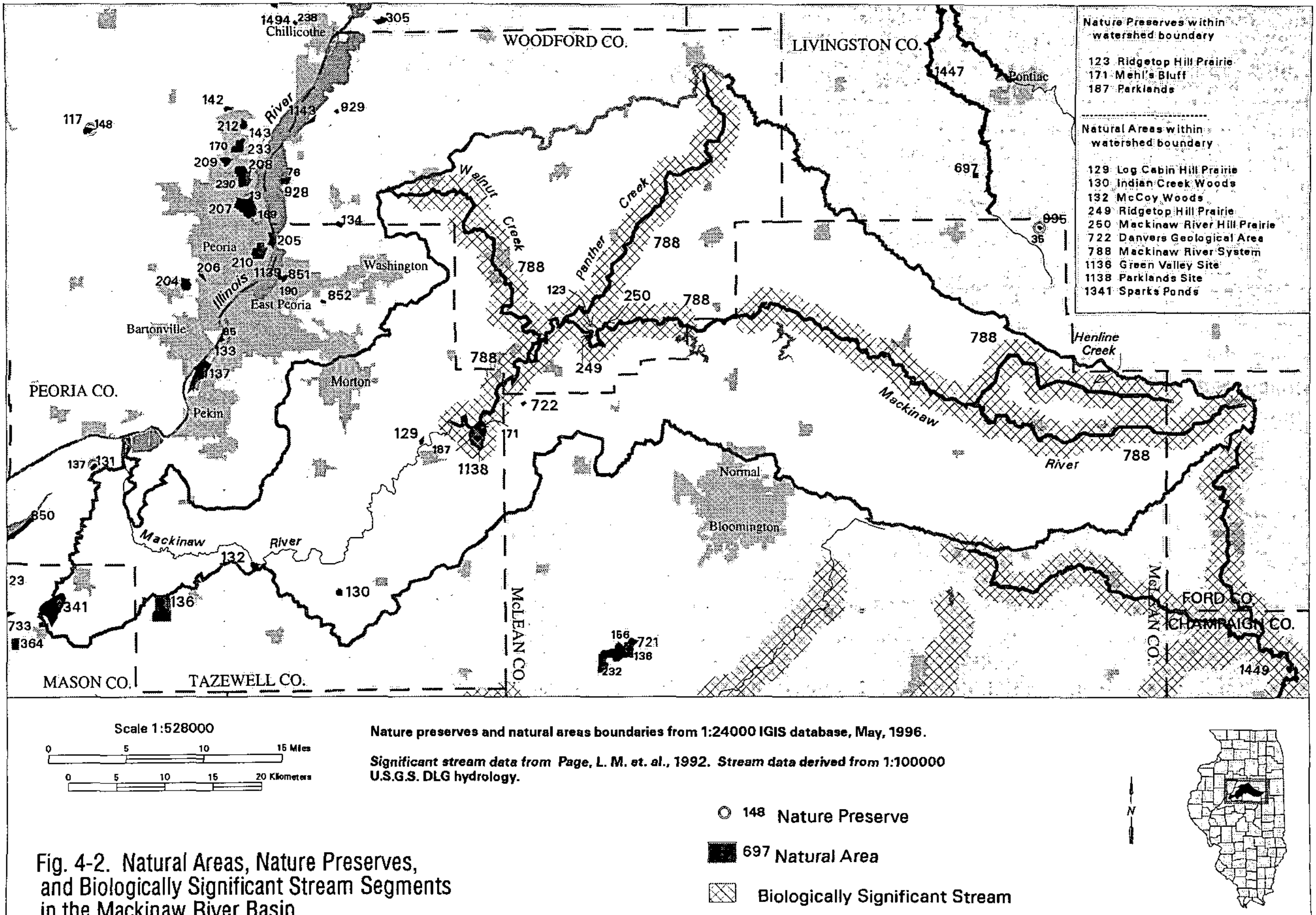

Fig. 4-2. Natural Areas, Nature Preserves, and Biologically Significant Stream Segments in the Mackinaw River Basin.

Table 4-5. Category I natural communities represented in the Mackinaw River Basin (MRB). Category I indicates natural communities that have remained relatively undisturbed and in high quality condition (Grade A and B).

Community type	Grades in MRB	Acres of Category 1 in the MRB			Acres of Category 1 in Illinois			% of IL represented in the MRB		
		Grade A	Grade B	MRB Total	Grade A	Grade B	Illinois Total	Grade A	Grade B	Illinois Total
Glacial drift hill prairie	A,B	0.5	0.5	1.0	14	20	34	3.6%	2.5%	2.9%
Loess hill prairie	B	-	0.5	0.5	158	214	372	0.0%	0.2%	0.1%
Dry-mesic barrens	B	-	0.5	0.5	-	18	18	0.0%	2.8%	2.8%
Mesic upland forest	B	-	26.0	26.0	1058	1473	2531	0.0%	1.8%	1.0%
Wet floodplain forest	A	15.0	-	15.0	336	2522	2858	4.5%	0.0%	0.5%
Total		15.5	27.5	43.0	1566	4247	5813			

Illinois streams have also been categorized based on their quality. One stream-quality index used to identify high-quality streams is the Biological Stream Characterization (BSC) (Hite and Bertrand 1989). The BSC was developed by the Illinois Department of Conservation and Illinois Environmental Protection Agency, and is derived from data on fish populations, water quality, and aquatic macroinvertebrates. In the BSC, stream segments are categorized from "A" (highest quality) to "E" (lowest). Twenty-four stream segments in Illinois currently are considered to be in the "A" category, and 50 in the "B" category (next highest).

Another study, entitled the "Biological Significant Streams of Illinois," (Page et al 1992) was conducted to expand the list of high-quality streams beyond the BSC "A" streams by considering additional data on biodiversity; specifically data on endangered and threatened species (fishes, crustaceans, mussels and plants) and on mussel diversity. The expanded list identified the most important streams to be protected and managed for their outstanding biological characteristics. Protection of the streams identified in the Biological Significant Streams report (Page et al 1992) will constitute a major step toward the protection of 100% of the stream-dependent biodiversity.

Table 4-6. Biologically Significant Stream segments in the Mackinaw River Basin.

Site Description	Length (Miles)
Panther Creek, Rte 24 to Mackinaw River	24.3
Walnut Creek, Eureka to Mackinaw River	21.2
unnamed, Mackinaw Twp, Tazewell County	2.6
Henline Creek	16.2
Mackinaw River at Colfax	7.2
Mackinaw River, Alloway Creek to Mclean Co. line	28.5
Mackinaw River, upstream of Money Creek	36.4
Total miles:	136.4

Seven areas of the Mackinaw River were recognized as "Biologically Significant Stream"(BSS) segments (Page et al 1992) (Table 4-6, Figure 4-2). Two of these streams are particularly important because of their mussel and fish diversity (Figure 4-2). One BSS segment is from Alloway Creek to the Woodford County line in Tazewell County. This stretch of the Mackinaw River has not been channelized and mussel diversity is high. The water is medium to fast-flowing with moderate turbidity. In periods of normal flow, water depth ranges to over three feet. The substrate consists of gravel, cobble, and sand. The wooded riparian zone varies and is predominantly silver maple, cottonwood, and sycamore. Half of this segment of the Mackinaw River was rated as a quality "A" stream in a "Biological Stream Characterization" (BSC) (Hite and Bertrand 1989). The second BSS segment in the MRB is Panther Creek from Illinois Route 24 to its confluence with the Mackinaw River, Woodford County. Panther Creek is a natural, clear water stream with a gravel and sand substrate. In some reaches a fine layer of silt covers the substrate. Aquatic vegetation consists of clumps of grass in the stream and filamentous algae. Surrounding the wooded riparian zone are row crops and pasture. This segment of Panther Creek supports a high diversity of mussels species and is a BSC "A" stream. These streams provide the best opportunities in the basin for the protection of large numbers of native species of fishes and other aquatic organisms. All BSS segments are also designated as "natural areas."

Threatened and Endangered Species

At least 10 species of state threatened or endangered plants and animals occur in the MRB (Table 4-7). Each of these species has special habitat requirements that are described in the following sections. Some species, such as the Loggerhead Shrike may be able to tolerate a high degree of human disturbance, whereas other species are more vulnerable and are likely to need protected areas in order to persist. Some of these species only occur in the natural areas or nature preserves mentioned above. There are very few other places with suitable habitat. For example, there is no federal land in the MRB, and the state land is restricted to one area, the 1383-acre Mackinaw River Fish and Wildlife Area (Figure 4-3).

Table 4-7. Threatened and endangered species occurring in the Mackinaw River Basin.
(SE = state endangered; ST = state threatened)

Plants:			
	heart-leaved plantain	*Plantago cordata*	SE
	spreading sedge	*Carex laxiculmis*	ST
	tall sunflower	*Helianthus giganteus*	SE
Birds:			
	long-eared owl	*Asio otus*	SE
	short-eared owl	*Asio flammeus*	SE
	veery	*Catharus fuscescens*	ST
	loggerhead shrike	*Lanius ludovicianus*	ST
Reptiles:			
	Kirtland's snake	*Clonophis kirtlandii*	ST
Mussels:			
	slippershell mussel	*Alasmidonta viridis*	SE
	rainbow mussel	*Villosa iris*	SE

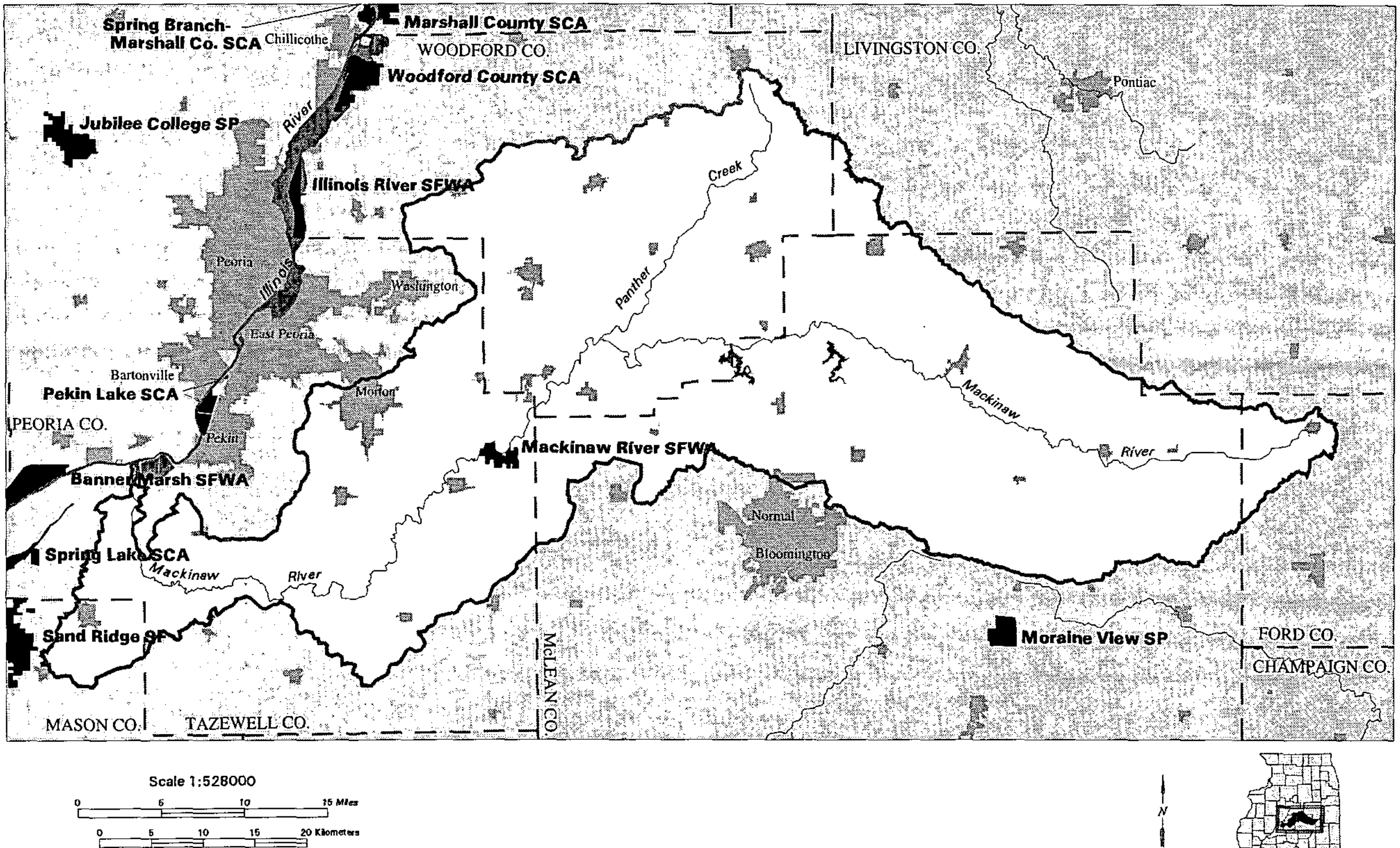

Figure 4-3. State land in the Mackinaw River Basin. State land is limited to parks (SP), conservation areas (SCA), forests (SF), and fish and wildlife areas (SFWA). There is no federal land in this assessment area.

Natural Vegetation Communities

The description of the vegetation for the Mackinaw River Basin (MRB) is organized into five sections: 1) Comparison to Statewide Patterns, 2) Threatened and Endangered Species, 3) Disturbance, Habitat Quality, and Restoration Potential, 4) Natural Community Descriptions for each habitat type, and 5) Summary and Recommendations.

Comparison of MRB Biodiversity to Statewide Patterns

In general, habitat losses in the MRB appear to exceed rates for the state as a whole. While about 0.01% of the original area of prairie persists in a high-quality condition throughout Illinois (White 1978), only about 0.0002% of the MRB remains as undegraded prairie. Since percentages of prairie were apparently greater in the MRB than the statewide presettlement level of about 61% (Iverson et al. 1989), the loss from the MRB compared with statewide levels is relatively much greater. About 30% of the original area of forest remains statewide (Iverson et al. 1989). While about 5% of the MRB remains forested, it is uncertain what percent this is of the original forested area. Since the total area of presettlement forest for McLean, Tazewell, and Woodford counties ranged from about 10 to 30%, the loss of forested land in the MRB may be somewhat similar to or slightly greater compared with the state as a whole. Natural wetlands in Illinois have declined from presettlement statewide estimates of about 23% of the land area to about 2.6% (Havera et al. 1994), or about 11% of the original total. The approximately 1% of the MRB remaining as wetland may be a greater loss compared with the statewide levels. If the estimates for the original wetland area in the principal counties of McLean, Tazewell, and Woodford, similar to statewide levels (about 23%), are similar to the original area within the MRB, about 4.5% of the original wetland area remains in the MRB. Savannas have declined in area throughout Illinois and the Midwest (Taft 1997) and the MRB is no exception to this trend. However, at least three remnants of savanna-like communities in the MRB warrant special attention (see sections on Natural Areas and Natural Communities below).

The species richness of vascular plants at the time of European settlement from within the MRB is not known. Approximately 268 plant taxa have been reported from within the watershed (Appendix 4-1). A total of 364 taxa are included in Appendix 4-1, including taxa known from the basin and taxa that may be present though unreported from the basin. Thirty-three taxa are listed in Appendix 4-1 (9% of total) that are not native to the MRB. These numbers probably underestimate species richness of both native and non-native taxa in the MRB. This compares to about 2,200 taxa of native taxa and 3,102 total taxa reported from Illinois (Mohlenbrock 1986). The extraordinary loss of habitat in the MRB also results in reduction in population sizes for taxa, particularly species sensitive to habitat degradation. As populations decline in size, they become more likely to undergo extirpations from local habitat fragments. As a result of loss of population sizes and species extirpations, species richness has probably declined in the MRB since European settlement. Prairie species appear to form a somewhat resistant species pool. Despite the tremendous loss of prairie habitat in Illinois, only about five taxa have been extirpated from the state (Taft 1995a). However, numerous prairie species occur at low population levels in the state, and about 103 are listed as threatened and endangered in Illinois (Herkert 1991; Taft 1995a).

Illinois Threatened and Endangered Plant Species

Three plant species listed by the IESPB as threatened or endangered species have been reported from within the MRB (Table 4-8). These species are spreading sedge (ST), heart-leaved plantain (SE), and tall sunflower (SE) (IDNR Natural Heritage Database and R. Anderson [pers. comm.]). Tall sunflower is included in a species list for a floodplain forest of the Mackinaw made during the winter months. A fourth taxon, decurrent false aster (SE, federally threatened [FT]) occurs along the Illinois River about 8 km (5 mi.) north of the mouth of the Mackinaw River. These species are discussed below.

Table 4-8. Illinois threatened and endangered plant species reported from the Mackinaw River Basin.

(SE = Illinois endangered, ST= Illinois threatened)

Common Name	Scientific Name	Status	Habitat
heart-leaved plantain	*Plantago cordata*	SE	gravel bars
spreading sedge	*Carex laxiculmis*	ST	mesic to dry-mesic forests
tall sunflower	*Helianthus giganteus*	SE	floodplain forest

Spreading sedge, *Carex laxiculmis* Schwein. - A population of the spreading sedge was discovered in 1987 in the Parklands Nature Preserve within the Mackinaw River State Conservation Area. Population data are currently unavailable. Spreading sedge is a distinctive sedge of mesic to dry-mesic forests in Illinois. This species is distributed primarily in the northeastern United States and adjacent Canada, extending west to southern Wisconsin and southern Iowa (Gleason and Cronquist 1991). Spreading sedge is reported to be a species of calcareous districts (Gleason 1952), and the known MRB population possibly could be found on forested slopes and near ravine crests where calcareous and gravelly glacial till may be near the surface. Once familiarity is gained with the diagnostic features of this taxon, it can be readily field identified in June and July. Spreading sedge is known from nine extant stations in nine Illinois counties including unreported populations in Jo Daviess and Will counties (Taft 1995b). This taxon was recently downgraded from endangered to threatened status by the IESPB because it has been found to be more common than previously believed (Herkert 1994).

Heart-leaved plantain, *Plantago cordata* Lam. - Heart-leaved plantain, a perennial semi-aquatic herb, occurs in the MRB as two colonies, one each in adjacent tributary ravines of the Mackinaw River in the Parklands Nature Preserve. Both colonies occur in steep-gradient streams with substrates of glacial till materials including gravel and sand. One colony is very small and vulnerable to extirpation while the other colony, though widely fluctuating in population size, is apparently more secure. Most plants are associated with gravel bars in the tributaries. In a study conducted at this site, severe erosive stream action was found to be damaging to the colonies, particularly seedling recruitment (Bowles and Apfelbaum 1989). Maintenance and enhancement of the forest buffer in the watershed of the Mackinaw River and tributaries is viewed as critical to the long-term persistence of the largest colony. Artificial population enhancement may be required at the small colony to avoid local extirpation with stochastic storm run-off events. This species requires some stream action to maintain suitable competition-free recruitment sites on gravel bars; however, severe stream action can eliminate adult plants from a colony.

Heart-leaved plantain ranges throughout the eastern United States extending west to Missouri (Steyermark 1963). Decline in populations throughout this species range, presumably due to changes in hydrological conditions, leads to consideration for listing this taxon as federally threatened or endangered (Department of the Interior 1985). Except for Missouri where several colonies persist, most Midwest colonies have been extirpated. Many of the colonies that remain are small. In Illinois, heart-leaved plantain formerly was known from about 22 counties throughout the state; currently, it is known from extant populations in six Illinois counties (Herkert 1991).

Tall sunflower, *Helianthus giganteus* L. - The tall sunflower is reported from extant populations in two northern Illinois counties where it occurs in sedge meadows and a graminoid fen (Herkert 1991). There is an historic record for this species in Tazewell County. Tall sunflower may also occur in the MRB. This species is included in a species list compiled during the winter for a floodplain forest along the Mackinaw River in McLean County (Anderson, pers. com.). Additional field work is needed to provide a voucher specimen, determine the population size, total distribution, and specific habitat for this sunflower species in the MRB.

Decurrent false aster, *Boltonia decurrens* (Torr. & Gray) Wood - Populations of decurrent false aster occur about 5 miles north of the mouth of the Mackinaw River at the Pekin Lake State Conservation Area (IDNR Natural Heritage Database) and near the McCluggage Bridge over the Illinois River further north of the MRB (Taft 1994). These locations are not within the MRB. However, because this species is capable of being dispersal by flood waters, it could potentially become established near or at the mouth of the Mackinaw River.

The decurrent false aster is a tall perennial forb in the sunflower family (Asteraceae) listed as a threatened species both by the IESPB and the US Fish and Wildlife Service (Herkert 1991). The decurrent false aster is apparently endemic to the Illinois River valley (Torrey and Gray 1840). The entire historic range of this taxon is limited mostly to the floodplain of the middle-to-lower Illinois River and near the mouth of the Illinois along the Mississippi River in Illinois and Missouri (Schwegman and Nyboer 1985). The original habitats for the decurrent false aster included wet prairie, shallow marshes, and river and lake shores (Schwegman and Nyboer 1985). Habitat destruction, altered flooding patterns and duration, siltation, and probably herbicides have contributed to reductions of populations. Several new colonies of decurrent false aster have been discovered in recent years, many in highly degraded habitats. Despite these new discoveries, this species is perceived to have a net population decline in recent years (Smith et al. 1993).

Decurrent false aster is distinguished from the similar *Boltonia asteroides* var. *recognita* by the presence of decurrent leaf tissue on the stem, by the absence of rhizomes, and by larger flower heads with pale violet ray flowers. *Boltonia asteroides* var. *latisquama* also lacks rhizomes, has similar flower size and color to the decurrent false aster, but lacks decurrent leaf tissue (Schwegman and Nyboer 1985).

Disturbance, Habitat Quality, and Restoration Potential

In addition to habitat loss through conversion, most remnant plant communities in the MRB have experienced anthropogenic disturbances that have resulted in differing levels of ***degradation***. ***Fire absence***, ***fragmentation***, and ***exotic species introductions*** are other typical consequence of intensive habitat conversion that have implications for habitat restoration potential. These issues are discussed below.

Disturbance is a general term referring to any perturbation. Plant communities (or ecosystems) are ***degraded*** when recovery to original condition is unlikely under normal circumstances. Degraded lands can be further distinguished by those that can be *restored* to original condition through management efforts and those which, at best, can be *reclaimed* for only limited use in severe examples (e.g., strip mining), or *rehabilitated* to a condition somewhat similar to the original but where compositional differences remain (Lovejoy 1975). Degraded lands are *derelict* when land uses become very limited (Brown and Lugo 1994). Perturbations that exceed the intensity, frequency, or duration of the natural disturbance regime can result in loss of species lacking tolerance or adaptations to the new levels. When certain "keystone" species, or assemblages of other taxa, are extirpated from a community, the system's capability for restoration is diminished and integrity is lowered. A common source of degradation in Illinois plant communities is over grazing.

An example of a large-scale natural disturbance in many midwestern plant communities is ***fire***, and fire frequency is an important determining factor for many community characteristics. The compositional and structural characteristics of many native Illinois plant communities demonstrate some level of fire dependency. Fire absence in these communities can result in profound changes in community characteristics. For example, vegetational changes common throughout Illinois, such as those from prairie to shrub thicket or forest, or oak-dominated woodland to maple-dominated forest, are attributable to reduced fire frequency and fire absence.

When habitat remnants become isolated by land conversions this process is termed ***fragmentation***. Fragmented habitats often undergo alterations in many environmental conditions. Increased surface area of edge compared to volume can result in changes in soil moisture conditions and levels of solar radiation, as well as increased opportunity for exotic species invasions and wind damage (Gehlhausen et al., in review). High levels of fragmentation limit restoration potential of degraded sites because species immigration, needed to compensate for the local extirpations of plants with low population levels, is seriously challenged (Taft 1996, 1997).

Integrity is lowered not only by the loss of native species, but also by the introduction of ***exotic*** (non-native, adventive) ***species***. Adventive taxa in a system may be sorting into disturbance or habitat niches that result in the replacement of native taxa. The establishment of adventive taxa can result in arrested development and interfere with rates of recovery processes. The recovery potential of plant communities with appropriate ecological restoration and management is an area much in need of additional research. Specific and general recommendations for restoration of natural communities in the MRB are offered in the "Summary and Recommendations" section following the Terrestrial Natural Communities descriptions section below.

Terrestrial Natural Community Descriptions

The natural communities within the MRB (Table 4-9) were determined by examining data from several sources. These include descriptions of existing community types as well as plant communities inferred to have occurred prior to European settlement. Specific data sources include: known community types found in INAI sites, descriptions of vegetation in publications and technical reports, habitat descriptions in the Illinois Department of Natural Resources (IDNR) Natural Heritage Database, and speculation based on available resource information (e.g., soil types) in the watershed. Floodplain forests in the MRB have been described by Adams and Anderson (1980), Anderson (IDOT report), Taft and Solecki (1985), and Thomas and Anderson (1990). Upland forests have been described by Adams and Anderson (1980), Rogers and Anderson (1978), Thomas and Anderson (1990), and IDNR Natural Heritage data. There are no published descriptions of prairie vegetation from within the MRB. Descriptions of the hill prairies are based on inventory data (IDNR Natural Heritage data). Descriptions of silt-loam prairies are based on characteristic species for undegraded prairies in central Illinois. Thomas and Anderson (1990) describe the canopy characteristics of presettlement savannas in the MRB. Present savanna descriptions are from Hime (1989) and Anderson et. al. (1994). General descriptions of savanna characteristics are summarized from White (1978) and Taft (1997). No published descriptions are available for the composition of wetlands in the basin. Seeps are described based on unpublished inventory data (Solecki 1996). Since native vegetation in the watershed has been so greatly converted, modified, and degraded, many of the following community types may no longer persist in the MRB. These are noted where appropriate. Throughout this chapter, classification of the plant communities follows White and Madany (1978). Botanical nomenclature follows Mohlenbrock (1986). Scientific names corresponding to the common names used in this text are in the summary species list for the MRB (Appendix 4-1).

Table 4-9. Terrestrial natural communities known to occur or believed to have formerly occurred in the Mackinaw River Basin[1].

Forest

- **Upland Forest**
  - dry upland forest
  - dry-mesic upland forest
  - mesic upland forest
  - wet-mesic upland forest
- **Sand Forest**
  - dry sand forest
  - dry-mesic sand forest
  - mesic sand forest
- **Floodplain Forest**
  - mesic floodplain forest
  - wet-mesic floodplain forest
  - wet floodplain forest

Savanna

- **Savanna**
  - dry-mesic savanna
  - mesic savanna
  - wet-mesic savanna
  - wet savanna
- **Sand Savanna**
  - dry-mesic sand savanna
- **Barren**
- dry-mesic barren

Prairie

- **Prairie**
  - dry-mesic prairie
  - mesic prairie
  - wet-mesic prairie
  - wet prairie
- **Sand Prairie**
  - dry-mesic sand prairie
  - mesic sand prairie
  - wet-mesic sand prairie
  - wet sand prairie
- **Hill Prairie**
  - loess hill prairie
  - glacial drift hill prairie

Wetland

- **Marsh**
  - marsh
- **Seep & spring**
  - seep

Lake and Pond

- **Pond**
  - pond

Primary

- **Cliff**
  - eroding bluff community

[1] Adapted from the Illinois Natural Areas Inventory's natural community classification (White and Madany 1978).

Forest

Forests in the MRB belong to the Prairie Peninsula Section in the Northern Division of the Oak-Hickory Forest Region (Braun 1950). Due to a level of protection from the presettlement prairie fires, forests in the MRB primarily were concentrated on the slopes, ravines, and bottomlands associated with the Mackinaw River. Prairie groves were occasional, sometimes associated with moraines, and persist mostly as degraded fragments. Forest subclasses include **upland forest, sand forest** (possibly), and **floodplain, or bottomland forest**. These forest types are characterized below. Of the 5% of the MRB remaining as forest, about 0.1% (41 acres) is considered to remain in a state of high ecological integrity (White 1978). Little descriptive data are available on the remaining forests in the MRB. Only species known from the MRB are listed, unless otherwise noted. In general, relative abundance data for these taxa are lacking.

Common ecological problems associated with forest communities, in general, include habitat degradation, fragmentation, exotic species introductions, and fire absence in upland forests. A typical source of habitat degradation in forests is over grazing which often produces changes in the compositional and structural characteristics. Like in much of Illinois, grazing- sensitive species probably have been eliminated from many forest remnants in the MRB. In contrast, species that increase with grazing (e.g., thorn-bearing taxa [red haw, honey locust, Missouri gooseberry, common blackberry, and black raspberry], exotic species [e.g., Osage orange, multiflora rose, and garlic mustard], and certain weedy native species) are often abundant in over-grazed forest remnants. In many cases, abundance of exotic species appears to be directly proportional to the historic grazing intensity. Recovery of these sites following cessation of grazing appears to be slow. Complete restoration may not be possible without intensive management including species reintroduction. Fire absence in upland forest communities typically results in compositional changes in more mesic sites and primarily structural changes in drier sites, such as increases in stem density of woody plants and shade. The result is often a reduction in cover and diversity of the herbaceous ground flora, typically the most diverse stratum in Illinois woodlands (e.g., Taft et al. 1995).

Upland Forest

Upland forest communities can be classified further by soil-moisture characteristics. *Dry, dry-mesic, mesic*, and *wet-mesic upland* forest communities are recognized in Illinois in context with increasing available soil-moisture (White and Madany 1978). Major tree species respond in predictable ways along these soil-moisture gradients (Adams and Anderson 1980; Fralish 1994; Taft et al. 1995). The following community types are known to or may occur in the MRB.

Dry Upland Forest - No remnants of dry upland forest have been described from within the MRB and it is unclear if any are present. Dry upland forests (on nonsandy sites) are rare and localized in central Illinois on ridge crests with xeric exposures (south and southwest-facing aspects). Degraded remnants of this community type may occur associated with barrens and hill prairies found locally along the north side of the Mackinaw River. Dry sand forest is commonly associated with the deep sand deposits found in the Illinois River and Mississippi River Sand Areas Natural Division. The possibility that sand forests occur or formerly occurred within the MRB is discussed under the heading of sand forests (see below).

The dominant **tree species** in dry upland forests would be black oak. Occasional species may include white oak, yellow chestnut oak, shagbark hickory, and white ash. **Subcanopy trees** may include gray dogwood, hazelnut, shadbush, and hop hornbeam. Pennsylvania sedge would be a characteristic ground-cover species. Tree composition of this community type would be relatively stable since mesophytic species like sugar maple would be limited by soil-moisture conditions. However, structural characteristics of the community could change with long fire-free intervals as oak and hickory species tolerant of dry conditions may increase in density. The primary ecological problems in dry upland forest are damaging grazing and fire absence. Relatively few exotic species pose severe problems in dry forests compared with other forest communities.

Dry-mesic Upland Forest - Dry-mesic upland forest occurs in the MRB on the upper slopes and ridges of the dissected terrain bordering the Mackinaw River. Some areas are associated with hill prairie and barrens remnants. The total extent in the MRB is unknown. No areas of dry-mesic upland forest in the MRB are recognized as high-quality by the INAI. **Dominant Canopy species** are black oak, white oak, and white ash where forest composition has not been altered by logging or a history of grazing. Occasional tree species include red oak, shagbark hickory, and black cherry. **Common subcanopy** species include sugar maple, hop hornbeam, and slippery elm. Typical **shrubs** include Missouri gooseberry, blackberries, redbud, and blackhaw. **Ground-cover** species include the vines poison ivy, Virginia creeper, and yellow honeysuckle, and several herbaceous species (e.g., Pennsylvania sedge, elm-leafed goldenrod, nodding fescue, Canada brome grass, enchanter's nightshade, false Solomon's seal, slender wild rye, white trout lily, sweet-scented bedstraw, common snakeroot, red trillium, and round-lobed liverleaf). Where oaks have been removed by selective logging practices, black cherry, shagbark hickory, and slippery elm gain prominence in the canopy. Exotic species in dry-mesic upland forest may include garlic mustard, Osage orange, and multiflora rose.

Mesic Upland Forest - Mesic upland forest is probably the most prevalent upland forest type in the MRB, though no data are available on the total extent. Mesic upland forests are found on lower slopes, in ravines, and on high terraces of the Mackinaw River and tributaries. A total of 26 acres of this community type in the MRB is recognized as having high ecological quality and is included in the INAI (Grade B Mesic Upland Forest [Natural Heritage Database]). This total is about 0.07% of the forest cover in the MRB, 6% of the high quality mesic upland forest in the Grand Prairie Natural Division, and 1.8% of the total remaining in Illinois (Natural Heritage Database) (Table 4-5).

Characteristic **canopy tree species** include sugar maple, red oak, and, locally, chinquapin oak. Occasional tree species include a rich mixture including mockernut hickory, shagbark hickory, bitternut hickory, American elm, slippery elm, bur oak, red oak, white oak, hackberry, black walnut, black cherry, basswood, and white ash. **Subcanopy species** include red mulberry, alternate-leafed dogwood, hop hornbeam, paw paw, Ohio buckeye, and, rarely, witch hazel. Typical **shrubs** include redbud, wahoo, blackhaw, bladdernut, and Missouri gooseberry. **Woody vines** include poison ivy, Virginia creeper, and grapes. **Herbaceous ground-cover** composition includes a rich assortment of species, particularly spring ephemerals. Selected taxa reported from the MRB include doll's eyes, mayapple, spring beauty, common snakeroot, black snakeroot, white snakeroot, sweet cicely, wild ginger, wild geranium, Jack-in-the pulpit, dwarf larkspur, toothwort, dutchman's breeches, Jacob's ladder, blue cohosh, Solomon's seal, red trillium, snow trillium, poke milkweed, American gromwell, wild sarsaparilla, American spikenard, smooth ruellia, bellwort, James' sedge, and hairy-leafed sedge. There remain local populations of ginseng and goldenseal, two herbs that have been extirpated from many Illinois woodlands by root collectors.

The only species listed as threatened or endangered by the IESPB known from mesic upland forest in the MRB is spreading sedge. A population of this distinctive sedge occurs in the Parklands Nature Preserve. Other populations could be found on suitable habitat in the MRB (see previous description under Threatened and Endangered Species). This sedge appears to be sensitive to grazing. For example, is it absent from many heavily grazed woodlands in Jo Daviess County, but locally common in undegraded woods (Taft 1995b). Suitable habitat may exist for certain other species not currently known from the MRB including Schreber's Aster (*Aster schreberi*) and arrowwood (*Viburnum molle*).

The major ecological problems associated with mesic upland forests are degradation from grazing and habitat fragmentation. Among the more abundant exotic species within mesic upland forest are garlic mustard, amur honeysuckle, high-bush cranberry, and multiflora rose.

Sand Forest

It is unclear from available data if any sand forests occur within the boundaries of the MRB. The portion of the basin within the Illinois River Section of the Illinois River and Mississippi River Sand Areas Natural Division may support local areas of sand forest. No areas have been identified as high quality by the INAI. Sand forests are further classified by soil-moisture conditions and include dry sand forest, dry-mesic sand forest, and mesic sand forest. Dry to dry-mesic sand forests in the Illinois River and Mississippi River Sand Areas Natural Division typically include black oak, blackjack oak, Texas hickory, and mockernut hickory (Adams and Anderson 1980). Ecological problems include grazing, fire absence, and exotic species invasions. Typical exotic species include black locust (not native to central Illinois) and garlic mustard. Sand communities appear to be relatively more resilient to damaging disturbances compared with silt-loam habitats and respond well to restoration efforts including prescribed fire. However, many rare plant species are associated with sand forest and sand prairie habitats and some appear to be sensitive to fire damage.

Floodplain Forest

Floodplain forests are characterized by edaphic conditions of poor drainage and slow permeability. Local areas of sand and gravel increase permeability. Floodplain forest communities in Illinois include *mesic*, *wet-mesic*, and *wet* floodplain forest and are classified according to characteristics of flooding. Wet floodplain forests occur in the floodplain bordering rivers and, for this report, include the river bank. Wet-mesic to mesic floodplain forests occur on low and high terraces, respectively. The total extent of floodplain forest in the MRB is estimated to be about 5,250 acres, or about 0.72% of the total MRB area (Suloway and Hubbell 1994). In general, the flooding regime, including depth and duration of flooding, is a strong selective force on composition and species richness in floodplain forests and also in regulating tree growth (Robertson 1992). Wet floodplain forests are often seasonally flooded and/or have perched water during a portion of the year, often in late winter and spring. Generally, flooding is of shorter duration and less frequency in mesic floodplain forests. Wet-mesic floodplain forests are intermediate. Diversity of species composition tends to increase from wet to mesic floodplain forest.

A total of 15 acres of wet floodplain forest was identified by the INAI as Grade A from within the MRB. This is 88% of the high-quality, undegraded floodplain forest habitat remaining in the Grand Prairie Natural Division and 4.5% of the total for the state. No threatened or endangered species are confirmed from floodplain forest habitats in the MRB. The heart-leaved plantain colonies, established primarily on gravel bars of tributary streams, occur in close association with floodplain forest habitat. These colonies are vulnerable to severe, scouring flood events; removal of vegetative cover in the watershed appears to increase the damage to colonies from flooding (Bowles and Apfelbaum 1989). Tall sunflower, an endangered species in Illinois (Herkert 1991), is reported from a floodplain forest in the MRB (Anderson, pers. com.).

Ecological problems in floodplain forest involve siltation from silt-laden flood waters, changes in the hydrological regime (e.g., stream entrenchment or increased flooding duration and frequency due to changes in the upper watershed), and exotic species invasion. Very little descriptive data are available on the floristic composition of floodplain forests from the MRB. A general description of the structure and composition of floodplain forest follows.

Mesic Floodplain Forest - A greater diversity of tree species are found in this high terrace community since the relatively brief flooding duration and lower flooding frequency pose fewer limitations to species compared with conditions in a wet floodplain forest.

Common to occasional **canopy tree species** include bur oak, chinquapin oak, red oak, white oak, sugar maple, white ash, blue ash, basswood, hackberry, honey locust, shagbark hickory, mockernut hickory, bitternut hickory, black walnut, black cherry, and American elm. **Subcanopy species** include Ohio buckeye, black haw, and red haw. **Shrubs and vines** include: Missouri gooseberry, bladdernut, wahoo, bristly catbrier, poison ivy, Virginia creeper, and grapes (*Vitis* spp.). No descriptions of the ground cover are available for level high terraces. **Ground-cover species** likely include: woodland phlox, mayapple, wild geranium, Solomon's seal, bellwort, common yellow violet, downy-blue violet, bristly buttercup, woodland blue grass, Virginia wild rye, silky wild rye, bluebells, white avens, common snakeroot, sweet cicely, goldenseal, honewort, harbinger of spring, green dragon, and Jack-in-the-pulpit. Ecological problems include over grazing and exotic species invasions. Exotic species include Osage orange, white mulberry, multiflora rose, and garlic mustard.

Wet-mesic Floodplain Forest - Common to occasional **canopy species** include: hackberry, honey locust, silver maple, green ash, black walnut, sycamore, cottonwood, American elm, slippery elm, bitternut hickory, and possibly kingnut hickory. **Subcanopy species** include Ohio buckeye, box elder, red haw, paw paw, and elderberry. **Shrubs and Vines** include Missouri gooseberry, bristly catbrier, riverbank grape, summer grape, poison ivy, and Virginia creeper. **Ground-cover species** include honewort, false nettle, wood nettle, black snakeroot, slender wild rye, Virginia wild rye, stout wood reed, Virginia waterleaf, fog-fruit, hairy wood violet, climbing false buckwheat, purple spring cress, blue-eyed Mary, enchanter's nightshade, white snakeroot, toothwort, swamp buttercup, wild chervil, woodland phlox, and sedges (*Carex* spp.). Ecological problems include changes in the watershed that alter the flooding regime, severe grazing, and exotic species introductions. Exotic species include Osage orange, white mulberry, multiflora rose, moneywort, and garlic mustard.

Wet Floodplain Forest - Common to occasional **canopy species** include silver maple, sycamore, cottonwood, green ash, and hackberry. **Subcanopy species** include box elder, black willow, paw paw, and red haw. **Vines** include: riverbank grape and bristly catbrier. **Ground-cover species** may include poison ivy, honewort, wood nettle, white avens, jewelweed, great blue lobelia, stout wood reed, clearweed, marsh buttercup, goldenglow, wild chervil, spring beauty, sweet-scented bedstraw, and small-flowered crowfoot. A total of 15 acres of Grade A wet floodplain forest occurs at the Mackinaw River Forest Natural Area and in Tazewell County.

Ecological problems include changes in the watershed that alter the flooding regime, severe grazing, and exotic species introductions. Exotic species include moneywort, creeping Charlie, and garlic mustard.

Prairie

Four prairie subclasses are recognized in Illinois: **Prairie** (tall-grass prairie on silt-loam soils), **Sand Prairie**, **Hill Prairie** (including loess and glacial drift hill prairie), and

Shrub Prairie (White and Madany 1978). Prairie and sand prairie, like upland forest communities, are further distinguished by soil-moisture regime (dry, dry-mesic, mesic, wet-mesic, and wet). Due to the near-complete elimination of prairie vegetation from within the MRB, few examples remain to document the characteristic species that were associated with undegraded natural communities in all soil-moisture conditions that presently or formerly occurred in the basin. Based on remnant prairies in the MRB, the following community types are present: *loess hill prairie* and *glacial drift hill* prairie. Considering the distribution of prairie and forest in Illinois at the time of European settlement (about 1820) much of the basin was tall-grass prairie (Anderson 1970; Iverson et al. 1989). Prairies also occurred in about 30% of the floodplain of the Mackinaw River (Thomas and Anderson 1990). Based on the soil-moisture conditions typical of the upland till plain and the floodplain of the basin, the following additional prairie types probably occurred in the MRB: *dry-mesic prairie, mesic prairie, wet-mesic prairie,* and *wet prairie*. We can further speculate, based on the partial inclusion in the MRB of the Illinois River and Mississippi River Sand Areas Natural Division ("SAND") that sandy soils in that part of the basin may have supported a variety of sand prairies types including *dry-mesic, mesic, wet-mesic,* and *wet sand prairie.* With the exception of hill prairies, no floristic data are available to describe silt-loam or sand prairies in the MRB. We have no evidence of shrub prairie occuring in the MRB. Throughout this discussion, floristic composition of prairie remnants in central Illinois outside the MRB is used to provide a general characterization for former communities in the MRB.

No threatened or endangered plant species are known to occur in prairie habitats of the MRB. Species currently listed by the IESPB as threatened or endangered formerly or currently known from the MRB that may have occurred in prairie habitats in the basin include the following taxa: grass pink orchid, white lady's slipper orchid, showy lady's slipper orchid, prairie white-fringed orchid, Queen-of-the-prairie, prairie dandelion, ear-leafed foxglove, and, possibly, Tennessee milk vetch.

Common ecological problems associated with tall-grass prairie, in general, include fragmentation, fire absence, exotic species invasions, and habitat destruction and degradation. Small, isolated fragments tend to support many species at low population levels (thus prone to local extinction) too distant to be enhanced through natural mechanisms of species dispersal. Isolated prairies may also be lacking appropriate pollinator species for successful sexual reproduction of many outcrossing species. The greater edge-to-volume ratios of small sites offer greater opportunities for exotic species invasions since the matrix areas typically are dominated by non-native vegetation. Highly fragmented and developed landscapes also lead to altered fire regimes often eliminating fire from prairie remnants until restoration efforts commence. Fire absence results in ecological changes such as encroachment of woody plants that can eliminate many prairie species. Fire absence can also lead to a severe invasion of exotic cool-season grasses like the ubiquitous species meadow fescue, smooth brome, and Kentucky bluegrass. Over-grazing by domestic stock typically degrades prairie remnants by eliminating many species and promoting the increase of several weedy native and non-native taxa. Soil disturbances, such as past efforts at cultivation, result in loss of species and opportunities for the establishment of weedy taxa. All of these factors, and combinations of factors, tend to result in loss of species diversity and ecological integrity for all prairie community types.

Prairie

Approximately 500,000 to 650,000 acres of tall-grass prairie on silt-loam soils (about 70 to 90% of the area of MRB) have been destroyed in the MRB, nearly eliminating prairie from the basin. No areas of silt-loam prairies have been identified as high-quality remnants. Possibly, there are remnants of tall-grass prairie in railroad rights-of-way or in pioneer cemeteries within the MRB that persist in a degraded condition. These should be identified as they may serve as valuable seed sources for prairie reconstruction and restoration efforts.

Many important prairie species respond in predictable ways along soil-moisture gradients. The characteristic species of each soil-moisture class for tall-grass prairie are described below.

Dry-mesic Prairie - Common **grass species** include little bluestem, northern prairie dropseed, Scribner's panic grass, Indian grass, side-oats grama, porcupine grass, and June grass. Common to occasional **sedge species** include *Carex meadii*, *C. tetanica*, and *C. bicknellii*. Characteristic **forbs** include sky-blue aster, aromatic aster, false toadflax, pale purple coneflower, sessile-leafed tick trefoil, flowering spurge, hairy puccoon, rough blazingstar, slender bush clover, wild bergamot, purple prairie clover, hairy mountain mint, wild petunia, black-eyed Susan, rosin weed, yellow pimpernel, false boneset, green milkweed, whorled milkweed, and showy goldenrod. **Shrubs** include leadplant, New Jersey tea, prairie willow, smooth sumac, and prairie rose.

Typical ecological problems in remnants include fire absence (and consequential woody plant encroachment) and exotic species invasion and establishment. Common exotic species include Kentucky bluegrass, Canada bluegrass, white and yellow sweet clovers, wild parsnip, and asparagus.

Mesic Prairie - Undegraded mesic tall-grass prairies are among the most species-rich plant communities per unit area (= species density) in North America. Typical remnants contain from 15 to 30 species in a half-meter-square sampling quadrat. About 100 to 130 taxa of vascular plants can be found in a few small (5 acre) pioneer cemetery remnants in central Illinois. Common **grass species** include big bluestem, little bluestem, northern prairie dropseed, Scribner's panic grass, Indian grass, porcupine grass, and switch grass. Common to occasional **sedge species** include *Carex meadii, C. tetanica, C. bicknellii,* and *C. brevior*. Characteristic **forbs** include Sullivan's milkweed, cream wild indigo, smooth wild indigo, wood betany, prairie phlox, spike lobelia, prairie dock, compass plant, rosin weed, golden Alexander, shooting star, purple prairie clover, white prairie clover, Ohio spiderwort, Indian plantain, common blue-eyed grass, prairie blazing star, rattlesnake master, feverfew, downy gentian, rigid sunflower, mountain mint, prairie alum root, and Culver's root. Common **shrubs** include leadplant, New Jersey tea, prairie willow, prairie rose, and hazel.

Typical ecological problems in remnants include fire absence (and consequential woody plant encroachment) and exotic species invasion and establishment. Common exotic species include Kentucky bluegrass, Canada bluegrass, white and yellow sweet clovers, wild parsnip, and asparagus.

Wet-mesic Prairie - Common **grass species** include big bluestem, cordgrass, and, possibly, blue-joint grass. Common to occasional **sedges** include *Carex stricta*, *C. buxbaumii*, and, possibly, *C. lanuginosa*. Characteristic **forbs** include prairie dock, saw-toothed sunflower, woundwort, closed gentian, grass-leafed goldenrod, smooth phlox. **Shrubs** are uncommon but may include pussy willow.

Ecological problems are associated primarily with enhanced drainage from tile and over grazing. Fire absence can result in woody plant encroachment. Exotic species may include Kentucky bluegrass.

Wet Prairie - Very few undegraded remnants of wet prairie remain in central Illinois. The characteristic **grass** species for the community type is cordgrass; blue-joint grass may also have been present. The **sedges** *Carex stricta* and *C. lanuginosa* may have been important. **Forbs** like the sawtooth sunflower, spotted Joe-pye weed, New England aster, smooth phlox, and common mountain mint likely occured in the MRB. **Shrubs** may have included pussy willow.

Sand Prairie

No descriptions are available for sand prairies within the MRB and it is unclear if any sand prairies remain, even in a degraded condition. Degraded sand pond communities occur in the MRB southwest of Manito in Illinois River and Mississippi River Sand Areas Natural Division but these are apparently bordered by degraded, often non-native, vegetation.

Many plant species that are rare in Illinois and listed by the IESPB as threatened or endangered are found in a variety of sand prairie habitats (Herkert 1991). None have been reported from within the MRB. Efforts should be made to identify remnants of prairie from within the small inclusion of the Sand Area Natural Division. Inventories of these remnants may yield discoveries of new threatened and endangered species for the MRB including gallingale and large-bracted corydalis.

Ecological problems include habitat destruction, degradation, and exotic species introductions. However, sand prairies are relatively more resilient to some disturbances compared with silt-loam prairies and show rapid improvement in ecological integrity with appropriate management and removal of the degrading disturbance factor. Exotic species can be less problematic, too, because the specialized edaphic conditions seem to favor native species over many adventive weeds. The following descriptions are based on sand prairies further south and west in Mason County. Since no dunes appear to occur within the MRB, no dry sand prairies probably were present. Dry sand communities are characterized by relatively sparse ground-cover and fuel. Reduced fire frequency under these conditions may promote development of sand savannas or forests (White 1978).

Dry-mesic Sand Prairie - Dry-mesic sand prairies include local areas of open sand that support many interstitial species. Common species include little blue stem, sand love grass, hairy grama, three-awn grasses (*Aristida tuberculosa* and *A. desmantha*), sand reed, purple sandgrass, sand bur, several sedges (e.g., *Cyperus filiculmis, C. schweinitzii, and* ***C. grayioides*** **ST**), poppy mallow, prickly-pear cactus, sand primrose, erect dayflower, western ragweed, horsemint, golden aster, goat's rue, hairy puccoon, rough blazing star, wild poinsettia, and cottonweed. A common shrub is sand fragrant sumac.

Mesic Sand Prairie - Mesic sand prairies can be very species rich; however, they typically have less area of open sand and can be characterized by high importance of matrix species such as little bluestem, Indian grass, and big bluestem. Other species may include sand reed, sand love grass, sand dropseed, panic grass (*Dichanthelium oligosanthes*), fall witch grass, sedges (*e.g., Carex umbellata* and *Scleria triglomerata*), purple prairie clover, leadplant, golden aster, goat's rue, hairy puccoon, rough blazing star, poppy mallow, Ohio spiderwort, and the shrub sand fragrant sumac.

Wet-mesic Sand Prairie - This community is characterized by the present of surface water for short periods. Local areas are occasionally associated with mesic sand prairie. Wet-mesic sand prairie may have occurred associated with the peat deposits reported near Manito (Smith et al. 1924; Vestal 1931). Characteristic species may include big bluestem, blue-joint grass, cordgrass, and several sedges (*Carex* spp.).

Wet Sand Prairie - Wet sand prairie is rare in the Illinois River Sand Areas Natural Division with only one known remnant, Matanzas Prairie Nature Preserve, meeting the standards of the INAI (White 1978). Species composition is similar to wet prairie. Ecological problems unique to wet-mesic and wet sand prairie include enhanced drainage.

Hill Prairie

Hill prairies typically occur on slopes with exposure to the south and south-west. Soil moisture conditions are usually very dry on these well drained sites. Hill prairies are modified not by soil moisture type but by substrate yielding for Illinois loess, glacial drift, gravel, and sand hill prairies (White and Madany 1978). In the MRB, there are remnants of loess hill prairie and glacial drift hill prairies. Hill prairies often occur as openings within a generally forested landscape. During long periods of fire absence, hill prairies often decline in area and many have been eliminated or severely reduced in size due to encroachment of woody plants (McClain 1983; Robertson and Schwartz 1994).

Two 0.5-acre glacial drift hill prairies in the MRB are recognized by the INAI as significant ecological resources. These comprise about 6% of the area of glacial drift hill prairie in Illinois (IDNR Natural Heritage Database). Most of the glacial drift hill prairie in Illinois occurs in the Grand Prairie Natural Division.

No threatened or endangered species are known from hill prairie habitats in the MRB. Species that may have occurred within the basin may have included Hill's thistle and prairie dandelion. Ecological problems in hill prairie habitats include woody encroachment (fire absence), over grazing resulting in a degraded species composition, and exotic species invasions. Exotic species often established in degraded hill prairies include white and yellow sweet clover and Kentucky bluegrass. It is possible that there remain many small and somewhat degraded hill prairies associated with slopes along the Mackinaw River. Prompt management including prescribed fire and brush cutting can enhance many such sites.

Loess Hill Prairie - A total of 0.5 acres of Grade B and an additional 0.2 acres of Grade C loess hill prairie occurs in the MRB (Log Cabin Hill Prairie) on a steep bluff just north of Mackinaw bordering the Mackinaw River (IDNR Natural Heritage Database). This is about 0.1% of the total high-quality loess hill prairie remaining in Illinois. The prairie occurs within a matrix of Grade C dry-mesic upland forest. Dominant species include the grasses little bluestem and Indian grass. Common forb species include sky-blue aster, bastard toadflax, flowering spurge, woodland sunflower, common mountain mint, showy goldenrod, and common cinquefoil. Common shrubs are leadplant and pasture rose.

A unique ecological problem sometimes associated with hill prairies on very steep slopes is slumping, particularly when adjacent to a riparian system with occasional flood events. Grazing is also a common problem, and sometimes is a compounding influence on slumping due to soil compaction. Exotic species include Canada bluegrass.

Glacial Drift Hill Prairie - About 1.0 acre of Grades A and B glacial drift hill prairie occurs in the MRB (IDNR Natural Heritage Database) at two nearby sites bordering the Mackinaw River in Woodford County (The Ridgetop Hill Prairie Nature Preserve and the Mackinaw River Hill Prairie [=Weigand Prairie Natural Heritage Landmark]). Both sites are included as statewide significant features on the INAI and are protected.

Ecological problems are woody encroachment due to periods of fire absence. Restoration activities at both sites (e.g., fire management and brush-cutting) have been underway and may be reversing the trends and enlarging the hill prairies.

Dominant species include little bluestem and side-oats grama. Additional **grasses** include Indian grass, Canada wild rye, poverty oat grass, porcupine grass, and northern prairie dropseed. **Forbs** include yellow false foxglove, sky blue aster, aromatic aster, silky aster, white false indigo, false toadflax, prairie coreopsis, pale purple coneflower, woodland sunflower, western sunflower, purple and white prairie clovers, wild petunia, early goldenrod, field goldenrod, puccoon (probably *Lithospermum canescens*), scurf pea, hairy mountain mint, prairie dock, yellow pimpernel, false boneset, flowering spurge, slender bush clover, cylindric blazing star, rough blazing star, green milkweed, and false dragonhead. Common **shrubs** include leadplant, New Jersey tea, prairie willow, and prairie rose.

Savanna

Savanna habitats occur throughout many parts of the North America. The Midwest, intermediate between the eastern forests and grasslands of the great plains, has the environmental conditions, and fire history, that supported many savanna-like habitats (Anderson 1983; Taft 1997). Savannas are characterized by scattered, open-grown trees, with or without shrubs, and a continuous herbaceous ground cover typically dominated by graminoid species (grasses and sedges) and numerous forbs. Density and percent cover of trees varies and is intermediate between open prairie and closed woodland or forest. In the dissected terrain of major river valleys, such as the Mackinaw valley (Thomas and Anderson 1990), savannas often occurred associated with a mixture of vegetation types including prairie, woodland, and forest. Midwestern savannalike habitats have several unifying characteristics. These include: 1) open-canopied structure (relative to closed forest); 2) canopy dominance by a few species of oaks; 3) a ground cover usually rich in species associated with tallgrass prairie; 4) a majority of floristic diversity contained in the ground-cover; and 5) dependence on fire and other disturbances for maintenance of diversity and stability. Oak-dominated systems particularly appear dependent on periodic fire for persistence (Lorimer 1985; Abrams 1992). In a period of a few decades of fire absence, savannas in the Midwest were altered through vegetational changes and habitat destruction. There was a rapid conversion of open savanna to closed woodland and forest. The once widespread oak savannas have become among the rarest plant communities (e.g., Curtis 1959; White 1978; Nelson 1985). Presently in the Midwest former savanna and open-woodland areas can still be recognized locally by the form and density of the oldest trees in closed woodland. Some small remnants persist where woody encroachment has been retarded (though not stopped) by droughty edaphic conditions. In addition, many savannalike areas have been structurally maintained by livestock grazing. Typically, the ground cover is floristically degraded and dominated by non-native species.

Three savanna subclasses are recognized in Illinois: **savanna** (generally on fine-textured soils), **sand savanna**, and **barrens** (local inclusions of a prairie flora within an otherwise forested landscape) (White and Madany 1978). Barrens typically persist only on sites with shallow or well-drained upland soils with exposures to the south and south-west. Another historic use of the term barrens has been for shrub-dominated (esp. hazel) prairies (Bowles and McBride 1994; White 1994). Savanna subclasses are further distinguished to community type by soil-moisture characteristics (White and Madany 1978). Barrens are distinguished by soil-moisture class (dry, dry-mesic, mesic); however, substrate type also influences species composition (Heikens 1991). About 0.2 ha of Grade B *dry-mesic barrens* was recognized from within the MRB as an exceptional feature at the Mackinaw River Hill Prairie in Woodford County. This represents 100% of the high-quality savannalike communities identified by the INAI from the Grand Prairie Natural Division and about 2.8% for the total in the state (White 1978; IDNR Natural Heritage Database). Based on inferred soils characteristics in the basin prior to settlement and notes from the Government Land Office survey of McClean County and the Mackinaw River valley (Rogers and Anderson 1978; Thomas and Anderson 1990), the following other savanna types probably also were present: *mesic savanna, wet-mesic savanna*, and *wet savanna*. Sand savannas may also have been present in the "SAND" portion of the basin. These are further distinguished by soil-moisture condition and, for the MRB, may have included dry-mesic and mesic sand savanna.

Compared with other habitat types, relatively few threatened and endangered plant species appear to be dependent on savanna habitats. Floristically, savannas contain species of both prairie and open woodlands, though many taxa appear to reach their greatest frequency in transitional (ecotonal) savannas. A few rare plant species that may occur associated with savanna habitats in the MRB include Hill's thistle, eared foxglove, and savanna blazing star.

Fire absence, fragmentation, habitat degradation, and exotic species are primary ecological problems associated with savanna habitats. Many areas of former savanna and barrens undoubtedly occur in the Mackinaw River valley that could be restored or at least rehabilitated with prompt vegetation management. Restoration activities including brush cutting, prescribed fire, and exotic species control, are already underway at several sites in the MRB. For example, Sibley Grove, close to the Mackinaw headwaters, is an old-growth stand of open-grown bur oaks southeast of Sibley. The ground cover was largely converted to weedy native and non-native species and a dense non-native shrub stratum was established. Intensive efforts at rehabilitation, including the methods listed above, have produced some very promising results. At the Merwin Preserve in McLean County, the exotic species Kentucky bluegrass is among the most abundant species in a savanna remnant (Anderson et al. 1994). Prescribed fire is being used to restore this community and reverse the abundance of this species. The following community descriptions are generalized depiction's of the (former) undegraded condition.

Savanna

Dry-mesic Savanna - Dominant **tree species** include white oak and black oak. In the presettlement vegetation, black oak was more common at the transitional zone from prairie to savanna in the uplands of McLean County, perhaps due to greater fire resistance (Rogers and Anderson 1979). Occasional species include chinquapin oak, white ash, (possibly) blue ash, and shagbark hickory. **Subcanopy** stratum characteristics are dependent on the recent fire history and may include many of the previous species in stages of recruitment. **Shrubs** include hazelnut, gray dogwood, New Jersey tea, leadplant, and prairie rose. **Ground-cover** species include a rich assortment of graminoid and forb species from prairie, savanna, and open woodland habitats. Important graminoid species (grasses and sedges) include panic grasses (e.g., *Dichanthelium acuminatum* and

D. villosissimum), bottlebrush grass, hairy brome, slender wild rye, nodding fescue, poverty oat grass, and the sedges *Carex pensylvanica* and *C. hirsutella*. Characteristic forb species include Virginia spiderwort, woodland agrimone, yellow pimpernel, shooting star, wild hyacinth, culvert's root, yellow-star grass, pussy-toes, pale purple coneflower, hoary puccoon, stiff tick seed, white prairie clover, scurf pea, pale Indian plantain, hairy mountain mint, field goldenrod, false dandelion, and early buttercup.

Mesic Savanna - Mesic savannas are particularly dependent on recurrent fire for maintenance. Without periodic fire, the soil-moisture conditions allow rapid development of woody vegetation cover. Consequentially, due to fire absence, habitat loss, and overgrazing, undegraded remnants are among the rarest plant communities in the Midwest. The compositional characteristics for mesic savannas in the MRB are poorly known, particularly for the ground-cover stratum. The most **characteristic tree species** of mesic savannas is bur oak. White oak may be common to occasional at some sites. **Shrubs** are similar to dry-mesic savanna. **Ground-cover species** may include greater importance of mesic prairie species. Big bluestem and Indian grass were probably common. Many of the ground-cover species from dry-mesic savanna were probably also present in mesic savannas.

Wet-mesic and *Wet Savanna* - About 38% of the floodplain of the Mackinaw River valley was characterized by the Government Land Office survey as savanna (Thomas and Anderson 1990). The most abundant tree species were, in rank-abundance order, sycamore, white oak, elm, and cottonwood. Occasional species included silver maple, bur oak, chinquapin oak, and black walnut. Tree density for this floodplain community was an extraordinarily low average of 2.7 per hectare (Thomas and Anderson 1990). This community was probably influenced by not only fire but also flooding. Fire-sensitive sycamore must have been most abundant closest to the river and protected in the wettest portions of the floodplain while white oak likely was restricted to terraces with better soil-drainage properties compared with the floodplain. Subcanopy and shrub strata were probably not well established but may have included elderberry and box elder. Characteristic ground-cover species may have included cordgrass, wood reed, *Agrostis perennis*, sedges (e.g., *Carex grayi, C. amphibola, C. sparganioides*), goldenglow, Jerusalem artichoke, saw-toothed sunflower, and giant ragweed.

Sand Savanna

Most of the presettlement vegetation of the Illinois River Section of the "SAND" portion of the MRB was marsh and prairie (Rogers and Anderson 1978). A small fraction is mapped as forest. Sand savannas may have been locally present, associated with both prairie and forest in this portion of the basin. In the absence of fire, sand savannas can develop into sand forests; with frequent fire sand prairies would increase in land cover (Anderson and Brown 1986). Compositional characteristics described below are based on sand savannas outside the MRB in Mason County.

Dry-mesic Sand Savanna - The most abundant **trees** are black oak, black jack oak, and Texas hickory (Rogers and Anderson 1978; Adams and Anderson 1980). **Shrubs** may include New Jersey tea and sand fragrant sumac. **Ground-cover** species would be similar to those of dry-mesic sand prairie.

Barrens

An area of Grade B dry-mesic barrens was recognized by the INAI at the Mackinaw Hill Prairie (= Wiegand's Prairie Natural Heritage Landmark) in Woodford County. The barrens is an open woodland community with several prairie species located on a steep slope above the Mackinaw River. Species composition includes many of the taxa listed for glacial drift hill prairie with scattered black and white oaks.

Brush encroachment is an ecological problem in this community. Prescribed fire and mechanical brush removal are needed to restore this community following long fire-free intervals.

Wetland

The distribution of wetlands in the MRB is depicted in Figure 1-3. The total area for all wetlands found in the MRB are shown in Table 4-2, where they are summarized by type of wetland based on the Illinois Wetland Inventory Classification (Suloway and Hubbell 1994). The MRB presently ranks 44th of 51 hydrological basins in amount of wetland area (Suloway and Hubbell 1994). Wetland community types, following natural community classification of White and Madany (1978), include floodplain forest, marsh, seep, pond, and lake. With the exception of 15 acres of Grade A wet floodplain forest, no other wetland areas have been identified in the MRB as high-quality, undegraded natural areas by the INAI. Floodplain forests are described in a previous section. Little descriptive information is available about nonforested wetland communities in the MRB.

Marsh

Marshes are palustrine wetlands characterized by having water at or near the surface during most of the growing season, dominance by herbaceous vegetation, with organic or mineral soils (White and Madany 1978). A total of about 1,230 acres of emergent marsh vegetation, 0.17% of the basin, are reported for the MRB (Suloway and Hubbell 1994; Table 4-2). At the mouth of the Mackinaw River, the presettlement condition has been described as a large marsh (Reber 1997) and, by the GLO surveys, as a swamp (Thomas and Anderson 1990). This area was probably characterized by open marsh with trees at the margins of the wetland. The contemporary distribution of marsh in the basin is characterized by scattered small remnants divided among marshes closely associated with riparian corridors and marshes on the level till plain of the uplands. No floristic descriptions of marshes are available currently from the MRB. The following description, selected from Suloway and Hubbell (1994), is based on typical species of marshes in central Illinois. **Characteristic species** include common cat-tail, blue flag, common bur-reed, fowl mannagrass, reed canarygrass, spotted water hemlock, swamp dock, swamp milkweed, tickseed sunflower, blue skullcap, arrowleaf, bluejoint grass, bulrushes (e.g., *Scirpus tabernaemontanii, S. atrovirens, S. fluviatilis*), rice cutgrass, and halberd-leafed rose mallow.

Ecological problems include siltation, altered flooding regimes, invasion of exotic species, and over-abundance of aggressive, disturbance-tolerant native species. Siltation and altered flooding regime can reduce the integrity of a marsh. When changes in flooding dynamics result in increased frequency and/or duration of flooding, species intolerant to the new levels will decline and species tolerant of the new levels will increase. Species that will increase under conditions of siltation and increased flooding include reed canary grass, common cat-tail, river bulrush, and reed. Compared with upland habitats, relatively few exotic species are present in wetland communities (Havera et al. 1994). However, a few taxa (e.g., purple loosestrife, glossy buckthorn) are serious pests that can threatened the diversity of a wetland site. These taxa have not been reported in floristic surveys from within the basin although they may be present.

Seep

Seeps are wetland communities characterized by a constant diffuse flow of ground water, typically from the lower slopes of glacial moraines, ravines, and terraces (White and Madany 1978). The ground water is mineralized by the material it flows through; the Mackinaw valley seeps tend to have circumneutral pH. Seeps are localized in the MRB and most common in forested tracts bordering the Mackinaw River. Characteristic species include jewelweed (locally dominant, particularly in degraded seeps), clearweed, slender wild rye, and fowl manna grass. Marsh marigold and skunk cabbage are characteristic of seeps along the Illinois River; however, it is not clear if these species are present in the MRB.

Ecological problems associated with seeps include degradation by over grazing and alterations to the watershed that influence ground water discharge.

Lake and Pond

Lakes and ponds are open-water habitats. In the MRB there are natural and artificial examples of ponds; all lakes are artificial impoundment's.

Ponds

No high quality natural pond remnants are known from the MRB. There are a total of about 46.8 acres of natural ponds in the MRB. A few occur in the Illinois River Section of the "SAND". Sand ponds and moist-sand habitats provide habitat for numerous threatened and endangered plant species (Herkert 1991). However, natural ponds, including those in the sand regions of Illinois, have been used for livestock and typically are very degraded.

Primary

Primary communities include **glade** and **cliff** communities. Cliff habitats includes *eroding bluff community*, which consists of vertical exposure of eroded unconsolidated material such as glacial drift (White and Madany 1978). No glade habitats are known from the MRB.

Cliff

Eroding Bluff Community - No areas of eroding bluffs were recognized by the INAI from within the MRB. Eroding bluffs are maintained by the erosive action of streams and may occur locally along the Mackinaw River. Floristic composition often is comprised of species that can become established and reproduce rapidly since the community is prone to slumping down slope. No descriptions have been made of the plant assemblage for the MRB.

Cultural Habitats

This class describes communities formed by anthropogenic disturbances and includes cropland, pasture, old fields, tree plantations, developed lands (urban), artificial lakes and ponds, and prairie reconstructions. This is the major community class in the MRB comprising about (684,130 acres), or about 94% of the land area. These areas impose some of the most challenging ecological problems for natural habitats in the MRB. No threatened or endangered species are known from these non-native habitats in the MRB and most native plant species are unable to become established in these disturbed habitats. Therefore, when native habitats are destroyed, many native species have no refugia in which to persist. Moreover, cultural habitats may serve as source areas for some exotic plant species that encroach into native habitats and displace native species. These issues are further discussed above under the section on "Disturbance, Habitat Quality, and Restoration Potential", and in the discussion of each natural habitat type (particularly "Prairies").

Prairie Restoration

One of the more important "cultural" habitats for native plants is the prairie restoration. They are considered a cultural habitat because they are not a natural community. Prairie restorations are perhaps more appropriately termed prairie reconstructions. Typically, prairie reconstructions are plantings of prairie species on grassland soils where the original natural community has been destroyed by development. Prairie species are planted, sometimes in an effort to produce a warm-season grassland and sometimes with the goal of attempting to recreate the original prairie community. Prairie reconstructions often are species poor and are strongly dominated by a few species. Within the MRB in Tazewell and Woodford counties there are a total of about 114.7 acres of native warm-season grass plantings and an additional 39 acres in Woodford County of switch grass monoculture (Paulsen 1996).

Summary and Recommendations

Due to widespread habitat destruction in the Mackinaw River Basin, there are many gaps in the knowledge of several natural communities, particularly the distribution, abundance, and qualitative condition of remnants. This is particularly true for silt-loam prairies, formerly the most abundant community class in the basin, and sand communities. No undegraded examples are known to exist for silt-loam or sand prairies and no descriptions are available from even degraded remnants in the basin. Although typical or characteristic species for certain communities are known, we do not have complete floristic data for many communities. Floristic inventory data are particularly valuable in determining levels of diversity for each community type. Additional survey efforts in the basin may identify new populations of the two threatened and endangered plants known from the basin (drooping sedge and heart-leaved plantain) and new species such as the recent report of an occurrence of tall sunflower in the MRB. The two known colonies of heart-leaved plantain in the MRB, particularly, are of critical concern. Though once a widespread species, this may be the last remaining population of this species for central and northern Illinois. The colonies of this semi-aquatic perennial herb are highly vulnerable to habitat loss (loss of perennial vegetative cover) in the local drainage that results in an increased frequency of damaging flooding events (Bowles and Apfelbaum 1989).

Many of the most challenging conservation issues in the MRB, like preserving the population of heart-leaved plantain, are primarily addressed at the community and ecosystem-levels. There are serious ecological problems that threaten the long-term maintenance of biodiversity in the basin. Throughout the natural community descriptions for the Mackinaw River Basin are consistent references to a set of related ecological problems. These are habitat fragmentation, habitat degradation, exotic species invasion, and, for several community types, fire absence. The following five steps are recommended as an approach for gaining further insights into the natural communities in the MRB and developing a plan for the long-term maintenance of biodiversity.

1. Inventory

The INAI provides data on the distribution and abundance of statewide-significant natural communities. However, many natural communities occur in Illinois that, though they do not meet the critical qualitative standards of the INAI for undegraded and statewide-significant natural areas, contain regionally noteworthy and exceptional natural features. Many natural communities in the MRB, although somewhat degraded, retain relatively high levels of ecological integrity and have potential for further improvement through restoration efforts. Since the INAI sites are few and small in total area, the somewhat degraded but restorable natural communities that remain are critical for the long-term maintenance of biodiversity in the basin. Remnants among all community classes (e.g., forest, prairie, savanna, wetland) need to be identified. For example, since no high quality mesic tall-grass prairie remnants are known from the MRB, identification of the degraded remnants is central to any recovery effort for prairie in the basin. Since no high-quality sand habitats (e.g., sand prairie, sand savanna, sand forest, sand pond) are known from the basin, identification of remnant degraded sites is central to any effort to capture the diversity of sand communities in the MRB. Floristic Integrity Assessment, a method for evaluating the natural quality of habitat remnants that employs numerous parameters of community characteristics (including floristic inventory data and INAI grades), is a promising technique for distinguishing remnants of native vegetation that have restoration potential (Taft et al. in press).

2. Map

All results from natural community inventory efforts should be categorized and mapped to provide a spatial context for the locations of habitats with differing ecological condition. This will aid in identifying focus areas. Trends in total area of each community class among qualitative units would serve as an aid in measuring success in restoration efforts (see below).

3. Protection

The natural communities with the greatest integrity need to be protected from further anthropogenic degradation such as damaging levels of grazing. Inventory and mapping in the basin will aid in the prioritization of protection efforts. Highly isolated remnants pose distinct conservation and protection challenges compared with clusters of restorable natural communities. Staff of the Illinois Nature Preserves Commission are familiar with the various protection options and incentives for private landowners.

4. Identification and Prioritization of Ecological Problems

As previously indicated, a host of related ecological problems consistently are present among remnant natural communities in the MRB (habitat fragmentation, habitat degradation, exotic species invasion, and fire absence). Some problems can be addressed more readily than others.

Habitat fragmentation is a widespread problem with potentially devastating consequences for ecological integrity, often resulting in an interruption of biological interactions, ecological processes, species migrations, and a reduction in habitat heterogeneity (Wilcove et al. 1986). A consequence, typically, is loss of species diversity. However, solutions to restoring biological connectivity and ecosystem-level process are extraordinarily complex and costly if the goal is to re-create connectivity for all species among regional habitats. High levels of fragmentation may impose limits on maintaining or enhancing biodiversity in the long-term.

Habitat degradation, in contrast, is a widespread problem that can be slowed and/or minimized at many sites by removing the degradation factor (e.g., grazing), although restoration to pre disturbance condition in severe cases may require intensive vegetation management. It is difficult to find a private woodland in Illinois that does not bear indications of past cattle grazing. The effects of over-grazing can be persistent. Certain species (e.g., many ferns, orchids, trilliums, blue cohosh, bellflower, bloodroot, several grass and sedge species) appear to be sensitive to grazing disturbance and are often absent while certain species that increase with grazing (e.g., unpalatable species, thorn-bearing species, and plants with bristly fruits) are dominant. For instance, a typical situation in Illinois woodlands is a ground-cover and shrub flora dominated by common snakeroot, white snakeroot, buckbrush, Missouri gooseberry, brambles, Virginia creeper, and garlic mustard. Usually, confounding influences such as grazing, increased shade, and siltation or other soil disturbances are involved.

Exotic species invasion can be considered both a species-level and a community-level problem. Some community-level management activities address more than one ecological problem. For example, garlic mustard invasion can be reversed with appropriately timed applications of fire (Nuzzo 1991; Schwartz and Heim 1996). Other serious exotic pests such as purple loosestrife require direct treatment or biological control (Thompson et al. 1987; Malecki et al. 1993). Exotic species known to pose severe ecological problems occur in the MRB. Recommended control measures are summarized in Table 4-10.

Fire is an ecological force that historically influenced many aspects of natural communities in the MRB. Many community types require fire for maintenance of community characteristics and diversity. Fire absence has resulted in changes in forest structure, composition, and diversity. Invasion of mesophytic species such as sugar maple into oak-hickory forests is a statewide phenomenon related to fire absence also occurring in central Illinois and the MRB. Many forests in Illinois are dominated in the canopy by oaks but have few oak saplings. Rather, shade-tolerant (and fire intolerant) species like sugar maple often are extraordinarily more common and dense than prior to settlement. An obvious consequence of this change is the possible loss of oak woodlands and the plant and wildlife species that depend on them. A rich assemblage of spring wildflowers can still be found in some woodlands because these spring ephemerals largely escape the ensuing shade of the dense overstory and thus selectively persist while typically only a few shade-tolerant species can be found in the summer and fall. Also, the spring flora have often been spared direct effects of cattle grazing because livestock historically were often rotated to fescue pastures during spring months. Infrequent application of prescribed fire appears unlikely to reverse these trends. Rather, a long-term program of repeated applications of prescribed fire is often necessary before compositional stability is achieved (Taft, unpublished data). Nevertheless, prescribed fires can be implemented in a wide variety of remnants and community types, at little cost, and achieve measurable improvements in many parameters of ecosystem integrity.

Table 4-10. List of invasive exotic species known or suspected to occur in the Mackinaw River Basin, and recommended eradication methods[1].

Species	Cut & Apply Stump-treatment Herbicide	Foliar Herbicide Application	Prescribed Fire	Hand Pull/Cut	Dig Root	Bio-Control
amur honeysuckle	X					
black locust	X - Garlon 4					
Canada bluegrass			X			
creeping Charlie		X	?	X		
fescue		X	X		X	
garlic mustard		X	X	X		
glossy buckthorn	X					
high-bush cranberry	X					
Kentucky bluegrass			X			
moneywort		X	?			
multiflora rose	X					
osage orange	X					
purple loosestrife		X		X		X
white mulberry	X					
white sweet clover			X	X		
wild parsnip[2]		X	X?		X	
yellow sweet clover			X	X		

[1]The recommended herbicide is typically Round-up (Glyphosate), except for black locust (Solecki 1997).
[2]This species has phototoxic properties and skin contact should be avoided.

5. Application of Appropriate Vegetation Management

Once the ecological problems for a natural community are identified and prioritized according to restoration effort and gain, a program of vegetation management needs to be implemented. Record keeping is vital to tracking activities and levels of success in implementing each treatment plan. Floristic Quality Assessment (Taft et al. 1997) methods may provide a framework useful in measuring progress of each restoration activity.

Many aspects of these steps are incorporated among the specific suggestions of the Biological Diversity Action Team (1997) for the Mackinaw River Project whose strategy is to improve the diversity of natural communities within the watershed. The highest priority Action Team recommendations are listed below.

1. Stabilize stream banks; encourage use of natural materials and native vegetation; establish, restore, or widen riparian zones where desirable; establish grass buffers along drainage ditches and other waterways where needed.

2. Seek public and private funding for stream restoration and biological restoration.

3. Identify and promote restoration of suitable wetland habitat; promote side stream storage such as sloughs and backwater lakes.

4. Identify and enhance or restore natural plant areas.

5. Recognized landowners (plaque, marker, certificate of appreciation) using good land management practices (e.g., leaving wooded riparian zones along a corridor).

6. Initiate a one-year stream cleanup program concentrating on bridge sites and visible locations with willing landowners.

Bird Communities

The MRB has a typical species list for central Illinois. At least 264 of the 299 species (88%) that regularly occur in the state (exclusive of vagrants) can be found in the area (Appendix 4-2). Of these 264 species, 134 breed or formerly bred there (Appendix 4-2). Of these 134, 37 are now either locally extinct, or are extremely rare in the area during the breeding season (species with a "r" in Appendix 4-2), which suggests that habitat loss has been a major problem in the area. Several other species that are globally extinct (Passenger Pigeon, *Ectopistes migratorius,* and Carolina Parakeet, *Conuropsis carolinensis*) formerly occurred in the basin, as did other species that are extinct or nearly so in Illinois (e.g., Bachman's Sparrow *Aimophila aestivalis,* Bewick's Wren *Thryothorus bewickii,* and American Swallow-tailed Kite *Elanoides forficatus*). At least one locally extirpated species, the Wild Turkey, has been reestablished in the basin.

The MRB is typical of primarily agricultural areas of central Illinois for birds. Most wildlife habitat exists where it is too steep or wet to plow or in small city parks. As such, it is not an ideal place to focus management efforts on restoring habitat specifically for breeding birds of forest or grassland habitats. It is extremely likely that the nesting success of species in these habitats is so low that they are likely population "sinks" in which reproductive success is too low to compensate for adult mortality (Brawn and Robinson 1996). This situation is unlikely to change even with large scale restoration efforts in the MRB. On the other hand, many migrating or overwintering birds do not require large, unfragmented habitats. The large number of these species (at least 130 species; see Appendix 4-2) coupled with the low availability of forest, wetland, and grassland habitat available throughout all of central Illinois suggests that migrants should occur at very high concentrations in suitable habitat during spring and fall. Therefore, the scarcity of nonagricultural habitat in the MRB makes it an ideal place to concentrate on enhancing habitat for migrating birds passing through the area on their way north to breeding areas or south to wintering areas. Small improvements in habitat quality could have a large benefit to many migrating birds that use these areas.

The bird species that live in the MRB are ecologically diverse, and although some species are able to live in a variety of habitats, many species are adapted to living in only one or a few habitats (Appendix 4-2). The following sections describe the bird communities typically found in the major habitat types of the MRB, as well as the unique environmental problems and management solutions for bird communities in each habitat.

Forest

Most of the remaining forest habitat in the MRB is found along the Mackinaw River and it's tributaries (Figure 1-2), particularly within the middle Mackinaw River and Panther Creek sub-basins that make up the Mackinaw's Resource Rich Area (Suloway et al. 1996; Figure 1-1).

Regularly Occurring Species

Typical breeding species of forest habitats in the MRB include: Wild Turkey, Yellow-billed Cuckoo [irregular], Barred Owl, Whip-poor-will [especially edges of woodlands], Ruby-throated Hummingbird, Red-bellied Woodpecker, Hairy Woodpecker, Downy Woodpecker, Great Crested Flycatcher, Eastern Wood-Pewee, Blue Jay, Black-capped Chickadee, Tufted Titmouse, White-breasted Nuthatch, House Wren, Carolina Wren, American Robin, Wood Thrush, Blue-gray Gnatcatcher, Yellow-throated Vireo, Red-eyed Vireo, Brown-headed Cowbird, Scarlet Tanager, Northern Cardinal, Rose-breasted Grosbeak, and Indigo Bunting, [mainly along edges]. Cooper's Hawk is likely to be an increasing nesting species. Most of these species are likely to be common in woodlots of 100 acres or greater. Pileated Woodpeckers also nest in some of the forest tracts. Northern Parulas and Ovenbirds nest in the Parklands site. See Appendix 4-2 for a more complete list of forest species occurring in the MRB.

Very few threatened or endangered species nest in forests of the MRB. The Long-eared Owl (state endangered - SE) may breed occasionally in riparian woodlots, as does the Brown Creeper (state threatened - ST), which is probably restricted to forested wetlands (see below). The Veery (ST) breeds occasionally in small numbers, especially at the Parklands site (Figure 4-2).

European Starlings were introduced into this country in 1890-1891 and spread to Illinois by 1922 (Bohlen and Zimmerman 1989). They are now one of the most abundant species in Illinois, and they are detrimental to native species because the compete with residents for nesting cavities, especially in smaller forest tracts.

Pines are not native to the MRB, and pine plantations have unusual bird communities. In addition to more generalized forest species, pine plantations in central Illinois occasionally attract nesting Long-eared Owls (SE) [also in winter], Chuck-will's-widows, Solitary Vireos, Black-throated Green Warblers, and Pine Warblers. Chipping Sparrows are often the most abundant nesting species in pine plantations. In winter, pines attract winter finches (e.g., Red Crossbills, Pine Siskin), Yellow-bellied Sapsuckers, and Red-breasted Nuthatches.

Population Dynamics and Management

Many bird species are declining across part or all of their breeding range in the Midwest (Peterjohn et al. 1994). The causes of such changes are likely related to problems with reproduction in highly fragmented landscapes. The primary factors controlling productivity of birds in the MRB are predation on eggs or young in nests and brood parasitism by Brown-headed Cowbirds. Cowbirds lay their eggs in the nests of other species and often destroy one of the hosts eggs when they lay their own. Cowbird young also grow faster than their host young and out-compete them for food, often leading to the starvation of the host young. Rates of nest predation and brood parasitism generally increase as a habitat becomes more fragmented, creating more feeding habitat for cowbirds and travel corridors for mammalian predators such as raccoons that often inhabit the edges of open country (Robinson et al. 1995). Given the small size of most forest tracts, it is likely that levels of nest predation and brood parasitism by Brown-headed Cowbirds are extremely high (Robinson et. al., in press). In general, nest predation rates in Illinois forests of less than 500 acres average 70-90% and parasitism levels for cowbird hosts average 80%. These levels are so high that woodlots in this region are very likely to be population "sinks" (Brawn and Robinson 1996) in which reproduction is far below rates necessary to sustain regional populations.

Remarkably, in spite of low productivity, many of species that nest commonly in regional woodlots are not obviously declining. This strongly suggests that their populations are being "rescued" by the settlement of individuals from much larger forest tracts outside of the region, or even outside of the state (Brawn and Robinson 1996). Therefore, to understand the population dynamics of breeding forest birds, it is necessary to monitor both population size and nesting success. Previous research on this subject in Illinois (Robinson and Hoover 1996) suggests that the best candidates for forest restoration are tracts that are, or can be 500 acres or larger, such as the forested core (600 acres) of the Parklands site in the middle Mackinaw River sub-basin. As will be described below, savanna restoration may be the best strategy for many sites given the high value of oaks to migrant birds (Graber and Graber 1983) and as a source of mast.

Wetland

Although historically there had been considerably more wetlands in the MRB (wet prairie), wetland habitats in the MRB are now rare (Figure1-3). Much of the wetlands have been drained for agricultural purposes (see discussion of wetlands in the section on vegetation communities earlier in this report.

Regularly Occurring Species

The loss of natural wetland habitats makes it somewhat difficult to characterize a typical wetland species in the basin. Currently, only a few species are likely to be common, including the Canada Goose, Mallard, Wood Duck [forested wetlands], Great Egret, Great Blue Heron, Green Heron, Killdeer, American Woodcock, Barred Owl, Ruby-throated Hummingbird [forested], Red-headed Woodpecker [forested], Great Crested Flycatcher [forested], Acadian Flycatcher [forested], Willow Fycatcher [forested], Northern Rough-winged Swallow, Tree Swallow, Blue-gray Gnatcatcher [forested], Yellow-throated Vireo [forested], Warbling Vireo [riparian corridors], Yellow Warbler, Common Yellowthroat, Common Grackle, Red-winged Blackbird, Baltimore Oriole [riparian corridors], Indigo Bunting, and Song Sparrow. Other species that would likely recolonize or increase greatly in restored wetlands include Pied-billed Grebe and Blue-winged Teal [marshes], Hooded Merganser [forested], Northern Harrier [marshes, especially in grassland areas], Red-shouldered Hawk [wide forested river corridors], American Bittern [marshes], Least Bittern [marshes], Virginia Rail [marshes], King Rail [marshes], Common Moorhen, American Coot, Common Snipe, Brown Creeper, Marsh Wren [marshes], Sedge Wren, Prothonotary Warbler [forested], Louisiana Waterthrush [forested], American Redstart [forested], Yellow-headed Blackbird [marshes], and Swamp Sparrow. Other species found in the wetlands of the Mackinaw are listed in Appendix 4-2).

Currently, few threatened or endangered species inhabit the wetlands of the MRB other than the Brown Creeper (ST). But, restored wetlands (especially marshes) would have a high potential to include many species, including the Pied-billed Grebe (ST), Northern Harrier (SE), Red-shouldered Hawk (ST), American Bittern (SE), Least Bittern (ST), Virginia Rail (ST), King Rail (ST), Common Moorhen (ST), and Yellow-headed Blackbird (ST).

No non-native species pose a major threat to native wetland birds in the MRB, although mute swans, which have been introduced from Europe, could become established.

Population Dynamics and Management

Currently, the main problem for birds inhabiting wetlands is a lack of habitat. Forested wetland species likely suffer from the same problems with fragmentation that affect forest species (cowbird parasitism and nest predation). We know little, however, about the effects of fragmentation on other wetlands habitats. In fact, there have been no studies of the population dynamics and nesting success of wetland birds in the region. Potentially, wetland species are more resistant to fragmentation, which may make this habitat a good target for restoration efforts in largely agricultural landscapes. Wetland habitats are also used heavily by migrating waterfowl, shorebirds, rails and long-legged waders (herons, bitterns, and egrets). These habitats therefore have the potential to be important stopover sites for birds during migration. Wetland restoration should be a high priority in the region for birds for reasons outlined above.

Savanna

Savanna habitats were once widespread in the Midwest, but due to habitat destruction and the absence of fire they are now one of the rarest habitats in the MRB (see section on vegetation communities above), and very little exists in a natural condition in the MRB.

Regularly Occurring Species

Savannas share many species with forest habitats. Perhaps the most typical species of savannas would be Whip-poor-will, Red-headed Woodpecker, Great Crested Flycatcher, Eastern Wood-pewee, Least Flycatcher [rare, but often associated with open woodlands], Blue Jay, House Wren, American Robin, Eastern Bluebird, Blue-gray Gnatcatcher, Yellow-throated Vireo, Baltimore Oriole,.Summer Tanager, Rose-breasted Grosbeak, Indigo Bunting, American Goldfinch, Lark Sparrow, Field Sparrow, and Chipping Sparrow. Of these species, the Summer Tanager may be the most specialized to savannas at this latitude. Other forest species remain common in savannas, including the Wild Turkey, Great Horned Owl, Ruby-throated Hummingbird, Northern Flicker, Red-bellied, Downy, and Hairy Woodpeckers, Black-capped Chickadee, Tufted Titmouse, White-breasted Nuthatch, House Wren, Brown-headed Cowbird, Scarlet Tanager, and Northern Cardinal. Blue Grosbeaks may also be restricted to open, sandy areas such as savannas at the northern edge of their range in central Illinois. The open, parklike structure of some savannas also attracts some species that are more characteristic of grassland habitats, such as the Red-tailed Hawk.

None of the species inhabiting savannas in this area are threatened or endangered, although the Barn Owl (SE) may have been a bird of very open savannas.

European Starlings are now one of the most abundant species in Illinois, and they are detrimental to native savanna species because they compete with resident birds (especially woodpeckers) for nesting cavities.

Population Dynamics and Management

Savannas may be associated with high levels of cowbird abundance and parasitism levels. However, many of the species that are most abundant in savannas are resistant to cowbirds (e.g., cavity nesters, American Robins, Baltimore Orioles). Unlike many forest birds, these species are able to recognize cowbird eggs and either eject them from their nests or rebuild the nests over them (Rothstein and Robinson 1994). The partial dependence of Cerulean Warbler on oaks may suggest that management practices such as burning that help maintain oaks will favor this rapidly declining species (Vanderah 1995). A detailed study of the effects of savanna restoration on bird populations, ecology, and nesting success is underway in adjacent watersheds (J.D. Brawn, unpubl. data). This study should be fully applicable to savannas in the MRB.

Savannas also appear to be a very favorable habitat for migrants. The heavy use of oaks by spring migrants (Graber and Graber 1983) and by mast-consuming species suggests that savanna restoration should be a high priority for birds in this region.

Prairie and Grassland

Native prairie habitat is extremely rare in the MRB (see the section on native vegetation communities), however, many bird species that historically lived in prairies are also able to live in grassland habitat such as hay fields, and sometimes pastures. These habitats are also relatively uncommon in the MRB. There are only about 98,000 acres of "grassland" in the basin, and most of this habitat occurs as narrow strips along the edges of country roads (Figure 1-4). Nonetheless, although patches of available grassland habitat in the MRB are small, they have considerable potential for restoration. Pastures in the area are mostly heavily grazed and little-used by grassland birds. They are also favored sites for foraging Brown-headed Cowbirds.

Regularly Occurring Species

Typical species in these habitats include a subset of those found on larger grasslands throughout the state: Red-tailed Hawk, American Kestrel, Northern Bobwhite, Ring-necked Pheasant, Eastern Kingbird, Horned Lark [recently burned], Barn Swallow, Brown Thrasher [shrubs], Bell's Vireo [shrubs], Common Yellowthroat, Eastern Meadowlark, Western Meadowlark, Red-winged Blackbird, Dickcissel, Savannah Sparrow, Grasshopper Sparrow, Vesper Sparrow, and Field Sparrow. See Appendix 4-2 for a more complete list of grassland species found in he Mackinaw region.

Currently, the Short-eared Owl (SE) and Henslow's Sparrow (SE) are the only endangered grassland species known to breed in the area.

Two introduced species are found in the grasslands of the MRB. The Ring-necked Pheasant, which is native to Asia, was first released in Illinois in about 1890 (Bohlen and Zimmerman 1989) and they continue to be released. Pheasants are abundant in prairie remnants statewide. European Starlings feed in grasslands following grazing, mowing, or burning.

Population Dynamics and Management

Certain species, such as the Grasshopper Sparrow, have declined precipitously as grasslands have been converted to row crops (Herkert 1991). Currently, prairie remnants and other grassland habitats are probably too small to sustain regular breeding populations and successful nesting of most prairie species. For example, the Short-eared Owl is highly area-sensitive and will require larger grasslands than exist currently to maintain a regular breeding population. Recently (1996) Henslow's Sparrows (SE) have bred in

Conservation Reserve Program (CRP) fields in the area (A. Capparrella, pers. comm.). This species is also area-sensitive and requires taller, ranker grass that has not recently been burned (Herkert 1994). King Rails (ST) and Northern Harriers (SE) would also be good candidates for re-establishment in restored grasslands. Upland Sandpipers (ST) nest in nearby areas, but they require mowing, grazing, or burning to keep the grass short. Upland Sandpipers are also area-sensitive and likely require larger grassland areas than are currently available. Other rare or locally extirpated species that would be likely to increase rapidly if grasslands were restored include Sedge Wren, Loggerhead Shrike (ST), Bobolink, and Lark Sparrow [sandy areas]. Because the currently available grasslands in the Basin are generally too small to sustain threatened and endangered grassland birds over the long run, prairie restoration and enhancement will be needed to attract grassland birds. Removal of woody vegetation may also be beneficial.

Shrub removal would likely negatively affect Bell's Vireos, but this species can also be managed in game areas or in prairie remnants that are too small to be useful for grassland birds. Other shrubland species that would be lost are of little or no regional concern because they have large global populations and are common throughout Illinois (e.g., Gray Catbird, Brown Thrasher, House Wren). Perhaps the best way to maintain desired shrubland birds (Bell's Vireo, Willow Flycatcher, Yellow-breasted Chat) would be to allow willow thickets to grow in low, wet areas that would not burn in most areas. Natural hazel thickets may also have provided habitat for these species historically. The guidelines provided by Herkert et. al. (1993) for grassland management should be followed. In particular, dense, tall stands of prairie grasses are rarely used by grassland birds and should be avoided.

Migrant birds use grasslands as stopover habitat, especially Smith's and Lapland Longspurs, various rails, bitterns, American Golden-Plovers, and Pectoral Sandpipers. Given that much of the global population of Smith's Longspur likely passes through Illinois in the spring, enhancement of prairie/grassland habitat in central Illinois should directly benefit this poorly known species. The same could be said for the American Golden-Plover, but they also use plowed fields, obviously a much less threatened habitat.

Lakes, Ponds, and Impoundments

There are no natural lakes or ponds in the MRB (see section on Aquatic Biota), and there are only two relatively large human-made impoundments in the area (Figure 1-5).

Regularly Occurring Species

Although Spotted Sandpipers may occasionally breed around lakes, ponds, and impoundments, there are usually few characteristic breeding birds. Common Grackles, Red-winged Blackbirds, and Song Sparrows likely nest along ponds, especially those with gradual shorelines and some emergent vegetation (e.g., *Typha*) along the edge. Barn

Swallows, Cliff Swallows, Purple Martins, and Tree Swallows forage over these open-water habitats as long as nest sites are available. Green Herons often nest along ponds lined with dense, woody vegetation.

There are no threatened or endangered species breeding in the open water habitats of the MRB, however, marshy vegetation along lakeshores would likely attract wetland species (see above).

The Mute Swan is the only non-native species that would be likely to occur in the area. Although they are rare in Illinois, some may visit local ponds.

Population Dynamics and Restoration

By far the most important role of lakes, ponds, and impoundments is as resting habitat for migrating waterbirds. These open-water habitats are often the only deepwater habitat available for loons, grebes, scaup, Common Goldeneyes, Buffleheads, and mergansers, all of which dive to catch food. Similarly, gulls and terns often forage over open water during migration. At low water, the edges of lakes are also used by shorebirds, herons, and egrets. All species of swallows use open-water for foraging, especially during cold weather.

A comparative study of the use of various ponds, lakes, and impoundments by migrating birds might help improve their design and management, but probably the most useful way to enhance these habitats is by increasing the amount of emergent vegetation along their edges. This essentially involves creating shallow wetlands along the edges of open water.

Creeks and Rivers

Relative to the rest of the state, the creeks and rivers of the MRB are in relatively good health (see aquatic section below), and over 136 miles of the Mackinaw River are designated as "Biological Significant Stream" segments (Table 4-6, Figure 4-2). Nonetheless, as with several other habitats, creeks and rivers have been greatly altered.

Regularly Occurring Species

Among the species found along creeks and rivers are the following: Canada Goose, Mallard, Wood Duck [forested], Cooper's Hawk [forested corridors], Bald Eagle [winters on rivers], Great Blue Heron, Green Heron [forested], Killdeer, Great Horned Owl [forested], Barred Owl [forested], Belted Kingfishers, Eastern Phoebe [especially near bridges], Willow Flycatcher [shrubby margins], Barn Swallow, Northern Rough-winged Swallow, House Wren [in woody debris], Cedar Waxwing, Warbling Vireo [woody corridors, especially cottonwoods and willows], Yellow Warbler [shrubby corridors], Yellow-throated Warbler [sycamore-lined natural levees], Common Yellowthroat [grassy and shrubby streamsides]. Common Grackle, Red-winged Blackbird, Orchard Oriole [willow-lined streams], Baltimore Oriole [woody corridors], Indigo Bunting, Song Sparrow [shrubby streamsides] are all found along creeks and rivers. Two typical streamside species, the Louisiana Waterthrush and Northern Parula, nest in the Parklands site, but are rare or absent elsewhere.

Population Dynamics and Management

We lack data on populations and nesting success of birds in riparian corridors of varying widths and of their use by migrants. However, increasing the amount of woody riparian corridor habitat should enhance populations of many species, and would help restore natural hydrology. Restoring the hydrology would, in turn, improve wetland habitat in the floodplain, both in woody backwaters and in oxbows (see above). It would also be interesting to measure the movements of migrants along corridors to determine if they act as flyways.

Cultural Habitats: Cropland

Most land within the MRB has been drastically modified for intensive human use (Figures 1-2 through1-7). Over 76% is currently used for crop production (Table 1-3). These habitats have much lower bird diversity than the original natural habitats.

Regularly occurring Species

Cropland bird communities in the MRB have the same bird species that are common statewide in this structurally simple habitat: Mallard, Red-tailed Hawk, American Kestrel, Ring-necked Pheasant, Killdeer, Rock Dove, Mourning Dove, Great Horned Owl, Eastern Phoebe [farmsteads], Horned Lark, Barn Swallow, American Crow, Eastern Bluebird, Loggerhead Shrike (ST), European Starlings, House Sparrow, Common Grackle, Brown-headed Cowbird, Red-winged Blackbird, Vesper Sparrow, and Field Sparrow.

Some species characteristic of recently burned and heavily grazed, dry grasslands have adapted to croplands, including the Horned Lark, Vesper Sparrow, and Loggerhead Shrike (ST). The shrike, however, also requires spiny hedgerows for nesting; it is now rare in the area.

Introduced species thrive in the agricultural habitats of the MRB. In fact, four of the most abundant species in the cropland of the Mackinaw area, Ring-necked Pheasant, Rock Dove, European Starling and House Sparrow, were all introduced from Europe or Asia.

Intensively farmed areas offer little in the way of stopover habitat except around farmsteads and wet fields in the spring for shorebirds.

Population Dynamics and Management

Warner (1994) documented the low populations and extremely low nesting success of birds in nearby Ford County, an area of very intensive agriculture. On the other hand, increasing grassy cover along roadsides, drainage ditches, and around farmsteads can substantially increase grassland bird habitat. Within an agricultural landscape, the CRP can also benefit cropland birds by providing nesting cover and attracting such species as Henslow's, Grasshopper, and Savannah Sparrows.

Cultural Habitats: Successional Fields

Successional habitats, such as abandoned fields and pastures, are relatively uncommon in the MRB. These habitats, which are often dominated by non-native plant species of shrubs and vines, may be structurally similar to native successional habitats that historically occurred along the edges of meandering rivers or in large treefall gaps. Such habitats usually have dense, protective cover and are often rich in fruit producing plants, and therefore offer rich habitat for breeding and migrating birds. However, given the scarcity of natural shrublands in the Midwest, we know little about "natural" shrublands. Nonetheless, many local species that use shrubby vegetation now depend almost entirely on anthropogenic disturbances to set back succession.

Regularly Occurring Species

Typical species include: Northern Bobwhite, Ring-necked Pheasant, American Woodcock, Mourning Dove, Yellow-billed Cuckoo, Black-billed Cuckoo [rare this far south], Ruby-throated Hummingbird, Northern Flicker, Downy Woodpecker, Eastern Kingbird, Willow Flycatcher [wet thickets], Blue Jay, Black-capped Chickadee, House Wren, Carolina Wren, Gray Catbird, Brown Thrasher, American Robin, Eastern Bluebird, Blue-gray Gnatcatcher, Cedar Waxwing, White-eyed Vireo, Bell's Vireo [very young thickets], Yellow Warbler, Common Yellowthroat, Yellow-breasted Chat, Red-winged Blackbird, Orchard Oriole, Baltimore Oriole [older thickets], Northern Cardinal, Rose-breasted Grosbeak [older thickets], Indigo Bunting, House Finch, American Goldfinch, Eastern Towhee, Lark Sparrow [sandy soils, open thickets], Field Sparrow, and Song Sparrow. Successional habitats add greatly to local diversity, but virtually none of these species are in any trouble, although the Yellow-breasted Chat and Field Sparrow are declining nationally. Two species typical of shrublands elsewhere in the state, Blue-winged Warbler and Prairie Warbler, are rare or absent form the Basin. Kentucky Warblers and Wood Thrushes also nest in late-successional thickets.

No threatened or endangered species are known to use the successional habitats in the MRB.

Most species found in successional habitats are native, although Ring-necked Pheasants use early successional fields, and House Finches breed in shrubbery.

Population Dynamics and Management

Although nest predation rates appear to be very high in successional habitats, brood parasitism levels are generally moderate-to-low (Robinson et. al., in press). Some species nesting in these habitats eject cowbird eggs (Gray Catbird, Brown Thrasher, Cedar Waxwing, Eastern Kingbird, Baltimore Oriole, American Robin), nest in cavities that are inaccessible to cowbirds (both wrens, chickadees, Eastern Bluebird), abandon many parasitized nests (Yellow Warbler, Bell's Vireo, Field and Chipping Sparrows), defend their nests aggressively (Red-winged Blackbird, Eastern Kingbird, Willow Flycatcher, Common Grackle), have inappropriate diets for cowbird nestlings (House Finch, American Goldfinch), or continue nesting until very late in the season when cowbirds have stopped laying and nest predation rates generally decline (Mourning Dove, Yellow-billed Cuckoo, Gray Catbird, Cedar Waxwing, White-eyed Vireo, Northern Cardinal, Indigo Bunting, American Goldfinch, and Eastern Towhee). As a result, early successional species may be able to thrive even in small patches in agricultural landscapes. An intensive study of habitat requirements, nesting success, and population dynamics of shrubland birds is now underway (S. K. Robinson, J. D. Brawn, and E. J. Heske, unpubl. data). This project has a statewide component, although the intensive field work is being carried out in the Middle Fork Fish and Wildlife Area. The results of this study should be applicable to shrubland birds in the MRB. Shrubland species may be excellent target species for lands managed to promote game species, especially Northern Bobwhites.

In addition to use during the breeding season, shrublands are very heavily used by migrating species, especially in habitats mingled with scattered trees. Shrubland-preferring migrants include Black-billed Cuckoo, Northern Saw-whet Owl [mainly in evergreens], Yellow-bellied Flycatcher, Alder Flycatcher, Least Flycatcher, Philadelphia Vireo, Golden-winged Warbler, Orange-crowned Warbler, Chestnut-sided Warbler, Mourning Warbler, Connecticut Warbler, Wilson's Warbler, Canada Warbler, and Lincoln's Sparrow. Shrubland habitats therefore provide real benefits to migrant birds and greatly increase local biodiversity.

Cultural Habitats: Developed Land

Residential and urban areas represent only about 2.3 % of the MRB (Table 1-3, Figure 1-7). These areas, scattered with lawns, parks, and other manicured vegetation, offer suitable breeding habitat for relatively few bird species.

Regularly Occurring Species

Typical breeding species include: Red-tailed Hawk [in more sparsely inhabited areas], American Kestrel [especially farmsteads], Killdeer, Rock Dove, Mourning Dove, Eastern Screech-Owl, Great Horned Owl, Common Nighthawk, Chimney Swift, Ruby-throated Hummingbird, Northern Flicker, Red-bellied Woodpecker ["urban forests"], Eastern Wood-Pewee, Eastern Phoebe, Barn Swallow, Purple Martin, Blue Jay, American Crow, Black-capped Chickadee, Tufted Titmouse, White-breasted Nuthatch, House Wren, Carolina Wren, Northern Mockingbird, Gray Catbird, Brown Thrasher, American Robin, Eastern Bluebird [farmsteads], European Starling, Warbling Vireo, Common Yellowthroat, House Sparrow, Common Grackle, Brown-headed Cowbird, Baltimore Oriole, Northern Cardinal, House Finch, Pine Siskin [sporadic], American Goldfinch, Chipping Sparrow, and Song Sparrow.

Developed lands contain an unusual mix of species that can use ornamental shrubs (e.g., Northern Mockingbird, Northern Cardinal, Song Sparrow), shade trees (e.g., Baltimore Oriole, Warbling Vireo, Black-capped Chickadee, Tufted Titmouse, Eastern Wood-Pewee), short mowed grass (e.g:, American Robin, Common Grackle, Northern Flicker, American Crow, Brown-headed Cowbird, Mourning and Rock Doves, European Starling, and Chipping Sparrow), and can nest safely in human structures (e.g., American Kestrel, Killdeer [roofs, roads], Common Nighthawk [roofs], Chimney Swift, Eastern Phoebe, Barn Swallow, Purple Martin, House and Carolina Wrens, American Robin, Eastern Bluebird, European Starling, House Sparrow and House Finch). This community has no parallel in the natural world.

Now that the Bewick's Wren is absent from the region, there are no threatened or endangered species found in residential or urban areas other than the Loggerhead Shrike, which often forages in mowed grass of rural farmsteads.

Many species in developed areas are introduced. Huge populations of introduced European Starlings, House Sparrows, Rock Doves, and House Finches compete with native species for nest sites and food at bird feeders. House Finches are native to the western U. S. but after a population was released on Long Island in the 1940's, they spread west from New York and are now common in the urban and rural areas of Illinois.

Migrating birds make heavy use of shade trees in developed areas and, when available, also use shrubs. Typical migrants of "urban forests" include: Cooper's and Sharp-shinned Hawks [both forage at bird feeders], Common Nighthawk, Ruby-throated Hummingbird [especially at feeders], Northern Flicker, Yellow-bellied Sapsucker, Red-breasted Nuthatch [conifers], Brown Creeper, Hermit Thrush, Golden-crowned Kinglet, Ruby-crowned Kinglet, Cedar Waxwing, Red-eyed Vireo, Tennessee Warbler, Cape May Warbler [conifers], Black-throated Green Warbler, Blackburnian Warbler, Bay-breasted warbler, Blackpoll Warbler, American Redstart, Rusty Blackbird, Evening Grosbeak [feeders], Purple Finch [feeders], Pine Siskin [feeders, conifers], American Goldfinch [feeders], Eastern Towhee [feeders], Dark-eyed Junco [feeders], American Tree Sparrow, White-crowned Sparrow, and White-throated Sparrow.

Population Dynamics and Management

Developed areas are characterized by abnormally high population densities of species that occasionally or regularly depredate nests (e.g., Blue Jay, American Crow, House Wren, Gray Catbird, Common Grackle, and Brown-headed Cowbird). Bird feeders further augment populations of many species in rural or urban areas, especially the House Finch, by increasing winter survival.

Nesting success of species of developed areas has not been systematically studied. Such studies could lead to recommendations for enhancing populations of the native species that have adapted to human developments. However, high populations of predatory birds domestic cats, and other mammalian predators may make it difficult for many species that build open-cup nests in accessible locations to nest successfully.

Overall Habitat Quality, Management Issues, and Concerns for Partnerships

The MRB currently has few high-quality areas for breeding birds. The Parklands natural area in the middle Mackinaw River sub-basin (Figure 4-2) has the best potential for creating a large, forest-interior tract of 500 acres or greater. This site already has Veeries (ST), Northern Parula, Louisiana Waterthrush, and Ovenbird. Cowbird parasitism is a likely problem at this site, but nest predation rates are unknown. The Parklands site is also large enough to contain significant areas of grassland and shrubland habitat. Most other upland sites in the basin are small and have little potential to be enlarged sufficiently to create interior habitat for forest or grassland birds. Breeding birds may not be the best focus for management of small sites. For these areas, plant community restoration coupled with judicious consideration of the needs of migrant birds (some shrubby areas and oak trees) might be the best management strategy.

Wetland restoration (including forested swamps, backwaters, and riparian corridors) is another viable strategy for this region. Wetlands have many threatened and endangered species that may not be as sensitive to fragmentation as forest and grassland birds. They are also heavily used by migrating birds. Integrating the needs of shrubland songbirds and game animal management may be a good approach to managing Fish and Wildlife Areas.

Grassland restoration also has an excellent potential to bring back populations of many threatened and endangered species. But, it cannot be done piecemeal. Sites must be relatively large (>100 acres) and dedicated to grassland management. Although restoration of native prairie grasses is a valid, long-term goal, introduced, cool-season grasses have the potential to act as good surrogate habitat for many species. Woody vegetation removal (except perhaps in areas that are too wet to burn) may be necessary to attract some birds and to increase their nesting success. Rotational mowing, burning, or grazing may maximize the number of grassland birds that can nest in an area.

Developed areas, especially urban forests and parks, can be managed to improve habitat by encouraging oaks and leaving shrubby areas for migrants. Agricultural areas benefit from increased cover provided by CRP fields, shrub-lined drainage ditches, and unmowed roadsides.

Mammal Communities

Information in this section has been compiled from range maps and known records in Hoffmeister (1989), the Illinois Natural Heritage Database (1982-1995), and personal communications from B. Bluett (Furbearer Biologist, IDNR). Taxonomy follows Wilson and Reeder (1993). There has not been a systematic survey of the mammals of the Mackinaw River Basin (MRB), but surveys of terrestrial mammals have been conducted in the nearby Funks Grove, McLean Co. (Calef 1953; E. J. Heske in litt.).

Mammal species known or likely to occur in the MRB are listed in Table 4-11. The 45 species in this table constitute ca. 73% of the 62 species listed as extant in Illinois by Hoffmeister (1989). Population status of these species in the MRB is unknown; designations in Table 4-11 are only probabilities suggested by their status in other parts of central Illinois. Only one state endangered species (river otter) is included in this table. However, sightings of bobcat (*Lynx rufus*) have occasionally been reported from areas just south or west of the MRB, and bobcats have been trapped in counties south of the MRB (B. Bluett, pers. comm.). Therefore, bobcats could also occasionally occur in the MRB, and conservation efforts could enhance the prospects that some might establish residence there. Systematic surveys of bats have not been conducted in the MRB. It is possible that the Indiana bat (*Myotis sodalis*) could occur in this drainage, but this area either does not contain suitable habitat or is outside the range of the other state or federally endangered species of bats.

Forest

Typical Species

Mammal species known or likely to occur in the MRB that are restricted to forested habitats include the hoary bat, silver-haired bat, eastern chipmunk, gray and fox squirrels, southern flying squirrel, pine vole, and gray fox (the bobcat would also be associated with forest, if it occurs in the MRB). Species that are primarily associated with forested habitats but occasionally occur in other habitats include the red bat, white-footed mouse, and raccoon. All other species of bats use forested habitats extensively, although many may roost in caves, abandoned mines, or buildings. Some species, such as eastern cottontail, woodchuck, and white-tailed deer, require wooded habitat at certain times of the year or specialize in forest edges. Additional habitat generalists typically found in forests in the MRB are listed in Table 4-11.

Most species of mammal associated with forests are not restricted to one type of forest (i.e., upland, floodplain, or flatwoods), and use a variety of forest types seasonally or opportunistically. However, species that hibernate (woodchucks, eastern chipmunks) or are primarily fossorial (pine voles) need well-drained, uninundated soils. Den sites in upland habitats are preferred by bobcat, although choice of den site can be flexible and is probably more sensitive to human disturbance. Gray foxes are more abundant in upland forests than swamps, but also may be abundant in bottomland forests (Hoffmeister 1989). Fox squirrels are more strongly associated with upland forests whereas gray squirrels can be abundant in both upland and floodplain forests, but both gray and fox squirrels overlap extensively in their habitat use and can be found in a variety of forest types. Tree squirrels, flying squirrels, and chipmunks tend to be most abundant in forests with a heavy component of mast-producing trees such as oaks and hickories. Raccoons are most abundant in forest tracts with close proximity to water.

Threatened and Endangered Species

Two of the nine mammal species listed as endangered or threatened in Illinois (IEPB 1994) - the Indiana bat and bobcat - could occur in the forested parts of the MRB, but there are no records of these species to date. Because unofficial sightings of bobcats have been reported in adjacent counties west and south of the MRB, it is likely that bobcats occasionally pass through the area. Conservation efforts could enhance the prospects for bobcat to establish in the MRB. A limited number of surveys have been conducted for Indiana bats in the MRB. Suitable roost sites probably exist for this species in the MRB, and additional surveys to determine if it is present would be valuable.

Habitat Requirements and Distributions of Listed and Rare Forest-Dwelling Species

Indiana bat (*Myotis sodalis*) — Indiana bats congregate in a limited number of caves or mines for hibernation, but are more widely dispersed during the summer. Indiana bat maternity colonies roost primarily beneath slabs of exfoliating bark on dead trees, but have also been found beneath the "shaggy" bark of certain live hickories (*Carya* ssp.) and in tree cavities (Cope et al. 1974; Humphrey et al. 1977; Gardner et al. 1991; Callahan 1993; Kurta et al. 1993a,1993b). Males and non reproductive females may also roost in caves or abandoned mines. Roost trees used by this species have been located in both upland and floodplain forests; most are relatively large (> 30 cm dbh). Tree species that have been used by maternity colonies in Illinois are slippery elm, northern red oak, shagbark hickory, silver maple, cottonwood, post oak, bitternut hickory, white oak, American elm, green ash, sweet pignut hickory, and sycamore (Gardner et al. 1991; Kurta et al. 1993a; INHS unpublished data). Indiana bats forage in and along the canopy of both riparian and upland forests (Humphrey et al. 1977; LaVal et al. 1977; Brack 1983; Clark et al. 1987; Gardner et al. 1991). In recent years the Indiana bat has been recorded in 22 counties in the southern two-thirds of Illinois during the summer (Illinois Natural Heritage Division [INHD]; Gardner et al. 1996).

Table 4-11. Mammal species known or likely to occur in the Mackinaw River Basin[1].

Common name[2]	Order *Scientific name*	Habitat[3]	Population status[4,5]
Marsupials:	Didelphimorphia		
Virginia opossum	*Didelphis virginiana*	W, G, F	C
Insectivores:	Insectivora		
masked shrew	*Sorex cinereus*	W, G, F (mesic)	C
northern short-tailed shrew	*Blarina brevicauda*	W, G, F	C
least shrew	*Cryptotis parva*	G	C
eastern mole	*Scalopus aquaticus*	G, F	C
Bats:	Chiroptera		
little brown bat	*Myotis lucifugus*	F, caves, buildings	C
northern long-eared bat	*Myotis septentrionalis*	F, caves, buildings	C
silver-haired bat	*Lasionycteris noctivagans*	F, caves (hibernation)	U?
eastern pipistrelle	*Pipistrellus subflavus*	F, caves, buildings	C
big brown bat	*Eptesicus fuscus*	F, caves, buildings	C
red bat	*Lasiurus borealis*	F	C
hoary bat	*Lasiurus cinereus*	F	U?
evening bat	*Nycticeius humeralis*	F, buildings	U?
Rabbits:	Lagomorpha		
eastern cottontail	*Sylvilagus floridanus*	G, F	C
Rodents:	Rodentia		
eastern chipmunk	*Tamias striatus*	F	C
woodchuck	*Marmota monax*	G, F (edges)	C
thirteen-lined ground squirrel	*Spermophilus tridecemlineatus*	G	C
Franklin ground squirrel	*Spermophilus franklinii*	G	U?
gray squirrel	*Sciurus carolinensis*	F	C
fox squirrel	*Sciurus niger*	F	C
southern flying squirrel	*Glaucomys volans*	F	C
plains pocket gopher	*Geomys bursarius*	G	C
beaver	*Castor canadensis*	W	C
western harvest mouse	*Reithrodontomys megalotis*	G	C
deer mouse	*Peromyscus maniculatus*	G	C
white-footed mouse	*Peromyscus leucopus*	W, G, F (mostly F)	C
meadow vole	*Microtus pennsylvanicus*	G	C
prairie vole	*Microtus ochrogaster*	G	C
pine vole	*Microtus pinetorum*	F	U?
muskrat	*Ondatra zibethicus*	W	C
southern bog lemming	*Synaptomys cooperi*	W, G	C
Norway rat *	*Rattus norvegicus*	buildings	C
house mouse *	*Mus musculus*	G, buildings	C
meadow jumping mouse	*Zapus hudsonius*	W, G	U?
Carnivores:	Carnivora		
coyote	*Canis latrans*	W, G, F	C
red fox	*Vulpes vulpes*	W, G, F	C
gray fox	*Urocyon cinereoargenteus*	F	U?

Table 4-11. Continued

Common Name	Order *Common Name*	Habitat	Population Status
raccoon	*Procyon lotor*	W, G, F	C
least weasel	*Mustela nivalis*	G	U?
long-tailed weasel	*Mustela frenata*	W, G, F	C
mink	*Mustela vison*	W, G (mostly W)	C
badger	*Taxidea taxus*	G	U
striped skunk	*Mephitis mephitis*	W, G, F	C
river otter (SE)	***Lontra canadensis***	W	U
Even-toed ungulates:	Artiodactyla		
white-tailed deer	*Odocoileus virginianus*	W, G, F	C

[1] Compiled from range maps and known records reported in Hoffmeister (1989), Illinois Natural Heritage Database (1995), and B. Bluett (personal communication).
[2]Bold type indicates a state endangered (SE) species; * = exotic species.
[3]Habitats: W = wetland, G = grassland, F = forest
[4]Population status: C = common, U = uncommon, R = rare, ? = status uncertain
[5]Subjective estimate based on personal experience of E. J. Heske in other areas of central Illinois.

Bobcat (*Lynx rufus*) — Optimal habitat for bobcats in the Midwest would be rough or rolling terrain where large tracts of second-growth forest with dense underbrush were interspersed with open areas (e.g. clearings or successional fields), streams, and rock outcrops (Schwartz and Schwartz 1981; McCord and Cardoza 1982). Bobcats also inhabit floodplain forests along major rivers and swamps (Hoffmeister 1989). Rollings (1945) thought that key factors in bobcat habitat selection were prey abundance, protection from severe weather, the presence of suitable den sites, dense cover, and a lack of human disturbance. Small caves, rock crevices, rock piles, logs, stumps, hollow trees, dense thickets, and brush piles are used as resting sites and natal dens (Jackson 1961; Schwartz and Schwartz 1981; McCord and Cardoza 1982). Bobcats change resting sites frequently, except for females with young who occupy dens in inaccessible areas. Bobcats travel extensively while hunting and require large tracts of suitable habitat (Rollings 1945; McCord and Cardoza 1982). Male bobcats in Missouri have annual home ranges of 46 to 72 km^2 and female ranges cover 13 to 31 km^2 (Schwartz and Schwartz 1981). Rhea (1982) identified areas greater than 259 km^2 with more than 50% forest cover and good interspersion of open areas, streams, and rocky terrain as optimal habitat for viable breeding populations of bobcats. According to these criteria, the best potential breeding habitat in Illinois is located in the Shawnee Hills region, along the lower Illinois River, and in the northwestern corner of the state. However, bobcats have been recorded in 24 Illinois counties since 1982 (INHD). Although there are no records to date for the MRB, it is possible that bobcats could occasionally occur in this area.

Exotic Species

The Norway rat and house mouse are the only known exotic mammals in the area. The Norway rat, in particular, is most strongly associated with human structures. Both species may be found in woodlots in close proximity to human structures, but neither is generally considered a forest species. These species are now so widespread that they are part of the mammalian fauna across the United States. There is not much that can be done to rectify this situation, and therefore it is not of concern when planning management stategies.

Information Gaps

Data on the status of populations of forest dwelling mammal species are not available for the MRB. Additional information on the distribution and population status of the silver-haired bat, hoary bat, evening bat, pine vole, and gray fox would be valuable. Because forest habitat is fragmented and reduced in area in many parts of the MRB, it would be valuable to assess the ability of the remaining forested tracts to support resident bobcats. Surveys to determine if the Indiana bat is present in the MRB should be conducted.

Enhancement and Restoration Potential

Protecting both upland and floodplain forested tracts, and maintaining dispersal corridors such as forested riparian zones, could enhance suitability of the MRB as habitat for bobcats and gray foxes. Managing forests to maintain large trees with exfoliating or shaggy bark could provide roosting habitat for Indiana bats, as well as for many other species of forest-roosting bats.

Wetland

Typical Species

Mammal species occurring in the MRB whose life history requires wetland habitats include beavers, muskrats, minks, and river otters. In addition, all species of bats found in the MRB use wetland areas, primarily as foraging habitat. The southern bog lemming and meadow jumping mouse use wetlands extensively in addition to grasslands. Other habitat generalists that use wetlands are listed in Table 4-11. Because the same subset of mammal species found in the MRB are likely to be associated with lakes, ponds, impoundments, creeks, and rivers as well as marshes, swamps, bogs, fens, etc., this section should serve as a report on mammals in mesic habitats in general. Small mammals such as the southern bog lemming and meadow jumping mouse may be found in mesic areas without open water (still or moving), whereas the larger mammals such as the river otter, beaver, muskrat, and mink require open water habitats.

Threatened and Endangered Species

In April 1996, 28 river otters (13 male, 15 female) were released into the MRB. Individuals were occasionally sighted in the MRB during the summer and fall of 1996 (B. Bluett pers. comm.), but no systematic survey of the area has been conducted to evaluate the success of the release or the current distribution of the otters. The Indiana bat forages above forested wetlands and may also roost in trees in floodplain forests or swamps during the summer; this species has not been observed in the MRB, however.

Habitat Requirements and Distributions of Listed and Rare Wetland Species

River otter (*Lontra canadensis*) — River otters occupy a variety of aquatic habitats, from coastal swamps and marshes to high mountain lakes (Toweill and Tabor 1982). They are abundant in estuaries, the lower reaches of rivers, and the tributaries and lakes of unpolluted river systems, but scarce in densely populated areas, especially if the water is polluted (Toweill and Tabor 1982). In Illinois, river otters have been found in shallow lakes, sloughs, cypress swamps, rivers, streams, drainage ditches, and ponds (Anderson 1982; Anderson and Woolf 1984). Habitat used by river otters in northwestern Illinois has the following characteristics: isolation from the main river channel (providing a relatively stable water level), extensive riparian forest (or emergent herbaceous vegetation), the persistence of open water during winter, good water quality (and healthy fish populations), the presence of suitable den sites (e.g. beaver lodges, log piles, exposed tree roots), and minimal human disturbance (Anderson and Woolf 1984). The shape of river otter home ranges is determined by the type of habitat and their size is influenced by prey abundance, topography, weather conditions, and the individual's reproductive status (Melquist and Hornocker 1983). At the Lamine River Wildlife Area in Missouri, otter home ranges were 11-78 km in length (Erickson et al. 1984). Only a portion of the range is used at any time; activity centers are located in areas with abundant food and suitable shelter and are changed frequently (Melquist and Hornocker 1983). River otters may travel long distances, 160 km or more, in search of suitable habitat (Jackson 1961).

River otters disappeared from most of Illinois in the late 1800's, but persisted in the Cache River area and possibly in northwestern Illinois. Reintroductions have recently been attempted in several watersheds around Illinois, including a release of 28 river otters into the MRB in April 1996.

Exotics

House mice occasionally can be found in wetland habitats. This species is so widespread that it is now part of the mammalian fauna across the United States. There is not much that can be done to rectify this situation.

Information Gaps

Many wetlands, especially emergent wetlands, exist as isolated habitat patches. The ability of wetland-associated mammals to disperse between such wetlands should be examined. Data on the status and distribution of the river otters released in 1996 should be obtained, and the success of this reintroduction attempt should be evaluated by regular monitoring. Beavers have been increasing in abundance throughout the state. The status of beaver populations in the MRB, and their impacts on the physical structure of riparian systems, should be evaluated.

Enhancement and Restoration Potential

Reduction of silt and chemical runoff into wetland habitats will improve their ability to attract and support reintroduced river otters.

Grassland

Typical Species

Mammal species likely to occur in the MRB that are restricted to grassland include the least shrew, thirteen-lined and Franklin's ground squirrels, plains pocket gopher, western harvest mouse, deer mouse, meadow vole, prairie vole, least weasel, and badger. Other species strongly associated with grasslands include the masked shrew, northern short-tailed shrew, eastern cottontail, woodchuck, southern bog lemming, and meadow jumping mouse. Additional species that use grasslands include the habitat generalists listed in Table 4-11.

Most of the grassland species discussed below are not restricted to "native" or undisturbed grassland habitat. Rather, the structure of rights-of-way, small grain fields and agricultural field edges, pastures, old fields, prairie restorations, and similar constructed or disturbed sites may provide suitable habitat for many of these species. Thirteen-lined ground squirrels are most abundant in short grasses, whereas Franklin's ground squirrels are found in grasses of intermediate height. Both species prefer areas that provide an unobstructed view; thus, tall grasses are inhabited rarely. Plains pocket gophers inhabit well-drained soils, as necessitated by their fossorial habits. The southern bog lemming, meadow jumping mouse, and to a lesser extent the meadow vole, generally prefer more mesic grasslands. Eastern cottontails and woodchucks are most abundant where grassland habitat occurs in proximity to other habitat types, and may be considered edge species. Other species use a variety grassland habitats opportunistically.

Threatened and Endangered Species

None of the mammal species primarily associated with grasslands in the MRB is listed as threatened or endangered in Illinois.

Exotics

The Norway rat and house mouse are strongly associated with human structures, but both species may be found in grasslands in proximity to human structures. The house mouse in particular can sometimes reach substantial numbers in grasslands near buildings. These species are now so widespread that they are part of the mammalian fauna across the United States. There is not much that can be done to rectify this situation, therefore it is not one for concern.

Information Gaps

Additional information on the population status and distribution of the Franklin's ground squirrel, meadow jumping mouse, and least weasel would be useful. Franklin's ground squirrel, in particular, appears to have become uncommon throughout much of its former range in Illinois, but has been reported in the Peoria area. Status of the badger in Illinois was recently investigated by Warner and Ver Steeg (1995); population status in the MRB should be determined more precisely. Although the red fox is not strictly a grassland species, it is most often associated with grasslands and other open habitats. There are suggestions that recent increases in the abundance of coyotes could have negatively affected populations of red foxes, and the status of red fox populations in the MRB should be evaluated.

Enhancement and Restoration Potential

Restored grasslands could provide valuable sites for reintroductions of Franklin's ground squirrels in areas where they no longer occur.

Amphibian and Reptile Communities

Information in this section has been compiled from range maps in Smith (1961), the Illinois Natural Heritage Database, the Illinois Amphibian and Reptile Vouchered Database (a computer database that contains information on specimens from museum, university, and private collections), unvouchered records from the literature, and unvouchered records taken from reliable biologists and naturalists. There has not been a systematic survey of the amphibians and reptiles of the Mackinaw River Basin (MRB), but Brown's (1985) amphibian and reptile survey prior to the construction of Interstate 39 included a large segment of the MRB. The MRB contains portions of four of Smith's (1961) 11 Herpetofaunal Divisions for the state; prairie, woodlands of the grand prairie, sand areas, and western division woodlands.

Amphibian and reptile species that are known or likely to occur in the MRB are listed in Table 4-12. The 13 amphibian species and 25 reptile species in Table 4-12 represent 29% of the amphibian species and 45% of the reptile species of the state. One species, the eastern massasauga, *Sistrurus massasauga*, has been extirpated from the MRB, probably as a result of the draining of prairie wetlands. In addition, the state threatened Kirtland's snake, *Clonophis kirtlandii*, was recorded in 1966 from Moraine View State Park, just outside the MRB, and the Smooth Softshell Turtle, *Apalone mutica*, has been recorded from just west of the MRB. It is possible that these species will eventually be found in the MRB. Three state listed species (Illinois chorus frog, [ST]; Illinois mud turtle, [SE]; and western hognose snake, [ST]) are included in Table 4-12. These three species are limited to the sand areas in the extreme southwest corner of the MRB. There are no exotic amphibian or reptile species in the MRB.

Most amphibian and reptile species are not restricted to a single habitat type. For example, all but two of Illinois' amphibians require some type of aquatic habitat (wetland, pond, creek or river) for breeding but the adults can also be found in a variety of terrestrial habitats. Reptiles are usually found in close proximity to aquatic habitats because they can find an abundance of prey items in these productive habitats.

Forest

Typical Species

Amphibian species known or likely to occur in the MRB that are typical of forested habitats include the eastern newt and both species of gray treefrogs. As outlined above, amphibians also require aquatic habitats for breeding. All three of these species breed in wetlands and ponds. Among the reptiles of the MRB, the Racer, Rat Snake, and Eastern Hognose Snake are typical of forested areas.

Threatened and Endangered Species

All three of the listed species in Table 4-12, the Illinois Chorus Frog, the Illinois Mud Turtle, and the Western Hognose Snake could be found in forested areas in the MRB if the underlying soil is predominantly sand. The chorus frog and the mud turtle also require the presence of non flowing bodies of water. Sandy soils are known in the MRB only from the extreme southwest corner, near the junction of Tazewell and Mason counties. All three of these species have been recently documented in this area but are uncommon to rare.

Habitat Requirements

Illinois chorus frog—This small, chubby frog is restricted to sand substrates where it can burrow down into the soil. This frog originally inhabited sand prairie but because this habitat has been almost completely eliminated in Illinois, these frogs have adapted somewhat to agricultural fields and waste areas where sand prairies were once common. It is seldom seen above ground except during the late winter and early spring breeding season when it can be heard chorusing from a variety of aquatic habitats, including sand ponds, flooded fields, roadside ditches, and marshes. This frog spends most of its life underground, coming to the surface only for a few weeks in March to breed. Unlike other fossorial frogs and toads, the Illinois chorus frog digs with its stout front limbs. The breeding call is a quick series of high-pitched whistles. The eggs are laid in small bunches attached to twigs and branches below the water's surface. Hatching occurs in a few days and transformation is complete in about a two months. Their diet consists of small insects which they can capture and eat underground. Threats to this species include cultivation and degradation of sand areas and draining of sand ponds.

Illinois Mud Turtle— Found in temporary to permanent ponds and backwaters associated with sand prairies and other sandy habitats in the Illinois, Mississippi and Green River drainage systems, this turtle spends most of the year in sand burrows, moving into aquatic habitats for a few weeks in spring and early summer. The omnivorous diet includes snails, insects, worms, tadpoles, fish, and aquatic plants. Three to seven, oblong brittle-shelled eggs are laid in burrows from mid-June through July. Predators include hognose snakes, raccoons, foxes and coyotes. Recently populations have been discovered at small temporary ponds in degraded sand prairies and pastures. Current threats include loss of pond habitat due to lowered water tables and farming activities (plowing, draining, irrigation).

Table 4-12. Amphibian and reptile species known or likely to occur in the Mackinaw River Basin, with an indication of habitat preference and relative abundance.

Common Name[1,2]	*Scientific Name*	Habitat[3]	Abundance[4]
Amphibians			
smallmouth salamander	*Ambystoma texanum*	U	C
tiger salamander	*Ambystoma tigrinum*	W,P,L	U
eastern newt	*Notophthalmus viridescens*	F,W	U
American toad	*Bufo americanus*	U	C
Fowler's toad	*Bufo woodhousii*	F,W,P	C
cricket frog	*Acris crepitans*	L,R	C
striped chorus frog	*Pseudacris triseriata*	U	C
Illinois chorus frog - ST	*Pseudacris streckeri*	W,P,C	R
Cope's gray treefrog	*Hyla chrysoscelis*	F,W	C
eastern gray treefrog	*Hyla versicolor*	F,W	C
bullfrog	*Rana catesbeiana*	U	C
northern leopard frog	*Rana pipiens*	F,W,P	U
plains leopard frog	*Rana blairi*	W,P	U
Reptiles			
snapping turtle	*Chelydra serpentina*	W,L,R	C
painted turtle	*Chrysemys picta*	W,L,R	C
Blanding's turtle	*Emydoidea blandingii*	W	R
Illinois mud turtle - SE	*Kinosternon flavescens*	W,L	R
map turtle	*Graptemys geographica*	L,R	U
spiny softshell turtle	*Apalone spinifer*	W,L,R	U
ornate box turtle	*Terrapene ornata*	P	R
slender glass lizard	*Ophisaurus attenuatus*	P	R
six-lined racerunner	*Cnemidophorus sexlineatus*	P	R
eastern hognose snake	*Heterodon platirhinos*	F,W,P,	U
western hognose snake - ST	*Heterodon nasicus*	P	R
racer	*Coluber constrictor*	U	U
smooth green snake	*Opheodrys vernalis*	W,P	U
rat snake	*Elaphe obsoleta*	F,W,P	U
fox snake	*Elaphe vulpina*	W,P,C	C
bullsnake	*Pituophis catenifer*	P	U
milk snake	*Lampropeltis triangulum*	F,W,P	U
prairie kingsnake	*Lampropeltis calligaster*	F,W,P	C
western ribbon snake	*Thamnophis proximus*	F,W,P,L,R	U
plains garter snake	*Thamnophis radix*	U	C
common garter snake	*Thamnophis sirtalis*	U	C
brown snake	*Storeria dekayi*	U	C
red-bellied snake	*Storeria occipitomaculata*	F,W	U
Graham's crayfish snake	*Regina grahamii*	W,L	U
northern water snake	*Nerodia sipedon*	U	C

[1] Nomenclature follows Collins (1990) unless noted.
[2] Bold type indicates a state threatened (ST) or state endangered (SE) species.
[3] F = forest W = wetland P = prairie and savanna L = lakes, ponds, impoundments
R = rivers & creeks C = cultural U = ubiquitous (all habitats)
[4] C = common U = uncommon R = rare ? = status uncertain

Western Hognose Snake—This slow moving snake is restricted to sand areas and adjacent woodlots along the upper Mississippi River, the Green River, and the Illinois River. It spends a large part of its time buried just below the surface in sand prairies but it also forages in sandy woodlots and savannas. Threats include destruction and degradation of sand prairies and woodlots.

Information Gaps

The only distribution information available for forest amphibians and reptiles of the MRB are for the Illinois Mud Turtle and Illinois Chorus Frog (Illinois Natural Heritage Database). Distribution and abundance information for any of the other species would be valuable.

Enhancement and Restoration Potential

Restoration of native forests in the sandy southwest area of the MRB would benefit all three of the listed species currently found in the MRB. On a broader scale, maintaining small, temporary, fishless ponds in forests of the MRB would benefit almost all of the reptiles and amphibians of the MRB as well as other species groups that depend on them for food. Creating or restoring small ponds in upland forests is particularly valuable because these habitats are among the rarest in the MRB and the state.

Wetland

Typical Species

As outlined above, all amphibians of the MRB require some type of aquatic habitat for breeding, but the Bullfrog, Plains Leopard Frog, and Northern Leopard Frog complete their entire life cycle in aquatic habitats, including wetlands. These species may also be found in ponds, lakes, creeks, and rivers. Among the reptiles of the MRB, only the Blanding's Turtle is restricted to wetlands. Other species such as the Western Ribbon Snake, Plains Garter Snake, and Common Garter Snake are typical wetland inhabitants, but are also found in other habitats.

Threatened and Endangered Species

The Illinois Chorus Frog and the Illinois Mud Turtle can be found near wetlands in the MRB if the underlying soil is predominantly sand. Sandy soils are known in the MRB only from the extreme southwest corner, near the junction of Tazewell and Mason counties. Both the Illinois Chorus Frog and the Illinois Mud Turtle have been recently documented in this area but are uncommon to rare.

Information Gaps

The only distribution information available for wetland amphibians and reptiles of the MRB are for Illinois Mud Turtle and Illinois Chorus Frog (Illinois Natural Heritage Database). Distribution and abundance information for any of the other species would be valuable.

Enhancement and Restoration Potential

Restoration of wetlands in the sandy southwest area of the MRB would benefit the Illinois Mud Turtle and Illinois Chorus Frog. On a broader scale, restoring prairie wetlands in the MRB would benefit a variety of amphibians and reptiles and enhance suitability of the MRB as habitat for Kirtland's Snake.

Prairie

Typical Species

Of the amphibian species listed in Table 4-12, the Tiger Salamander and Striped Chorus Frog are typical of prairie habitats in the MRB. The Tiger Salamander requires fishless ponds and wetlands for breeding. Because of the destruction and degradation of these habitats, the tiger salamander has declined drastically in the MRB. The Striped Chorus Frog has a shorter larval period and therefore can breed in more temporary aquatic habitats such as flooded fields and ditches. Reptile species in the MRB that are typical of prairie habitats include the Six-lined Racerunner, Ornate Box Turtle, Slender Glass Lizard, Smooth Green Snake, Bullsnake, and Plains Garter Snake. Of these grassland species, the Smooth Green Snake is most dependent on native grassland and the Six-lined Racerunner, Ornate Box Turtle, and Slender Glass Lizard are restricted to the sand prairies of the southwest corner of the MRB. The other species can tolerate more disturbed habitats such as mowed rights-of-way, pastures, old fields, and agricultural edges.

Other species such as the Smallmouth Salamander, Prairie Kingsnake, Fox Snake, and Brown Snake can be found in grasslands of the MRB. They too can tolerate disturbed grassland habitats.

Threatened and Endangered Species

The Illinois Chorus Frog and the Illinois Mud Turtle can be found in prairie habitats in the MRB if the underlying soil is predominantly sand. Sandy soils are known in the MRB only from the extreme southwest corner, near the junction of Tazewell and Mason counties. Both the Illinois Chorus Frog and the Illinois Mud Turtle have been recently documented in this area but are uncommon to rare.

Information Gaps

The only distribution information available for prairie amphibians and reptiles of the MRB are for Illinois Mud Turtle and Illinois Chorus Frog (Illinois Natural Heritage Database). Distribution and abundance information for any of the other species would be valuable. It would be especially informative to document the distribution and abundance of the Tiger Salamander in the MRB because we have several historical accounts of this species to use as a comparison. It would also be helpful to document whether Kirtland's Snake occurs in the creeks and rivers of the MRB.

Enhancement and Restoration Potential

Restoration of sand prairie in the southwest corner of the MRB would benefit the Illinois Mud Turtle and Illinois Chorus Frog. On a broader scale, restoring native prairie in the MRB would benefit a variety of amphibians and reptiles and enhance suitability of the MRB as habitat for Kirtland's Snake, Smooth Green Snake and Tiger Salamander.

Lakes, Ponds, and Impoundments

Typical Species

Of the amphibian species listed in Table 4-12, the Tiger Salamander, Bullfrog, and Cricket Frog are typical of ponds, lakes, and impoundments in the MRB. The Tiger Salamander requires fishless ponds and wetlands for breeding. Because of the destruction and degradation of these habitats, the tiger salamander has declined drastically in the MRB. The Cricket Frog and Bullfrog have developed strategies for coexisting with fish and are therefore more widely distributed than the Tiger Salamander. Among the reptiles of the MRB the Snapping Turtle, Painted Turtle, Spiny Softshell, Common Garter Snake, Graham's Crayfish Snake, and Northern Water Snake are typical of lakes, ponds, and impoundments. Of these species, Graham's Crayfish Snake is most dependent on lakes, ponds, and impoundments.

Threatened and Endangered Species

The Illinois Chorus Frog and the Illinois Mud Turtle can be found in sand ponds in the extreme southwest corner of the MRB, near the junction of Tazewell and Mason counties. Both the Illinois Chorus Frog and the Illinois Mud Turtle have been recently documented in this area but are uncommon to rare.

Information Gaps

The only data on the distribution of amphibians and reptiles of ponds, lakes and impoundments of the MRB are for Illinois Mud Turtle and Illinois Chorus Frog (Illinois Natural Heritage Database). Distribution and abundance information for any of the other species would be valuable. It would be especially informative to document the distribution and abundance of the Tiger Salamander in the MRB because we have several historical accounts of this species to use as a comparison.

Enhancement and Restoration Potential

Restoration of sand ponds in the southwest corner of the MRB would benefit the Illinois Mud Turtle and Illinois Chorus Frog. On a broader scale, leaving at least part of the shore around ponds, lakes and impoundments unmowed and providing forest or grassland connections among ponds, lakes, and impoundments in the MRB would benefit a variety of amphibians and reptiles and enhance suitability of the MRB as habitat for Kirtland's Snake.

Creeks and Rivers

Typical Species

Of the amphibian species listed in Table 4-12, the Cricket Frog and Bullfrog are typical of creeks and rivers in the MRB. Among the reptiles of the MRB, the Snapping Turtle, Map Turtle, Spiny Softshell, and Northern Water Snake are typical of creeks and rivers. Of these species, the Map Turtle is most dependent on creeks and rivers.

Threatened and Endangered Species

None of the listed species known from the MRB are found in creeks or rivers.

Information Gaps

No distribution or abundance data are available for amphibians and reptiles of the MRB creeks and rivers. Abundance information for any of the species would be valuable. It would be especially informative to document whether the Smooth Softshell Turtle occurs in the creeks and rivers of the MRB. This turtle requires clean sandy-bottomed creeks and rivers and its presence indicates excellent water quality.

Enhancement and Restoration Potential

Restoring the riparian zone along creeks and rivers in the MRB would benefit a variety of amphibians and reptiles and enhance suitability of the MRB as habitat for Smooth Softshell Turtle.

Cultural Habitats

Typical Species

Of the amphibian species listed in Table 4-12, the Smallmouth Salamander, American Toad, Striped Chorus Frog, and Bullfrog are typical of cultural habitats in the MRB. These species can be found in cropland, pasture, successional field, developed land, and tree plantations providing adequate breeding sites (ditches, flooded fields, stock tanks) are present. The Illinois Chorus Frog can be found in these same habitats providing the underlying soil is sandy. Among the reptiles of the MRB, the Racer, Fox Snake, Plains Garter Snake, Common Garter Snake, Brown Snake, and Northern Water Snake are typical of cultural habitats in the MRB.

Threatened and Endangered Species

The Illinois Chorus Frog can be found in most cultural habitats in the MRB if the underlying soil is predominantly sand and breeding ponds are available. Sandy soils are known in the MRB only from the extreme southwest corner, near the junction of Tazewell and Mason counties. The Illinois Chorus Frog has been recently documented in this area but is uncommon to rare.

Information Gaps

The only distribution information for amphibians and reptiles of cultural habitats of the MRB are for Illinois Chorus Frog (Illinois Natural Heritage Database). Distrubution and abundance information for any of the other species would be valuable.

Enhancement and Restoration Potential

Small stock ponds and farm ponds can provide important breeding sites for amphibians of the MRB if the ponds are fish free. Most of these ponds are not capable of supporting sport fisheries so this does not present a conflict between amphibian conservation and recreation opportunities.

Overall Habitat Quality

Overall, opportunities for amphibians and reptiles in the MRB are poor. Compared to pre settlement, the present landscape of the MRB lacks a significant amount of native prairie, especially wet prairie. As noted above, this is probably the reason the eastern massasauga is no longer present in the MRB. This may also explain the absence (or scarcity) of Kirtland's Snake in the MRB. Other habitats whose decline or disappearance in the MRB since European settlement has severely affected amphibians and reptiles include sand prairie, sand ponds, and temporary ponds in upland forests.

Current Management Concerns for Partnership

The most critical management concern for the MRB Partnership is habitat fragmentation. Natural habitats in the MRB are typically found in small patches separated from each other by agricultural or developed land. Habitat connectedness is important for amphibians because they usually travel long distances between their breeding and nonbreeding habitats. For example, the American Toad spends most of its time in upland habitats such as forests or prairies but migrates to lowland areas for breeding. Reptiles require habitat connections because many species move to upland retreats for winter hibernation.

Terrestrial Insect Communities: Butterflies and Skippers

The information presented in this section has been compiled from distributional records in Irwin and Downey (1973) and Sedman and Hess (1985) and from range maps in Opler and Malikul (1992). The insect fauna of the MRB is not well-known, and no specific study of the butterflies and skippers of the area has been undertaken. Adams (1968) published a list of the butterflies of the "Peoria area" (a circle of some 30 miles radius centered at Peoria), but that author gave no particulars regarding localities and dates of collection or observation for any but two species.

The butterflies and skippers known to have been collected in the MRB are listed in Table 4-13 along with species deemed by the writer to be of likely or possible occurrence. No information is available concerning the population status in the MRB of any of the species listed.

Typical Species

The distributions of the butterflies and skippers of a geographic area are tied to the distributions of the host plants and nectar sources of each species. Few species are rigidly habitat-specific as adults. On the contrary, wandering adults are often observed far removed from their larval feeding sites. Thus, for example, forest species can be observed in prairies, savannas, wetlands, and in areas of cultivation and disturbance.

Forest

Typical forest species likely to be observed in MRB include two swallowtails whose caterpillars feed on understory shrubs. These are the Giant Swallowtail on prickly ash and wafer ash and the Spicebush Swallowtail on spicebush. Another shrub feeding species is the Spring Azure on dogwoods. The Northern Pearly Eye, whose larvae feed on bottle brush and broad-leaved uniola, is likely to be present. Among the skippers, Juvenal's Dusky Wing, feeding on oaks, is likely to be encountered.

Prairie

Although few records are available from MRB, a number of prairie species are to be expected. Among the butterflies, the Dione Copper on docks, the Eastern Tailed Blue on legumes, the Gorgone Checkerspot on sunflowers, and the Monarch on milkweeds seem likely to occur.

Savanna

Few, if any MRB species, are likely to be restricted in distribution to savannas. Several species, however, are often encountered in savanna situations. These include three butterflies, namely, Edward's Hairstreak on scrub oak, the Little Copper on sheep sorrel, and the Regal Fritillary on birdsfoot violet. Also to be expected, are the Dusted Skipper on big and little bluestem and the Silver-Spotted Skipper on legumes.

Wetland

Two willow-feeding butterflies probably are to be found in MRB. These are the Acadian Hairstreak and the Viceroy. The Bronze Copper and the Purplish Copper, both feeders on docks, are likely to be present. The Least Skipper, a grass feeder, will occur.

Cultural Habitats

Many butterflies and skippers are commonly found in disturbed areas, cultivated areas, and in urban and suburban developments. Indeed, some such as the Cabbage Butterfly and the Alfalfa Butterfly have pest status. Both certainly occur in MRB. Species of broad host range such as the Painted Lady occur commonly in cities and towns, as does the Tiger Swallowtail, which feeds on a wide variety of commonly cultivated trees and shrubs. The Common Sooty Wing, feeding on Amaranths and Lambs Quarters occurs in yards and gardens.

Information Gaps

MRB needs to be surveyed for all species of butterflies and skippers. The current state of knowledge concerning all of these species in MRB is rudimentary to say the least. In the butterflies only 29 species of the 70 likely to occur have been recorded, and for the 3 counties treated in detail in Table 4-13, only 34 of a possible 210 county records are available. The situation is even worse for the skippers. Six species recorded out of 35 species deemed likely, and 7 county records out of a possible 105.

The species of butterfly that could benefit most from detailed study and management attention is the Regal Fritillary. This handsome butterfly is in decline throughout its range.

Table 4-13. Butterflies and skippers known (+) or likely (-) to occur in the Mackinaw RiverBasin[1].

Species[2,3,4]	Habitat[5]	McLean Co.	Tazewell Co.	Woodford Co.
Pipe Vine Swallowtail				
Battus philenor	F	-	-	-
Black Swallowtail				
Papilio polyxenes	P,C	+	-	+
Giant Swallowtail				
Papilio cresphontes	F	-	-	-
Tiger Swallowtail				
Papilio glaucus	F,C	-	-	+
Spicebush Swallowtail				
Papilio troilus	F	-	-	+
Zebra Swallowtail				
Eurytides marcellus	F	+	-	-
Checkered White				
Pontia protodice	F,C	-	-	+
*Cabbage Butterfly				
Pieris rapae	F,C	+	-	-
*Alfalfa Butterfly				
Colias eurytheme	P,C	-	-	-
Clouded sulphur				
Colias philodice	P,C	+	-	-
Dog Face				
Colias cesonia	W,C	-	-	-
Cloudless Sulphur				
Phoebis sennae	W,C	-	-	+
Little Sulphur				
Eurema lisa	P,C	-	-	+
Sleepy Orange				
Eurema nicippe	W,C	-	-	+
Dainty Sulphur				
Nathalis iole	P,C	-	-	-
Olympia Marble				
Euchloe olympia	S	-	-	-
Coral Hairstreak				
Satyrium titus	P,C	-	-	-
Striped Hairstreak				
Satyrium liparops	F,W	-	-	-
Banded Hairstreak				
Satyrium calanus	F,P,S	-	-	-
Hickory Hairstreak				
Satyrium caryaevorum	F	-	-	-
Edward's Hairstreak				
Satyrium edwardsii	S	-	-	-
Acadian Hairstreak				
Satyrium acadica	W	-	-	-
Red-Banded Hairstreak				
Calycopsis cecrops	P,C	-	-	-

Table 4-13. Continued

Species[2,3,4]	Habitat[5]	McLean Co.	Tazewell Co.	Woodford Co.
Henry's Elfin *Incisalia henrici*	F	-	-	-
Eastern Pine Elfin *Incisalia niphon*	F,C	-	-	-
Olive Hairstreak *Mitoura grynea*	P,C	-	-	-
Southern Hairstreak *Fixenia favonius*	F,W	-	-	-
White-M Hairstreak *Parrhasius m-album*	F	-	-	-
Gray Hairstreak *Strymon melinus*	F,P,C	-	-	-
Bronze Copper *Lycaena hyllus*	W	+	-	-
Dione Copper *Lycaena dione*	P	+	-	-
Purplish Copper *Lycaena helloides*	W	-	-	-
Little Copper *Lycaena phlaeas*	P,S,C	-	+	-
Reakirt's Blue *Hemiargus isola*	P,S,C	-	-	-
Eastern Tailed Blue *Everes comyntas*	P,C	+	-	+
Silvery Blue *Glaucopsyche lygdamus*	F	-	-	-
Spring Azure *Celastrina argiolus*	F,C	+	-	-
Dusky Blue *Celastrina ebenina*	F	-	-	-
Harvester *Feniseca tarquinius*	F,W	+	-	-
American Snout *Libytheana carinenta*	F,W	-	-	-
Goatweed Butterfly *Anaea andria*	F,C	-	-	-
Hackberry Butterfly *Asterocampa celtis*	F,W,C	+	-	-
Tawny Emperor *Asterocampa clyton*	F,W,C	+	-	-
Red-Spotted Purple *Limenitis arthemis*	W	-	-	+
Viceroy *Limenitis archippus*	W	+	-	+
Red Admiral *Vanessa atalanta*	F,C	-	-	-

Table 4-13. Continued

Species[2,3,4]	Habitat[5]	McLean Co.	Tazewell Co.	Woodford Co.
American Painted Lady				
Vanessa virginiensis	F,P,C	-	-	-
Painted Lady				
Vanessa cardui	F,P,S,C	-	-	+
Buckeye				
Junonia coenia	P,W,C	-	-	+
Milbert's Tortoise Shell				
Nymphalis milberti	F,W,C	-	-	-
Mourning Cloak				
Nymphalis antiopa	F,C	-	-	-
Question Mark				
Polygonia interrogationis	F,C	+	-	+
Hop Merchant				
Polygonia comma	F,C	+	-	-
Gray Comma				
Polygonia progne	F,W	-	-	-
Silvery Checkerspot				
Chlosyne nycteis	F,C	+	-	+
Gorgone Checkerspot				
Chlosyne gorgone	P	-	-	-
Pearl Crescent				
Phyciodes tharos	F,P,S,C	+	-	+
Baltimore				
Euphydryas phaeton	W	-	-	-
Silver-Bordered Fritillary				
Boloria selene	P,W	-	-	-
Meadow Fritillary				
Boloria bellona	P,W	-	-	-
Regal Fritillary				
Speyeria idalia	P,S	+	-	-
Great Spangled Fritillary				
Speyeria cybele	W,P,C	+	-	-
Aphrodite				
Speyeria aphrodite	W,P,C	-	-	-
Variegated Fritillary				
Euptoieta claudia	P,C	+	-	-
Monarch				
Danaus plexippus	P,S,W,C	+	-	-
Northern Pearly Eye				
Enodia anthedon	F,W	-	-	-
Eyed Brown				
Lethe eurydice	W	-	-	-
Little Wood Satyr				
Megisto cymela	F,P	-	-	-
Common Wood Nymph				
Cercyonis pegala	P,S,W,C	-	-	-

Table 4-13. Continued

Species[2,3,4]	Habitat[5]	McLean Co.	Tazewell Co.	Wodford Co.
Eufala Skipper				
Lerodea eufala	C	-	-	-
Pepper and Salt Skipper				
Amblyscirtes hegon	F	-	-	-
Roadside Skipper				
Amblyscirtes vialis	F,C	-	-	-
Dusted Skipper				
Atrytonopsis hianna	P,S	-	-	-
Dion Skipper				
Euphyes dion	W	-	-	-
Black Dash				
Euphyes conspicuus	P,W	-	-	-
Two-Spotted Skipper				
Euphyes bimacula	W	-	-	-
Dun Skipper				
Euphyes vestris	PWC	+	-	-
Hobomok Skipper				
Poanes hobomak	F	-	-	-
Zabulon Skipper				
Poanes zabulon	F	-	-	-
Byssus Skipper				
Problema byssus	P	-	-	-
Delaware Skipper				
Atrytone delaware	P,W,C	-	-	-
Sachem				
Atalopedes campestris	C	-	-	-
Little Glassy Wing				
Pompeius verna	C	-	-	-
Northern Broken Dash				
Wallengrenia egeremet	C	-	-	-
Peck's Skipper				
Polites peckius	C	-	-	-
Tawny-Edged Skipper				
Polites themistocles	P,C	-	+	+
Crossline Skipper				
Polites origenes	P,C	-	-	-
Ottoe Skipper (ST)				
Hesperia ottoe	P	-	-	-
Leonard's Skipper				
Hesperia leonardus	P	-	-	-
Fiery Skipper				
Hylephila phyleus	C	-	-	-
European Skipper				
Thymelicus lineola	W,C	-	-	-
Least Skipper				
Ancyloxypha numitor	W	-	-	+

Table 4-13. Continued

Species[2,3,4]	Habitat[5]	McLean Co.	Tazewell Co.	Woodford Co.
Common Sooty Wing *Pholisora catullus*	C	-	-	+
Checkered Skipper *Pyrgus communis*	C	-	-	-
Sleepy Dusky Wing *Erynnis brizo*	F	-	-	-
Wild Indigo Dusky Wing *Erynnis baptisiae*	P,C	-	-	-
Mottled Dusky Wing *Erynnis martialis*	F,P	-	-	-
Horace's Dusky Wing *Erynnis horatius*	F	-	-	-
Juvenal's Dusky Wing *Erynnis juvenalis*	F	-	-	-
Scalloped Sooty Wing *Staphylus hayhurstii*	F,C	-	-	+
Southern Cloudy Wing *Thorybes bathyllus*	F	-	-	-
Northern Cloudy Wing *Thorybes pylades*	F	-	-	-
Hoary Edge *Acholarus lyciades*	F	-	-	-
Silver-Spotted Skipper *Epargyreus clarus*	P,S,C	-	-	+

[1]Sources of data for this table are listed in the reference section of this report.
[2]Scientific and common names of species follow Opler and Malikul (1992).
[3]Order of treatment follows Irwin and Downey (1973), except that skippers follow butterflies.
[4]Bold type indicates an Illinois threatened species (ST); * = Introduced species
[5]Habitats: F = forest, P = prairie, S = Savanna, W = wetland, C = cultural.

Aquatic Biota

The MRB supports a large diversity of aquatic species. Known from the basin are 66 species of fishes, 31 species of unionids (mussels) and nine species of malacostracans (large crustaceans). Although some species have disappeared from the drainage in recent decades, the aquatic biota of the basin are in better condition than in many other regions of Illinois and, with improvements in water quality, those species that are extirpated could return and natural communities could become reestablished in areas where they have been eliminated or altered.

The MRB also supports a large diversity of other aquatic macroinvertebrate species. Unfortunately, existing data on the distribution and natural community associations of these species are inadequate to summarize typical, unique, or rare species, or to identify exotic species. Extensive surveys of aquatic macroinvertebrate populations have been limited to selected sites in the upper MRB. In particular, surveys for aquatic macroinvertebrates were conducted by INHS personnel during October and November of 1984 and again in April and May of 1985 in conjunction with environmental assessments for terrestrial and aquatic resources in the vicinity of the U.S. Route 51 and Interstate 39 highway corridors between Bloomington / Normal in McLean County and LaSalle / Peru in LaSalle County (Wetzel 1986). During that study, aquatic macroinvertebrates, fishes, unionid mollusks, phytoplankton and zooplankton communities, and water quality were surveyed at eight sites, six of which were located in the upper MRB (Panther Creek, East Branch Panther Creek, three sites on the Mackinaw River proper, and Six Mile Creek). During that study, representatives of six phyla, 17 orders, 66 families, 170 genera, and over 222 taxa of macroinvertebrates (exclusive of phyto- and zooplankton) were identified.

Common Species

Sixty-six species of fishes are known from the Mackinaw River drainage (Table 4-14, Table 4-15). The most common species include the red shiner, sand shiner, bigmouth shiner, striped shiner, bluntnose minnow, slenderhead darter, johnny darter, orangethroat darter, green sunfish and smallmouth bass.

The headwaters are dominated by creek chubs and orangethroat darters; the creeks by red shiners, sand shiners, bigmouth shiners, striped shiners, bluntnose minnows, and johnny darters; the small river habitats by red shiners, sand shiners, bigmouth shiners, striped shiners, slenderhead darters, green sunfish, and smallmouth bass; and the lower Mackinaw River, a medium-sized river, by gizzard shad, red shiners, sand shiners, bigmouth shiners, bluegills, and largemouth bass.

Thirty-one species of unionid mussels have been reported from the MRB (Table 4-16, Table 4-17). However, only 24 species of mussels have been found alive in the basin since 1980 (see Table 4-16, 4-17). The most common species include the white heelsplitter, squawfoot, threeridge, Wabash pigtoe, mapleleaf, pimpleback, plain pocketbook, fat mucket, yellow sandshell, and fragile papershell. These species, with the exception of the yellow sandshell, are widespread and common in Illinois.

Nine species of crayfishes, isopods, and amphipods are found in the basin (see Table 4-18, Table 4-19). The most common crayfish is the virile crayfish, which usually is found over rocky substrates or around woody debris or vegetation. The devil crayfish also is common and lives in burrows along the margins of streams. The only isopod known from the basin is *Caecidotea intermedia*, which lives in rocky areas and on woody debris. The most common amphipod is *Hyalella azteca*, which is found on vegetation, usually filamentous algae growing on rocks or logs.

In general, the aquatic macroinvertebrate populations of the MRB appear to be more diverse than those of many other watersheds in Illinois that have been surveyed in a similar manner. Table 4-20 lists additional aquatic macroinvertebrate taxa known to occur in the MRB. Most of these species are considered relatively common in the state of Illinois. Although many of these species are known to occur in both standing and running water, the paucity of accessible historical records and the limited recent information for taxa known to occur within the MRB make it currently impossible to associate them with specific habitat types, such as headwaters, larger streams, small or medium reaches of rivers, or with standing water habitats such as ponds, lakes, and reservoirs.

Threatened and Endangered Fishes

The only state endangered fish recorded for the MRB is the blacknose shiner, *Notropis heterolepis,* a species that was last observed in the basin in 1880 and is almost certainly extirpated. The blacknose shiner is a small slender silvery minnow (maximum length about 3.75 in.) with a dusky black stripe along the side of the body and around the snout, and black crescent-shaped marks on the side of the body. The species once had a large range, extending from Canada south to Ohio, Illinois, Missouri, and Kansas, but is disappearing from much of the southern portion of its range. In Illinois in the late 1800s, the blacknose shiner occurred throughout much of northern and central Illinois and was present but highly localized in southern Illinois. Today, populations remain in Illinois only in the Kankakee, Fox, and Rock River basins in the northern part of the state.

The habitat of the blacknose shiner is clear vegetated lakes and pools of creeks and small rivers and usually is found over sand. Its disappearance from much of Illinois is thought to be a result of the increasing turbidity and sedimentation associated with poor agricultural practices. As the aquatic vascular plants and sandy substrate required by this species are covered with silt and disappear, the blacknose shiner is unable to feed and reproduce.

Table 4-14. Freshwater fishes recorded from the Mackinaw River Basin[1].

FAMILY *Scientific Name*[2,3]	Common Name	Headwaters	Creeks	Small Rivers	Medium Rivers	Standing Water
LEPISOSTEIDAE						
Lepisosteus platostomus	shortnose gar				X	
CLUPEIDAE						
Dorosoma cepedianum	gizzard shad			X	X	X
CYPRINIDAE						
Campostoma anomalum	central stoneroller	X	X	X		
Campostoma oligolepis	largescale stoneroller		X	X		
Cyprinella lutrensis #	red shiner		X	X	X	
Cyprinella spiloptera	spotfin shiner		X	X	X	
Cyprinella whipplei	steelcolor shiner		X	X	X	
Cyprinus carpio *	common carp			X	X	X
Hybognathus nuchalis	Mississippi silvery minnow		X	X	X	
Luxilus chrysocephalus #	striped shiner	X	X	X	X	
Lythrurus umbratilis	redfin shiner		X	X	X	
Macrhybopsis aestivalis	speckled chub			X	X	
Macrhybopsis storeriana	silver chub				X	
Nocomis biguttatus	hornyhead chub		X	X		
Notemigonus crysoleucas	golden shiner			X	X	X
Notropis atherinoides	emerald shiner				X	
Notropis dorsalis #	bigmouth shiner		X	X	X	
***Notropis heterolepis* SE**	**blacknose shiner**		**X**	**X**		
Notropis stramineus #	sand shiner		X	X	X	
Notropis rubellus	rosyface shiner		X	X	X	
Opsopoeodus emiliae	pugnose minnow			X	X	
Phenacobius mirabilis	suckermouth minnow		X	X	X	
Phoxinus erythrogaster	southern redbelly dace	X	X			
Pimephales notatus #	bluntnose minnow	X	X	X	X	
Pimephales promelas	fathead minnow		X	X		
Pimephales vigilax	bullhead minnow			X	X	
Rhinichthys atratulus	blacknose dace	X	X			
Semotilus atromaculatus	creek chub	X	X			
CATOSTOMIDAE						
Carpiodes carpio	river carpsucker			X	X	
Carpiodes cyprinus	quillback		X	X	X	
Carpiodes velifer	highfin carpsucker			X	X	
Catostomus commersoni	white sucker		X	X	X	
Erimyzon oblongus	creek chubsucker	X	X	X		
Hypentelium nigricans	northern hog sucker		X	X	X	
Moxostoma anisurum	silver redhorse			X	X	
Moxostoma duquesnei	black redhorse		X	X	X	
Moxostoma erythrurum	golden redhorse		X	X	X	
Moxostoma macrolepidotum	shorthead redhorse			X	X	

Table 4-14. Continued

FAMILY *Scientific Name*[2,3]	Common Name	Headwaters	Creeks	Small Rivers	Medium Rivers	Standing Water
ESOCIDAE						
Esox lucius	northern pike			X	X	X
ICTALURIDAE						
Ameiurus melas	black bullhead		X	X	X	X
Ameiurus natalis	yellow bullhead		X	X	X	X
Ictalurus punctatus	channel catfish			X	X	X
Noturus exilis	slender madtom		X	X		
Noturus flavus	stonecat		X	X		
Noturus gyrinus	tadpole madtom		X	X		
Noturus nocturnus	freckled madtom		X	X		
Pylodictis olivaris	flathead catfish			X	X	X
CYPRINODONTIDAE						
Fundulus notatus	blackstripe topminnow		X	X	X	
ATHERINIDAE						
Labidesthes sicculus	brook silverside			X	X	X
MORONIDAE						
Morone chrysops	white bass			X	X	X
CENTRARCHIDAE						
Ambloplites rupestris	rock bass		X	X	X	
Lepomis cyanellus #	green sunfish		X	X	X	X
Lepomis humilis	orangespotted sunfish		X	X	X	
Lepomis macrochirus	bluegill		X	X	X	X
Lepomis megalotis	longear sunfish		X	X	X	
Micropterus dolomieu #	smallmouth bass		X	X	X	X
Micropterus punctulatus	spotted bass		X	X	X	
Micropterus salmoides	largemouth bass		X	X	X	X
Pomoxis annularis	white crappie		X	X	X	X
PERCIDAE						
Etheostoma flabellare	fantail darter	X	X	X		
Etheostoma nigrum #	johnny darter	X	X	X	X	
Etheostoma spectabile #	orangethroat darter	X	X	X		
Etheostoma zonale	banded darter		X	X	X	
Percina caprodes	logperch		X	X	X	
Percina maculata	blackside darter	X	X	X	X	
Percina phoxocephala #	slenderhead darter		X	X	X	

[1]Data from the Illinois Natural History Survey fish collection.
[2]Bold type indicates a State Endangered Species (SE); * = non-native Species; # = common species.
[3]Total number of species = 66 (65 native, 1 introduced).

Table 4-15. Freshwater fishes recorded from the Mackinaw River Basin, by habitat[1].

FAMILY Scientific Name[2,3]	Common Name	Streams Riffles	Streams Runs	Streams Pools	Standing Water Littoral	Standing Water Open Water
LEPISOSTEIDAE						
Lepisosteus platostomus	shortnose gar		X		X	X
CLUPEIDAE						
Dorosoma cepedianum	gizzard shad		X			X
CYPRINIDAE						
Campostoma anomalum	central stoneroller	X	X			
Campostoma oligolepis	largescale stoneroller	X	X			
Cyprinella lutrensis #	red shiner		X	X		
Cyprinella spiloptera	spotfin shiner		X	X		
Cyprinella whipplei	steelcolor shiner		X	X		
Cyprinus carpio *	common carp			X	X	
Hybognathus nuchalis	Mississippi silvery minnow		X	X		
Luxilus chrysocephalus #	striped shiner		X	X		
Lythrurus umbratilis	redfin shiner		X	X		
Macrhybopsis aestivalis	speckled chub		X			
Macrhybopsis storeriana	silver chub			X		
Nocomis biguttatus	hornyhead chub		X	X		
Notemigonus crysoleucas	golden shiner			X	X	X
Notropis atherinoides	emerald shiner			X		
Notropis dorsalis #	bigmouth shiner		X	X		
***Notropis heterolepis* SE**	**blacknose shiner**			**X**		
Notropis stramineus #	sand shiner		X	X		
Notropis rubellus	rosyface shiner		X	X		X
Opsopoeodus emiliae	pugnose minnow			X		
Phenacobius mirabilis	suckermouth minnow	X	X			
Phoxinus erythrogaster	southern redbelly dace			X		
Pimephales notatus #	bluntnose minnow		X	X		
Pimephales promelas	fathead minnow			X		
Pimephales vigilax	bullhead minnow		X	X		
Rhinichthys atratulus	blacknose dace	X	X			
Semotilus atromaculatus	creek chub			X		
CATOSTOMIDAE						
Carpiodes carpio	river carpsucker		X	X		
Carpiodes cyprinus	quillback		X	X		
Carpiodes velifer	highfin carpsucker		X	X		
Catostomus commersoni	white sucker		X	X		
Erimyzon oblongus	creek chubsucker		X	X		
Hypentelium nigricans	northern hog sucker	X	X			
Moxostoma anisurum	silver redhorse		X	X		
Moxostoma duquesnei	black redhorse		X	X		
Moxostoma erythrurum	golden redhorse		X	X		
Moxostoma macrolepidotum	shorthead redhorse		X	X		

Table 4-15. Continued

FAMILY Scientific Name	Common Name	Streams Riffles	 Runs	 Pools	Standing Water Littoral	 Open Water
ESOCIDAE						
Esox lucius	northern pike			X	X	
ICTALURIDAE						
Ameiurus melas	black bullhead			X	X	
Ameiurus natalis	yellow bullhead			X	X	
Ictalurus punctatus	channel catfish		X	X	X	
Noturus exilis	slender madtom	X	X			
Noturus flavus	stonecat	X				
Noturus gyrinus	tadpole madtom		X	X		
Noturus nocturnus	freckled madtom		X	X		
Pylodictis olivaris	flathead catfish			X	X	
CYPRINODONTIDAE						
Fundulus notatus	blackstripe topminnow			X		
ATHERINIDAE						
Labidesthes sicculus	brook silverside			X	X	X
MORONIDAE						
Morone chrysops	white bass			X	X	
CENTRARCHIDAE						
Ambloplites rupestris	rock bass			X		
Lepomis cyanellus #	green sunfish			X		X
Lepomis humilis	orangespotted sunfish			X		
Lepomis macrochirus	bluegill			X	X	
Lepomis megalotis	longear sunfish			X		
Micropterus dolomieu #	smallmouth bass			X		X
Micropterus punctulatus	spotted bass		X	X		
Micropterus salmoides	largemouth bass			X	X	
Pomoxis annularis	white crappie			X		X
PERCIDAE						
Etheostoma flabellare	fantail darter	X				
Etheostoma nigrum #	johnny darter		X	X		
Etheostoma spectabile #	orangethroat darter	X		X		
Etheostoma zonale	banded darter	X				
Percina caprodes	logperch		X	X		
Percina maculata	blackside darter			X		
Percina phoxocephala #	slenderhead darter	X	X			

[1]Data from the Illinois Natural History Survey fish collection.
[2]Bold type indicates a State Endangered Species (SE); * = non-native Species; # = common species.
[3]Total number of species = 66 (65 native, 1 introduced).

Table 4-16 Freshwater mussels recorded from the Mackinaw River Drainage[1].

Family Sub-family *Scientific Name*[2,3,4]		Headwaters/ Creeks	Small Rivers	Medium Rivers	Standing Water
Unionidae					
Anodontinae					
Alasmidonta marginata	elktoe		X	X	
Alasmidonta viridis **SE**	**slippershell mussel**	X	X		
Anodontoides ferussacianus	cylindrical papershell	X	X		X
Arcidens confragosus	rock-pocketbook			X	
Lasmigona complanata #	white heelsplitter	X	X	X	X
Lasmigona compressa	creek heelsplitter	X	X		
Lasmigona costata	flutedshell		X	X	
Pyganodon grandis	giant floater		X	X	X
Strophitus undulatus #	squawfoot		X	X	X
Utterbackia imbecillis	paper pondshell		X	X	X
Ambleminae					
Amblema plicata #	threeridge		X	X	
Elliptio dilatata **ST**	**spike**		X	X	
Fusconaia flava #	Wabash pigtoe		X	X	
Pleurobema sintoxia	round pigtoe		X	X	
Quadrula quadrula #	mapleleaf		X	X	
Quadrula pustulosa #	pimpleback		X	X	
Tritogonia verrucosa	pistolgrip		X	X	
Uniomerus tetralasmus	pondhorn	X	X		X
Lampsilinae					
Actinonaias ligamentina	mucket		X	X	
Lampsilis cardium #	plain pocketbook		X	X	
Lampsilis siliquoidea #	fatmucket		X	X	X
Lampsilis teres #	yellow sandshell		X	X	
Leptodea fragilis #	fragile papershell		X	X	
Ligumia recta	black sandshell			X	
Potamilus alatus	pink heelsplitter		X	X	
Potamilus ohiensis	pink papershell		X	X	
Toxolasma parvus	lilliput	X	X	X	X
Truncilla donaciformis	fawnsfoot			X	
Truncilla truncata	deertoe			X	
Venustaconcha ellipsiformis **SC**	**ellipse**		X	X	
Villosa iris SE	rainbow		X	X	
Corbiculidae					
Corbicula fluminea *	Asian clam	X	X	X	X

[1]Data from the Illinois Natural History Survey Mollusk Collection and other museum collections.
[2]Bold type indicates a State Endangered Species (SE); State Threatened (ST); Illinois Special Concern (SC)
[3]* = Non-native Species; # = Common Species
[4]Total number of species = 32 (31 native, 1 introduced).

Table 4-17. Freshwater mussels recorded from the Mackinaw River Drainage, by habitat[1].

Family Sub-family *Scientific Name*[2,3,4]		Streams Riffles	Streams Runs	Streams Pools	Standing Water Littoral Zone
Unionidae					
Anodontinae					
Alasmidonta marginata	elktoe	X	X		
***Alasmidonta viridis* SE**	**slippershell mussel**	X	X		
Anodontoides ferussacianus	cylindrical papershell		X	X	X
Arcidens confragosus	rock-pocketbook		X	X	
Lasmigona complanata #	white heelsplitter		X	X	X
Lasmigona compressa	creek heelsplitter	X	X		
Lasmigona costata	flutedshell	X	X		
Pyganodon grandis	giant floater		X	X	X
Strophitus undulatus #	squawfoot		X	X	X
Utterbackia imbecillis	paper pondshell		X	X	X
Ambleminae					
Amblema plicata #	threeridge	X	X	X	
***Elliptio dilatata* ST**	**spike**	X	X		
Fusconaia flava #	Wabash pigtoe	X	X		
Pleurobema sintoxia	round pigtoe	X	X		
Quadrula quadrula #	mapleleaf	X	X	X	
Quadrula pustulosa #	pimpleback	X	X		
Tritogonia verrucosa	pistolgrip	X	X		
Uniomerus tetralasmus	pondhorn		X	X	X
Lampsilinae					
Actinonaias ligamentina	mucket	X	X		
Lampsilis cardium #	plain pocketbook	X	X	X	
Lampsilis siliquoidea #	fatmucket	X	X	X	X
Lampsilis teres #	yellow sandshell	X	X		
Leptodea fragilis #	fragile papershell	X	X	X	
Ligumia recta	black sandshell	X	X		
Potamilus alatus	pink heelsplitter	X	X	X	
Potamilus ohiensis	pink papershell	X	X	X	
Toxolasma parvus	lilliput	X	X	X	X
Truncilla donaciformis	fawnsfoot	X	X		
Truncilla truncata	deertoe	X	X		
***Venustaconcha ellipsiformis* SC**	**ellipse**	X	X		
***Villosa iris* SE**	**rainbow**	X	X		
Corbiculidae					
Corbicula fluminea *	Asian clam	X	X	X	X

[1]Data from the Illinois Natural History Survey Mollusk Collection and other museum collections.
[2]Bold type indicates a State Endangered Species (SE); State Threatened (ST); Illinois Special Concern (SC)
[3]* = Non-native Species; # = Common Species
[4]Total number of species = 32 (31 native, 1 introduced).

Table 4-18. Freshwater crustaceans recorded from the Mackinaw River System[1].

ORDER Family *Scientific Name*	Common Name	Headwaters	Creeks	Small Rivers	Medium Rivers	Standing Water
ISOPODA (Isopods)						
Asellidae						
Caecidotea intermedia		X	X	X	X	
AMPHIPODA (Amphipods)						
Crangonyctidae						
Crangonyx gracilis						
Hyalellidae						
Hyalella azteca		X	X	X	X	X
DECAPODA (Crayfishes & shrimps)						
Cambaridae						
Procambarus acutus	White River crawfish		X	X	X	X
Procambarus gracilis	prairie crayfish			burrower		
Orconectes immunis	calico crayfish	X	X	X	X	X
Orconectes propinquus	clearwater crayfish		X	X	X	
Orconectes virilis	virile crayfish		X	X	X	X
Cambarus diogenes	devil crawfish			burrower		

[1] Data from the Illinois Natural History Survey Crustacean Collection.

Table 4-19. Freshwater crustaceans recorded from the Mackinaw River System, by habitat[1].

ORDER Family		Streams			Standing Water	
Scientific Name		Riffles	Runs	Pools	Littoral	Open Water
ISOPODA (Isopods)						
Asellidae						
Caecidotea intermedia		X		X		
AMPHIPODA (Amphipods)						
Crangonyctidae						
Crangonyx gracilis				X	X	
Hyalellidae						
Hyalella azteca		X	X	X	X	
DECAPODA (Crayfishes & shrimps)						
Cambaridae						
Procambarus acutus	White River crawfish			X	X	
Procambarus gracilis	prairie crayfish			burrower		
Orconectes immunis	calico crayfish			X	X	
Orconectes propinquus	clearwater crayfish	X				
Orconectes virilis	virile crayfish	X	X		X	
Cambarus diogenes	devil crawfish			burrower		

[1] Data from the Illinois Natural History Survey Crustacean Collection

Table 4-20. Aquatic macroinvertebrates, exclusive of the Crustacea and unionoidean Mollusca, recorded from the Mackinaw River Basin[1].

Phylum NEMATODA - Nematode Worms

Phylum NEMATOMORPHA - Horsehair Worms
Gordiidae
Gordius sp.
Paragordius sp.

Phylum BRYOZOA - Moss Animacules
Phylactolaemata
Plumatellidae
Plumatella repens

Phylum TURBELLARIA - Flatworms
Tricladida
Planariidae
Dugesia tigrina

Phylum ANNELIDA - Segmented Worms
Class APHANONEURA - Suction-Feeding Worms
Aeolosomatida
Aeolosomatidae
Aeolosoma sp.
Class BRANCHIOBDELLAE - Crayfish Worms
Branchiobdellida
Cambarincolidae
Genus *Cambarincola* sp.
Class OLIGOCHAETA - Oligochaete Worms
Lumbriculida
Naididae
Amphichaeta leydigi
Chaetogaster diaphanus
Chaetogaster diastrophus
Chaetogaster limnaei
Dero digitata
Dero nivea
Nais behningi
Nais bretscheri
Nais communis
Nais pardalis
Nais simplex
Nais variabilis
Ophidonais serpentin
Paranais frici
Pristina aequiseta
Pristina leidyi
Pristinella osborni
Slavina appendiculata
Tubificidae
Aulodrilus pigueti
Branchiura sowerbyi
Ilyodrilus templetoni
Limnodrilus cervix
Limnodrilus hoffmeisteri
Tubifex tubifex
Lumbricidae
Eisenia foetida
Eiseniella tetraedra
Class HIRUDINEA - Leeches
Rhynchobdellida
Glossiphoniidae
Placobdella papillifera
Pharyngobdellida
Erpobdellidae
Erpobdella punctata

Phylum ARTHROPODA - Arthropods
Class INSECTA - Insects
Ephemeroptera - Mayflies
Baetiscidae
Baetisca sp.
Baetidae
Baetis sp.
Callibates sp.
Caenidae
Caenis sp.
Ephemeridae
Hexagenia limbata
Heptageniidae
Heptagenia sp.
Stenacron interpunctatum
Stenonema terminatum
Oligoneuriidae
Isonychia sp.
Potamanthidae
Potamanthus sp.

Table 4-20. Continued

Odonata - Damselflies and Dragonflies

Zygoptera - Damselflies

Calopterygidae

Calopteryx maculata

Hetaerina americana

Coenagrionidae

Argia apicalis

Argia fumipennis violacea

Argia moesta

Argia tibialis

Enallagma antennatum

Enallagma basidens

Enallagma civile

Enallagma exsulans

Ischnura verticalis

Lestidae

Lestes unguiculatus

Anisoptera - Dragonflies

Aeshnidae

Aeshna umbrosa

Anax junius

Boyeria vinosa

Gomphidae

Gomphus graslinellus

Corduliidae

Somatochlora sp.

Somatochlora linearis

Somatochlora tenebrosa

Macromiidae

Didymops transversa

Libellulidae

Celithemis eponina

Erythemis simplicicollis

Libellula luctuosa

Libellula lydia

Libellula pulchella

Pachydiplax longipennis

Perithemis tenera

Sympetrum corruptum

Sympetrum vincinum

Plecoptera - Stoneflies

Capniidae

Allocapnia granulata

Allocapnia vivipara

Perlidae

Acroneuria abnormis

Attaneuria ruralis

Neoperla clymene complex

Perlesta decipiens complex

Perlodidae

Isoperla nana

Taeniopterygidae

Strophopteryx fasciata

Taeniopteryx burksi

Pteronarcyidae

Pteronarcys pictetii

Heteroptera - True Bugs

Pleidae

Neoplea striola

Nepidae - Water Scorpions

Ranatra fusca

Corixidae - Water Boatmen

Palmocorixa buenoi

Palmocorixa gillettei

Sigara alternata

Sigara modesta

Trichocorixa calva

Trichocorixa kanza

Notonectidae - Backswimmers

Notonecta undulata

Hebridae - Velvet Water Bugs

Merragata hebroides

Mesoveliidae - Water Treaders

Mesovelia amoena

Mesovelia mulsanti

Gerridae - Pond Skaters

Aquarius remigis

Gerris comatus

Neogerris hesione

Rheumatobates tenuipes

Veliidae - Little Water Striders

Microvelia americana

Rhagovelia oriander

Coleoptera - Beetles

Dryopidae

Helicus lithophilus

Helicus striatus

Dytiscidae

Agabus sp.

Acilius semisculcatus

Copelatus glyphicus

Hydroporus consimilis

Laccophilus maculosus

Laccophilus proximus

Table 4-20. Continued

Uvarus lacustris
Elmidae
Ancyronix variegatus
Dubiraphia minuta
Dubiraphia quadrinotata
Macronychus glabratus
Stenelmis vittipennis
Gyrinidae
Dineutus assimilus
Gyrinus analis
Gyrinus maculiventris
Gyrinus marginellus
Haliplidae
Peltodytes duodecimpunctatus
Peltodytes edentulus
Peltodytes sexmaculatus
Haliplus borealis
Haliplus triopsis
Haliplus ohioensis
Helodidae
Cyphon sp.
Prionocyphon discoideus
Hydrophilidae
Berosus aculeatus
Berosus infuscatus
Berosus peregrinus
Cymbiodyta blanchardi
Enochrus pygmaeus nebulosus
Helophorus sp.
Hydrobius fuscipes
Hydrochus neosquamifer
Hydrochus squamifer
Laccobius agilis
Paracymus communis
Paracymus subcupreus
Tropisternus blatchleyi modestus
Tropisternus collaris striolatus
Tropisternus glaber
Tripisternus lateralis nimbatus
Tropisternus natator
Hydraenidae
Hydraena pennsylvanica
Scirtidae
Cyphon sp.
Scirtes sp.
Trichoptera - Caddisflies
Hydropsychidae
Cheumatopsyche sp.
Cheumatopsyche pettiti
Cheumatopsyche lasia
Hydropsyche bifida
Hydropsyche cuanis
Hydropsyche orris
Potamyia flava
Hydroptilidae
Hydroptila sp.
Leptoceridae
Ceraclea transversus
Oecetis cinerascens
Nectopsyche candida
Diptera - Flies
Tipulidae
Erioptera sp.
Limonia sp.
Tipula sp.
Chaoboridae
Chaoborus punctipennis
Culicidae
Anopheles sp.
Culex sp.
Empididae
Ephydridae
Psychodidae
Stratiomyidae
Ceratopogonidae
Ceratopogon sp.
Culicoides sp.
Simuliidae
Simulium spp.
Chironomidae
Chironominae
Chironomini
Chironomus sp.
Cladopelma sp.
Cryptochironomus sp.
Dicrotendipes sp.
Endochironomus sp.
Endochironomus nigricans
Glyptotendipes sp.
Microtendipes sp.
Parachironomus sp.
Polypedilum sp.
Stenochironomus sp.
Stictochironomus sp.

Table 4-20. Continued

Tribelos sp.
Pseudochironomini
Pseudochironomus sp.
Tanytarsini
Cladotanytarsus sp.
Paratanytarsus sp.
Rheotanytarsus sp.
Tanytarsus sp.
Orthocladiinae
Brillia sp.
Bryophaenocladius sp.
Corynoneura sp.
Cricotopus / Orthocladius complex
Cricotopus anulator
Cricotopus bicinctus
Cricotopus intersectus
Cricotopus ornatus
Cricotopus sylvestris
Cricotopus triannulatus
Eukiefferiella sp.
Hydrobaenus sp.
Nanocladius sp.
Parakiefferiella sp.
Parametriocnemus sp.
Thienemanniella sp.
Tanypodinae
Coelotanypodini
Coelotanypus sp.
Natarsiini
Natarsia sp.
Procladiini
Procladius sp.
Pentaneurini
Ablabesmyia sp.
Labrundinia sp.
Larsia sp.
Thienemannimyia sp.
Tanypodini
Tanypus sp.
Tabanidae
Chrysops sp.

Phylum MOLLUSCA - Mollusks
Gastropoda - Snails
Ancylidae
Ferrissia sp.
Hydrobiidae
Limnaeidae
Fossaria sp.
Stagnicola sp.
Physidae
Physa sp.
Physella sp.
Pelecypoda - Bivalve Mollusks
Sphaeriidae
Pisidium sp.
Sphaerium cf. *fable*

[1]Data are from the Illinois Natural History Survey Insect and Annelida collections, and stonefly database.

Threatened and Endangered Mussels

This region historically has supported four special status species of mussels including one species of special concern (ellipse), one state threatened species (spike), and two state endangered species (slippershell and rainbow).

The spike has never been collected alive in the MRB and is presumed to be extirpated. Old weathered-dead shells were found in 1995 in the Mackinaw River near Hopedale, Green Valley, and Goodfield and in Panther Creek near Panola (Tazewell and Woodford counties).

The slippershell was found alive in the Mackinaw River near Colfax in McLean County (1948) and in Panther Creek in Woodford County (1955). Only weathered, dead shells of this species were found in these localities in 1987 and 1995. Live slippershells were found by staff of The Nature Conservancy in Henline Creek near Colfax in 1995. The Henline creek population is the only known population in the drainage. The slippershell is a headwater species, and further searching in smaller streams in the drainage may yield additional populations.

The rainbow has never been found alive in the MRB. Old weathered-dead shells were found in 1995 in the Mackinaw River near Green Valley and in Prairie Creek near Hopedale (Tazewell County). It is presumed extirpated from the drainage.

Other than the mussels mentioned above, the current literature discussing federal and state listed threatened and endangered species, species under consideration for such listing, or other species considered rare or of special concern (Herkert 1992; Herkert 1994; Illinois Endangered Species Protection Board 1994; U.S. Department of Interior Fish and Wildlife Service 1995, 1996) does not list any aquatic macroinvertebrate species. Wetzel (1985a) addressed the endangered and threatened species of the MRB in conjunction with an environmental assessment conducted for the Illinois Department of Transportation.

Non-Native Species

The common carp has been introduced to the MRB. It can be found in almost any type of habitat but prefers warm sluggish waters of streams and lakes and is very tolerant of high turbidity and low oxygen levels. Native to Eurasia, the common carp has been present in Illinois since the earliest fish surveys, making its effect on native species difficult to determine. The species tends to destroy vegetation and increase water turbidity by dislodging plants and rooting around in the substrate, causing a deterioration of habitat for species requiring vegetation and clear water. The species attains a large size and has become an important commercial food species in Illinois; however, it may have done so at the expense of ecologically similar native species such as carpsuckers and buffalos. It was distributed throughout Illinois by the time of Forbes and Richardson's (1908) survey of Illinois fishes, and was described as abundant in all parts of the state by Smith (1979). It remains common in most areas of Illinois.

The Asian clam is fairly widespread in MRB. Native to Asia, the species was first collected in the Mackinaw River and Panther Creek in 1987. The Mackinaw River populations are on the northwestern periphery of the range of the Asian clam in Illinois. Effects of the Asian clam on native species and communities are difficult to measure, but the species probably competes with native mussels for food.

Two other non-native species that are having major impacts on aquatic communities have not yet been found in the MRB but are present in the Illinois River. The zebra mussel (*Dreissena polymorpha*) and the rusty crayfish (*Orconectes rusticus*) are contributing to declines in native mussels and crayfishes in other parts of the United States and are expected to have the same impact in Illinois.

Of the additional aquatic macroinvertebrate taxa known or thought likely to occur in the MRB (Table 4-20), none is thought to have been introduced.

Information Gaps

The MRB has been fairly well studied with respect to fishes, crayfishes, and mussels. However, additional survey work in the smaller tributaries would better define the limits of some of the species, especially mussels, and possibly uncover additional populations of the state endangered slippershell.

Long-term population monitoring of selected species and communities is needed throughout the state to provide information on trends in biological resources and on the success of various management strategies. Mark-recapture studies also are badly needed to understand normal movements of fishes and other aquatic organisms and, hence, to provide baseline data for interpreting the impacts of environmental alterations and management strategies.

The other major groups of aquatic macroinvertebrates in the MRB (Table 4-20) have not been as well studied as mussels and crustaceans. Wetzel (1986) provided the most recent survey of the upper MRB for aquatic macroinvertebrates conducted by INHS personnel during 1984 and 1985. The aquatic macroinvertebrate fauna of the lower MRB, however, has not been studied recently. Although historical collections of aquatic macroinvertebrates do exist in the INHS Collections, this information is not easily retrievable because either specimens have not yet been identified, or the identified material has not yet been incorporated into a searchable database. Once these specimens have been identified and incorporated into a database, comparisons of historical material with that obtained during more recent collections could be made to determine changes in distribution and abundance. Moreover, long-term monitoring of selected groups of aquatic macroinvertebrates in habitats throughout the state, particularly in headwater streams and, to a lesser extent, in small ponds, lakes and wetland areas, would provide needed information on population trends and habitat associations.

Water Quality

In a Water Quality Report by the Illinois Environmental Protection Agency (1990), the Mackinaw River was rated as "Full Support" for most of its length. The lower Mackinaw River was rated as "Partial Support/Minor Impairment." High turbidity and nutrients were identified as causes of water-quality problems. More about this may be found in Part 3 of this volume.

The Biological Stream Characterization (Hite and Bertrand 1989) rated all segments of Henline, Panther, and Walnut creeks and the Mackinaw River from Denman Creek to Mud Creek and upstream from Money Creek as "A" streams (i.e., Unique Aquatic Resource, the highest ranking possible). Segments of the Mackinaw River from Money Creek to Denman Creek and from Mud Creek to Dillon Creek were rated as "B" streams (Highly Valued Aquatic Resource). The remainder of the Mackinaw River was rated as a "C" stream (Moderate Aquatic Resource). Tributaries to the Mackinaw rated as "B" streams included three unnamed headwater creeks in McLean County, Buck Creek, Turkey Creek, Rock Creek, Mud Creek, Little Panther Creek, West Branch of Panther Creek, Red River, Little Mackinaw River, and Hickory Grove Ditch. As a percentage of total drainage area, the MRB has the highest number of "A" streams in Illinois.

Using fishes as biological indicators, Smith (1971) rated the Mackinaw River as "Good" to "Excellent" with siltation, agricultural pollution, and dredging identified as water-quality problems.

Biologically Significant Streams

Two areas of the Mackinaw River were recognized as Biologically Significant Streams (BSS) (Page et al. 1992) because of their mussel and fish diversity (Figure 4-2). These streams provide the best opportunities in the basin for the protection of large numbers of native species.

1. Mackinaw River, from Alloway Creek to Woodford County Line, Tazewell County. This stretch of the Mackinaw River has not been channelized, and mussel diversity is high. The water is medium- to fast-flowing with moderate turbidity. In periods of normal flow, water depth ranges to over three feet. The substrate consists of gravel, cobble, and sand. The wooded riparian zone varies and is predominantly silver maple, cottonwood, and sycamore. Half of this segment of the Mackinaw River was rated as a BSC "A" Stream.

2. Panther Creek from Illinois Rt. 24 to its confluence with Mackinaw River, Woodford County. Panther Creek is a natural, clear water stream with a gravel and sand substrate. In some reaches a fine layer of silt covers the substrate. Aquatic vegetation consists of clumps of grass in the stream and filamentous algae. Surrounding the wooded riparian zone are row crops and pasture. This segment of Panther Creek supports a high diversity of mussel species and is a BSC "A" stream.

Several sites in the MRB were sampled for aquatic macroinvertebrates by Wetzel (1986). None of these sites, however, occurred in the reach of the Mackinaw River listed as a BSS. All of the study sites in the Mackinaw River were located in reaches of the river that are between 15 and 30 river miles upstream of the site listed by Page et al. (1992). Although none of the sites surveyed by Wetzel (1986) occurred in the BSS reach of the Mackinaw River, two sites surveyed during that study were located nine and eight miles upstream (Panther Creek, at old U.S. Route 51, and East Branch Panther Creek at the U.S. Route 51 bridge), respectively. Each of these two sites was sampled twice; during the autumn of 1984 and again during the spring of 1985. If one were to rely exclusively on the diversity indices calculated for macroinvertebrate collections from these two sites on these two occasions, one could conclude that these sites were relatively unpolluted, with a moderately diverse macroinvertebrate community present at each site. This further supports the results of the fish surveys conducted at these two sites.

Environmental Problems

Stream ecosystems are fragmented by landscape changes that render stream habitats unsuitable for aquatic organisms and by instream modifications that eliminate stream habitats. Smith (1971) ranked the causes of extirpation or declines in fish species in Illinois as follows: siltation (as the primary factor responsible for the loss of 2, and decimation of 14, species), drainage of bottomland lakes, swamps, and prairie marshes (0, 13), desiccation during drought (0, 12), species introductions (2, 7), pollution (2, 5), impoundments (0, 4), and increased water temperatures (0, 1). All of these factors render habitats unsuitable for many aquatic species throughout Illinois and lead to extirpations.

Streams in Illinois naturally have wooded floodplains that are extremely important in maintaining a healthy aquatic environment. The vegetation on a floodplain shades the stream and keeps it from becoming excessively hot during the summer, stabilizes the streambank and reduces erosion, and acts as a filter that removes topsoil and pesticides which would otherwise reach the stream as water drains from croplands. During periods of high water, vegetated floodplains provide feeding and spawning areas for many species of aquatic organisms and nurseries for developing larvae. When floodplains are converted to crop production as they have been throughout much of Illinois, they no longer provide these benefits to aquatic organisms.

Another major landscape change that has negatively impacted streams has been the tiling of land for agriculture. Land that once drained slowly drains quickly once it is tiled. Rapid drainage of land increases the pulse of a flood and increases the intensity and duration of low-flow once the water has moved downstream. These artificially extreme fluctuations in water levels subject stream organisms to environmental conditions to which they are not adapted and can lead to the extirpation of populations.

Siltation, increased water temperatures, and desiccation follow the removal of riparian vegetation and the tiling of fields as land is prepared for agriculture. The excessive siltation associated with the removal of floodplain vegetation is among the most damaging forms of stream pollution. The clean rock and gravel substrates that are normally characteristic of riffles and other stream habitats with fast-flowing water provide living space for many species of aquatic insects and other invertebrates and important spawning habitat for many species of fishes. The deposition of silt covers the rocks, leaving no place for small organisms to hide or for fishes to hide their eggs. Silt can also cover the leaves of aquatic plants and, if sufficient to prevent gas exchange or photosynthesis, will cause the plants to die. The reduction of plant life in a stream has a cascading negative impact on the stream ecosystem. Many animals, in particular insect larvae and fishes, use the plants as places to hide and forage. Some fishes use plants to hide from predators, whereas others use plants as sites from which to ambush prey. As plants are eliminated, populations of insects and fishes are reduced or eliminated because they have fewer places to live.

The impact of increased water temperatures resulting from the loss of riparian vegetation and reduced water flow during warm seasons is difficult to separate from the effects of siltation and other factors that occur concomitantly. However, throughout Illinois, increased water temperatures per se are probably especially harmful to cool-water species such as northern pike and species dependent on springs and spring-fed streams, such as the southern redbelly dace and many species of amphipods, isopods, and crayfishes.

Stream desiccation is thought to be primarily an effect of the artificially extreme fluctuations in water levels that follow tiling of fields for agriculture. The rapid drainage of surrounding land increases the intensity and prolongs the duration of low-flow once the water has moved downstream. A drought that historically would have had the impact of decreasing the flow in a stream can now lead to a dry stream bed.

Floodplains of large rivers normally have low areas that fill with water during floods and survive year-round as shallow lakes. These lakes provide primary habitat for a wide variety of plants and animals, and because they naturally have luxuriant plant growth, they are important feeding areas for waterfowl, and they provide spawning areas, nurseries for larvae, and overwintering refugia for fishes. Unfortunately, most of the bottomland lakes in Illinois have been drained to create cropland, and those that remain have become shallow and barren because of the tremendous silt loads deposited in them each year during periods of high water. The shallow muddy lakes no longer support the plant life that was fundamental to successful completion of the life cycles of many aquatic species.

The impacts of introduced fishes include competition (for food and/or habitat), predation, inhibition of reproduction, environmental modification, transfer of parasites and diseases, and hybridization. Freshwater mussels and crayfishes have been seriously impacted in Illinois in recent decades by non-native invaders, most notably the zebra mussel (*Dreissena polymorpha*) and the rusty crayfish (*Orconectes rusticus*). Nalepa (1994) documented the severe decline in native mussels due to the invasion of zebra mussels in Lake St. Clair over a six-year period. He found that mussel densities declined from 2.4/m^2 1986 to 0/m^2 in 1992 in areas heavily infested with zebra mussels. The rusty crayfish, introduced through its use as fishing bait, is rapidly spreading through Illinois and displacing native crayfishes (Taylor and Redmer 1996).

Point sources of pollution include industrial wastes and domestic sewage. In Illinois, considerable progress has been made in identifying and eliminating point sources of pollution, and water quality has improved as a result. Nonpoint sources are now a larger problem than are point sources and include siltation and agricultural pesticides that reach streams following the removal of floodplain vegetation.

Impounding a stream converts it into a standing body of water that lacks the riffles, runs, pools, and other habitats that stream-inhabiting organisms require. When a stream is dammed, most native species are eliminated from the inundated area, and upstream and downstream populations become isolated from one another. Dams block migrations of fishes that in many species are necessary for reproduction. The loss of migratory fishes from a stream ecosystem can lead to the loss of mussels using the migratory fishes as glochidial hosts.

Channelization is the straightening of a stream to enhance drainage of the surrounding land. The straightening converts the diversity of habitats in a stream to one continuous straight channel that supports few species. Because of their sedentary nature, mussels are particularly susceptible to the effects of channelization.

Potential Management Strategies for Aquatic Species

Management strategies for aquatic ecosystems should consider the entire watershed. Attempting to correct problems locally without consideration of upstream activities and downstream implications will result in partial, and probably temporary, improvement.

Correction of some factors that have led to stream habitat fragmentation in past decades is relatively easy. Important initiatives include building sewage treatment plants and avoiding the construction of mainstream impoundments when possible. Other initiatives, such as stopping the removal of riparian vegetation, cessation of stream channelization, and the drainage of bottomland lakes, require more public education and governmental action including, perhaps providing better incentives to landowners. Assuming that pollution will be held at current levels or reduced, nothing will be more beneficial to the biota of Illinois streams than to have natural riparian vegetation restored. Siltation, desiccation, and higher than normal temperatures would all be reduced to acceptable levels if streams were lined with native plants that shaded the stream, stabilized the banks, and filtered sediment and chemicals from runoff before they reached the stream.

Most introductions of non-native fishes have been done in an effort to improve sport or commercial fishing, and usually governmental agencies have been responsible for the introductions. We now know that non-native species alter ecosystems, and the long-term effect of any introduction is likely to be negative rather than an improvement.

Given the opportunity, streams will restore themselves and, often, the best approach to restoration may be to encourage the reestablishment of the native vegetation of the drainage basin (particularly in the riparian zone), correct any additional existing pollution problems, and let the stream return to natural conditions. In some instances additional measures, such as reintroducing extirpated species, may be advisable.

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Appendix 4-1. List of plant species mentioned in this report, including a list of the characteristic species normally found in each community type mentioned in the text. Many, but not all of these species have been documented to occur in the Mackinaw River Basin (MRB). The 27 community affinity codes for the community types used in the appendix are as follows:

Community Name	Code	Community Name	Code
dry upland forest	1	wet-mesic sand prairie	15
dry mesic upland forest	2	loess hill prairie	16
mesic upland forest	3	glacial drift hill prairie	17
sand forest	4	savanna (general)	18
mesic floodplain forest	5	dry-mesic savanna	18
wet-mesic floodplain forest	6	mesic savanna	19
wet floodplain forest	7	wet-mesic and wet savanna	20
prairie (general)	8	dry-mesic sand savanna	21
dry mesic prairie	9	barrens	22
mesic prairie	10	marsh	23
wet-mesic prairie	11	seeps	24
wet prairie	12	prairie reconstruction	25
dry-mesic sand prairie	13	successional field	26
mesic sand prairie	14	pine plantation	27

Common Name[1,2,3]	*Scientific Name*	Community Affinities[4,5]
alternate-leaved dogwood	*Cornus alternifolia*	3
American elm	*Ulmus americana*	3 5 6
American gromwell	*Lithospermum latifolium*	3
American spikenard	*Aralia racemosa*	3
amur honeysuckle**	*Lonicera maackii*	3
annual bedstraw	*Galium aparine*	5
aromatic aster	*Aster oblongifolius*	9 17
arrowleaf	*Sagittaria latifolia*	**23**
arrowleaf aster	*Aster sagittifolius*	17
asparagus**	*Asparagus officinalis*	9 10
awnless brome grass**	*Bromus inermis*	10 **26**
basswood	*Tilia americana*	**3** 5
bastard toadflax	*Comandra umbellata*	16 17
bellwort	*Uvularia grandiflora*	3 5
Bicknell's sedge	*Carex bicknellii*	9 10
big bluestem	*Andropogon gerardii*	**10** **11** 12 14 15 **16** **17** 19 **25**
bitternut hickory	*Carya cordiformis*	3 **5** 6
bittersweet	*Celastrus scandens*	17
black cherry	*Prunus serotina*	2 3 5
black haw	*Viburnum prunifolium*	2 3 5
black locust*	*Robinia pseudocacia*	4
black oak	*Quercus velutina*	**1** **2** 3 **4** 5 17 18 21 22
black raspberry	*Rubus occidentalis*	1 2 3 4 5

Appendix 4-1. Continued.

Common Name[1,2,3]	*Scientific Name*	Community Affinities[4,5]
black snakeroot	*Sanicula gregaria*	2 3 5 6
black walnut	*Juglans nigra*	3 **5** 6 16 20
black willow	*Salix nigra*	7 11 12
black-eyed Susan	*Rudbeckia hirta*	9 10 16 17
black-jack oak	*Quercus marilandica*	**4** **21**
bladdernut	*Staphylea trifolia*	3 5
bloodroot	*Hepatica nobilis var. acuta*	3 17
blue ash	*Fraxinus quadrangulata*	5 18
blue beech	*Carpinus caroliniana*	2 3 17
blue cohosh	*Caulophyllum thalictroides*	**3** 5
blue flag	*Iris shrevei*	#
blue lobelia	*Lobelia siphilitica*	7 23
blue skullcap	*Scutellaria lateriflora*	23
blue toadflax	*Linaria canadensis*	17
blue vervain	*Verbena hastata*	11 12
blue-eyed grass	*Sisyrinchium albidum*	10 11 16 17
blue-eyed Mary	*Collinsia verna*	6
blue-joint grass	*Calamagrostis canadensis*	11 **12** 15 **23** 25
bluebells	*Mertensia virginica*	3 5 **6**
bottlebrush grass	*Elymus hystrix*	16 17 18 25
box elder	*Acer negundo*	3 5 7 20
bristly buttercup	*Ranunculus hispidus*	5
bristly catbrier	*Smilax hispidus*	5 6 7 17
broad leaved galium	*Galium circaezans*	17
bulrush	*Scirpus atrovirens*	23
bulrush, soft-stemmed	*Scirpus tabernaemontanii*	23
bushy knotweed	*Polygonum ramosissimum*	25
Canada bluegrass**	*Poa compressa*	9 10 16 17
canada thistle**	*Cirsium arvense*	10
Canada wild rye	*Elymus canadensis*	10 11 17 25
candle anemone	*Anemone cylindrica*	10 11 16
chinquipin oak	*Quercus muhlenbengii*	3 5 17 18 20
clearweed	*Pilea pumila*	7 24
climbing false buckwheat	*Polygunum scandens*	6
closed gentian	*Gentiana andrewsii*	11
columbine	*Aquilegia canadensis*	3 17
common blackberry	*Rubus allegheniensis*	2 3 4 5 16
common blackberry	*Rubus pensylvanicus*	2
common blue phlox	*Phlox divaricata*	**3** **5** 6
common bur-reed	*Sparganium eurycarpum*	**23**

Appendix 4-1. Continued.

Common Name[1,2,3]	*Scientific Name*	Community Affinities[4,5]
common burdock**	*Arctium minus*	5 26
common cat-tail	*Typha latifolia*	**23**
common cinquefoil	*Potentilla simplex*	16 17
common ironweed	*Vernonia fasciculata*	25
common milkweed	*Asclepias syriaca*	25
common mountain mint	*Pycnanthemum virginianum*	23 25
common ragweed	*Ambrosia artemisiifolia*	26
common teasel**	*Dipsacus sylvestris*	25
common water horehound	*Lycopus americana*	11 12
common yarrow**	*Achillea millefolium*	25
common yellow violet	*Viola pubescens*	5
compass plant	*Silphium laciniatum*	10
cordgrass	*Spartina pectinata*	**11** **12** 15 20
cottonweed	*Froelichia floridana*	13
cottonwood	*Populus deltoides*	6 **7** 20
cream wild indigo	*Baptisia leucophaea*	10 16
creeping Charlie**	*Glechoma hederacea*	7
culver's root	*Veronicastrum virginicum*	10 16 18
cylindric blazing star	*Liatrus cylindracea*	17
dogbane	*Apocynum cannabinum*	17 25
doll's eyes	*Actaea pachypoda*	**3**
downy gentian	*Gentiana puberulenta*	10 17
dutchman's breeches	*Dicentra cucullaria*	**3**
dwarf bindweed	*Calystegia spithamaea*	17
dwarf larkspur	*Delphinium tricorne*	3
ear-leaved foxglove - ST	*Tomanthera auriculata*	8 18
early buttercup	*Ranunculus fasicularis*	2 18
early goldenrod	*Solidago juncea*	17
elderberry	*Sambucus canadensis*	6
elm-leaved goldenrod	*Solidago ulmifolia*	2
enchanter's nightshade	*Circaea lutetiana*	6
erect dayflower	*Commelina erecta*	13
European high-bush cranberry**	*Viburnum opulus*	3
everlasting	*Antennaria plantaginifolia*	16
fall switch grass	*Panicum virgatum*	10 25
false boneset	*Brickellia eupatorioides*	9 17
false dandelion	*Krigia biflora*	18
false dragonhead	*Physostagia virginiana*	17
false nettle	*Boehmeria cylindrica*	6
false shagbark hickory	*Carya ovalis*	2 3

Appendix 4-1. Continued.

Common Name[1,2,3]	*Scientific Name*	Community Affinities[4,5]
false Solomon's seal	*Smilacina racemosa*	2 3 17
false toadflax	*Comandra richardsiana*	9 10 17
feverfew	*Parthenium integrifolium*	9 **10** **18**
field goldenrod	*Solidago canadensis*	17 **26**
field pepper grass**	*Lepidium campestre*	26
field thistle	*Cirsium discolor*	10 11 25
fleabane daisy	*Erigeron annuus*	17
fleabane daisy	*Erigeron philidelphicus*	3
flowering spurge	*Euphorbia corollata*	9 10 16 17
fog-fruit	*Phyla lanceolata*	6
fowl manna grass	*Glyceria striata*	23 **24**
frostweed	*Helianthemum bicknelii*	17
garlic mustard**	*Alliaria petiolata*	3 4 5 6 7
giant ragweed	*Ambrosia trifida*	6 7 25 26
ginseng	*Panax quinquefolius*	3
goat's rue	*Tephrosia virginiana*	13 14
golden Alexanders	*Zizia aurea*	**10** 17
golden aster	*Heterotheca camporum*	13 14
goldenglow	*Rudbeckia laciniata*	6 **7** 20
goldenseal	*Hydrastis canadensis*	3 5
grapes	*Vitis spp.*	3 5
grass pink orchid - ST	*Calopogon tuberosus*	9
grass-leaved goldenrod	*Euthamia graminifolia*	11
gray dogwood	*Cornus racemosa*	1 **2** 3 18
gray goldenrod	*Solidago nemoralis*	10 17 25
green ash	*Fraxinus pennsylvanica*	3 5 **6** **7**
green dragon	*Arisaema dracontium*	5
green milkweed	*Asclepias viridiflora*	9 10 17
green stemmed Joe-Pye weed	*Eupatorium purpureum*	11 12 25
hackberry	*Celtis occidentalis*	3 **5** **6** 7
hairy aster	*Aster pilosa*	7 25
hairy brome	*Bromus pubescens*	2 18
hairy grama	*Bouteloua hirsuta*	13
hairy hawkweed	*Hieracium scabrum*	17
hairy mountain mint	*Pycnanthemum pilosum*	9 10 12 16 17 18
hairy puccoon	*Lithospermum caroliniana*	**13** **14**
hairy wood violet	*Viola sororia*	5 6
hairy-leaved sedge	*Carex hirsutella*	3
halberd-leaved rose mallow	*Hibiscus laevis*	23
harbinger of spring	*Erigenia bulbosa*	3 5

Appendix 4-1. Continued.

Common Name[1,2,3]	*Scientific Name*	Community Affinities[4,5]
hazelnut	*Corylus americana*	1 10 **18**
heart-leaved plantain - SE	***Plantago cordata***	5
heath aster	*Aster ericoides*	10 25
Hill's oak	*Quercus ellipsoidalis*	3
Hill's thistle - ST	*Cirsium pumilum*	18
hoary puccoon	*Lithspermum canescens*	**9** **10** 16 17
hoary tick trefoil	*Desmodium canescens*	17
honewort	*Cryptotaenia canadensis*	**5** **6** 7
honey locust	*Gleditsia triacanthos*	3 5 6
honeysuckle**	*Lonicera tatarica*	3 5
hop hornbeam	*Ostrya virginiana*	1 2 3 5 16 17
horsetail milkweed	*Asclepias verticillata*	16 25
Indian grass	*Sorghastrum nutans*	**9** **10** 11 12 **14** **16** **17** **19** **25**
Indian plantain	*Cacalia tuberosa*	10
Indian tobacco	*Lobelia inflata*	5
jack pine*	*Pinus banksiana*	27
Jack-in-the pulpit	*Arisaema triphyllum*	3 5
Jacob's ladder	*Polemonium reptans*	3
James' sedge	*Carex jamesii*	3
Jeruselum artichoke	*Helianthus tuberosa*	5 20
June grass	*Koeleria macrantha*	9
Kentucky bluegrass**	*Poa pratensis*	9 10 11 25
kingnut hickory	*Carya laciniosa*	6
late golden rod	*Solidago gigantea*	11 12 25
leadplant	*Amorpha canescens*	**9** **10** **14** **16** **17** 18
lion's paw	*Prenanthes alba*	17
little bluestem	*Schizachyrium scoparium*	**9** **10** **13** **14** **16** **17** 25
long-haired panic grass	*Panicum praecocius*	16
lopseed	*Phryma leptostachya*	3 5 17
Marsh marigold	*Caltha palustris*	**24**
Maryland senna	*Cassia marilandica*	17
mayapple	*Podophyllum peltatum*	3 5
Mead's sedge	*Carex meadii*	**9** **10**
meadow fescue**	*Festuca pratensis*	8 25 26
milk vetch	*Astragulus canadensis*	17
Missouri gooseberry	*Ribes missouriense*	1 2 3 5 6
Missouri ironweed	*Vernonia missurica*	11 12 16 25
mockernut hickory	*Carya tomentosa*	3 4 5
moneywort**	*Lysimachia nummularia*	6 7
multiflora rose**	*Rosa multiflora*	2 3 5 6 10 26

Appendix 4-1. Continued.

Common Name[1,2,3]	*Scientific Name*	Community Affinities[4,5]
musk bristle thistle**	*Carduus nutans*	11 12
New England aster	*Aster novae-angliae*	10 11 12 25
New Jersey tea	*Ceanothus americanus*	**9** **10** 16 17 **18** 21
nodding fescue	*Festuca obtusa*	2 3
northern prairie dropseed	*Sporobulus heterolepis*	**9** **10** 17
Ohio buckeye	*Aesculus glabra*	3 5 6
Ohio spiderwort	*Tradescantia ohiensis*	10 14 16 17
one-flowered broomrape	*Orobanche uniflora*	3
Osage orange**	*Maclura pomifera*	3 5 6
pale Indian plantain	*Cacalia atriplicifolia*	17
pale purple coneflower	*Echinacea pallida*	**9** **10** **17** **18** 25
pale touch-me-not	*Impatiens pallida*	24
panic grass	*Dichanthelium acuminatum*	18
panic grass	*Dichanthelium villosissimum*	18
panic grass	*Dichanthelium oligosanthes*	14 17
partridge pea	*Cassia fasciculata*	16 17
pasture rose	*Rosa carolina*	**9** **10** 16
path rush	*Juncus tenuis*	17
paw paw	*Asimina triloba*	3 6 7
Plains oval sedge	*Carex brevior*	10
poison hemlock	*Cicuta maculata*	5 23
poison ivy	*Toxicodendron radicans*	2 **3** **5** 6 7
poke milkweed	*Asclepias exaltata*	3
poppy mallow	*Callirhoe triangulata*	13 14
porcupine grass	*Stipa spartea*	9 10 17
poverty oat grass	*Danthonia spicata*	17 18 **22**
prairie alum root	*Heuchera richardsonii*	10
prairie blazing star	*Liatris pycnostachya*	**10**
prairie coreopsis	*Coreopsis palmata*	17
prairie dandelion - SE	*Nothocalais cuspidata*	16
prairie dock	*Silphium terebinthinaceum*	**10** **11** 17 25
prairie phlox	*Phlox pilosa*	**10**
prairie rose	*Rosa setigera*	**9** **10** 17
prairie white-fringed orchid - SE	*Platanthera leucophaea*	8
prairie willow	*Salix humilus*	9 10 16 17 25
prickly-pear cactus	*Opuntia humifusa*	13
purple oxalis	*Oxalis violacea*	3
purple prairie clover	*Dalea purpurea*	**9** **10** 14 **17**
purple sandgrass	*Triplasis purpurea*	13
purple spring cress	*Cardamine douglasii*	6

Appendix 4-1. Continued.

Common Name[1,2,3]	*Scientific Name*	Community Affinities[4,5]
pussy willow	*Salix discolor*	11 12
Queen Anne's lace**	*Daucus carota*	10 **25** 26
rattlesnake master	*Eryngium yuccifolium*	**10** 16 25
red haw	*Crataegus mollis*	3 5 6 7
red mulberry	*Morus rubra*	3
red oak	*Quercus rubra*	2 3 5
red pine*	*Pinus resinosa*	27
red trillium	*Trillium recurvatum*	2 3
redbud	*Cercis canadensis*	2 3
reed canary grass	*Phalaris arundinacea*	11 12 23 25
rice cutgrass	*Leersia oryzoides*	23
rigid goldenrod	*Solidago rigida*	11 12 25
rigid sunflower	*Helianthus rigidus*	10
river bulrush	*Scirpus fluviatilis*	23
riverbank grape	*Vitis riparia*	6 7
rosinweed	*Silphium integrifolium*	9 10 16
rough blazing star	*Liatris aspera*	9 10 13 14 16 17
round fruited St. Johnswort	*Hypericum spaerocarpum*	17
round-headed bush clover	*Lespedeza capitata*	10 16 17
Russian olive*	*Eleagnus umbellatus*	25 26
sand bur	*Cenchrus longispinus*	13
sand dropseed	*Sporobolus cryptandrus*	14
sand fragrant sumac	*Rhus aromatica var. arenaria*	13 21
sand love grass	*Eragrostis trichodes*	13 14
sand primrose	*Oenothera rhombipetala*	13
sand reed	*Calamovilfa longifolia*	13 14
sandbar willow	*Salix exigua*	11 12
savanna blazing star - ST	*Liatris niewlandii*	18
savanna sedge	*Carex pensylvanica*	1 2 **18**
saw-toothed sunflower	*Helianthus grosseserratus*	11 12 20 **23** 25
scotch pine**	*Pinus sylvestris*	27
scurf pea	*Psoralea tenuiflora*	18 17
sedge	*Carex amphibola*	20
sedge	*Carex buxbaumii*	11
sedge	*Carex grayi*	5
sedge	*Carex sparganioides*	5
sedge	*Carex stricta*	11 12
sedge	*Carex tetanica*	**9** 10
sedge	*Carex umbellata*	14
sedge	*Cyperus filiculmis*	**13**

Appendix 4-1. Continued.

Common Name[1,2,3]	*Scientific Name*	Community Affinities[4,5]
sedge	*Cyperus schweinitzii*	13
sedge - ST	*Cyperus grayioides*	13
self heal**	*Prunelia vulgaris*	26
sessile-leaved tick trefoil	*Desmondium sessilifolium*	17
shadbush	*Amelanchier arborea*	1
shagbark hickory	*Carya ovata*	1 **2** **3** 5
shingle oak	*Quercus imbricaria*	3
shooting star	*Dodecatheon meadia*	2 10 22
showy goldenrod	*Solidago speciosa*	9 16
showy lady's slipper orchid - SE	*Cypripedium reginae*	8
side-oats grama	*Bouteloua curtipendula*	**9** **17**
silky aster	*Aster sericeus*	**17**
silver maple	*Acer saccharinum*	5 6 7
skunk cabbage	*Symplocarpus foetidus*	24
sky blue aster	*Aster azureus*	9 16 17
slender bush clover	*Lespedeza virginica*	9 16 17
slender wild rye	*Elymus villosus*	2 5 6 18 24 25
slippery elm	*Ulmus rubra*	2 3 6
small fruited agrminony	*Agrimonia parviflora*	17
small-flowered crowfoot	*Ranunculus abortivus*	3 7
smooth blue aster	*Aster laevis*	10
smooth phlox	*Phlox glaberrima*	11 12
smooth ruellia	*Ruellia strepens*	3
smooth sumac	*Rhus glabra*	9
smooth wild indigo	*Baptisia lactea*	10 17
snow trillium	*Trillium nivale*	3
Solomon's seal	*Polygonatum commutatum*	3 5
spike lobelia	*Lobelia spicata*	10
spotted Joe-pye weed	*Eupatorium maculatum*	12
spotted touch-me-not	*Impatiens capensis*	7 **24**
spreading sedge - ST	***Carex laxiculmis***	3
spring beauty	*Claytonia virginica*	3 7
stiff golden rod	*Solidaga rigida*	10 17
stout wood reed	*Cinna arundinacea*	6 7 20
sugar maple	*Acer saccharum*	3 5
Sullivan's milkweed	*Asclepias sullivantii*	10
summer grape	*Vitis aestivalis*	6
swamp buttercup	*Ranunculus septentrionalis*	7
swamp milkweed	*Asclepias incarnata*	**23**
swamp tickseed	*Bidens comosa*	5

Appendix 4-1. Continued.

Common Name[1,2,3]	*Scientific Name*	Community Affinities[4,5]
sweet cicely	*Osmorhiza claytonii*	3 5
sweet-scented bedstraw	*Galium triflorum*	2 7
sycamore	*Platanus occidentalis*	5 6 **7**
tall boneset	*Eupatorium altissimum*	17
tall coreopsis	*Coreopsis tripteris*	16
tall nut rush	*Scleria triglomerata*	14
tall sunflower - SE	***Helianthus giganteus***	5
Tennessee milk vetch - SE	*Astragalus tennesseensis*	8
Texas hickory	*Carya texana*	**4** 21
thimbleweed	*Anemone virginiana*	17
three awned grass	*Aristida tuberculosa*	#
three-awn grass	*Aristida desmantha*	13
tickseed	*Desmodium glutinosum*	17
toothwort	*Dentaria laciniata*	3 6
torrey rush	*Juncus torreyi*	25
Virginia creeper	*Parthenocissus quinquefolius*	2 **3** 5 6 17
Virginia waterleaf	*Hydrophyllum virginianum*	5 6
Virginia wild rye	*Elymus virginicus*	3 5 **6**
wahoo	*Euonymus atropurpurea*	3 5
water parsnip	*Sium suave*	23
western ragweed	*Ambrosia psilostachya*	13
western sunflower	*Helianthus occidentalis*	17
white ash	*Fraxinus americana*	1 2 **3** 5 18
white avens	*Geum canadense*	5 7
white lady's slipper orchid - SE	*Cypripedium candidum*	8
white mulberry**	*Morus alba*	5 6
white oak	*Quercus alba*	1 **2** **3** 5 17 18 19 20 22
white pine*	*Pinus strobus*	27
white snakeroot	*Eupatorium rugosum*	3 6
white sweet clover**	*Melilotus alba*	10
white trout lily	*Erythronium albidum*	2
white willow**	*Salix alba*	11 12 25
whorled milkweed	*Asclepias quadrifolia*	9 17
wild bergamot	*Monarda fistulosa*	**9** **10** 11 12 17 25
wild chervil	*Chaerophyllum procumbens*	5 6 7
wild geranium	*Geranium maculatum*	3 5
wild ginger	*Asarum canadense*	3
wild hycinth	*Camassia scilloides*	18
wild onion	*Allium tricoccum*	3
wild parsnip**	*Pastinaca sativa*	25

Appendix 4-1. Continued.

Common Name[1,2,3]	*Scientific Name*	Community Affinities[4,5]
wild petunia	*Ruellia humilis*	9 17
wild sarsaparilla	*Aralia nudicaulis*	3
wild strawberry	*Fragaria virginiana*	3 17
wingstem	*Verbesina alternifolia*	5
witch hazel	*Hamamelis virginiana*	3
wood betony	*Pedicularis canadensis*	**10** 17
wood nettle	*Laportea canadensis*	**6** **7**
woodland blue grass	*Poa sylvestris*	5
woodland sunflower	*Helianthus divaricatus*	16 17
woolly mullein**	*Verbascum thapsus*	10 11 12
yellow chestnut oak	*Quercus prinoides var. acuminata*	1 2 5
yellow cone flower	*Ratibida pinnata*	10 16 17 25
yellow false foxglove	*Aureolaria grandiflora*	17
yellow honeysuckle	*Lonicera prolifera*	2
yellow lady's slipper orchid	*Cypripedium pubescens*	3
yellow pimpernel	*Taenidia integerrima*	9 16 17 18 22
yellow star grass	*Hypoxis hirsuta*	3 18
yellow sweet clover**	*Melilotus officinale*	9 11 12

[1]Species names in bold highlight threatened or endangered species that have been documented from the MRB.
[2]ST = state threatened, SE = state endangered.
[3]A single asterisk (*) indicates that the species is not native to the MRB; A double asterisk (**) indicates that the species is not native to Illinois.
[4]Bold community affinity codes indicate species that are characteristic of that community type.
[5]Underlined community affinity codes indicate species not yet verified to occur in that community type in the MRB.

Appendix 4-2 . Bird species that regularly occur in the Mackinaw River Basin. These are species that are likely to be present every year. This list excludes the many wandering or "vagrant" species that have been recorded in the area. The purpose is to list only species that have or could have significant populations in the area. The table also lists the habitats that are most likely to be occupied during each season.

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
Common Loon *Gavia immer*			Aq
Pied-billed Grebe - ST ***Podilymbus podiceps***	W[r]		Aq W
Horned Grebe *Podiceps auritus*			Aq
Double-crested Cormorant - ST ***Phalarocorax auritus***			Aq
American Bittern - SE ***Botaurus lentiginosus***	W[r]		W
Least Bittern - SE ***Ixobrychus exilis***	W[r]		W
Great Blue Heron *Ardea herodias*	Aq W Fs F	Aq	Aq W
Great Egret - ST ***Casmerodius albus***	W[r]		Aq W
Snowy Egret - SE ***Egretta thula***			W
Cattle Egret *Bubulcus ibis*			Ag G W
Green Heron *Butorides striatus*	A W Fs		Aq W Fs
Black-crowned Night-Heron - SE ***Nycticorax nycticorax***			Fs W
Yellow-crowned Night-Heron - ST ***Nycticorax violaceus***			Fs
Tundra Swan *Cygnus columbianus*			Aq
Mute Swan *Cygnus olor*			Aq
Greater White-fronted Goose *Anser albifrons*			W Ag
Snow Goose *Chen caerulescens*			W Ag Aq
Canada Goose *Branta canadensis*	W Ag Aq R	W Ag Aq R	W Ag Aq R
Wood Duck *Aix sponsa*	Fs W		Fs W
Green-winged Teal *Anas crecca*			W

Appendix 4-2. Continued

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
American Black Duck *Anas rubripes*			W Aq
Mallard *Anas platyrhynchos*	W Aq	W Aq	W Aq
Northern Pintail *Anas acuta*			W
Blue-winged Teal *Anas discors*	W[r]		W
Northern Shoveler *Anas clypeata*			W
Gadwall *Anas strepera*			W
American Wigeon *Anas americana*			W
Canvasback *Aythya valisineria*			Aq
Redhead *Aythya americana*			Aq
Ring-necked Duck *Aythya collaris*			Aq
Greater Scaup *Aythya marila*			Aq
Lesser Scaup *Aythya affinis*			Aq
Oldsquaw *Clangula hyemalis*			Aq
Surf Scotor *Melanitta perspicillata*			Aq
White-winged Scoter *Malanitta fusca*			Aq
Common Goldeneye *Bucephala clangula*		Aq	Aq
Bufflehead *Bucephala albeola*			Aq
Hooded Merganser *Lophodytes cucullatus*	F[r] S[r]		Aq
Common Merganser *Mergus merganser*			Aq
Red-breasted Merganser *Mergus serrator*			Aq
Ruddy Duck *Oxyura jamaicensis*			Aq
Turkey Vulture *Cathartes aura*	F G Ag	F G Ag	F G Ag S
Osprey - SE ***Pandion haliaetus***			Aq

Appendix 4-2. Continued

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
Bald Eagle - SE FE *Haliaeetus leucocephalus*	Aq		Aq
Northern Harrier - SE *Circus cyaneus*	G[r] W[r]	G Ag W	G Ag W
Sharp-shinned Hawk - SE *Accipiter striatus*		F S R	F S R
Coopers Hawk *Accipiter cooperii*	F S	F S R	F S R
Northern Goshawk *Accipiter gentilis*		F S	F S
Red-shouldered Hawk - SE *Buteo lineatus*	F[r] S[r]	F S	Fs
Broad-winged Hawk *Buteo platypterus*	F[r]		F
Red-tailed Hawk *Buteo jamaicensis*	Ag G R S	Ag G R S	Ag G R S
Rough-legged Hawk *Buteo lagopus*		Ag G	Ag G
Golden Eagle *Aquila chrysaetos*			F S G
American Kestrel *Falco sparverius*	R Ag G S	R Ag G S	R Ag G S
Merlin *Falco columbarius*			All
Peregrine Falcon - SE, FE *Falco peregrinus*			All
Ring-necked Pheasant *Phasianus colchicus*	Ag G	Ag G	Ag G
Wild Turkey *Meleagris gallopavo*	F S Fs	F S Fs	F S Fs
Northern Bobwhite *Colinus virginianus*	S G Ag	S G Ag	S G Ag
Yellow Rail - SE *Coturnicops noveboracensis*			G W
King Rail - ST *Rallus elegans*	W[r]		G W
Virginia Rail *Rallus limicola*	W[r]		W
Sora *Porzana carolina*			W
Common Moorhen - ST *Gallinula chloropus*	W[r]		W Aq
American Coot *Fulica americana*	W[r]		W Aq
Sandhill Crane - SE *Grus canadensis*			W G Ag

Appendix 4-2. Continued

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
Black-bellied Plover *Pluvialis. squatarola*			Ag W
American Golden-Plover *Pluvialis dominicus*			Ag W
Semipalmated Plover *Charadrius semipalmatus*			W
Piping Plover - SE, FE ***Charadrius melodus***			W
Killdeer *Charadrius vociferans*	Ag W R G		Ag W R G
American Avocet *Recurvirostra americana*			W
Greater Yellowlegs *Tringa melanoleuca*			W
Lesser Yellowlegs *Tringa flavipes*			W
Solitary Sandpiper *Tringa solitaria*			W Aq
Willet *Catoptrophorus semipalmatus*			W
Spotted Sandpiper *Actitis macularia*	Aq[r]		W Aq
Upland Sandpiper - SE ***Bartramia longicauda***	G[r]		G
Hudsonian Godwit *Limosa laemastica*			W
Ruddy Turnstone *Arenaria interpres*			W
Sanderling *Calidris alba*			W
Semipalmated Sandpiper *Calidris pusilla*			W
Western Sandpiper *Calidris mouri*			W
Least Sandpiper *Calidris minutilla*			W
White-rumped Sandpiper *Calidris fuscicollis*			W
Baird's Sandpiper *Calidris bairdii*			W
Pectoral Sandpiper *Calidris melanotos*			Ag W G
Dunlin *Calidris alpina*			W Aq
Stilt Sandpiper *Micropalamus himantopus*			W

Appendix 4-2. Continued

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
Buff-breasted Sandpiper *Tryngites subruficollis*			G W
Short-billed Dowitcher *Limnodromus griseius*			W
Long-billed Dowitcher *Limnodromus scolopaceus*			W
Common Snipe *Gallinago gallinago*			W G
American Woodcock *Scolopax minor*	Fs S		Fs S
Wilson's Phalarope - SE ***Phalaropus tricolor***			W
Franklin's Gull *Larus pipixon*			W Aq Ag
Bonaparte's Gull *Larus philadelphia*			Aq
Ring-billed Gull *Larus Delawarensis*		W Aq Ag	W Aq Ag
Herring Gull *Larus argentatus*		Aq	W Aq Ag
Caspian Tern *Sterna caspia*			Aq
Common Tern - SE ***Sterna hirundo***			Aq
Forster's Tern - SE ***Sterna forsteri***			W Aq
Black Tern *Chlidonias niger*			W Aq
Rock Dove *Columba livia*	R Ag	R Ag	R Ag
Mourning Dove *Zenaida macroura*	R Ag S	R Ag S	R Ag S
Black-billed Cuckoo *Coccyzus erythropthalmus*	S[r]		F S
Yellow-billed Cuckoo *Coccyzus americanus*	F S		F S
Barn Owl - SE ***Tyto alba***	Ag[r] G[r]	Aq G	Ag G
Eastern Screech-owl *Otus asio*	R S F	R S F	R S F
Great Horned Owl *Bubo virginianus*	F Ag R	F Ag R	F Ag R
Snowy Owl *Nyctea scandiaca*		Ag	
Barred Owl *Strix varia*	F Fs	F Fs	F Fs

Appendix 4-2. Continued

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
Long-eared Owl - SE *Asio otus*	F[r]	F S	F S
Short-eared Owl - SE *Asio flammeus*	G[r]	G	G
Northern Saw-whet Owl *Aegolius acadicus*		F S	F S
Common Nighthawk *Chordeiles minor*	R		R G Ag
Whip-poor-will *Caprimulgus vociferus*	F		F
Chimney Swift *Chaetura pelagica*	R F S		R F S Ag
Ruby-throated Hummingbird *Archilochus colubris*	F S R Fs		F S R Fs
Belted Kingfisher *Ceryle alcyon*	Aq	Aq	Aq
Red-headed Woodpecker *Melanerpes erythrocephalus*	F Fs R Ag	F Fs	F Fs Ag R
Red-bellied Woodpecker *Melanerpes carolinus*	F Fs S R	F Fs S R	F Fs S R
Yellow-bellied Sapsucker *Sphyrapicus varius*		F Fs R	F Fs R
Downy Woodpecker *Picoides pubescens*	F Fs R S	F Fs R S	F Fs R S
Hairy Woodpecker *Picoides villosus*	F Fs	F Fs R S	F Fs R S
Northern Flicker *Colaptes auratus*	S F R Fs	S F R Fs	S F R Fs
Pileated Woodpecker *Dryocopus pileatus*	F Fs	F Fs	F Fs
Olive-sided Flycatcher *Contopus borealis*			F Fs R S
Eastern Wood-Pewee *Contopus virens*	F Fs R		F Fs R
Yellow-bellied Flycatcher *Empidonax flaviventris*			F S
Acadian Flycatcher *Empidonax virescens*	F Fs		F Fs
Alder Flycatcher *Empidonax alnorum*			W S
Willow Flycatcher *Empidonax traillii*	W S		W S
Least Flycatcher *Empidonax minimus*	F[r]		F S R
Eastern Phoebe *Sayornis phoebe*	R Fs		R Fs

Appendix 4-2. Continued

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
Great Crested Flycatcher *Myiarchus crinitus*	F Fs		F Fs S R
Eastern Kingbird *Tyrannus tyrannus*	S G Ag		S G Ag. F
Horned Lark *Eremophila alpestris*	Ag	Ag	Ag
Purple Martin *Progne subis*	Aq R W G		Aq W G
Tree Swallow *Tachycineta bicolor*	Aq W Fs G		Aq W Fs G
Northern Rough-winged Swallow *Stelgidopteryx serripennis*	A W Fs G		Aq W G
Bank Swallow *Riparia riparia*	Aq W G		Aq W G
Cliff Swallow *Hirundo pyrrhonota*	Aq[r] W[r] G[r]		Aq W G
Barn Swallow *Hirundo rustica*	Ag R W Aq G		Ag R W Aq G
Blue Jay *Cyanocitta cristata*	R F Fs S Ag	R F Fs S Ag	R F Fs S Ag
American Crow *Corvus brachythynchos*	All	All	All
Black-capped Chickadee *Parus atricapillus*	F S R Fs	F S R Fs	F S R Fs
Tufted Titmouse *Parus bicolor*	F R Fs S	F R Fs S	F R Fs S
Red-breasted Nuthatch *Sitta canadensis*		R	F R
White-breasted Nuthatch *Sitta carolinensis*	F R Fs	F R Fs	F R Fs
Brown Creeper - ST ***Certhia americana***	F[r] Fs[r] S[r]	F Fs R	F Fs R
Carolina Wren *Thryothorus ludovicianus*	R F Fs S	R F Fs S	R F Fs S
House Wren *Troglodytes aedon*	R F S		R F S
Winter Wren *Troglodytes troglodytes*		F Fs W	F Fs W
Sedge Wren *Cistothorus platensis*	W[r] G[r]		W G
Marsh Wren *Cistothorus palustris*	W[r]		W
Golden-crowned Kinglet *Regulus satrapa*		F Fs	F Fs
Ruby-crowned Kinglet *Regulus calendula*			F Fs S

Appendix 4-2. Continued

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
Blue-gray Gnatcatcher *Polioptila caerulea*	F Fs S		F Fs S
Eastern Bluebird *Sialia sialis*	Ag G S R	S F R	S F Ag G R
Veery - ST ***Catharus fuscescens***	F Fs[r]		F Fs R Fs
Gray-cheeked Thrush *Catharus minimus*			F Fs R
Swainsons Thrush *Catharus ustulatus*			F S R Fs
Hermit Thrush *Catharus guttatus*		S F Fs R	S F Fs R
Wood Thrush *Hylocichla mustelina*	F Fs		F Fs R
American Robin *Turdus migratorius*	R S F Fs	R S F Fs	R S F Fs
Gray Catbird *Dumetella carolinensis*	S Fs R		S Fs R
Northern Mockingbird *Mimus polyglottos*	R S	R S	R S
Brown Thrasher *Toxostoma rufum*	S R Ag G		S R Ag
American Pipit *Anthus spinoletta*			Ag W
Cedar Waxwing *Bombycilla cedrorum*	R S Fs F	R S Fs F	R S Fs F
Northern Shrike *Lanius excubitor*		G Ag S	
Loggerhead Shrike - ST ***Lanius ludovicianus***	G[r] S[r] Ag[r]	G S Ag	G S Ag
European Starling *Sturnus vulgaris*	R Ag Fs G	R Ag Fs G	R Ag Fs G
White-eyed Vireo *Vireo griseus*	S Fs		S Fs
Bell's Vireo *Vireo bellii*	S[r] G[r]		S G R
Solitary Vireo *Vireo solitarius*			F Fs S
Yellow-throated Vireo *Vireo flavifrons*	F Fs		F Fs R
Warbling Vireo *Vireo gilvus*	S R Fs		S R F Fs
Philadelphia Vireo *Vireo phiadelphicus*			S F R
Red-eyed Vireo *Vireo olivaceus*	F Fs		F Fs S R

Appendix 4-2. Continued

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
Blue-winged Warbler *Vermivora pinus*			S F R
Golden-winged Warbler *Vermivora chrysoptera*			F S Fs R
Tennessee Warbler *Vermivora peregrina*			F R S Fs
Orange-crowned Warbler *Vermivora celata*			S F R
Nashville Warbler *Vermivora ruficapilla*			S F R
Northern Parula *Parula americana*	Fs[r]		F Fs R
Yellow Warbler *Dendroica petechia*	S W		S W R
Chestnut-sided Warbler *Dendroica pensylvanica*			S F Fs R
Magnolia Warbler *Dendroica magnolia*			F S R
Cape May Warbler *Dendroica tigrina*			R F S
Black-throated Blue Warbler *Dendroica caerulescens*			F R Fs
Yellow-rumped Warbler *Dendroica coronata*			F S R Fs
Black-throated Green Warbler *Dendroica virens*			F R
Blackburnian Warbler *Dendroica fusca*			F Fs R
Yellow-throated Warbler *Dendroica dominica*	Fs[r]		F Fs
Pine Warbler *Dendroica pinus*			F Fs
Prairie Warbler *Dendroica discolor*			S
Palm Warbler *Dendroica palmarum*			Fs S F R W G
Bay-breasted Warbler *Dendroica castanea*			F R Fs S
Blackpoll Warbler *Dendroica striata*			F Fs R S
Cerulean Warbler *Dendroica cerulea*	F[r] Fs[r]		F Fs R
Black-and-white Warbler *Mniotilta varia*			F R Fs S
American Redstart *Setophaga ruticilla*	Fs		F Fs S R

Appendix 4-2. Continued

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
Prothonotary Warbler *Protonotaria citrea*	Fs[r]		Fs
Worm-eating Warbler *Helmitheros vermivorus*	F[r]		F
Ovenbird *Seiurus aurocapillus*	F		F R S
Northern Waterthrush *Seiurus noveboracensis*			Fs W
Louisiana Waterthrush *Seiurus motacilla*	F		F Fs
Kentucky Warbler *Oporornis formosus*	F		F
Connecticut Warbler *Oporornis agilis*			S F Fs
Mourning Warbler *Oporornis philadelphia*			S F Fs
Common Yellowthroat *Geothlypis tricolor*	G Ag W S		G Ag W S
Hooded Warbler *Wilsonia citrina*	F[r]		F R Fs
Wilson's Warbler *Wilsonia pusilla*			S F Fs R
Canada Warbler *Wilsonia canadensis*			F Fs S R
Yellow-breasted Chat *Icteria virens*	S		S
Summer Tanager *Piranga rubra*	F		F
Scarlet Tanager *Piranga olivacea*	F Fs		F R Fs
Northern Cardinal *Cardinalis cardinalis*	R F Fs S Ag	R F Fs S Ag	R F Fs S Ag
Rose-breasted Grosbeak *Pheucticus ludovicianus*	F Fs		F Fs R S
Blue Grosbeak *Guiraca caerulea*	S		S
Indigo Bunting *Passerina cyanea*	F Fs S		F Fs S Ag R
Dickcissel *Spiza americana*	G Ag		G Ag
Eastern Towhee *Pipilo erythrophthalmus*	S F	S	S F Fs R
American Tree Sparrow *Spizella arborea*		S G Ag R W	S G Ag R W
Chipping Sparrow *Spizella passerina*	R		R Ag F

Appendix 4-2. Continued

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
Clay-colored Sparrow *Spizella pallida*			S
Field Sparrow *Spizella pusilla*	S G Ag	S G W	S G Ag W
Vesper Sparrow *Pooecetes gramineus*	Ag G		Ag G
Lark Sparrow *Chondestes grammacus*	S[r] Ag[r]		S Ag G
Savannah Sparrow *Passerculus sandwichensis*	G		G
Grasshopper Sparrow *Ammodramus savannarum*	G		G
Henslows Sparrow - SE ***Ammodramus henslowii***	G		G
LeConte's Sparrow *Ammodramus leconteii*			G W
Nelson's Sharp-tailed Sparrow *Ammodramus caudacutus*			W
Fox Sparrow *Passerella iliaca*		S Fs	S Fs F R
Song Sparrow *Melospiza melodia*	R S W Ag	R S W Ag	R S W Ag
Lincoln's Sparrow *Melospiza lincolnii*			S W Fs R
Swamp Sparrow *Melospiza georgiana*	W[r]	W S Fs	S W Fs
White-throated Sparrow *Zonotrichia albicollis*		R S F Fs	R S F Fs
White-crowned Sparrow *Zonotrichia leucophrys*		S Ag R	S Ag R
Dark-eyed Junco *Junco hyematis*		R S F Fs G Ag	R S F Fs G Ag
Lapland Longspur *Calcarius lapponicus*		Ag G	Ag G
Smith's Longspur *Calcarius pictus*			G Ag
Snow Bunting *Plectrophenax nivalis*		Ag G	
Bobolink *Dolichonyx oryzivorus*	G[r]		G
Red-winged Blackbird *Agelaius phoeniceus*	W Ag R G S	Ag G	W Ag R G S
Eastern Meadowlark *Sturnella neglecta*	G Ag	G Ag	G Ag
Western Meadowlark *Sturnella magna*	G Ag		G Ag

Appendix 4-2. Continued

Species[1]	Breeding[2,5,6]	Winter[3,5]	Migrant[4,5]
Yellow-headed Blackbird - SE *Xanthocephalus xanthocephalus*	W[r]		W
Rusty Blackbird *Euphagus carolinus*			R Ag Fs
Common Grackle *Quiscalus quiscula*	R Ag W Fs F	Ag R	R Ag Fs
Brown-headed Cowbird *Molothrus ater*	All	Ag R	All
Orchard Oriole *Icterus spurius*	S R W		S R W
Baltimore Oriole *Icterus galbula*	R F Fs S		F Fs R S
Purple Finch *Carpodacus purpureus*		F R	F Fs R S
House Finch *Carpodacus mexicanus*	R S	R S	R S
Red Crossbill *Loxia curvirostra*		F R	F R
Common Redpoll *Carduelis flammea*		G S R	
Pine Siskin *Carduelis pinus*	R S F	R S F	R S F
American Goldfinch *Carduelis tristis*	S R G	S R G F Fs Ag	S R G F Fs Ag
Evening Grosbeak *Coccothraustes vespertinus*		R F	R F
House Sparrow *Passer domesticus*	R Ag	R Ag	R Ag

[1] Species in bold are: State Threatened - ST, State Endangered - SE, Federally Endangered -FE
[2] Breeding = species that currently or historically have bred in the area.
[3] Winter = species present from December through February.
[4] Migrant = species present during the March - May and late August - November periods.
[5] The following habitat codes are used:

- Aq = Aquatic (Open water of lakes, ponds, impoundments, and larger rivers)
- W = Wetland (seasonally flooded, open habitats such as marshes and sedge meadows)
- Fs = Forested Swamp (Forested wetland, including wet floodplain forest)
- F = Upland and mesic forest
- S = Shrublands (open habitats dominated by shrubs, including old fields)
- G = Grassland (inlcuding pasture and hayfield)
- Ag = Agricultural (row crops only)
- R = Residential areas (including urban centers and the "urban forest")

[6] r = species that is currently a rare and local breeder or may be locally extirpated (such species are good candidates for reestablishment in restored habitats)