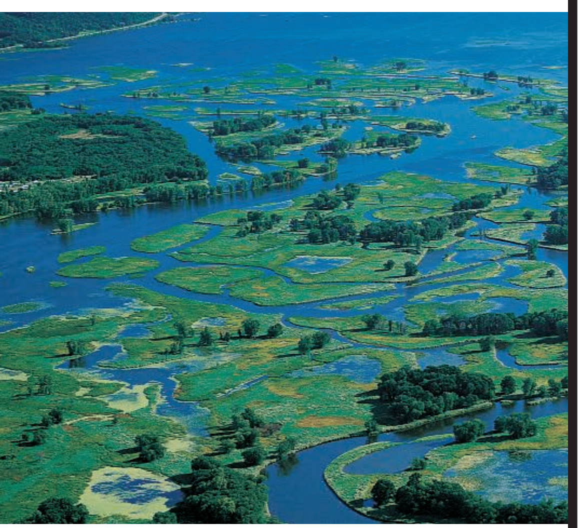
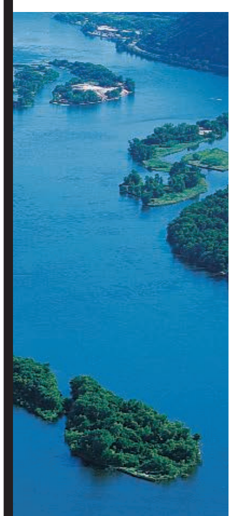
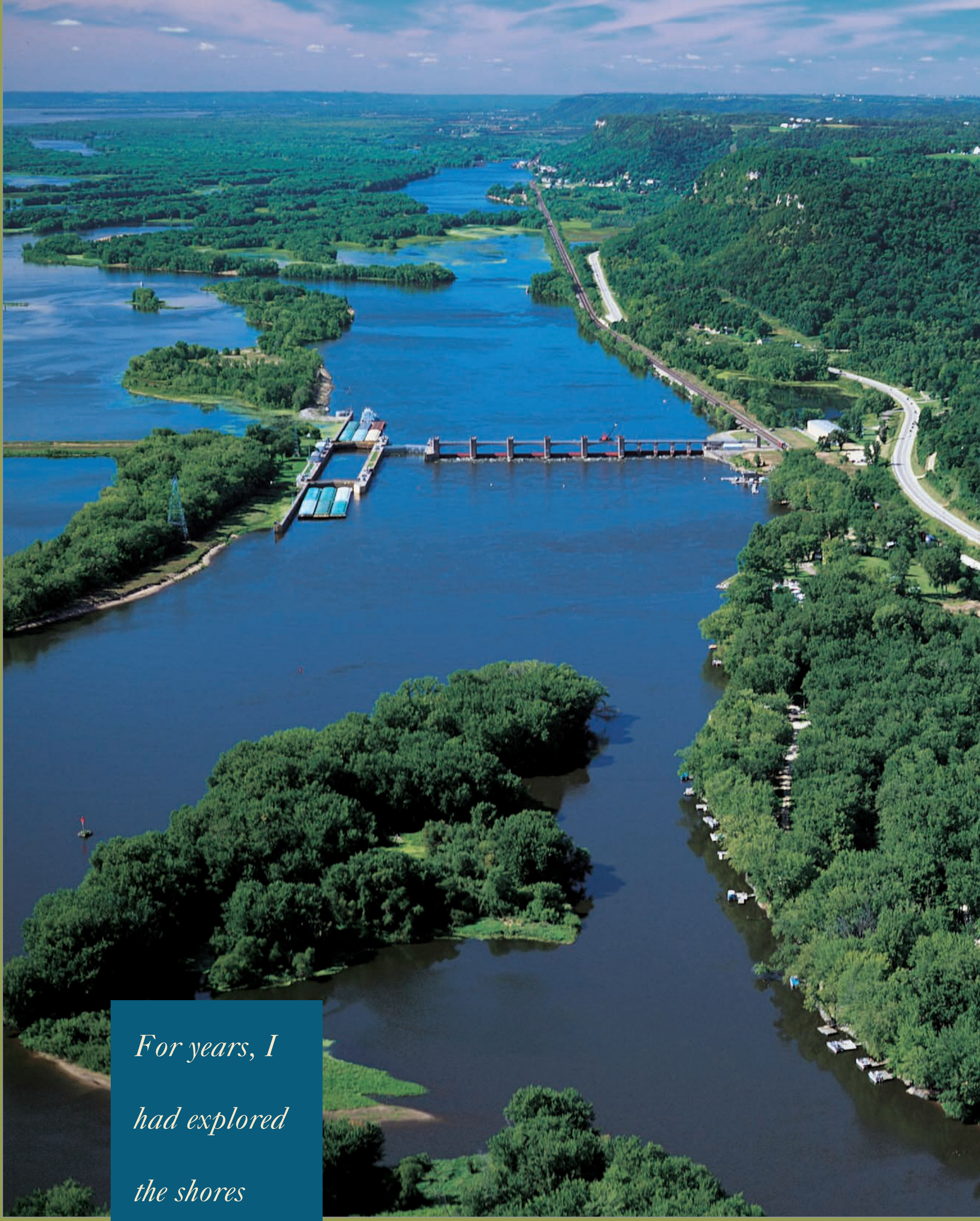
A Strategy for the Natural Resources of the Upper Mississippi River System

# A River That Works and a Working River





The Upper Mississippi River Conservation Committee



*For years, I*

*had explored*

*the shores*

*of the river...*

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UPPER MISSISSIPPI RIVER CONSERVATION COMMITTEE

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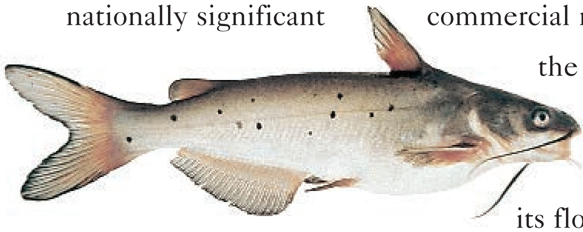
Our thanks to the many resource managers, scientists and citizens who have given generously of their time, energy and wisdom. We hope this report does their work justice and helps us all do a more effective job of restoring the Upper Mississippi and its watershed as a place where people prosper and birds, fish and wildlife thrive, in a healthy environment.

**For more than 200 years** this nation has benefited from the natural and economic resources of the Upper Mississippi River System (UMRS). The United States Congress declared, in 1986, that this large floodplain river is both a nationally significant ecosystem and a nationally significant commercial navigation system. This is affirmed by all of us who use the river or benefit from its bounty. ● As we have used the river and settled along its shores, we have also changed how the river flows and significantly modified its floodplain. We have improved and maintained the river as a commercial navigation system. We have built levees to confine the river's flow and protect farms and cities. In the process, we have nearly destroyed the physical processes that sustain the natural resources of the river: the diverse habitat conditions and the plants and animals they support. ● If the UMRS is to continue to survive as a nationally and internationally significant ecological and economic resource we, who are its beneficiaries and stewards, will have to develop, very soon, more efficient and effective restoration and management strategies. For the long run, we need to integrate how we operate and maintain the commercial navigation system, the flood control system and the natural ecosystem. ● This report describes the critical elements of a strategy for operation and maintenance of the natural resources of the Upper Mississippi River and its navigable tributaries. (We use the term "natural resources system" and "ecosystem" interchangeably, to describe the plants and animals of the river and how they interact with each other and their surrounding environment.) The report was prepared by the Upper Mississippi River Conservation Committee, (UMRCC). ● In chapter I we describe the significance of the natural resources of the river. In chapter II we describe a set of objectives to maintain those benefits. Chapter III describes the physical river processes that support those objectives. Chapter IV is an overview of the strategy and the nine tools and measures to restore natural river processes. Chapter V recommends "next steps" to implement the strategy and discusses potential leadership roles for agencies, organizations and individuals. ● This report lays the foundation for agencies and the public to support programs which will improve and maintain the ecological integrity of the Upper Mississippi River System.

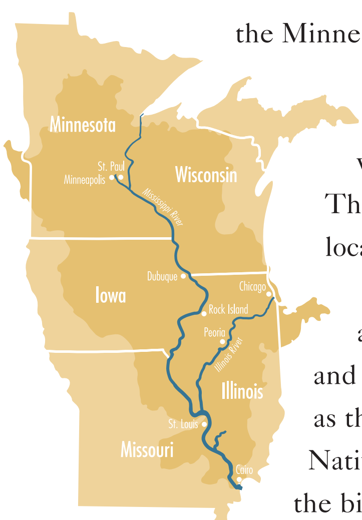


# A Strategy to Restore and Maintain the Upper Mississippi River System

# National Benefits of the Upper Mississippi River Ecosystem

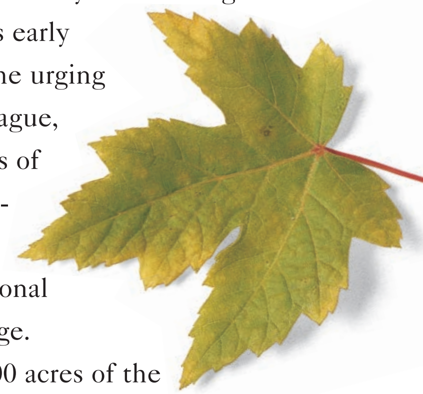
**The UMRS is a** dynamic, large floodplain river ecosystem. It is part of the largest riverine ecosystem in North America and third largest of seventy-nine such river systems in the world. The river valleys within the system were carved by the meltwaters of glaciers. Today, within these valleys, broad floodplains carry the surface water, ground water, nutrients and sediment from the 189,000 square mile Upper Mississippi River Basin.

The UMRS is defined as the natural floodplain between the head of navigation at Minneapolis, Minnesota and the confluence with the Ohio River at Cairo, Illinois. It also includes the floodplains of the entire length of the Illinois River and navigable portions of the Minnesota, St. Croix, Black and Kaskaskia rivers. Together, these floodplains cover 2,570,000 acres of land and water area.




This floodplain ecosystem complex, located in the temperate heart of North America, is critical habitat for both aquatic and terrestrial species of flora and fauna. This has been true as long as there has been life on this continent. Native Americans have long honored the biological diversity and significance of this river floodplain complex. European explorers, beginning with French explorers, Jacques Marquette and Louis Joliet, in 1673 have chronicled the river's character.

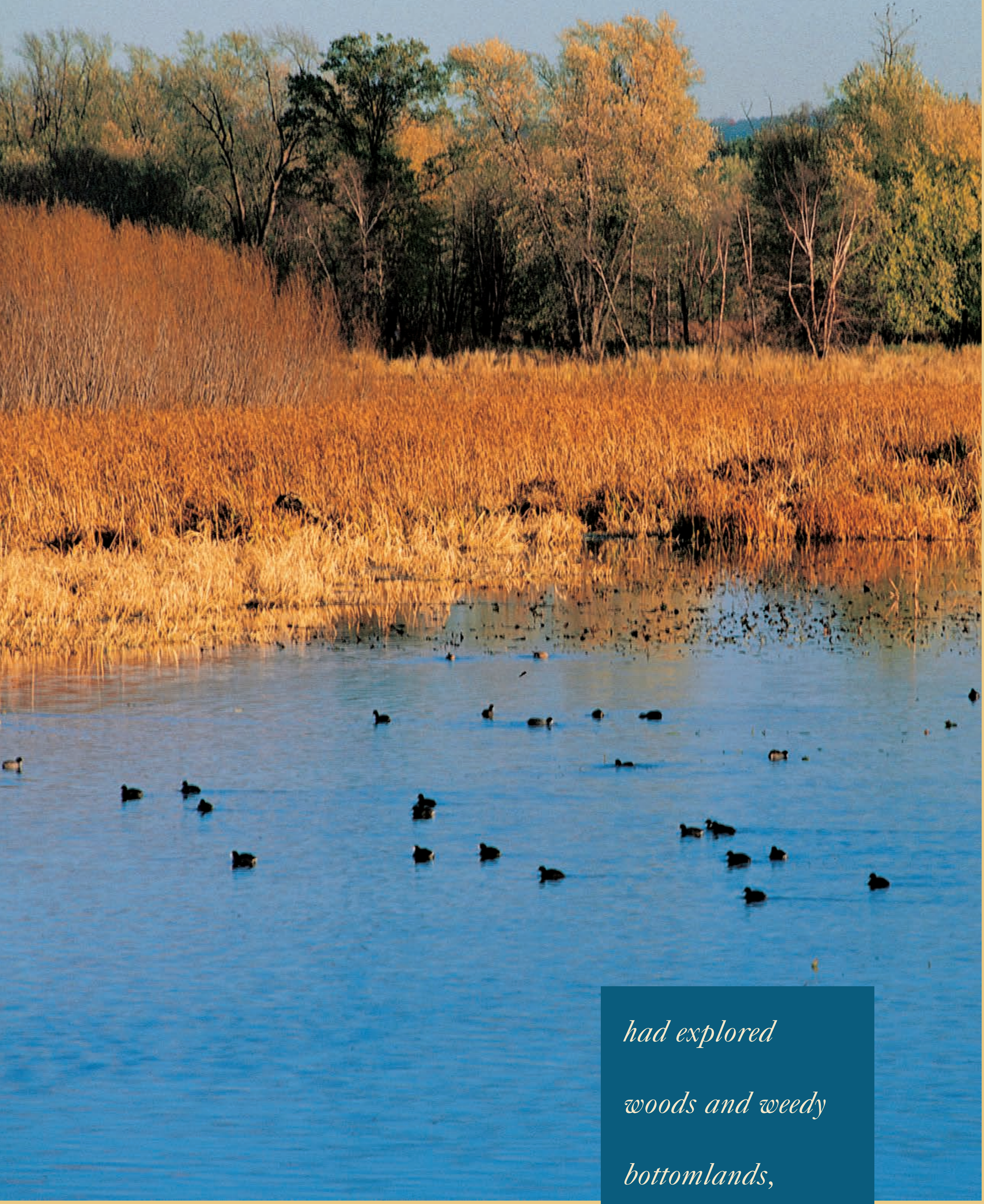
The ecological significance of this floodplain, as a commercial and recreational fishery and migratory waterfowl nesting area, flyway, and hunting area, was formally acknowledged by the U.S. Congress as early as 1924. That year, at the urging of the Izaak Walton League, more than 200,000 acres of floodplain was designated by Congress as the Upper Mississippi National Wildlife and Fish Refuge.



Today, some 297,000 acres of the floodplain are now within the Wildlife Refuge System, with the addition of the Trempealeau and Mark Twain refuges on the Upper Mississippi River main stem; the Illinois River Refuge System and the Minnesota Valley Refuge. In addition, the States of Minnesota, Wisconsin, Illinois, Iowa and Missouri manage some 190,000 acres of habitat located at more than 80 sites on the system.

The diverse habitat conditions that existed along this system in the early 1800s have been significantly changed as a result of human settlement within the basin and human use and modification of the river itself. Yet the river valley is home and habitat for 485 species of fish, mussels, birds, mammals, amphibians and reptiles.

In the Water Resources Development Act of 1986, the U.S. Congress acknowledged and reaffirmed the importance of this floodplain for fish and wildlife habitat when it formally declared the Upper Mississippi River, among other things, "a nationally significant ecosystem." It is this ecosystem that is now at risk and in need of restoration and maintenance for this and future generations.



*had explored*

*woods and weedy*

*bottomlands,*

*and waded swamp*

*and marsh ...*

*had walked*

*sand bars,*

*open shores*

*and along*

*rocky cliffs…*

*About half of the* **30 million residents** *of the watershed rely on the water from The Upper Mississippi River and its tributaries for municipal and industrial water supplies.*

*It provides for over $6.6 billion dollars in revenue annually from some 12,000,000 visitor-days of use by people that* **hunt, fish, boat, sightsee** *or otherwise visit the river, its magnificent bluffs and communities.*

*Recreation and tourism* **employ 143,000 people** *in the corridor.*

*It is a* **migratory flyway** *for 40% of all North American waterfowl.*

*It is a globally important flyway for* **326 bird species** *(60% of all species in North America).*

*At least* **260 fish species** *have been reported in the basin (25% of all fish species in North America).*

*The river is habitat for 37 species of* **fresh-water mussels.**

*The river corridor is habitat for* **45 amphibian and reptile species** *and 50 mammal species.*

# The Significance of the Natural Resources of the UMRS[1]

*It is critical habitat for 286 state-listed or candidate species and 36 federal-listed or candidate species of* **rare, threatened or endangered plants and animals** *endemic to the Upper Mississippi River Basin.*

*It provides the important, but intangible, benefit of over 1,300 river miles of* **diverse natural, rural and urban open space** *for human exploration, experiential education, spiritual renewal and aesthetic enjoyment.*

*It is a 2.5 million acre* **large river floodplain laboratory.** *It is a "system of systems" for us to use, understand and appreciate. It is a place for this and future generations to learn how to restore and maintain a "living river" in the face of a global human population that will grow by 1 billion people in the next 12 years.*

# A Great River but a Degraded River

**The physical and** biological condition of today's river is a product of decades of change to the river and its watershed. This chapter describes five major modifications we have made and how the river has responded. It also presents goals and objectives for restoration and protection of the river's ecological health.

## We have modified the river and its watershed

Some 200 years of expanding human settlement in the river basin and human use of the river have significantly modified its physical and biological characteristics. We continue to modify the landscape and change the character of the river and its watershed.

In so doing, we have altered the natural physical processes that are necessary for the life and well being of fish, wildlife and bird communities and the habitats that sustain them. Human progress, so far, has been at the expense of maintaining the natural ecosystem. We are now learning better ways to manage large floodplain rivers. We have an opportunity to reverse the historic trend of ecosystem degradation.

Although the river ecosystem has been affected by many factors, five types of modifications of the UMRS floodplain and its basin have caused the most detrimental changes.

We have modified the river over time:

1. By levee construction, resulting in a 50% reduction in floodplain area.
2. By construction of 36 locks and dams, converting most of the free-flowing river into a series of slackwater "pools."
3. By channelization of the formerly meandering river in order to maintain the nine-foot navigation channel.
4. By human settlement and use of the river's watershed, we have degraded water quality and increased the amount and altered the rate of sediment and nutrient flows in the system.
5. By connecting Lake Michigan to the Illinois River we have created a pathway for invasion of non-native species.

The impacts of each of these modifications varies, depending upon location in the system. The physical and biological characteristics of the river change from the headwaters to the mouth. The nature of our modifications are different in the pooled reaches of the river than in the open river.

The geology, soils, amount of precipitation, land use practices and land differ within the watershed.

1

**Levee Construction has resulted in a 50% reduction in the floodplain area.**

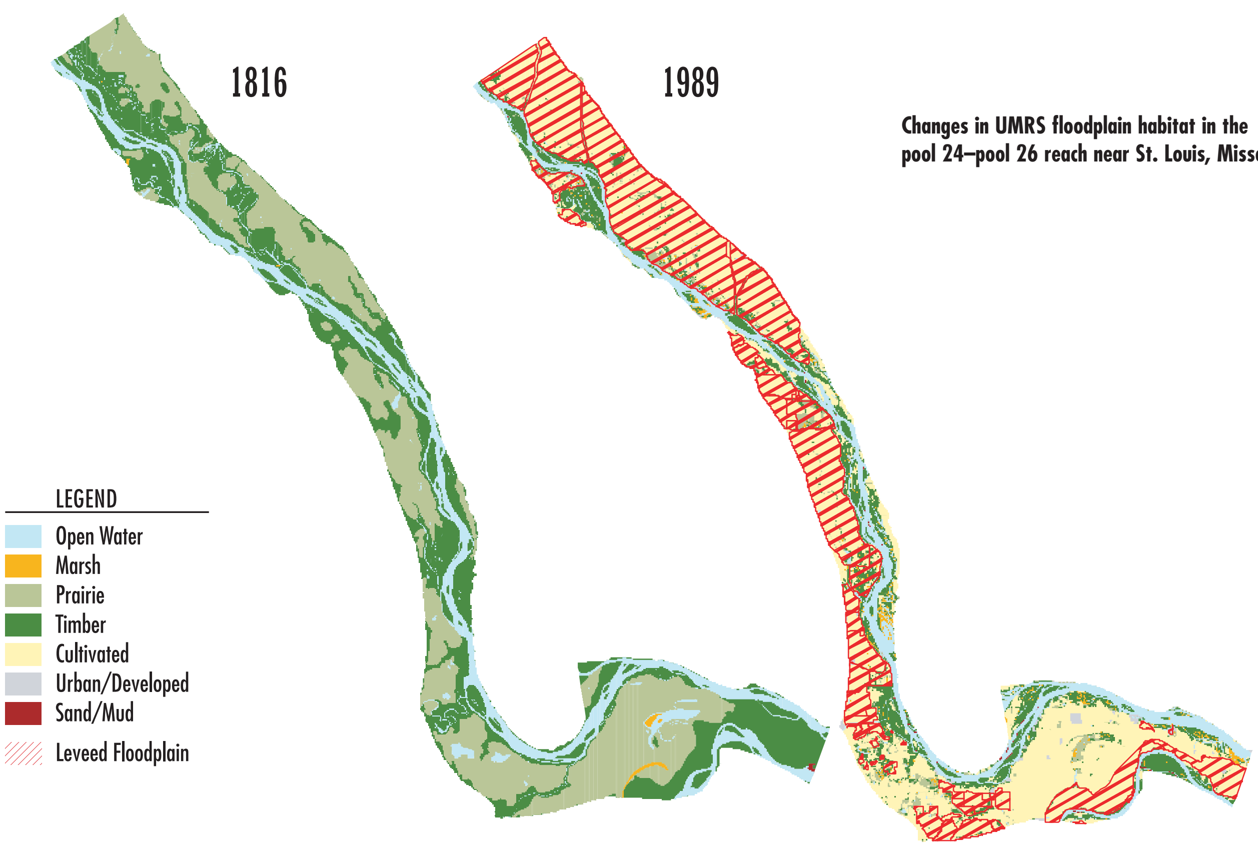
On the 858 river miles of the Mississippi River between Minneapolis, Minnesota and the confluence with the Ohio River at Cairo, Illinois, we have isolated more than 50% of the floodplain behind flood control and agricultural levees. That is 1,092,000 acres of the 2,165,000-acre floodplain. The most pronounced effect has been in a 203-mile unimpounded reach. Along the "Middle Mississippi River," between Alton and Cairo, Illinois, 82% of the floodplain has been isolated behind levees. On the 323 mile-long Illinois River, similarly, about 50% of the 400,000-acre natural floodplain has been isolated through construction of levees and the use of water pumping stations.

The result is a reduction in the acreage and complexity of habitat and the species it supports. Levees prevent the exchange of nutrients between the river's floodplain and the aquatic habitat of the backwaters, side channels and main channel. In addition, the confinement of the river to a more restrictive area has significantly altered the annual hydrograph of the river. Floodplain restrictions also further exacerbate the impact of rapid runoff due to tiling, loss of native vegetation, channelization, and paving within tributary watersheds. These factors have resulted in flood peaks that are higher because the river cannot spread out over its natural (and much wider) floodplain.[2]

2

**Construction and operation of locks and dams has converted most of the free-flowing river to a series of pools.**

The effects of isolation of more than half of the natural floodplain behind levees has been compounded by the construction of locks and dams. As a result, the upper 655 miles of the river are




**Changes in UMRS floodplain habitat in the pool 24–pool 26 reach near St. Louis, Missouri.**

now a series of 29 slackwater "pools."

Each navigation dam on the river holds back the normal flow of the river so that a minimum of nine feet of water depth can be maintained between each dam. This area of stored water between dams is called a "pool." Water levels are regulated in each pool and in the system, by the use of gates that allow excess water to flow down to the next pool. The result is a staircase of water that is maintained at an artificially high level during the navigation season. At each dam is a lock chamber which allows passage of recreational and commercial boats both upstream and down.

On the 323-mile Illinois River we have constructed 7 locks and dams which, with the effect of Mississippi River Lock and Dam 26, have also transformed the Illinois River from a free-flowing river to a series of pools.

The affect has been to modify the flow and seasonal water level variations on the river. The dams also cause sediment and nutrients to be retained in backwaters and in the lower ends of each pool rather than move normally in the system. The effect has been to create a series of sediment traps behind the dams, reduce aquatic and terrestrial habitat diversity and dramatically reduce the variability of river flows and the habitats that are supported by such variability. Another effect of this modification has been to block fish movement during most river stages.

## 3

## The River has been channelized and maintained for navigation.

In order to maintain the nine-foot navigation channel, approximately 10,000,000 cubic yards of material are dredged from the river at 150 high-frequency sites. This main-channel dredging and disposal of the dredged material, primarily elsewhere in the floodplain, along with the construction and maintenance of channel training structures such as wing dams, closing dams, and bank stabilization, have all further modified the river's ability to sustain itself as a natural ecosystem.

In the reach from Minneapolis, Minnesota to Guttenberg, Iowa, there are an estimated 1,519 channel training structures (primarily wing dams) in the river.[3] In the reach from Guttenberg to Saverton, Missouri there are an estimated 1,100 structures.[4] In the reach from Saverton to the confluence with the Ohio River there are an estimated 1,300 channel training structures.[5] Not all of the structures are still visible or functional.

## 4

## Changes in land use and land use practices have degraded water quality and increased sediment and nutrient problems in the river and the Gulf of Mexico.

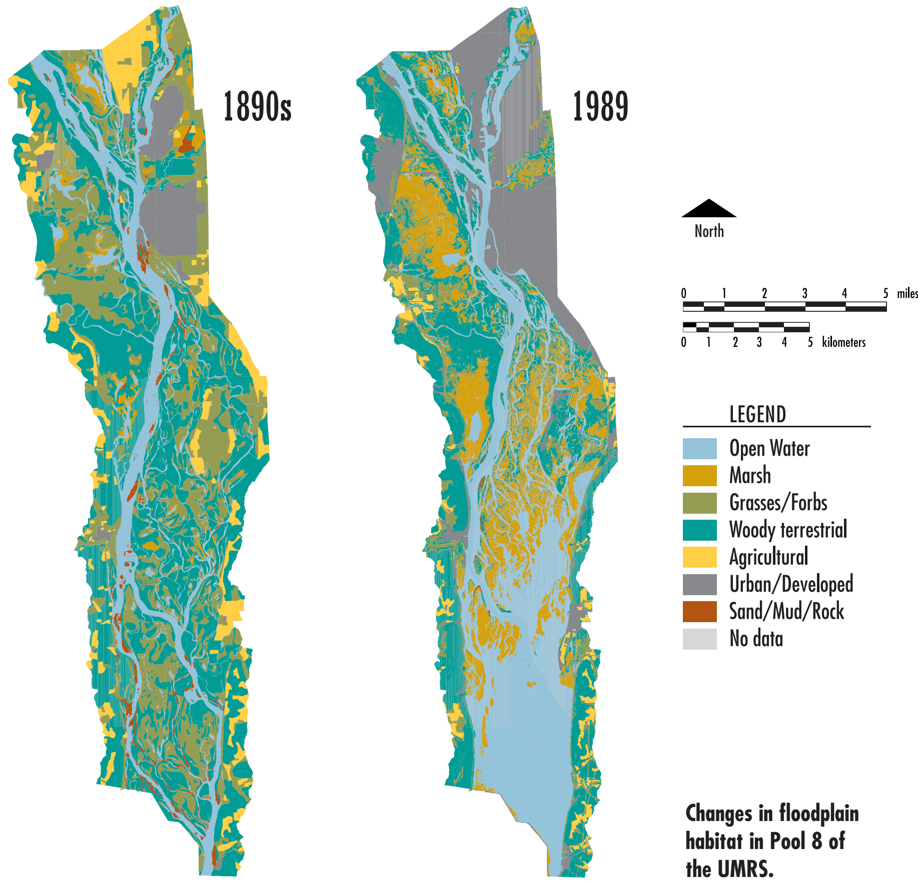
Our settlement and use of the Upper Mississippi Basin during the last 200 years has converted most of the terrestrial landscape of the watershed from native prairie, savanna, forest and wetlands to a mosaic of agricultural, rural, suburban and urban land uses. Tributary rivers and streams have been straightened and channelized so that surface and ground water travel more quickly through the system instead of being retained in the watershed.

More and faster runoff of water and sediment, elimination of filtering wetlands, and the contamination of those waters and sediment with new compounds have all, in turn, affected the quality of their receiving waters in the floodplain of the Upper Mississippi River. This was particularly well documented in the post-1993 flood analyses done as part of several federal studies.[6]

These studies show that the impacts of wetland loss, fertilizer and chemical contamination and changes in water quality and sediment transport have been pervasive throughout the system. Impacts of contamination and sedimentation of the small streams and tributaries in the basin can be both local as well as cumulative as these waters converge and accumulate in the main stem of the Upper Mississippi River itself.

Because we retain water in the river pools and maintain a navigation channel, we also cause sediment to move to and settle in backwaters and side-channels critical for fish and wildlife. It has been well-documented in studies going back to the 1970s, that sediment is filling in backwaters and side channels as well as the lower reaches of pools. Conversely, in some reaches, fast flowing water and artificially high water levels are destroying islands and eroding riverbanks.

The effects of increased nutrient levels in the river have been documented to reach all the way to the Gulf of Mexico. Recent estimates by researchers working for a Gulf of Mexico Hypoxia Task Force attribute the Upper Mississippi River Basin with contributing 31% of the nutrients reaching the Gulf. The decomposition of these nutrients uses all available oxygen in the water. The result has been a "dead zone" of some six to seven thousand square miles in size. The impacts have been detrimental to fish and wildlife as well as to those who rely on commercial fishing for a livelihood.




**Changes in floodplain habitat in Pool 8 of the UMRS.**

**5**

**By connecting Lake Michigan to the Illinois River we created a pathway for non-native species.**

We have only recently begun to comprehend the full significance of a modification started in 1848 and completed in 1900 - the linkage of Lake Michigan to the Illinois River (and thus the Mississippi River) for navigation and sewage treatment purposes. In addition to affecting water quality and sediment transport, this linkage has exposed the Illinois, Mississippi, and possibly other tributary rivers to the invasion of zebra mussels, the European ruffe, the round goby and other exotic species.

Since 1991, zebra mussels have moved down the Illinois River and up the main stem of the Mississippi River as far as the Twin Cities, Minnesota. The rapid spread and expansion of the zebra mussel population is now a serious environmental threat. Native mussels are being colonized by the prolific zebra mussels at a high rate in many reaches of the river. For example, mussel densities as high as 25,000 per square yard were reported in pools 9 and 10 in1997.[7]

This connection continues to provide a pathway for other non-native species. The introduction and reproduction of non-native species is a major impediment to our efforts to maintain or restore aquatic habitat.

**The Overall Goal of This Strategy:**

**To obtain public support, congressional appropriations, and public and private leadership to operate and maintain the ecological health of the Upper Mississippi River System.**

## The strategy

recommended herein, in some ways, parallels the existing strategy for Operation and Maintenance of the nationally significant nine-foot channel navigation system on the UMRS. We already have the means, infrastructure, continuing authority and budget process to support the existing navigation system and periodically evaluate the need for improvements or modifications.

Now we need the means, infrastructure and appropriations to support the nationally significant natural resource system. We must do more than simply protect remaining habitat patches and the fish, wildlife and bird populations they sustain. We must establish operation and maintenance of the river ecosystem as a well-designed, integrated and fully funded effort. It must be a common understanding that the Upper Mississippi River is our common wealth and its restoration and maintenance is in the national interest.

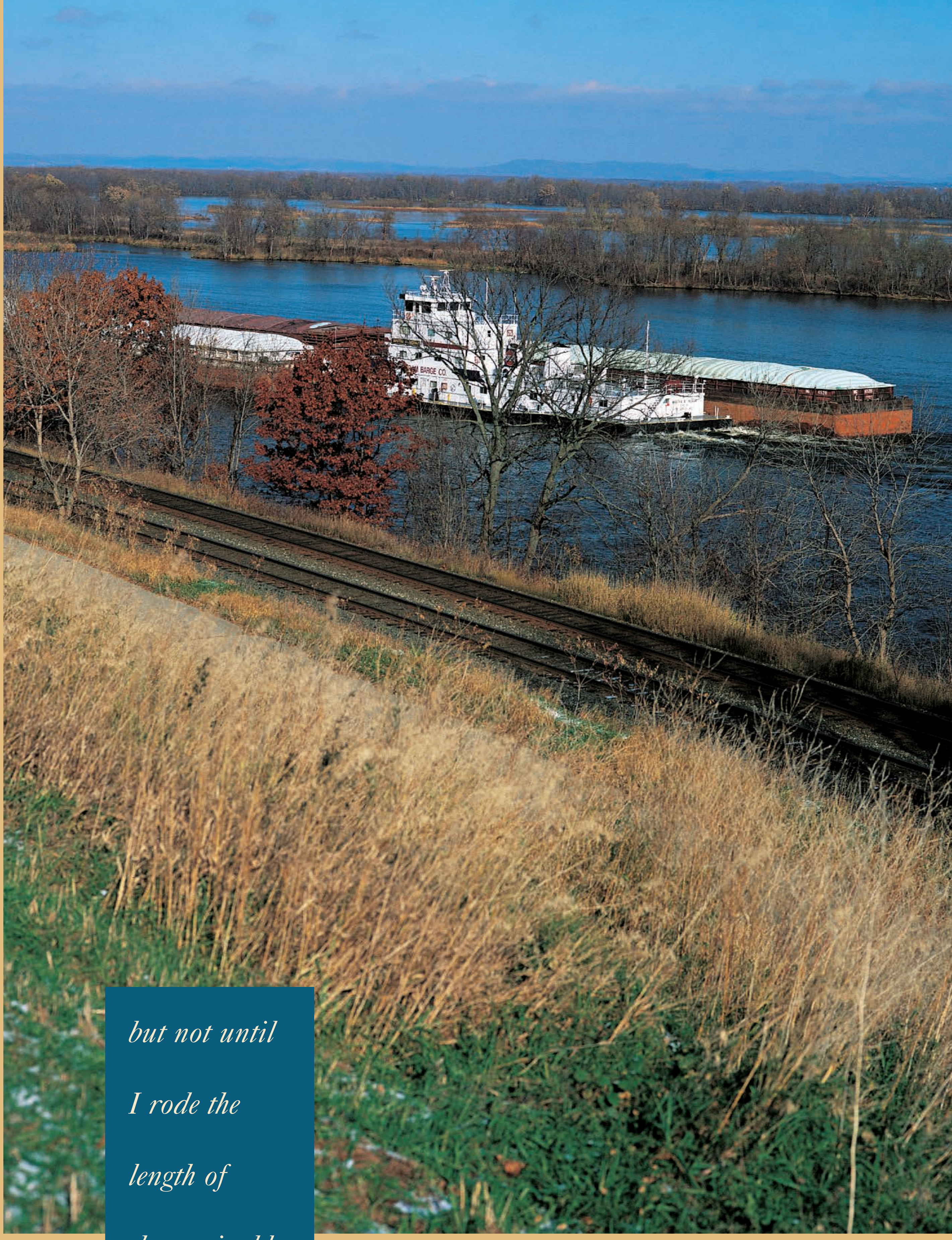
To reach this goal, this strategy has six objectives:

- Support projects and programs that improve water quality and improve sediment management in order to restore the system's biological integrity.
- Support projects and programs which will enable existing large floodplain river hydrologic processes to work, or where necessary, restore those processes so that the system will be able to maintain, sustain and rejuvenate itself for not just a few years, but for decades to come.
- Support small-scale, site-specific natural resource restoration and rehabilitation projects in the watershed and in the floodplain of the river where larger-scale projects are not possible or feasible.
- Build upon existing programs, agency missions, interagency agreements and existing authorities, but urge innovation and experimentation. Chief among these is the Environmental Management Program (EMP). This program provides the framework for an interagency cooperative approach to river management and should be used as one of the most important of several means of working together.

## The Goals and Objectives of this Strategy

- Create opportunities for improved communication among resource managers, scientists and the public to share information about adaptive management and new opportunities for river restoration.
- Communicate new recommendations for action clearly to the public in order to garner their support and to agencies and organizations that can provide leadership toward implementation.

This is an ongoing process, presented with the understanding that, collectively, we will need to continue (1) refining the objectives, (2) improving and expanding upon the specific recommendations, and (3) encouraging leadership and public support for the effort.



*but not until*

*I rode the*

*length of*

*the navigable*

*Mississippi …*

**The keys to** restoration of river health are to understand how rivers work and to apply that knowledge in designing and implementing programs and projects that restore or mimic natural river processes. In this chapter we describe the essential needs of a living river and present six criteria for river health.

## Learning How Rivers Work

The last time the agencies and public engaged in a process to evaluate the UMRS as a system was in the early 1980s. The results were published by the now-defunct Upper Mississippi River Basin Commission in a report entitled "A Comprehensive Master Plan for the Upper Mississippi River System.[8]" The Plan listed four system-wide environmental objectives, as follows:

- To maintain and improve the quantity and quality of physical and biological resources which contribute to aquatic and terrestrial wildlife habitat.
- To provide fishable and swimmable waters and protect the system's water from future degradation.
- To preserve and protect unique physical, biological and cultural resources of the system.
- To protect and enhance environmental resources which may be affected by existing and future operations and maintenance of the navigation system.

Since that report was published, we have learned much about river science and management. Our understanding has been enhanced by monitoring of the river through the Environmental Management Program and other research, including an evaluation of the flood of 1993. As a result there is heightened public awareness of the river and new attention is being given to understanding the interdependence of river process, habitat and species.

Much of what we have learned in the last decade is now being reported in agency reports, scientific journals and publications. Throughout the world this work is being confirmed by that of others. Currently, new articles relevant to this strategy are being published monthly. Current efforts, such as the Adaptive Environmental Assessment Project[9] and the Habitat Needs Assessment[10] have the potential to add to our understanding of this system.

We now realize that programs that address specific backwaters or side channels, or that are driven only by the desire to protect certain species, while helpful, are not adequate to address larger systemic issues and problems. Attention must also be directed toward the river basin and the river's physical processes, its geomorphology and the biological relationships within the system.

System objectives need to address how to effectively and efficiently manage the UMRS to sustain those processes and the underpinnings of large floodplain river form and function. Then, within this context, we can also begin to better determine appropriate actions and geographic scales.

**Enabling Physical River Processes is the Key to Successful Natural Resource Management**

## Processes That Sustain the River System

The river system needs to have the capability to support and maintain a dynamic, integrated and adaptive community of organisms that is diverse and comparable to that which the river would sustain under conditions less influenced by man.

We recognize that we have extensively modified the river to provide for human needs and will continue to do so. While it is impractical to recommend a return to pre-settlement conditions, we can take steps to restore and maintain some of the processes that support comparable conditions.

**Scientists say:**

*"In large alluvial river-floodplain ecosystems, the prime* **abiotic factors affecting biotic integrity** *are water and sediment quality and the temporal patterns of water and sediment flows (hereafter called the water and sediment regimes) that shape the river channel and the floodplains themselves. These factors strongly* **influence habitat structure,** *the trophic base, and biotic interactions. Ecosystem management includes: maintaining water and sediment quality within limits that preserve biological integrity and maintaining or restoring the master processes that enable the* **river-floodplain ecosystem** *to maintain, repair, and rejuvenate itself. Master processes include the abiotic processes of erosion and sedimentation that maintain floodplains and deltas and the biotic processes of colonization and succession that rebuild communities following disturbances. Giving the ecosystem some scope to maintain itself is probably more cost-effective in the long run than attempting to control or replace all natural functions with human intervention. We first need to* **appreciate and understand the river-floodplain** *ecosystem and then adapt our management accordingly."*

**Sparks, Richard E., 1995. Need for Ecosystem Management of Large Floodplain Rivers and Their Floodplains, Bioscience, 45, 168-182.**

## The River Needs:

### Clean Water

Water quality is affected by point and non-point source pollution. Excessive nutrients, chemicals and sediment loads threaten its biological integrity. To improve the quality of water of the UMRS, inputs from point and non point sources must be more effectively managed throughout the system. Inherent in this strategy is the need for monitoring and more effective partnerships among agencies and programs operating in the basin.

### Normal Rates of Sediment Transport

The transport of sediment is a natural function of rivers. But our modifications of the landscape, primarily the deforestation, agricultural development and urbanization of the lands within the basin have accelerated the rate of erosion of soil into tributary streams and the main channel of the river. This has reduced the fertility of the lands within the watershed and carried excessive amounts of nutrients and sediment into the river. The result has been degradation and loss of habitat in the floodplain. Improving habitat requires identifying significant sources and then reducing soil erosion and nutrient loading throughout the basin. Existing federal, state and local programs provide the tools. They must be more effectively used if we are to reduce sediment and nutrient inputs.

### Natural River Processes

Before there were channel training structures, levees, locks, dams, and dredging, river habitat was greatly influenced by periodic flood "pulses" and intermittent periods of low flow. Prior to these kinds of modifications the Illinois River, for example, had an annual protracted winter/spring flood pulse followed by a gradual decline to a summer low when *did I get the true perspective of the river…*

plants could grow on newly deposited mud flats and in clear shallow lakes and backwaters.

On the Upper Mississippi River there were two distinct flood pulses per year – a spring flood, followed by summer low water, then a smaller late summer/fall rise followed by a winter low water condition. Rates of change on the Upper Mississippi River were more rapid than the Illinois, but the same effect, the creation of mud flats and colonization of these flats and the backwaters, occurred during low water summer conditions.

Without channel training, locks, dams and levees, there was ample room in the floodplain for the water and sediment to meander back and forth, alternately creating and filling side-channels, backwaters and islands but always maintaining a diversity of habitat conditions.

These two conditions: (1) periodic flood pulses followed by lower water levels, and, (2) the ability of the river to meander in a wide floodplain, are important and necessary for the establishment of communities of plant and animal species and natural plant succession. The connections among the main channel, side channels and backwaters also provide for relatively unrestricted movement of fish as seasonal conditions change.

### Control of Exotic Species

Before the construction of the St. Lawrence Seaway allowing ocean vessels to travel into the Great Lakes (in 1959), there was a barrier to the introduction of exotic species brought by vessels from around the world. After the Seaway was completed, the ship canal connecting Lake Michigan to the Illinois River since 1900 became a pathway for the transport of exotic species and access to the entire system of rivers in the Mississippi Basin. Intra-basin dispersal of other exotics is a growing problem.

## Six Criteria of River Health

During the last 15 years scientists and resource managers have been taking the river's "vital signs" as part of the Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System. In April, 1999, the LTRMP released its first "Status and Trends Report"[11] for the river. The report described the following six criteria for river health and applied them to four river reaches:

- The ecosystem supports habitats and viable native animal and plant populations similar to those prior to any disturbance.
- The ecosystem is able to return to its preexisting conditions after a disturbance, whether it is natural or human-induced.
- The ecosystem is able to sustain itself.
- The river reach can function as part of a healthy basin.
- The annual flood pulse "connects" the main channel to the floodplain.
- Infrequent natural events (floods and droughts) are able to maintain ecological structure and processes within the reach.

These criteria and the information contained in the Status and Trends Report reinforce the discussion herein and lend support to this strategy. It will require a mix of tools and measures, at various spatial scales, to improve and maintain the river's health.

## Components of A Strategy for Operation and Maintenance of the UMRS Ecosystem

| Objectives | Tools or Measures | Goals and Benefits |
|---|---|---|
| **1 Improve water quality for all uses.** | More effective use of federal/state/local tools. | Meet Clean Water Act goals by 2010 |
| **2 Reduction in erosion and sediment impacts.** | More effective use of federal/state/local tools. | Target programs for improved results by 2010 |
| **3 Return of natural floodplain to allow channel meanders and habitat diversity.** | Implement 3-step effort: moratorium, no-net-loss, and acquisition from willing sellers. | Increase of 60,000 acres of floodplain forest and wetlands by 2010 and reduced flood damages |
| **4 Provide for seasonal flood pulse effect and periodic low flows to improve nutrient base, plant growth and succession.** | Design/implement operations at selected dams to mimic natural events and restore floodplain area & connectivity (open river). | Complete five new successful projects resulting in increased biological diversity and improved river health by 2010 |
| **5 Enable connectivity of backwaters to main channel.** | Incorporate into above measures and augment by site specific projects. | Restore 100,000 acres of aquatic habitat and add recreational benefits by 2010 |
| **6 Provide for opening of side channels, create islands, shoal and sandbar habitat.** | Use pool modeling and/or backwater dredging, water level controls, islands and channel modifications. | Restore 100,000 acres of sandbar, floodplain forest and island habitat and add recreational benefits by 2010 |
| **7 Manage channel maintenance and disposal to support ecosystem objectives.** | Seek ways to reduce dredging needs and manage to support ecosystem integrity. | Improve main channel fishery, reduce dredging needs, & test ways to manage for multiple uses |
| **8 Sever the pathway for exotics into and spread within the UMRS.** | Use physical barriers or other means. (New area of research and development.) | Economic and environmental benefits based on zebra mussel damages evaluation |
| **9 Provide native fish passages at dams.** | Modify dam structure or operations. | Improve populations of specified fish species |

# Nine Tools and Measures to Benefit the System

**Nine objectives** and nine types of "tools or measures" to meet those objectives are described in this chapter. Each tool or measure is designed to result in specific goals and benefits to the river system. The objectives are inter-related, recognizing that a river is a reflection of its watershed.

## 1 Improve Water Quality

### Objectives

The quality of the water in the river and its value for plants and animals in the system is dependent upon what is happening within stream systems and watersheds feeding the main stem of the river. Therefore, if water quality in the river is to be significantly improved, a broad approach must be taken. (In the case of some water and airborne toxics, only a global approach will truly address the issue.)

Current land use and land cover in the basin, interpreted from satellite photography, reveals that the UMRS basin is primarily agricultural, with extensive forest cover in the northeast reaches and, to a lesser extent, the southeast. Several large urban areas also exist on river main stems in the basin. In the northern reaches of the main stem high river bluffs add a unique ecological and scenic element to the landscape. In middle and southern reaches of the main stem, broad floodplains, leveed for flood protection and farming are evident.

In the aftermath of the 1993 flood, an extensive analysis was completed and published which added to our understanding of the biological characteristics of the basin. Planners, policy makers, scientists and resource managers now have access to more information than ever about the relationship of the river to its basin. The challenge is to apply this knowledge, understanding and skill in the interest of restoring and maintaining the ecological integrity of the UMRS. Fortunately, many measures that achieve this objective also reduce the threat to human life and property.

Much of the work that needs to be done to address this process must be done at the basin or stream network scales. There are several ways in which the basin can be segmented for planning and program purposes. One of the earliest overviews of the basin delineated 17 "Plan Areas" around 16 major tributary systems and the main stem.

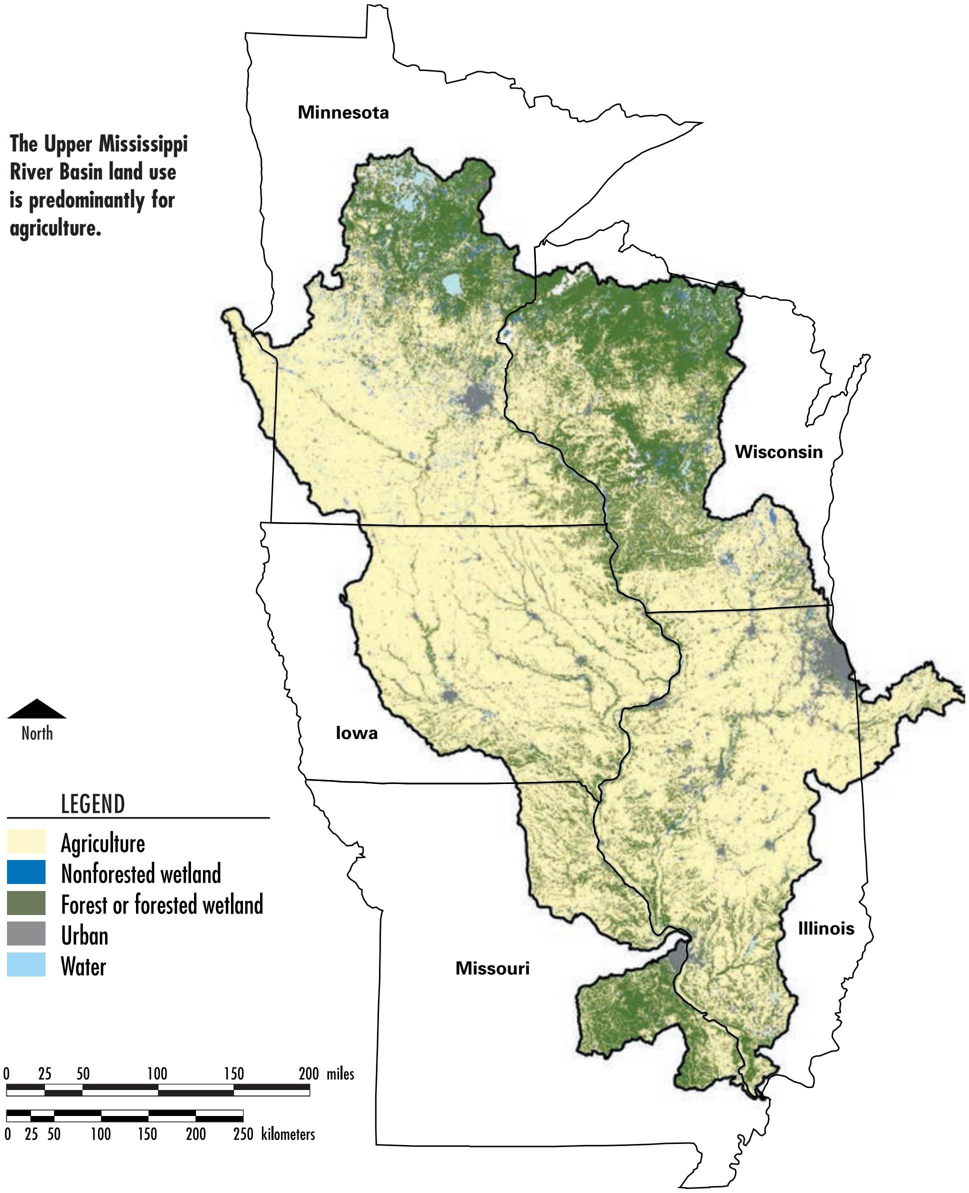
### Tools and Measures

Managing water regimes so that water quality is maintained at high standards to support the diverse life forms in the river requires two key tools:

- Targeted management of point and non-point source pollution and nutrients.
- Control of water and airborne toxic and non-toxic chemical inputs.

These tools and measures already exist within current government programs and are being implemented at the watershed scale with success in some areas. Examples for which there is current support include some significant partnerships in process on the Mississippi River in the Twin Cities Metropolitan Area where a major separation of storm and sanitary sewer systems was recently completed.

What is currently lacking is a deliberate effort to apply a "big picture" perspective at the UMRS




**The Upper Mississippi River Basin land use is predominantly for agriculture.**

basin scale. Until this is done, the design and implementation of these existing measures will continue to be fragmented and, likely, inadequate to meet the systemic needs of the UMRS. Addressing this problem at the basin scale is no small task, made more complex by the fact that the basin covers parts of five states and many tributary watersheds. Any agency or partnership of agencies which agrees to take a leadership role in this issue must be able to be a "keeper of the map" and be able to work at several geographic scales and with several levels of government.

There are models for such efforts elsewhere in the world, such as the work of the multinational International Commission for the Rhine River[12] and strategic planning being done on the Danube River[13] with support from the World Wildlife Fund (WWF).

## Goals and Benefits

All species that live in the water are perhaps the most directly benefited by clean, clear water. Aquatic plants, micro and macro invertebrates and fish immediately benefit by an improvement in their habitat – the water in the river.

Humans who use the river as their source of drinking water benefit by improved water quality conditions. Cleaner water in the river means less expensive efforts to make it suitable for public consumption. Cleaner water is more inviting and safe for humans for recreational pursuits – both an economic and environmental benefit to the nation. One example of a highly popular river within the UMRS, used intensively for recreation, is the Lower St. Croix. It has been documented to have more than 2,000 watercraft in active use on 52 miles of river on many weekends and holidays.[14] These levels of use are markedly higher than the main channel of the Mississippi River in the same vicinity. Both rivers are in proximity to a large metropolitan area. A key factor in the St. Croix's popularity is that it is significantly cleaner, safe for swimming and very popular as a fishery.

## 2

## Reduction in Erosion, Sediment and Nutrient Impacts

### Objectives

Soil erosion and the downstream movement of fine and coarse sediments begins in the uplands and tributary streams of the UMRS. While it is a necessary process which helps support life in the system under normal conditions, modifications to the landscape by human use and settlement have accelerated runoff, sediment and nutrient transfer rates to the detriment of fish and wildlife resources as well as to humans Now, about 60% of the basin is in agricultural use. Sedimentation rates from such tributaries as the Minnesota, Chippewa, Wisconsin, Maquoketa, Illinois and Missouri Rivers have been significantly increased since human settlement. In addition the sediment carries nutrients, pesticides, herbicides and other chemicals that may be toxic to fish and wildlife species in the rivers of the system.

To reduce upland and tributary erosion rates and reduce nutrient flows to the river requires a multi-faceted approach that begins in the uplands and continues down the tributary streams and main stem of the river. While we have long known that sediment and nutrients from the Upper Mississippi River basin can eventually travel all the way to the Gulf of Mexico, we are just beginning to evaluate the nature and extent of this problem. This research has been prompted by the documentation of what has become known as the "dead zone" in the Gulf where all available oxygen is being used to decompose nutrients from the Mississippi River. As a result both habitat and a significant commercial fishery has been greatly damaged.

**Scientists Say**

*"A growing body of evidence indicates that physical (geomorphic) processes and features control the* **biological diversity** *of large floodplain rivers, particularly at large spatial scales. Scientists generally agree that the ecological diversity and* **integrity of large floodplain** *rivers are maintained by fluvial dynamics (annual flood pulses and channel-forming floods) and river-floodplain connectivity. Anything that tends to suppress the natural flood regime or constrain channel migration will disrupt these interactive pathways and lead to reduced* **ecological diversity and integrity.***"*

**(Delaney & Craig, 1997)**

### Tools and Measures

Managing sediment and nutrient transfer to the main stem of the river to reduce the amounts, rate, and impacts at the basin scale requires three tools:

- Upland and stream bank soil erosion control.
- Reduction of the use of nutrients, pesticides and herbicides.
- Re-establishing meanders in selected reaches of tributary rivers.

The tools and measures already exist, and, in some places, are already being used very effectively. Throughout the UMRS and its basin, there are success stories of significant reductions in upland erosion rates, particularly where the Conservation Reserve Program (CRP) has been widely implemented on hilly land most subject to erosion. Some examples are the following:

- A concerted federal/state partnership effort in the Minnesota River valley where a multi-county joint powers agreement and strategic use of the Conservation Reserve Program and state programs is seeking reductions in sediment loading to the river system.

- A recent strategy adopted for the Illinois River basin is another example of a broad approach to applying workable and available programs to meet specific needs.
- A partnership effort on the Maquoketa River where the Iowa Natural Heritage Foundation, the Iowa Department of Natural Resources and the Natural Resource Conservation Service (NRCS) are working together to pinpoint areas of high soil erosion and runoff and treat them.
- The Floodplain Committee of the Upper Mississippi Summit is also evaluating the prospects for dechannelizing some of the tributary rivers such as the Zumbro, Upper Iowa, Maquoketa and Skunk rivers. This may require the purchase of some lands from willing sellers and is a program that has the potential to be implemented through a combined effort of public agencies and non-profit organizations.

### Goals and Benefits

A reduction in the amount and rate transfer of sediments from agricultural lands into the main stem of the UMRS will directly benefit the owners and operators of farms who will retain the topsoil and attached nutrients on the farm. This soil, which took centuries to develop, is the very foundation of our agricultural production. Most of the Upper Mississippi River Basin is losing soil at rates somewhere between tolerable (called "T") and twice the tolerable level or "2T" as defined by the U.S. Department of Agriculture. Where the Conservation Reserve Program has been applied, annual soil erosion has declined from 20.6 tons per acre to 1.6 tons per acre per year.[15]

The other beneficiaries of soil erosion control are the fish, wildlife and people who depend upon the waters of receiving streams and rivers in the watershed. Cleaner and less toxic water means cleaner and healthier life support systems for fish, wildlife and humans. The benefits of reduced sedimentation can be dramatic. For example, where backwaters are protected from sediment input, either due to natural barriers or man-made, the improvement of water clarity, plant growth, biological processes and development of aquatic invertebrates and vertebrates has been rapid and beneficial. These benefits accrue on a wider scale if we can reduce sediment inflow into entire backwater and side-channel systems in the river.


The Upper Mississippi River System.

## 3 Return of Natural Floodplain to Enable More Habitat Diversity

### Objectives

Within the UMRS floodplain, the most extensive modification made by humans has been the reduction in the acreage of natural floodplain area because of levee construction for flood control and to enable agricultural practices. Levee and drainage districts in rural areas and urban flood control projects, coupled with channel training, have restricted the river's normal ability to meander. They have also reduced the nutrient-ameliorating effects of the riparian zone and minimized or eliminated what is normally a continual process of scouring and filling

The extent to which this has occurred varies by reach. In the UMRS from the head of navigation to Rock Island, Illinois, a relatively small 3% of the floodplain is behind levees. In the reach from Rock Island to St. Louis, Missouri, some 53% of the floodplain is behind levees. In the Middle Mississippi, from St. Louis to the confluence with the Ohio River, 82% of the floodplain is now behind levees.

### Tools and Measures

A three-step process is recommended to increase the amount of floodplain available for natural river processes:

- First, establish and enforce a moratorium on levee construction projects pending a systemic assessment to determine where removal, lowering or retreat of existing levees would produce the most beneficial ecosystem results.
- Second, establish and enforce a no-net-loss policy on the quantity of non-leveed floodplain area.
- Third, increase the net gain of quality and quantity of habitat within the natural floodplain by selectively removing, lowering or retreating levees, and acquire floodplain lands from willing sellers. Use information from the Habitat Needs Assessment (in process at time of publication) to guide an integrated floodplain management and habitat restoration program.

In implementing this process, special attention should be paid to evaluating the highly diverse tributary/main stem confluence areas. The Upper Mississippi River Summit process has identified a list of candidate sites which should be considered as a first step. The valuable role that non-profit organizations and voluntary programs could play as partners in this strategy needs to be recognized and supported. Public/private partnership efforts may play a particularly valuable role in this effort.

### Goals and Benefits

The most direct benefit will be an increase in wetland habitat acreage in a region that has lost more than 314,000 acres of wetland between 1982 and 1992.[16] Because of continuing decline in the availability of wetland habitat in other parts of the basin, the main stem of the Upper Mississippi and Illinois Rivers are increasingly important places for aquatic species and migratory waterfowl. The benefits to the nation will include additional recreation opportunities and the economic expenditures associated with those opportunities.

Perhaps the most significant benefit will be a reduction in the frequency and intensity of flooding and resultant flood damages. The U.S. Army, Corps of Engineers and interagency assessment teams have documented these benefits in post-1993 flood studies.

**Scientists Say**

*"The dynamic* **interaction between water and land** *is the principal process that produced river-floodplains, maintains them, and has affected adaptations of biota that have evolved therein. The* **flood-pulse concept** *was developed to summarize these effects on the biota using available information from tropical and temperate systems. (Junk, et al. 1989)... The flood pulse is postulated to enhance biological productivity and* **maintain diversity in the system.** *The principal agents associated with this typically annual process are plants, nutrients, detritus, and sediments... A gradient of plant species adapted to seasonal degrees of inundation, nutrients, and light exists along the* **aquatic/terrestrial transition zone.**

(Junk et al. 1989), which is subsequently referred to as the floodplain."(Bailey, BioScience Vol.45 No.3)

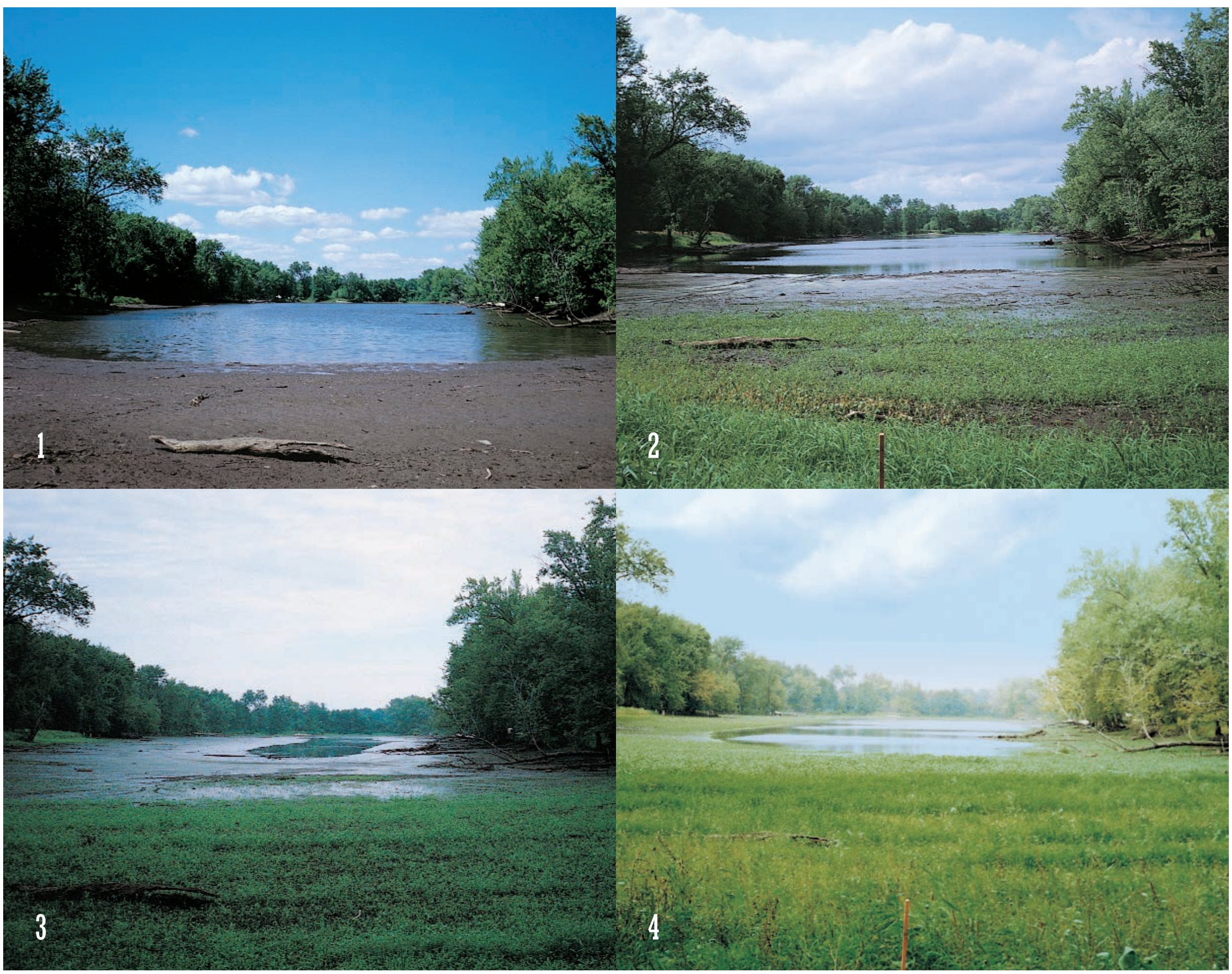
4

## Seasonal Flood Pulse and Periodic Low Flow Conditions

### Objectives

Within the floodplain of the river there is a place technically called the "aquatic/terrestrial transition zone". It is located on the riverbank and on islands between the highest and lowest points covered by water. In a meandering river with multiple channels and natural changes in water levels, there may be several such areas along a typical floodplain cross-section. The seasonal flooding within a floodplain and the periodic low water levels provide a diversity of physical and biological conditions which river species have adapted to. The diversity of habitat conditions and the diversity of species composition are dependent upon both flood pulse and fluctuating water levels. This changing interface between land and water, particularly on large floodplain rivers, is what makes this ecosystem unlike any other.

On the UMRS, particularly in the floodplain just above each of the navigation dams, the normal flood pulse has been attenuated and, in some places, even inverted. These dams, built and operat-




**Water Level Management Projects, such as this temporary water level reduction at Peck Lake backwater can bring immediate habitat benefits.**

ed to maintain minimum channel depths, have also stabilized higher water levels during the summer months when, under normal conditions, lower flows and reduced water depths would have exposed many mud flats and transition zones. Further, where we have constricted the river by levees and lined the natural riverbank with dikes, floodwalls, and rock, we have seriously impaired the opportunity for the dynamic interaction necessary to sustain biological integrity.

### Tools and Measures

Two measures could be implemented to provide for, or mimic, the natural processes of flood pulse and fluctuating water levels.

- Modify operation of the dams.
- Implement water level reductions at reach, pool and site scales.

Although not applicable everywhere on the UMRS, changing the operating procedures of dams from control at the midpoint of the pool to control at the dam itself would be beneficial. In some pools this may require the acquisition of additional easements or fee title to lands which would be flooded.

This could be augmented by periodic water level reductions to compact and dehydrate sediments and restore vegetation in selected areas. These reductions could take place along extensive river reaches, within one or a selected series of pools.

The potential for more extensive use of these measures is currently being explored. Water level reductions have already been implemented in pools 24, 25 and 26 at the pool scale and in pool 5 at the site scale, as a demonstration of this measure. Multi-agency teams in three UMRS Corps of Engineer districts have been evaluating other sites, pools and reaches as candidate areas for use of this measure and are currently focusing on pools 8 and 13.

### Goals and Benefits

Where water level management has been implemented, the benefits have sometimes been immediate. The compaction and stabilization of sediments, the growth of new plant life and the subsequent improvement in habitat, are the types of benefits that can be provided on a much broader scale on the UMRS.

The long-term benefits could include the creation of the underlying conditions necessary to support greater plant and animal diversity. This is yet to be determined. But there is much documented evidence in the field of ecology that plant and animal species diversity is one of the primary criteria for maintaining the health of an ecosystem. Each step we can take to restore and maintain native species diversity is a step in support of the long-term health of the river.

The benefits of a healthy river convert into recreational benefits for people who hunt, fish, bird-watch, camp, clam and sightsee on the river. There is virtually no place on the Upper Mississippi and Illinois Rivers that have not suffered from simplification of habitat or a reduction in the abundance of native species. Therefore, simply reversing the trend and moving toward increased diversity of conditions and a rebuilding of some species populations will be significant steps in the right direction.

## 5

## Restore Backwater/Main Channel Connectivity

### Objectives

The wide floodplains of the UMRS prior to the construction of the extensive levee system and locks and dams provided for a mosaic of habitat conditions. At high flow conditions, areas normally isolated from the main channel flows would be reconnected, allowing for nutrient exchange and fish movement to areas most conducive to fish spawning or rearing. Under low flow conditions, some backwaters would again be isolated and mud flats exposed, as earlier noted. In some cases, isolation of side channels may also be beneficial under these conditions.

The relationship between backwaters and the main channel have been simplified due to dam construction, the placement of dredged material, sediment accumulation behind the dams, and side channel blockages. Some have termed this simplification process "pool aging" and note that, eventually, each of the navigation pools, without any further management on our part, will reach a new equilibrium. How long this will take will vary by reach. Pool aging, under current management practices, will lead to increased simplification and loss of habitat diversity. It could result in greater habitat diversity if, in the process, we are able to allow the river to erode and create new side channels and backwaters in some places, and create new islands and terrestrial habitat in others.

## Tools and Measures

The use of tools and measures 1-3 would aid in improving the connectivity between main channel and backwaters. Examples are described in the Environmental Management Program, Report to Congress (December 1998). These measures should also be taken into consideration in the development and implementation of channel maintenance management plans in each Corps of Engineer district on the UMRS.

**The Environmental Management Program has resulted in several habitat rehabilitation and enhancement projects to support fish, wildlife and recreation.**

Measures that can be instituted at the site scale include:

- Backwater dredging
- Water level management (dikes and water control systems)
- Secondary channel modifications
- Island Restoration

The costs of these measures (which sometimes only mimic natural conditions rather than provide the physical conditions for sustained biological renewal) have been a matter of some concern in the past. For the long term, the use of these measures may be most beneficial if they are used to augment more systemic measures and tools.

## Goals and Benefits

The primary benefits will be increased genetic diversity across the system and improved biological productivity in specific reaches. On the UMRS there are, at a minimum, 255,000 acres of aquatic habitat in the pooled reaches of the Upper Mississippi River, 61,000 acres in the open river reach, and 81,000 acres on the Illinois River that could immediately benefit by implementing backwater restoration activities.[17]

The national benefits of improved backwater habitat would accrue to all recreational users who enjoy hunting, fishing, small boat and canoe touring and camping, nongame species observation, and, perhaps least observable but very important, the preservation of genetic diversity. We are only recently beginning to understand the biological and medicinal value of the preservation of genetic diversity.

## 6 Management of Sediment Transport, Deposition and Side Channels

### Objectives

The management of sediment transport and deposition within the river floodplain may be the best means of accomplishing site-specific changes to the river and moving us toward fulfillment of ecosystem objectives. Since sediment in the floodplain is carried by water, the management of water processes (magnitude, frequency, direction, timing and rate of change) serves two purposes.

These measures would be unnecessary if normal geomorphic river processes were allowed unconstrained. But, because we have so dramatically influenced the river processes and the floodplain ecosystem, we must now also manage sedimentation processes to meet ecological objectives. Most of the measures are designed to address specific sites in the floodplain.

### Measures and Tools

Innovative tools and measures mentioned in the previous section should be augmented by more traditional projects. The following have potential for habitat rehabilitation and enhancement and are currently being used at 48 sites on the UMRS (see map on next page):

- Island creation and stabilization
- Selective water flow introduction
- Selective backwater isolation
- Side channel modifications

**Island creation projects** are being implemented with the goal of reducing river flow or wave energy that transports or resuspends sediments. On the upper reaches of the river they are used to replace islands that have eroded by river currents and wave action. In the southern reaches they are used to protect existing islands or to create islands in large, open backwater areas. It may be useful, in evaluating future projects, to compare the costs and benefits of natural island creation (through sediment management) versus physically building new islands by mechanical means.

**Introduced flow projects** are devised to counteract oxygen depletion in backwaters or isolated side channels. These projects either remove obstructions or construct dikes with water control structures. These projects are designed to raise oxygen levels in backwaters and, in some locations, modify flows and water temperatures to provide over-wintering sites for fish.

**Backwater isolation projects** are designed to manage sediment input and, in some cases, enable

**Scientists Say**

"**Upper Mississippi River** *ecological integrity has been severely compromised by human activity during the last 50 years. In response to the continuing* **decline of natural resource values,** *two approaches for protecting and improving the Upper Mississippi River-floodplain ecosystem have been used. Habitat rehabilitation and enhancement projects are being constructed at 54 locations to provide site-specific rehabilitation. The projects are designed to counteract the adverse ecological* **effects of sedimentation** *through (1) flow introductions; (2) isolation of backwaters, and (3) flow diversions and water breaks. Channel maintenance projects are being re-evaluated in an attempt to construct or modify existing river training structures that are environmentally sympathetic. The latter works with the river's energy whereas the former attempts to overcome riverine processes. Both approaches have* **significant limitations** *because they affect limited areas.*"

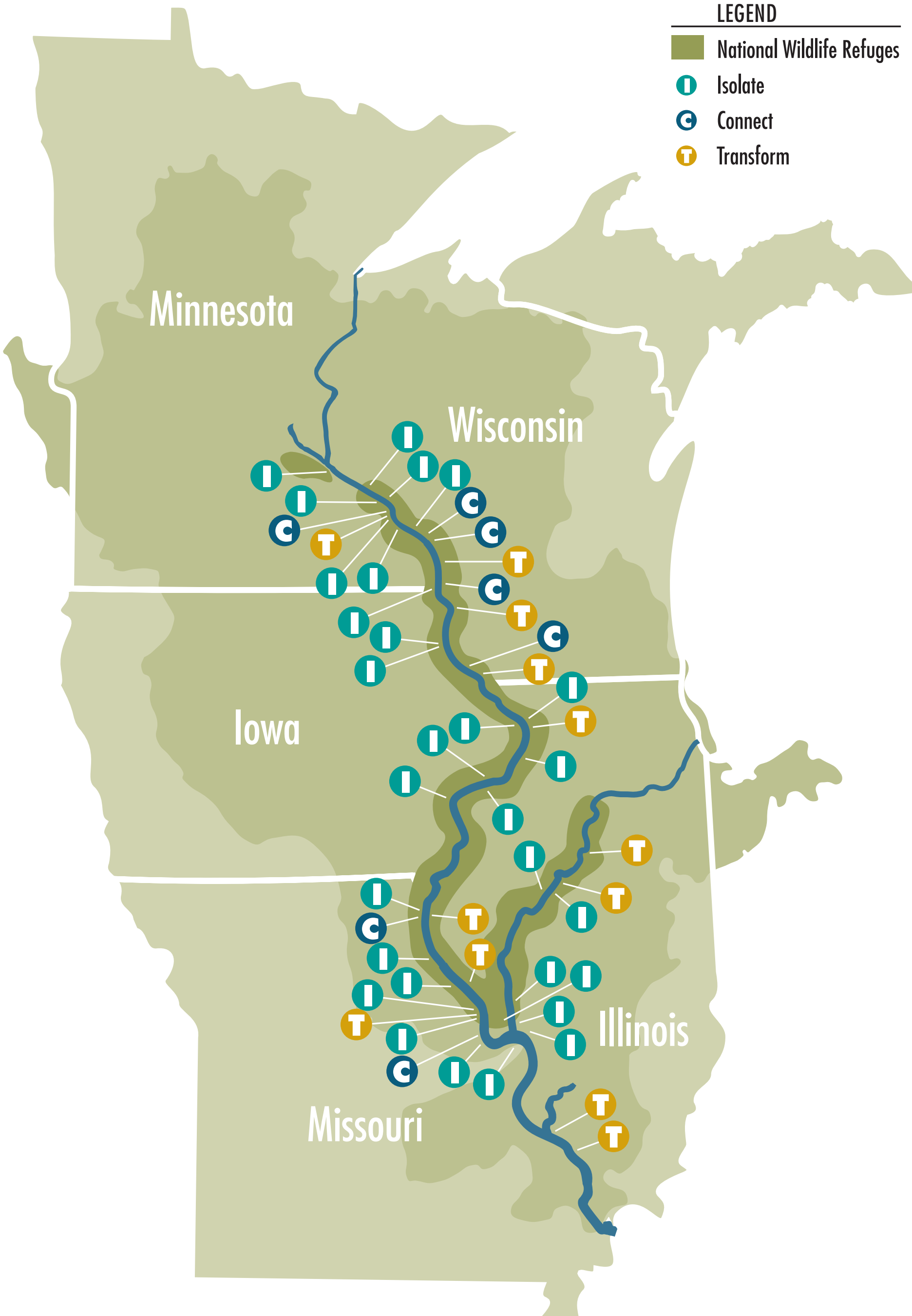
**Theiling, Regulated Rivers: Research and Management, Vol 11, 227-238 (1995)**

site-specific water level management measures. These projects involve dike construction, pump installation, the design of a water level management strategy, and monitoring. Depending upon the management objectives (such as the production of food or nesting area for migratory waterfowl or fishery habitat) the design and management of sites may vary.

Isolation and artificial management of backwaters is recognized as necessary under current management practices. It may always be necessary as long as locks and dams exist in the system. Over time, however, resource managers hope that restoration of natural river processes can minimize the need for such projects.

Side channel modifications have been implemented for at least 25 years on the river, beginning as early as the GREAT studies in the mid-1970s. The strategy for designing and constructing side channel projects for intended benefits has been enhanced as a result of more recent efforts to model various options in advance and test the results either with computer models or tabletop models. Pretesting of projects by modeling a river reach and trying alternatives on the model are currently in use as part of the river engineering program in the St. Louis District of the U.S. Army Corps of Engineers. (For example, the recent Sante Fe Chute side channel modification project in the open river reach was first modeled on the tabletop scale before being constructed in the field.)

Because the above-described projects have performance monitoring programs built into their design, operation and budgets, they have not only the potential




**Examples of Current Habitat Rehabilitation and Enhancement Projects on the UMRS.**

to provide the desired physical and biological results, but they provide a learning opportunity for future river management activities.

### Goals and Benefits

The benefits of the above measures are similar in nature to those described earlier. They are, however, relatively expensive compared to applying more systemic, and less expensive, tools and measures which employ the river's natural sediment and nutrient transport capabilities.

In the early 1980s the Environmental Work Team for the Upper Mississippi River System Master Plan estimated that there was the potential to improve a minimum of 277,000 acres of semi-aquatic and terrestrial habitat in the pooled reaches of the UMRS. In addition, the team recommended restoration potential for another 144,000 acres of terrestrial habitat in the open river reach of the UMRS and 11,000 acres of terrestrial habitat on the Illinois River[18]. We now have an opportunity to update those estimates through the completion of the Habitat Needs Assessment in process as this report went to press.

The species that depend on the National Wildlife Refuges and the other areas (such as shore birds, egrets and herons, amphibians, reptiles and mammals) would all benefit by protection, restoration or enhancement of some 300,000 acres of semi-aquatic and terrestrial habitat in the UMRS. This would be a significant recreational and related economic benefit to the nation.

## 7

## Manage Dredging and Channel Maintenance

### Objectives

Channel maintenance activities on the UMRS provide economic benefits but often conflict with efforts to sustain the ecological integrity of the system. We should strive to either minimize negative impacts or provide positive impacts on the river ecosystem. Activities that should be evaluated for improvement include:

- Main channel dredging
- Dredged material disposal
- Wing dikes
- Bank revetments
- Side channel closing dams and side channel structures to create channel meanders

Dredging and disposal of dredged material has been documented to have significant cumulative adverse impacts. This activity is managed somewhat differently in each of the three Corps of Engineer districts in the UMRS. In the St. Paul and Rock Island Districts, channel maintenance plans were one of the most extensive products of the Great River Environmental Action Team reports completed in the late 1970s.

Since then, these plans have been used to guide the channel maintenance program in both districts. Multi-agency on-site inspection teams advise the Corps particularly on matters of material disposal. In the St. Paul District, the process has been taken a step further with the development of an extensive Channel Maintenance Management Plan, recently completed but still under review by partner agencies.

More recently, the "Avoid and Minimize Program" in the St. Louis District of the Corps of Engineers has provided innovative approaches to river engineering. This program is addressing several options for improvement of river habitat in that portion of the UMRS which carries not only the flow of the Upper Mississippi River Basin, but the flow of the Missouri River as well.

Wing dikes, perpendicular stone dikes extending from bank lines, have long been used to constrict the flow of water toward the navigation channel during times of low flow. Sediment

**Dredging is required to maintain the nine-foot navigation channel.**

accumulation between the dikes, particularly in the Middle Mississippi, has resulted in conversion of these areas from aquatic to terrestrial habitat. In other areas, where these dikes remain below the water surface (as in the case of much of the pooled river) these areas have value for the sport fishery. Notching of wing dikes is one way to create depth diversity.

Bank revetments are used to maintain shoreline structure. They, by design, interfere with the natural tendency of the channel to migrate within its floodplain. In Pool 24, the use of large Type A (5,000 lb.) stone for bank revetments provided improved fish habitat over that provided by smaller stone[19]. Accompanying this effort, bank grading and clearing of vegetation and the destruction of the transition zone between land and water occurs.

Side channel closings (rock and/or earthen dams) have accompanied dredging, wing dams, and revetments as a means of maintaining the navigation channel. As the term implies, dams are constructed to reduce or eliminate the flow of water out of the main navigation channel, thereby maintaining water depths required for navigation. The resultant elimination or reduction of flows into backwaters and side channels destroys or impairs aquatic habitat conditions by affecting water quality and quantity and the exchange of nutrients. It further impedes movement of species and can block areas important for the river fishery.

In some side channels, it may be beneficial to place rock structures to recreate channel meandering, such as was done in Sante Fe Chute in the Middle Mississippi reach.

### Tools and Measures

To reduce the impacts of channel maintenance activities and in some cases actually improve habitat, six measures should be used where determined to be appropriate:

- Improving channel maintenance and dredge material disposal through changes in channel maintenance management plans
- Notching of existing wing dikes
- Constructing off-bankline revetments as an alternative to bank stabilization
- Constructing chevron dikes as an alternative to closing dams
- Using bendway weirs
- Removing or modifying selected closing dams

The strategy outlined in the Channel Maintenance Management Plan developed by the St. Paul District of the Corps of Engineers holds promise as a template for interagency cooperation and reduced ecological impacts. Such a strategy, with adaptations for regional differences, should be considered as a system-wide goal. Off-channel disposal, in particular, needs to be addressed in lower pools.

Notching of wing dikes has been used in many locations and may be useful to create scouring, reduce bed aggradation, and improve conditions which would support greater numbers of fish species and abundance.

Off-bankline revetments are being tested in the St. Louis District (Blackbird Island, for example) to reduce bank stabilization costs and increase habitat diversity in the main channel. These hold promise, particularly if accompanied by refined dredging and disposal techniques in the same reaches.

In some locations, chevron dikes may be an effective alternative to closing structures in side-channels. These dikes, as the name implies, are v-shaped rock structures placed facing downstream and staggered to provide an effect similar to a solid structure. They can be designed to allow the river to sculpt the riverbed (and dredged material deposited there) into a more diverse physical environment.

At river bends, where erosion of the outside of the bend is a continuous threat and deposition on the inside a maintenance problem, a new type of structure is being tested. Called a "bendway weir" the structure consists of a series of submerged dikes, constructed around the outer edge of the river bend. The dikes are constructed low enough to allow passage of tows over them and they are angled upstream perpendicular to divert flow in a progressive manner to the inner bank. The resultant channel bottom provides increased hydraulic diversity while also reducing scouring of the bank line. These areas are difficult to monitor, but there is hope that, over time, some ecological benefits in a big river environment can be demonstrated.

**Scientists Say**

*"Although* **restoration of large rivers** *to a pristine condition is probably not practical, there is considerable potential for rehabilitation, that is, the partial restoration of riverine* **habitats and ecosystems.** *Renewal of physical and biological interaction between the main channel, backwaters and floodplain is central to the rehabilitation of large rivers. Experience with large river rehabilitation is rare relative to smaller streams, probably due to the cost and the complexity of the physical and biological systems involved... Proposals and concepts for large river restoration are much more abundant than are demonstrations. However, it has been demonstrated that* **localized rehabilitation projects** *have been successful. The challenge that awaits those who value rivers is to readdress this imbalance while protecting large rivers from further degradation."*

**(Gore and Shields Jr., BioScience Vol 45 No.3.)**

## Goals and Benefits

The main channel and main channel border habitats of the UMRS are perhaps far more important resources than many resource managers originally thought. On the open river reaches, recent sampling indicates that the deep main channel areas are home to greater numbers of fish and greater numbers of species than was previously known.

To the extent we can reduce dredging requirements by improved channel management (structural and non-structural measures) we can minimize disruptions in the channel and along main channel borders.

Measures which result in a reduction in negative impacts of channel maintenance activities could have the added benefit of showing that it is possible to maintain and manage a large floodplain river for both navigation system and ecosystem benefits. If channel maintenance

**Zebra mussels encase native mussels on the Illinois and Mississippi Rivers.**

and management activities continue to result in significant negative (and cumulative) impacts to the ecosystem, it becomes increasingly difficult for resource managers and the public who benefit from the natural resources of the river to support continued operation and maintenance activities for commercial navigation.

## 8 Sever Pathways for Exotic Species

### Objectives

Exotic species migration from Lake Michigan to the UMRS via the Chicago Ship Canal is an ecological threat whose magnitude and seriousness has only in recent years become a matter of common discussion among resource managers. Increasingly, scientists, resource managers and environmental groups are suggesting that more attention be paid to the prevention of exotic species introduction to the UMRS. At the 1999 Upper Mississippi River Summit, several environmental groups submitted a joint paper expressing concern about this problem and suggested the use of "dispersal barriers" as one means of controlling the spread of some species.

### Tools and Measures

Tools and measures to address this problem are not yet well defined. In order for resource managers and scientists to be able to find solutions, it is critical that federal and state agencies request and receive additional funds specifically to attack this problem.

### Goals and Benefits

The ecological and environmental damage already done because of the introduction of the zebra mussel to the UMRS is known to be extensive, if not yet quantified. The damages, even when totaled, will be "after the fact." Thus, to determine the benefits of prevention of future similar infestations, we might take a lesson from the zebra mussel story. One of the lessons we should have learned is that it is critical to thoroughly evaluate proposed projects prior to making major physical changes to river systems.

## 9 Provide Opportunities for Native Fish Passage at the Dams

### Objectives

We have long known that dams block movement of certain wide-ranging fish species. A study of the Keokuk power dam (completed in 1913) found that the dam affected movement of paddlefish, American eel, skipjack, shad, buffalo, gar, drum, carp, catfish, sturgeon and sauger.

In much more recent studies, navigation dams have been shown to hinder at least upstream movement of certain species. Much of this movement is related to the reproductive cycle. Thus restrictions in movement can affect reproductive success and population numbers. As biologists have come to realize that adequate spawning habitat for certain species may not be available in every pool of the river, passage of fish through the dams has become of greater concern. These species may be able to reproduce successfully only in years where floods put the dams out of operation during spawning periods.

### Tools and Measures

Dam rehabilitation and major construction at some of the locks may offer opportunities in the near future for construction of fish passageways as mitigation. However, the modification of operation of certain dams could provide an immediate solution if velocities through the dam gates are reduced to a level surmountable by fish moving upstream. It may be possible to manipulate the locks to entice fish into an open chamber, then "lock through" those fish.

### Goals and Benefits

Improved fish passage could result in more consistent reproductive success of several species, leading to expanded populations. Greater abundance would assist recovery of species such as paddlefish, and improve fisheries for sport and commercial species.

## Moving Toward Success

A strategy for restoring and maintaining the ecological integrity of the UMRS can be described as a logical progression through a series of steps and scales, each more directed and at a smaller geographical scale than the next. Although actual on-the-ground projects at each scale may be quite local, the intention is that choices made at each scale are based on whether or not the policies, programs and projects under consideration will move us toward, or away from, the stated mission and objectives of this strategy.

To initiate an evaluation of which tools and measures may be most appropriate and at what scales, the UMRCC and the National Audubon Society are completing a first-cut evaluation. The product, which will be called An Atlas of Habitat Restoration and Protection Opportunities, will be completed in 2000.

The maps will: (1) illustrate the nature and extent of changes that have occurred within the floodplain of the UMRS due to human modifications and (2) describe and recommend tools and measures, and appropriate scales for implementation.

The maps will be based upon information gathered at public meetings and from resource managers. The final report will be available to users upon publication.

**Logical Progression of Tools, Measures and Scales For Successful Natural Resource Management of the UMRS**

| System Input | Physical Processes | Biological Output |
|---|---|---|
| **Management of Water and sediment Sources and rates. (basin and watersheds)** | **Maintain and restore natural physical processes (reaches and pools)** | **Habitat succession, species abundance management (pools and sites)** |

*For the river is*

*a world apart.*

*It is a liquid*

*avenue endlessly*

*in motion ...*

# Leadership and Implementation

**People and agencies** make decisions every day that will move us closer or further away from meeting the goals described earlier in this document. This chapter issues a call for action and leadership by the many agencies, organizations and people who affect river policy now and will do so in the future. It concludes by suggesting the "next steps" that we need to take to leave a legacy of a "River that Works and a Working River."

## Using Appropriate Geographical Scales

A rational approach to ecosystem management must begin at the basin scale and work inward through the subsequent series of smaller units within it. Envision, if you will, the childhood toy consisting of a series of barrels. The smallest barrel (an island or backwater marsh) fits inside of a larger barrel (the pool or river reach) which fits inside of a larger barrel, which is the river floodplain, which fits inside of a larger barrel, which is the river basin.

### The Basin or Watershed

If we are to be truly effective in the long run, we must extend our efforts or form working relationships with other agencies or groups to develop an integrated management plan that includes the entire basin or watershed. To do this in a way that is affordable and takes advantage of the many programs and agencies already in existence, we need to create a better mechanism for, and commitment to, interagency and public/private planning and management at the basin scale.

In certain stream networks, assemblages of habitats, and plant and animal communities may be critical components of the larger UMRS ecosystem. Where these exist, they need to be addressed through special planning and management efforts. An example of such an effort currently underway is in the Minnesota River Watershed, where a 32-county joint powers board is addressing problems of land use and water quality on both the main stem and tributaries. The Integrated Plan for the Illinois River Watershed is also a step in this direction.

### The Floodplain, River Reaches and Pools

In turn, and nested within that basin plan, an integrated floodplain ecosystem plan is needed. Where possible, for example, locks and dams should be used to manage water levels, on an opportunistic or systematic basis, to mimic the natural hydrograph, to gain the ecological benefits of natural flood pulses and the subsequent low water conditions.

Between the Quad Cities and the confluence with the Ohio River, a long term program to remove or set back flood protection levees, to allow a more ecologically diverse floodplain would provide one of the single most valuable contributions we could make to a systemic restoration of the biological diversity of the river. When flood damages or other economic factors lead to the availability of land from willing sellers, we should capitalize on every opportunity to reconnect that land to the river ecosystem.

Within river reaches, tributary confluence areas should be managed to optimize their ecological diversity. Habitat which has been degraded by sedimentation of backwaters and side channels could be renewed by re-integrating them with the main stem of the er and replicating the exchange of nutrients and species that would occur in an unconstrained river.

### Site Specific Project Areas

Where it is not possible to mimic or re-establish natural large river floodplain conditions on a large scale, it may be possible to manage for desired conditions at a site-specific scale. The current Habitat Enhancement and Rehabilitation Project (HREP) of the Environmental Management Program is testing various means of improving habitat through site-specific projects. Each project has an ongoing monitoring program that will help us assess success and future application opportunities.

### The Opportunity Spectrum

To obtain a healthier, more diverse, "Living River" system, we need a more active and extensive program of natural resource system operation and maintenance than we now have. An integrated program needs to seek results across the spectrum of geographic scales.

It is clear that, at least for a while, we will need to work from both ends of the spatial scale (watershed to site-specific) toward the middle (the pool-scale). At the same time we are implementing an overall ecosystem management strategy for the entire river, we need to continue to use and improve upon our existing efforts through the Environmental Management Program, the Avoid and Minimize Program and other existing avenues for improvement. The Habitat Needs Assessment (HNA) started in 1998 and expected to be complete in 2001, is another opportunity to provide further guidance toward an integrated program of river management.

River restoration on such a complex system within such a large watershed is not accomplished simply by adopting a plan or even one strategy. It is accomplished by setting goals, taking steps to reach those goals and, in the process, constantly adapting what we do as we continue to learn from our actions and new information.

## Existing Institutions

For nearly a quarter century – ever since a nine-volume Upper Mississippi River Comprehensive Basin Study was prepared for the United States Water Resources Council in 1970-1972, policy makers and others have debated the issue of geographic scale in water resource planning. Since then, various agencies and groups have worked on issues from as broad as basin plans on one end of the continuum to site-specific dredge material disposal site plans on the other.

In the ensuing years we have made attempts to address river issues at several scales. Some examples are:

- Great River Study Plans at three Corps of Engineers district levels
- Refuge Master Plans at the refuge scale
- The Upper Mississippi River System Master Plan at the main stem river system scale
- "Level B" plans at the river reach scale
- A Channel Maintenance Management Plan at the Corps of Engineers district scale
- Several specialized plans for specific reaches
- Site plans for EMP Habitat Rehabilitation and Enhancement Projects

We have not had an overall planning authority like the Water Resources Council or the Upper Mississippi River Basin Commission since 1981. Thus, any elements of a strategy which would suggest work at a basin scale would most likely have to be done by voluntary action among federal, state or local agencies, non profit organizations, or some combination of these entities. The other option would be the re-institution of some overall planning authority once again.

The Upper Mississippi River Basin Association (UMRBA), created by and funded by its five state members (Illinois, Iowa, Minnesota, Missouri and Wisconsin) provides for non-voting federal agency participation. As such, it most closely represents its predecessor, the Basin Commission.

The governors of all five states recently signed a proclamation affirming their participation in and support for the Association as the forum for working together and with federal agencies on issues of common interest and concern on the UMRS.

The UMRBA helps coordinate the work of the Environmental Management Program Coordinating Committee and provides a forum to address many inter-jurisdictional issues. This forum would be a good vehicle for inter-agency discussion of this report and its recommendations.

Another move toward unification of effort has occurred within the U.S. Army Corps of Engineers. In 1997, at the direction of the U.S. Congress, the Corps initiated a restructuring process which resulted in the elimination of the North Central Division and consolidation of the St. Paul, Rock Island and St. Louis Districts under the singular command and control of a new Mississippi Valley Division. This has expanded the geographic territory of the Mississippi Valley Division to include the entire length of the Mississippi River.

*a restless pathway which is never the same from one minute to the next or from one mile to another...*

Since 1997, the Division, along with the Mississippi River Commission, has annually toured the Mississippi River from the head of navigation to the Gulf of Mexico, holding public hearings and briefings along the way. The extent to which the Mississippi River Commission may expand its involvement or membership to include the upper reaches of the Mississippi River is yet to be determined. Other institutional partnerships and agencies that are opportunities for implementation of this strategy include:

**1.** The existing River Resources Forum in the St. Paul District of the Corps of Engineers, the River Resources Coordinating Team in the Rock Island District (both outgrowths of the Great River Environmental Action Teams – GREAT – in the 1970s) and the River Environmental Engineering program in the St. Louis District.

**2.** The Environmental Management Program Coordinating Committee (EMPCC) with staff services of the Upper Mississippi River Basin Association.

**3.** The UMRCC itself, with its technical sections and executive committee and coordinator provided under agreement with the U.S. Fish and Wildlife Service.

**4.** The now combined programs of the USGS Upper Midwest Environmental Sciences Center (the former Environmental Management Technical Center and former Mississippi Science Center).

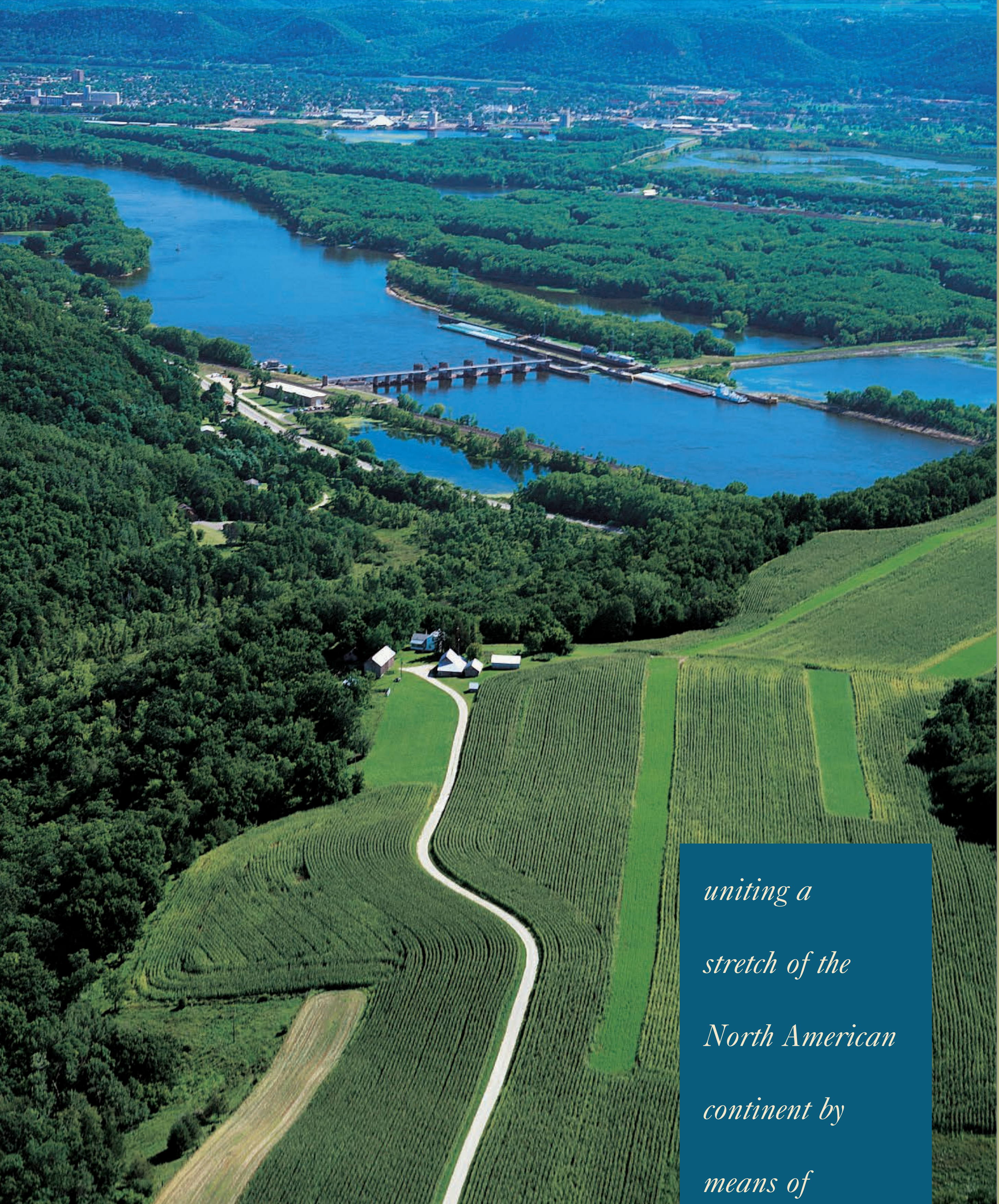
**5.** The U.S. Department of Interior, Fish and Wildlife Service, through its refuges. Fisheries and Ecological Services field offices and regional headquarters.

**6.** The U.S. Environmental Protection Agency and its emerging Mississippi River program and the U.S. Department of Agriculture (particularly for addressing toxics, endocrine disrupters, upland water quality and sediment control plans, programs and projects.)

**7.** The National Park Service, particularly in urban areas, and sometimes in association with local government and museums throughout the UMRS, as a provider of public information and interpretation services about the river and its cultural and natural history.

**8.** Partnerships such as The Mississippi Interstate Cooperative Resource Association (MICRA), representing fisheries management coordination on inter-jurisdictional fisheries shared throughout the Mississippi River Basin.

**9.** The numerous non-governmental organizations, such as the affiliates of the four-state Blufflands Alliance, and the river-related programs of groups such as the World Wildlife Fund, American Rivers, the Sierra Club, the Nature Conservancy, the National Audubon Society, the Izaak Walton League, the Environmental Defense Fund, the Mississippi Basin Alliance and others, through their land protection activities, public information and education efforts, habitat restoration and river advocacy programs.



*uniting a*

*stretch of the*

*North American*

*continent by*

*means of*

*2,552 miles of*

*running water…*

In addition to the above, the U.S. Coast Guard, the Federal Emergency Management Agency, the Federal Energy Regulatory Commission and the U.S. Maritime Administration all have some level of authority and responsibility on the UMRS, but it is unlikely that any of them would play a major role in implementing the strategy recommended herein.

## Agency Leadership

Decisions are constantly being made about policies, programs and projects that affect this system. To move from the status quo toward a more integrated and effective strategy for river management will require leadership, partnership and innovation. It will require representatives of states, agencies and organizations who are:

- Willing to assume leadership responsibility.
- Committed to working in partnership toward successful implementation of this strategy.
- Willing to explore innovative strategies and ideas within existing authorities.

The Upper Mississippi Basin Association (UMRBA) and the Environmental Management Program Coordinating Committee (EMPCC) are the two existing partnerships available through which federal and state agencies and other interests can work together on systemic and basin-wide issues. These groups meet in conjunction with each other quarterly.

The UMRBA is the natural forum for inter-agency evaluation and consideration of the recommendations for leadership contained in the matrix (see page 38). Each lead agency or entity recommended in the matrix should, as a next step, adopt an action plan, budget and working schedule to move the strategy forward.

Agency leadership and public funding for this strategy will, by necessity, have to come from several sources and through several agency budgets at the federal, state and local levels.

## Public and Non-Profit Organization Involvement

Non-profit organizations, with the help of private contributions and foundation support, are in a position to:

- Provide information to the public, other organizations, resource managers and agencies.
- Be advocates for the river ecosystem and seek citizen, agency and congressional support for programs that will restore and maintain the ecological health of the river.
- Work as strategic partners in the implementation of the tools and measures described in this report.

This strategy needs a strong and lasting public involvement element. Both agencies and non-profits should look for opportunities to make better use of electronic and print media, using some well-developed themes which reach both urban and rural audiences.

All avenues should be explored for implementation, including working agreements with non-profit organizations. With the recent surge of interest in the Upper Mississippi River by non-profit organizations and strong support from foundations, corporations and individuals, there is fertile ground for the development of new public/private partnerships.

In the last 50 years, river scientists and managers have monitored, studied and watched the decline of the UMRS ecosystem. While we have reduced sediment input in some areas and improved water quality in others, we have not done enough. More needs to be done. There are steps we can take to restore the system and protect it for the future. There is a wide spectrum of costs and rates of success in the field of habitat restoration and ecosystem management. The ecological and economic benefits and costs will vary depending upon the choices we make. The strategy described herein is based upon six underlying concepts:

## Underlying Concepts of This Strategy

1. Develop and implement programs to restore or mimic natural river processes at a combination of geographic scales. The preservation, restoration and maintenance of the physical underpinnings of the natural system (such as a more natural floodplain and a more normally functioning river, along with more natural water level fluctuations) are critical to the sustainability of a diverse and healthy river ecosystem.
2. Build upon existing knowledge and programs to achieve natural resource restoration and protection goals. At the same time, we should not confine our thinking to existing processes or management paradigms. Adaptive management could lead to breakthroughs yet undiscovered.
3. Build a strategy for river management that acknowledges a continuum of spatial scales, including site-specific, river pool, river reach, system and watershed. Some recommendations may call for action at multiple scales to be successful.
4. Increasingly integrate our efforts as we learn from our work. Information is available to begin to design and implement a more integrated management strategy. However, it is critical that we continue to monitor our efforts and provide a means for evaluation and feedback as we move forward.
5. Achieve success through applying scientific knowledge, using management skills, and engaging people to be leaders and advocates for the natural resources of this system. We need to overcome the paralysis that exists due to size and complexity of the UMRS, its multiple purposes, and the fact that its stewardship is the responsibility of no single agency but the domain of many interests who see themselves as equal partners. River interests need to concur in the assignment of leadership roles and hold leaders accountable for making definitive progress in restoring and maintaining the river ecosystem.

6. Provide a means for people and groups to be informed about this strategy. Encourage them to participate in the design and implementation of future recommendations, and make sure they have access to new information gained through ongoing monitoring and adaptive management.

## Summary of Proposed Leadership and Program Responsibilities

*(Subject to agreement by the organizations and agencies listed.)

| Tools and Measures | Geographic Scales | Proposed Leadership Roles* |
|---|---|---|
| **Coordinate more effective programs for water quality.** | Basin and stream networks | Ask UMRBA to serve as a forum. (EPA/DOA lead?) |
| **Coordinate more effective agency programs for erosion control.** | Basin and stream networks | Ask UMRBA to serve as a forum. (EPA/DOA lead?) |
| **Implement a 3-step program to restore floodplain by acquisition and/or easements from willing sellers.** | Evaluate at reach scale. Note the confluence areas of tributaries and main stem. | Ask Mississippi Valley Division, COE, NRCS, FEMA, USFWS, states, non-profits to accept roles. |
| **Design and implement projects to modify dam operations in some pools and modify flows in open river to provide flood pulse and low flow conditions.** | Evaluate at reach scale. Implement at pool/reach scales. Augment at site scale. | Ask St. Paul, Rock Island and St. Louis Corps districts to lead interagency teams that include USFWS, states and others. |
| **Design and implement projects to restore floodplain connectivity of backwaters and main channel.** | Evaluate at pool scale. Implement at pool/reach scales. Augment at site scale. | Ask St. Paul, Rock Island and St. Louis Corps districts to lead interagency teams that include USFWS, states and others. |
| **Design and implement projects to open side channels and manage deposition of sediments.** | Evaluate and Implement at Corps district scale. | Ask St. Paul, Rock Island and St. Louis Corps districts to lead interagency teams (as above.) |
| **Manage channel maintenance and dredge material disposal to support natural resource management system objectives.** | Work at pool and reach scales within each Corps district. Use Avoid and Minimize Program, Channel Maintenance Management Plans as templates. | Ask each Corps district to continue to improve and implement channel maintenance management (and avoid and minimize program in St. Louis District). |
| **Evaluate and implement measures to prevent exotics from entering and spreading within the UMRS.** | Evaluate and implement at scales appropriate to problem and impacts. | Ask MICRA to lead an evaluation and recommend programs and partners. |
| **Provide opportunities for native fish passage at the dams.** | Evaluate at each dam location. | Ask USFWS to lead an evaluation team with representation from COE and states and recommend actions. |

See key to acronyms on back flap.

## Immediate Next Steps

The implementation of this strategy will require the identification of increasingly more detailed action steps. The chart on page 38 summarizes the actions that could be taken subject to the capabilities and willingness of lead agencies and non-profit organizations to support this strategy and the action steps described.

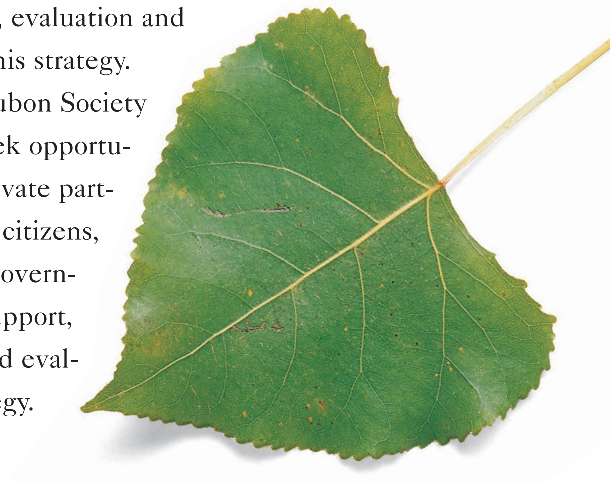
In the Year 2000:

- The UMRCC will present this report to the Upper Mississippi River Basin Association and request the Association to serve as a forum for its consideration.
- The UMRCC with assistance from the National Audubon Society will complete the Atlas of Habitat Restoration and Protection Opportunities and provide the information to agencies, organizations and the public as we continue to work for river restoration strategies that support a healthy ecosystem.

As this strategy is implemented, as other decisions are made which affect the resource (i.e. flood protection and navigation projects) and as we learn more about how this system works and identify the most appropriate management techniques, there will be a need to periodically evaluate this strategy. Through ongoing evaluation, existing action steps may be revised and new steps created. Modified or new institutional arrangements for leadership and coordination may also be deemed necessary. Adaptive management that involves ongoing learning opportunities and exchange of information among managers and restoration advocates, will be an important aspect of this work.

In the Year 2000 and Beyond:

- The UMRCC will meet with the Environmental Management Program Coordinating Committee and recommend that it evaluate the use of the Long Term Resource Monitoring Program (LTRMP) as a primary tool for monitoring, evaluation and improvements to this strategy.
- The National Audubon Society will continue to seek opportunities for public/private partnerships to engage citizens, organizations and government in ongoing support, implementation and evaluation of this strategy.



## Conclusion

We hope that federal and state agencies, organizations and individuals from throughout the Upper Mississippi River Basin will endorse this strategy and use it to work together to restore the ecological health of the river. Perhaps then we can leave a legacy for future generations of a *"River that Works and a Working River."*

*Quote running throughout this report is by Virginia S. Eifert from the introduction to her book River World: Wildlife of the Mississippi, New York, Dodd Mead, 1959.*

# End Notes

**For purposes of this report,** the term floodplain is used in its broadest sense, referring to the land and water area along the river which would be flooded were there no man-made levees or floodwalls. The terms floodplain and floodway have different meanings in different reaches of the UMRS or to different agencies. It may be useful to agree on a common term throughout the system.

Water level reduction is the term used by the Water Level Management Task Force of the River Resources Forum in pools 1-10. The term "water level drawdown" is used elsewhere and refers to the same technique. It may be useful to adopt a common term for use throughout the system.

[1] Initial data primarily from August and December, 1997 versions of the Report to Congress, Environmental Management Program and Galat, David L. and Frazier, Ann G. (Editors) Overview of River-Floodplain Ecology of the Upper Mississippi River Basin, 1996, subsequently updated by reviewers.

[2] Interagency Floodplain Management Review Committee, A Blueprint for Change, Main Report and Volume V. U.S. Government Printing Office, 1994 (The Main Report is commonly referred to as "The Galloway Report" after the Committee's Chair, Brigadier General Gerald E. Galloway, U.S. Army.)

[3] Summarized estimate from St. Paul District, Corps of Engineers data.

[4] Summarized estimate from Rock Island District, Corps of Engineers data.

[5] Summarized estimate from data from St. Louis District, Corps of Engineers data.

[6] See Volumes 1-5, Science for Floodplain Management in to the 21st Century, Scientific Assessment and Strategy Team (SAST) 1994 through 1997.

[7] Status and Trends Report, draft 1998, and final, 1999, U.S. Geological Survey, Long Term Resource Monitoring Program.

[8] Upper Mississippi River Basin Commission, 1982 Comprehensive Master Plan for the Management of the Upper Mississippi River System, Minneapolis, Minnesota.

[9] Adaptive Environmental Assessment Steering Committee and Modeling Team, Phase I Report, June, 1997. Available from the Upper Mississippi River Basin Association, St. Paul, Minnesota.

[10] See recommendations in Chapter 7, Report to Congress, December, 1997, Environmental Management Program. Also based upon personal communication, Bob Clevinstine, US. Fish and Wildlife Service, February, 1998.

[11] Ecological Status and Trends of the Upper Mississippi River System 1998. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse,Wisconsin, April, 1999.

[12] From information gathered on-site in 1996 and 1997 by Dan McGuiness with support from World Wildlife Fund.

[13] From information gathered on-site in 1997 by Dan McGuiness with help of World Wildlife Fund.

[14] Minnesota-Wisconsin Boundary Area Commission, 1977-1997, Recreational Boating Aerial Photographic Studies.

[15] U.S. Department of Agriculture, 1996, Geography of Hope.

[16] ibid.

[17] Upper Mississippi River Basin Commission, 1981, in Environmental Work Team Report, Technical Report D, Comprehensive Master Plan for the Management of the Upper Mississippi River System.

[18] ibid.

[19] Farabee, G. B. 1986. Fish Species Associated with Revetted and Natural Main Channel Border Habitats in Pool 24 of the Upper Mississippi River, North American Journal of Fisheries Management 6:504-508, 1986.

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Map: Page 24
Based on a map from "Regulated Rivers, Vol. II No. 2, page228, in Theiling, 1995

Special thanks to Mary Craig of the USGS Upper Midwest Environmental Sciences Center for assistance with graphics and photo documentation.

# List of Acronyms

COE - US Army Corps of Engineers

DOA - Department of Agriculture

EPA - Environmental Protection Agency

FEMA - Federal Emergency Management Administration

MICRA - Mississippi Interstate Cooperative Resource Association

NRCS - Natural Resources Conservation Service

UMRBA - Upper Mississippi River Basin Association

UMRCC - Upper Mississippi River Conservation Committee

UMRS - Upper Mississippi River System

USFWS - US Fish and Wildlife Service

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