CHAPTER 16

# Assessments and Forecasts of the Ecological Health of the Upper Mississippi River System Floodplain Reaches

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Our knowledge of the ecology of Upper Mississippi River System (UMRS) floodplain reaches is extensive, as demonstrated in previous chapters. That knowledge, however, is rarely complete for a selected habitat, species, or biological process. Although many historical data gaps cannot be filled, the Long Term Resource Monitoring Program (LTRMP) has made major strides in initiating and maintaining the consistent standard observations necessary to assess important ecological trends.

A well-designed monitoring system is the first step toward being able to improve and sustain the ecological quality of the UMRS floodplain reaches. The next step is to assist the river community in the creation of an objective, functional grading system to measure the acceptability of ecological conditions within each reach and clarify what management actions are the most urgent.

In this chapter we compare the river health criteria described in Chapter 2 with the UMRS observations presented in Chapters 4 through 15. This comparison is an initial assessment step within an evolving adaptive river management strategy being developed by scientists, natural resource managers, and members of the public. Assessment criteria may be changed or refined during future comparisons. Initial scores will change to reflect management actions.

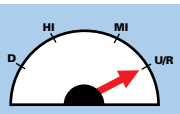
## Status Gauges

For a grading system to be of the greatest value to the river community, it must be brief, understandable, objective, and relevant. The system of gauges used in Table 16-1 visually describes the ecological health of the four floodplain reaches of the UMRS. The notations in Figure 16-1 are used to evaluate each river reach.

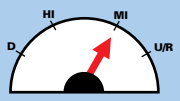
**For a grading system to be of the greatest value to the river community, it must be brief, understandable, objective, and relevant.**

In addition to pointing to current status, the gauges (Figure 16-1; Table 16-1) indicate whether the conditions are believed to be stable, improving, or declining. The term "stable," as it applies to floodplain river ecological health, refers to conditions assessed over multiple years (optimally 5–10 years). It disregards seasonal or year-to-year changes that are associated strictly with short-term hydrologic regimes. The criteria of recovery from disturbance and sustainability are by nature intimately tied to changes defined over relatively long time intervals.

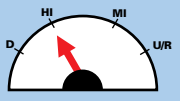
**Figure 16-1.** Gauges and definitions used in explanation of ecological health.



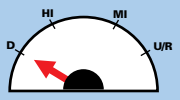

*Unchanged/Recovered* Most factors associated with this condition have either remained relatively unchanged over time or recovered from any disturbances. No evidence exists to indicate that management action is required to maintain, restore, or improve conditions.




*Moderately Impacted* Many factors associated with this condition have changed measurably over time and some are near or approaching ecologically unacceptable levels. Selected management action is now required to maintain or improve present conditions.




*Heavily Impacted* Many factors associated with this condition have degraded over time and are below or forecasted to be below ecologically acceptable levels. Evidence of degradation suggests that rehabilitation, not just maintenance, is required to raise conditions to an acceptable level.




*Degraded* Most factors associated with this condition are now below ecologically acceptable levels. Multiple management actions are required to raise these conditions to acceptable levels.

**Criterion 1**
**The ecosystem supports habitats and viable native animal and plant populations similar to those present prior to any disturbance.**

In regards to the UMRS, the greatest amount of information is available to assess this first criterion.

## Habitats

Three factors in particular have altered aquatic and terrestrial floodplain habitats within the UMRS: the commercial navigation system, agricultural levees, and water quality.

### *Navigation Channel Training Structures and Impoundments*

As described in Chapter 4, the floodplains of the UMRS were—before engineering improvements—dominated by terrestrial habitats, primarily bottomland forests and prairie savannas intersected with braided channels. Early navigation improvements fixed the main channel in place, reducing the river's ability to reshape itself. Reshaping was a dynamic process that, in part, kept the bottomland forests in various successional stages.

**Early navigation improvements fixed the main channel in place, reducing the river's ability to reshape itself—a dynamic process that, in part, kept the bottomland forests in various successional stages.**

After navigation dams were built, low-lying floodplain areas were permanently inundated. Impoundment initially resulted in increased aquatic productivity—aquatic plant species and backwater fisheries flourished. These conditions persist in much of the Upper Impounded Reach of the Upper Mississippi River (UMR) and are indicators of ecological health. However, long-term hydrodynamic consequences of impoundment suggest that many of these conditions are not sustainable (see Criterion 3).

### *Levee Construction*

Levee construction began in the UMRS in the late 1800s. Since then, significant portions of the Lower Impounded and Unimpounded Reaches of the UMR and

the Lower Illinois River Reach have been isolated from the river. Levees prevent flood waters from inundating the floodplain and reduce the size of the river reach flood zones. Levees also restrict the flow of flood waters laterally, increasing the height of flood peaks and concentrating sediments between the levees. Agricultural use of the floodplain reduces available bottomland forest, wet-meadow and successional habitats, and diversity of habitats.

*Water Quality*

The national movement to improve water quality is one of the most positive events to affect the health of the UMRS. Physical and chemical conditions have improved over the last 25 years as municipalities and industries along the river responded to authorization of the Clean Water Act. Before this legislation, some waters—especially in and below metropolitan areas—were so contaminated that they could support only the most pollution-tolerant species. Today some of these same locations support species once thought extirpated.

## Native Plant and Animal Species

*Submersed Aquatic Vascular Plants*

Submersed aquatic vegetation (SAV) is an important indicator of the ecological health of the impounded river reaches of the UMRS, providing food and structure for invertebrates, fish, and waterfowl, and recycling nutrients. Although annually variable, its continuing presence in upstream reaches suggests that physical conditions have not declined past acceptable ecological levels.

Abrupt changes in the Lower Reach of the Illinois River during the mid-1950s provide an example of the value of SAV and invertebrates. Pollution- and sediment-related factors caused a decline in these SAV populations during that decade and the subsequent impact on the river's fish and waterfowl have been extensively reported. Submersed aquatic vegetation on the Lower Illinois River is presently restricted to isolated waterfowl management areas.

The abundance of SAV in the Upper Impounded Reach of the UMR has changed considerably from year to year in response to many factors, but especially annual water and sediment regimes. These changes are considered normal at present; the positive response of SAV to more favorable water years is an additional sign of health (see Criterion 2).

**The national movement to improve water quality is one of the most positive events to affect the health of the UMRS.**

*Forests*

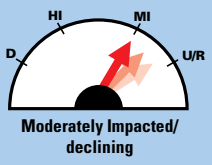
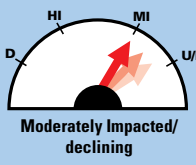
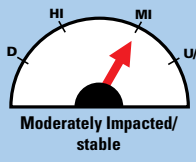
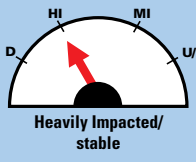
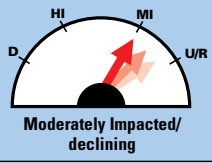
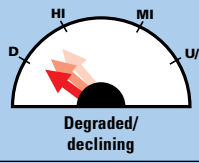
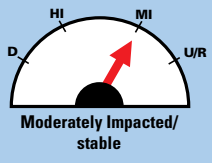
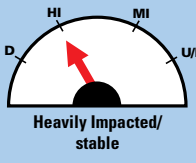
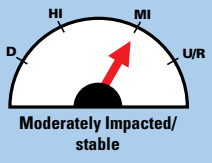
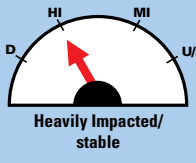
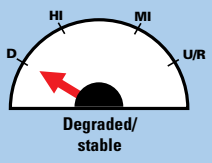
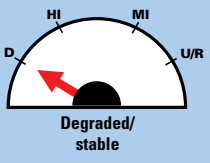
Modern UMRS forests represent only a small portion of pre-European settlement floodplain forests. In 1817, forests covered 56 percent of the landscape at the confluence of the Illinois and Mississippi Rivers. By 1975, these forests were reduced to 35 percent of the landscape. In 1809, floodplain forests covered 71.4 percent of the landscape in a 63-mile (102-km) long portion of the Unimpounded Reach but, by 1989, covered only 18.3 percent of the same landscape. Land clearing for agriculture, steamboat fuel, and lumber production was responsible for most of the changes, although modified hydrology also has affected forest community structure and species composition.

*Macroinvertebrates*

Fingernail clams and mayflies are distributed throughout UMRS aquatic habitats with soft substrates. They are an important food source for many species of waterfowl and fishes and are sensitive to many kinds of disturbance. Their decline along the middle and lower Illinois River in the 1950s caused shifts in diving duck migration patterns and fish condition.

Fingernail clam collections in the

**Table 16-1.** Status report on the ecological health of four floodplain reaches of the Upper Mississippi River System using a gauge grading system.

| Criteria | Upper Mississippi River: Upper Impounded Reach (Pools 1-13) | | Upper Mississippi River: Lower Impounded Reach (Pools 14-26) | |
|---|---|---|---|---|
| **Ecosystem** | | | | |
| 1. Viable native populations and their habitats |  | Declining structural diversity; zebra mussels threatening native mussels |  | Floodplain habitat moderately altered by levees; forest diversity limited |
| 2. Ability to recover from disturbances |  | Recovery demonstrated by invertebrates and aquatic vegetation |  | Limited regeneration of willows and cottonwoods |
| 3. Ecosystem sustainability |  | Habitat quality declining as pools slowly age |  | Greater sediment loads increase pool aging rates |
| **Floodplain River** | | | | |
| 4. Capacity to function as part of a healthy basin |  | Least amount of basin land-cover change |  | Land-cover change has altered water and materials delivery |
| 5. Annual floodplain connectivity |  | Low-flow, floodplain drying eliminated by impoundment; 3% of floodplain leveed |  | Low-flow, floodplain drying eliminated by impoundment; 53% of floodplain leveed |
| 6. Ecological value of natural disturbances |  | Ecological value of floods reduced by channel stabilization; low stages eliminated |  | Ecological value of floods reduced by channel stabilization; low stages eliminated |

**Change indicator**

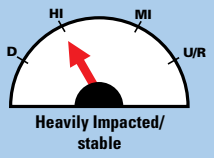
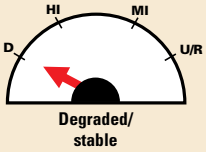
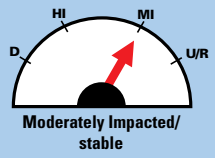
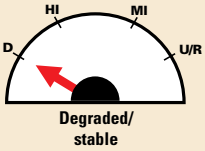
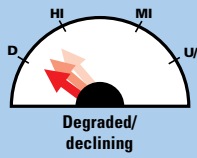
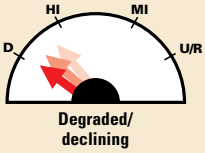
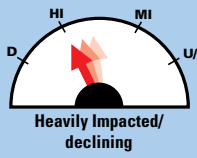
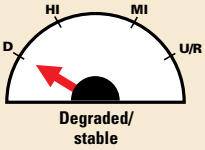
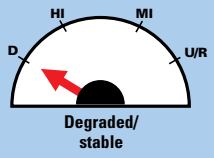
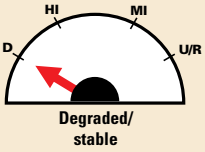
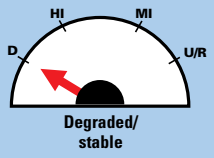
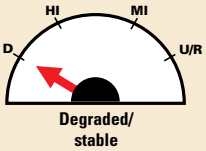
 = Stable

 = Declining

 = Improving

**Present status**

D = Degraded
HI = Heavily Impacted
MI = Moderately Impacted
U/R = Unchanged/Recovered

| Unimpounded Reach | | Illinois River<br>Illinois River Lower Reach | |
|---|---|---|---|
|  | Floodplain habitat greatly altered by levees; side channels closed |  | Aquatic vegetation, invertebrates, waterfowl degraded |
|  | Willows and cottonwoods regenerating |  | Neither aquatic plants nor invertebrates have recovered from 1950s disturbances |
|  | Incidence of greater floods and lower low-flows increasing |  | Reduced point-source pollution offset by high sediment loads |
|  | Land-cover change and Missouri River dams have altered water and sediment delivery |  | Land-cover change has altered water and material delivery |
|  | Flood-pulse value reduced by rapid water-level changes; 82% of floodplain leveed |  | Low-flow floodplain drying eliminated by impoundment; 50% of floodplain leveed |
|  | Ecological value of floods reduced by channel stabilization |  | Ecological value of floods reduced by channel stabilization; low stages eliminated |

Impounded Reaches of the UMR have produced mixed results. In Pool 19 on the Mississippi River, population densities of fingernail clams exceeding 83,000 per square yard (100,000 per square meter) were observed in the late 1960s. Their numbers gradually declined until none were found in the early 1990s. The Pool 19 fingernail clam population appears to have fluctuated with flood and drought years and the community recovered after the Flood of 1993. Several site-specific studies conducted in Mississippi River Pools 2 through 9 documented declines in fingernail clam populations through the 1980s. A variety of potential causes have been suggested, but no single explanation has been accepted. Recent studies in non-LTRMP pools found population densities more typical of the mid-1970s.

Mayflies are subject to many of the same perturbations as fingernail clams. Among the LTRMP trend analysis areas, mayflies presently occur in greatest abundance in Pools 4, 8, and 13. In Pool 19 the population has appeared stable since 1984 after increasing from lower levels from the 1970s.

*Mussels*

Under natural conditions, aquatic habitats of the UMRS support one of the most diverse and abundant mussel populations of the world. Consistent long-term mussel monitoring has not been conducted within the UMRS, but available study results indicate that the number of mussel species has declined from 48 to 37 (23 percent) in the Upper Mississippi River and from 45 to 25 (44 percent) in the Illinois River. The decline has been attributed to a variety of factors, including pollution, sedimentation, overharvest, impoundment, and most recently, competition from the nonnative zebra mussel. (The decline of Illinois River zebra mussel populations within the last 2 or 3 years suggests these populations have yet to stabilize in their new habitat. Zebra mussel populations continue to increase in the Upper Mississippi River.)

**Channel management strategies in the lower portions of the UMR, particularly from St. Louis, Missouri, to Cairo, Illinois, have resulted in a loss of side channel fish habitats.**

*Fishes*

The LTRMP, during the program's first 5 years, has documented the presence of 127 fish species in the UMRS. River wide, there is no evidence that the number of fish species has declined over time. Changes in the abundance and distribution of many species have been reported, but species richness is greater in the northern LTRMP study areas than in the southern areas. Channel management strategies in the lower portions of the UMR, particularly from St. Louis, Missouri, to Cairo, Illinois, have resulted in a loss of side channel fish habitat. The greater physical complexity of the northern-most reaches contributes to their higher species richness.

Traditionally, local factors have made it difficult to quantify the relation between habitat and fish community structure. Data gathered by the LTRMP are now beginning to reveal "how much habitat is enough." The relative abundance of bluegill, a backwater species, in the Unimpounded Reach is typically less than one-third of that in other study reaches; abundance also is lower in Pool 26 than in Pools 4, 8, and 13. Backwaters constitute larger fractions of the floodplain in La Grange Pool of the Illinois River and Pools 4, 8, and 13 of the Mississippi River than in Pool 26, and especially the Unimpounded Reach. These results suggest that the abundance of bluegills and other important centrarchids such as crappies and largemouth bass may be limited by the availability of suitable backwater habitat. Other analysis also may provide initial estimates of how much backwater habitat is needed in a given reach to achieve target management levels.

*Birds*

The ecological value of the Mississippi and Illinois Rivers as migration corridors for waterfowl is well documented. Diving ducks rely heavily on the tubers of wild-celery and on fingernail clams; their use of the river has been linked to the availability of these foods. Dabbling ducks exploit numerous shallow marshes where they feed on seeds and insects. Declines in dabbling ducks have been linked to habitat degradation.

Waterfowl use of the Illinois River has declined considerably. Dabbling duck populations have declined steadily since the late 1940s when peak mallard numbers during the fall migration exceeded 1.5 million birds. A shift in mallard migration routes is evident after 1960 when mallards began to use Mississippi River habitats more and Illinois River habitats less. Today, the combined populations may barely exceed 500,000 birds, a full two-thirds reduction from earlier levels.

After World War II, fish-eating birds such as bald eagles, cormorants, and wading birds were affected by the use of DDT. After it was banned in 1973, eagles and commorants have been closely monitored and are recovering. Swans, white pelicans, and the Federally endangered least tern are more common now than in the recent past.

**Criterion 2**
**The ecosystem is able to return to its preexisting condition after a disturbance, whether natural or human-induced.**

This criterion is similar to the first in that it relates to habitats, species, and biological processes. Unlike Criterion 1, recovery from disturbance cannot be assessed with a single set of observations made over a short period of time. However, we can evaluate a series of recent events on the UMRS and retroactively observe if habitats, species, and biological processes have recovered.

*Submersed Aquatic Vegetation*

In the Upper Impounded Reach, SAV appears to be recovering from the decline that followed the late 1980s drought. In the Lower Impounded Reach, SAV prospered during this drought because water levels were stable and water was clearer than normal. Loss of SAV during flooding in 1993 differed with flood magnitude. Aquatic vegetation has recovered well in the Upper Impounded Reach, but still is rare elsewhere. The SAV communities in the Illinois River recovered from early 1900s pollution, reappearing in the 1930s. However, SAV has not recovered in the Illinois River since the decline in the 1950s.

**In the Upper Impounded Reach, SAV appears to be recovering from the decline that followed the late 1980s drought.**

*Forests*

Floodplain forests were affected by the Flood of 1993, especially in the Lower Impounded and Unimpounded Reaches. Floodplain forests can endure brief inundation, but prolonged inundation can be deadly to individuals of many species. Tree mortality was highest in the Lower Impounded and Unimpounded Reaches; smaller trees experienced the highest mortality. The flood reset forest succession in the Unimpounded Reach, regenerating early successional species such as cottonwood, but had little effect on successional stages in the pooled reaches. Forests in the Lower Impounded Reach experienced high mortality but are regenerating to late-successional stages of mixed maple forest.

These responses indicate that the UMRS retains its ability to regenerate early successional forest communities only in the Unimpounded Reach, where water levels fluctuate. Forests in pooled reaches

apparently are limited by water-level regulation for commercial navigation and show little ability to reset in response to disturbance. The navigation dams likely will limit the health and diversity of forests within the Impounded Reaches for the foreseeable future. Forest losses to agriculture and urban development cannot recover given these land-use practices.

*Macroinvertebrates*

From Pools 2 to 4, mayflies were eradicated between 1957 and 1976 because of pollution from the Twin Cities. Sampling conducted as early as 1986 and recent observations of mass emergences that reached nuisance levels reveal a strong recovery in response to improved sewage treatment. This recovery has been faster than that of fingernail clams, possibly because mayflies filter surface water while fingernail clams filter sediment pore water that may be contaminated.

**Mussels have complex life histories and are sensitive to many types of disturbances. Because of these characteristics, some species—or at least selected beds—may never recover.**

*Mussels*

Mussels have complex life histories and are sensitive to many types of disturbances. Because of these characteristics, some species—or at least selected beds—may never recover. Recent observations, however, of the recovery of species once thought lost from the Upper Illinois River offer hope that other species may return over the long term in other floodplain reaches.

*Fishes*

Illinois River fishes have recolonized formerly polluted river reaches. This capability stems partly from their mobility and the existence of viable tributary populations that provide immigrants. The ability of river fish communities to recover quickly from disturbances is an important justification for continued habitat rehabilitation throughout the UMRS.

**Criterion 3**
**The ecosystem is able to sustain itself**

This criterion holds that healthy ecosystems are able to sustain relatively constant conditions by themselves without human management. Two important long-term trends within the reaches of the UMRS suggest that present conditions are not sustainable. These trends relate to the pool aging and sedimentation processes occurring within impounded reaches and changes in the relation between river discharges and water levels in the Unimpounded Reach of the UMR.

*Pool Aging and Sedimentation*

Sedimentation is one of the most critical resource problems affecting impounded areas within the UMRS. As the navigation pools age, sedimentation continues to degrade the quantity and quality of nonchannel aquatic habitats. Sediments that originate from both basin and floodplain sources (island and bank erosion) tend to settle in the deepest portions of the aquatic habitats first. The result is continued loss of depth diversity and simplification of aquatic habitats.

Studies indicate that sediment accumulation in aquatic areas probably is slower now than in the initial years after dam construction. This pattern is consistent with other disturbed river systems. Change is greatest following the initial disturbance (impoundment) and tapers off as a new equilibrium is approached. It is difficult to forecast exactly when each UMRS navigation pool will achieve a new sediment transport equilibrium, but we can predict they will continue to progress toward shallow, more uniform conditions.

Anticipated ecological responses to pool aging include poorer water quality (e.g., more frequent dissolved oxygen problems, higher turbidity levels), poorer substrate quality, the reduction of submersed aquatic

plant and benthic invertebrate populations, less diverse fish communities, and fewer areas that can support migratory waterfowl.

Scientists differ in opinion about whether these changes will happen gradually or suddenly as each navigation pool ages. The foremost controlling factors are physical processes such as hydrology, water quality, and sedimentation, which in addition to being interrelated affect habitat and species in many complex ways. Changes were rapid on the Illinois River in the mid-1950s. Because many pools of the UMR receive less sediment than those of the Lower Illinois River, future changes on the UMR may well be more gradual than those observed on that waterway.

Whether pool aging processes result in gradual or rapid changes in the ecosystem, it is clear that existing conditions in many pools are not self-sustaining. Some pools, especially in the Upper Impounded Reach of the UMR, are filling at lower rates than those downstream and may remain relatively unchanged for decades. Some changes, however, will continue in all of the pools. To maintain ecosystem quality under the artificial conditions of impoundment, active management such as habitat rehabilitation is necessary. The costs of such management will increase as sedimentation continues.

*Discharge and Elevation in the Unimpounded Reach of the Upper Mississippi River*

Analysis of discharge data from the Unimpounded Reach indicates the following trends: (1) at equivalent low discharges water-surface elevations are lower now than in the past and (2) at equivalent high discharges, water-surface elevations are higher. Thus, at low-river discharges, habitats that previously were aquatic are now dry, whereas at high discharges, some of the few remaining unleeved land areas that previously would have been dry are now inundated during floods. Analysis of maximum water levels for 10-year periods at five stations from St. Paul, Minnesota, to near Cape Girardeau, Missouri, shows that flood heights have increased over time.

The number of days an area is above flood stage also is increasing. Water levels at St. Louis, Missouri, were measured at above flood stage for 217 days in a 38-year period from 1880 to 1917. That figure rose to 312 days for the 38 years between 1918 and 1955 and to 485 days from 1956 to 1993. Immediately above the Missouri River the change is even more significant. In Pool 24 the number of days above flood stage for the same three periods was 295, 470, and 1,166, respectively. The increase in the occurrence of flood-stage water levels is thought to be rapid runoff from the basin creating high-peak flows of short duration. The river system's hydrology has become more "spiky" in response to watershed drainage, stream channelization, and levee construction.

While floods generally are considered ecologically beneficial, levees, impoundments, and channelization limit their benefits. We do not know if trends toward greater hydrologic variability will stabilize or continue to increase in the future.

**Whether pool aging processes result in gradual or rapid changes in the ecosystem, it is clear that existing conditions in many pools are not self-sustaining.**

**Criterion 4**
**The reach can function as part of a healthy basin.**

This criterion treats a river reach not as an independent ecosystem but as part of a larger ecosystem, the reach's basin. It recognizes that a floodplain river provides important ecological services (water and material transport, nutrient cycling, migration routes) that affect the health of the basin and downstream ecosystems.

Basin land cover and land use control a variety of physical and biological conditions within the UMRS. They affect the distribution and rate of snow melt and

rainwater run-off, and thus delivery of materials (sediments, nutrients, contaminants) to floodplain river reaches. Before European colonization, the stream network delivered these materials to the rivers at rates to which river plant and animal populations were adapted. The materials originated in undisturbed subbasins with riparian forests, prairies, and wetlands that stored water during wet periods and slowly released it during dry periods. High and low flows were additionally buffered by the storage capacities of the stream network.

Today, much of the UMRS basin landscape is dominated by agricultural practices, especially corn and soybean production. These landscapes typically release greater amounts of sediments, nutrients, and contaminants, and concentrate flows in both space and time because modern urban and rural drainage networks deliver run-off to the rivers faster and at higher stages than in the past. Agricultural and urban land uses also generate a variety of contaminants not present in the past. Fertilizers and herbicides are delivered in concentrated pulses if these chemicals are applied just before a heavy rainfall.

**A unique basin-scale feature of the UMRS is its artificial interbasin connection with the Great Lakes through the Illinois Waterway, which has exposed the stream network to exotic and potential nuisance species.**

A unique basin-scale feature of the UMRS is its artificial interbasin connection with the Great Lakes through the Illinois Waterway, which has exposed the stream network to exotic and potential nuisance species. Zebra mussels, the European ruffe, and round goby are recent examples.

Only recently have scientists emphasized the need to understand the role that UMRS floodplain reaches play in their basin ecosystems. This emphasis was stimulated partly by hypotheses that link low dissolved oxygen concentrations in the Gulf of Mexico to nutrient loading within the UMRS. Researchers are developing databases to document how nutrient and sediment loading vary throughout the basin and over time. Our ability to evaluate this criterion will improve greatly over the next 5 to 10 years.

**Criterion 5**
**The annual flood pulse "connects" the main channel to its floodplain.**

This criterion focuses on the reach's annual hydrologic regime, and especially on the spring flood pulse. A second element of the regime, the annual summer low-water period, is beginning to receive more attention as a model for experimental water drawdowns.

Under natural conditions, spring high flows that result from snow melt and rainfall within the basin would overflow channel banks and inundate low areas of the floodplain. From year to year, the size and duration of the inundated area (flood zone) would vary depending on the magnitude and length of the flood.

A growing body of ecological information indicates how important the extent and annual duration of flood-zone inundation is to river species and several important ecological processes. Fish spawning and annual recruitment, nutrient recycling, and emergent plant growth and distribution intimately depend on the timing, duration, and extent of the annual flood pulse.

Reductions in the size of potential flood zones in the UMRS are the result, either direct or indirect, of several river uses. Chief among these activities was navigation that led to construction of the river's navigation dams and levees. Dams permanently flooded areas that previously drained and were exposed during a considerable portion of the annual discharge cycle. Levees effectively eliminated a large portion of the floodplain from high-water inundation. These changes and their consequences to species, habitats, and ecological processes limit the ecological health of the UMRS.

**Criterion 6**
**Infrequent natural events—floods and droughts—are able to maintain ecological structure and processes within the reach.**

Criteria 1 through 5 relate to relatively short time periods of years or decades. Criterion 6 recognizes that floodplain rivers, by nature, are geomorphically dynamic in response to hydrologic events that occur at intervals of centuries or millennia. The long-term structural dynamics of all UMRS floodplain reaches have been reduced by the development of levees and the commercial navigation system (see Criteria 1). Notable ecological effects of these disturbances are decreases in species diversity and age structure of the forest community.

## Forecasts by River Reach

The management value of forecasting the ecological health of the UMRS river reaches, even given well-recognized limitations about what we know, was described in Chapter 1. Knowledge limitations include not only many specific items about river ecological status and causal factors, but also the future decisions humans will make about how the river should be used. The following sections present broad forecasts for each of the reaches, based on what we consider to be reasonably well-established facts.

### *Upper Mississippi River: Upper Impounded Reach*

Although the Upper Impounded Reach supports the best ecological conditions within the UMRS, several habitat variables are deteriorating and others are worthy of concern. Impounded habitats in the lower ends of the pools in this reach are degrading as the pools fill with sediment and islands erode. River forces alone are presently unable to sustain the character of these areas.

The rates of filling and erosion (processes not quantified for all navigation pools) are slower now than they were immediately after impoundment. The endpoints for these processes are unknown, and probably will vary among pools. Modeling efforts are now being accelerated to estimate the future structure of these areas under present river management.

Habitat projects designed to offset the process of sedimentation and islands constructed to reestablish terrestrial and aquatic structural diversity are needed to offset deteriorating habitat conditions. Drawdown projects that alter regulated water levels to restore some aspects of the reaches' natural hydrograph have the potential to maintain or improve the reaches' ecological health.

Although water quality has improved in this reach as a result of point-source pollution control, high loads of sediment, nutrients, and agricultural chemicals continue to pose threats.

Past experience indicates that introduced exotic species usually reach stable thresholds after an initial period of abundance. Zebra mussels, however, may continue to out-compete and eliminate native mussels in this reach in the near future.

**A growing body of ecological information indicates how important the extent and annual duration of flood-zone inundation is to river species and several important ecological processes.**

### *Upper Mississippi River: Lower Impounded Reach*

The Lower Impounded Reach of the UMR presently is limited by many of the same factors (pool-aging, sedimentation) that constrain the ecological health of, but to a greater extent than, the Upper Impounded Reach. This is not expected to change in the near future. Greater tributary sediment, nutrient, and agricultural chemical loads within this reach are expected to continue, along with a more rapid rate of ecological degradation relative to the Upper Impounded Reach. The greater degree of floodplain development in the Lower Impounded Reach, in combination with more rapid delivery of water from its tributary

basins, will continue to produce atypical water-level fluctuations less suitable to native river species. Larger islands in this reach commonly are protected from bank erosion by rock revetment and therefore their future rate of loss is not a major concern from the perspective of degrading habitat diversity.

*Upper Mississippi River: Unimpounded Reach*

Rapid water-level fluctuations and the extent of floodplain isolation in this reach will limit any near-term improvement in ecological health. The lack of publicly owned land in this reach will continue to make it difficult to establish annual reconnections between the floodplain and the channel, but previously closed side channels are receiving increased attention as targets for habitat rehabilitation. It is unknown whether flood peaks will stabilize or continue to increase over the next several decades.

**Despite the need for varying degrees of rehabilitation, the ecological potential of the UMRS remains great.**

*Illinois River: Lower Reach*

Many degraded conditions in this reach will continue to limit its ecological health. Floodplain isolation, altered water regimes, sedimentation, and poor sediment quality all require attention, and it is uncertain whether resolving only one or two of the problems in this reach will provide the necessary stimulus for turning the system around. Improved water quality in the upper Illinois River has resulted in subsequent improvements in its aquatic vegetation and fish community. Gradual expansion of water-quality improvements to the Lower Reach may slowly promote similar biological responses, especially if other constraints can be eliminated simultaneously.

## Conclusion

The scientific evidence provided in this report suggests the floodplain river reaches of the Upper Mississippi River System need continuing attention if (1) ecological conditions are to be maintained at 1998 levels and (2) conditions that have degraded are to be restored. Historical observations and research findings together make it clear that the reaches have been changed by human activity in ways that diminished their ecological health.

Criteria selected to assess the ecological health of the four UMRS floodplain reaches in this report include biological, chemical, structural, and hydrological ecosystem conditions. The degree to which each condition has been altered differs substantially from one reach to another.

Despite the need for varying degrees of rehabilitation, the ecological potential of the UMRS remains great. Balance among economic and ecological values increasingly is being accepted as a common system goal. Maintaining that balance in the future, however, will require full knowledge of the relation between river uses and ecological conditions, and regular assessments of ecological status.

As river management becomes more collaborative and adaptive, the ecological future of each reach will be determined by the community responsible for its ecological health. This report marks the first time broad ecological criteria have been used to assess the reaches of the UMRS. It initiates an assessment process that needs review and discussion by the public and river management agencies.

The continuing role of the scientific community will be to quantify the assessment criteria so the results of management actions can be viewed in the context of the ecological health of each river reach.

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