How Do Human Impacts and Geomorphological Responses Vary with Spatial Scale in the Streams and Rivers of the Illinois Basin?

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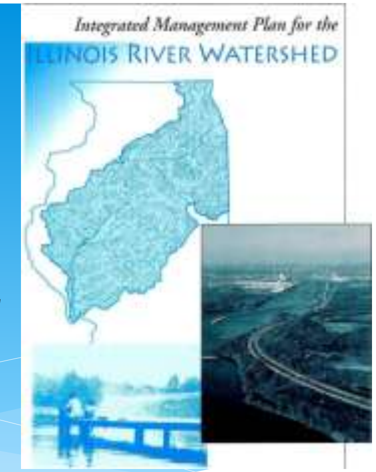
Focus of this talk:
Changes in Water, Sediment, and River Channels associated with Human Activity and the Implications for Water Quality and Aquatic Habitat



- **Integrated Management Plan for the Illinois River Watershed**
  - "Each year 14 million tons of sediment are transported through the watershed. More than half of this sediment load is deposited in the Illinois River Valley, and the balance is carried to the Mississippi River. Most backwater lakes have lost more than 70 percent of their storage capacity, destroying wildlife and recreational areas."
  - "The sediment, coupled with unseasonal flooding, yield a river system less capable of "managing" its sediment through a natural pattern of deposition, drying and compaction. Operation and maintenance of the navigation system is increasingly difficult, due to accumulation of sediment in the channel and rapidly fluctuating water levels."
  - Threats: the prior alteration of natural patterns of water and sediment movement
  - Objectives
    - Reduce the river's deviation from the natural hydrograph (volume, depth, and duration of water flows).
    - A measurable reduction of the amount of sediment entering the Illinois River and its tributaries.
    - Healthy levels of abundance, distribution, and diversity of plant and animal communities

Why are scale considerations important?

- To achieve water, sediment, ecosystem objectives, it is important to recognize that not all parts of the watershed system are the same
- Human impacts and geomorphological responses vary with scale
- Effective management of the Illinois River Basin depends on sound understanding of variations of these impacts and responses at different scales

Overview of the Illinois River Basin: Geomorphology

Low-relief glaciated terrain

Elevations throughout much of the basin are between 600 and 800 ft. above sea level

Local relief generally greatest along the main river valley (200-400 ft)

Majority of basin local relief is less than 50-75 feet

Local relief slightly higher in western portion of the basin – Illinois versus Wisconsin glaciation

Overview of the Illinois River Basin: Land Use

Predominate land use is row-crop agriculture

Forest in bottomlands along major tributaries

Chicago urban area in northeast

Headwaters Scale

Drainage Area   1 – 100 km²

Many streams channelized as drainage ditches

Streams are altered to support tile drainage of farmland

Channels subjected to periodic maintenance

Channels flanked by farm fields or narrow grass buffer

Channels generally disconnected from floodplains, promoting rapid downstream movement of runoff

Headwaters Scale

Streams have "flashy" hydrologic regimes

Agricultural ditches generally are erosionally stable because of low gradients, flow energy, high strength of boundary materials

High nutrient loads from fertilizer applications and tile drainage

Headwaters Scale

Net deposition occurring in many ditches over time (thus the perceived need for maintenance)

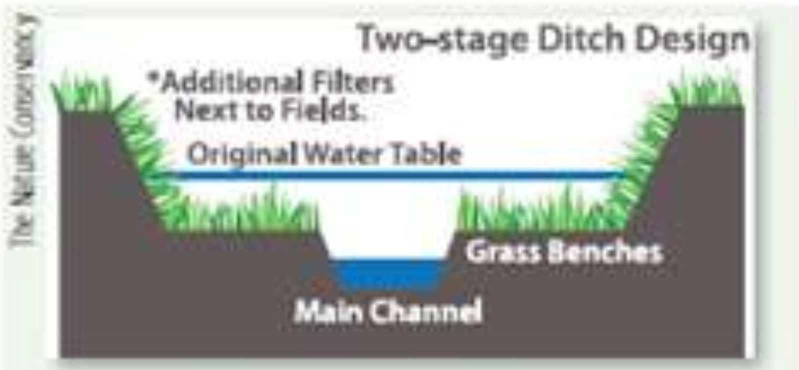
Change represents geomorphological recovery to human alteration

Recovery leads to development of inset channels and benches flanking these channels

Recovery promotes enhanced habitat, filtering of sediment, and denitrification

Headwaters Scale

Research on natural geomorphological adjustments in ditches provides basis for two-stage ditch design to "naturalize" these channels



The concept of the two-stage ditch was developed by observing natural processes that form stable streams and rivers.

Headwater streams will meander if not ditched, but time scale is usually long (decades to centuries)

Currently, little or no incentive for allowing ditches to recover – maintenance is the dominant practice

Headwaters Scale

Most headwater urban streams are also ditches

May be erosionally unstable

Flashy hydrological regimes

Poor physical habitat and water quality for aquatic organisms

Naturalization of urban streams has involved remeandering of channels (Spring Brook, DuPage Co.) and implementation of pool-riffle structures to enhance habitat and water quality (WFNBCR – Northbrook, IL)

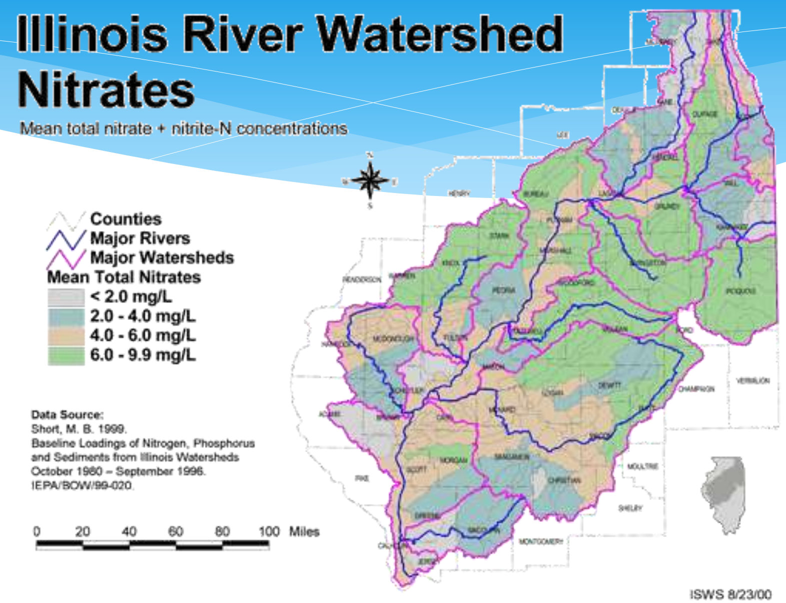
Major Tributary Scale

Drainage area 100s to 1000s km²

Rivers have meandering patterns, too large to "ditch"

Flanked by farm fields or narrow riparian corridor

Major Tributary Scale

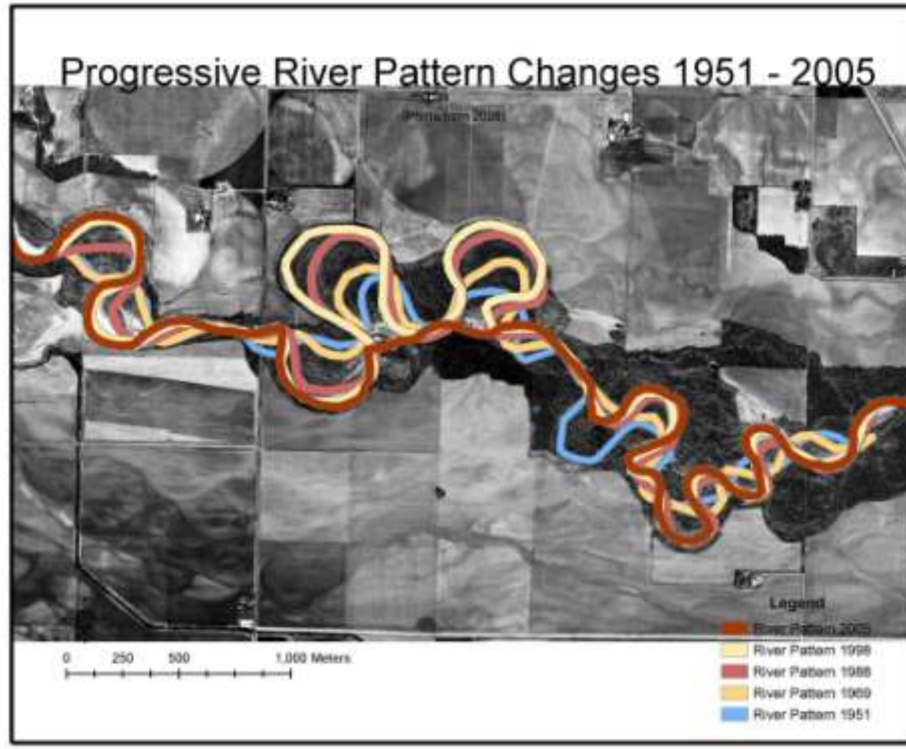


These rivers have higher nutrient and sediment loads, flashier hydrological responses, and carry greater runoff volumes than prior to European settlement

Flow may be regulated by low-head dams or water-supply reservoirs

Major Tributary Scale

Mackinaw River



Rivers are actively meandering

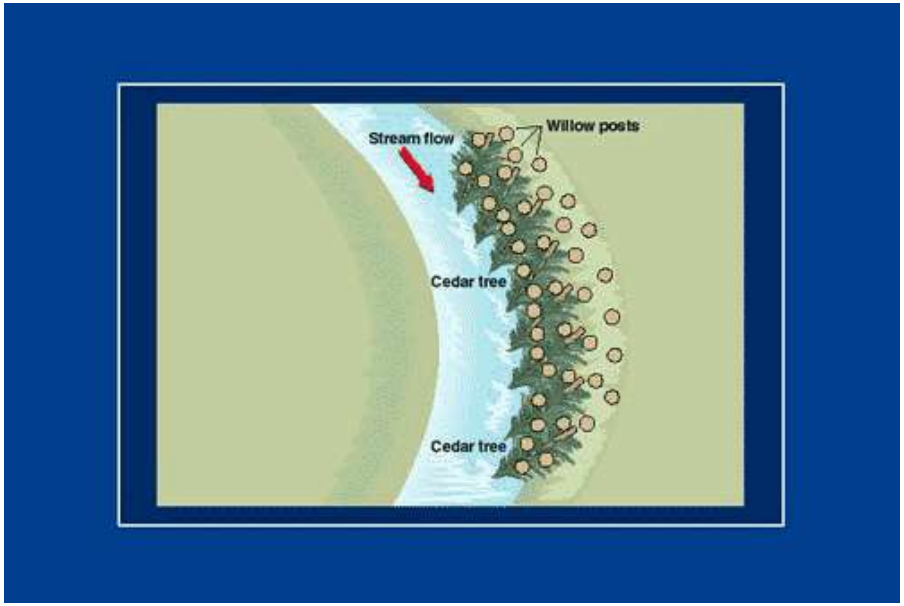
Some channels have high rates of bank erosion

Erosion rates generally related to spatial variations in land use (riparian) and energy of flow

Major Tributary Scale

Attempts to control erosion have involved implementation of bank protection schemes such as bendway weirs and vegetation plantings

"Success" is mixed and even if it works the fix is local whereas the problem (increased runoff, land use) is systemwide



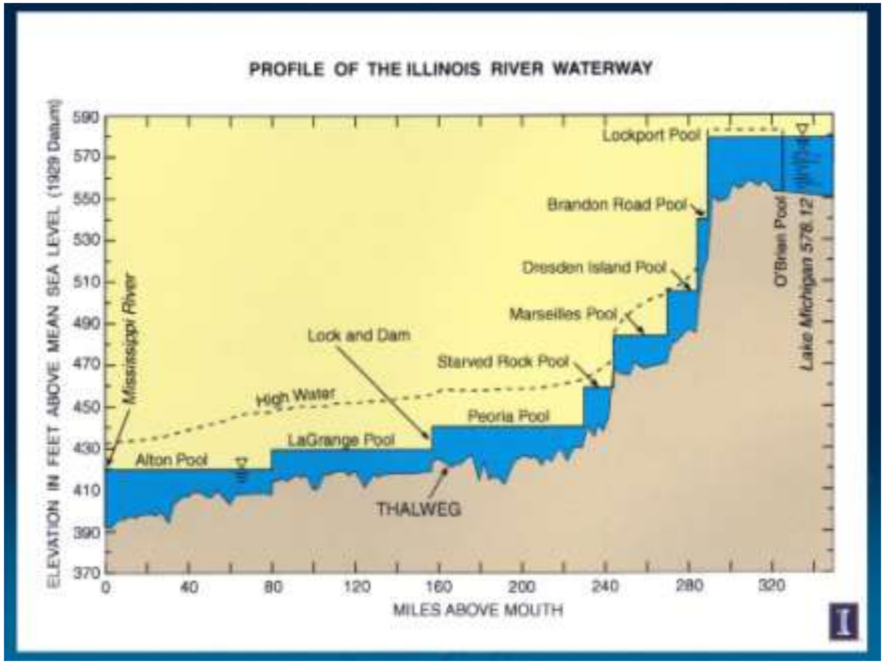
Illinois River Main Valley

Drainage area 10,000+ km²

Flanked by bottomland wetlands within an incised, bluff-bounded ancestral glacial drainageway

Bounded by levees that restrict the flood pulse on the floodplain

Regulated by navigation locks and dams – series of navigation pools

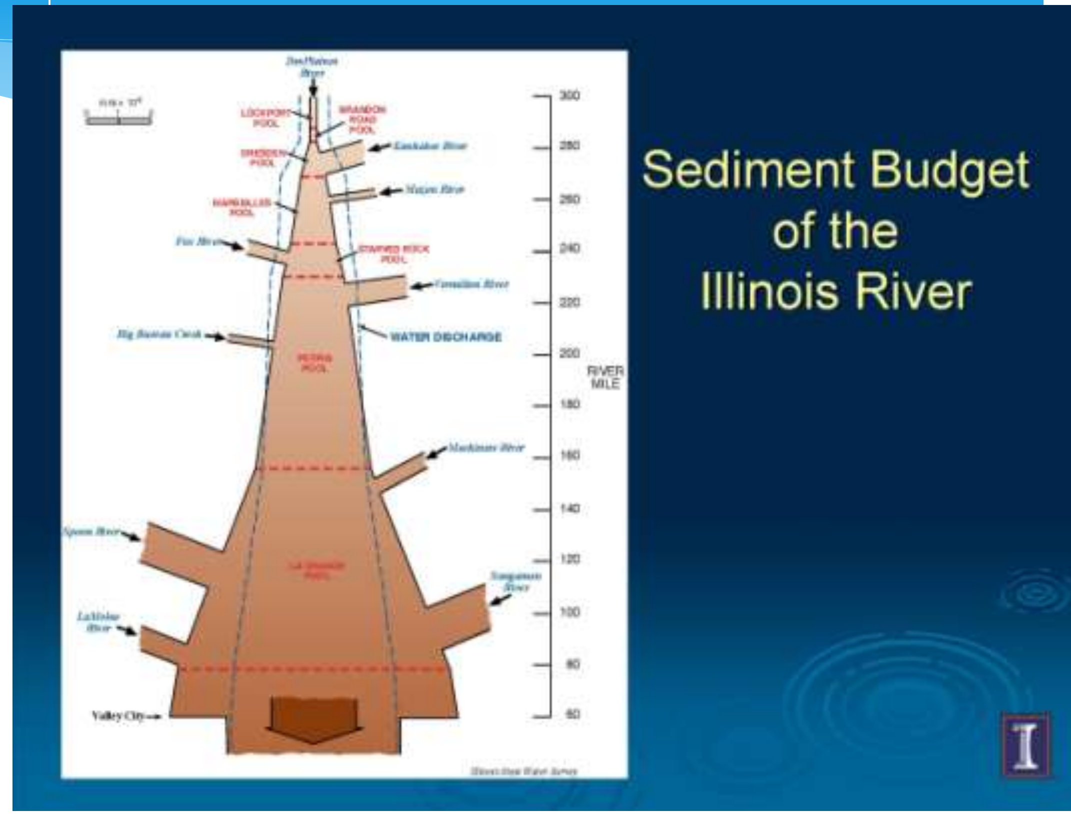


Illinois River Main Valley

River is not actively meandering

Sediment delivery much higher and hydrological regime less variable than prior to European settlement

Both channel and backwater areas on floodplain are experiencing net sedimentation



Sediment Input 12.1 million tons per year → Sediment Output 5.4 million tons per year → Sediment Stored in Main Valley 6.7 million tons per year

Largest contributions in lower valley from Spoon River, LaMoine River and Sangamon River

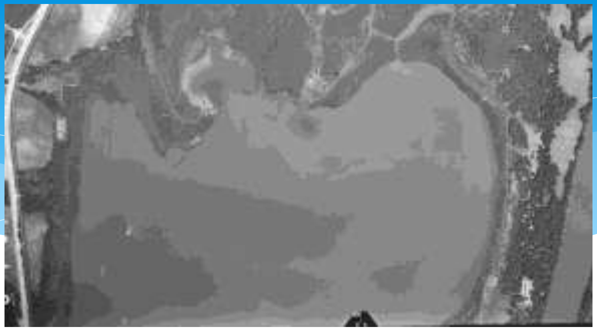
Illinois River Main Valley

Backwater lakes are infilling from tributaries draining from uplands and bluffs

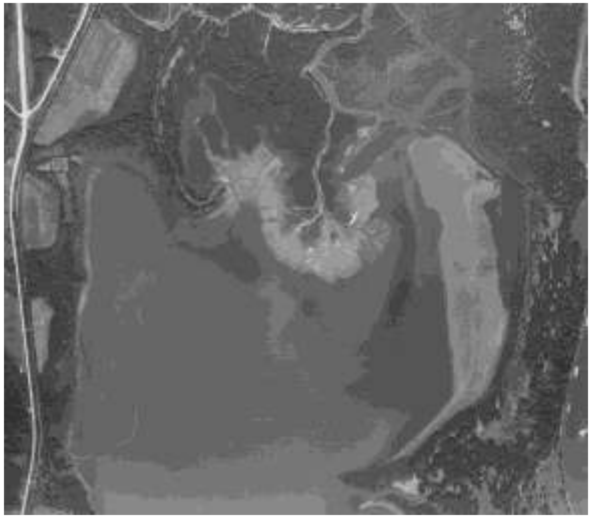
Example from Goose Pond – a backwater lake near the Big Bend, in the Illinois River

Bureau Creek drains into Goose Pond

1964



1979



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Conclusions

- Three major scales of river conditions can be identified in the Illinois River Basin: **Headwaters, Major Tributaries, and Main Valley**
- Understanding the ways in which human activity has affected river processes at each scale provides insight into spatial variation in the geomorphological responses of streams and rivers throughout the watershed
- These responses are important for determining how sediment fluxes and habitat conditions vary throughout the watershed
- Such determinations can guide management: the history of the basin is largely a story of downstream-directed effects, i.e. changes in the headwaters have resulted in altered water and sediment fluxes that have produced responses in the major tributaries and main stem
- Recent attempts to improve environmental conditions in the main stem (enhance habitat, water quality and reduce sedimentation) are reactions both to effects generated by changed conditions in the headwaters (channelization, ditching) and major tributaries (high rates of channel erosion) and to those associated with alteration of the main stem itself (lock-and-dam and levee construction)