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Patterns of erosion and sedimentation in the Illinois River basin

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Abstract The Illinois River, one of the major tributaries to the Mississippi River in the central United States, has a drainage area of 75 156 km^2 that covers portions of three states: Illinois, Indiana, and Wisconsin. Land used for agriculture in Illinois has been increasing steadily over the years. At present, more than 80% of the Illinois River basin is used for agricultural purposes resulting in higher soil erosion. The most significant impact of soil erosion in the Illinois River basin is the high rate of sedimentation in the bottomland lakes of the Illinois River valley. Bottomland lakes have lost on the average more than 72% of their capacities, and some lakes are completely filled with sediment. Sedimentation patterns along the river also change the geomorphology of the Illinois River.

INTRODUCTION

The Illinois River, one of the major tributaries to the Mississippi River in the central United States, has a drainage area of 75 156 km^2 that covers portions of Illinois, Indiana, and Wisconsin (Fig. 1). As a result of repeated glaciation, most of the Illinois River drainage basin is flat and covered with fine loess soil, making it one of the best agricultural regions in North America. More than 80% of the Illinois River basin is presently used for agricultural purposes. Illinois agriculture started to expand very rapidly in the nineteenth century, growing from 8.2 million acres in 1866 to about 20 million acres in 1918. Even though the rate of increase in agricultural acreage since 1918 has been gradual, several changes in agricultural practices during the same period have significantly affected erosion processes in the Illinois River basin. One of the major changes is the increase in land area used for soybeans accompanied by a proportional decline in land used for the production of grassy crops, such as wheat, oats, and hay. Other factors that may have contributed to increased erosion are improved tractors and ploughing techniques that pulverize the soil more efficiently and the increased use of inorganic fertilizers for continuous farming of marginal areas without crop rotation.

The most significant impact of soil erosion in the Illinois River basin is the high rate of sedimentation in the bottomland lakes of the Illinois River valley. These lakes are remnants of a much larger glacial river system that once occupied the Illinois River valley, and they provide important ecological and recreational functions. The bottomland lakes have lost on the average more than 72% of their capacities, with some of them now completely filled with sediment. Although there is a great interest in restoring or saving some of the lakes along the river, this has been a very difficult task, because of the high rates of sediment delivery into the Illinois River valley.

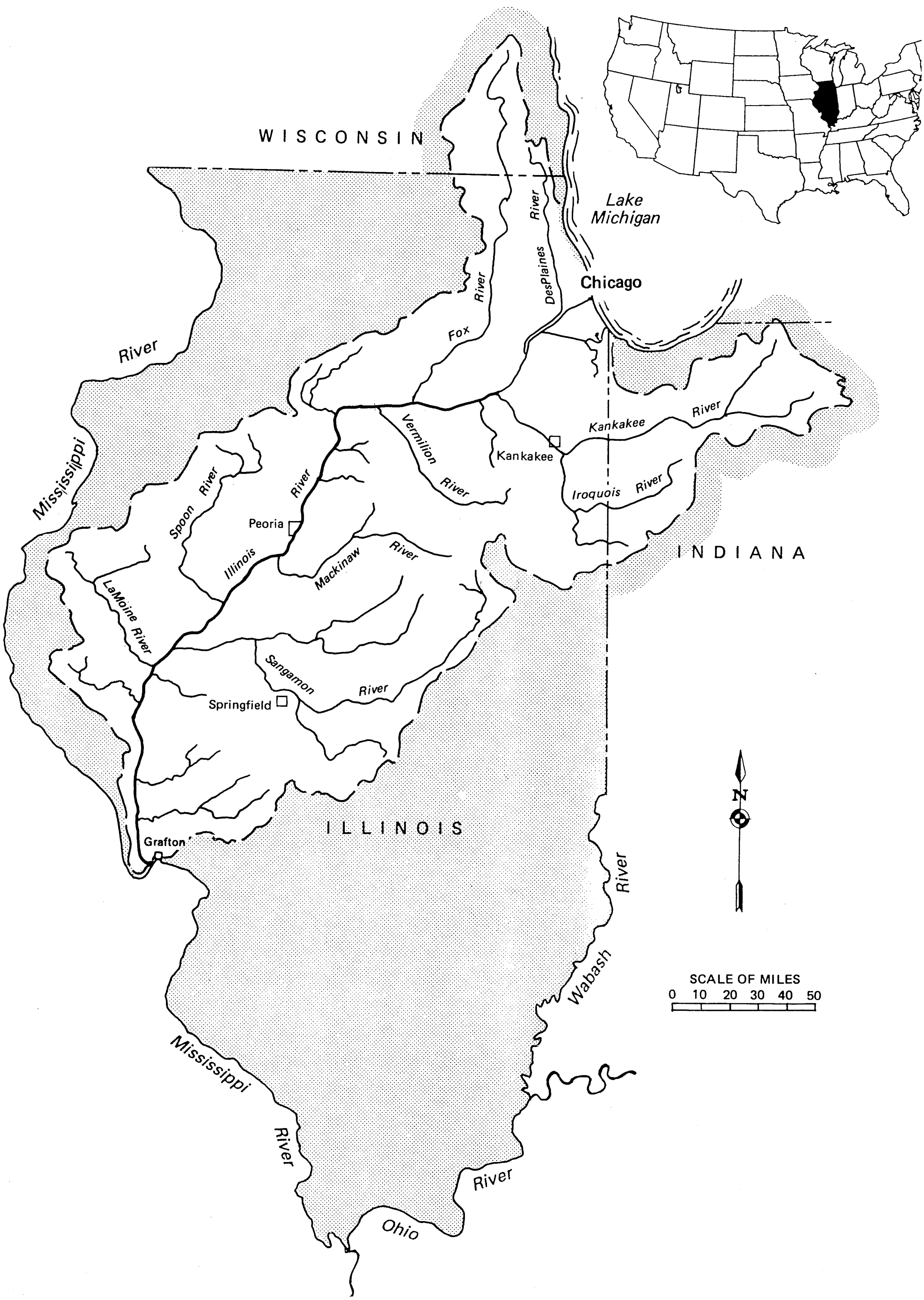

Fig. 1 Location of the Illinois River basin.

Sedimentation patterns along the river are also changing the geomorphology of the Illinois River. Because of navigation requirements, a minimum water depth of 2.7 m is maintained along a narrow navigation channel 90 m wide by a system of locks and dams along the river and by dredging when necessary. Outside the navigation channel, the water depth rapidly decreases due to continued sediment accumulation. The Illinois River is therefore gradually transforming itself into a narrow river channel in the middle of a wide flood plain without the diversity of small side channels and bottomland lakes.

Land use changes and soil erosion

More than 80% of the Illinois River basin is used for agricultural purposes. The change in areas used for different crops in Illinois over time is shown in Fig. 2. Agriculture in Illinois started to expand very rapidly in the nineteenth century, from 8.2 million acres in 1866 to about 15 million acres in 1881. There were increases in all major crop types. After 1881, the total crop acreage increased at a reduced rate until 1918 when a period of decline commenced. Total crop acreage started to increase gradually in 1940 until it peaked in 1980. In addition to an increase in total agricultural area, several changes in agricultural practices during the same period have significantly affected erosion processes in the Illinois River basin. An increase in land area used for soybeans has been accompanied by a proportional decline in land area used for the production of grassy crops, such as wheat, oats, and hay. Soybean acreage increased from zero to 8.5 million acres from 1919 to 1987, while the acreage for grassy crops decreased from 20 million to 2 million acres during the same period. Assuming that soil erosion rates from soybeans are greater than for grassy crops, it can be concluded that this change in land

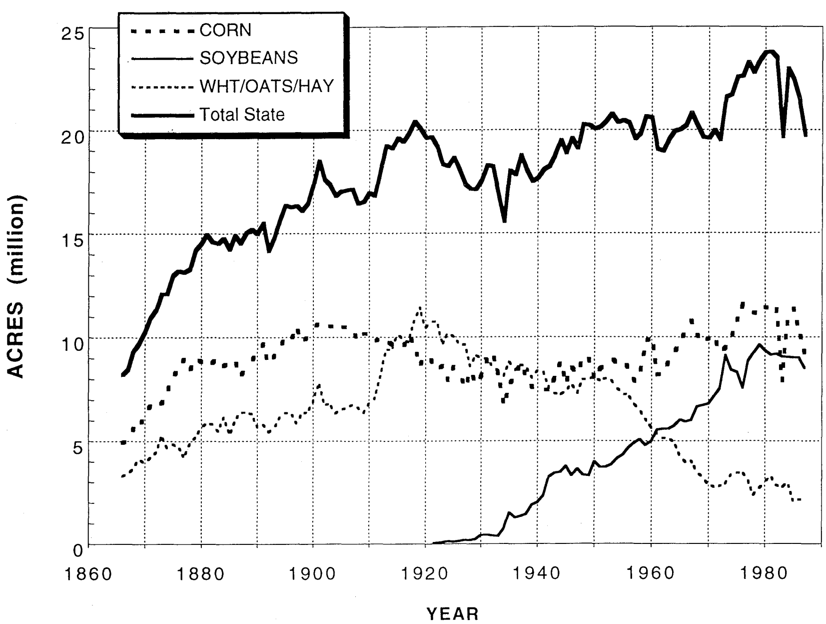

Fig. 2 Changes in agricultural crop acreages for the state of Illinois from 1866 to 1988.

use has resulted in increased soil erosion from agricultural lands in the Illinois River basin, even though the total agricultural acreage has not increased drastically since the introduction of the soybean. Other factors that have contributed to increased erosion are improvements in tractors and ploughing techniques that pulverize the soil more efficiently and the increased use of inorganic fertilizers to farm marginal areas continuously without crop rotation (Walker, 1984).

Sediment budget calculations based on suspended sediment data in recent years show that tributary streams on the average deliver 13.8 million tonnes of sediment into the Illinois River valley, of which 5.6 million tonnes are discharged to the Mississippi River and 8.2 million tonnes are trapped in the Illinois River valley (Demissie *et al.*, 1992). This conservative estimate does not take account of contributions from bank and bluff erosion along the Illinois River that were not included as part of the tributary stream input. This recent rate of sediment delivery is estimated to be greater than the rate in the late nineteenth and early twentieth centuries. Because of the absence of long-term sediment load data, the only way to estimate the long-term trend of erosion and sediment delivery is based on sedimentation rates in the bottomland lakes in the valley. For example, the long-term sediment accumulation in Peoria Lake, the longest bottomland lake in the Illinois River valley, from 1903 to 1985 is shown in Fig. 3, which indicates that the rate of sedimentation in more recent years is greater than during the early 1900s. However, it is still difficult to determine when the rate of sedimentation started to increase because of the lack of lake sedimentation data between 1903 and 1985.

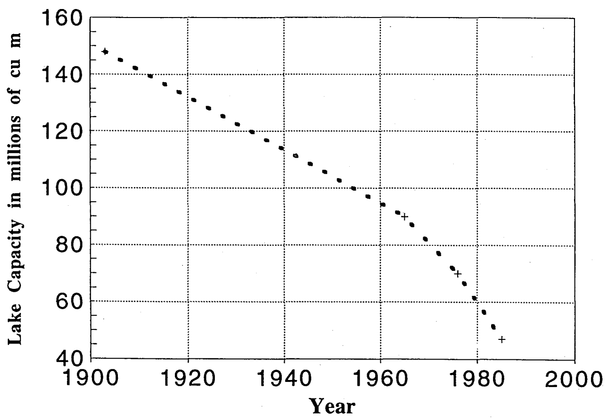

Fig. 3 Rates of sedimentation in Peoria Lake.

Sedimentation in bottomland lakes along the Illinois River

Bottomland lakes along the Illinois River are important ecological, recreational, and economical resources of the state of Illinois. Because of a combination of natural geologic conditions and manmade hydraulic controls, there are numerous bottomland lakes along the Illinois River valley. The present-day Illinois River occupies only a small part of an ancient river valley formed by glacial action when the Illinois River valley was the drainage outlet for much of the Upper Mississippi River basin. The ancient river that occupied the valley carried a much greater flow than the present Illinois River. During the last stages of the glacial period, drainage into the Illinois River valley was significantly reduced when drainage from the Upper Mississippi and Rock Rivers was diverted into the present-day Mississippi River valley. This left the Illinois River valley with a much reduced flow and a smaller channel that occupied only a small portion of the valley and could not transport the sediment delivered by tributary streams, resulting in the formation of alluvial fans and deltas near the mouths of the tributary streams. These fans and deltas created narrow constrictions that held back water in the deeper channels and depressions in the flood plain forming some of the bigger bottomland lakes in the valley. Natural levees were also created along the riverbanks by deposition of sediment from overbank flows during floods, isolating old channels, sloughs, depressions, and lakes from the main river. Over time these natural processes have created a number of bottomland lakes along the Illinois River valley. Under normal flow conditions, most of the lakes are connected to the main river by narrow outlet channels (Demissie & Bhowmik, 1986; Division of Waterways, 1969).

The conditions of bottomland lakes along the Illinois River valley were significantly altered when the state of Illinois increased the diversion of water from Lake Michigan

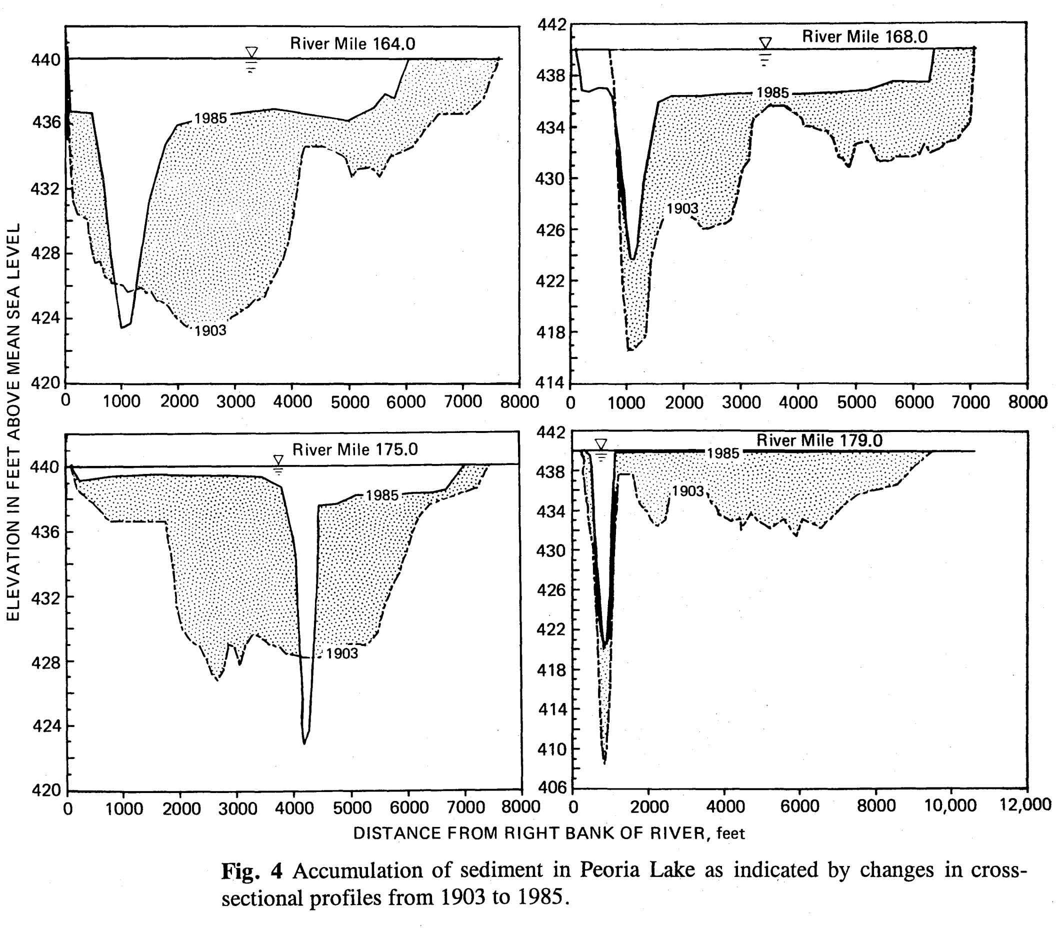

Fig. 4 Accumulation of sediment in Peoria Lake as indicated by changes in cross-sectional profiles from 1903 to 1985.

to the Illinois River through the Sanitary and Ship Canal starting in 1900. The increased diversion raised the low water level in the Lower Illinois River valley resulting in an increase in size of the bottomland lakes. Sloughs, marshes, ponds, wetlands, and small lakes were inundated by the higher low water to create bigger lakes. The completion of the 9-foot navigation waterway with a system of locks and dams along the Illinois River in the 1930s further increased the low water level, resulting in increased bottomland lake surface areas in the valley. At the same time, however, large areas formerly occupied by bottomland lakes, sloughs, ponds, and wetlands were protected by levees and drained

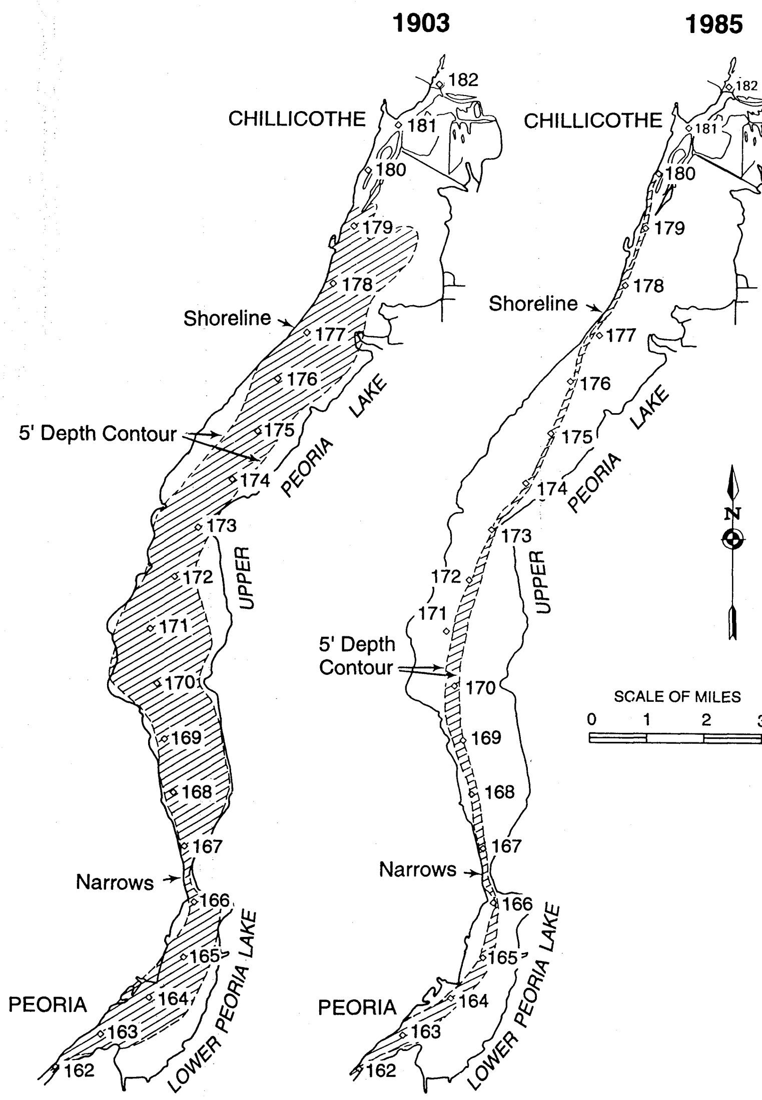

Fig. 5 Shrinkage of lake area with water depth greater than 1.5 m in Peoria Lake from 1903 to 1985.

for agricultural purposes (Bellrose *et al.*, 1983). It was estimated that there were 53 bottomland lakes with surface areas greater than 50 acres in the Illinois River valley in 1975. The total surface area of the bottomland lakes was estimated to be 39 000 acres occupying only 5.2% of the flood plain area (Lee & Stall, 1976).

Sedimentation has long been identified as a major problem for bottomland lakes in the Illinois River, since most of them have been filling up with sediment (Lee & Stall, 1976, 1977; Bellrose *et al.*, 1984; Illinois Division of Water Resources, 1987; Demissie *et al.*, 1992). It was estimated that on the average the bottomland lakes in the Illinois River valley had lost 72% of their water storage capacity to sedimentation by 1990 (Demissie *et al.*, 1992). Some lakes have completely filled with sediment. In addition to the loss of capacity, there is concern over the quality of sediment in the lakes. As the lakes become shallower, waves generated by wind and river traffic continuously re-suspend the bottom sediment. If contaminants are stored in the sediment, they are re-suspended along with the sediment and become available to aquatic biota in the water column.

The impact of sedimentation on the bottomland lakes is clearly illustrated by what has happened to Peoria Lake, the largest and deepest lake in the Illinois River valley. It is located near the city of Peoria in central Illinois, between River Miles 162 and 182 on the Illinois River. River miles on the Illinois River are measured starting from Grafton, Illinois, where the Illinois River joins the Mississippi River (Fig. 1) The cumulative result of sedimentation in Peoria Lake is shown in Fig. 4, which compares the 1903 and 1985 lake bed profiles at four locations along the lake. As can be inferred from Fig. 4, much of the lake has filled with sediment. Sedimentation is more severe in the upper reaches of the lake (River Miles 175 and 179) than in the lower reaches (River Miles 164 and 168). As a result, the lake gets shallower in the upstream direction. The overall impact of the sedimentation pattern in Peoria Lake is the shrinking of the deeper parts of the lake as illustrated in Fig. 5, which compares that portion of the lake deeper than 1.5 m for 1903 and 1985. In 1903 much of the lake would have been deeper than 1.5 m under present-day normal pool conditions, while in 1985 much of the lake was shallower than 1.5 m, with a narrow navigation channel in the middle of the lake. As sedimentation continues and the shallow flat areas start supporting vegetation, much of the lake will be transformed into seasonally flooded wetland.

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