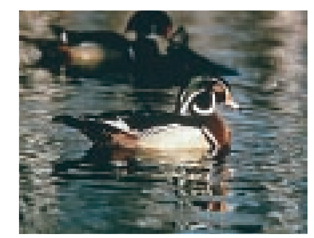
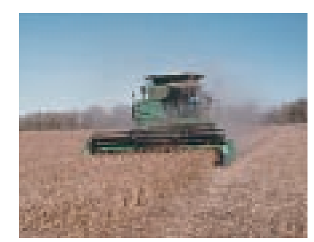
U.S. Army Corps of Engineers
St. Louis District
1222 Spruce St.
St. Louis, MO 63103

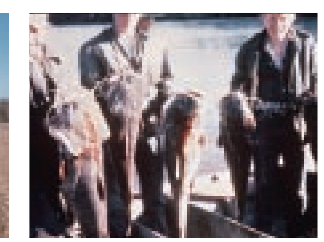
Upper Mississippi River System

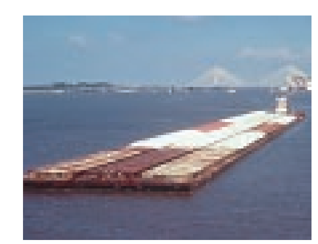
Habitat Needs Assessment

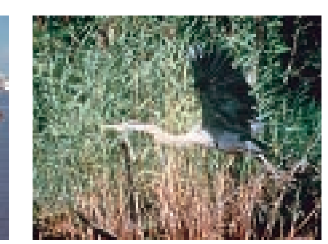
Summary
Report
2000

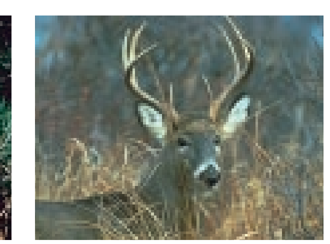


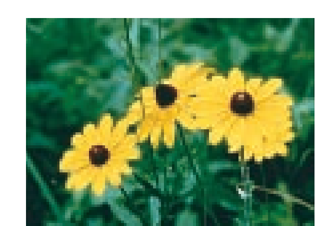












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Upper Mississippi River Navigation System

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Deer	U.S. Fish and Wildlife Service
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Contents

Executive Summary

There is a broadly recognized need among resource managers and scientists for improved habitat quality, increased habitat diversity, and a closer approximation of the pre-development hydrologic regime.

This summary report describes the first Habitat Needs Assessment (HNA), in support of the Upper Mississippi River System (UMRS), Environmental Management Program (EMP). The EMP Habitat Needs Assessment was designed to help guide future Habitat Rehabilitation and Enhancement Projects on the UMRS. To identify habitat needs, historical, existing, forecast, and desired future conditions were compared. Issues of scale are important in this regard because ecological processes and needs vary at the system, reach, and pool levels. In addition, a wide variety of habitat characteristics must be addressed including habitat fragmentation, connectivity, and diversity. To accomplish this assessment, a GIS tool and a new floodplain vegetation successional model were developed. These tools allow geomorphic and land cover characteristics to be translated into the potential habitat areas for species to occur.

The Results

Over time, the landscape, land use, and hydrology of the Upper Mississippi River and its basin have changed. Much of the grasslands, wetlands, and forests have been converted to agricultural use, which now occupies 50 percent of the floodplain. Impoundment, channelization, and levee construction have altered the hydrologic regime and sedimentation patterns, resulting in loss of backwaters, islands, and secondary channels. While future changes in broad geomorphic features are expected to be relatively small, habitat degradation is expected to continue. There is a broadly recognized need among resource managers and scientists for improved habitat quality, increased habitat diversity, and a closer approximation of pre-development hydrologic regime.

The Habitat Needs Assessment identified clear differences in habitat types and conditions among river reaches. Those differences are largely related to the amount and distribution of public land, the degree of floodplain development, the geomorphic form of the river, and the effects of impoundment for navigation. The differences also suggest that habitat needs and restoration objectives will vary by river reach and pool.

The Habitat Needs Assessment yielded gross quantitative and qualitative estimates of habitat needs both system-wide and within river reaches. These estimates provide the first approximation of a set of system-wide objectives for Habitat Rehabilitation and Enhancement Projects. While they do not offer quantitatively precise goals, they will help focus future planning on the most important geomorphic processes both system-wide and in specific river reaches. However, perhaps the greatest contribution this first Habitat Needs Assessment has made is the development of new and improved tools for future planning for Habitat Rehabilitation and Enhancement Projects. In particular, the GIS Query tool will help evaluate the potential distribution of species and habitat area types throughout the UMRS. While the results of the Habitat Needs Assessment are not a substitute for the more detailed and spatially explicit planning that will be done at the pool scale, it has provided new tools for that planning.

The Future

This is the first Habitat Needs Assessment undertaken as part of the Environmental Management Program and it is anticipated to be updated on a regular basis. Future assessments will benefit from additional spatial data about the river system, improved ecological understanding, improved GIS and modeling tools, and additional public input.

Limitations of the Initial HNA

- The Habitat Needs Assessment simplifies access to, analysis of, and graphic display of vast amounts of data, but the results still require careful interpretation by individuals familiar with UMRS resources.
- Because there were schedule and cost constraints, this study relied heavily on existing studies and it is limited by the quality and uniformity of data contained within those studies. The HNA will continually evolve as new information is acquired and it will be periodically updated in accordance with the Water Resources Development Act of 1999. Its value will continue to increase as new and more comprehensive data is incorporated during subsequent updates.
- The HNA was limited to the use of existing system-wide data. System-wide habitat models used relatively uniform low resolution land cover data and are therefore very general, even in data rich areas.
- The HNA provides an additional tool to help determine how Habitat Rehabilitation and Enhancement Projects are identified and selected, but it does not replace the project planning process.

Introduction

U.S. Fish and Wildlife Service

Ducks in flight.

U.S. Army Corps of Engineers

Finger Lakes Habitat Rehabilitation and Enhancement Project.

This summary report describes the first Habitat Needs Assessment (HNA), in support of the Upper Mississippi River System Environmental Management Program (EMP). The UMRS-EMP was authorized by Section 1103 of the Water Resources Development Act (WRDA) of 1986. The two major parts of the EMP are the Long Term Resource Monitoring Program, and a program of Habitat Rehabilitation and Enhancement Projects.

The authorizing language in WRDA 1986 required an evaluation to determine the program's "effectiveness, strengths and weaknesses, and contain recommendations for the modification and continuance or termination" of the EMP. In response, in 1997, the Corps of Engineers, Mississippi Valley Division submitted a report to Corps Headquarters recommending a variety of changes to the program. One of these recommendations was that a HNA be done when Congress reauthorized the EMP in WRDA 1999, the HNA was recognized as an ongoing feature of the EMP.

Purposes of the Habitat Needs Assessment (HNA) include:

- achieve a collaborative planning process that produces technically sound and consensus based results;
- address a variety of habitat requirements including physical, chemical, and biological parameters;
- address the unique habitat needs of distinct river reaches and pools;
- describe historical, existing, and projected future habitat conditions, and identify objectives for future habitat conditions;
- define habitat needs at system, reach, and pool scales;
- provide additional tools for planning future Habitat Rehabilitation and Enhancement Projects.

This HNA is the latest effort to document broad habitat protection and restoration needs to assist in planning future EMP habitat projects. This HNA begins to identify, at the system, reach, and pool scales, the long-term system-wide habitat needs. This HNA can also serve to focus future monitoring and research activities under the reauthorized EMP. Future refinements of this HNA will provide better estimates of habitat need as new information is acquired and additional public input is obtained.

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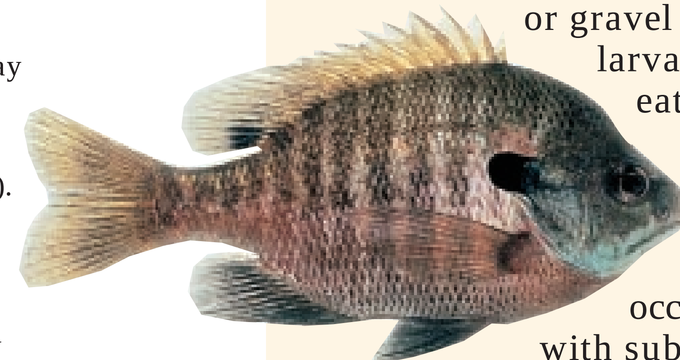
Lock and Dam 13, Clinton, Iowa.

Habitat

A habitat is an organism's "home." Defining the characteristics of the "home" for a host of river species is challenging. Many species may also have different habitat needs at different life stages and times of year (see sidebar). Habitat can be described in different levels of detail to narrow down the potential areas that may be occupied by an organism of interest. First, larger geographic areas and land cover types can be used. Next, other relevant attributes of habitat, such as current velocity, water depth, forest community type, etc. can be applied. For this HNA, habitats have been characterized broadly at the first level using floodplain land cover and aquatic area types. The "habitats" thus defined may be quite large, of low resolution, and only generally identify where species are likely to occur. Future refinements of this HNA will include additional physical and chemical habitat attributes and will define habitat for individual species in greater detail.

Bluegills in the UMRS spawn in shallow areas with sand or gravel bottom. The larvae hatch and eat plankton in open water areas for a time, then the juveniles occupy areas with submersed aquatic plants that provide shelter from predators; larger adults may move back to open water habitats. In winter, bluegills need warmer, well-oxygenated backwater areas out of the current.

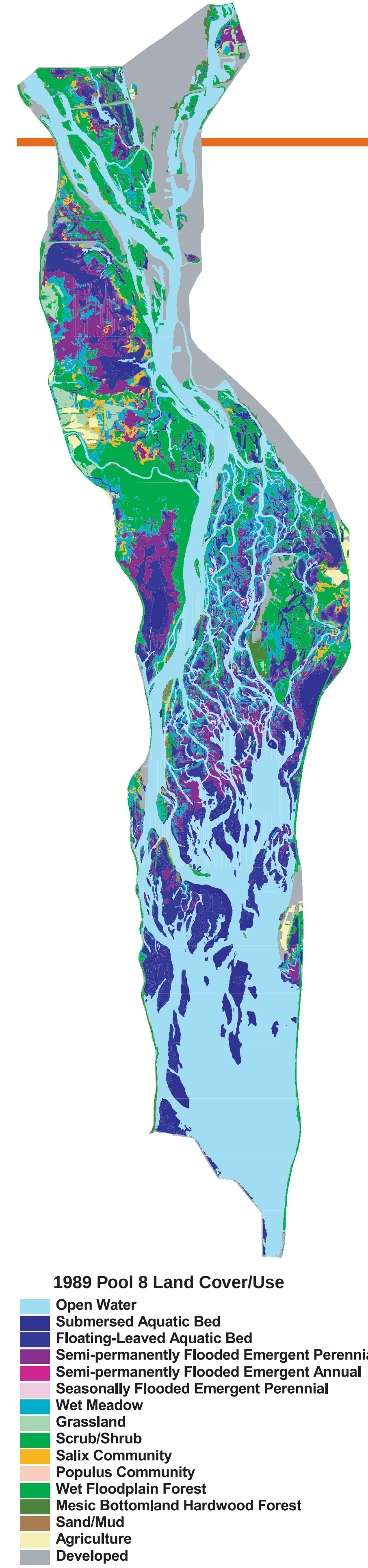


Bluegill sunfish

New Hampshire Dept. of Inland Fisheries

Scott D. Whitney

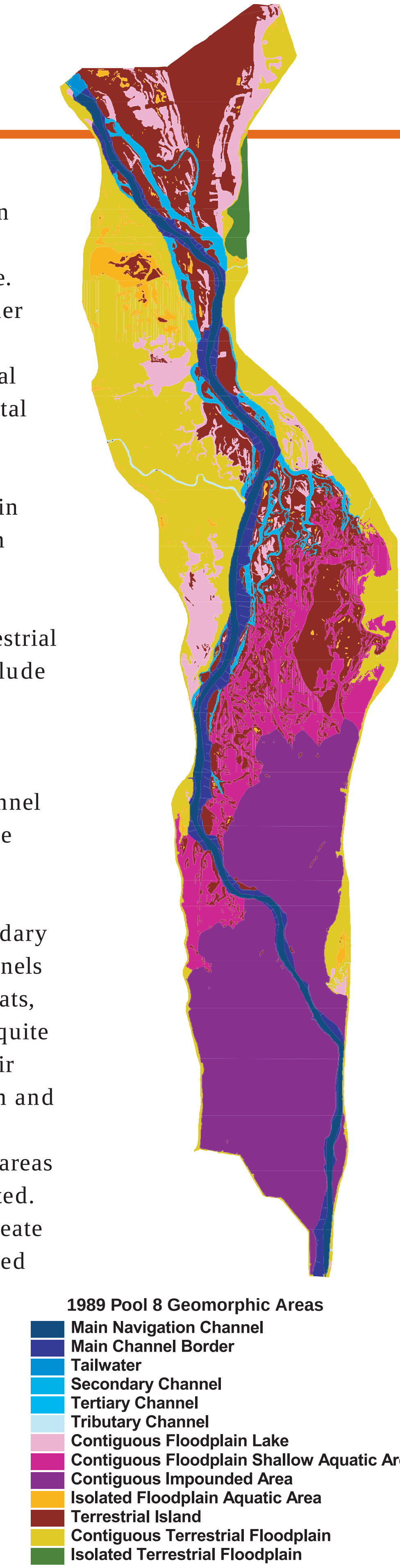
Bluegills guarding nests.



The higher level land cover classes are floodplain forest, grassland, marsh, developed, and agriculture. Forest and marsh are further separated into four classes each, and several additional aquatic classes create 17 total land cover classes (left).

Geomorphic areas describe physical habitats in the river floodplain system (right). The highest level geomorphic classification separates aquatic and terrestrial areas. Terrestrial areas include islands and connected and isolated floodplain areas.

Aquatic areas are separated into several channel and backwater classes. The main channel and channel border areas convey the greatest river flow. Secondary channels and tertiary channels are typically flowing habitats, but the amount of flow is quite variable depending on their location in the river system and their connectivity with the main channel. Backwater areas may be connected or isolated. In some areas, the dams create large contiguous impounded backwaters and shallow aquatic areas.



River floodplain ecosystems support a wide variety of species, which are distributed along flood frequency gradients (Fig. 1). Low elevation floodplain areas, which are usually inundated, support aquatic and wetland plants. Areas subject to frequent flooding support flood tolerant species. The least flood tolerant plant species occur on well-drained, high elevation areas. Flooding is the major disturbance on low elevation floodplains. Fire was once an influence on high elevation floodplains, but fires have been suppressed and agriculture is currently the major influence.

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Extreme flooding.

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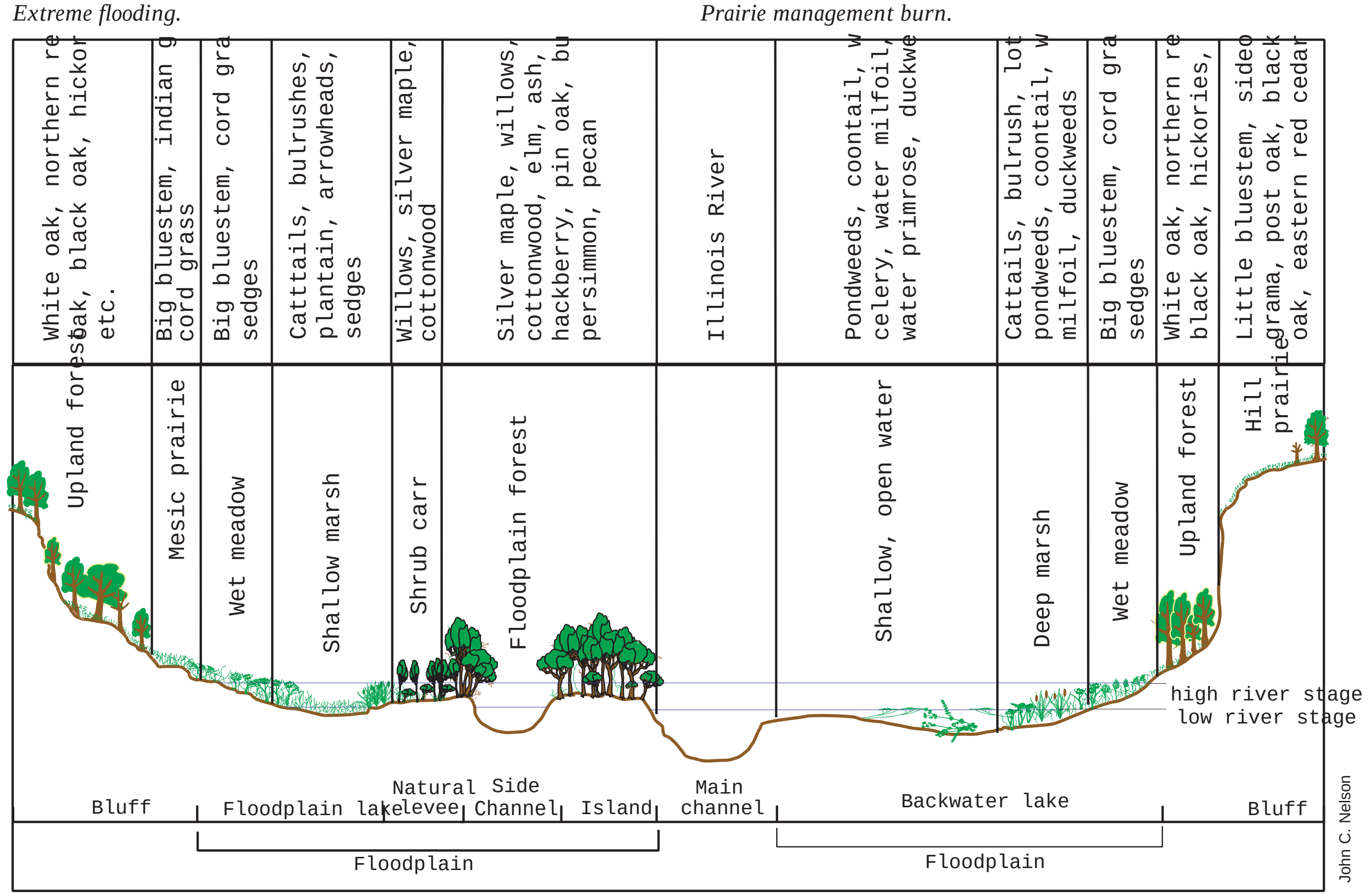
Prairie management burn.



John C. Nelson

Fig. 1. Hypothetical floodplain cross-section.

Habitat classification systems can be quite complex, and so can the analytical tools used to investigate the characteristics of habitat. Three important habitat characteristics used in the relatively young sciences of landscape and conservation ecology were incorporated into the HNA.

Habitat fragmentation is a measure of the size of continuous blocks, or patches, of plant species or communities (Fig. 2).

Habitat connectivity is the consideration of organisms' ability to move through a landscape to fulfill its normal life cycle (Fig. 3). Some organisms have limited mobility, and rely on wind, water, or other animals for dispersal of seeds or young. Other more mobile species, particularly fish, are restricted in their movements within the river system by dams and levees. At the other end of the spectrum, birds are generally highly mobile and can traverse obstacles that present barriers to other species.

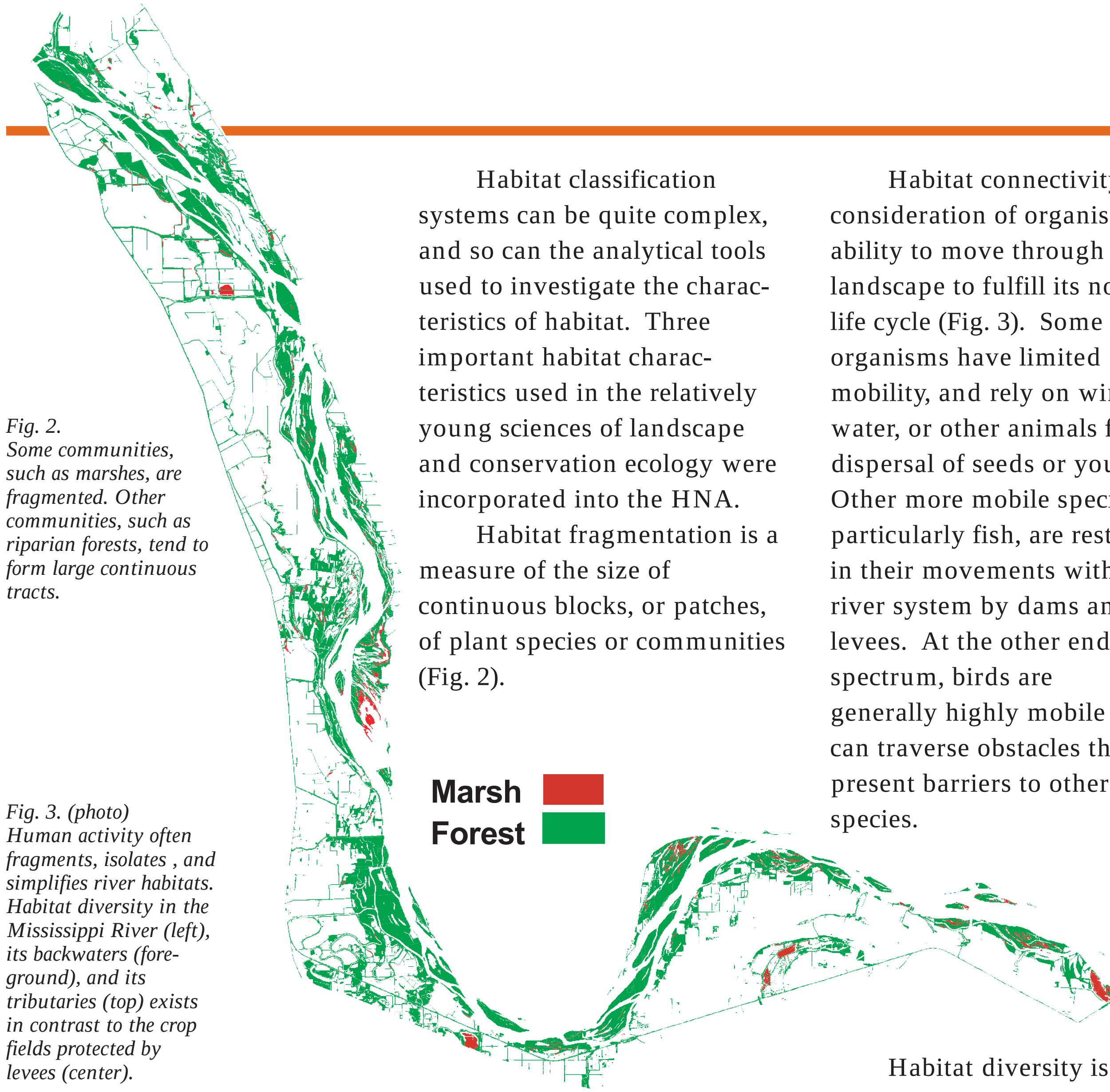


Fig. 2.
Some communities, such as marshes, are fragmented. Other communities, such as riparian forests, tend to form large continuous tracts.

U.S. Army Corps of Engineers

Fig. 3. (photo)
Human activity often fragments, isolates , and simplifies river habitats. Habitat diversity in the Mississippi River (left), its backwaters (foreground), and its tributaries (top) exists in contrast to the crop fields protected by levees (center).

Habitat diversity is a measure of the mix of species or communities present in a given area. Low diversity habitats have large expanses of a single species or community type (e.g., sedge meadow). High diversity habitats support many species or communities. The classification system used to characterize habitat and the size of the area under investigation can greatly influence these types of analyses.

The Importance of Scale in Large River Ecosystems

Depending on their mobility and life requirements, the scale or geographic extent of habitats is important to river organisms. Aquatic and floodplain species in the UMRS have adapted to the size of river habitats and the dynamic set of river habitat conditions for millennia. The major landforms of the present UMRS developed over 11,000 years ago during the retreat of glaciers. The north-south orientation of the Mississippi River provided refuge for species during glacial times and continues to provide a corridor for migration and dispersal of many life forms.

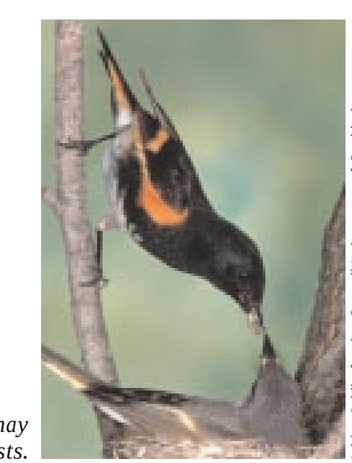
The UMRS basin is approximately 190,000 square miles. Within the mainstem rivers there are over 2.6 million acres of aquatic and floodplain habitat.

Basin and Continental Scales

The basin and larger scales are appropriate when considering the habitat needs of animals that migrate over long distances. Among fish, paddlefish, sturgeon, skipjack herring, and the American eel are notable long distance migrants. Many bird species migrate between North, Central, and South America. Although many species migrate beyond the UMRS, they all require specific habitat resources when they use areas along the rivers.

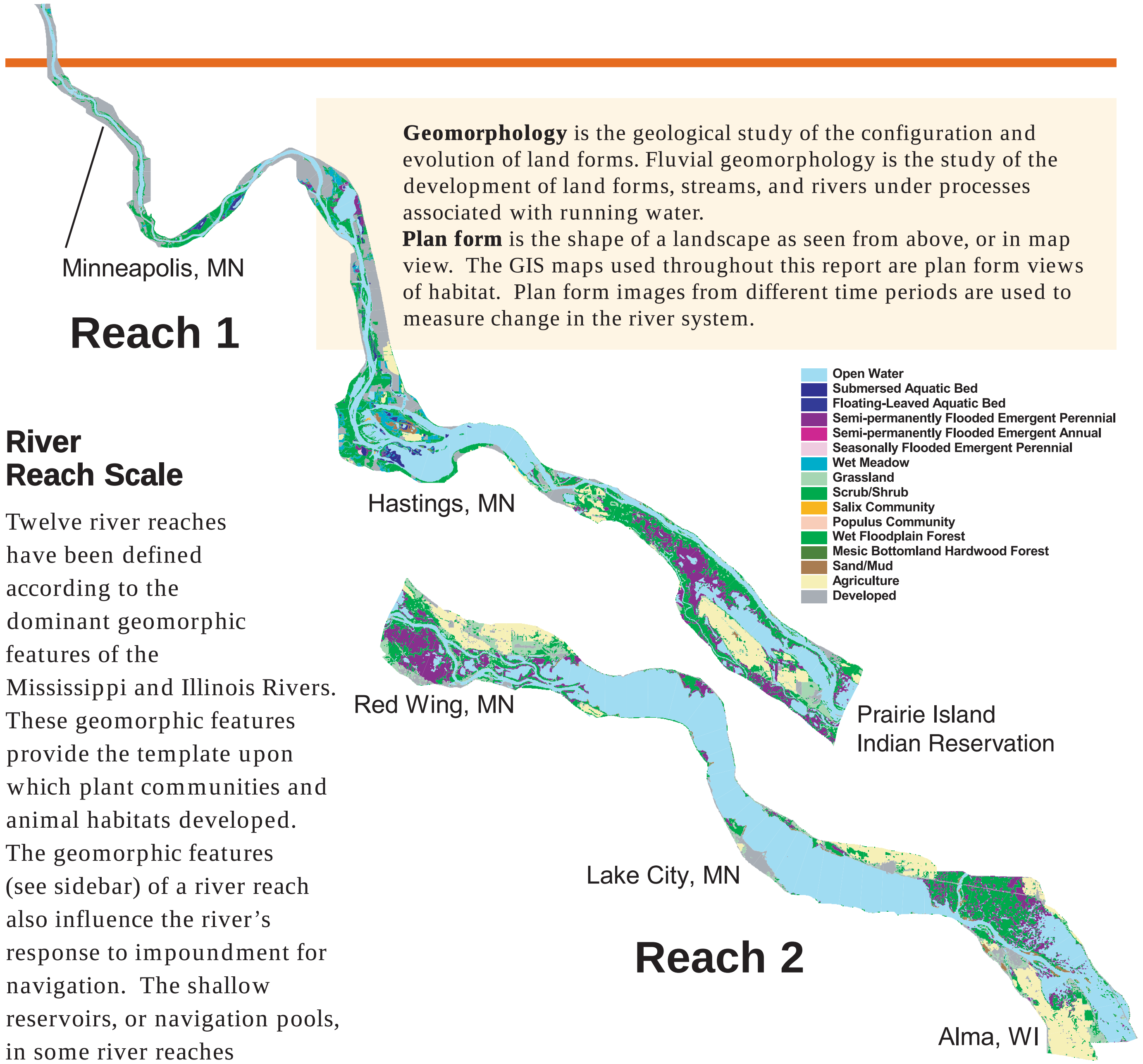
System Scale

The UMRS, as defined by EMP authorizing legislation, includes the Upper Mississippi River from Minneapolis, Minnesota to Cairo, Illinois, the entire Illinois River, and navigable portions of the Minnesota, St. Croix, Black, and Kaskaskia Rivers. This HNA covers the aquatic and floodplain areas of the UMRS.



Isidor Jeklin for the Cornell Laboratory of Ornithology

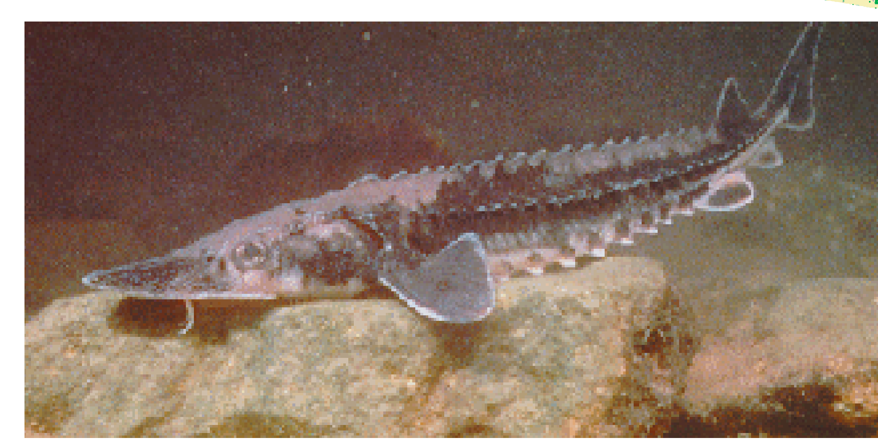
Neotropical migrants such as American redstarts may winter in South America and breed in UMRS forests.



Geomorphology is the geological study of the configuration and evolution of land forms. Fluvial geomorphology is the study of the development of land forms, streams, and rivers under processes associated with running water.
Plan form is the shape of a landscape as seen from above, or in map view. The GIS maps used throughout this report are plan form views of habitat. Plan form images from different time periods are used to measure change in the river system.

River Reach Scale

Twelve river reaches have been defined according to the dominant geomorphic features of the Mississippi and Illinois Rivers. These geomorphic features provide the template upon which plant communities and animal habitats developed. The geomorphic features (see sidebar) of a river reach also influence the river's response to impoundment for navigation. The shallow reservoirs, or navigation pools, in some river reaches developed broad, open-water impounded areas, whereas others show little apparent plan form (see sidebar) change due to impoundment. Habitats and the ecological communities they support differ among river reaches, thus resource opportunities, problems, and management differ among the river reaches.



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Lake sturgeon and other fish species may migrate hundreds of miles among river reaches.

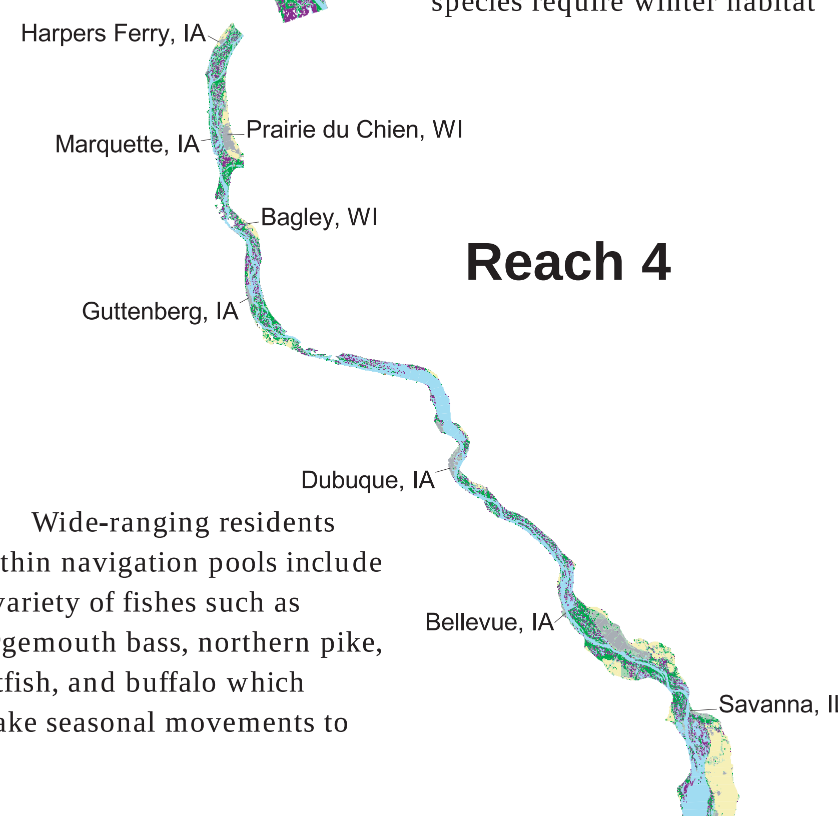

U.S. Army Corps of Engineers

Locks and dams such as this one near Bellevue, Iowa establish boundaries of the navigation pools.

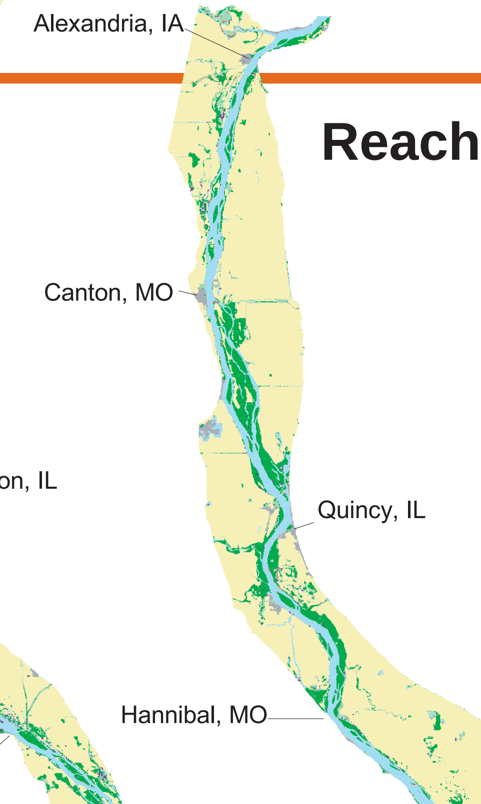
Some species migrate over a regional scale to complete their life cycle. Regional migratory fish include species such as walleye, smallmouth bass, white bass, and some sucker species that move upstream to spawn, often in tributaries to the mainstem rivers. Dams and tributary habitat degradation have reduced access to habitat for these fishes. Many bird species migrate along the Mississippi River to find warmer winter temperatures in southern states.

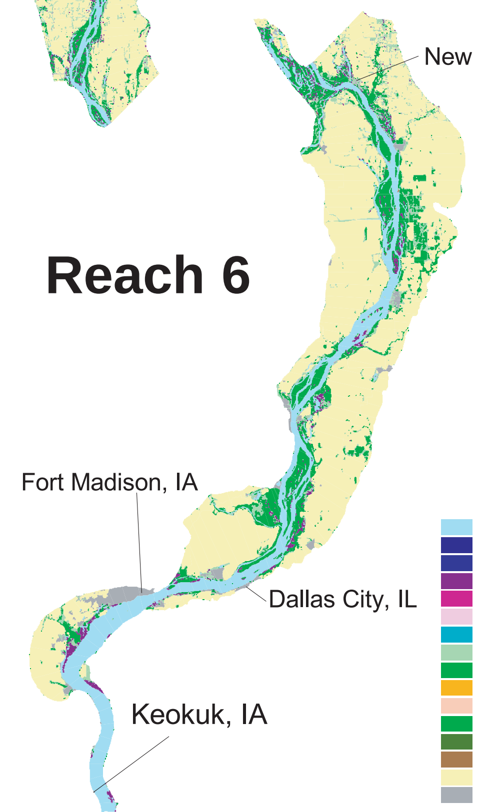
Navigation Pool Scale

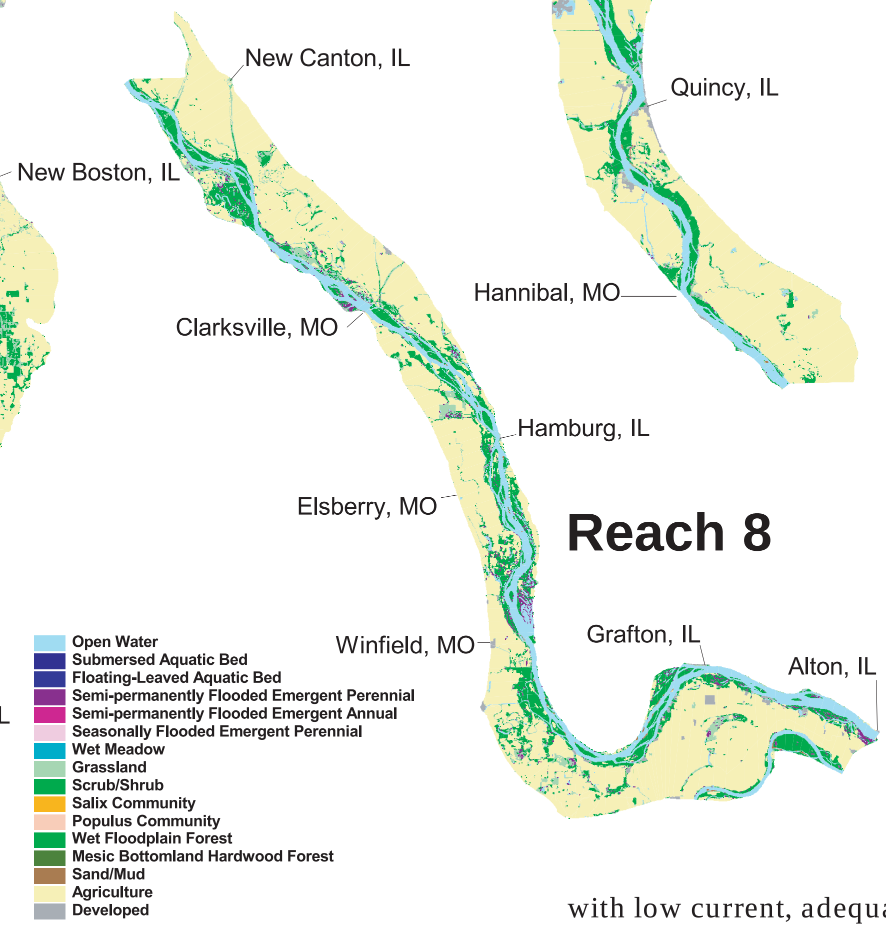
The mainstem dams of the UMRS navigation project formed a series of shallow reservoirs called navigation pools. The pool scale is important in assessing the physical environment that defines habitat for species that display seasonal movements of about 20 miles or less. UMRS navigation pools differ in their mix of habitats among river reaches.



Wide-ranging residents within navigation pools include a variety of fishes such as largemouth bass, northern pike, catfish, and buffalo which make seasonal movements to find appropriate habitats to spawn, feed, or over-winter. Some species require flooded vegetation to spawn, others need structure and undercut banks, and some require firm bottom substrate. Most fish species require winter habitat with low current, adequate levels of dissolved oxygen, and water temperatures higher than freezing. All seasonal habitat needs for resident species must be met within a navigation pool because dams restrict access to other navigation pools. Resident birds maintain home ranges over many square miles. Cardinals, blue jays,








U.S. Fish and Wildlife Service

Largemouth bass and other species may make seasonal movements of 10-20 miles.


J. R. Woodward for the Cornell Laboratory of Ornithology

Cardinals and other resident birds have large local home ranges.

woodpeckers, crows, and many others may use both floodplain and upland habitats. Some bird species may nest in one floodplain habitat and feed in another which requires that important habitats are available within their home range.

Habitat Scale

The habitat scale is the level that is actually occupied by organisms. UMRS habitats must provide suitable resources to meet the needs of a variety of riverine organisms. Habitats for long-distance migrants and wide-ranging species are large, while relatively immobile organisms such as freshwater mussels have small habitat areas. Most riverine organisms have habitat needs that can be measured in square yards to tens of acres. Many river organisms require diverse habitat conditions, with multiple habitat types in close proximity. Most river processes act at the habitat scale and protection and restoration is generally focused at this scale.

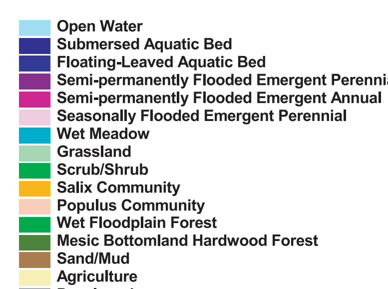
Many animal species have small home ranges that meet all their life history needs. Even migratory species will use small home ranges within their seasonal habitats. For species with system-wide distribution it is important that critical habitats are available and of suitable quality to support local populations. Aquatic invertebrates are generally restricted to small areas, but may drift in currents or migrate during adult aerial stages. Freshwater mussels are a particularly threatened group of animals that have suffered greatly through harvest or pollution due to their lack of mobility. Many panfish and minnows and most small mammals have limited ranges.

U.S. Army Corps of Engineers

Backwater areas support migrating species when they are present, but they also support many resident species throughout the year and throughout their life cycles.

Scott D. Whitney

Crappie, bluegills, and many minnows may live their entire life in one backwater lake.



Allen Blake Sheldon

Similarly, muskrats may stay in one marsh for their entire life.

Dan Kelner

Freshwater mussels are channel bottom residents that rarely move.

The Role of Disturbance in the UMRS Ecosystem

Large rivers are dynamic ecosystems where habitats evolved and persist in response to a variety of natural and human-caused disturbances (Table 1). Floods and droughts are natural disturbances that occur seasonally, but exhibit an approximately decadal cycle of extreme events on the UMRS. Seasonal flooding drives a highly productive and diverse ecosystem.

Sediment transport and channel-forming processes are active continuously. Channel and floodplain geometry can change slowly over a period of decades or rapidly during extreme floods. Impoundment and river regulation for navigation have significantly modified the hydrologic regime and the pattern of sedimentation.

Fire was once a dominant force maintaining floodplain grassland-savanna landscapes. Ice flows, tree falls, and log jams are all natural occurrences that help define local habitats and maintain high habitat diversity. Biological disturbances (e.g., beavers) are important in the development of floodplain landscapes.

The great flood of 1993 was one of the country's worst disasters.

Table 1. Ecological Disturbances

Natural	Man Made
Flood	Water level regulation
Drought	Dredging and dredged material disposal
Sedimentation	Channel training structures
Channel migration	Boat generated waves
Sediment resuspension	Levee construction
Fire	Agriculture
Ice shear	Nutrient enrichment
Tree wind-throw	Logging
Log jam	Urban development
Beavers	Contaminants

Impoundment, water level regulation, channelization, levee construction, logging, and urban and agricultural development are the dominant human activities affecting river habitats on the UMRS. Navigation dams converted free flowing rivers to a series of shallow impoundments. Portions of the floodplain were permanently flooded by the dams and backwater area increased significantly in some river reaches (Fig. 4). Since impoundment, sedimentation of backwaters, island loss, and loss of secondary channels have greatly modified the pattern of river habitats.

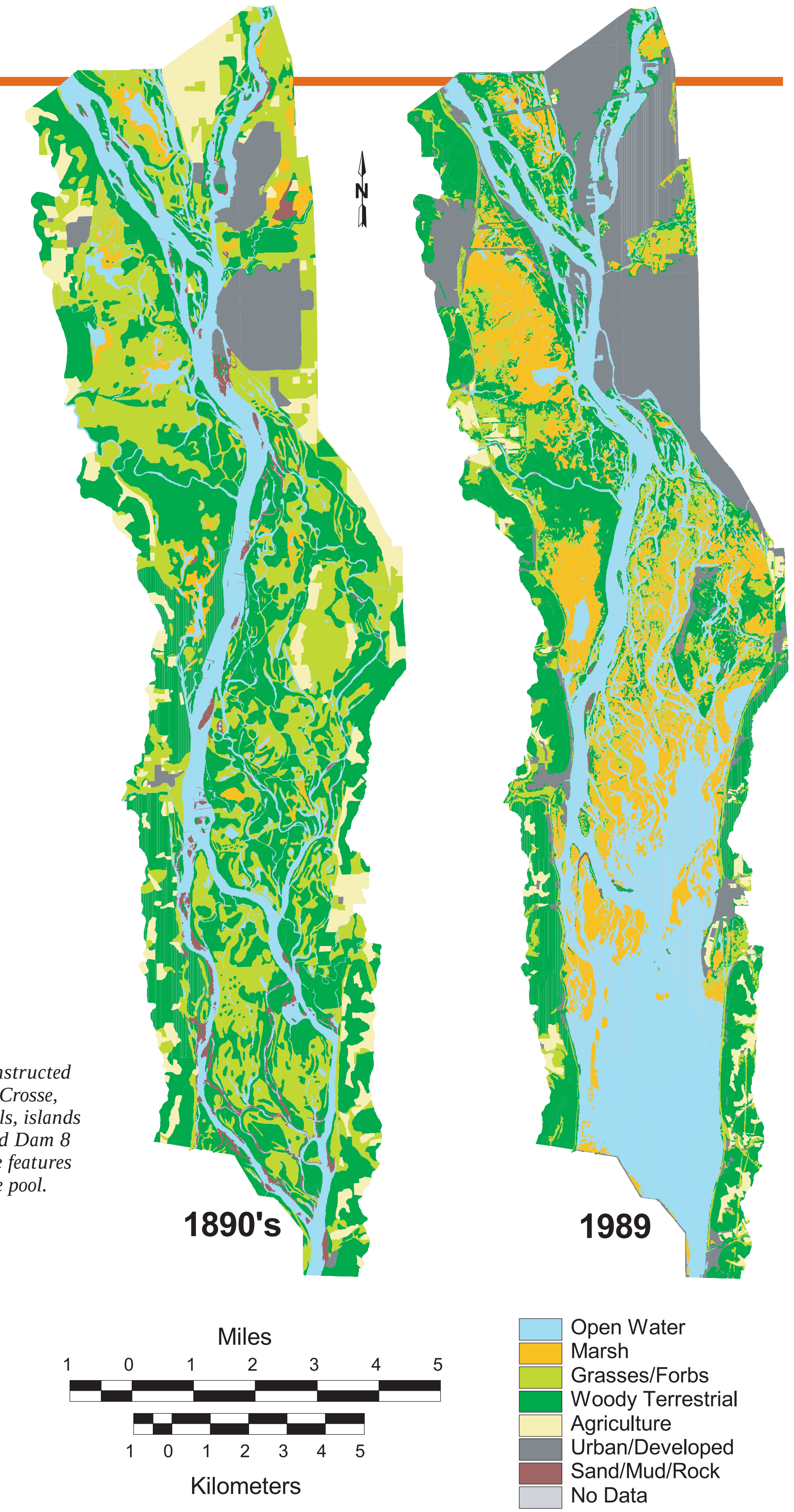
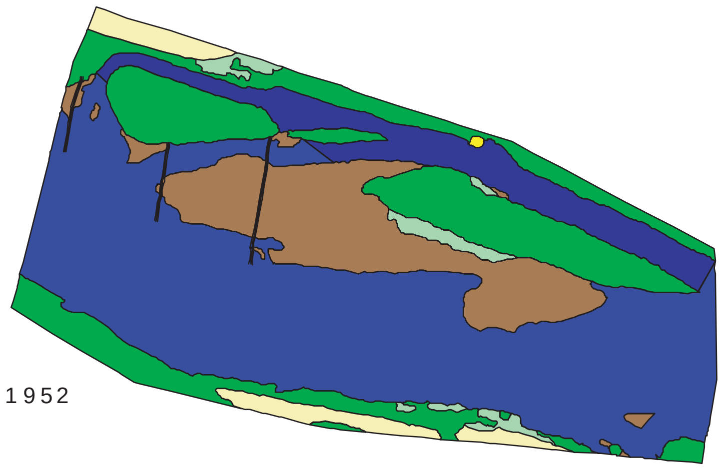


Fig. 4. Before dams were constructed (ca. 1890), the river near La Crosse, Wisconsin had many channels, islands forests and marshes. Lock and Dam 8 permanently inundated these features in the downstream half of the pool.



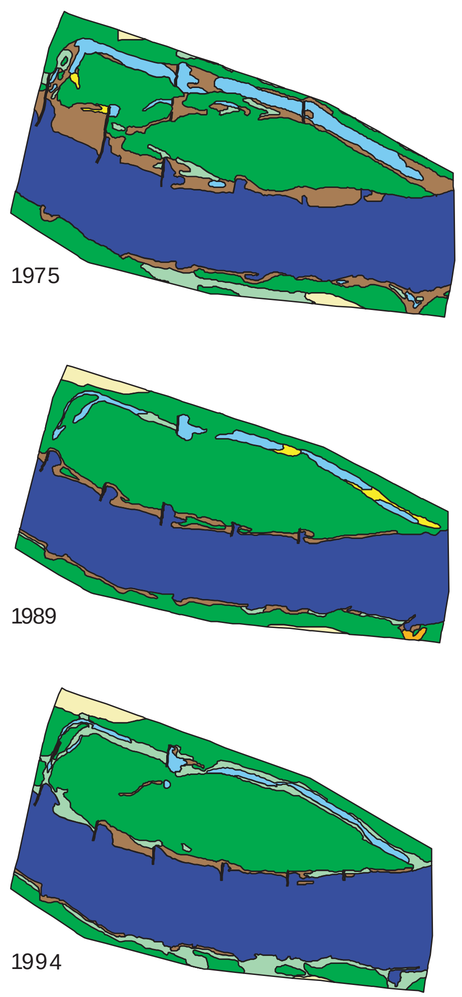


Fig. 5. An example of side channel loss south of St. Louis.

Rock wing dams, closing dams, and bank revetments are used to maintain the navigation channel and to reduce dredging requirements. These structures decrease bank erosion and force flow into the main river channel. In the Open River reach, channel training structures have greatly reduced the number and quality of secondary channels (Fig. 5). There has also been loss of channel area as sediment filled the area between wing dams.

Much of the floodplain south of Pool 16 on the Mississippi River and on the La Grange and Alton pools on the Illinois River has been isolated by levees (Fig. 6). The distribution of levees as proportion of total floodplain area is about:

- 3 percent north of Pool 13;
- 50 percent from Pool 14 through Pool 26;
- 80 percent in the Open River; and
- 60 percent of the lower 160 miles of the Illinois River.

In total, more than 1.1 million acres, mostly agricultural land, are protected from moderate floods by levees.

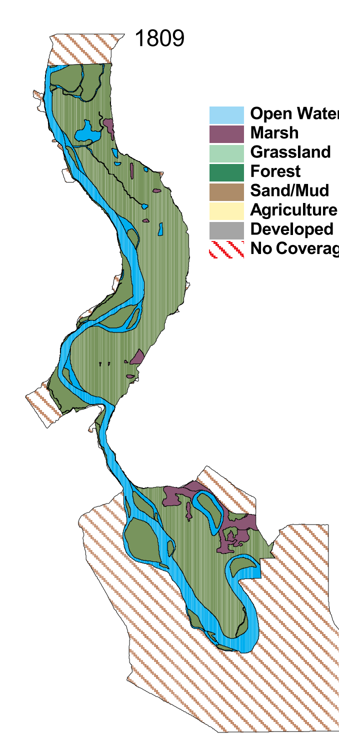
Logging has caused significant habitat degradation throughout the river floodplains and northern parts of the basin. Logging was necessary to supply fuel-wood for steamboats and railroads, firewood for heat and cooking, and lumber to build cities. In most floodplain areas deforested land was rapidly converted to agriculture. The impact is particularly dramatic below the Kaskaskia River where the densely forested floodplain was almost completely cleared (Fig. 7).

U.S. Geological Survey – Upper Midwest Environmental Sciences Center

Fig. 6. The photograph illustrates the difference between floodplain agricultural area protected by levees and natural floodplain habitat that remains connected to the river.

Deforestation and agricultural conversion throughout the basin increased sediment delivery to the mainstem rivers.

Urban development displaced native habitats, but also caused indirect impacts. Sewage and industrial pollution caused significant water quality problems that eradicated sensitive species downstream of large cities. The problem has subsided since the 1970s.



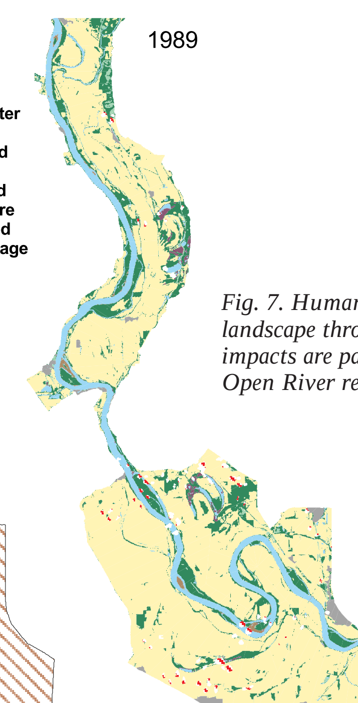


Fig. 7. Humans have altered the landscape throughout the UMRS. The impacts are particularly evident in the Open River reach south of St. Louis.

Habitat Needs Assessment Approach

Habitat needs were identified through comparison of existing, predicted, and desired future conditions. UMRS geomorphology and climate, historic land cover change, and ecological disturbances were reviewed in the context of their influence on habitat conditions. An evaluation of existing habitat conditions was also conducted throughout the UMRS, reviewed and refined forecast future habitat conditions, and attempted to identify ecologically and socially desired future habitat conditions. The HNA addresses the system-wide, river reach, and pool scales and includes the bluff-to-bluff extent of the floodplain.

A new Geographic Information System (GIS) query tool developed as part of the HNA allows queries of where species and their habitats are likely to occur throughout the UMRS. A second new tool completed for the HNA is a floodplain vegetation successional model to predict future land cover.

Existing Conditions

GIS Database

A systemic HNA Areas GIS database was developed from existing data to standardize geomorphic area (location in the river system) and land cover (plant communities and land use) classification systems (Fig. 8). The GIS database defines various aquatic areas, islands, and contiguous and isolated floodplain areas, as well as 17 ecologically relevant land cover classes. Aquatic habitat areas were further described using spatial data about proximity to shorelines, wing dams, and closing dams. The 1989 HNA land cover GIS database also includes boundaries for EMP habitat project areas. Links to habitat project fact sheets provide information on project goals and objectives.

Fig. 8. High resolution data derived from photos is available for much of the Mississippi River north of St. Louis, but low resolution satellite data only are available for much of the Open River reach and the Illinois River.

Habitat: Species Relationships

The UMR supports a large number of species including: over 200 aquatic macroinvertebrate species, 44 mussel species, 143 fish species, 73 reptile and amphibian species, over 300 bird species, and over 50 mammal species, in addition to the hundreds more plant, insect, and microbe species. This large number of species was organized by combining species of aquatic macroinvertebrates, mussels, fish, reptiles and amphibians into groups of animals, called guilds, that have similar habitat requirements and habitat use. Birds, mammals, reptiles and amphibians, and some fish are considered at the species level because much is known of their life history.

Relational tables were developed to link species and guilds with the HNA Areas GIS database (Table 2). These relational tables provide a coarse system-wide overview of habitat areas that have the potential to support different species and guilds. Potential habitat for species and guilds was rated by regional experts using a 0 to 3 score:

0 = very low potential occurrence,

1 = low potential occurrence,

2 = moderate potential occurrence,

3 = high potential occurrence.

HNA Query Tool

The HNA GIS Query Tool was developed to assist the Habitat Needs Assessment (Fig. 9). It helps evaluate potential distribution of species and habitat area types throughout the UMRS. The user may query on a species and obtain habitat information, or may query on a habitat to obtain species information. These queries are accomplished using the matrices developed to associate a species' potential to occur within various types of habitat. The query tool presently incorporates land cover and geomorphic area data. An advanced version of the tool incorporates more data layers to define habitat in more detail and to create better habitat models. Application of the advanced tool is presently limited because spatial data about habitat attributes needed to use it to its full capability are still lacking for most of the river system.

The HNA GIS Query Tool was designed to generate information about user-specified species, guilds, or habitats for selected portions of the UMRS. This includes the production of GIS themes,

Table 2. Example of reptile and amphibian guild-by-habitat relation table.

	Habitat Modifiers (1 or 0)			Aquatic Channel Areas							Backwater Areas				Terrestrial		
Guild	shoreline	wing dam	rip-rap	main nav. Channel	channel border	tailwater	secondary	tertiary	tributary	excavated	contiguous FP lake	shallow AQ	impounded	isolated	Islands	Floodplain contiguous	isolated
Lotic Aquatic Salamanders	0	1	1	0	2	3	2	1	2	0	0	0	1	0	0	0	0
Lentic Aquatic Salamanders	1	0	0	0	0	0	0	0	1	0	1	3	1	3	2	3	1
Terrestrial Salamanders	1	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	1
Terrestrial Frogs and Toads	1	0	0	0	1	0	1	1	2	1	2	3	2	3	0	3	2
Semi-Aquatic Frogs	1	0	1	0	2	1	2	2	1	2	3	3	2	3	1	3	3
Aquatic Frogs	1	0	1	0	2	2	3	3	3	3	3	1	3	2	2	3	3
Arboreal Frogs	1	0	0	0	0	0	0	0	0	0	1	1	1	3	0	1	2
Lentic Turtles	1	1	1	1	2	1	3	1	2	2	3	1	3	2	3	3	2
Lotic Turtles	1	1	1	1	3	2	3	1	2	1	3	1	2	0	2	2	0
Terrestrial Turtles	1	0	0	0	1	0	0	0	1	0	1	1	1	1	0	3	3
Woodland Lizards	1	0	0	0	2	0	2	2	2	0	1	0	2	2	0	2	3
Prairie Lizards	1	0	0	0	1	0	1	0	1	0	0	0	0	0	0	2	3
Woodland Snakes	1	0	0	0	1	0	1	0	2	0	1	1	1	1	0	2	1
Prairie Snakes	1	0	1	0	1	0	1	1	2	1	2	3	3	3	0	3	3
Aquatic Snakes	1	1	1	0	3	1	3	1	2	1	3	1	2	2	1	3	1

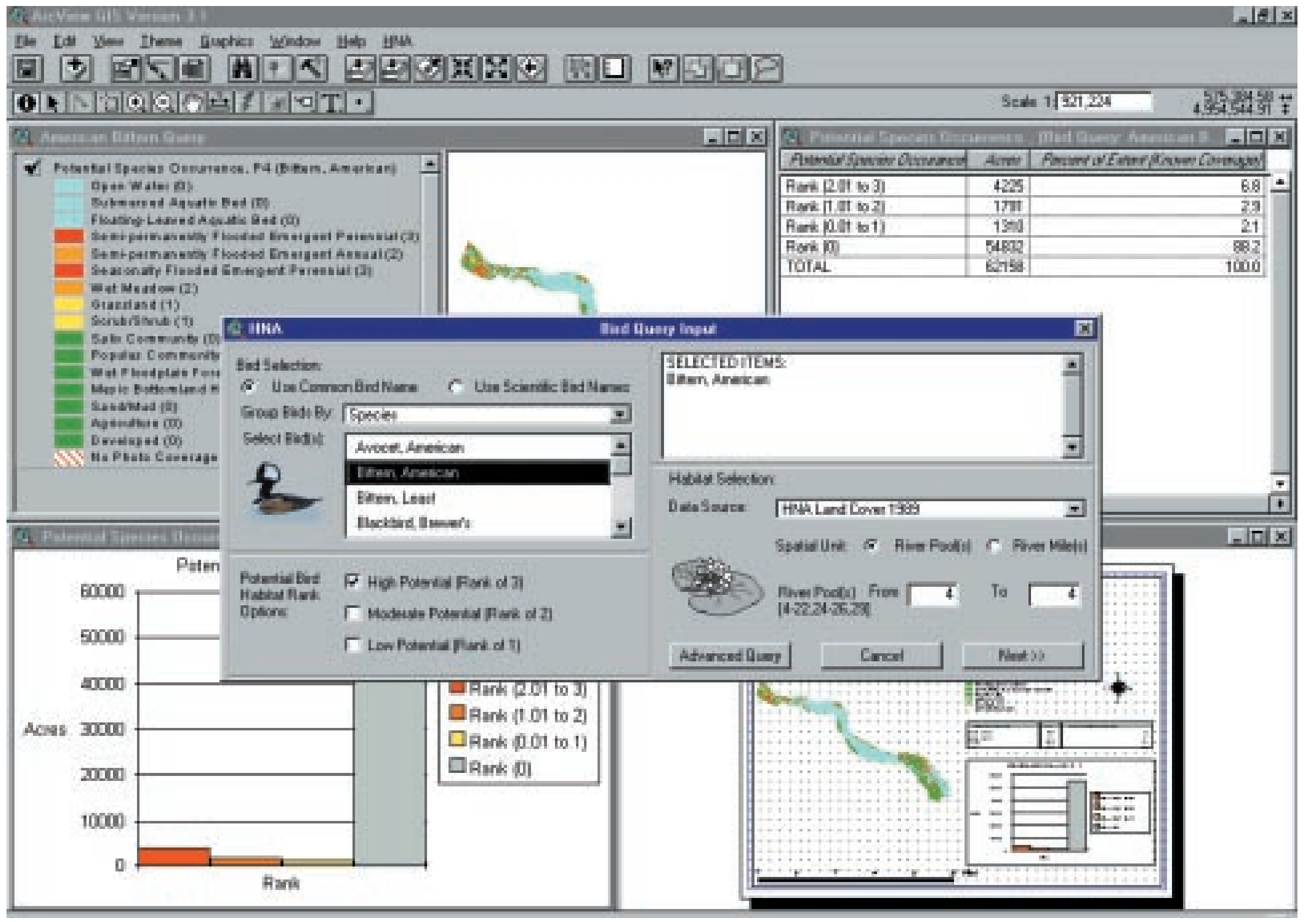


Fig. 9. The HNA query tool is an easy to use interface for natural resource managers to incorporate the power of GIS into their work.

tables, charts, maps, and text reports describing potential species habitat, occurrence, and diversity (Table 3).

Forecast Future Conditions

Quantitative Assessment of Forecast Geomorphic Change

A review of published reports was used to characterize forecast geomorphic changes in the UMRS over the next 50 years. The Cumulative Effects Study, completed for the Upper Mississippi River–Illinois Waterway Navigation Feasibility Study, was the most recent attempt to quantify a forecast of future conditions for the UMRS. The Cumulative Effects study team compiled historic maps, photos, channel bathymetry, sediment transport estimates, dredging statistics, and many other data to assess apparent geomorphic changes resulting from and incurred since impoundment to help predict plan form change over the next 50 years. The review was more comprehensive in Pools 4 – 26 than in the rest of the river system.

Qualitative Assessment of Site-Specific Geomorphic Change

Two methods were used to provide a qualitative site-specific assessment of geomorphic change. Both methods incorporated an analysis of historic change to predict future conditions. The first assessment was completed as part of the Cumulative Effects Study, in which the consultant team reviewed historic maps and photos to identify areas of extensive change. Using this method, only large plan form changes were detectable. The second method incorporated the knowledge and experience of natural resource managers, many with 20 or more years of experience working in specific regions of the river. Workshops were held to have managers locate areas showing past change or expected to change in the next 50 years on maps. The manager's local knowledge allowed a more detailed analysis because they could provide insight into changes occurring below the water's surface. For example, backwaters that may not have displayed discernable change in surface area may have lost significant depth that reduced their value as habitat.

Floodplain Vegetation Successional Model

A terrestrial vegetation successional model was developed to help predict land cover change. A rule-based approach was employed to estimate the system-wide percent change of one land cover class to other land cover classes over a fifty-year time period. An expert panel of Upper Mississippi River System foresters, botanists, and ecologists was convened to develop the rule based successional model. The panel first agreed on the set of plant

Table 3. HNA query tool output.

Products	Description
Textual Reports	
Query Report	A textual query report is produced with every query. It contains information about the query parameters and results.
Red Flag Report	A textual red flag report is produced with every query. It contains information about the specific habitat needs, ecological bottlenecks, and UMRS distribution of queried species.
Species Products	
Potential Species Occurrence	Displays potential species habitat within the selected extent Values range from 0 to 3. Zero is considered to have very low potential for species occurrence and 3 is considered to have high potential for species occurrence.
Potential Species Occurrence by River Mile or Pool	Products display average potential species occurrence by river mile or pool The values are determined by area-weighted-averaging. Values range from 0 to 3. Zero is considered to have very low potential for species occurrence and 3 is considered to have high potential for species occurrence.
Potential Species Richness	Displays potential species richness within the selected extent. The values represent the total number of species (selected by the user) that potentially exist in each habitat class.
Potential Species Richness by River Mile or Pool	Products display potential species richness values by river mile or pool. Values represent the total number of species (selected by the user) that potentially exist in each river mile or pool.
Habitat Products	
Potential Species Habitat or Potential Habitat	Displays potential species habitat for a species query. Displays selected habitat for a habitat query.
Potential Species Habitat or Potential Habitat by River Mile or Pool	Products display potential species habitat or selected habitat by river mile or pool. Habitat areas are noted as acres or percent.
Habitat Richness and Diversity by River Mile or Pool	Displays habitat richness and diversity by river mile or pool For a species query, the habitat richness values represent the total number of potential habitat types for the selected species that occur within each river mile or pool For a habitat query, the habitat richness values represent the total number of selected habitats that occur within each river mile or pool The habitat diversity values are determined using Simpson's Diversity Index which takes into account the proportion of each habitat within each river mile or pool. Values range from 0 to 1 with areas becoming more diverse as their values approach 1.

community types to be included in the analysis. The panel also agreed on a set of assumptions that would limit the range of future change under consideration. The assumptions include:

1) Land presently in agricultural use will remain in agricultural use,

2) Developed land will remain developed,

3) Existing plans for floodplain vegetation management will be implemented,

4) The climate and hydrologic regime will not change,

5) The present set of natural disturbances (wind, fire, flood, ice, diseases, etc.) will continue.

The panel then developed the basic pathways for change from early successional classes to later successional classes. A smaller team estimated the proportion of each land cover anticipated to change to other land cover classes using terrestrial area change estimates from the Cumulative Effects Study where available. The calculations were conducted at the pool scale and summarized in the HNA technical report appendices. Locations of change were not predicted.

Desired Future Habitat Conditions

Consultations With Resource Managers

Workshops were held to consider historic conditions, existing conditions, the available forecast of future conditions, and ongoing geomorphic processes to ultimately identify desired future habitat conditions. Information developed previously to assess historic, existing, and predicted UMRS plan form habitat changes was distributed to participants in advance of the workshops. A qualitative assessment asked five questions to elicit responses important to assessing: 1. the quality of the approach and information used in the description of historic, present, and predicted habitat, 2. desired habitat quality, 3. areas, processes, species, or habitat characteristics critical to maintaining habitat integrity, 4. threatened habitats, and 5. stressors or altered disturbance regimes limiting restoration potential. In an effort to quantify desired future habitat conditions, resource managers expressed their professional opinion regarding the proportion of geomorphic area classes in "desirable" condition for the present, predicted future and desired future.

Beth Whetsell, Illinois Natural History Survey

Lake Chautauqua, Illinois River, outside of the restoration project.

Beth Whetsell, Illinois Natural History Survey

Lake Chautauqua, Illinois River, inside of the restoration project.

These percentages were then transformed into an approximation of "desirable" acres needed for each geomorphic area type.

Public Involvement

Public involvement was recognized as a vital part of the Habitat Needs Assessment process. During this first HNA, several approaches were developed by a multi-agency HNA Public Involvement Team to assess the public's understanding, values, and expectations regarding desired future habitat conditions for the UMRS. These approaches were by no means comprehensive, but were

U.S. Fish and Wildlife Service

Fall waterfoul hunting is poular throughout the river system.

U.S. Army Corps of Engineers

Water skiing near Grafton, Illinois.

considered to be the most practical and effective means of engaging the public in the initial HNA.

Information was collected from the public at two levels: institutions, and the public at large. A compilation of mission statements and UMRS management plan objectives were reviewed to identify institutional priorities and activities related to river habitat. A series of 12 open public meetings conducted in April and May 1999 and a series of ten focus group meetings conducted in July and August 2000 were used to assess the general public's understanding, values, and expectations regarding desired future UMRS habitat conditions.

Information from governmental and non-government organizations with interests in and responsibilities for habitat management in the UMRS were obtained to identify institutional intent with respect to UMRS habitat. The institutional intent was evaluated by examining the mission statements of agencies and organizations, resources identified as being important or as the target of management activities, and statements in management plans about UMRS habitat.

During April and May 1999, the National Audubon Society and Upper Mississippi River Conservation Commission convened public meetings at 12 locations on the Upper Mississippi River System. Maps showing local river resources were provided prior to the formal program portion of each meeting. Following two informative presentations about the condition of the river system, meeting participants were invited to respond to the following questions:

I: What are the important natural resources in the Mississippi (Illinois) River ecosystem?

II: What do you think are the problems and opportunities in the river ecosystem?

III: How will you recognize successful restoration of the river ecosystem?

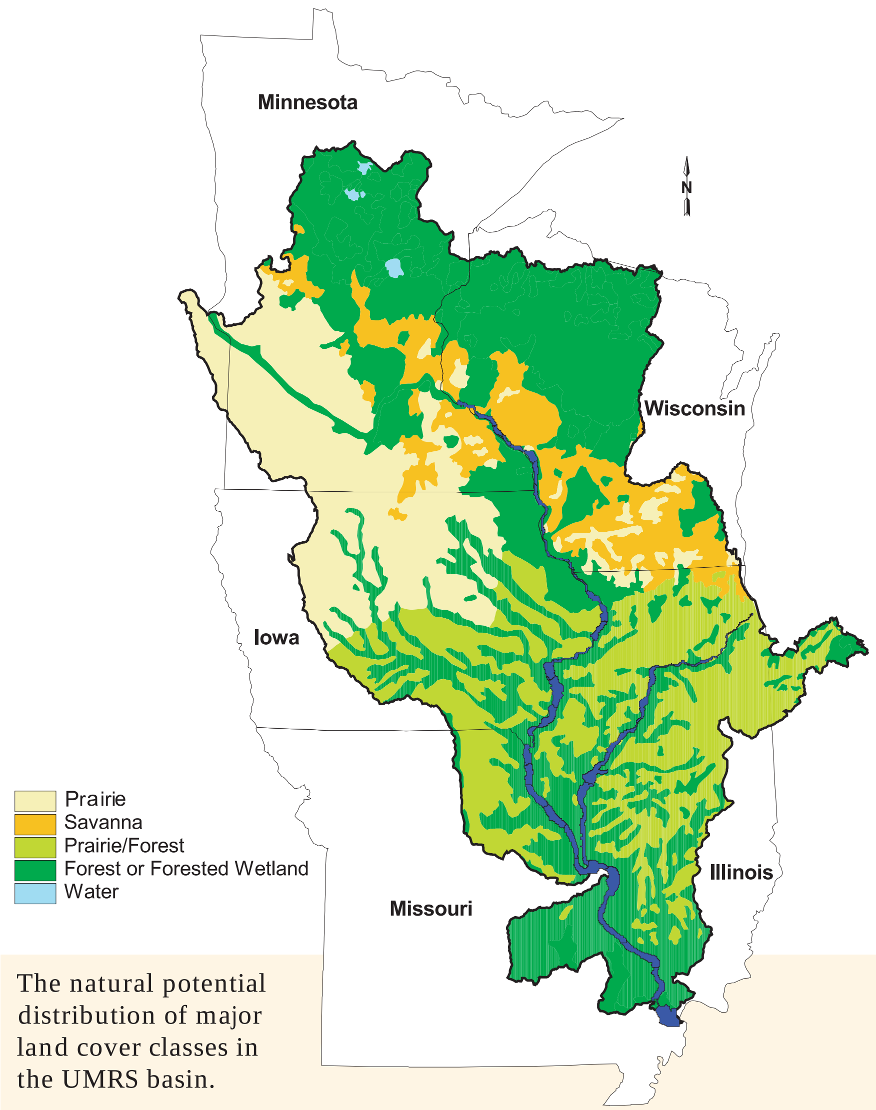
Focus groups convened by the U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, and the Upper Mississippi River Basin Association were the second method used to obtain public views of UMRS resources and the HNA process. Various river interests were reflected in the 92 focus group participants, including perspectives from environmental groups, industrial and transportation groups, fishers and hunters, landowners, and river residents. A presentation on the HNA process and results was followed by facilitated discussions on three points developed by the HNA Public Involvement team: (1) to gauge public reaction to details of the HNA process; (2) to capture public perspectives of desired future habitat conditions; and (3) to capture perspectives and preferences for future public involvement in the HNA/EMP process.

Historical Change in Upper Mississippi River System Habitats

Prior to widespread European settlement of the region, the Upper Mississippi River Basin was a diverse landscape of tallgrass prairie, wetlands, savannas, and forests. Logging, agriculture, and urban development over the past 150 years has resulted in the present landscape that is more than 80 percent developed. Millions of acres of wetland drainage, thousands of miles of field tiles, road ditches, channelized streams, and urban stormwater sewers accelerate runoff to the mainstem rivers. The modern hydrologic regime is highly modified, with increased frequency and amplitude of changes in river discharge. Dams and river regulation throughout the basin also modify river flows. The modern basin landscape delivers large amounts of sediment, nutrients, and contaminants to the river.

At the system-wide scale there were natural gradients in habitat among river reaches. Northern river reaches were more forested and were composed of mixed silver maple forests, river channels, seasonally flooded backwaters, floodplain lakes, marsh, and prairie. Beginning around the northern Iowa border and along the lower Illinois River, grasslands and oak savanna dominated floodplain plant communities. Historic surveys reveal a higher proportion of oaks and other mast trees in the forest community than at present. Below the Kaskaskia River, the floodplain was heavily forested with species characteristic of southern bottomland hardwood communities. Impacts of river floodplain development include forest loss and water gain in northern reaches, and grassland and forest losses in the rest of the UMRS. (Table 4, Fig. 10).

At the pool scale since impoundment, sediment accumulation and littoral (i.e., wind and wave) processes in the navigation pools have greatly altered aquatic habitats.



The natural potential distribution of major land cover classes in the UMRS basin.

Table 4. Percent composition of land cover types in selected Upper Mississippi and Illinois River reaches in pre-settlement (ca. early 1800s) and contemporary (1989) periods.

Geomorphic Reach	Pool	Pre-Settlement					Contemporary						
		Open Water	Marsh	Prairie	Timber	Swamp	Open Water	Marsh	Prairie	Timber	Swamp	Developed	Agriculture
1	--	--	--	--	--	--	--	--	--	--	--	--	--
2	4	49.8	1.5	7.9	40.2	0.2	53.0	6.0	5.0	23.0	0.0	5.0	8.0
3	8	21.0	14.8	8.0	55.5	0.6	52.8	8.1	9.8	17.7	0.0	11.1	0.5
4	13	19.7	4.5	35.1	39.1	1.6	19.6	18.3	5.3	18.6	0.0	6.6	31.6
5	17	14.6	0.7	57.0	25.8	1.9	25.4	1.8	6.6	28.4	0.0	5.4	32.4
6	--	--	--	--	--	--	--	--	--	--	--	--	--
7	22	13.3	0.0	35.0	51.7	0.0	9.9	0.1	3.6	12.2	0.0	1.8	72.4
8	24	13.2	0.1	46.4	40.3	0.0	10.3	0.7	3.3	13.4	0.0	0.9	71.4
	25,26	18.3	0.4	46.3	35.0	0.0	17.9	1.3	5.6	18.6	0.0	3.1	53.4
9	--	--	--	--	--	--	--	--	--	--	--	--	--
10	OR	6.9	0.0	0.0	86.7	6.4	3.6	0.0	2.4	20.9	0.0	0.4	68.0
IR 2	LaGr	15.3	2.4	20.3	57.5	4.1	17.5	1.9	9.8	22.9	0.0	2.5	45.4

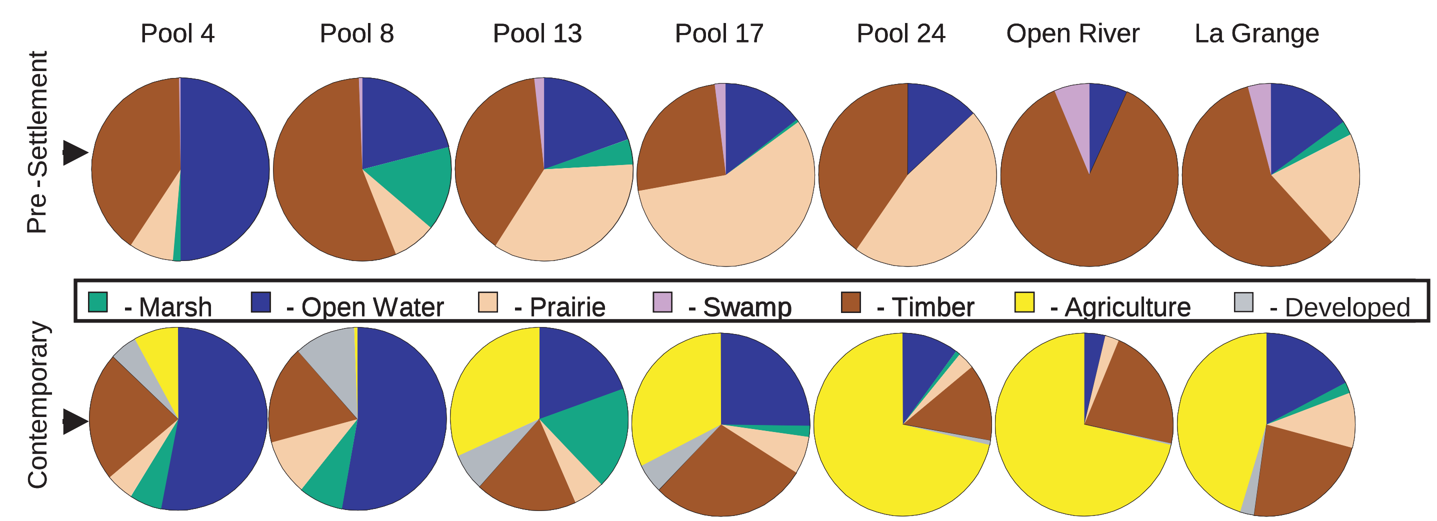


Fig. 10. Presettlement and contemporary land cover in selected Upper Mississippi and Illinois River reaches illustrates the conversion of natural communities to water and agriculture.

Existing Conditions

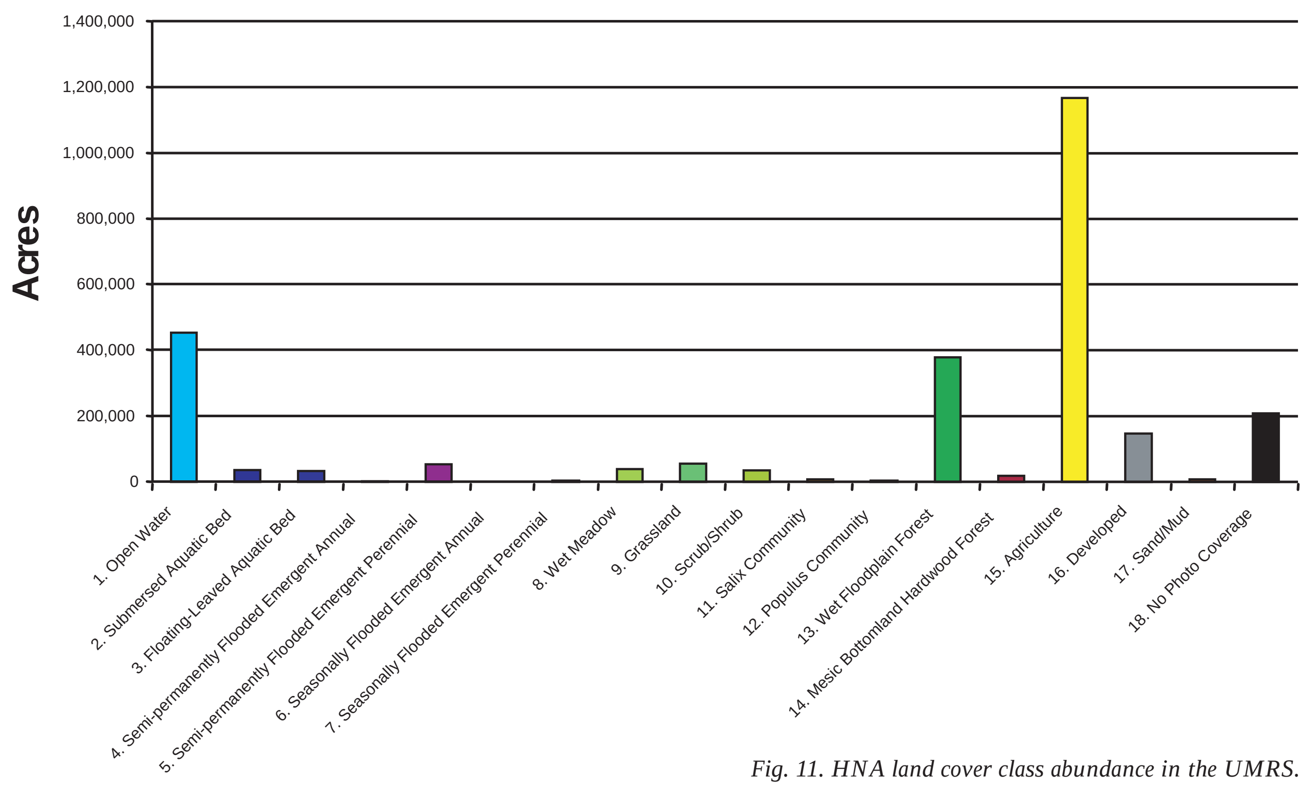


Fig. 11. HNA land cover class abundance in the UMRS.

Land Cover

The Upper Mississippi River System floodplain area encompasses over 2.6 million acres (Fig. 11). Agriculture is the dominant land cover class, occupying about 50 percent of the floodplain. Open water is the second dominant land cover class, covering 17 percent of the floodplain. Floodplain forests follow closely, occupying 14 percent of the floodplain. None of the other classes exceeds 10 percent of the floodplain area, and only developed land areas exceed 5 percent.

Land cover classes are unevenly distributed throughout the river system, and the absolute floodplain area of river reaches and pools may also differ greatly (Fig. 12). The largest differences occur in the amount and distribution of agriculture and the proportion of open water in the floodplain. Agriculture dominates the floodplain south of Rock Island, Illinois (Pool 14), and open water occupies a greater proportion of the floodplain between Minneapolis (Pool 1) and Clinton, Iowa (Pool 13). Wetland classes are generally more abundant between Minneapolis and Clinton. Grasslands are fairly evenly distributed but are rare throughout the river system. Woody classes are important throughout the river system and generally occupy between 10 to 20 percent of the floodplain.

Floodplain and Aquatic Areas

Geomorphic areas, or aquatic and terrestrial features within river reaches, are parts of the river system that have similar geologic origins, formed by similar river processes or manmade structures. They include channel, backwater, and floodplain areas. Aquatic areas are either contiguous (connected with the river) or

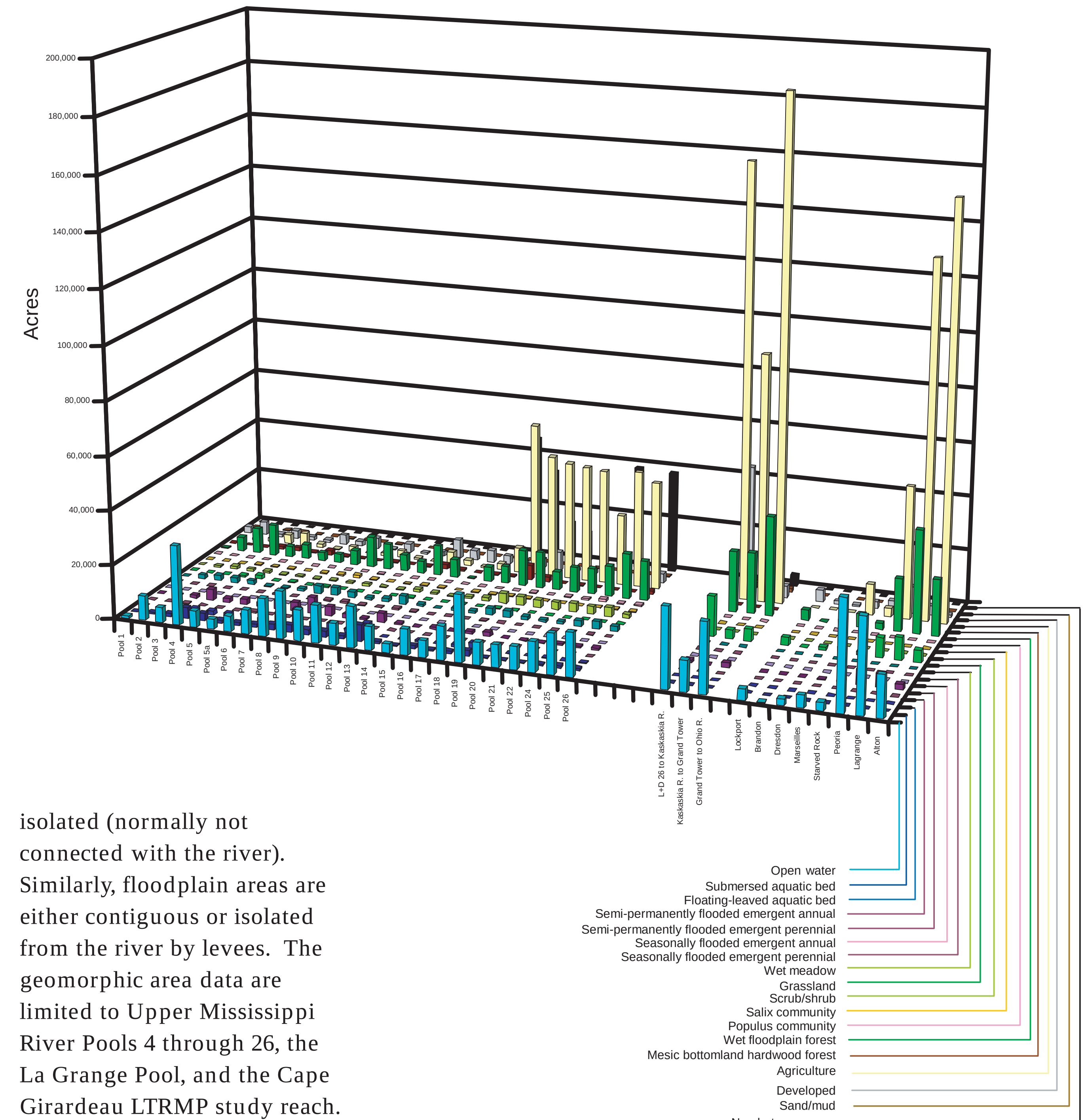


Fig. 12. System wide abundance of UMRS land cover classes.

isolated (normally not connected with the river). Similarly, floodplain areas are either contiguous or isolated from the river by levees. The geomorphic area data are limited to Upper Mississippi River Pools 4 through 26, the La Grange Pool, and the Cape Girardeau LTRMP study reach. The summary of the reach from Lake Pepin to St. Louis, Missouri shows that about 40 percent of the total floodplain area (including both aquatic

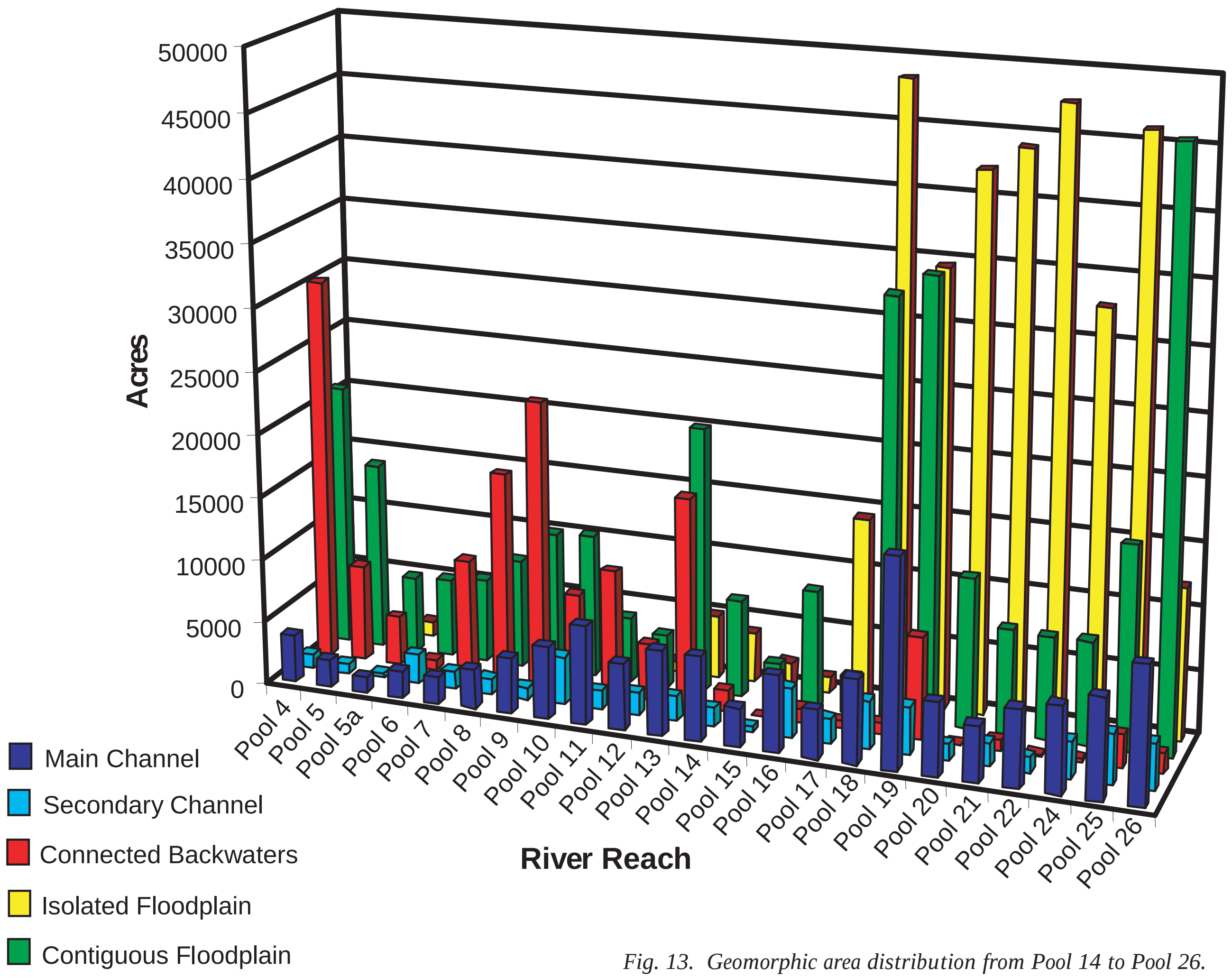


Fig. 13. Geomorphic area distribution from Pool 14 to Pool 26.

and floodplain areas) is leveed, but levees are concentrated south of Rock Island, Illinois (Fig. 13). This figure closely approximates the amount of agriculture in the floodplain. The distribution of leveed areas as proportion of total floodplain area is about:

- 3 percent north of Pool 13;
- 50 percent from Pool 14 through Pool 26;
- 80 percent in the Open River; and
- 60 percent of the lower 160 miles of the Illinois River.

Contiguous floodplain susceptible to seasonal flooding constitutes about 23 percent of the floodplain area system-wide. Islands are about 8 percent of the floodplain area, bringing the total terrestrial area to about 70 percent of the floodplain from Minneapolis to St. Louis.

The range of the proportional contribution of aquatic area types was 10 to 70 percent of the total river floodplain area, which is indicative of the geomorphic variability among river reaches and the differing effects resulting from impoundment. Backwater aquatic area classes are more prominent in the northern pooled reaches, and channel habitats are more prominent in the southern pooled reaches. Overall:

- channel border is 6.6 percent of the total area,
- impounded area is 4.6 percent,
- contiguous backwaters are 3.9 percent,
- secondary channels are 3.7 percent,
- navigation channel is 3.2 percent,
- shallow aquatic area is 2.8 percent,
- and isolated backwaters are 2.0 percent.

Tailwaters, tertiary channels, tributary channels, and excavated channels are 0.2 percent or less of the total floodplain area, respectively.

Terrestrial Habitat Distribution

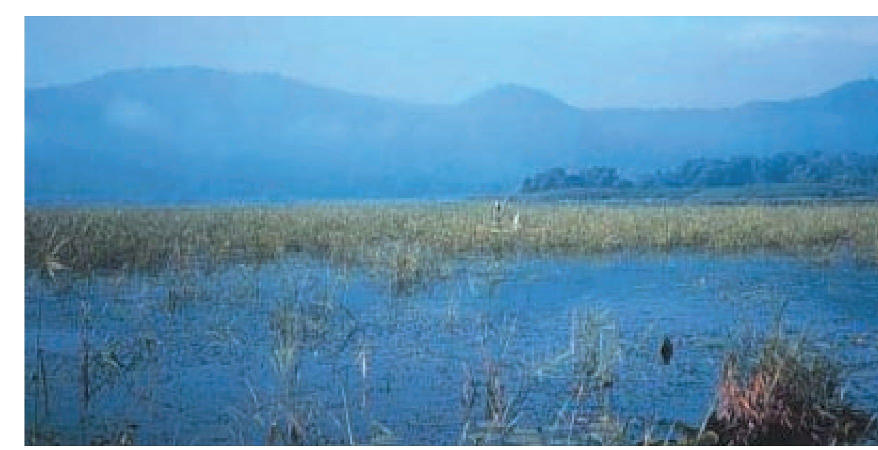
It is useful to examine the patterns of landscapes when assessing their ability to support desirable animal communities. An analysis of long-term change in several broad habitat classes helps assess general change over time. When examining existing conditions, or managing for discrete habitat or species, attention to fine details of habitat may be more appropriate.

U.S. Army Corps of Engineers

Grassland.

U.S. Army Corps of Engineers

Forest.



U.S. Geological Survey –
Upper Midwest Environmental Sciences Center

Marsh.

Grassland

The review of historic ecological change presented earlier clearly demonstrates the loss of grassland land cover from Iowa to southern Illinois. The extent of grassland fragmentation and conversion are the most extreme changes in many parts of the UMRS. Grassland patch connectivity has been highly reduced, and connectivity to other natural habitats has been reduced where agriculture or development are adjacent to grassland patches.

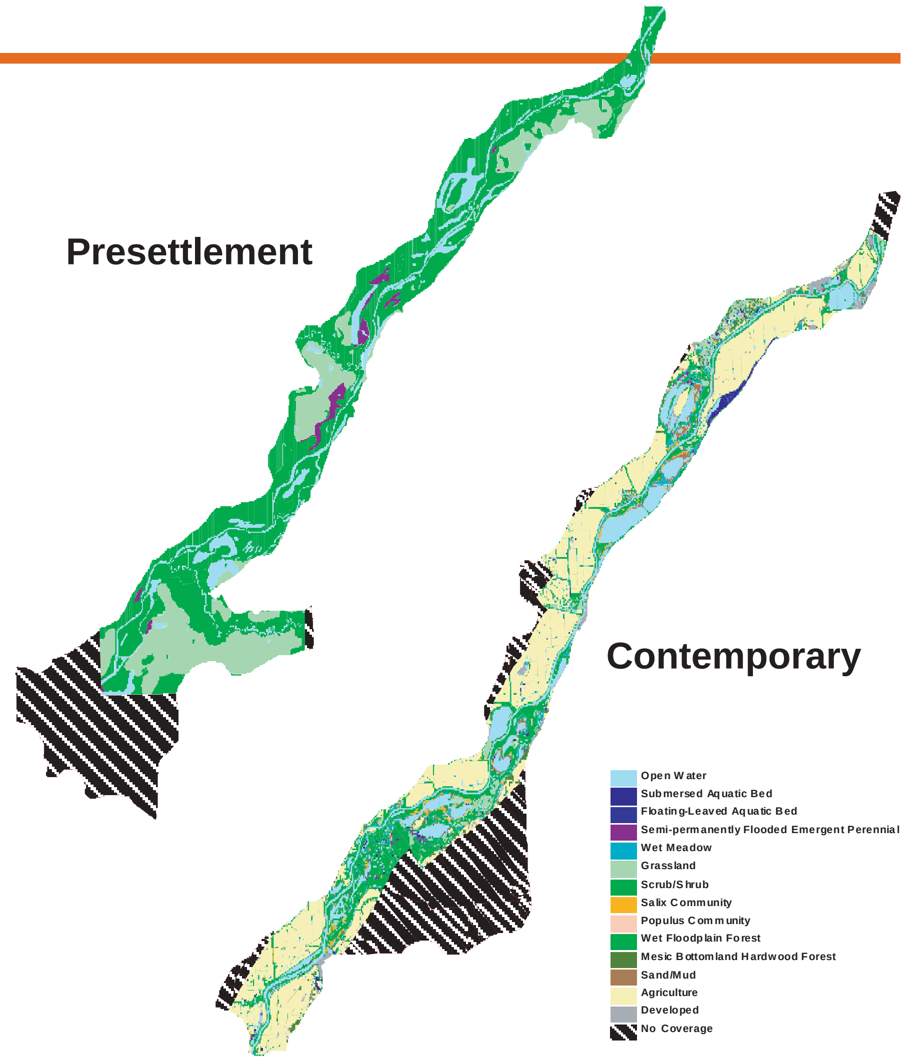


Fig. 14. As revealed in the historic land cover analysis, these maps illustrate the loss of grasslands in the La Grange Pool on the Illinois River south of Peoria.

William Paff for the Cornell Laboratory of Ornithology

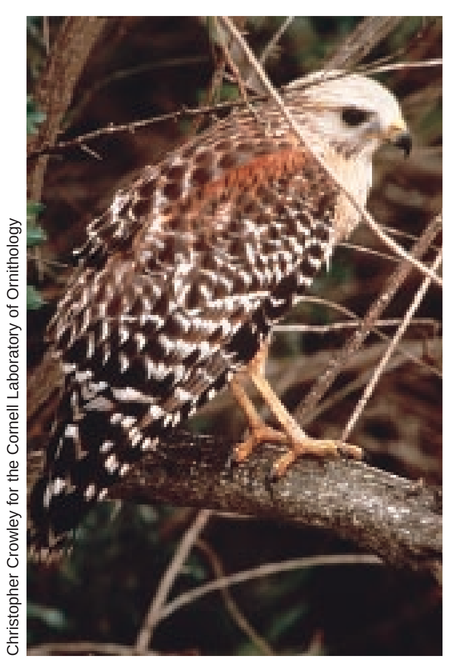
Meadowlark.

Allen Blake Sheldon

Prairie Kingsnake.

Forest

Forest was and remains an important component of the floodplain landscape for many reptile, amphibian, bird, and mammal species. Contemporary forests are distributed differently and have different species composition than in the past. They are even aged and have low tree species diversity. Changes in response to river and floodplain development differ among geomorphic reaches. Floodplain forests in northern pooled reaches were replaced mostly by water impounded by dams and also by development. Forests remaining in the upper pooled reaches have species composition similar to the past. In the southern pooled reaches, the lower Illinois River, and the Open River south to the Kaskaskia River, open forests and grassland-oak savannas joining dense riparian forests and grasslands were eliminated, but riparian forests remain largely intact. In the Open River south of the Kaskaskia River, the floodplain was once almost completely forested, but was later cleared and levees were constructed to protect crops.



Christopher Crowley for the Cornell Laboratory of Ornithology

Red-Shouldered Hawk.

Allen Blake Sheldon

Tiger Salamander.

Marsh

Marsh fragmentation is difficult to assess because river marshes were not well mapped in early periods and they are inherently fragmented along backwater margins, wet meadows, and river banks. Generally, contemporary marsh communities are more abundant in northern river reaches than in southern reaches, where there are few backwaters, river water is turbid, and sediment quality is poor.

Marsh patches are so small and widely separated in southern river reaches that they can barely even be seen at this map scale.

There is greater absolute acreage of marsh habitat in northern pooled reaches, and the proportion of total floodplain area is very much greater, because the northern reaches have less total area than southern reaches (Fig. 14). In other words, marsh habitats are more abundant, widely distributed, and common in northern river reaches.

U.S. Geological Survey – Upper Midwest Environmental Sciences Center

Green Heron.

U.S. Geological Survey – Upper Midwest Environmental Sciences Center

Marsh turtles.

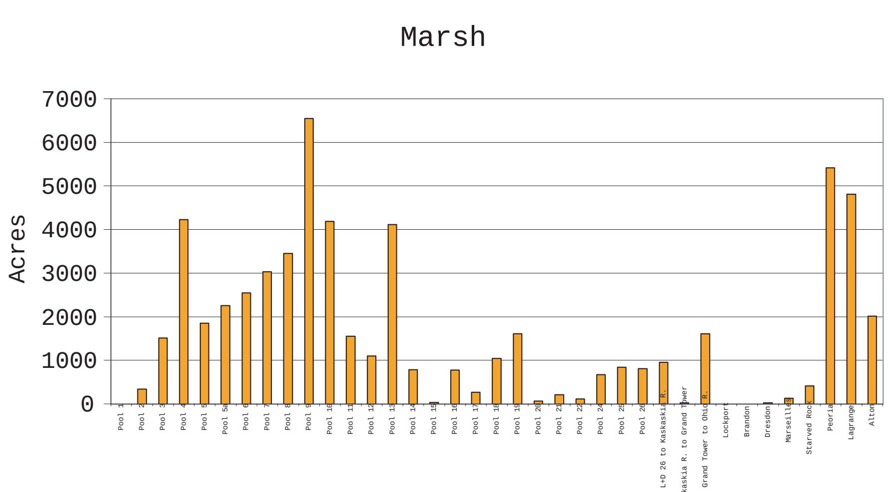


Fig. 14. Marsh distribution among UMRS reaches.

Agriculture

Croplands currently occupy about one-half of the total UMRS floodplain area, and agriculture is the dominant land cover class. Cropland distribution is skewed toward southern river reaches where levees protect the wide fertile floodplains. Agriculture is the largest continuous land cover class in the lower 500 miles of the Upper Mississippi River and the lower 200 miles of the Illinois River. Grasslands once occupied most of the current agricultural land, but forested areas were also converted to crops.

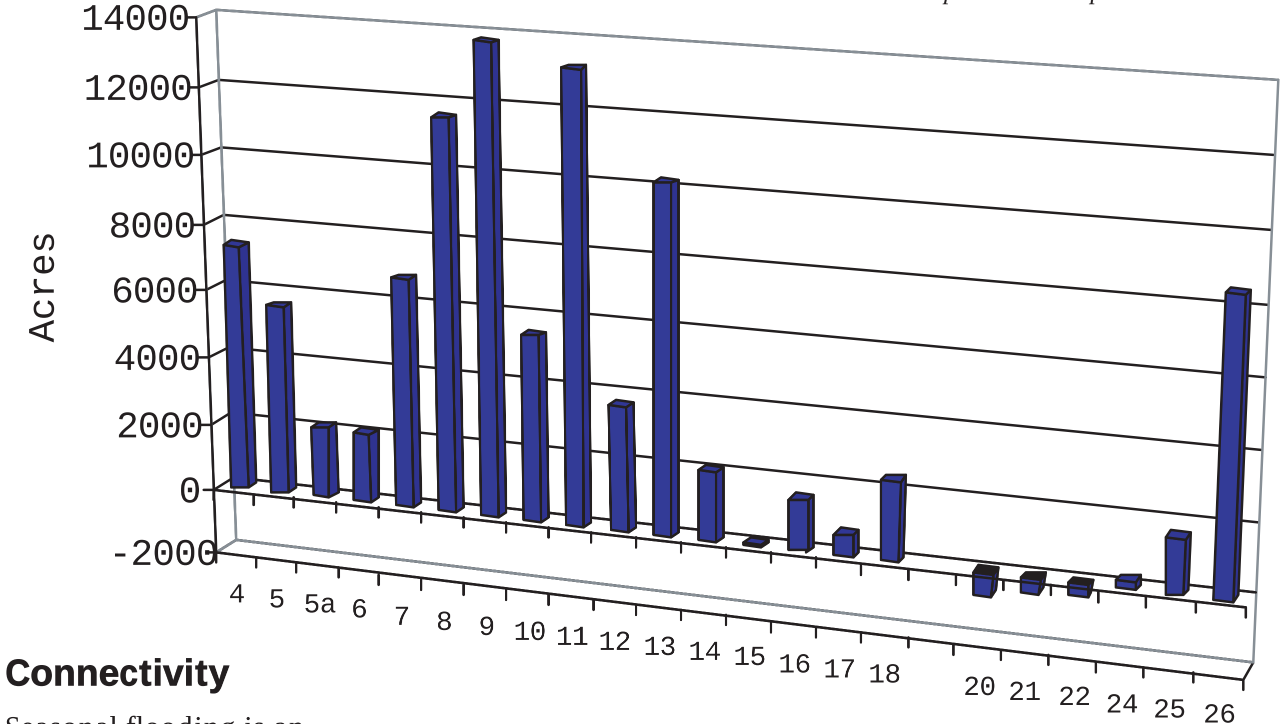
U.S. Fish and Wildlife Service

Corn harvest.

U.S. Geological Survey – Upper Midwest Environmental Sciences Center

Floodplain farms, south of St. Louis, dominate the landscape.

Fig. 15. The increase in aquatic area attributable to impoundment is most pronounced in pools 4 to 13.



Connectivity

Seasonal flooding is an ecologically important process in large river floodplain ecosystems because it connects the river with its floodplain. In the UMRS many low elevation floodplain areas are no longer subject to seasonal flooding because they are permanently flooded from impoundment by navigation dams. Comparing pre-dam and post-dam, total open water area has decreased or remained stable in Pools 5a, 6, 14 to 25, the Open River, and the Illinois River, but it increased in Pools 4, 5, 7 to 13, and 26 (Fig. 15). Stability implies that dams had little effect on the plan form outline and amount of open water area. Decreases in water area are attributable to several geomorphic processes including: loss of contiguous backwaters, filling of isolated backwaters, loss of secondary channels, filling between wing dams, and delta formation. Increases in water area are apparent where dam impacts inundated significant amounts of low elevation floodplain in lower pool areas.

Connectivity of UMRS aquatic habitats has also been modified by dams that block fish migration on the mainstem rivers and up into tributaries. Flood control and hydroelectric dams block access to over one-half of the length of tributary streams and rivers. Fish use tributaries for spawning and to seek refuge from harsh flow or water quality conditions on the main river. Upper Mississippi River System navigation dams are used to maintain low flow navigation, so the dams were constructed to allow high flows to pass freely through the dams with all gates open. Locks and dams 1 and 19 present nearly complete barriers to upriver fish migration because they are also hydroelectric dams with high fixed crests. The other dams are open from 1 to 30 percent of the time, which provides some opportunity for upriver fish passage (Fig. 16).

U.S. Army Corps of Engineers

Pool 5a clearly displays the impounded area and expanded backwaters created by the dam.

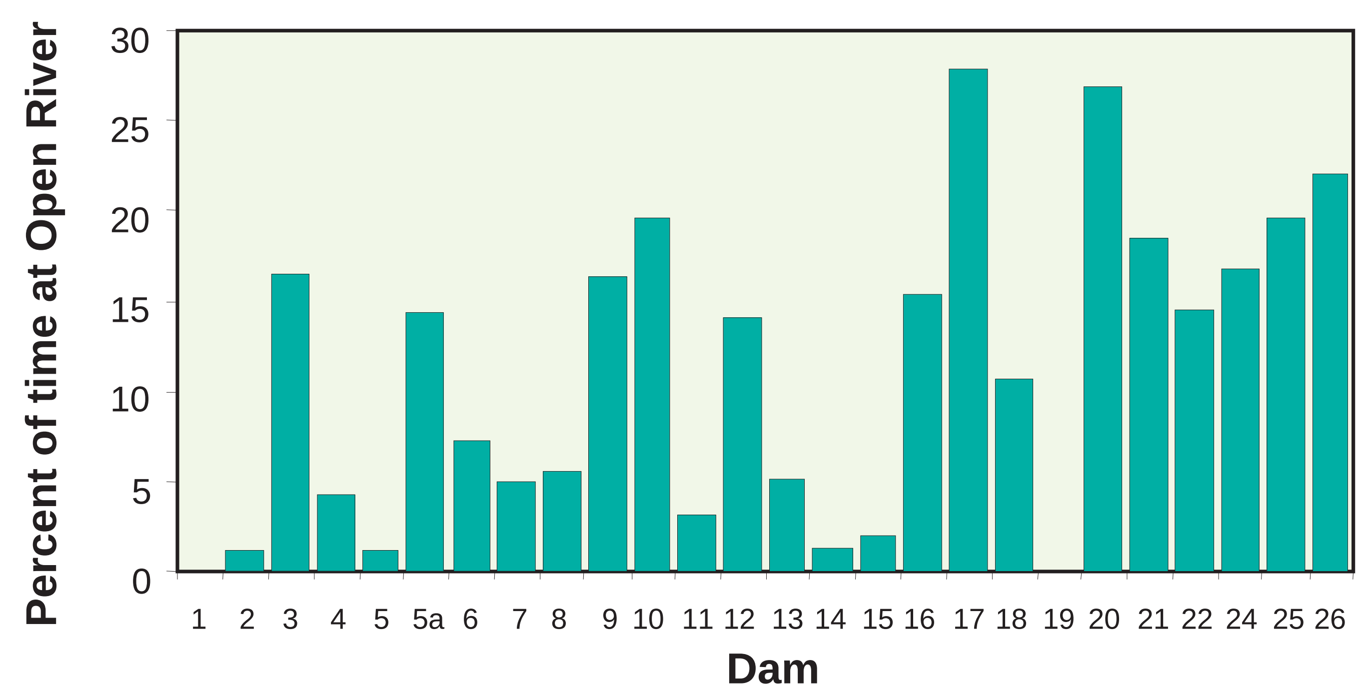


Fig. 16. Percent of time that UMRS dams have all gates open.

Fragmentation

Natural habitats are highly connected south of Minneapolis to Clinton, Iowa, because there is abundant public land (Fig. 17). However, discontinuity in the distribution of public lands and levees (Fig. 18) has resulted in significant habitat fragmentation south of Rock Island and along the lower Illinois River (Fig. 19). The riparian forest remains fairly contiguous in a narrow band along the longitudinal gradient of the rivers, but large tracts of other native floodplain terrestrial communities only remain as remnants in the national wildlife and fish refuges and state conservation areas.

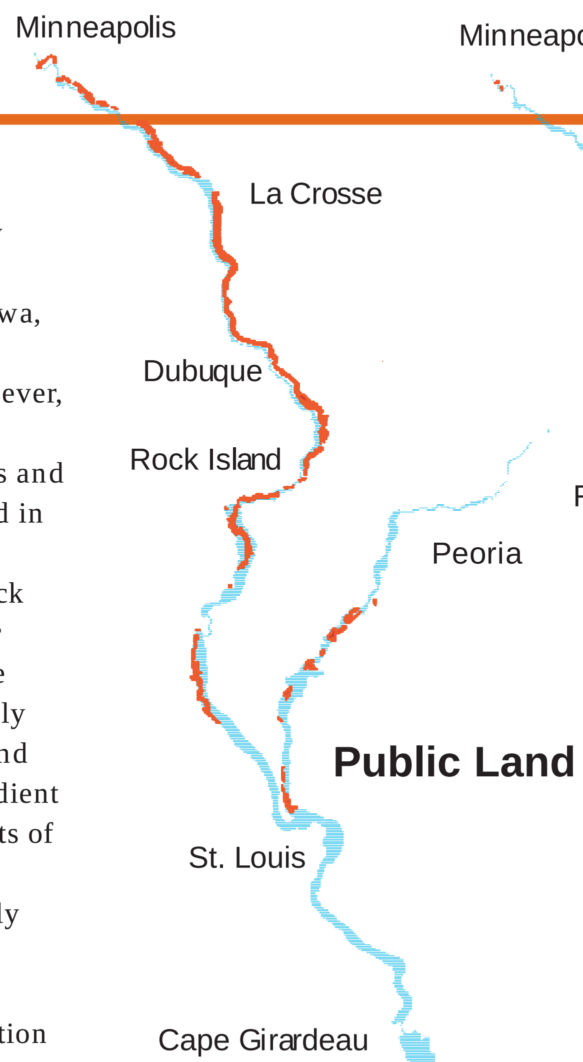


Fig. 17.
Public land distribution in the UMRS.

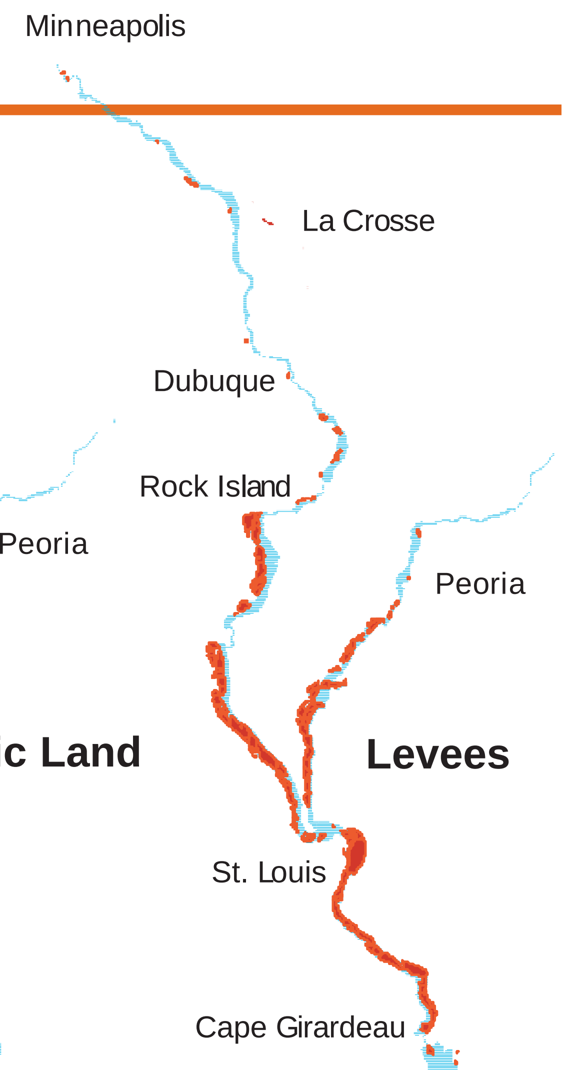


Fig. 18.
Levee distribution in the UMRS.

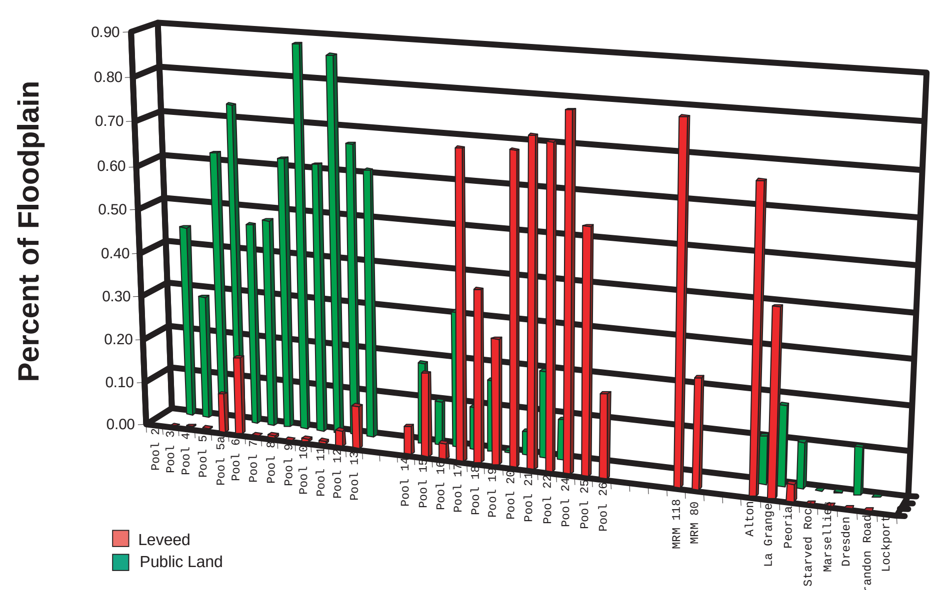


Fig. 19. Proportional abundance of leveed area and public land in the UMRS.

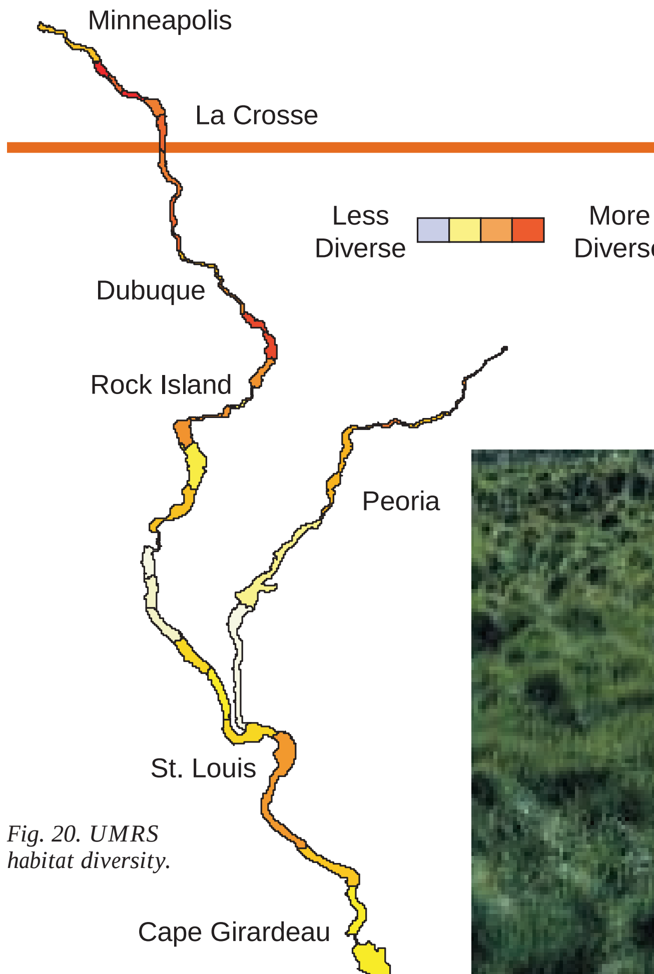


Fig. 20. UMRS habitat diversity.

U.S. Geological Survey – Upper Midwest Environmental Sciences Center

Agriculture is an obvious low diversity environment but even natural communities such as this sedge marsh can have few species.

U.S. Geological Survey – Upper Midwest Environmental Sciences Center

A more diverse marsh supports many different types of herbaceous and woody plants.

Diversity

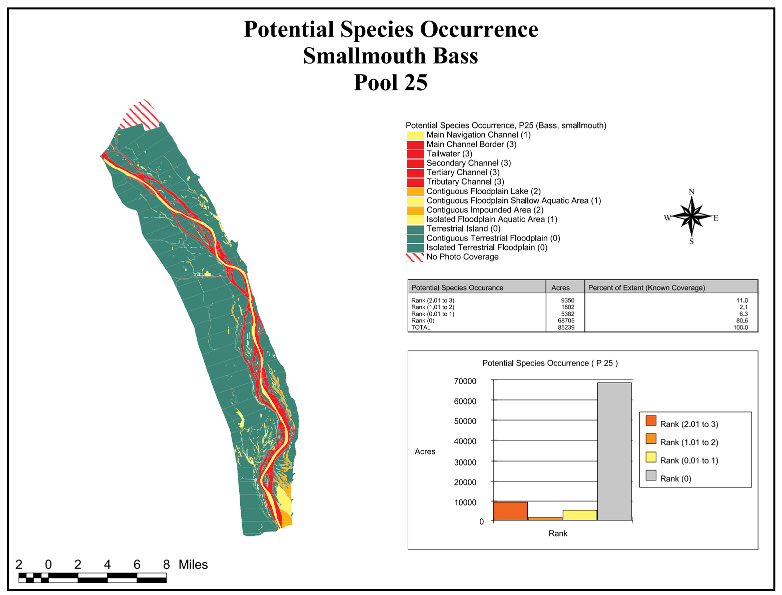
Habitat diversity is a measure of the different types of habitats, their size, and their relative abundance in a defined area. Habitat diversity can be calculated for both land cover and geomorphic areas. Land cover diversity is highest along Minnesota, Wisconsin, and northern parts of Illinois and Iowa (Fig. 20). Pools 1 to 4, 14 to 19, and the Illinois River have moderate diversity. Pools 1 and 15 are highly urbanized, Pool 18 and Alton Pool are highly agricultural and have incomplete data. Pool 20 and southward have the lowest diversity scores. These lower reaches are highly developed for agriculture. Geomorphic area diversity follows a pattern very similar to land cover diversity.

Query Tool Application

The HNA query tool represents a great advance in the application of GIS tools to UMRS natural resource management. However, this version of the tool was constructed to operate at the system-wide scale, and is therefore quite general due to the resolution of available system-wide data. The basic query tool calculates the potential acreage of occurrence for species or guilds based on their preferred land cover and geomorphic area classes (Fig. 21). It can also summarize land cover within a defined area and report the species likely to occur within the area (Fig. 22). The query tool was designed to allow users to select three levels of habitat preference (Fig. 23).

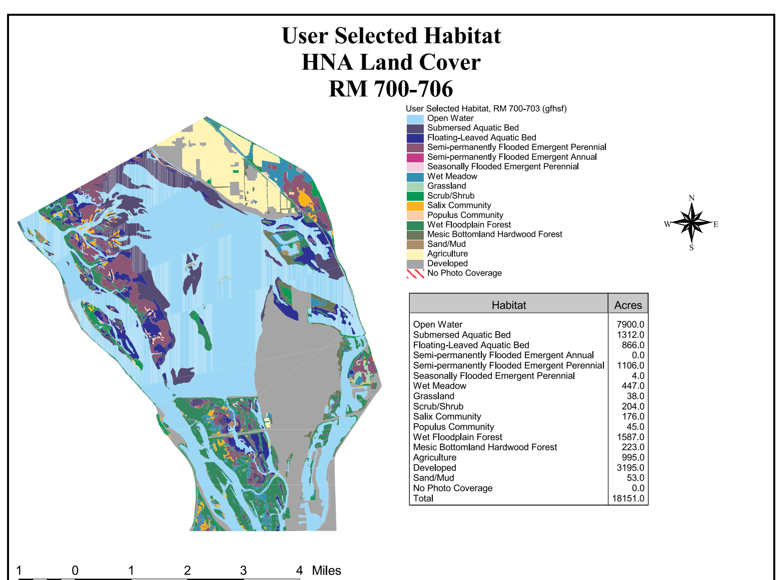
The variability of species life history requirements can greatly influence their potential habitat estimate. Widespread species, or "habitat generalists," have very large potential occurrence estimates (Fig. 24). For habitat specialists that are adapted to one or few land cover types potential habitat predictions may be quite small (Fig. 25).

The query tool presently incorporates land cover and geomorphic area data, an advanced version of the tool incorporates more data layers to define habitat in more detail and to create better habitat models. The application of the advanced tool is currently limited because data necessary to use it to its full capability are still lacking for most of the river system.



Potential Species Occurance	Acres	Percent of Extent (Known Coverage)
Rank (2.01 to 3)	9350	11.0
Rank (1.01 to 2)	1802	2.1
Rank (0.01 to 1)	5382	6.3
Rank (0)	68705	80.6
TOTAL	85239	100.0

Fig. 21. An example of a species query output.



Habitat	Acres
Open Water	7900.0
Submersed Aquatic Bed	1312.0
Floating-Leaved Aquatic Bed	866.0
Semi-permanently Flooded Emergent Annual	0.0
Semi-permanently Flooded Emergent Perennial	1106.0
Seasonally Flooded Emergent Perennial	4.0
Wet Meadow	447.0
Grassland	38.0
Scrub/Shrub	204.0
Salix Community	176.0
Populus Community	45.0
Wet Floodplain Forest	1587.0
Mesic Bottomland Hardwood Forest	223.0
Agriculture	995.0
Developed	3195.0
Sand/Mud	53.0
No Photo Coverage	0.0
Total	18151.0

Fig. 22. An example of a habitat query. A list of species likely to occur within habitats is also provided.

Red-winged blackbird.

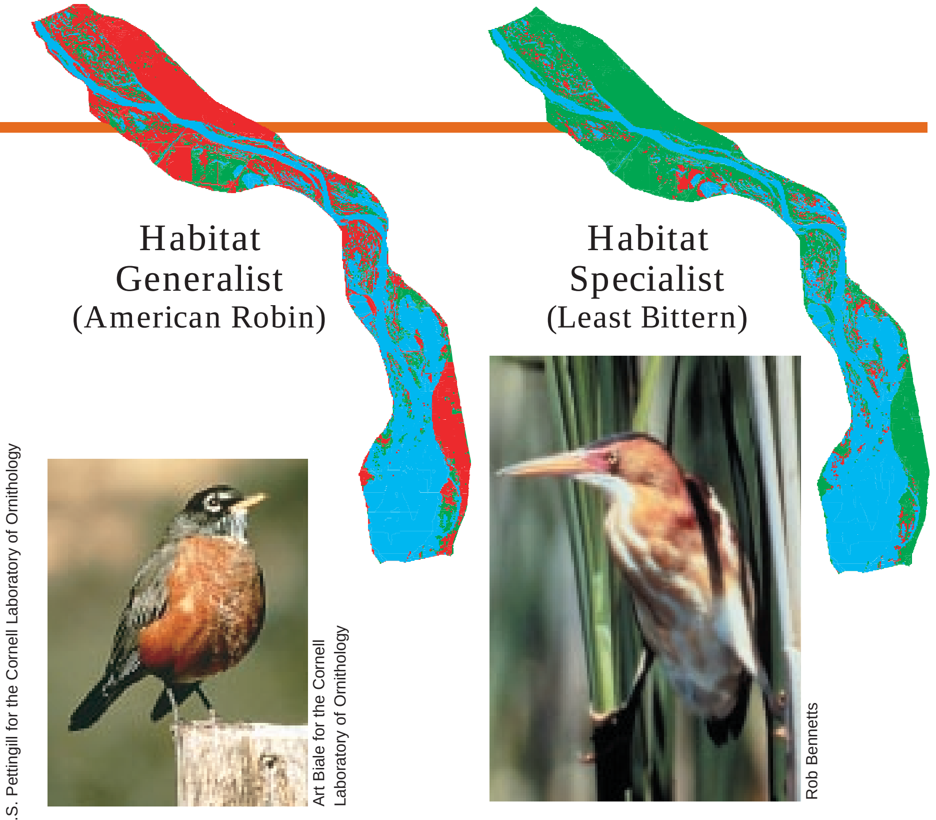


Fig. 24. Robins and other common birds tend to use many habitat types.

Fig. 25. Bittern and other uncommon birds may be specially adapted to a narrow range of habitats.

Pool 25 – Potential red-winged blackbird habitat

High 4,150 acres + Medium 44,199 acres + Low 459 acres = Total potential habitat 48,808 acres

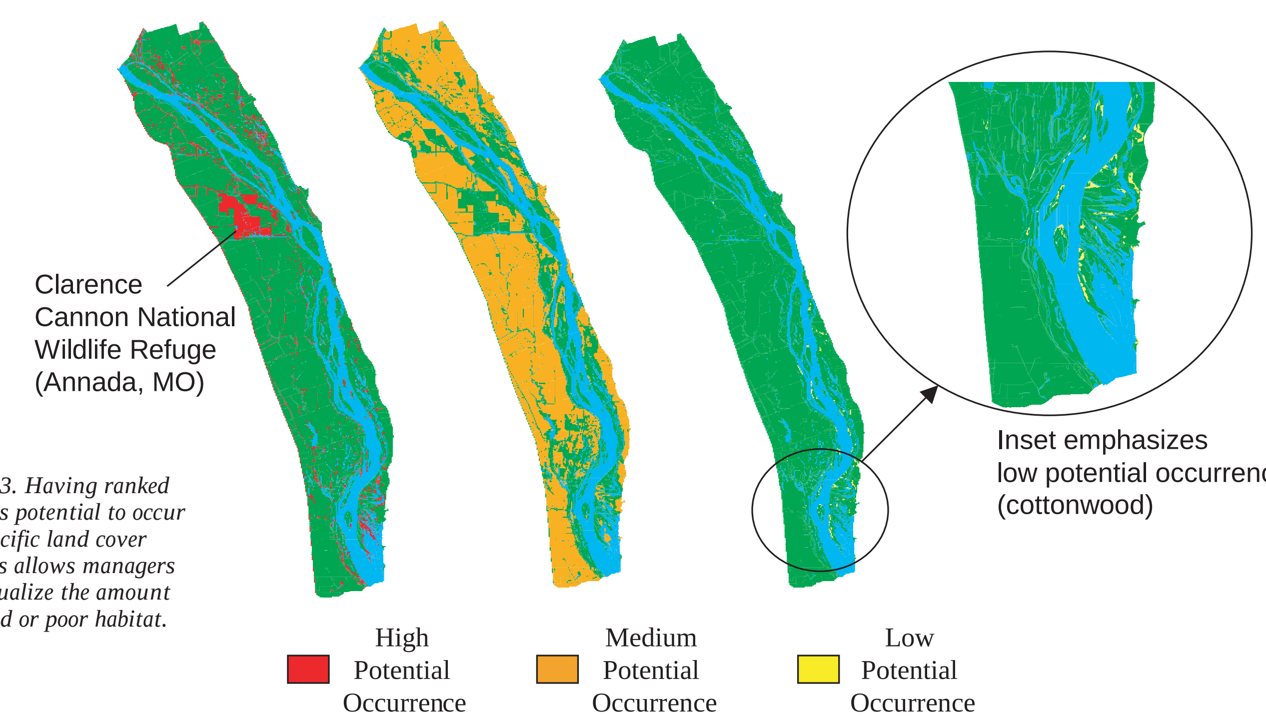


Fig. 23. Having ranked species potential to occur in specific land cover classes allows managers to visualize the amount of good or poor habitat.

Forecast Future Condition

Quantitative Geomorphic Change

The plan form features of the UMRS are quite stable and are not projected to change much in absolute area over the next fifty years. The projected changes for all the pools along the UMR include a prediction that total water area will decrease by only 1.4 percent by the year 2050. The area of aquatic area classes is predicted to change as follows:

contiguous backwaters decrease by 2.1%;

isolated backwaters decrease by 3.6%

main channel decreases by 0.7%;

secondary channels decrease by 2.6%;

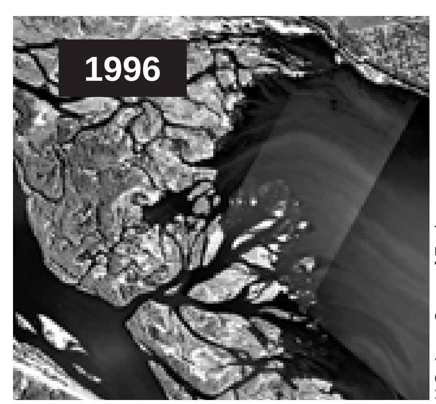
island area decreases by 2.0%.

Island loss is largely due to island erosion predicted to occur in Reach 3. For many other reaches, the area of islands actually increases. Overall, the total perimeter of islands is predicted to decrease by 3.7%. The acreage change predictions should not be considered to be precise estimates of change, but should rather be considered as indicators of the types and general amounts of changes likely to occur in the future. Also, it must be emphasized that the predictions include changes in surface area only, and do not account for many factors that affect habitat quality.

The Cumulative Effects Study projected geomorphic change for much of the UMRS and concluded that Reach 3 (Pools 5-9) has been and is predicted to continue to be dominated by island erosion. Reach 3 (Pools 5-9) is the only reach where total open water area is expected to increase. This is due to the predicted continued erosion of islands in the reach. In all other reaches, total water area is expected to decrease, including both isolated and contiguous backwater areas.

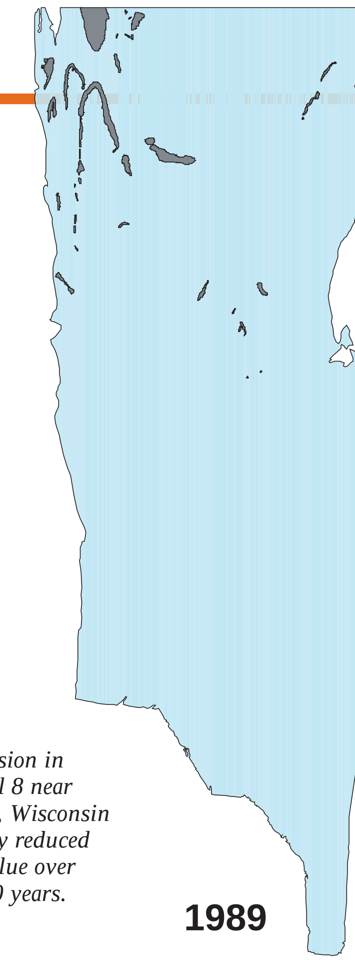
Reaches 4 through 10 (Pools 10 – Open River) have all experienced loss of contiguous backwater, especially reaches 6 through 10 (Pools 18 – Open River) where loss of isolated backwater has also been occurring. Generally, both of these processes are expected to continue for these reaches.

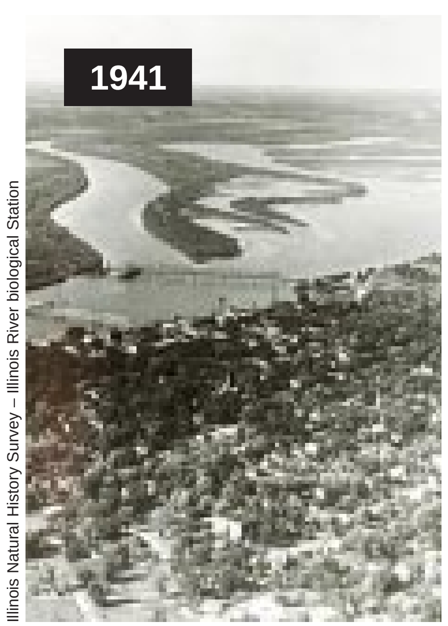
Filling between wing dams decreases main channel area.

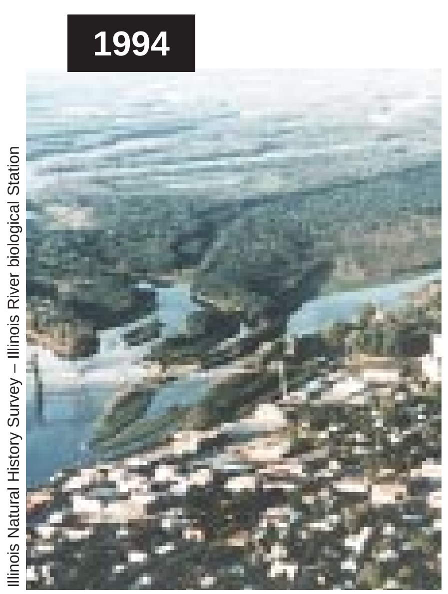


Deltas can encroach into a variety of aquatic habitats. This is sometimes beneficial to support high habitat diversity, but will also result in loss of aquatic area.

Island erosion in lower Pool 8 near La Crosse, Wisconsin has greatly reduced habitat value over the last 60 years.







These photos of Muscooten Bay near Beardstown, Illinois dramatically demonstrate the high sedimentation rate in the Illinois River Valley. Thousands of acres of backwaters have been lost or degraded.

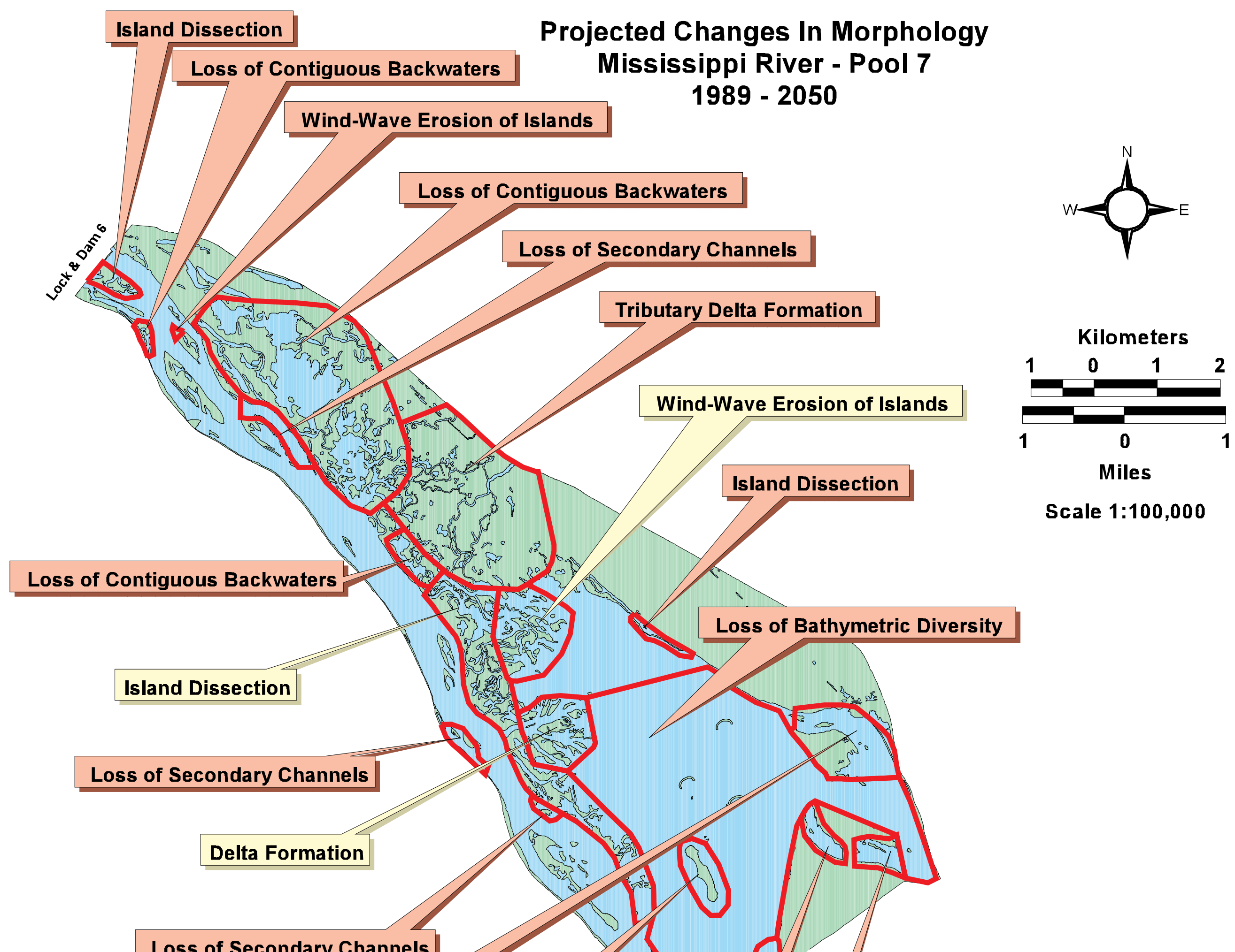


Fig. 26. Resource managers identified areas expected to change throughout the UMRS similar to this example from Pool 7 near La Crosse, Wi.

Geomorphic Change Processes

The Cumulative Effects Study identified 58 locations in pools 4 through 26 influenced by one or more of nine geomorphic processes. Consultations with resource managers yielded an additional 347 areas in the same reach and an additional 125 areas in Pools 2-3, the Open river, and the Illinois River. A total of 530 areas expected to change were plotted on maps (Fig. 26; Table 5).

Table 5. Projected UMRS geomorphic change.

Geomorphic Process	Number of Occurrences
Channel Formation	3
Delta Formation	3
Filling between Wing Dams	34
Island Dissection	15
Island Formation	20
Island Migration	4
Loss of Contiguous Impounded	9
Loss of Bathymetric Diversity	12
Loss of Continguous Backwaters	153
Loss of Isolated Backwaters	49
Loss of Cont / Iso Backwaters	32
Loss of Secondary Channels	116
Loss of Tertiary Channels	5
Shoreline Erosion	8
Tributary Delta Formation	43
Wind-Wave Erosion of Islands	25

Floodplain Vegetation Succession

Open water and scrub-shrub habitats are projected to decline. No change is predicted for grassland, agriculture, and developed area. Small increases are projected for wet meadow. Rather large changes are projected for early successional stage communities (i.e., willows and cottonwoods). Increased sand-mud is due to loss of open water area. The simple rule-based terrestrial vegetation successional model probably overestimates the amount of early successional species likely to occur on the UMRS.

Table 6. Land cover class change predicted by the UMRS terrestrial vegetation successional model.

HNA Class	Total Existing Acres	Predicted Change (acres)	Predicted Change (percent)
1. Open Water	452,587	–33,095	–7.3
7. Seasonally Flooded Emergent	3,750	4,281	114.2
8. Wet Meadow	38,449	10,389	27.0
9. Grassland	54,454	0	0.0
10. Scrub / Shrub	34,393	–14,142	–41.1
11. Salix Community	6,357	14,418	226.8
12. Populus Community	3,294	6,277	190.6
13. Wet Floodplain Forest	378,282	–6,376	–1.7
14. Mesic Bottomland Hardwood Forest	17,989	14,402	80.1
15. Agriculture	1,166,691	0	0.0
16. Developed	147,277	0	0.0
17. Sand / Mud	6,308	4,640	73.6
18. No Photo Coverage	207,808	0	0.0

Desired Future Habitat Conditions

A primary element of the Environmental Management Program Habitat Needs Assessment was to identify the various natural resource management agencies' and the publics' desired future mix of habitats throughout the Upper Mississippi River System. This effort was pursued through review of recent agency management plans, a series of meetings with the public, and a series of workshops with river scientists and natural resource managers. In general, agency management plans were found to lack specific quantified objectives for specific land cover or habitat classes. Certain documents such as the recently completed Partners in Flight Bird Conservation Plans and the Upper Mississippi & Great Lakes Region Joint Venture Implementation Plan articulate goals to restore avian populations to specified levels, and contain state-by-state objectives for habitat management and restoration. Through the resource manager meetings, we obtained rather uniform qualitative expressions for future desires, but quantitative estimates of desired future habitat conditions were more variable depending on the part of the river considered. The desired future conditions identified in this first Habitat Needs Assessment can be considered a good first approximation of goals for habitat protection and restoration for the UMRS. It is likely that future desires, and thus habitat needs, will be revised as new information is obtained and the public has an opportunity to provide additional input.

Consultations with Resource Managers and Scientists

The workshops with resource managers resulted in fairly consistent qualitative expressions of future desires. In particular, resource managers and scientists indicated that the future should be characterized by: improved habitat quality, habitat diversity, and a closer approximation of the pre-development hydrologic regime. They believe these changes are critical to the sustainable ecological integrity of the river ecosystem. Deep backwaters, grasslands, hardwood forests, and marsh habitats were rated the most threatened habitats. River regulation, sedimentation, and floodplain development were rated as the primary stressors affecting river habitats.

The qualitative assessments revealed which habitats are threatened or degraded and in need of preservation or restoration at the pool scale. However, quantitative results from the workshops differed among river reaches due to differences in the quality and amount of information about existing and forecast future conditions. In particular, resource managers found existing data inadequate for an in-depth, uniform, system-wide quantitative habitat needs assessment. Also, of note is the concern that not all future habitat changes are detected by using estimates of geomorphic change and by relying on one-time "snapshots" of habitat conditions.

Despite these limitations, a first approximation of quantitative desired future habitat was identified and used to calculate habitat needs (see HNA Technical Report). This information represents the first time system-wide objectives have been identified for use in planning Habitat Rehabilitation and Enhancement Projects on the UMRS.

Scott D. Whitney

Deepwater marsh habitat.

U.S. Army Corps of Engineers

Floodplain grasslands.

Public Involvement

In 1996, the Long Term Resource Monitoring Program published the results of a public expectations survey. While the survey was not designed specifically for use in the Habitat Needs Assessment (HNA), it revealed that:

- 99% of respondents value the rivers for future generations,
- 70% of respondents want to control industrial pollution,
- 55% of respondents want improved water quality,
- 45% of respondents want improved fish and wildlife habitat,
- 25% of respondents want improved sport fishing, and
- 15% of respondents want less barge traffic.

The public involvement meetings, convened in April and May 1999 and used as input to the HNA, revealed five themes or areas of interest for the future of the Upper Mississippi River System:

- more fish and wildlife in general (habitat diversity, species diversity, and abundance),

- clean and abundant water,
- reduced sediment and siltation,
- balance between the competing uses and users of the river, and
- restoration of backwaters, side channels, and associated wetlands.

While the five themes were clear, there appeared to be slight regional variations in how the respondents expressed their views. These differences may be related to the quality of the habitat in their area or the degree of access for recreation.

Respondents cited the assurance of acceptable water quality and quantity for human consumption, industrial processes, and aquatic habitat conditions as a priority. Sedimentation was cited as a concern because it jeopardizes features such as backwater lakes, the navigation channel, recreational access to various areas, water quality, and riverbed conditions. Among the habitats of interest, backwater lakes and associated wetlands are of particular concern as fish spawning and overwintering sites, food sources during key periods for migratory waterfowl, and critical linkages to both terrestrial and deeper aquatic environments. In addition to the difficult and essential task of balancing competing uses that affect resource quality, it is noteworthy that respondents cited other "social" aspects of the river: the need for more citizen awareness and initiatives related to the river and the need to improve government agency coordination for consistent management and project completion.

In July-August 2000, a series of focus groups offered insights into the public's view of the HNA process itself. Participants in the focus groups generally thought the HNA is another useful tool for river resource management in the UMRS. The concept of using

Unique Habitat Areas

Despite the extensive habitat changes brought about by development of the navigation system and floodplains, there are many unique habitat areas in the UMRS that provide examples of presettlement habitat conditions, are relatively undisturbed, and support high biodiversity. Unique habitat areas on the UMRS range from channels with gravel and bedrock substrate, to tributary delta areas, clear vegetated backwater lakes, mast-bearing (oaks, hickories, pecan) floodplain forests, cypress swamp forests, and remnant floodplain prairies. State Natural Heritage inventories have identified most of the unique habitat areas.

Many of the unique habitat areas are in public ownership and are protected. Some should be expanded to make the unique habitat areas more complete and buffered from disturbance. Other unique habitat areas are not publicly owned and are in need of protection.

Some examples of unique UMRS habitat areas include:

- Rush River Delta State Scientific and Natural Area, Mississippi River Pool 4
- Kellogg-Weaver Dunes State Scientific and Natural Area, Mississippi River Pool 5
- Reno Bottoms, Mississippi River Pool 9
- Sanganois State Fish and Wildlife Area, Illinois River
- Remnant cypress swamps, Shawnee National Forest, southern Illinois

Robert J. Hurt, Architectural Environments

An urban riverfront park in La Crosse, Wisconsin.

habitat classifications to frame river management issues was acceptable to the majority of participants; they were generally comfortable that the specified habitat classes chosen by the HNA developers were workable and useful. However, participants wanted more definition of those habitats, and many participants felt that more factors needed to be considered, such as water quality and the impacts of dynamic river processes on static habitat classifications. While focus group participants tended to think of river issues at a local level, the majority agreed that a broader scale was necessary for planning, at least at the system if not at the watershed level. Participants also generally accepted the use of presettlement river system conditions as a reference point, although concerns were raised about the compatibility of older data sources and the utility of incorporating in the planning process a river condition that could never again be replicated. Administrative aspects of the HNA that participants found particularly important were further development of the HNA, multiagency cooperation, and continued public involvement in and access to the HNA. Many participants expressed confusion about the actual application and end result of the HNA.

The desired future river conditions participants expressed generally reflected the five themes from the spring 1999 public meetings. A "multi-use" river was the most frequently expressed desired condition. Two conflicting, overarching desired conditions were expressed: a return to more naturally variable conditions and a stabilization of existing conditions. Other desirable river conditions expressed included a sustainable, natural river ecosystem and increased biodiversity. Most participants felt strongly that a diverse public should be continually involved in river management programs.

Habitat Needs

The EMP Habitat Needs Assessment defines habitat "needs" as the difference between "existing conditions" and "desired future conditions." To calculate "need," a system-wide accounting of existing, predicted, and desired habitat conditions was thus developed. This effort revealed some clear differences among river reaches. For example, land cover analysis clearly documents an abundance of certain valuable habitat types in northern river reaches, versus a scarcity of those habitats in southern river reaches. The differences are largely related to the amount and distribution of public land, the degree of floodplain development, the geomorphic form of the river, and effects of impoundment for navigation. In addition, analysis of geomorphic changes indicates that some changes (such as loss of backwaters) are systemic, while other changes (such as island dissection) are more localized. Understanding these differences can help identify what types of restoration efforts are most appropriate for each river reach.

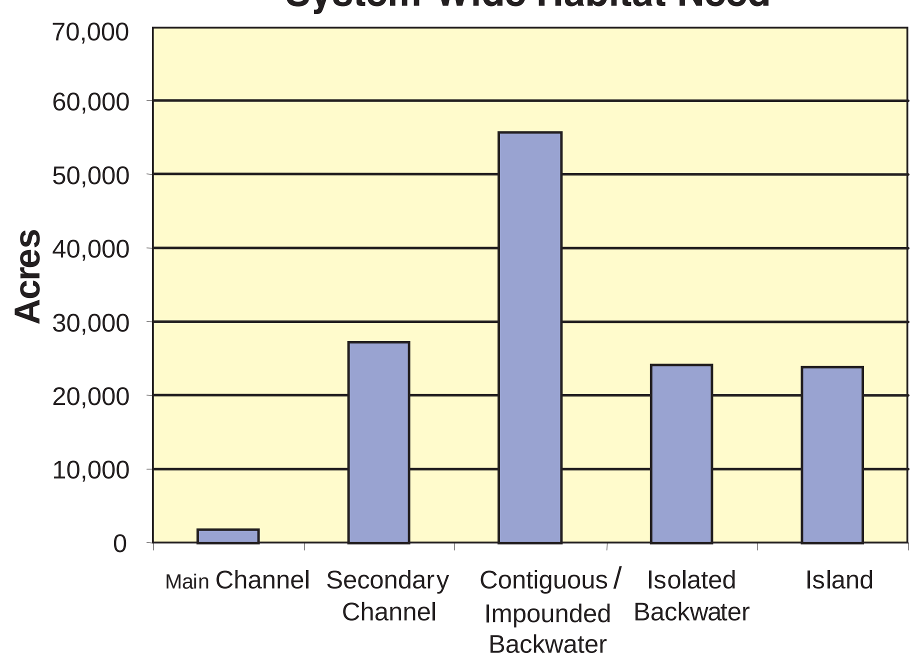
Though differences among reaches are significant, resource managers have generally concluded that habitats are currently degraded and

Habitat Need* = Desired Future Condition – Existing Conditions

*Presumes existing desirable habitat is maintained.

- Main Channel
  - Main Navigation Channel
  - Main Channel Border
  - Tailwater
- Secondary Channel
  - Secondary Channel
  - Tertiary Channel
  - Tributary Channel
  - Excavated Channel
- Contiguous/Impounded Backwater
  - Contiguous Floodplain Lake
  - Contiguous Floodplain Shallow Aquatic Area
  - Contiguous Impounded Area
- Isolated Backwater
- Island

System-Wide Habitat Need



expected to get worse. The factors responsible for degradation (e.g., sedimentation, impoundment, channelization, levees, etc.) also suggest the most promising avenues for ecological restoration.

Quantitative assessments of need are obviously difficult and thus do not provide precise estimates of change or need. Nor do the gross quantitative estimates suggest precisely where on the river changes are needed. Nevertheless this initial assessment, based on input from resource managers and scientists, identifies which types of geomorphic areas need emphasis in various river reaches and pools to achieve the broad restoration objectives.

System-wide Habitat Needs

Create or restore:
- 1,700 acres of main channel habitat
- 27,000 acres of secondary channel habitat
- 55,500 acres of contiguous backwater habitat
- 24,000 acres of isolated backwater habitat
- 24,000 acres of island habitat

Upper Impounded Reach (Pools 1-13) Needs

Create or restore:
- 3,500 acres of main channel (i.e., main channel, channel border, and tailwater) habitat
- 9,300 acres of secondary channel habitat
- 24,000 acres of contiguous backwater or impounded backwater habitat
- 5,800 acres of isolated backwater habitat
- 1,000 acres of island habitat

Lower Impounded Reach (Pools 14-26) Needs

- Reduce main channel habitat by 1,800 acres
- Create or restore:
  - 9,000 acres of secondary channel habitat
  - 10,500 acres of contiguous backwater habitat
  - 5,000 acres of isolated backwater habitat
  - 3,000 acres of island habitat

Open River Reach Needs

- Create or restore 25,000 acres of backwater and secondary channel habitat, of which 7,000 acres should be isolated backwaters
- Increase the amount of prairie, marsh, and forest by about 100,000 acres
- Restore geomorphic processes that create and maintain sand bars and shoals

Illinois River Needs

- Restore existing backwaters so that 25 percent of backwater lakes (19,000 acres) have an average depth of 6 feet
- Increase depth diversity and connectivity throughout the river
- Restore hydrologic variability needed to restore and maintain existing backwater habitats

Estimates of needs are expected to nearly double by 2050 if no action is taken.

Information Needs

This first Habitat Needs Assessment for the UMRS reveals clear needs for additional information that is necessary to characterize river habitats. As an example, more detailed information is needed to improve the rule-based approach to predicting successional change of UMRS plant communities. Such a model should incorporate site characteristics (geomorphic unit type, hydrologic regime), and information on plant community response to disturbances (flood, wind, fire). Better information on existing floodplain plant communities is also needed. A list of information needs is presented below to help improve future UMRS Habitat Needs Assessments.

1. System-Wide High Resolution Topographic Data.
2. System-Wide Bathymetric Data
3. Numerical Hydraulic Models of all Navigation Pools
4. Substrate Type Characterization
5. Habitat Spatial Structure Metrics
6. Floodplain Inundation Models.
7. Floodplain Geomorphic Classification and Survey
8. Surveys of Existing Floodplain Plant Communities
9. Characterization of the Existing and Pre-Impoundment Hydrologic Regime
10. Confirmation / Validation of Species:Habitat Models Using Stratified Random Sampling Data
11. Development of Refined Life History Information
12. Development of Refined Species:Habitat Models
13. Analysis of Seasonal Habitat Availability

Conclusion

The Approach

The EMP Habitat Needs Assessment was designed to help guide future Habitat Rehabilitation and Enhancement Projects on the UMRS. To identify habitat needs, historical, existing, forecast, and desired future conditions were compared. Issues of scale are important in this regard because ecological processes and needs vary at the system, reach, and pool levels. In addition, a wide variety of habitat characteristics must be addressed including habitat fragmentation, connectivity, and diversity. To accomplish this assessment, a GIS tool and a new floodplain vegetation successional model were developed. These tools allow geomorphic and land cover characteristics to be translated into the potential for species to occur.

The Results

Over time, the landscape, land use, and hydrology of the Upper Mississippi River and its basin have changed. Much of the grasslands, wetlands, and forests have been converted to agriculture use, which now accounts for 50 percent of the floodplain. Impoundment, channelization, and levee construction have altered the hydrologic regime and sedimentation patterns, resulting in loss of backwaters, islands, and secondary channels. While future changes in broad geomorphic features are expected to be relatively small, habitat degradation is expected to continue. There is a broadly recognized need among resource managers and scientists for improved habitat quality, increased habitat diversity, and a closer approximation of pre-development hydrologic variability.

The Habitat Needs Assessment identified clear differences in habitat types and conditions among river reaches. Those differences are largely related to the amount and distribution of public land, degree of floodplain development, the geomorphic form of the river, and the effects of impoundment for navigation. The differences also suggest that habitat needs and restoration objectives will vary by river reach and pool.

The Habitat Needs Assessment yielded gross quantitative and qualitative estimates of habitat needs both system-wide and within river reaches. These estimates provide the first approximation of a set of system-wide objectives for Habitat Rehabilitation and Enhancement Projects. While they do not offer quantitatively precise goals, they will help focus future planning on the most important geomorphic processes both system-wide and in specific river reaches. However, perhaps the greatest contribution this first Habitat Needs Assessment has made is the development of new and improved tools for future habitat planning. In particular, the GIS Query tool will help evaluate the potential distribution of species and habitat area types throughout the UMRS. While the results of the Habitat Needs Assessment are not a substitute for the more detailed and spatially explicit planning that will be done at the pool scale, it has provided new tools for that planning.

Jeff Janvrin

An accurate assessment of habitat needs today will help ensure that river resources are preserved for future generations.

The Future

This is the first Habitat Needs Assessment undertaken as part of the Environmental Management Program and it is anticipated to be updated on a regular basis. Future assessments will benefit from additional spatial data about the river system, improved ecological understanding, improved GIS and modeling tools, and additional public input.

Acknowledgements

HNA Technical Committee

Gordon Farabee – Chair	Missouri Department of Conservation, Jefferson City, MO
Robert Clevenstine	U.S. Fish and Wildlife Service, Rock Island, IL
Michael Thompson	U.S. Army Corps of Engineers, St. Louis, MO
Dan Wilcox	U.S. Army Corps of Engineers, St. Paul, MN
Scott Whitney	U.S. Army Corps of Engineers, Rock Island, IL
T. Miller	U.S. Army Corps of Engineers, St. Louis, MO
Michael Davis	Minnesota Department of Conservation, Lake City, MN
Jeffery Janvrin	Wisconsin Department of Natural Resources, La Crosse, WI
Michael Griffin	Iowa Department of Natural Resources, Bellevue, IA
William Bertrand	Illinois Department of Natural Resources, Aledo, IL
Richard Steinbach	U.S. Fish and Wildlife Service, Quincy, IL

Report Contributors

Charles Theiling	U.S. Geological Survey, La Crosse, WI
Dan Wilcox	U.S. Army Corps of Engineers, St. Paul, MN
Carl Korschgen	U.S. Geological Survey, La Crosse, WI
Henry DeHaan	U.S. Geological Survey, La Crosse, WI
Timothy Fox	U.S. Geological Survey, La Crosse, WI
Jason Rhoweder	U.S. Geological Survey, La Crosse, WI
Larry Robinson	U.S. Geological Survey, La Crosse, WI
Holly Stoerker	Upper Mississippi River Basin Association, St. Paul, MN
Jeffery Janvrin	Wisconsin Department of Natural Resources, La Crosse, WI
Scott Whitney	U.S. Army Corps of Engineers, Rock Island, IL

Species Group Specialists

Eileen Kirsch	U.S. Geological Survey, La Crosse, WI
Melinda Knutson	U.S. Geological Survey, La Crosse, WI
Kevin Kenow	U.S. Geological Survey, La Crosse, WI
Robert Hrabik	Missouri Department of Conservation, Jefferson City, MO
John Pitlo	Iowa Department of Natural Resources, Bellevue, IA
John Tucker	Illinois Natural History Survey, Brighton, IL
Gary Swensen	U.S. Army Corps of Engineers, Rock Island, IL
John C. Nelson	Illinois National History Survey, Brighton, IL