ENV Report 40-2

FINAL REPORT

UPPER MISSISSIPPI RIVER
AND
ILLINOIS WATERWAY
CUMULATIVE EFFECTS STUDY

VOLUME 2:
ECOLOGICAL ASSESSMENT

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1 INTRODUCTION

This volume of the report provides an overview of the ecological effects, as measured by the responses of biota, to changes that have occurred since impoundment on the Upper Mississippi and Illinois Rivers (UMRS, Upper Mississippi River System). It also predicts changes between the present and 2050, given current management protocols and planned or anticipated habitat enhancement projects. Cumulative effects are, "... the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions." (40 CFR Section 1508.7). This chapter provides a basis, using best available ecological information, on which to assess cumulative effects of future actions that would affect the UMRS environment.

The geographic extent of this cumulative effects assessment is the Upper Mississippi River from Pool 4 near Alma, Wisconsin, to the mouth of the Ohio River, and the Illinois River from its confluence with the Mississippi River near Grafton, Illinois, up to and including the Peoria Pool near La Salle, Illinois. The Illinois River project area does not extend to Lake Michigan because the upstream reaches are highly urbanized. This geographic scope does not correspond directly to the project area considered in the Upper Mississippi River-Illinois Waterway (UMR-IWW) System Navigation Study. The Navigation Study included the entire river north to St. Anthony Falls, and up to the T. J. O'Brien dam on the Illinois River. The greatest data availability and analytical effort were focused in the pooled portions of the Mississippi River. Analyses consider the period from immediate post-dam (1940) through 2050 and assume that no major construction or operational changes occur.

Most of the navigation dams on the Mississippi and Illinois Rivers were constructed in the 1930's. This cumulative effects assessment does not address the impacts of construction of the navigation system and the initial effects of impounding the rivers, but the impacts of impoundment are explained in the section "Other Human Activities that Affect the Condition of the River Environment" (Section 3.1). This analysis focuses on the changes that have occurred in the UMR-IWW river environment since construction of the navigation system and on a forecast of future conditions. The temporal scale of the cumulative effects assessment is from the early post-impoundment period (roughly 1940) through the present, to the year 2050. The time period from the present to 2050 corresponds to the planning time horizon for the Navigation Study.

Navigation system operation and maintenance activities and navigation traffic are not the only human activities affecting the condition of the UMRS ecosystem. Many other human activities have altered, and continue to affect, the UMRS river environment (Figure 1-1). A brief summary of the human activities in the UMRS Basin that affect the condition of the river environment is as follows:

- Impoundment and river regulation
- Channel training structures
- Dredging and material placement
- Levees and floodplain drainage
- Habitat restoration and protection projects
- Impoundment of tributaries
- Tributary channelization
- Tiling, ditching, and wetland drainage
- Land use
- Point source discharges
- Non-point source loadings
- Entrainment of fish at power plants
- Introduction of exotic species

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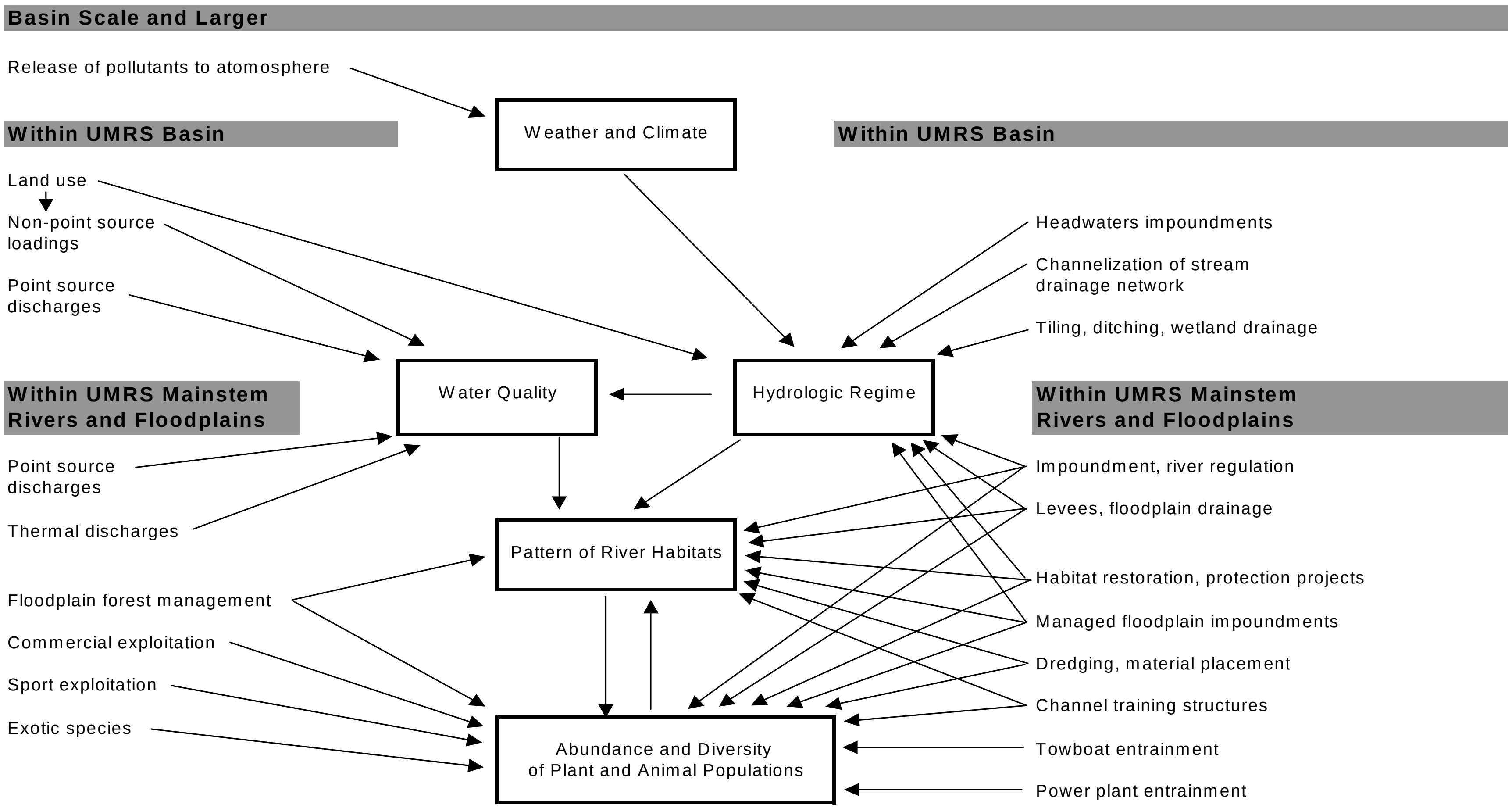


Figure 1-1: Human activities that affect the Upper Mississippi River System Environment.

2 APPROACH

This section briefly reviews the approach used earlier in this report to estimate geomorphic change since impoundment and to forecast future change. We provide an ecologically based definition of the aquatic habitats described earlier in this report and discuss floodplain habitats not considered in this analysis. We define 23 guilds of aquatic organisms used in our analysis. After defining the guilds, we describe the approach used to assess change through time and to forecast future conditions over the next 50 years. We identify other human activities considered in the study and describe our approach to assessing them. It is important to point out that we were not able to complete a formal risk assessment because of the limitation of both physical and ecological information. It is also important to qualify these analyses as representative of summer low-flow habitat conditions and adult aged organisms (except immature forms of aquatic insects). No attempt was made to consider the implications of seasonal and inter-annual flow variation, though limitations in assessing habitat distribution will be stated where appropriate.

Changes in the physical condition of the UMRS since impoundment have resulted from a combination of impoundment and river regulation, channel maintenance activities, navigation traffic, construction of habitat projects, construction and operation of levees and floodplain drainage districts, the effects of land use in the river basin, climate, and geomorphic processes. The approach used in assessing physical changes in the rivers was first to identify geomorphically distinct river reaches. A time series of maps and aerial photographs of the rivers and their floodplains, a time series of river geometry data, records of channel maintenance dredging and material placement, and information on channel training structures (wing dams, closing dams, bank revetments) were compiled and examined. A sediment budget for the UMR was developed. Each navigation pool and river reach was examined to identify important geomorphic processes and significant changes over time (see Volume 1).

A classification of river plan form features (main channel, secondary channels, contiguous backwaters, and isolated backwaters) was used to analyze changes over time. Starting with hard copy plan form maps and aerial photos, river plan form features were delineated, individually identified, and planimetered to determine their area. The plan form features classification used was a simplification of the Long Term Resource Monitoring Program (LTRMP) aquatic areas classification (Wilcox 1993) and the hydraulic classification of aquatic areas developed for the Navigation Study (Nickles and Pokrefke 1998) (Figure 5-29, see Section 5.5.1, Volume 1). The mapping rules employed for delineation of plan form features were carried through consistently in the analyses of river plan form maps generated from aerial photos and Geographic Information Systems (GIS) coverages from different years since system impoundment. Available plan form maps from up to four time periods were examined for each UMRS pool and river reach. The time periods of available maps generally coincided with immediate pre-impoundment (1930), immediate post-impoundment (1940's), early 1970's, and 1989 (see Section 5.5.1, Volume 1 for details). Approximately 25,000 river plan form features were delineated, measured, and analyzed. Areas of plan form change and the probable geomorphic processes causing change were identified. The important geomorphic processes, the areas in which they are expected to occur, and the areal extent of expected plan form changes by year 2050 were forecasted.

2.1 Geomorphic Changes Since Impoundment

Changes in the area of river plan form features were estimated based on the delineation of the time series of maps for each navigation pool and river (Appendix E). Areas of main channel, secondary channels, contiguous backwaters, isolated backwaters, islands, island number, and perimeter length of islands were estimated. The plan form data were summarized by upper and lower portions of the navigation pools, by total for each pool, and by river reach. A detailed discussion of the geomorphic changes since impoundment is provided in Chapter 5 of Volume 1.

2.2 Forecast of Future Geomorphic Changes

The forecast of future geomorphic changes in the UMRS was based on a series of assumptions about continuing geomorphic processes as influenced by climate, land use in the basin, the hydrologic regime, and river regulation. Although change can be expected in all of these factors affecting geomorphic processes on the UMRS over the next five decades, for purposes of this cumulative effects assessment, the “without project” or “current conditions” assumption was adopted with respect to river regulation and further habitat restoration and protection projects (see Section 3.1.5).

The area of river plan form features was measured for each UMR pool and river reach for as many as four historic time periods. Channel cross sections and longitudinal profiles, sediment budgets, dredging and material placement records, and channel training structures were considered. Based on these data, the primary geomorphic processes acting in each pool and river reach were identified, and the trend of change of plan form features was forecast for the year 2050 (Tables 7-1 through 7-4, Figures 7-1 through 7-3, Volume 1). A detailed discussion of the forecast of geomorphic change is provided in Chapter 7 of Volume 1.

2.3 Definition of Aquatic Habitats

The aquatic areas chosen for delineation were based on habitat requirements of various plant and animal species guilds (see below). They represent distinct aquatic habitats based on connectivity with the main channel and presumed depth, current velocity, and substrate type. Table 2-1 presents the linkages among the several classification systems and presumed conditions. Average current velocity distributions for each aquatic area were calculated from the results of RMA2 hydraulic models of Pools 5, 8, 13, 21, and 26 (see Chapter 4, Figure 4-1 and Table 4-2, Volume 1). Ranges for current velocity categories were based on U.S. Fish and Wildlife Service (USFWS) Habitat Suitability Index (HSI) models for several species of fish (Table 2-2). The values used to categorize current velocities are: High = > 0.45m/sec (1.8 ft/sec); Med. = 0.15 to 0.45m/sec (0.5 ft/sec to 1.8 ft/sec); Low = <0.15m/sec (<0.5 ft/sec). The distribution of current velocity was determined for each aquatic area defined for this study: Main Channel (MC), Secondary Channel (SC), Contiguous Backwaters (CB), and Isolated Backwaters (IB).

The plan form analysis relies on data collected at mid summer, low-flow conditions which does not include seasonal flooding or inter-annual changes in discharge. The analysis does not consider the extent of flooding and the impact of seasonal access to flooded terrestrial habitats important to many riverine species. It also does not account for the complex chemical and material cycling in seasonally flooded areas.

2.4 River Habitats Not Included in Assessment

The Upper Mississippi and Illinois Rivers and floodplains form a complex environment of major habitat types (Figure 2-1), which in turn support discrete microhabitats defined by a number of physical and biological attributes.

Floodplain habitats, and the faunal groups associated with them, were not considered in this assessment because of a lack of elevation data at a resolution necessary to quantify the hydrologic regime, including the seasonal timing, amplitude, and duration of inundation on the floodplain. Data are currently available as GIS coverages at 5- and usually 10-foot contour intervals, but water level variation within those bounds can be very significant and affect large areas. Also, most of the impacts of increased commercial traffic assessed in the Navigation Study occur in aquatic, rather than floodplain terrestrial areas.

Floodplain plant community guilds are defined in a literature review by Galatowitsch and McAdams (1994). The guilds, including the aquatic and emergent species considered in this report, are summarized in Table 2-3; representative species are presented in Appendix L.

Table 2-1: Comparison of aquatic area classification systems and generalized depth, substrate, and current velocity.

Cumulative Impacts Classification	Navigation Study Hydraulic Classification	Long Term Resource Monitoring Program Classification	Depth Characteristics	Substrate Characteristics	Velocity Characteristic[1,2]
Main channel	Main channel, Channel border	Main channel, Channel border, Contiguous impounded area	>9 foot channel bordered by shallower areas	Shifting sand with some silt and clay laterally toward bank	High = 12% Med. = 78% Low = 10%
Secondary channel	Secondary channel	Secondary channel	< or > 9 foot channel connected to main channel	Sand, sand/silt, or silt/clay	High = 16% Med. = 66% Low = 18%
Contiguous backwater	Contiguous backwater, Single open backwater, Harbor	Contiguous Floodplain Lake: Abandoned channel, Borrow pit, Floodplain depression, Lateral levee, Manmade, Scour channel, Tributary delta; Contiguous floodplain shallow aquatic area; Tertiary channel	Typically < 6 feet connected to main channel by one or more openings	Silt/clay	High = 0% Med. = 13% Low = 87%
Isolated backwater	Isolated backwater	Isolated Floodplain Lake: Abandoned channel, Borrow pit, Floodplain depression, Lateral levee, Manmade, Scour channel, Tributary delta; Floodplain shallow aquatic area	Typically < 6 feet and not connected to main channel	Silt/clay	Low = 100% (by definition)

1. Average current velocity calculated from RMA2 model results from five Mississippi River reaches.
2. High = > 0.45m/sec (1.8 ft/sec); Med. = 0.15 to 0.45m/sec (0.5 ft/sec to 1.8 ft/sec); Low = <0.15m/sec (<0.5 ft/sec).

Table 2-2: Fish current velocity preferences. Unless noted, all "preferences" represent conditions required for adult fishes during summer, low-flow conditions. Seasonal habitat requirements, such as access to inundated floodplains, are not considered.

Species	Guild[1]	Velocity Preference	Reference
White bass (juvenile)	Pelagic rheo-limnophil	<0.46m/s	Hamilton and Nelson 1984
Bigmouth buffalo	Pelagic limno-rheophil	<0.7m/s	Edwards 1983
Lake sturgeon	Rheo-limnophil	0.02 to 0.57m/s	Fristik *et al.* 1998
Emerald shiner	Rheo-limnophil	0 to 0.5m/s	Fristik *et al.* 1998
Sauger	Rheo-limnophil	0.12 to 1.21m/s	Fristik *et al.* 1998
Walleye (winter) (adult) (spawn)	 Rheophil Rheophil Rheophil	 <0.3m/s <0.15m/s 0.6 to 1.1m/s	 Nav. Studies 1998 McMahon *et al.* 1984a
Paddlefish (spawn site) (egg) (adult)	 Limno-rheophil Limno-rheophil Limno-rheophil	 >0.25m/s >0.3m/s <0.45m/s	 Hubert *et al.* 1984
Slough darter	Rheo-limnophil	<0.19m/s	Edwards *et al.* 1983
Smallmouth buffalo (adult) (sub adult)	 Pelagic limno-rheophil Pelagic limno-rheophil	 0.3 to 1.3m/s <0.25m/s	 Edwards and Twomey 1982
Smallmouth bass	Limno-rheophil	<0.15m/s	Edwards *et al.* 1983
Channel catfish	Rheophil	0 to 0.26m/s	Fristik *et al.* 1998
Flathead catfish	Rheo-limnophil	0 to 0.6m/s	Fristik *et al.* 1998
Largemouth bass (winter) (summer)	 Limnophil	 <0.01m/s < 0.13m/s	 Fristik *et al.* 1998 Stuber *et al.* 1982a
Warmouth	Limnophil	<0.13m/sk	McMahon *et al.* 1984b
Black bullhead	Limnophil	<0.2m/sk	Stuber 1982
Bluegill	Limnophil	<0.2m/sk	Stuber *et al.* 1982b
Green sunfish	Limnophil	<0.2m/sk	Stuber *et al.* 1982c

1. Guild assignment after Poddubny and Galat (1995) with assignments by Hrabik (1998) (Appendix 4; personal communication, Robert Hrabik, Missouri Department of Conservation, Cape Girardeau, MO).

Table 2-3: Upper Mississippi River plant guilds; after Galatowitsch and McAdams (1994).

Guild	Flood Periodicity	Soil	Comments
Woody Vegetation			
Flood Tolerant Pioneering Trees	Annual flooding, >3 weeks	Newly formed, Sand and Mud	Abundant seeds, fast germination
Flood Tolerant Pioneering Shrubs	Annual flooding, >3 weeks	Newly formed, Sand and Mud	Abundant seeds, fast germination
Flood Intolerant Pioneering Trees	Most years, 3 weeks	Old field, Abandoned dredge spoil	Tolerate saturated soil
Flood Tolerant Stable Shrubs	Tolerate standing water	New substrate	Not tolerant of disturbance
Softwood Floodplain Trees	Annual flooding, >3 weeks	Established substrate	Non-invasive
Bottomland Hardwood Trees	Most years, 3 weeks	Terraces	Tolerate saturated soil, heavy seeds
Swamp Forest	Permanent	Stable	Southern reaches only
Woodland Shrub	Brief in most years, <3 weeks	Old field	Tolerate saturated soil
Semi Aquatic and Terrestrial Herbs			
Spring Ephemerals			Herbaceous spring perennials
Autumnal Woodland Forbes			Perennial summer/fall, shade
Woodland Graminoids			Perennial grasses, sedges, rushes, shade
Vines	Varied		Climbing or ground cover
Meadow Graminoids	Annual, >3 weeks		Perennial rushes, sedges, grasses, open
Meadow Forbs	Annual, >3 weeks		Herbaceous perennials, open
Semi-Aquatic Annual Forbs	Annual, >3 weeks		Annual forbs, between floods or inundated, open
Semi-Aquatic Annual Grasses	Annual, >3 weeks		Annual forbs, between floods or inundated, open
Terrestrial Annual Forbs	Most years, brief	Old field, dredge spoil	Dry disturbed areas, open
Parasitic Vegetation			
Terrestrial Annual Graminoids	Most years, brief	Old field, dredge spoil	Dry disturbed areas, open
Aquatic Vegetation			
Emergent Perennials	Persistent, shallow		Leaves well above water, rooted
Emergent Annuals	Persistent, shallow		Leaves above water, rooted
Rooted Submersed Aquatics	Permanent		Leaves submersed
Unrooted Submersed Aquatics	Permanent		Leaves submersed
Floating Perennials	Permanent		Leaves floating/emergent, rooted
Floating Annuals			Leaves floating, no roots/short roots

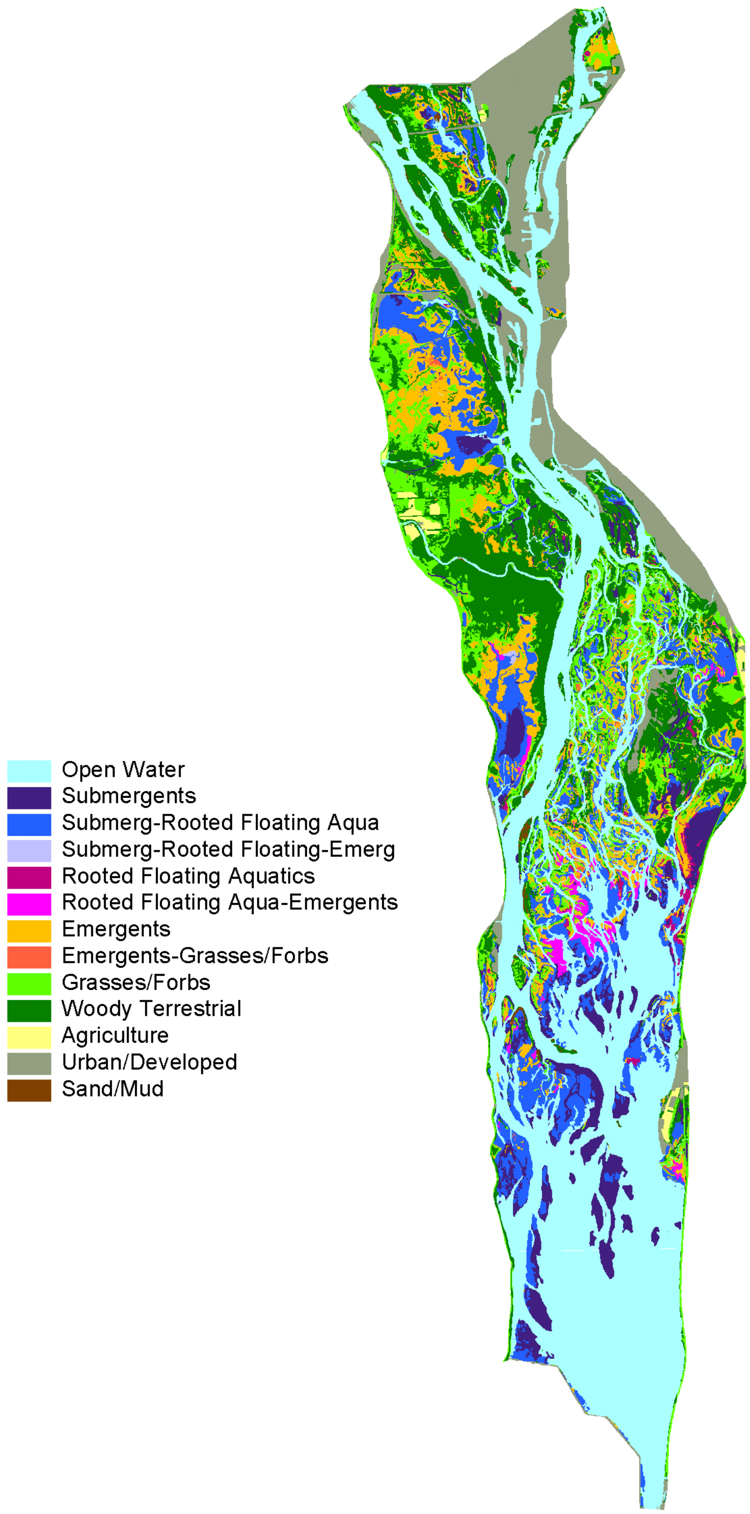


Figure 2-1: Long Term Resource Monitoring Program terrestrial land cover classification for Pool 8, Upper Mississippi River.

2.5 Definition of Guilds of River Organisms

The UMR supports a large number of species, including approximately 350 algal species, almost 600 plant species, over 200 aquatic macroinvertebrate species, 30 mussel species, 150 fish species, 73 reptile and amphibian species, over 300 bird species, and over 50 mammal species (Appendixes L through R). This large number of species was organized by combining those aquatic species with similar life history requirements. These species combinations are called guilds and are comprised of plant or animal species with similar habitat requirements (Simberloff and Dayan 1991; Balon 1975).

The guilds and aquatic areas selected for this assessment are listed in Table 2-1 and explained individually below. They were determined primarily by their relationship to current velocity, proximity to the main channel, and substrate requirements. Proximity to the main channel was determined from the aquatic area classification. Current velocity was approximated from the output of the RMA II models for Pools 5, 8, 13, 21, and 26 (see Chapter 4, Figure 4-1 and Table 4-2, Volume 1). Substrate type was inferred from a combination of proximity to the main channel and current velocity.

Table 2-4: Plant and animal guilds selected for the UMR/IWW Cumulative Effects Study.

Biological Community/Guild	Habitat Requirements[1]	Velocity Preference[2]
Aquatic Vegetation		
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED
Unrooted Submersed Aquatics	CB,IB	LOW
Floating Perennials	CB,IB	LOW,MED
Floating Annuals	CB,IB	LOW
Perennial Emergent Aquatics	CB,IB	LOW
Annual Emergent Aquatics	CB,IB	LOW
Macroinvertebrates		
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH
Lotic Depositional (running-water pools and margins)	MC,SC, CB	LOW
Lentic Limnetic (standing water)	CB,IB	LOW
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW
Lentic Profundal (standing water, basin)	CB,IB	LOW
Freshwater Mussels		
Lotic	MC,SC,	MED,HIGH,LOW
Lentic	CB	MED,HIGH,LOW
Fish		
Rheophil	MC,SC	MED,HIGH
Rheo-Limnophil	MC,SC,CB	MED,LOW, HIGH
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW, HIGH
Limno-Rheophil	CB,SC,MC	MED,LOW
Pelagic Limno-Rheophil	CB,SC,MC	MED,LOW
Limnophil	CB,IB	LOW
Amphibians and Reptiles		
Lotic	MC,SC	LOW
Lentic	CB,IB	LOW
Waterfowl		
Diving Ducks	MC,SC,CB	MED,LOW
Dabbling Ducks, Geese and Swans	CB,IB, SC, MC	LOW

1. MC = main channel, SC = secondary channel, CB = contiguous backwater, IB = isolated backwater.
2. High = > 0.45m/sec (1.8 ft/sec); Med. = 0.15 to 0.45m/sec (0.5 ft/sec to 1.8 ft/sec); Low = <0.15m/sec (<0.5 ft/sec).

2.5.1 Rooted Submersed Aquatic Vegetation

Rooted submersed aquatic vegetation is likely to occur north of Lock and Dam 13 in shallow off-channel areas and channels with low to moderate flow. Their occurrence declines downstream as a result of lower backwater habitat availability, wide variations in river stages, and high ambient turbidity. There are approximately 31 species (Appendix L), but most are rare. Most species are found in depths less than 3 to 5 feet where flow is low. The depth at which vegetation is found gradually decreases downstream (Rogers and Theiling 1999). Backwaters with stable water levels and no flow support the most species, but some narrow-leaved species tolerate (or may require) moderate flow in secondary channels and channel borders. Most are rooted in firm silt/clay or silt/sand substrates and obtain nutrients from the substrate.

Few fish or frogs eat aquatic vegetation directly, but many consume the aquatic macroinvertebrates, algae, and bacterial flora supported by the vegetation. Small fish and tadpoles also find refuge from predation among the stems and leaves. Waterfowl, muskrats, turtles, and macroinvertebrates feed directly on the epiphytes, vegetation, seeds, and tubers.

Representative Species Include: pondweeds (*Potamogeton* spp.), water naiads (*Najas* spp.), and wild celery (*Vallisneria americana*)

Current Velocity: Low to medium

Depth: < 3 feet

Aquatic Areas: MC, SC, CB, IB

2.5.2 Unrooted Submersed Aquatic Vegetation

Unrooted submersed aquatic vegetation grows in contiguous and isolated backwaters, but can frequently be found drifting in channels when caught up in flowing water. One species, coontail (*Ceratophyllum demersum*), is among the most abundant submersed aquatic plant species in the river. As with rooted vegetation, most unrooted submersed aquatic vegetation is found at depths less than 3 feet except when drifting in currents. This guild is easily displaced by flow in backwaters during floods and is most suited to stable water levels. Unrooted submersed aquatic vegetation can derive nutrients directly from the water or soil; bladderwort (*Utricularia vulgaris*) also can capture small invertebrates.

Few wildlife species eat these aquatic species directly, but many consume the aquatic macroinvertebrates supported by the vegetation. Small fish also find refuge from predation among the stems and leaves. Macroinvertebrates thrive in the dense leaves of these species.

Species Include: coontail (*Ceratophyllum demersum*) and bladderwort (*Utricularia vulgaris*)

Current Velocity: Low

Depth: < 3 feet

Aquatic Areas: CB, IB

2.5.3 Floating Perennial Aquatic Vegetation

Floating perennial aquatic vegetation includes water lilies (*Nymphaea adorata*, *Nuphar advena*) and lotus (*Nelumbo lutea*), plants with broad circular leaves floating on the surface and attached to the substrate by long stems. They reproduce primarily through rhizomes and tubers, but also by seed. They are limited to contiguous and isolated backwaters, usually in water less than 3 feet deep and where water levels are relatively stable. This guild derives its nutrients from the substrate which is usually silt/clay or silt/sand.

Vegetation in this guild does not support high densities of invertebrates, nor provide as much refuge to fish as submersed species. The leaf cover does, however, shade the underlying water which may provide thermal refuge during bright summer days and it also reduces wave energy.

Species Include: lotus (*Nelumbo lutea*), water lily *Nymphaea odorata,* and spatter dock (*Nuphar advena*)

Current Velocity: Low

Depth: < 3 feet

Aquatic Areas: CB, IB

2.5.4 Floating Annual Aquatic Vegetation

Floating annuals include the duckweeds (*Lemna* spp.) and their relatives. These are small plants (< ¼ inch) whose leaves float at the surface and roots dangle in the water. They are common in shallow, stagnant water where they form thick mats covering the water's surface. They provide little nutrient or refuge value for fish and wildlife. They are sometimes found drifting at the surface in channels if swept into currents during high flow.

Species Include: water meal (*Wolffiella floridana, Wolffia spp*.), duckweed (*Lemna spp*.), mosquito fern (*Azolla mexicana*)

Current Velocity: Low

Depth: < 3 feet

Aquatic Areas: CB, IB

2.5.5 Perennial Emergent Aquatic Vegetation

Perennial aquatic vegetation includes a large number of wetland graminoids and forbs. They are species that can tolerate flooding for more than a few weeks and are found in zones defined by the relative elevation above the low river stage. Many species require a period of dewatered mudflat conditions for seed germination. They are usually found in open areas. Galatowitsch and McAdams (1994) define three semi-aquatic and aquatic emergent perennial plant guilds: Meadow Graminoids include perennial rushes, sedges, and grasses; Meadow Forbs include many genera of herbaceous perennials; and Emergent Perennials include cattails, arrowhead, and sedges.

Species Include: Rushes (*Juncus* spp.), sedges (*Scirpus* spp., *Carex* spp.), cattails (*Typha* spp.), and arrowhead (*Sagittaria* spp.)

Current Velocity: Low

Depth: < 0.5 foot

Aquatic Areas: CB, IB

2.5.6 Annual Emergent Aquatic Vegetation

Annual emergent aquatic vegetation completes its life cycles between floods but can tolerate inundation for more than a few weeks. They become established on exposed substrate, but remain viable when river stages rise. Many species are valued for their wildlife food benefits because they produce large quantities of nutritious seeds. Galatowitsch and McAdams (1994) define three semi-aquatic and aquatic emergent annual plant guilds: Semi-aquatic Annual Forbs include smartweeds (*Polygonum*); Semi-aquatic Annual Grasses include sedges and wild millet; and Emergent Annuals include wild rice.

Species Include: Sedges (*Cyperus* spp.), wild millet (*Echinochlora* spp.), and wild rice (*Zizania aquatica*)

Current Velocity: Low

Depth: < 0.5 foot

Aquatic Areas: CB, IB

2.5.7 Lotic Erosional Macroinvertebrates

Lotic erosional macroinvertebrates are found in main channel, channel border, and swift flowing secondary and tertiary channels. They are most abundant where structure, such as snags and wing dams, is present, but some species are adapted to life in the shifting sands at the bottom of the channel. Numerous life history strategies have evolved to permit existence in this high-flow environment.

Tube building and net spinning are common adaptations that macroinvertebrates employ to survive in high flows. The net spinning caddis flies (Hydropsychidae) construct fine meshed nets on rock, wood, or animal substrates to provide flow refuge and to filter fine organic material as water flows through the net. They are frequently the most abundant taxa in lotic environments. Many chironomid species (Chironomidae) construct tubes from particulates in their environment to shelter themselves from high flows. Other adaptations include dorso-ventral flattening (mayflies and stoneflies) that permits organisms to shelter themselves in a hydraulic boundary layer near rock surfaces where flow is low, and/or secretive behaviors that keep organisms secluded in gaps and crevices in their environment. A final adaptation is exclusive to an exotic invader, the zebra mussel (*Dreissena polymorpha*), that secrete byssal threads that "glue" the organism to their substrate.

Representative Species Include: Diptera (Chironomidae; *Polypedilum convictum*, *Rheotanytarsus* sp.), Ephemeroptera (Heptageniidae, Heptageniidae), and Trichoptera (Hydropsychidae). The recently arrived zebra mussel is also an inhabitant of this habitat.

Substrate: Primarily rock and snags; some found in shifting sands.

Current Velocity: Medium to high

Depth: Wide range

Aquatic Areas: MC, SC

2.5.8 Lotic Depositional Macroinvertebrates

Lotic depositional macroinvertebrates are found in soft substrates in all low current velocity channel habitats. They include a variety of worms (Annelida), midges (Diptera; Chironomidae), burrowing mayflies (Ephemeridae), and fingernail clams (Sphaeriidae). Under proper conditions, high population density is possible and is of great food value to fishes and migratory waterfowl.

Most members of this guild burrow in the substrate where they feed and seek refuge from predation. The economically important mayflies and fingernail clams are filter feeders who derive energy from interstitial and overlying waters. Midges and worms feed primarily on detritus in the sediment, but many feeding strategies may be exhibited.

Representative Species Include: Chironomids (midges), burrowing mayflies, and fingernail clams

Substrate: Silty/clay, clay, silt

Current Velocity: Low

Depth: Wide range

Aquatic Areas: MC, SC, CB

2.5.9 Lentic Limnetic Macroinvertebrates

Lentic limnetic macroinvertebrates include the group of invertebrates that float or swim in the water column. Though a little small to be classified as macroinvertebrates, zooplankton can be considered in this group along with a common Dipteran *Chaoborus* sp., the phantom midge, which migrates from the bottom up into the water column at night. This group of invertebrates makes up an important part of the diet of planktivorous fishes and the young of many fish species.

This guild is restricted to non-flowing, contiguous and isolated backwaters where these organisms feed on algae suspended in the water column. They are likely to be swept into channel areas during high-flow periods.

Representative Species Include: phantom midges (*Chaoborus* spp.), and zooplankton

Substrate: Silt/clay, silt, clay

Current Velocity: Low

Depth: Wide range

Aquatic Areas: CB, IB

2.5.10 Lentic Littoral Macroinvertebrates

Lentic littoral macroinvertebrates are found among the vegetation in shallow backwaters and channel border habitats. This is a complex guild that supports very high densities of invertebrates ranging from the very small zooplankton to large predaceous beetles. Generally, the community consists of herbivores that feed on the algae growing on plant leaves (mayflies, caddis flies), detritivores consuming decomposing plant material (amphipods, chironomids), and a group of primary predators (beetles, dragonflies, damselflies, true bugs) that feed on the smaller species. Fish and waterfowl feed on all types of macroinvertebrates.

Organisms in this guild are found primarily in shallow, vegetated, contiguous and isolated backwaters. They may occur in plant beds in channel habitats, but would be susceptible to being dislodged by current and swept up in the drift. Some species are likely to be swept into channel areas during high-flow periods, but many migrate along the rising edge of the floodwaters and feed on decaying terrestrial vegetation.

Representative Species Include: Odonata (dragonflies and damselflies), Trichoptera (case building caddisflies), amphipods (scuds), Ephemeroptera (caenid mayflies), Diptera, and worms.

Substrate Preference: Aquatic vegetation

Current Velocity: Low

Depth: Generally < 3 feet

Aquatic Areas: CB, IB

2.5.11 Lentic Profundal Macroinvertebrates

Lentic profundal macroinvertebrates are found in the deep open water of backwater lakes. They are generally detritivores that burrow in soft, silty clay. The most common organisms are worms and large chironomids, but predaceous Diptera (Certopoginidae, biting midges) are also common. Many species are adapted to survive periods of low dissolved oxygen concentrations. The animals occur typically too deep for waterfowl, but are an important part of the diet of many fishes.

This guild is found primarily in deep backwaters, but can also be found in shallow areas where aquatic vegetation is lacking. In some Mississippi and Illinois River backwaters where vegetation is lacking, this is the most abundant guild.

Representative Species Include: Worms, Diptera (*Chironomus* sp., *Ceratopogonidae* sp., *Chaoborus* sp.)

Substrate Preference: Silt/clay, silt, clay

Current Velocity: Low

Depth: Variable, but generally > 6 feet

Aquatic Areas: CB, IB

2.5.12 Lotic Freshwater Mussels

Most freshwater mussels (Unionidae) are found in flowing water habitats where they bury their posterior end about two-thirds into the substrate. They are filter feeders that take river water in through a siphon, absorb organic particles, expel inorganic material, and expel the water. A single mussel can filter several gallons of water each day. They are typically found in large concentrations (beds). Freshwater mussels require a fish host to complete their life cycle.

This guild is found primarily in channel habitats, with gravel, sand/gravel, sand/clay, or silt/clay substrates with some species being more tolerant of silt than others. High dissolved oxygen concentrations and river currents are necessary for this guild.

Representative Species Include: Threeridge, deertoe, washboard, pink heelsplitter, spike, muckets, sandshells, and papershells. (Scientific names listed in Appendix N.)

Substrate Preference: Gravel, sand/gravel, silt clay

Current Velocity: Medium, high, and low

Depth: Variable

Aquatic Areas: MC, SC

2.5.13 Lentic Freshwater Mussels

One group of mussels, floaters, is adapted to life in backwater habitats. They have life histories similar to lentic mussels, but have a special adaptation to accumulate air and float from one spot to another. They are also more tolerant of silt substrates. This guild is found most commonly in contiguous backwaters and is not present in most isolated backwaters.

Representative Species Include: Floaters (Scientific names listed in Appendix N)

Substrate Preferences: Silt/clay

Current Velocity: Low

Depth: Variable

Aquatic Areas: CB

2.5.14 Rheophilic Fish

Rheophilic fishes are found in swift-flowing main and secondary channel habitats. They have physical and behavioral adaptations that allow them to survive in the high-flow environment. Species adaptations include living at the bottom of the river where currents are slower and seeking shelter in flow refugia such as dike fields and snags.

Representative Species Include: Shovelnose sturgeon, pallid sturgeon, lake sturgeon, blue catfish, channel catfish, speckled chub, flathead chub, sicklefin chub, silver chub, blue sucker, stonecat, freckled madtom, western sand darter, plains minnow, and crystal darter. (Scientific names listed in Appendix O.)

Substrate Preferences: Variable

Current Velocity: Medium and high

Depth: Variable

Aquatic Areas: MC, SC

2.5.15 Rheo-Limnophilic Fish

This guild is similar to the Rheophils in that they, too, have behavioral and physical adaptations to moderate flow. In addition to bottom dwelling, some species show streamlined shapes that ease swimming in high velocity current. While adapted for life in channel habitats, members of this guild may also occur in backwaters. Some species may use or require inundated floodplains.

Representative Species Include: Chestnut lamprey, longnose gar, shortnose gar, American eel, skipjack herring, goldeye, mooneye, Mississippi silvery minnow, emerald shiner, ghost shiner, river shiner, red shiner, silverband shiner, sand shiner, blacktail shiner, channel shiner, bullhead minnow, black buffalo, shorthead redhorse, river redhorse, flathead catfish, brook silverside, river darter, and sauger. (Scientific names listed in Appendix O.)

Substrate Preferences: Variable

Current Velocity: Medium and low

Depth: Variable

Aquatic Areas: MC, SC, CB

2.5.16 Pelagic Rheo-Limnophilic Fish

This is a guild of schooling predators adapted to survival in the open water regions of main channel, secondary channel, and contiguous backwater areas. They seek out areas of moderate current to cope with harsh channel environments.

Representative Species Include: White bass (Scientific names listed in Appendix O)

Substrate Preferences: Variable

Current Velocity: Medium and low

Depth: Variable

Aquatic Areas: MC, SC, CB

2.5.17 Limno-Rheophilic Fish

Limno-Rheophilic fishes are species that are primarily adapted for low current velocity, backwater habitats. They can tolerate moderate current velocity for short periods or may seek areas in channel habitats where they can find adequate flow refugia. They can be found in both channel and backwater habitats, and many species are likely to occur in inundated floodplains.

Representative Species Include: Spotted gar, common carp, pugnose shiner, spottail shiner, weed shiner, quillback, river carpsucker, highfin carpsucker, spotted sucker, silver redhorse, golden redhorse, smallmouth bass, mud darter, bluntnose darter, johnny darter, yellow perch, and walleye. (Scientific names listed in Appendix O.)

Substrate Preferences: Silt/clay, gravel

Current Velocity: Low, Medium

Depth: Variable

Aquatic Areas: CB, SC, MC

2.5.18 Pelagic Limno-Rheophilic Fish

This guild of fishes is found in low current velocity portions of the water column in backwaters and channel habitats. They may tolerate higher current velocity, but will seek refuge from high current velocities. The paddlefish (*Polyodon spathula*) is a species known to make seasonal longitudinal migrations; the buffalo spawn in inundated floodplains.

Common Species: Paddlefish, bigmouth buffalo, and smallmouth buffalo. (Scientific names listed in Appendix O.)

Substrate Preference: Silt/clay

Current Velocity: Low

Depth: Variable

Aquatic Areas: CB, SC, MC

2.5.19 Limnophilic Fish

Limnophilic fish are those species common to lakes and backwaters. They are not strong swimmers and do not tolerate high current velocity for long periods. They may also be strongly oriented toward vegetated habitats where they feed on invertebrates living among the vegetation. Most species are likely to be found in inundated terrestrial areas. Many species are opportunistic feeders, some are specialized insectivores, and others are piscivores.

Representative Species Include: Gizzard shad, threadfin shad, black bullhead, yellow bullhead, tadpole madtom, northern pike, central mudminnow, green sunfish, warmouth, orangespotted sunfish, bluegill, largemouth bass, white crappie, and black crappie. (Scientific names listed in Appendix O.)

Substrate preferences: Silt/clay

Current Velocity: Low

Depth: Variable

Aquatic Areas: CB, IB

2.5.20 Lotic Amphibians and Reptiles

A few species of turtles are found most commonly in channel habitats. Softshell turtles show strong adaptation to the environment in their platter shape, which they bury in sand. They, too, require floodplain soils for nesting and often select dredged material deposits.

Representative Species Include: Softshell turtles and map turtles. (Scientific names listed in Appendix P.)

Substrate Preference: Sand, mud

Current Velocity: Low

Depth: Variable

Aquatic Areas: MC, SC

2.5.21 Lentic Amphibians and Reptiles

Many species of frogs and turtles live in river floodplain backwaters. They require both aquatic and terrestrial habitats in their life cycles. Isolated backwater puddles and pools without fish provide exceptional frog breeding habitat from which they can migrate to larger water bodies after they grow and begin to actively feed. Adult turtles feed primarily on aquatic vegetation and spend most of the time in permanent water bodies, but they incubate their eggs in floodplain soils above the flood stage elevation. Painted turtles are most common in the north, and red-eared sliders dominate in the south. Snapping turtles are widely distributed.

Representative Species Include: Painted turtles, red-eared sliders, snapping turtles, water snakes, green frogs, and bullfrogs. (Scientific names listed in Appendix P.)

Substrate Preference: Silt/clay

Current Velocity: Low

Depth: Variable

Aquatic Areas: CB, IB

2.5.22 Diving Ducks

Diving ducks are migratory waterfowl that swim to the bottom to feed on plant and animal resources in the rivers. The main prey items are fingernail clams found in channel borders and secondary channels, and the main plant foods are tubers of wild celery and sago pondweed. They distribute themselves in relation to their food sources and shelters, and can be found in most river habitats.

Representative Species Include: Canvasback, lesser scaup, and greater scaup. (Scientific names listed in Appendix Q.)

Substrate Preference: Variable

Current Velocity: Low, Med

Depth: 1.5 to 4.5 feet

Aquatic Areas: MC, SC, CB

2.5.23 Dabbling Ducks

Dabbling ducks are species found mostly among emergent and submersed aquatic vegetation in water less than 1.5 feet deep. These ducks are opportunistic feeders that shift their diets seasonally from primarily invertebrate foods during the spring migration to plant foods during the fall migration. Dabbling ducks can be found loafing in all river habitats, but generally prefer sheltered backwaters or inundated floodplains.

Representative Species Include: Mallards and teal. (Scientific names listed in Appendix Q.)

Substrate Preference: Silt/clay

Current Velocity: Low

Depth: <1.5 feet

Aquatic Areas: CB, IB, SC, MC

2.6 Assessment of Ecological Effects of Change

The assessment of the ecological effects of change in physical habitat conditions over time since impoundment and the forecast of future ecological conditions was limited by availability of bathymetric and sediment type data in off-channel areas and availability of data on plant and animal populations. The assessment of ecological effects was made using the estimates of river plan form changes since impoundment, the forecasts of future plan form changes, and assumptions about current velocity, sediment types, and water depth in backwater areas. Effects of physical changes in condition of the river environment on guilds of river organisms were assessed using our collective professional judgment.

It was assumed, for example, that the average current velocity for specific aquatic areas derived from the available RMA II hydraulic models represented typical velocities in other pools. We also assumed that sediment type was distributed in relation to flow, with sand occurring in high-flow areas; mixed sand, silt, and clay in medium-flow areas; and silt and clay in low-flow areas. Assumptions of depth in backwaters are difficult, but it was agreed that backwaters in the southern pooled reaches and in the Illinois River have experienced a greater amount of fine-grained sedimentation (Bellrose *et al*. 1983, Nielsen *et al.* 1984, DeMissie *et al.* 1992) than the upper pools. Wave-induced sediment resuspension also was assumed to be greater in southern pools and Illinois River backwaters. Consistent with the UMR-IWW System Navigation Feasibility Studies, it was assumed that submersed aquatic vegetation primarily occurs in Pool 13 and above.

To evaluate changes in the guilds, their major habitat requirements were compared with the amount of increase or decrease in suitable habitat estimated during the period immediately post dam construction (1940) to 2050. The best professional judgment of the consultant team was used to account for changes due to contamination, sedimentation, harvest, and other stressors. The percent change in the area of available habitats was assumed to proportionally affect the abundance of individuals within each guild.

The classification system used will overestimate the actual areal extent of habitat for most guilds, but the resolution of historical data does not permit investigation of all the factors affecting the distribution and abundance of plants and animals.

2.7 Identification of Other Stressors

Navigation system operation and maintenance activities and navigation traffic are not the only human activities affecting the condition of the UMRS ecosystem. Many other human activities have altered, and continue to affect, the UMRS river environment (Figure 1-1). We briefly summarize effects of the following human activities in the UMRS Basin that affect the condition of the river environment:

- Impoundment and river regulation
- Channel training structures
- Dredging and material placement
- Levees and floodplain drainage
- Habitat restoration and protection projects
- Impoundment of tributaries
- Tributary channelization
- Tiling, ditching, and wetland drainage
- Land use
- Point source discharges
- Non-point source loadings
- Entrainment of fish at power plants
- Introduction of exotic species.

3 ASSESSMENT OF ECOLOGICAL EFFECTS OF HABITAT CHANGE AND OTHER HUMAN ACTIVITIES

Summaries of ecological change on the UMRS are the subject of several comprehensive reviews (Fremling and Claflin 1984; Sparks 1984; EMTC 1999). Systemic surveys, long-term monitoring, and site-specific investigations provide more recent information on current conditions and systemic patterns and trends. All are used in this assessment to provide an overview of ecological change and current conditions. Where possible, changes resulting specifically due to operation and maintenance of the navigation system will be highlighted. Changes resulting from the other human activities or the cumulative impacts of multiple stressors also will be identified.

The following section, Section 3.1, summarizes human activities that affect the river environment. Section 3.2 presents a pool-by-pool assessment and a guild-by-guild assessment of ecological changes related to changes in plan form characteristics.

3.1 Other Human Activities that Affect the Condition of the River Environment

3.1.1 Effects of Impoundment and River Regulation

There are 26 dams on the UMR and 8 on the IWW. The dams (except Locks and Dams 1 and 19) were constructed for the specific purpose of increasing low and moderate flow water surface elevations to maintain a continuous 9-foot navigation channel from St. Louis, Missouri, to Minneapolis, Minnesota, and Lake Michigan. Because Mississippi River dams are designed to maintain low-flow navigation, most are opened completely during high-flow events. The gates at Lock and Dam 19 have only been completely opened once since it was built in 1913, during the 1993 flood.

The geometry of the pools created by the dams is such that water level variation differs within each pool reach. In plan form, the dams impound greater open water area in the downstream portion of the pools where the floodplain has been inundated. In the middle pool areas, water depths are not as great, and island braided channels and shallow marshes exist. In the uppermost portion of each pool, the river maintains much of its pre-dam character with island braided channels and secondary channels (see Figure 2-1). The plan form changes due to impoundment are most apparent in pools north of Pool 13.

Hydrologic variability within pool reaches is similar among the pools, and some examples from the UMRS and IWW are presented below. Water level variations in upstream portions of the pools generally respond closely to river discharge. The correlation between discharge and elevation decreases with proximity to the downstream dam. Some dams are operated such that lower pool drawdowns occur during moderate flow. Water levels in Pools 8 and 26 on the Mississippi River and the La Grange Pool on the Illinois River were examined with respect to hydrologic effects of impoundment.

Water surface elevation and river discharge at a location in what is currently Pool 8 was closely correlated prior to construction of the dams (r = 0.78; Figure 3-1, Panel A). When the dams were constructed, the discharge-stage correlation was disrupted. Water levels in the tailwater of Lock and Dam 7 correspond very closely to discharge at the gauge located 24 miles upstream in Pool 6 (r = 0.91; Figure 3-1, Panel B). At the mid-pool gauge (Figure 3-1, Panel C) the correlation is lower (r = 0.48). At the pool gauge at Lock and Dam 8 (Figure 3-1, Panel D), the correlation is weakly negative (r = -0.11) because the pool is managed with a mid-pool control point and a drawdown of 1 foot during moderate flows.

Water surface elevation and river discharge at the confluence with the Illinois River was also closely correlated prior to construction of the dams (r = 0.98; Figure 3-2 Panel A), though the average range of variation was twice as great as in upstream reaches. When the dams were constructed, the discharge-stage correlation was disrupted. Water levels in the tailwater of Lock and Dam 25 correspond very closely to discharge at the gauge located 13 miles downstream (r = 0.92; Figure 3-2, Panel B). At the mid-pool gauge (Figure 3-2, Panel C) the correlation is lower (r = 0.63). At the headwater gauge of Lock and Dam 26 (Figure 3-2, Panel D), the correlation is weakly negative (r = -0.06) because the pool is managed with a mid-pool control point and a drawdown of 1 foot during moderate flows. The average headwater elevation in Pool 26 masks the true range of drawdowns that can be as much as 6 feet and persist for weeks to months during moderate discharge.

Water surface elevations in the Illinois River were first modified by water diversions from Lake Michigan to divert urban wastes from the growing Chicago region. Water surface elevations were increased between 3 to 6 feet at the initial rate of discharge, but the flow was subsequently cut due to concern for lowering water levels in Lake Michigan. The dams did not increase water elevations appreciably over that of the diversion, but the artificially high stages were fixed by the dams. Hydrologic modifications, on average, are not as extreme in the La Grange Pool as in Pools 8 and 25 because the river frequently goes to “open river” condition, where flow determines river stage (Figure 3-3). The average, however, masks daily fluctuations that have become much more rapid since the basin, floodplain, and river have been developed (Figure 3-4). Gate manipulations at the Peoria Dam on the IWW can cause tailwater water level fluctuations in excess of 1 foot per day.

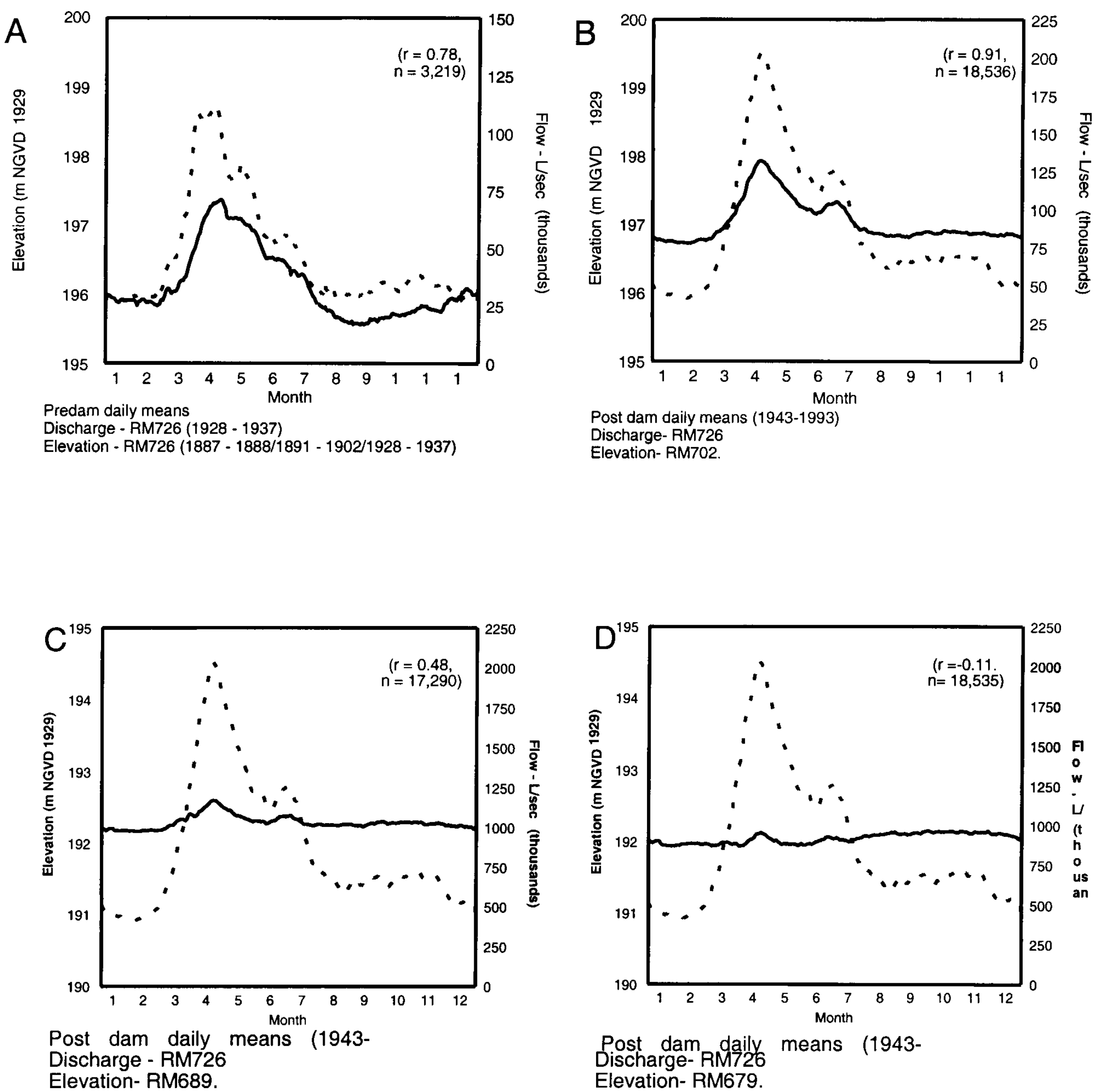


Figure 3-1: Discharge and elevation stage correlations in UMR Pool 8. Panel A presents the pre-dam relation, panels B, C, and D show the post-dam change in upper Pool 8, middle Pool 8, and lower Pool 8, respectively. The mean post-dam stage increases somewhat, and the range of variation is attenuated in the downstream direction. Discharge = dashed line, Elevation = solid line (NGVD = National Geodetic Vertical Datum).

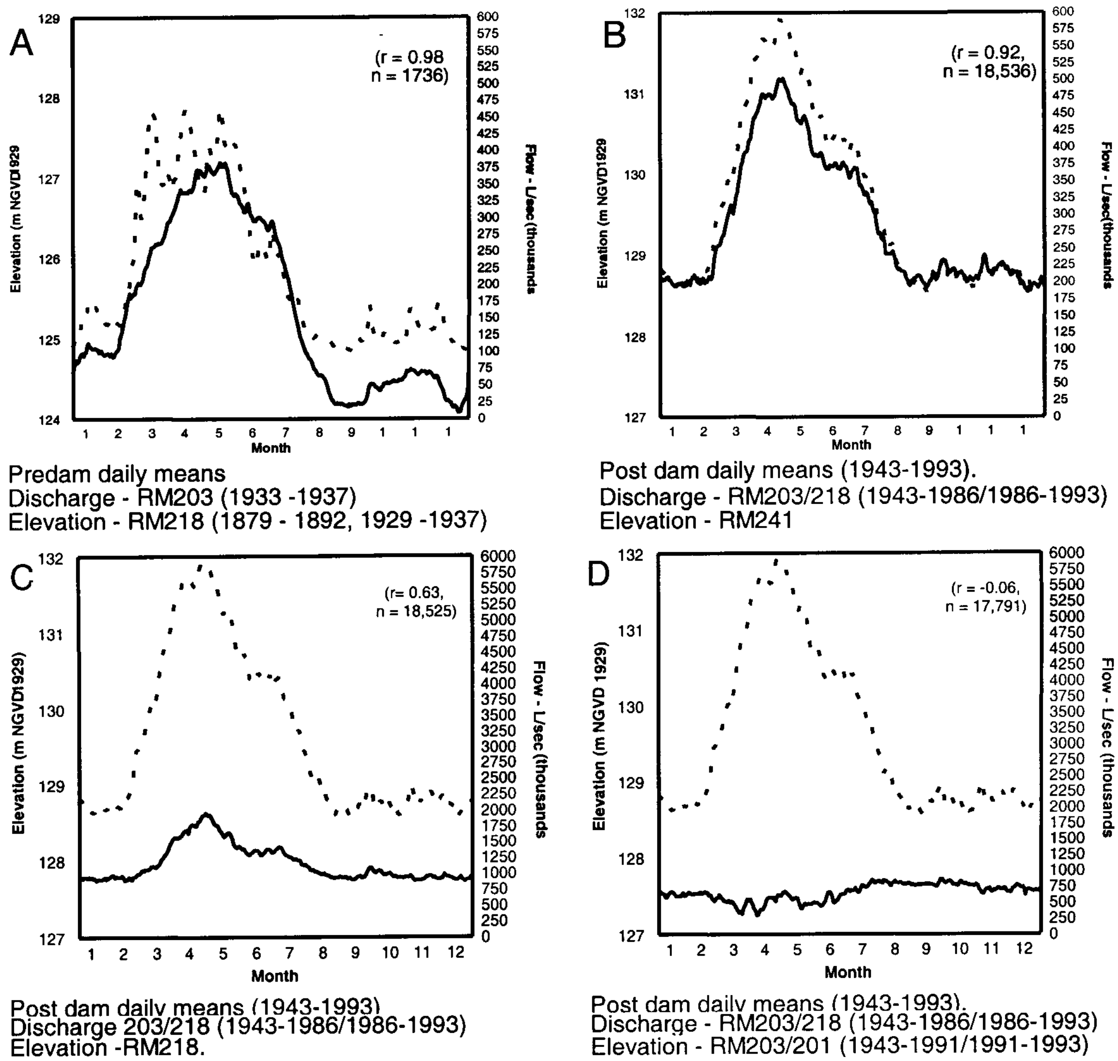


Figure 3-2: Discharge and elevation stage correlations in UMR Pool 26. Panel A presents the pre-dam relation, panels B, C, and D show the post-dam change in upper Pool 26, middle Pool 26, and lower Pool 26, respectively. The mean post-dam stage increases somewhat and the range of variation is attenuated in the downstream direction. Maximum lower pool drawdowns up to 1.8 m are masked by the mean. Discharge = dashed line, Elevation = solid line (NGVD = National Geodetic Vertical Datum).

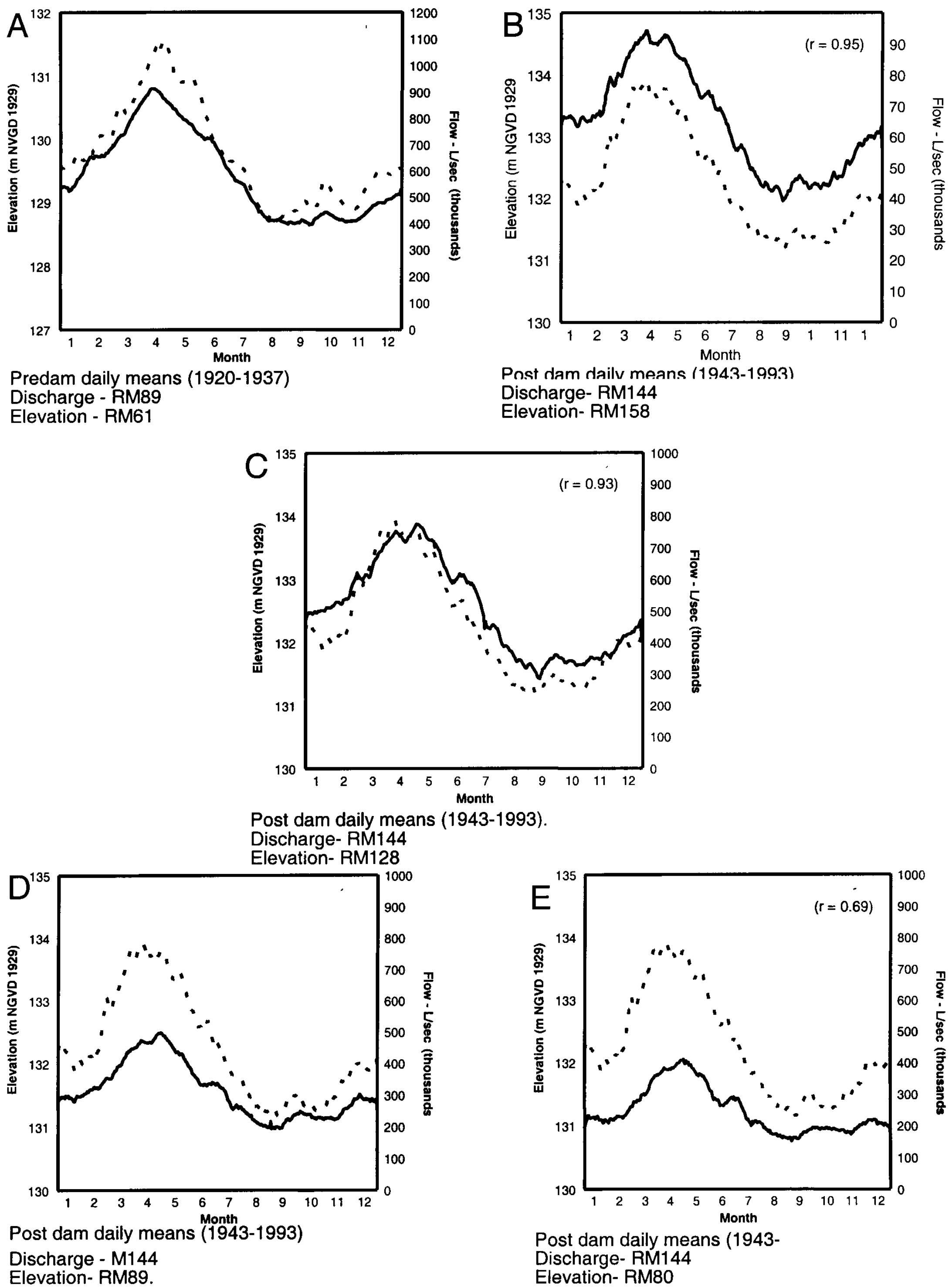


Figure 3-3: Discharge and elevation stage correlations in Illinois River La Grange Pool. Diversions and impoundment increased the mean annual stage, and attenuated stage variation near the dam. The means mask changes in the rate and amount of variation. Discharge = dashed line, Elevation = solid line (NGVD = National Geodetic Vertical Datum).

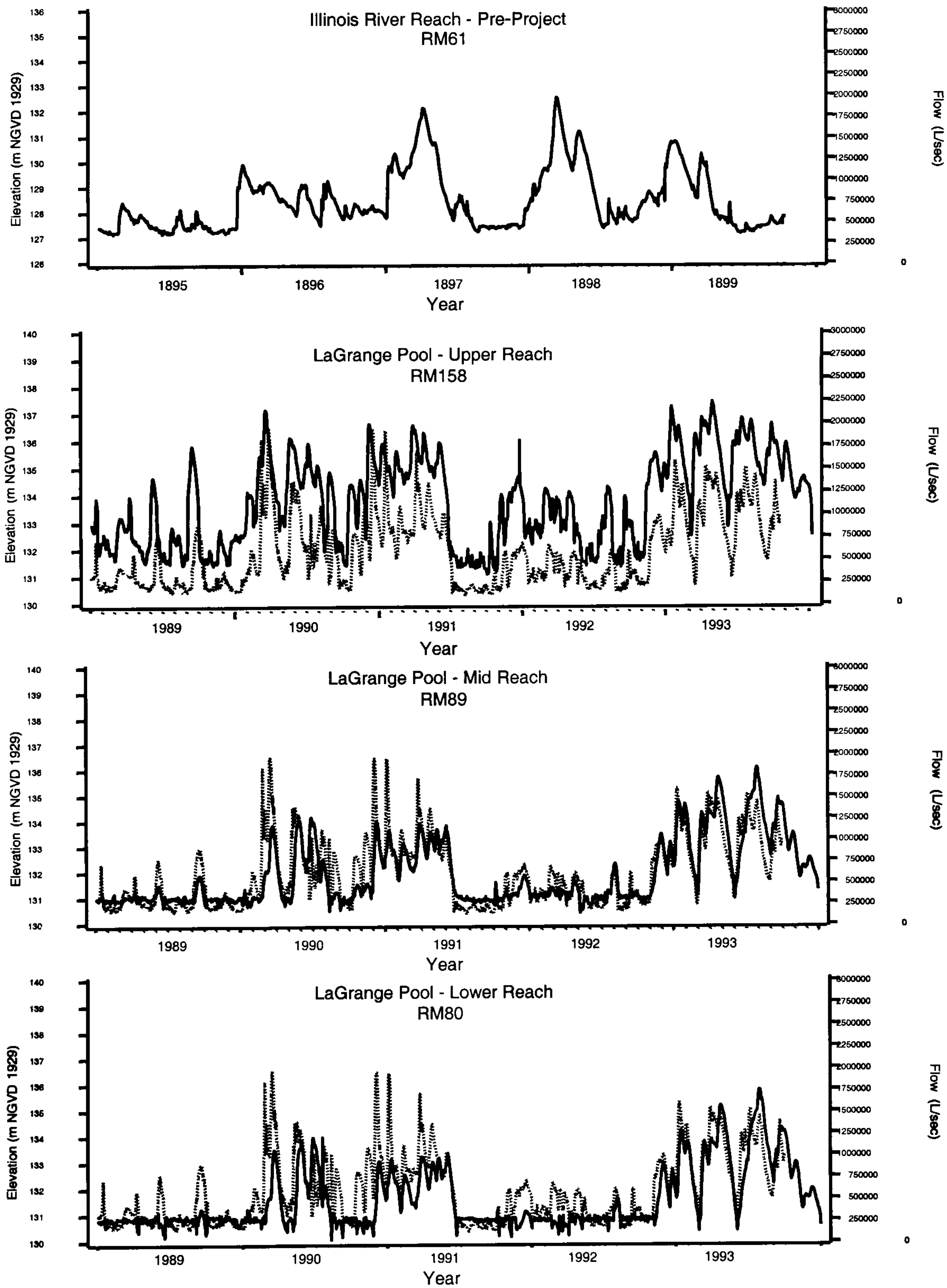


Figure 3-4: The rate of water delivery (i.e., flow routing) (discharge - dashed line) to the Illinois River has increased since the late 1800's. The frequency and amplitude of river stage fluctuations have also increased. Discharge = dashed line, Elevation = solid line (NGVD = National Geodetic Vertical Datum).

3.1.2 Pattern of Habitats Created by Impoundment

The spatial pattern of aquatic and floodplain terrestrial habitats in the UMR navigation pools is determined by the template of preimpoundment channels and floodplain features, with the effects of impoundment superimposed. Impoundment of the navigation system in the 1930's inundated extensive floodplain areas and created a series of shallow riverine reservoirs, called navigation pools (see Chapter 5, Volume 1). The depth of inundation of the floodplain was greater in the downstream portions of the navigation pools, creating open impounded areas and leaving the upper portions of the navigation pools nearly unchanged. High elevation features of the floodplain (natural levees, terrace remnants) became islands upon inundation. Secondary and tertiary channels, which were only seasonally flowing prior to impoundment, became continuously flowing channels. Many secondary and tertiary channels became inundated, with submerged banklines. Littoral processes of shoreline erosion and sediment transport greatly modified the lower parts of the navigation pools since impoundment. The deeper, submerged channel areas filled with sediment, and many islands were eroded. Extensive impounded areas in the lower parts of the navigation pools now have relatively uniform depths.

Floodplain lakes became larger and permanent upon impoundment, resulting in more open conditions with greater wind fetch, wave action on shorelines, and little water level variability. Littoral features such as beach ridges, sand spits, and bay-mouth bars have developed on some of the larger floodplain lakes since impoundment. The water level regimes on Lake St. Croix, a large lake at the southern end of the St. Croix River formed by a natural levee of the Mississippi River, and Lake Pepin, a large mainstem Mississippi River lake formed by the delta of the Chippewa River, have been influenced by impoundment and maintenance of the UMR navigation channel. The water level of St. Croix was raised about 1 foot at low levels of river discharge by Lock and Dam 3. At higher levels of river discharge, dredging in the main UMR channel has resulted in lower water levels in Lake St. Croix than prior to impoundment. On Lake Pepin, dredging of the main channel at the outlet and below initially resulted in lower water levels in Lake Pepin. Regulation of Pool 4 with a primary control point at Wabasha, Minnesota, has resulted in lower Lake Pepin water levels during low to moderate levels of river discharge due to the routine drawdown at Lock and Dam 4. These lakes (Lake Pepin and Lake St. Croix) have established new beach zones and littoral features in the six decades since impoundment in response to these changes in water level regime.

The increased water levels following impoundment formed extensive shallow aquatic and wetland habitat in the formerly seasonally inundated floodplain. The higher and continuous water levels in the floodplain soil profile resulted in a modified floodplain forest which is now dominated by the most flood-tolerant trees such as silver maple (*Acer saccharinum*). The higher groundwater table has restricted the rooting depth of trees growing in the floodplain, making them more vulnerable to wind throw. Wind throw of trees has accelerated island and shoreline erosion processes in portions of navigation pools where the floodplain surface is near the water level, primarily in the downriver half of the navigation pools.

Impoundment of the navigation pools raised the base level of many tributary rivers, causing delta formation farther up in the tributary valleys and raising the water table in the tributary floodplains near the mainstem rivers. Existing tributary wetlands were inundated in areas, such as the Turkey River in Iowa, the Black and Buffalo Rivers in Wisconsin, and the Whitewater, Zumbro, and Vermillion Rivers in Minnesota, but wetlands developed higher in the tributary valleys.

The spatial pattern of habitats in the unimpounded reach of the UMR has been determined by engineering works. Levees have isolated most of the floodplain from the river and have allowed conversion of most floodplain habitat to agriculture. Channel training structures have created a repeating pattern of scour holes below wing dams, and shallow sand habitat adjacent to the main channel and between wing dams. The closing dams have effectively reduced the flow entering secondary channels, reducing the number and area of secondary channels in the unimpounded reach of the UMR.

On the Illinois River, the increased flow from the diversion from Lake Michigan increased minimum water levels throughout the system. Much of the floodplain has been isolated by levees, but the increased water levels from impoundment by the navigation dams and the flow diversion from Lake Michigan increased the area and stabilized water levels of the remaining floodplain lakes.

3.1.3 Effects of Channel Training Structures

Channel training structures include wing dams, closing dams, revetted banks, and several newer structures designed to be more sensitive to ecological concerns. Wing dams and closing dams are rock structures designed to concentrate flow; to control the magnitude, velocity, and direction of flow along the river; and to influence the location of channel erosion and sedimentation. Wing dams are typically positioned perpendicular to the main flow of the rivers to concentrate flow in the main channel, thus scouring the river bed to maintain navigable depths. Wing dams are frequently located in areas that required repetitive dredging to reduce the frequency of dredging. Revetted banks are armored with limestone rock of various sizes to reduce erosion of islands and bank lines exposed to high velocity currents. Closing dams block flow to secondary channels to improve navigation in the main channel and reduce dredging requirements.

Wing dam construction began in the 1800's during the development of the 4- and 6-foot navigation channel projects. Willow fascine mats were used to construct wing dams, closing dams, and revetments from the 1880's into the 1920's (see David Bosse print illustrating wing dam construction http://www.mvp.usace.army.mil/history/pamphlets/bosse/default.htm#four). After that time, repairs to structures and new structures have been built entirely of rock. The distal ends of many wing dams in the upper pools remain exposed in the main channel borders, while the landward ends are buried in sediment. Many wing dams in the upper pools, as well as old revetment, are now entirely buried in sediment. They remain "effective" in narrowing and realigning the navigation channel. In the lower pooled reaches and especially in the Mississippi River below the confluence with the Missouri River, wing dams are common and are visible above the water line except during floods. A summary of the distribution of wing dams is presented in Section 5.4.2. of Volume 1.

Wing dams are frequently concentrated in an area to form dike fields. The structures induce sediment deposition within the dike field that can result in the transition of aquatic to terrestrial habitat between the wing dams (see Figure 5-47, Volume 1). Another impact on habitat quality is the development of eddy flows behind the wing dams that can trap and retain organic matter. The dike fields provide low-flow refugia from high current velocities in the main channel and provide overwintering habitat for some fishes. In the Mississippi River below St. Louis, dike fields provide much of the available low current velocity fish habitat because most of the naturally occurring off-channel habitats have been isolated behind levees, closing dams, or filled with sediment.

Newer structures, such as bendway weirs, chevron dikes, and other innovative, environmentally sympathetic designs, have been developed recently and are being studied to assess their effectiveness to maintain navigation and to determine their habitat value. Older structures have also been redesigned, mostly by notching, to increase flow in the dike field and to increase habitat diversity in dike fields.

3.1.4 Effects of Dredging and Material Placement

3.1.4.1 Background - Upper Mississippi River

The Rivers and Harbors Act of 1866 authorized a 4-foot navigation channel project on the UMR. Clearing, snagging, and dredging by scraping down sand bars was performed along with a survey of the river. Dredging by scraping was found to be inefficient, and starting in the 1870's, steam-powered dipper dredges were used. The Rivers and Harbors Act of 1878 authorized a 4.5-foot-deep channel from the mouth of the Missouri River to St. Paul. This was accomplished primarily through construction of headwater reservoirs in Minnesota to augment summer low flows, and through construction of wing dams and closing dams on secondary channels, bank revetment, and continued dredging. A 6-foot-deep channel was authorized by the Rivers and Harbors Act of 1907. The additional channel depth was obtained by constructing more wing dams and additional dredging. The Rivers and Harbors Act of 1930 authorized the construction of UMR navigation dams and continued dredging to maintain the navigation channel. The UMR navigation channel is authorized to be 300 feet wide in straight reaches and 500 feet wide in bends.

3.1.4.2 Background - Illinois Waterway

In 1822, through the Illinois and Michigan Canal Act, Congress authorized the State of Illinois to survey and mark, through public lands, the route of a canal to connect the Illinois River with Lake Michigan. Construction on the Illinois and Michigan Canal began in 1836 and was completed in 1848, connecting Lake Michigan at Chicago with the Illinois River at La Salle. The State of Illinois built two locks and dams at Henry and Copperas Creek in 1871. The Federal Government built locks at Kampsville and La Grange. This completed a 7-foot channel from La Salle to the mouth. The locks were approximately 75 feet by 350 feet.

In 1900, the upper end of the Illinois and Michigan Canal as far south as Lockport was replaced by the Chicago Sanitary and Ship Canal. This replacement was constructed primarily to remove waste effluent and storm drainage from the Chicago metropolitan area, but also provided sufficient depth for navigation. In 1908, the State of Illinois approved canalization of the Des Plaines and Illinois Rivers from Lockport to Utica. Construction did not begin until 1921. In 1922, the Metropolitan Sanitary District of Greater Chicago completed construction of the Calumet-Sag Channel to prevent pollution of Lake Michigan by reversing the flow of the Calumet River. This channel also connected the heavily industrialized area surrounding the Calumet River with the Waterway and was used for navigation.

Under the provisions of the 1930 Rivers and Harbors Act, the State of Illinois transferred to the United States, its partially completed project on the Illinois and Des Plaines Rivers between Utica and Lockport. Under the provisions of the 1935 Rivers and Harbors Act, the 1930 Act was modified to include improvement of the Calumet-Sag Channel and to provide for three locks and dams. The authorized locks and dams were Peoria and La Grange on the IWW and Alton (original Lock and Dam 26) on the Mississippi River.

The IWW today includes the following segments: the Illinois River from its mouth at Grafton, Illinois, to the confluence of the Kankakee and Des Plaines Rivers, a distance of 286 miles; the Des Plaines River to Lockport Lock, a distance of 16 miles; the Chicago Sanitary and Ship Canal to Calumet-Sag Junction, a distance of 12 miles; and the Calumet-Sag Navigation Project, which provides a connection to the deep-draft project at Lake Calumet and upper limit of Calumet Harbor via the Calumet-Sag Channel, the Little Calumet River, and the Calumet River, a total distance of 24 miles. An alternate route to Lake Michigan is provided from the Calumet-Sag junction to the Chicago harbor via the Chicago Sanitary and Ship Canal and the Chicago River, a distance of 22 miles.

The authorized project dimension of the existing channel between Grafton and Lockport, Illinois, is 300 feet, with additional widths at bends, except in the Marseilles Canal where it is 200 feet. The authorized project dimension of the Chicago Sanitary and Ship Canal is 160 feet, and the authorized project dimension of the Calumet-Sag Channel is 225 feet.

3.1.4.3 Dredging on the Upper Mississippi River

Material dredged from the navigation channel was formerly deposited in the channel border areas and between wing dams. Over the years, many natural river levee islands were raised with dredged material; dredged material was also deposited in channel border areas forming new islands and placed between wing dams to further constrict the navigation channel. Many of the present islands along the main channel border of the UMR are dredged material deposits. In the St. Paul and Rock Island District reaches of the UMR, much of the dredged material was placed back into the main channel or channel border areas. In the St. Louis District reach of the UMR, nearly all of the dredged material was placed back into the main channel, but some was placed along the river banks.

In the 1970's, the Great River Environmental Action Teams (GREAT I and II) conducted interagency studies and developed detailed recommendations for channel maintenance dredging. Implementation of the GREAT dredging recommendations resulted in reduced frequency and volume of dredging in the St. Paul and Rock Island Districts reaches of the UMR. GREAT dredging recommendations also included use of dredged material containment sites to limit the "footprint" of dredged material deposits and encouraged transport of dredged material out of the floodplain for beneficial uses.

3.1.4.4 Dredging on the Illinois Waterway

The Rock Island District annually dredges sediment from the Illinois River navigation channel. Dredging is generally required at 5 to 15 sites per year, with an average annual volume of approximately 350,000 cubic yards. Due to the large sediment load carried by the waterway and continually changing flows, dredging locations and quantities vary from year to year. On the Illinois River, dredged material is placed in the channel border areas and along the river banks. This practice is changing to placement of dredged material behind levees and onto agricultural fields in the floodplain.

3.1.4.5 Analysis of Dredging Records

Channel improvements for the Upper Mississippi 4-Foot Channel Project in the 1860's included blasting a channel in the Rock Island Rapids and some beam scraping of sand bars. The Corps of Engineers acquired two boats in 1868, the Montana and the Caffrey, and outfitted them for dredging and snag removal. Dredging on the Upper Mississippi River has continued since then. Records of the timing, locations, and volumes of early dredging on the Upper Mississippi and Illinois Rivers no longer exist. Most of the older dredged material deposits above water level have become vegetated and now are generally indistinguishable from surrounding island and floodplain areas.

Records of dredging and material placement have been maintained in the Rock Island District since 1940, and available St. Paul District dredging records date back to 1956. St. Louis District dredging records date back to 1963 (Appendix U).

GIS databases of main channel dredging locations (dredge cuts) and dredged material placement sites were developed from the available dredging records (see Figure 5-24, Volume 1). The dredge cuts and the placement sites were delineated, to the extent possible, from hard copy dredging records and maps. The "footprints" of the dredge cuts are fairly accurate because dredge cut layout drawings for the dredging jobs still exist. The areal extent of the dredged material deposits are indicated in the GIS database by rectangles and only generally delimit the actual placement sites. Multiple placement sites were routinely used for dredging jobs from a single dredge cut within the Rock Island District, while single placement sites per dredge cut have been the norm in the St. Paul District. Dredging data were analyzed to estimate the area, frequencies, and locations of dredging disturbance of the river bed; the volumes of material dredged; and the area, frequencies, and locations of dredged material placement. Two time periods were examined: the period of record prior to 1975 (pre-GREAT era) and from 1975 through 1997.

The dredging GIS database was analyzed along with the LTRMP 1989 land cover database to estimate the areas of different cover types affected by deposition of dredged material, based on adjacent cover types. The LTRMP land cover GIS database also was used to examine the succession of vegetation cover on dredged material deposits over time. The vegetation cover type on dredged material placement sites within each Rock Island District and St. Paul District UMR pool was examined based on the number of years since material was last placed. St. Paul District dredged material placement sites are nearly all designated placement sites which continue to receive dredged material deposits.

3.1.4.6 Dredging Methods

Channel maintenance dredging in the UMRS is accomplished using both hydraulic and mechanical machinery. Hydraulic dredging involves mechanical disturbance of the river bed by a cutterhead and pumping the sediment-water slurry through a pipeline to the placement site (either in the water or on land). Mechanical dredging is conducted using a crane equipped with a clamshell bucket, a backhoe, or a dragline. Mechanically dredged material is placed on barges for off-loading elsewhere.

3.1.4.7 Volume and Type of Material Dredged

Table 3-1, Table 3-2 and Table 3-3 provide summaries of dredging activity on the UMR and Illinois Rivers. River bed sediments dredged for channel maintenance are primarily coarser bed material typical of the UMR main channel. In Pool 4, for example, 37% of the sand fraction of the total average annual sediment inflow to the pool is dredged each year, while only 0.49% of the average annual load of fines (silts and clay - sized sediment) is dredged (U.S. Army Corps of Engineers 1997b). The amount of the average annual sediment load to each UMR navigation pool that is dredged each year declines from a high of about 21% in Pool 4, to about 2% in Pool 11, to considerably less than 1% in the lower UMR navigation pools. The first percentage refers to the estimated 37% of the sand fraction of the total average sediment inflow is dredged each year. The second percentage mentioned, 21%, is the average annual percent of the total sediment load to Pool 4 that is estimated to be dredged. The difference from north to south in the fraction of the sediment load dredged is primarily due to the greatly increased sediment load and size of the river in the southern parts of the UMR. Implementation of GREAT I and II recommendations for channel maintenance has resulted in a decline in dredging since the mid-1970's, in the number of dredge cuts dredged each year, and in the volume of material dredged (see Figures 5-20 and 5-21 in Section 5.4.4, Volume 1).

3.1.4.8 Frequencies and Locations of Dredging

Channel maintenance dredging on the UMR and Illinois Rivers is conducted in main channel areas where sediment accumulates, resulting in shoals. These areas are generally at channel crossings (where the river thalweg crosses from one side to the other), at point bars (where sediment building on the inside of bends extends into the navigation channel), at, and downstream of, large tributary delta areas, and near locations where secondary channels diverge from the main channel. The dredge cuts on the UMR have become named sites, and dredging records provide the frequency of repeated dredging. Table 3-1 summarizes dredge cuts and frequency of dredging in the St. Paul District. Appendix U-1 includes annual frequency of dredging for each dredge cut. Dredge cuts on the UMR with the highest frequency of dredging occur below the confluences with major tributaries, such as the Chippewa, Wisconsin, Turkey, Iowa, Des Moines, and Illinois Rivers. The frequency of dredging at individual cuts ranges from a high of about once per year at Crat's Island below the mouth of the Chippewa River in Pool 4, and over twice per year at Bolter's Island in Pool 26, to very infrequent, less than once in 10 years at many of the historic dredge cuts.

A total of 1,538 acres of UMR main channel habitat within the St. Paul District has been disturbed by channel maintenance dredging the period 1975 through 1996 (Table 3-1). This is approximately 6.2% of the total UMR main channel habitat area in the Pools 4 to 10 river reach (LTRMP classification, main navigation channel + channel border area). Of the dredge cuts within the St. Paul District, 288 acres has been dredged more than four times during the 1975-1996 time period, 115 acres has been dredged four times, 164 acres has been dredged three times, 273 acres has been dredged twice, and the rest, 699 acres, has been dredged only once.

On the Upper Mississippi River within the Rock Island District during the same time period, a total of 1,576 acres of main channel habitat has been disturbed by dredging (Table 3-2). These active dredge cuts cover approximately 2.0% of main channel habitat (LTRMP classification, main navigation channel + channel border area) in Pools 11 through 22. Dredge cuts covering a total of 56 acres have been dredged more than four times, 62 acres has been dredged four times, 117 acres has been dredged three times, 309 acres has been dredged twice, and 1,032 acres has been dredged only once.

The available dredging records for the UMR within the St. Louis District did not allow an analysis of both the dredge cut areas and dredging frequencies.

On the Illinois River during the 1975 through 1996 period, 813 acres of main channel habitat have been disturbed by dredging (Table 3-3). Of the Illinois River dredge cuts, 36 acres have been dredged more than four times, 31 acres have been dredged four times, 66 acres have been dredged three times, 161 acres have been dredged twice, and 519 acres have been dredged only once.

The future frequency and volume of dredging activity on the UMRS is forecasted to remain the same or decline somewhat in the future, assuming no major change in sediment delivery rates from tributaries to the mainstem rivers. Improved capabilities for modeling sediment transport processes will allow more efficient design of channel training structures and main channel dredging activity.

3.1.4.9 Placement of Dredged Material

Available dredging records for 1956-1997 in the St. Paul District reach of the UMR indicate that that dredged material has been placed covering a total of 1,410 acres of aquatic and floodplain habitat. Most of the dredged material has been placed in woody terrestrial areas (547 acres), open water (370 acres), and on sand/mud areas (234 acres). The total area of dredged material deposits covers about 0.5% of total aquatic and floodplain terrestrial habitats (Table 3-4). Over the next 40 years, the St. Paul District plans to place nearly all dredged material at designated placement sites in floodplain terrestrial areas, except where placed at upland sites for beneficial use or used for habitat restoration projects such as island construction.

In the Rock Island District, over the 1940-1997 period of record, dredged material has been placed in 1,918 acres of open water area and 1,153 acres of wooded terrestrial area (Table 3-5). Long-term dredging and material placement plans are presently being developed in the Rock Island District. Future placement of dredged material will be primarily on floodplain terrestrial areas, behind levees, and in agricultural fields, except where used for habitat restoration projects such as island construction.

In the St. Louis District, dredged material has been historically placed in open water within the main channel and channel borders (Table 3-6). This practice will change to placement on and behind levees, and onto agricultural fields in the floodplain.

On the Illinois River, dredging records are incomplete, but nearly all of the dredged material has been placed in main channel border areas (499 acres) and along the river banks (1,009 acres) (Table 3-7). Future placement of dredged material will be primarily on floodplain terrestrial areas, behind levees, and in agricultural fields, except where used for habitat restoration projects such as island construction.

Table 3-1: Dredge cut areal extent and frequency of disturbance within the USACE St. Paul District (Period of Record: 1956-1996).

In Hectares: Number of Times Dredged Between 1975 and 1996

Pool	never, but old cut	once	Twice	three times	four times	more than four times
SAF	2.9	7.4	3.3	2.4	2.5	10.0
1	31.4	12.5	6.4	3.5	1.8	4.4
2	85.7	33.3	13.9	9.4	5.4	10.0
3	76.2	15.9	5.8	4.6	2.5	1.0
4	118.3	54.1	17.7	11.9	8.7	40.6
5	49.3	36.7	15.3	11.0	6.5	17.8
5a	59.3	15.3	6.0	2.5	2.3	4.5
6	46.9	9.4	2.4	0.6	0.1	0.1
7	50.0	37.7	17.2	5.7	5.5	6.9
8	84.3	25.0	9.2	5.4	4.8	10.0
9	75.8	13.1	4.9	3.7	3.5	9.7
10	68.5	22.4	8.2	5.4	3.0	1.7
Total	748.6	282.8	110.4	66.2	46.6	116.7

Total hectares disturbed between 1975 and 1996: 622.6

In Acres: Number of Times Dredged Between 1975 and 1996

Pool	never, but old cut*	once	Twice	three times	four times	more than four times
SAF	7.2	18.3	8.2	5.8	6.3	24.7
1	77.6	30.8	15.8	8.6	4.4	10.8
2	211.8	82.3	34.4	23.3	13.4	24.7
3	188.2	39.4	14.3	11.3	6.1	2.5
4	292.3	133.8	43.8	29.4	21.5	100.4
5	121.8	90.6	37.7	27.2	16.2	44.1
5a	146.5	37.8	14.8	6.2	5.6	11.2
6	115.9	23.1	5.8	1.6	0.4	0.2
7	123.6	93.2	42.6	14.1	13.5	17.0
8	208.3	61.7	22.8	13.4	11.9	24.6
9	187.3	32.3	12.1	9.2	8.7	24.0
10	169.3	55.3	20.3	13.3	7.4	4.3
Total	1,849.7	698.7	272.7	163.5	115.3	288.4

Total acres disturbed between 1975 and 1996: 1,538.5

Table 3-2: Dredge cut areal extent and frequency of disturbance within the USACE Rock Island District (Period of Record: 1940-1996).

In Hectares: Number of Times Dredged Between 1975 and 1996

Pool	never, but old cut*	Once	twice	three times	four times	more than four times
11	141.9	29.7	5.9	1.5	0.4	0.0
12	79.6	17.2	5.5	0.0	0.0	0.0
13	159.1	55.2	8.2	1.9	0.0	0.0
14	134.0	30.3	4.5	1.3	1.6	0.6
15	32.9	4.8	3.9	0.0	0.0	0.0
16	87.1	39.9	14.8	8.5	6.7	5.5
17	81.6	4.1	2.4	1.4	1.8	1.0
18	191.4	59.1	16.7	3.8	3.0	3.2
19	255.4	16.8	8.8	1.9	0.7	0.0
20	194.2	47.1	6.4	4.2	4.5	10.2
21	148.3	64.0	29.0	13.6	1.9	0.0
22	138.8	49.3	19.0	9.4	4.3	2.2
Total	1,644.3	417.6	125.1	47.5	24.9	22.8

Total Hectares Disturbed Between 1975 and 1996: 637.9 hectares

In Acres: Number of Times Dredged Between 1975 and 1996

Pool	never, but old cut*	Once	twice	three times	four times	more than four times
11	350.6	73.5	14.6	3.7	0.9	0.0
12	196.6	42.5	13.5	0.1	0.0	0.0
13	393.0	136.5	20.2	4.7	0.1	0.0
14	331.0	74.9	11.2	3.2	4.0	1.4
15	81.2	11.9	9.6	0.0	0.0	0.0
16	215.3	98.7	36.6	20.9	16.7	13.6
17	201.7	10.0	6.0	3.5	4.4	2.5
18	472.8	145.9	41.3	9.4	7.4	8.0
19	631.2	41.5	21.8	4.6	1.6	0.0
20	480.0	116.3	15.8	10.3	11.2	25.3
21	366.5	158.2	71.5	33.7	4.8	0.0
22	343.1	121.8	46.9	23.3	10.6	5.5
Total	4,063.1	1,031.8	309.2	117.3	61.6	56.3

Total Acreage Disturbed Between 1975 and 1996: 1,576.3 acres

Table 3-3: Dredge cut areal extent and frequency of disturbance within the USACE Rock Island District, Illinois River reach (Period of Record: La Grange and Peoria Pools 1940-1996, rest of IWW 1988-1996).

In Hectares: Number of Times Dredged Between 1975 and 1996

Pool	never, but old cut*	Once	twice	three times	four times	more than four times
LaGrange	379.1	118.0	52.5	18.3	9.4	10.8
Peoria	353.9	53.6	6.7	4.9	1.3	0.5
Starved Rock	0.0	19.7	3.5	1.4	1.1	1.0
Marseilles	0.0	11.0	1.8	2.1	0.7	1.6
Dresden Island	0.0	7.0	0.6	0.1	0.2	0.5
Brandon Road	0.0	0.7	0.0	0.0	0.0	0.3
Total	733.0	210.0	65.0	26.9	12.7	14.6

Total Hectares Disturbed Between 1975 and 1996: 329.2 hectares

In Acres: Number of Times Dredged Between 1975 and 1996

Pool	never, but old cut*	Once	twice	three times	four times	more than four times
LaGrange	936.8	291.5	129.7	45.2	23.1	26.6
Peoria	874.6	132.5	16.5	12.1	3.2	1.2
Starved Rock	0.0	48.7	8.6	3.4	2.7	2.5
Marseilles	0.0	27.1	4.4	5.3	1.9	3.9
Dresden Island	0.0	17.4	1.4	0.3	0.6	1.2
Brandon Road	0.0	1.7	0.0	0.0	0.0	0.8
Total	1,811.3	518.9	160.6	66.4	31.4	36.2

Total Acreage Disturbed Between 1975 and 1996: 813.5 acres

Table 3-4: Summary of the areal extent of USACE St. Paul District material placement on land cover types identified in the 1989 LTRMP GIS coverage.

Acres

Land Cover Types	Total in Placement Sites All Pools	Total Area by Land Cover Type - All Pools	Percent Affected by Material Placement
Agriculture	0	15,633	0.00%
Emergents	12	22,911	0.05%
Emergents-Grasses/Forbs	2	3,813	0.05%
Grasses/Forbs	49	17,764	0.27%
No Coverage	20	32	61.42%
Open Water	370	96,632	0.38%
Rooted Floating Aqua-Emergents	0	888	0.00%
Rooted Floating Aquatics	0	2,133	0.02%
Sand/Mud	234	689	33.96%
Submergents	30	17,340	0.17%
Submerg-Rooted Floating Aqua	6	17,837	0.03%
Submerg-Rooted Floating-Emerg	0	2,000	0.00%
Urban/Developed	141	18,494	0.76%
Woody Terrestrial	547	65,162	0.84%
Total	1,410	281,329	0.50%

Hectares

Land Cover Types	Total in Placement Sites All Pools	Total Area by Land Cover Type - All Pools	Percent Affected by Material Placement
Agriculture	0	6,329	0.00%
Emergents	5	9,276	0.05%
Emergents-Grasses/Forbs	1	1,544	0.05%
Grasses/Forbs	20	7,192	0.27%
No Coverage	8	13	61.42%
Open Water	150	39,122	0.38%
Rooted Floating Aqua-Emergents	0	360	0.00%
Rooted Floating Aquatics	0	864	0.02%
Sand/Mud	95	279	33.96%
Submergents	12	7,020	0.17%
Submerg-Rooted Floating Aqua	2	7,222	0.03%
Submerg-Rooted Floating-Emerg	0	810	0.00%
Urban/Developed	57	7,488	0.76%
Woody Terrestrial	222	26,381	0.84%
Total	571	113,899	0.50%

Table 3-5: Summary of the areal extent of USACE Rock Island District Mississippi River material placement on land cover types identified in the 1989 LTRMP GIS coverage.

Acres

Land Cover Types	Total in Placement Sites All Pools	Total Area by Land Cover Type - All Pools	Percent Affected by Material Placement
Agriculture	36	342,704	0.01%
Emergents	13	8,725	0.15%
Emergents-Grasses/Forbs	6	3,022	0.20%
Grasses/Forbs	158	37,735	0.42%
No Coverage	35	17,514	0.20%
Open Water	1,918	127,412	1.51%
Rooted Floating Aqua-Emergents	0	317	0.00%
Rooted Floating Aquatics	0	5,634	0.01%
Sand/Mud	160	966	16.57%
Submergents	45	15,547	0.29%
Submerg-Rooted Floating Aqua	5	6,445	0.07%
Submerg-Rooted Floating-Emerg	0	353	0.00%
Urban/Developed	172	37,851	0.45%
Woody Terrestrial	1,153	118,322	0.97%
Total	3,700	722,547	0.51%

Hectares

Land Cover Types	Total in Placement Sites All Pools	Total Area by Land Cover Type - All Pools	Percent Affected by Material Placement
Agriculture	15	138,747	0.01%
Emergents	5	3,532	0.15%
Emergents-Grasses/Forbs	2	1,223	0.20%
Grasses/Forbs	64	15,277	0.42%
No Coverage	14	7,091	0.20%
Open Water	776	51,584	1.51%
Rooted Floating Aqua-Emergents	0	128	0.00%
Rooted Floating Aquatics	0	2,281	0.01%
Sand/Mud	65	391	16.57%
Submergents	18	6,294	0.29%
Submerg-Rooted Floating Aqua	2	2,609	0.07%
Submerg-Rooted Floating-Emerg	0	143	0.00%
Urban/Developed	70	15,324	0.45%
Woody Terrestrial	467	47,904	0.97%
Total	1,498	292,529	0.51%

Table 3-6: Summary of the areal extent of USACE St. Louis District material placement on land cover types identified in the 1989 LTRMP GIS coverage.

Acres

Land Cover Types	Total in Placement Sites All Pools	Total Area by Land Cover Type - All Pools	Percent Affected by Material Placement
Agriculture	0	248,616	0.00%
Emergents	0	3,050	0.00%
Emergents-Grasses/Forbs	0	453	0.00%
Grasses/Forbs	57	19,088	0.30%
No Coverage	0	19,178	0.00%
Open Water	1,297	59,658	2.17%
Rooted Floating Aqua-Emergents	0	136	0.00%
Rooted Floating Aquatics	0	891	0.00%
Sand/Mud	58	1,321	4.37%
Submergents	6	2,883	0.19%
Submerg-Rooted Floating Aqua	0	301	0.00%
Submerg-Rooted Floating-Emerg	0	10	0.00%
Urban/Developed	7	7,518	0.09%
Woody Terrestrial	97	81,052	0.12%
Total	1,522	444,154	0.34%

Hectares

Land Cover Types	Total in Placement Sites All Pools	Total Area by Land Cover Type - All Pools	Percent Affected by Material Placement
Agriculture	0	100,654	0.00%
Emergents	0	1,235	0.00%
Emergents-Grasses/Forbs	0	183	0.00%
Grasses/Forbs	23	7,728	0.30%
No Coverage	0	7,764	0.00%
Open Water	525	24,153	2.17%
Rooted Floating Aqua-Emergents	0	55	0.00%
Rooted Floating Aquatics	0	361	0.00%
Sand/Mud	23	535	4.37%
Submergents	2	1,167	0.19%
Submerg-Rooted Floating Aqua	0	122	0.00%
Submerg-Rooted Floating-Emerg	0	4	0.00%
Urban/Developed	3	3,044	0.09%
Woody Terrestrial	39	32,815	0.12%
Total	616	179,819	0.34%

Table 3-7: Summary of the areal extent of USACE Rock Island District, Illinois River (La Grange and Peoria Pools) material placement on land cover types identified in the 1989 LTRMP GIS coverage.

Acres

Land Cover Types	Total in Placement Sites All Pools	Total Area by Land Cover Type - All Pools	Percent Affected by Material Placement
Agriculture	28	115,654	0.02%
Emergents	4	973	0.44%
Emergents-Grasses/Forbs	0	170	0.00%
Grasses/Forbs	199	23,879	0.84%
No Coverage	11	13,415	0.08%
Open Water	499	61,319	0.81%
Rooted Floating Aqua-Emergents	0	9	0.00%
Rooted Floating Aquatics	0	273	0.00%
Sand/Mud	68	2,206	3.07%
Submergents	1	1,431	0.05%
Submerg-Rooted Floating Aqua	0	241	0.00%
Submerg-Rooted Floating-Emerg	0	0	0.00%
Urban/Developed	80	9,991	0.80%
Woody Terrestrial	1,009	65,375	1.54%
Total	1,899	294,936	0.64%

Hectares

Land Cover Types	Total in Placement Sites All Pools	Total Area by Land Cover Type - All Pools	Percent Affected by Material Placement
Agriculture	12	46,823	0.02%
Emergents	2	394	0.44%
Emergents-Grasses/Forbs	0	69	0.00%
Grasses/Forbs	81	9,668	0.84%
No Coverage	4	5,431	0.08%
Open Water	202	24,826	0.81%
Rooted Floating Aqua-Emergents	0	4	0.00%
Rooted Floating Aquatics	0	110	0.00%
Sand/Mud	27	893	3.07%
Submergents	0	579	0.05%
Submerg-Rooted Floating Aqua	0	97	0.00%
Submerg-Rooted Floating-Emerg	0	0	0.00%
Urban/Developed	32	4,045	0.80%
Woody Terrestrial	408	26,468	1.54%
Total	769	119,407	0.64%

3.1.4.10 Impacts of Dredging and Material Placement

Dredging disturbs main channel habitat, killing the resident benthic macroinvertebrates and temporarily leveling the dune and swale bed forms. Channel bed forms re-form rapidly. Benthic macroinvertebrates rapidly recolonize disturbed river bed areas from the continuous downstream macroinvertebrate drift, but may take at least one growing season to recolonize to pre-disturbance densities. Unionid mussels recolonize dredge cuts much more slowly and may take many years to re-establish full diversity and abundance following disturbance. Impacts of initial channel modifications in the 19^{th} century were likely extreme, but no records exist to quantify the impact. Most main channel dredge cut areas have unstable sand substrate, support few mussels, and support few species of other macroinvertebrates.

Dredging results in temporary and localized increased suspended solids concentration downstream. Suspended solids plumes emanating from the cutterhead of hydraulic dredges and from mechanical dredging operations in the UMR are generally undetectable within about one-half mile downstream, with suspended solids concentrations rapidly returning to ambient concentrations. Hydraulic dredging operations have placement sites where the dredged sediment is deposited and pumped water returns to the river. Suspended solids plumes from hydraulic dredging pumped water returning to the river from placement sites can extend up to about one mile downriver before returning to ambient concentrations. Mechanical dredging results in less sediment resuspension than does hydraulic dredging. Dredging is a localized and intermittent activity that does not add significantly to ambient suspended solids concentrations in the rivers.

Dredging does disturb bottom sediments and associated contaminants. Main channel dredge cut sediment is periodically sampled for analysis to determine bulk chemical concentrations of contaminants for use in assessing the water quality effects of dredging. A long-term database of sediment physical properties and bulk chemical contaminant concentrations has been developed for the St. Paul and Rock Island Districts reaches of the UMR. Contaminants (heavy metals, organic compounds) are primarily adsorbed to finer silt and clay sized particles. Most in-place pollutants are found in the lower velocity areas in the river where fine-grained sediment accumulates. Contaminant concentrations (metals, PCBs) are highest from Minneapolis and St. Paul down through Lake Pepin and in the La Crosse, Quad Cities, and St. Louis areas. Over 90% of the material dredged from main channel dredge cuts on the UMR is sand-sized material or larger, carrying very small concentrations of contaminants. Exceptions include the Minnesota River, lower Pool 2, and the upper end of Lake Pepin, where dredged material contains higher fractions of fine-grained sediment and associated contaminants. No analysis of the effects of dredging on the mass balance of contaminant mobilization and transport in the UMR has been conducted, although the low fraction of fine materials dredged compared to the total sediment transport indicates that channel maintenance dredging mobilizes an insignificant fraction of the sediment contaminants in the UMR.

On the Illinois River, much finer and more contaminated material is dredged than from the UMR. In addition to heavy metals and synthetic organic compounds emanating from the Chicago area, organic materials and pesticides from the intensive agricultural activity contribute to sediment contamination. In the Illinois River, in harbors, and in the Minnesota River, dredging can mobilize reduced interstitial water from anoxic sediment, resulting in dissolved oxygen depletion. Release of unionized ammonia from the sediments during dredging can produce toxic effects on aquatic life. The fraction of sediment contaminants mobilized by dredging on the Illinois River is probably small compared to total sediment transport and associated mobilization of contaminants.

3.1.4.11 Pattern of Habitat Types Resulting From Placement of Dredged Material

Placement of dredged material in main channel and channel border aquatic habitat areas covers the existing flora and fauna, substrate, woody debris, and bed forms. River bed forms re-establish over a few days, and although the water depth may remain less for some time, placement of dredged material does not change the general habitat type. Recolonization of benthic macroinvertebrates in open water dredged material placement sites is currently under investigation in the Rock Island District.

Placement of dredged material in shallow aquatic, wetland, and floodplain terrestrial areas changes habitat conditions at all but routinely used dredged material placement sites. Existing substrates, vegetation cover, and associated organisms are buried with washed sand. The resulting sand deposits on floodplain terrestrial sites are generally hot, dry, and hostile to recolonization by plants. Dredged material deposits are slow to recolonize except at locations where finer dredged material is placed over the sand and at sites where soil amendments are added and vegetation is planted. The rate of recolonization of dredged material placement sites is influenced by the thickness of the dredged material deposit, the grain size distribution of the material, the height above the water surface, the degree of shading, protection from wind, vegetative encroachment, and organic matter provided from adjoining areas.

The succession of vegetation on dredged material deposits was examined by analyzing the frequency distribution of vegetation cover types on dredged material deposits over 5-year periods since the last material placement. This analysis was performed for each Rock Island District navigation pool where dredged material has been historically placed on floodplain terrestrial areas.

Overall, available records indicate that dredged material has been placed on approximately 8,531 acres of UMRS aquatic and floodplain habitat. This area is approximately 0.9% of the non-agricultural and non-urban UMRS aquatic and floodplain area (Table 3-1). The total area where dredged material has been historically placed could be more than double the area that the available recent records indicate, given that dredging has been conducted since the late 1860's and much of the area between wing dams was filled with dredged material.

Future placement of dredged material will be concentrated in confined placement sites in floodplain terrestrial areas in the St. Paul District. Most future placement sites within the Rock Island District will be in non-wetland areas, predominantly on leveed or unleveed agricultural fields, and along the inside of levee slopes and right-of-ways. More channel maintenance dredged material will be used in habitat restoration projects, such as island construction in the lower parts of navigation pools. The area “footprint” of dredged material placement sites in the Rock Island and St. Paul Districts will continue to decrease as various planning documents such as Dredged Material Management Plans, Channel Maintenance Management Plans (e.g., U.S. Army Corps of Engineers 1997b), and Pool Plans are implemented. Existing sand and mud dredged material deposits no longer receiving dredged material will become vegetated, either through planting or natural succession.

Table 3-8: Systemic summary of the areal extent of USACE material placement on land cover types identified in the 1989 LTRMP GIS coverage.

Acres

Land Cover Types	Total in Placement Sites All Pools	Total Area by Land Cover Type - All Pools	Percent Affected by Material Placement
Agriculture	64	722,607	0.01%
Emergents	28	35,659	0.08%
Emergents-Grasses/Forbs	8	7,458	0.10%
Grasses/Forbs	464	98,467	0.47%
No Coverage	65	50,138	0.13%
Open Water	4,083	345,020	1.18%
Rooted Floating Aqua-Emergents	0	1,350	0.00%
Rooted Floating Aquatics	1	8,931	0.01%
Sand/Mud	519	5,183	10.02%
Submergents	81	37,201	0.22%
Submerg-Rooted Floating Aqua	11	24,823	0.04%
Submerg-Rooted Floating-Emerg	0	2,364	0.00%
Urban/Developed	400	73,855	0.54%
Woody Terrestrial	2,807	329,911	0.85%
Total	8,531	1,742,966	0.49%

Hectares

Land Cover Types	Total in Placement Sites All Pools	Total Area by Land Cover Type - All Pools	Percent Affected by Material Placement
Agriculture	26	292,553	0.01%
Emergents	12	14,437	0.08%
Emergents-Grasses/Forbs	3	3,019	0.10%
Grasses/Forbs	188	39,865	0.47%
No Coverage	26	20,299	0.13%
Open Water	1,653	139,684	1.18%
Rooted Floating Aqua-Emergents	0	547	0.00%
Rooted Floating Aquatics	0	3,616	0.01%
Sand/Mud	210	2,098	10.02%
Submergents	33	15,061	0.22%
Submerg-Rooted Floating Aqua	4	10,050	0.04%
Submerg-Rooted Floating-Emerg	0	957	0.00%
Urban/Developed	162	29,901	0.54%
Woody Terrestrial	1,136	133,567	0.85%
Total	3,454	705,654	0.49%

3.1.5 Effects of Environmental Management Program Habitat Projects

Habitat protection and restoration projects [Habitat Rehabilitation and Enhancement Projects (HREPs)] are being planned and constructed as part of the Upper Mississippi River System-Environmental Management Program (UMRS-EMP). Twenty-four habitat projects were constructed as of early 1998 (at the time of the EMP Report to Congress) (Figure 3-1). There are presently 28 projects completed, and 12 are under construction. About 13 projects are in various stages of planning, and design. Chapter 4 of the EMP Report to Congress (U.S. Army Corps of Engineers 1997a) provides a detailed description of the HREP program. The EMP Report to Congress is available via the Internet through the Rock Island District home page at: http://www.mvr.usace.army.mil/pdw/emp/rtc_home.htm. Fact sheets and detailed information about individual habitat projects are available via the Internet at: http://www.emtc.nbs.gov/.

The 24 projects implemented as of early 1998 affect approximately 28,000 acres of aquatic and floodplain habitat. The 26 projects presently under construction and in general design will increase the total affected area to about 97,000 acres, approximately 11% of the total UMRS floodplain and aquatic habitat area, not counting agricultural and urban areas. The HREP projects incorporate a variety of habitat protection and restoration features.

Each HREP project has a set of objectives for future habitat conditions. HREP project areas are monitored to determine the physical changes (water depth, substrate type, current velocity, hydrologic regime, etc.) and vegetation response to determine if habitat objectives are met. Selected HREP project areas (Finger Lakes, Lake Onalaska, Pool 8 Islands, Brown's Lake, Chautauqua Lake, Peoria Lake, Swan Lake, Pharr's Island) have been monitored to determine biological responses of HREP projects and causal effects. Nearly all the projects constructed to date have produced the desired physical changes in habitat conditions. Biological responses to HREP projects are specific to each project, and only a select number of projects have been monitored to determine population-level response. An analysis of land cover and aquatic areas changes induced by the HREP projects has not yet been conducted.

3.1.5.1 Types of Projects

HREP projects constructed to date have included dredging of shallow backwater areas, water level management, construction of islands, shoreline stabilization, secondary channel modifications, and hydrologic modification to improve water quality (Table 3-1). In addition to these categories, there have been a variety of other habitat protection, restoration, and management features applied, such as planting of prairie grasses, planting oaks and hickories, construction of potholes, rock riffles, rock groins, and sediment control on local watersheds.

3.1.5.2 Spatial Distribution of Projects

As of early 1998, thirty-three HREP projects have been constructed on the UMR, one project on the Minnesota River, and four have been built on the Illinois River (Figure 3-1).

3.1.5.3 Future Habitat Projects

The present authorization for the UMRS-EMP extends through the year 2002. Efforts are underway to reauthorize and extend the duration of the EMP. A Habitat Needs Assessment is being developed to provide a "blueprint" for the desired future condition of UMRS habitats. The Habitat Needs Assessment will provide an improved scientific basis for selection of future HREP projects.

Table 3-9: Habitat Rehabilitation and Enhancement Project (HREP) design components and associated HREPs

Backwater Dredging	Andalusia Refuge, Bertom and McCartney Lakes, Big Timber, Brown's Lake, Bussey Lake, Calhoun Point, Cold Springs, Dresser Island, Indian Slough, Island 42, Lake Onalaska, Monkey Chute, Peterson Lake, Pool 8 Islands, Potters Marsh, Rice Lake, Spring Lake Peninsula, Stump Lake, Swan Lake, Trempealeau National Wildlife Refuge
Water Level Management (Dikes and Water Control Systems)	Andalusia Refuge, Banner Marsh, Batchtown, Bay Island, Bussey Lake, Brown's Lake (dike only), Calhoun Point, Clarksville, Quiver Island, Dresser Island, Guttenberg Ponds, Lake Chautauqua, Peoria Lake, Princeton, Rice Lake, Spring Lake, Stump Lake, Swan Lake, Trempealeau National Wildlife Refuge
Islands	Andalusia Refuge, Bertom and McCartney Lakes, Bussey Lake, Lake Onalaska, Peoria Lake, Polander Lake, Pool 8, Pool 9, Swan Lake
Shoreline Stabilization	Bertom and McCartney Lakes, East Channel, Lake Onalaska Islands, Peterson Lake, Polander Lake, Pool 8 Islands, Rice Lake, Spring Lake Peninsula, Trempealeau
Secondary Channel Modifications	Bertom and McCartney Lakes, Blackhawk Park, Quiver Island, Indian Slough, Island 42, Lansing Big Lake, Peterson Lake, Peoria Lake, Polander Lake, Spring Lake Peninsula
Aeration	Andalusia Refuge, Blackhawk Park, Brown's Lake, Cold Springs, Finger Lakes, Island 42, Lake Onalaska, Spring Lake
Other	Banner Marsh (littoral zone grading, warm season grasses), Batchtown (upland sediment control), Bay Island (mast trees), Bertom and McCartney Lakes (mussel bed), Big Timber (mast trees, potholes), Brown's Lake (mast trees), Cottonwood timber sale, mast trees, notch wing dams, potholes), Quiver Island (mast trees, rock hard points), Indian Slough (rock riffle, tree groins, oak savanna), Island 42 (willow and grass planting), Peoria Lake (herbaceous vegetation), Pharrs Island (bullnose dike), Pool 8 (willow and grass planting), Potters Marsh (prairie grass, potholes), Princeton (mast trees), Rice Lake (woody vegetation), Small Scale Drawdown (drawdown), Swan Lake (upland sediment control)

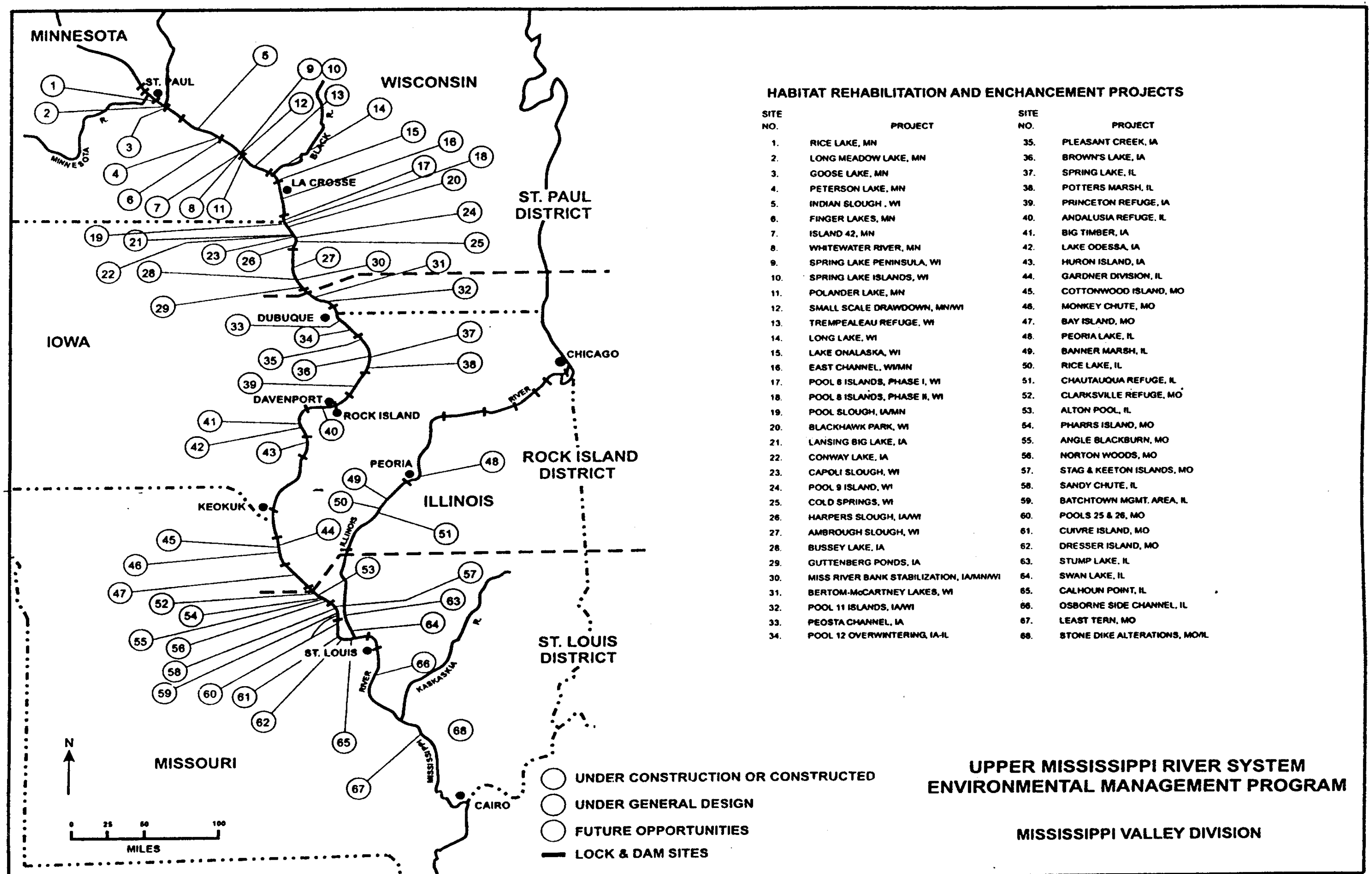


Figure 3-5: Environmental Management Program, Habitat Rehabilitation and Enhancement Project distribution.

3.1.6 Connectivity of UMRS Habitats

Aquatic habitat connectivity (connection by surface water of sufficient depth to allow movement of materials and organisms) is important for the movement of water, dissolved oxygen, sediment, plant nutrients, organic matter, and river organisms (Knowlton and Jones 1997). Lateral connectivity of aquatic habitats in floodplain rivers is dynamic, and greatly affected by river discharge. Much of the floodplain of the UMR is seasonally flooded, greatly increasing the amount of aquatic habitat available to fish and other riverine life. Many plant and animal species are adapted to, and require, the seasonal changes in extent of aquatic habitat and the variety of habitats that become available with changing water levels.

Impoundment of the UMRS navigation system increased lateral connectivity by continuously flooding low-lying portions of the floodplain, which were formerly only seasonally inundated. This increased the total area of continuously flooded aquatic habitat, but may have reduced productivity through lower nutrient and organic matter cycling and lower production of moist soil and perennial aquatic plants, which require dewatered mudflat conditions for seed germination.

The navigation dams decreased longitudinal habitat connectivity for migratory fishes by impeding movements along the main channels within the river system (see discussion below).

Many of the secondary and tertiary channels within the floodplain of the UMRS have filled with sediment since impoundment. The reduced gradient of the impounded river has resulted in reduced velocities and sediment transport competence of the smaller channels; in addition, the system of channel training structures has reduced flow into secondary channels. This process has reduced connectivity of small channel and shallow backwater habitats over time since impoundment. This effect has been most pronounced in the Open River of the UMR, which has lost all but 25 secondary channels (see Chapter 7, Volume 1). However, in some reaches, such as geomorphic reach 3, the actual quantity of flow that enters backwaters from the main channel has increased since impoundment as the secondary channels have enlarged and closing structures have become submerged due to impoundment.

Regulation of the UMR headwaters and tributary rivers has reduced connectivity of habitats in the mainstem river floodplains during flood periods by attenuating peak flood discharge through storage of spring runoff in reservoirs. Regulation of tributary rivers has slightly increased connectivity of UMR aquatic habitats during low-flow periods through low-flow augmentation. Connectivity of Illinois River aquatic habitat was increased by the increased flow from the diversion of water from Lake Michigan.

Thousands of miles of stream and river channels in the UMRS Basin have been channelized, primarily for agricultural drainage and urban flood control. Stream channelization has resulted in losses of extensive wetland areas and has greatly reduced connectivity between the stream drainage network and associated floodplains, floodplain water bodies, and wetlands. In addition, many streams and rivers have been channelized in northern and central Illinois, central and northern Iowa, southern and central Wisconsin, and central Minnesota.

Channelization of the lower reaches of UMRS tributaries for agricultural land drainage and flood damage reduction has reduced connectivity of aquatic habitat in tributary floodplains and delta areas at their confluences with the Mississippi and Illinois Rivers. The lower reaches of the Zumbro, Whitewater, and Upper Iowa Rivers in Minnesota, the Turkey and Makoqueta Rivers in Iowa, and much of the Sangamon River in Illinois have been channelized, greatly reducing access from the mainstem rivers to tributary floodplains, tributary floodplain lakes, and delta distributary channel habitats.

Levees isolate floodplain areas from the river, eliminating connectivity between floodplain habitats and the main river channels, and allow conversion of natural floodplain habitats to other land uses. Many of the agricultural and urban flood protection levees on the UMRS were constructed prior to impoundment of the navigation system. The locations of levee and drainage districts on UMRS floodplains are presented in Appendix C (Scientific Assessment and Strategy Team 1995). Although little of the floodplain has been sequestered from the river by levees in Pools 4 through 14, over half of the floodplain area of the UMR from the Quad Cities to Cairo and the Illinois River floodplain is isolated from the river by levees (Delaney and Craig 1997). The total areas of contiguous (at least during flood periods) floodplain and the area of floodplain isolated by levees within the UMRS navigation pools and river reaches have not yet been calculated. Railroad and highway embankments also serve as levees and restrict connectivity of habitats. A number of floodplain areas on the UMRS have been sequestered with low levees for wildlife habitat management purposes.

Impoundments for waterfowl management, or moist soil units, typically sequester portions of contiguous and impounded backwaters behind low (3 to 6 feet) levees. Most are overtopped during typical spring floods and many have water level manipulation capabilities through the use of gravity drains and/or pumps. Drains and/or pumps are used to lower water levels that emulate pre-impoundment, low-flow water surface elevations. The technique allows managers greater control to prevent small hydrologic variations that can limit emergent aquatic plant production. Public and private management areas with water control capabilities affect about 10% on the non-leveed Illinois River Floodplain and about 7% of the non-leveed Mississippi River between Pool 12 and Pool 26 (Havera *et al.* 1995).

Moist soil management areas provide needed food for migratory birds that is no longer available from natural wetlands. The moist soil areas support many other wetland species, including threatened and endangered species, in addition to the target waterfowl species. Moist soil management units sequester areas of river floodplain, preventing access by fish, or trap adult and young-of-year fish that are produced within the units. Pumped releases from moist soil units can entrain and kill young-of-year fish, and may discharge water with low dissolved oxygen to the rivers. Some moist soil management units can provide suitable spawning habitat for a number of lentic fishes, resulting in high production of young-of-year fish, but the potential for managing these areas for river fisheries as well as for waterfowl has not yet been adequately assessed.

3.1.6.1 Fish Passage Through Navigation Dams

An important attribute of aquatic habitat for river fishes is connectivity—the continuous nature of main channels, secondary channels, floodplain water bodies, and tributaries. Fish in rivers have evolved migratory patterns to make use of the seasonal availability of a variety of habitats. Dams reduce the connectivity of aquatic habitat by restricting movements of river fishes, in addition to other effects of impoundment and river regulation.

At least 25 fish species are migratory in the UMR (Wilcox *et al.*, in press). These include silver lamprey, lake sturgeon, shovelnose sturgeon, paddlefish, goldeye, mooneye, American eel, Alabama shad, skipjack herring, bigmouth buffalo, smallmouth buffalo, blue sucker, white sucker, spotted sucker, blue catfish, channel catfish, flathead catfish, northern pike, white bass, yellow bass, largemouth bass, smallmouth bass, walleye, sauger, and freshwater drum (Scientific names listed in Appendix O). Most of these species can be considered potadromous, with annual movements of populations within the river system (e.g., Meyers 1949, Harden-Jones 1968). Daget (1960) recognized both longitudinal (within the main channel) and lateral (main channel to the floodplain) migration, and Welcomme (1979) mentioned that these categories of fish migration are applicable to floodplain rivers worldwide. Some of the UMR migratory fishes, including lake sturgeon, paddlefish, American eel, Alabama shad, skipjack herring, blue sucker, blue catfish, northern pike, white bass, walleye, and sauger, were formerly long-distance longitudinal migrants within the UMR.

Most of the navigation dams on the UMR allow some upriver fish passage due to their unique design and operating characteristics. With gates that extend to sills on the river bed, most of the UMR dams were designed to maintain minimum water levels to allow navigation during periods of low to moderate flow. The dams were designed to allow river flow to pass unrestricted with gates raised entirely from the water during periods of high river discharge. Estimates of velocities in the dam gate openings made using a physical hydraulic model indicate that velocities are sufficiently low for upriver passage by most UMR migratory fish species (under 3 ft./sec) during uncontrolled discharge conditions. Open channel hydraulic conditions through the dam gate openings occur during periods of higher river discharge. Velocities through the gate bay openings are higher during periods of lower river discharge under controlled conditions when the dam gates are in the water, and upriver fish passage during periods of low river discharge is unlikely. The lowest velocities occur when river discharge reaches controlled discharge capacity at the dam and the gates are first raised from the water.

Lock and Dam 19 at Keokuk, Iowa, is a high dam built in 1913 for hydropower. Lock and Dam 19 has gone to open river conditions (gates out of the water) only once since it was constructed, during the extreme flood of 1993. Lock and Dam 1 in Minneapolis is also a high dam. These two dams are complete barriers to upriver fish movements. Lock and Dam 1 is 8 km downriver from St. Anthony Falls, which is a natural barrier to upriver fish movements. Lock and Dam 19, however, denies fish access to 482 miles of mainstem UMR and numerous tributaries. Lock and Dam 19 also serves to block upriver movements of exotic fish species (see discussion of exotic and nuisance species below).

Locks and Dams 3, 5a, 9, 10, 12, 16, 17, 20, 21, 22, 24, 25, and 26 go to uncontrolled conditions early in the discharge hydrograph and may provide opportunity for upriver fish passage during most years. Locks and Dams 2, 5, 7, 11, 14, and 15 have high controlled discharge capacity for their sites, have low probability for uncontrolled conditions, and present barriers to upriver fish passage during most years.

A limited number of the 25 migratory fish species in the UMR with the highest swimming speeds appear to have the best opportunity for upstream passage through most UMRS dams during most years, based on their swimming performance, timing of upriver movements, and hydraulic conditions at the dams. Lake sturgeon, shovelnose sturgeon, paddlefish, white bass, yellow bass, and possibly skipjack herring are strong swimmers and tend to migrate high in the water column (skipjack herring are restricted to the UMR below Lock and Dam 19). The other migratory species appear to be able to pass upriver through UMRS dams only during periods when hydraulic conditions at the navigation dams are most favorable, when open river conditions at the dams coincide with periods of upriver fish migration, or not at all. Some fish species, such as northern pike, probably do not have the swimming performance to swim upriver through UMR navigation dams. Other species that migrate during periods of lower river discharge, such as white sucker, walleye, and freshwater drum, have limited opportunity for upriver fish passage due to timing of their migrations. Depending on the controlled discharge capacity of the navigation dams and the timing of fish migrations, the window of opportunity for upriver passage varies markedly between dams and fish species. The presence of multiple dams reduces the cumulative probability of successful upriver migration for long distance migrants.

The consequences of restricted upriver fish passage include disruption of migration behavior and reproductive activity, access to foraging and wintering areas, and may combine to limit growth, recruitment, overwinter survival, and population size if access to essential habitat is denied. Evidence for these effects on UMR fish populations is limited. Examination of the relative abundance and interpool distribution of UMR fishes (Pitlo *et al.* 1995) provides little indication of the consequences of restricted upriver fish passage on the UMR. UMR fish population data are generally not available to compare the health of populations of the same species in adjoining navigation pools with a greater and lesser amount of accessible habitat, as mediated by opportunity for fish passage through dams. Sufficient interpool movement of most UMR fishes probably occurs to prevent genetic isolation.

The only fish species that have been nearly extirpated from the UMR by dam construction are the Alabama shad and the skipjack herring. The Alabama shad is an anadromous species that formerly migrated from the sea to the UMR. The skipjack herring winters in the Middle and Lower Mississippi River and migrated into the upriver reaches of the UMR during warmer periods. The large migrations of skipjack herring (noted by many early river travelers) were blocked by construction of Lock and Dam 19 at Keokuk, Iowa, in 1913 (Coker 1930).

Although still present above Lock and Dam 19, impoundment of the UMR may have contributed to the greatly reduced abundance of other long-distance migratory species such as lake sturgeon, paddlefish, blue sucker, and blue catfish. The large schools of long-distance migrants prior to dam construction (Coker 1930) may have contributed to their reproductive success. Restricted opportunity for access and availability of winter habitat may reduce over-winter survival for a number of lateral migratory species, such as largemouth and smallmouth bass, in some parts of the UMR.

Genetic isolation, near-complete interruption of recruitment, and near extirpation of the Unionid mussel ebony shell (*Fusconaia ebena*) in the northern reaches of the UMR has been attributed to the markedly reduced upriver migrations of the ebony shell's glochidial host fish, skipjack herring (Eddy and Surber 1943, Fuller 1980). Restricted movements of fish between navigation pools may restrict gene flow within mussel species dependent on a single fish species as glochidial host (Romano *et al.* 1991).

On the Illinois River, the wicket gate dams at Peoria and La Grange allow open river passage to fish most of the time. The dam at Starved Rock, however, rarely goes to an open river condition and presents a barrier to upriver fish passage most of the time. Although some fish may occasionally find their way upriver through the lock chambers, the upper Illinois River dams (Starved Rock, Marseilles, Dresden Island, Brandon Road, and O'Brien) all present complete barriers to upriver fish passage.

3.1.6.2 Fish Access to Tributaries

Connectivity of UMRS aquatic habitat has also been reduced by dams on tributary rivers. An analysis has not been conducted on the total stream network length, and the length of free-flowing reaches that remain between the first dams on tributaries and confluences with the mainstem Mississippi and Illinois Rivers. Prior to construction of the UMR navigation system and tributary dams, fish had access to most of the drainage network within the UMRS basin, except the headwaters of the Mississippi, St. Croix, Chippewa, Wisconsin, and Black Rivers where falls imposed natural barriers to upriver fish movements. Hundreds of dams have been built on UMRS tributary rivers (Figure 5-26, Volume 1). Many are small, low-head former mill and hydropower dams which remain barriers to fish movements. Over 266 larger dams impounding reservoirs of over 5,000 acre-feet exist on UMRS tributaries (as of 1988) (see Section 5.4.6 Watershed Reservoirs). The Chicago Sanitary and Ship Canal and the diversion of water from Lake Michigan into the Illinois River extended aquatic habitat connectivity between the Great Lakes and the UMRS, allowing the introduction of Great Lakes and exotic species (see below). Table 3-1 provides information on UMRS tributaries, natural barriers, and dams. The effect of reduced access by UMRS migratory fishes to the tributary river network has probably reduced the population size of a number of species due to limited access to more optimal spawning, nursery, foraging, and overwintering habitats. Also, fish communities in the impounded tributary streams are no longer affected by the seasonal presence of fish from the mainstem rivers.

Table 3-10: Dams on UMRS tributaries that limit upriver fish movements.

State	River	Natural barrier	First dam
MN	Mississippi mainstem	St. Anthony Falls	St. Anthony Falls
	Minnesota	None	Granite Falls
	Vermillion	Hastings	none
	Cannon	None	Byllesby
	Zumbro	Zumbro Falls	Lake Zumbro
	Whitewater	None	none
	Root	None	none
WI	St. Croix	St. Croix Falls	St. Croix Falls
	Chippewa	Chippewa Falls	Dells Dam Eau Claire
	Black	Black River Falls	Black River Falls
	Wisconsin	Bull Falls Wausau	Prairie du Sac
	Grant	None	none
	Platte	none	none
IA	Upper Iowa	None	near Decorah
	Turkey	None	Elkader
	Macoqueta	None	Macoqueta
	Wapsipinicon	None	Anamosa
	Cedar	None	Waterloo
	Iowa	None	Iowa City
	Des Moines	None	Ottumwa
IL	Galena	None	none
	Apple	None	Hanover
	Rock	None	Rock Island
	Kaskaskia	None	Kaskaskia Lock and Dam
MO	Salt	None	Cannon
	Quiver	None	none
	Missouri	Great Falls Montana	Gavins Point S. Dakota
	Meramec	None	None
	Big Muddy	None	Rend Lake
	Tributaries to the Illinois River		
IL	Sangamon	None	Petersburg
	Spoon	None	Bernadotte
	Mackinaw	None	none
	Vermillion	None	none
	Fox	None	Dayton
	Kankakee	None	Wilmington

3.1.6.3 Future Connectivity of UMRS Aquatic Habitat

Continuing sedimentation in secondary and tertiary channels and in backwaters (see Chapter 7, Volume 1), particularly in the southern reaches of the UMR, will further reduce both the areal extent and connectivity of aquatic habitat. Habitat restoration projects will offset some of these losses of secondary channels and contiguous backwater habitat.

A number of projects are beginning to restore stable channels, floodplains, and riparian corridors along channelized rivers in the UMRS Basin. Restoration of the lower reaches of some UMR tributaries is beginning to occur, such as the lower Whitewater and Zumbro Rivers in Minnesota, which will improve aquatic habitat connectivity in tributary delta areas.

Construction of new dams on UMRS tributaries is unlikely in the foreseeable future. New levee systems are also unlikely in the foreseeable future, although existing levee systems may be raised to provide additional flood protection. There is the possibility that buy-outs of flood-prone levee and drainage district areas and levee setbacks will result in conversion of some isolated floodplain back to contiguous floodplain.

No fish passage facilities presently exist on UMRS mainstem rivers or tributaries. Low-cost fishways that simulate natural rapids have been installed to provide fish passage at dams in Minnesota and Wisconsin. An electrical and/or behavioral barrier will probably be installed on the upper Illinois River to prevent further invasion of exotic fishes and other organisms from Lake Michigan into the UMRS. Efforts to improve opportunity for fish passage through UMRS dams may result in operational modifications and/or fish passage facilities. The potential for improved opportunity for fish passage through UMR navigation dams exists, but future implementation and effectiveness of such efforts remains undetermined. Fishways on some tributary dams may be installed as part of hydropower relicensing efforts, and some dams will be removed as they deteriorate, but greatly increased connectivity of aquatic habitat into the tributary stream network of the UMRS may take many decades to attain.

3.1.7 Changes in the UMRS Basin

Historical recreations of basin landscapes indicate that forest and prairie were the major land cover types before European settlement in the basin (Kuchler 1964). In the 18th and 19th centuries, European settlers migrated to the basin to mine minerals, log forests, harvest river resources, and farm rich prairie soils. The settlers cleared the natural vegetation and drained many wetlands to meet the demand for forest and agricultural products. Today, agriculture is the dominant land use in the UMRS Basin, and nearly 75% of the total area of the basin is being intensively used for agricultural purposes (Figure 3-1). The major cash crops in the basin are corn and soybeans. Prairies were essentially eliminated from the landscape, and the area under deciduous forest was reduced from about 33% to 12% of the basin area (EMTC 1999). Including both agriculture (~75%) and urban development, more than 80% of the basin's landscape was altered to meet the needs of the basin's human population of about 30 million people and to accommodate grain production. Currently, the UMR floodplain provides significant proportions of wetland habitat along the mid-continental migratory bird corridor, as well as significant habitat within the Midwest region (Figure 3-2).

While land conversion was widespread and affected most land cover classes, wetland loss was very significant. Wetland loss in the UMRS Basin and Missouri River Basin together account for 26 million acres, or about 6% of the total area, in the two basins since 1878 (Hey and Philippi 1995). In Illinois and Iowa, wetland loss exceeds 95% of their prior distribution. Wetland losses are especially critical because they help regulate hydrology, filter sediment and nutrients in runoff, and sustain highly diverse floral and faunal populations. Wetlands are important breeding areas for many migratory birds, reptiles, amphibians, and mammals; changes in wetland distribution and abundance have affected their populations. In addition to the loss of wildlife habitat, the UMRS Basin lost about 70% of its natural water holding capacity over the past 150 years (Brady 1990) and the characteristics of the UMR hydrograph reflect these changes. Flood stages are currently higher, and floodwaters reach the river faster than in the past because of human development in the basin and floodplain. Prairies and forests have been converted to crop fields, and wetland conversion and stream channelization have reduced upland water retention capacity. Low flows are currently lower in many tributaries because water that would have been released from wetlands during low-flow periods is currently being routed downstream at a rapid rate rather than being stored in wetlands (DeMissie and Khan 1993).

Because most of the basin's natural landscape has been altered, remaining wetlands and forests along the Mississippi River have increased importance for wildlife in and migrating through the basin. The importance of the river within four regions of the basin was calculated using land cover data collected by satellites (Hank DeHaan, USGS, Long Term Resource Monitoring Program, Onalaska, WI, personal communication, 1998). The results (Figure 3-2) indicate that the Mississippi and Illinois Rivers provide about 40% of the wetland habitat in the Open River and the Illinois River sub-basins, respectively. The relative importance of river wetlands decreases upstream, especially in the Upper Impounded Reach, where it represents only 3% of the basin wetlands. The distribution of floodplain wetlands, whether contiguous with the river or isolated by levees, has not been calculated. Isolation of wetlands reduces their habitat value to riverine fishes that make seasonal movements to backwaters and floodplains.

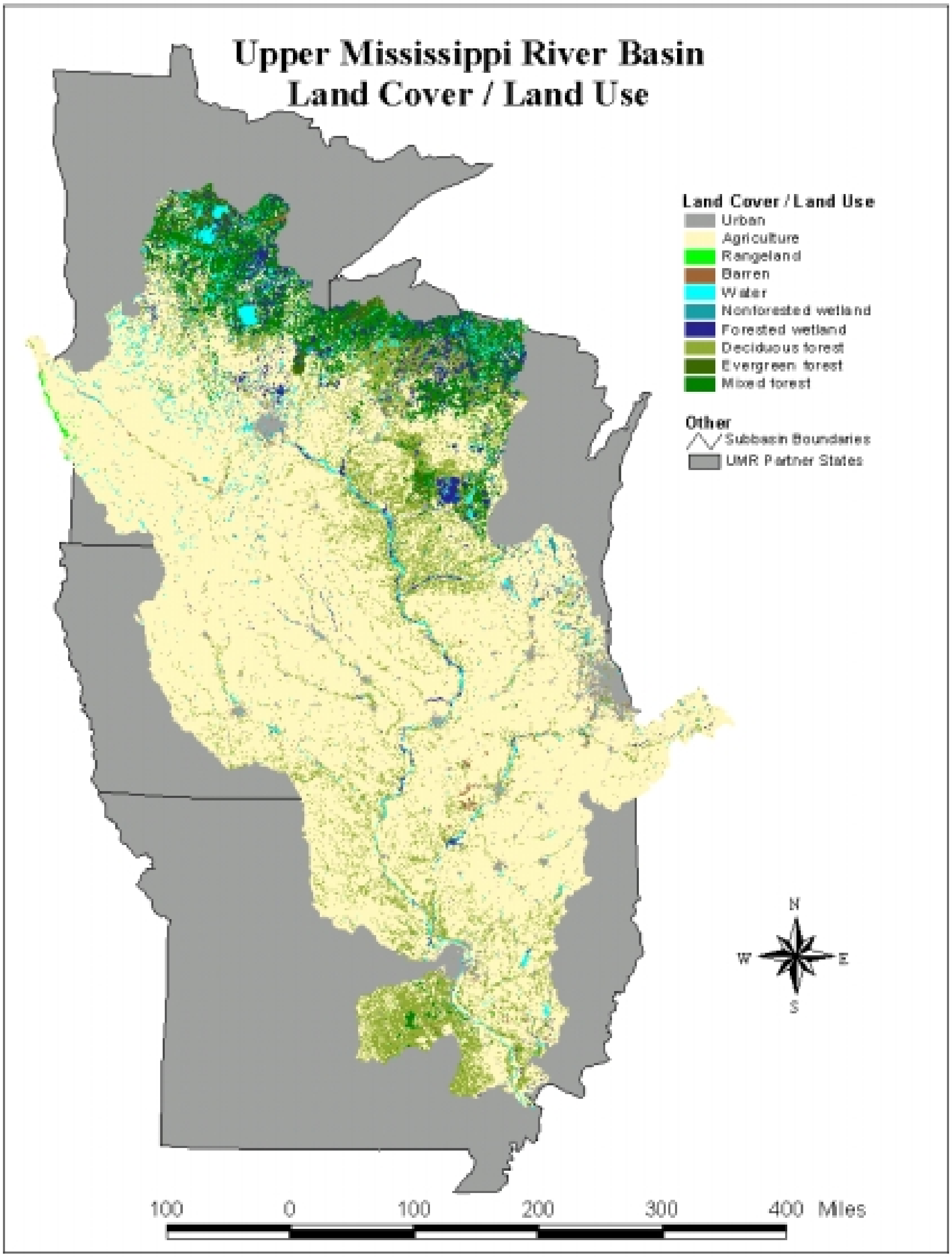
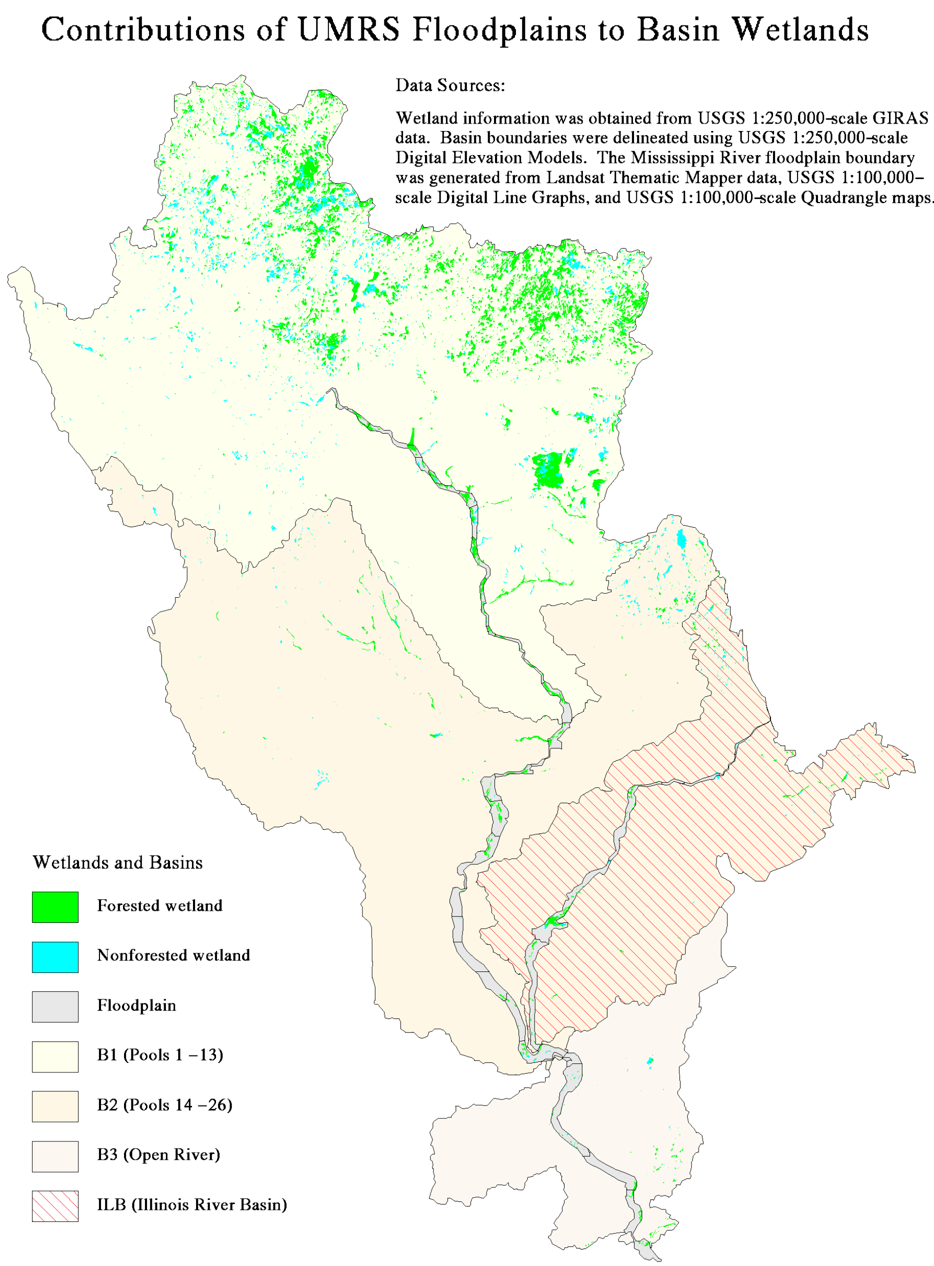


Figure 3-6: Upper Mississippi River basin land cover. (Source: Hank DeHaan, USGS-BRD, UMESC, Onalaska, Wisconsin).



Basin	Wetland Type	Total Basin Acres	Total Floodplain Acres	Percent UMRS Contribution
B1	Forested	3, 018, 731	118, 132	4%
	Nonforested	1, 114, 124	12, 309	1%
B2	Forested	288, 082	64, 808	22%
	Nonforested	208, 041	5, 343	3%
B3	Forested	44, 429	20, 682	47%
	Nonforested	10, 813	3, 566	33%
ILB	Forested	85, 312	46, 523	55%
	Nonforested	52, 514	12, 043	23%

Figure 3-7: A comparison of the relative contribution of UMR/IWW floodplain wetlands to total wetland availability in the sub-basin area of four floodplain reaches defined by Lubinski (1993). (Source: Hank DeHaan, USGS-BRD, UMESC, Onalaska, Wisconsin).

3.1.8 Changes in UMR-IWW floodplain Land Use and Land Cover

Land cover in the floodplain was intensively converted between the 1850's and 1930's, and floodplain development continues today. The structure of pre-settlement floodplain land cover was reconstructed using Government Land Office survey data collected after the Louisiana Territories were acquired (Nelson *et al*. 1994, Yin and Nelson 1995, Yin *et al*. 1997, and John Nelson, Illinois Natural History Survey, Alton, IL, personal communication, 1998). The reconstruction indicated that prairies were once a dominant feature of the floodplain. Nelson *et al*. (1994) used the distribution of land cover type and tree species' fire tolerance to identify how two disturbances acted to define floodplain structure. Fire was dominant on the higher elevation floodplain where prairie and oak groves were present. Closer to the river at lower elevations, flood influences and moisture-tolerant species dominated. Oaks and other mast-producing species were more common in the past. By the late 1800's, most floodplain prairies were converted to agricultural production. Forests were cut for steamboat fuel wood and lumber and then converted to agriculture, most severely in the reach below the Missouri River where almost the entire floodplain was logged (Yin and Nelson 1995, Norris 1997). Much of the floodplain was logged and developed for agriculture north of Pool 14, but the establishment of the Upper Mississippi River Fish and Wildlife Refuge has allowed much of the area to regenerate to mixed maple forests. Dams, however, inundated much of the former floodplain area, creating large, open-water areas such as lower Pool 8. GIS coverages of pre-settlement and late-1800's land cover are available for many reaches; the remaining reaches, and/or the Brown's Surveys, could be completed to provide systemic coverages.

Most of the levees were constructed prior to 1930, but they have been modified and improved through time. In addition to protecting agricultural and urban areas from moderate floods, levees prevent sediment from being distributed across the floodplain. Sediment-laden waters are concentrated into the floodplain area between the levees, and many of the lakes are subject to sediment deposition as current velocities decrease in the expanded floodwaters. Levees also contribute to increased flood heights and increased water level variability because floodwaters are confined in a smaller area (Belt 1975, Chen and Simons 1986, Bellrose *et al.* 1983). The combined effects of levees are to prevent animal migrations, disrupt hydrologic controls, and degrade aquatic habitats by contributing to backwater sedimentation. Levees are least abundant on the Upper Impounded Reach (3% of floodplain area leveed), followed by the Lower Impounded and Illinois River reaches (about 50 to 60% of floodplain area leveed), and the Open River (>80% of floodplain area leveed).

3.1.9 Changes in Emergent and Submersed Aquatic Vegetation

Emergent and submersed aquatic plant distribution and abundance has changed considerably. In the pre-development era, submersed aquatic vegetation was not as abundant as at present and was generally found in backwater lakes (Green 1960). Emergent aquatic vegetation was widely distributed at the margins of lakes and channels, especially in the marginal zone of backwater lakes where water levels dropped during low-flow periods. When levees were constructed, much of the wetland marsh area was drained and emergent vegetation was replaced by crops. When the dams were constructed, the elevated water levels inundated many of the wetland marshes and created habitat more favorable for submersed aquatic vegetation. Immediately after impoundment, anecdotal evidence indicates that most backwaters were colonized by submersed aquatic vegetation. However, through time, pollution and sedimentation eliminated much of the submersed aquatic vegetation, especially in the Illinois River and the Mississippi River below Pool 13. Currently, fine sediments resuspended by boat and wind-generated waves increase ambient turbidity that limits light penetration and reduces submersed aquatic production. In the Upper Impounded Reach, submersed aquatic vegetation is common, but populations can be variable. Some wind swept and/or tributary influenced areas have lost vegetation through time. In some areas, such as the Trempeleau Wildlife Refuge (Pool 6) and Weaver Bottoms (Pool 5a), emergent vegetation has disappeared from formerly vegetated littoral zones due to wave action. Littoral processes of wave action, sediment resuspension, and littoral drift of sediment cause erosion of islands and shorelines, including vegetated areas.

3.1.10 Effects of Point-Source Discharges to the UMRS

Point sources of pollutants include municipal sewage treatment plants and industries. Electricity generating plants and some other industries discharge heated water to the rivers. Although tributaries convey materials to the mainstem rivers at their confluences and urban storm drains discharge to the rivers, these are considered non-point discharges due to the spatially diffuse sources of the pollutants. The states administer the National Pollutant Discharge Elimination System, under which permits are issued for discharge of pollutants to surface waters. There are approximately 4,500 permits issued throughout the UMR Basin (Walter Redmond, U.S. EPA, Chicago, Illinois, personal communication, 1998). The history of contaminant discharge and regulation is well documented and will be reviewed only briefly here. Sewage disposal in the river near large metropolitan areas such as Minneapolis-St. Paul, Minnesota; the Quad Cities, Illinois and Iowa; St. Louis, Missouri; and Chicago, Illinois, was the first widely recognized problem. Untreated sewage was discharged directly into the rivers from primitive sewage systems as late as the 1970's when the 1972 Clean Water Act was established; in St. Louis, treatment plants still provide only secondary treatment at most facilities. The sewage wastes greatly increased biological oxygen demand and subsequently created conditions tolerable to only the most hardy species. In the Illinois River downstream from Chicago, Forbes and Richardson (Quoted in Starrett 1972) describe the river at "its lowest point of pollutional distress," the water was black and bubbling with the gases of decomposing sewage. Below Minneapolis down to Lake Pepin mayflies, mussels, and other sensitive species were eradicated, not to return in large numbers until the 1980's after secondary treatment was implemented.

Industrial contaminants were also linked to large metropolitan areas. Polychlorinated biphenyls (PCBs), components of industrial solvents, are concentrated in Mississippi River sediments below Minneapolis and, to a lesser extent, near the Quad Cities and St. Louis. In addition, PCBs, mercury, and cadmium are found in higher concentrations in the tissues of adult mayflies near these cities (Steingraeber *et al.* 1994, Steingraeber and Wiener 1995). Sources of PCBs to the Mississippi River have not been identified, but probably include a variety of industrial sources, old electrical transformers, and surface runoff from contaminated areas, municipal waste treatment plants, and aerosol deposition on the landscape throughout the basin. Lead in sediments is concentrated in Lake Pepin, which serves as a sediment sink that traps contaminants from Minneapolis, and in Pool 12 where it is leached from lead mines in the driftless area of southwestern Wisconsin and northwestern Illinois. Tris-2-chloroethylphosphate (TCLEP), a flame retardant added to polyurethane foams and textiles, in the Mississippi is derived almost exclusively from the Illinois River Basin (Meade 1995).

Agricultural contaminants sometimes enter the rivers at high concentrations where tributaries with intensive agricultural land use join the larger rivers. The impact is similar to point source discharges in that spikes in contaminant concentrations can be detected in the Mississippi River downstream from the mouths of major tributaries. Atrazine concentrations provide an example of the effect where concentrations exceeding maximum contaminant levels (MCL) entering the Mississippi River from the Illinois and Missouri rivers raise Mississippi River concentrations above the MCL (Meade 1995).

The 1972 Clean Water Act resulted in significant improvements to overall water quality in the UMRS. Total contaminant discharges have been reduced, and contaminated sediments are being buried by newer, cleaner sediments in Lake Pepin (Meade 1995) and in Illinois River backwaters (Sparks 1984). Secondary sewage treatment has been implemented in most major municipalities. Treatment facilities in Minneapolis-St. Paul have implemented tertiary treatment and they have separated storm and waste sewers to provide greater protection. Major clean water initiatives have also been implemented in the Chicago area to reduce the municipal waste impact on the Illinois River.

Impacts of contamination on fish and wildlife are apparent in some cases. Sewage disposal loaded the river with organic wastes that led to oxygen deprivation and the eradication of all but the most tolerant species. Illinois River fishes showed significant deformities and cancerous lesions during surveys in the 1950's and 1960's. The occurrences of lesions and deformities have declined recently (Sparks and Lerczak 1993), and mussels are being found in places where they were once thought extirpated (Scott Whitney, USCOE, Rock Island, personal communication, 1998). Improvements are most evident in the upper Illinois River, where sedimentation impacts are not so severe. In the upper reaches of the Mississippi River, mink populations declined, and individuals contained elevated levels of PCBs (Wiener *et al.* 1998). Fish-eating birds (cormorants, eagles, herons) are also believed to have experienced reduced reproductive success because some contaminants impede calcium metabolism that leads to thin shells susceptible to breakage, though recent recovery is evident. In many cases, the impacts of contaminants are unknown.

3.1.11 Effects of Non-Point-Source Discharges to the UMRS

Non-point-source discharges into the UMRS include a variety of sediment, agricultural chemicals, and urban pollutants that originate in the basin and get transported into the UMRS stream network with runoff. The quantity of pollutants entering from urban runoff has not been well documented, but the chemical constituents likely to occur are known.

Urban non-point source runoff or stormwater runoff has been recognized as a cause of water quality degradation and contains very large quantities of heavy metals (Wilbur and Hunter 1979, Owe *et al.* 1982, Livingston and Cox 1985). Heavy metals found in urban runoff are 10-10,000 times the concentration of heavy metals found in sanitary sewage (Wanielista 1978). Among the toxic heavy metals detected in stormwater runoff, lead, zinc, and copper appear to be the most abundant and detected the most frequently (Nightingale 1987). Cadmium, although not present in high concentrations in all urban environments, is significant because of its extreme toxicity (Wigington *et al.* 1983). Heavy metal sources are largely associated with the operation of motor vehicles, atmospheric fallout, and road surface materials (Harper 1985). Some sources of heavy metals are displayed in Table 3-1. Metal contamination is more widespread from commercial and roadway development than from residential, light industrial, or mixed urban land use (Whalen and Cullum 1988). To address concerns regarding non-point-source runoff, many cities, municipalities, and states have implemented regulations requiring that stormwater runoff be treated in a pond or other alternative system.

Agricultural chemical use and soil loss have been documented in the UMRS. Changes from the past are somewhat speculative, but upstream impoundments, especially those on the Missouri River, have greatly reduced the amount of sediment transported to the river. Conversely, agricultural development and logging have stripped native vegetation and converted the land to erodible crop land. Agricultural practices at the turn of the century were crude and fostered very high rates of erosion. In Wisconsin, soil conservation efforts initiated in the 1930's significantly reduced soil loss (Knox 1977). In the corn belt of Illinois and Iowa, soil loss increased after World War II in response to increased mechanization and a conversion of pastureland to soybeans (see Figure 3-3, Volume 1). Recent surveys conducted by the Natural Resources Conservation Service show reductions in the rate of soil loss since 1982 (see Table 3-2, Volume 1), but sediments stored in the stream network will continue to be a substantial source of sediments in the UMRS for many years (Knox 1989, DeMissie *et al*. 1992).

The concentration of suspended sediments in the UMRS increases in the downstream direction. A U.S. Geological Survey systemic survey reveals 1959 to 1990 mean annual suspended sediment discharge at Burlington, Iowa (Pool 19) of about 9 million metric tons per year. Sediment discharge at St. Louis, Missouri, increases by an order of magnitude to a little more than 100 million metric tons per year (Meade 1995). LTRMP sampling in six study reaches also helps identify tributaries with high suspended sediment discharge. The Maquoketa and Wapsipinicon Rivers discharge about 200 mg/l of suspended sediment to Pool 13, the Illinois River discharges about 80 mg/l to Pool 26, and the Missouri River discharges about 300 mg/l to the Mississippi River above St. Louis (Figure 3-1 and Figure 3-2). The majority of both suspended sediment and contaminants are transported to the river during spring floods that coincide with planting and fertilizer and herbicide applications (Meade 1995). Missouri River sediment transport is not included in the figures, but see Section 5.3 (Volume 1) for a more thorough analysis of sediment transport.

Currently, chemical fertilizer and herbicide application rates in the UMRS Basin are among the highest in the country (Meade 1995). LTRMP data indicate that tributaries transporting high concentrations of sediment also discharge high concentrations of nitrogen and phosphorus. USGS systemic data indicate that the streams mentioned above and other major tributaries in agricultural sections of the basin transport high concentrations of herbicides as well as fertilizers (Figure 3-3, Figure 3-4, Figure 3-5, and Figure 3-6). Nitrogen in its toxic form (ammonium) has been responsible for die-offs of fingernail clams and mussels in the Illinois River (Sparks 1984). High ammonium concentrations are also suspected to impact invertebrates in the Mississippi River, but the evidence has not been sufficiently documented (Wilson *et al.* 1995). High nitrogen and phosphorus concentrations may be fueling localized eutrophication by increasing aquatic plant production. Plant and animal response to pesticides in the UMRS has not been studied.

The ecological impact of sediment delivery to the rivers can be demonstrated by the distribution of aquatic vegetation. Currently, submersed aquatic plants are most abundant in the Mississippi River north of Pool 14. Based on LTRMP suspended solids and light extinction coefficient data, and plant growth models for wild celery and sago pondweed, ambient turbidity in channel borders and contiguous backwaters south of Pool 13 is generally too high to allow plant growth, and vegetation is restricted to isolated backwaters. Farther south in the pooled portions of the Mississippi and Lower Illinois rivers, sediment accumulated in shallow backwaters remains flocculent because it is not exposed and dried in impounded areas. Flocculent sediments are subject to resuspension by waves, which limits plant production in contiguous and isolated backwaters.

Table 3-11: Sources of heavy metals found in stormwater runoff. Sources: Wigington *et al.* 1983, Harper 1985, Whalen and Cullum 1988, Harper 1990, Campbell 1995.

Source	Cadmium	Chromium	Copper	Nickel	Lead	Zinc
Gasoline	X		X		X	X
Exhaust Emissions				X	X	
Motor Oil and Grease	X		X	X	X	X
Antifreeze			X			X
Undercoating					X	X
Brake Linings		X	X	X	X	X
Rubber	X		X		X	X
Asphalt			X	X		X
Concrete			X		X	X
Diesel Oil	X					
Engine Wear			X			

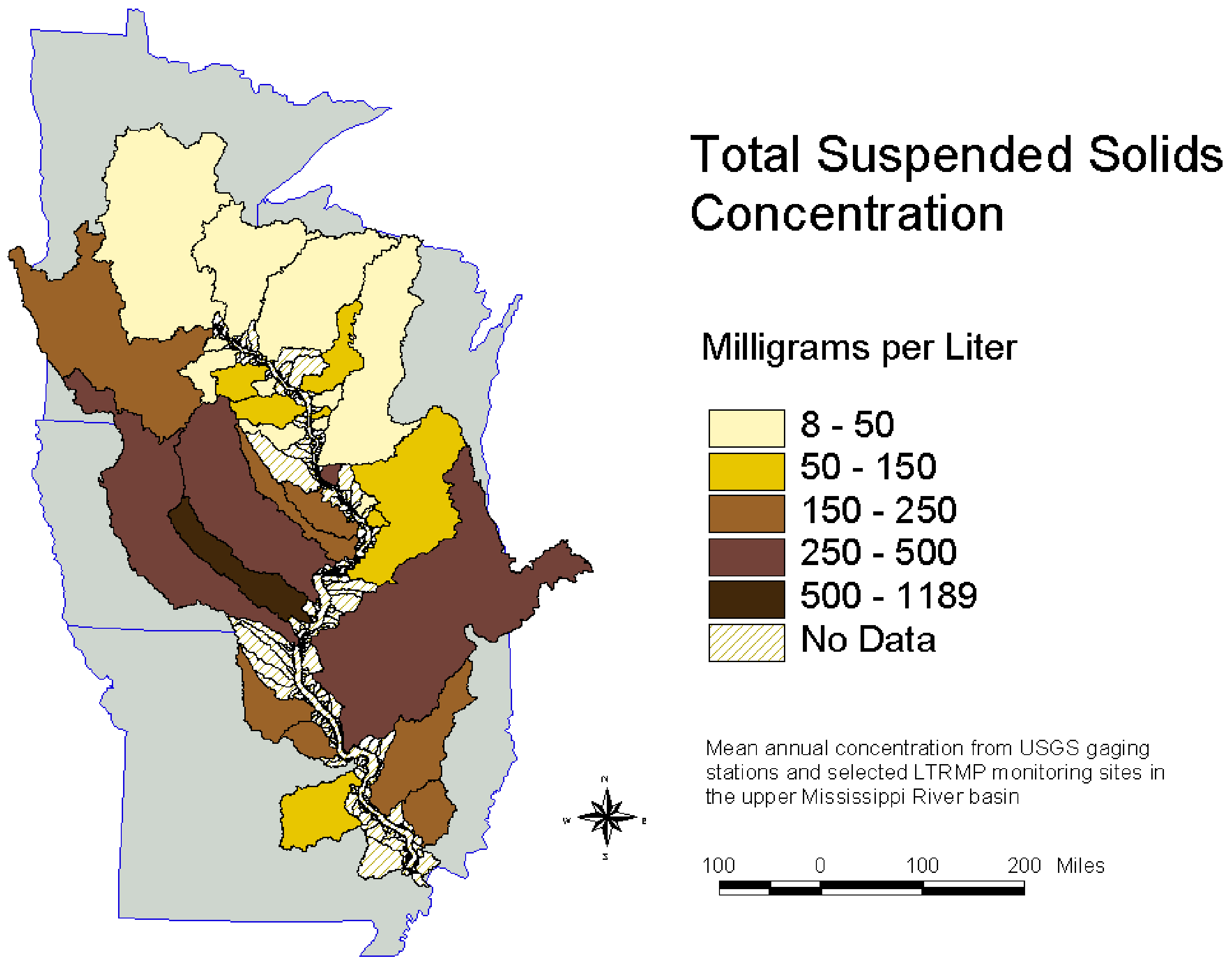


Figure 3-8: Average annual total suspended solids concentration in stream water of major UMR tributaries (Source: USGS - LTRMP, La Crosse, Wisconsin).

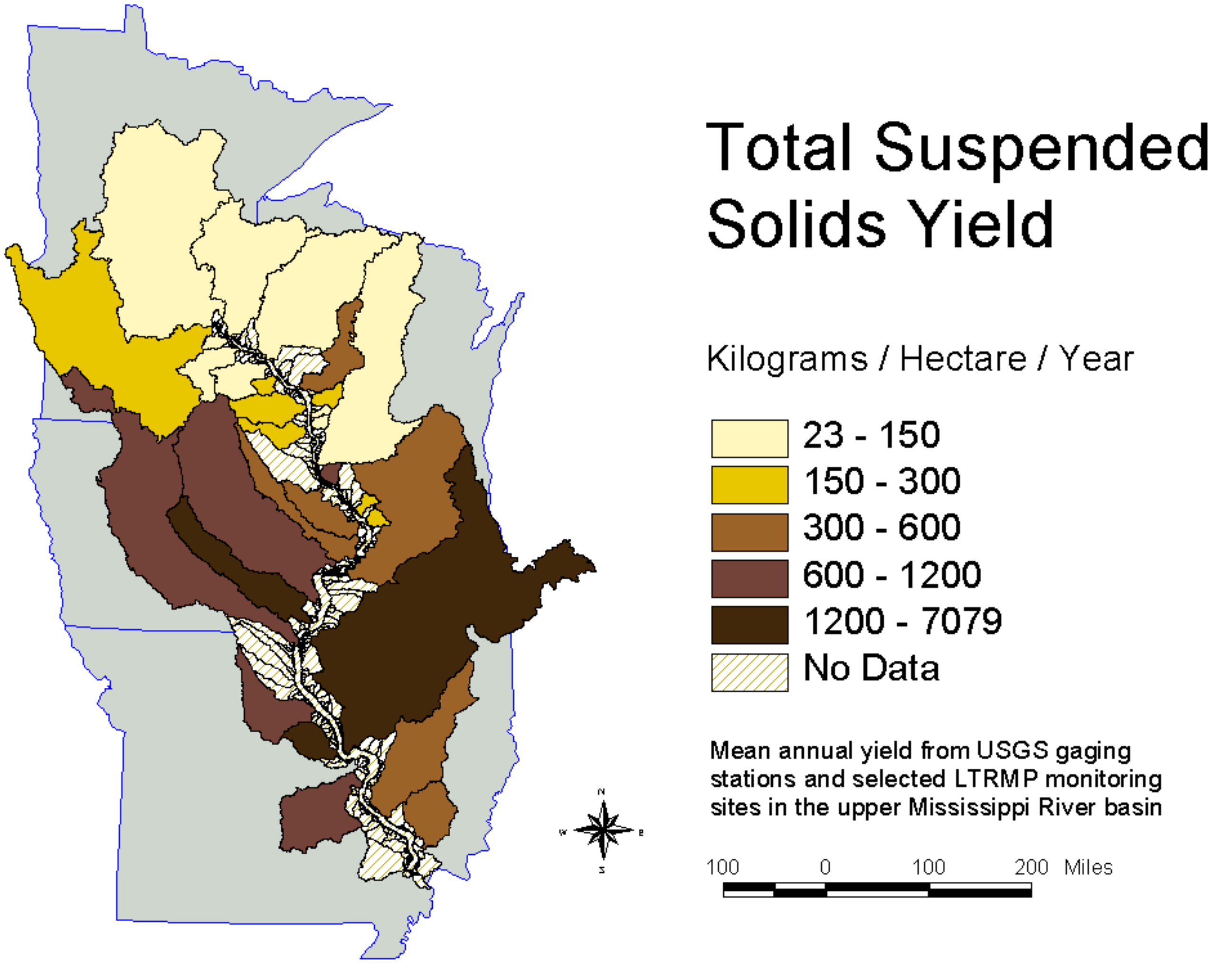


Figure 3-9: Average annual total suspended solids yield entering the UMR from major tributaries (Source: USGS - LTRMP, La Crosse, Wisconsin).

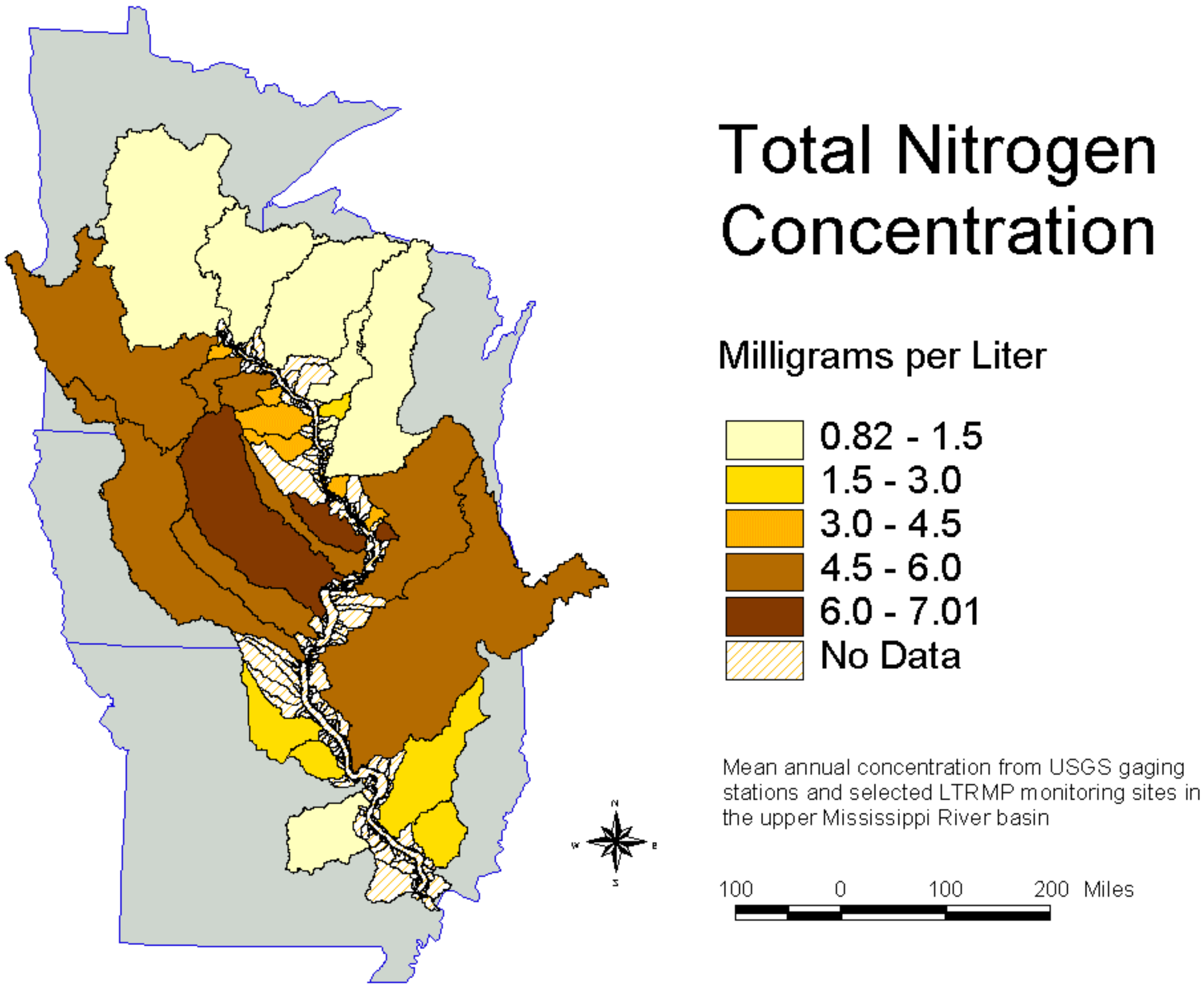


Figure 3-10: Average annual total nitrogen concentration in stream water of major UMRS tributaries.

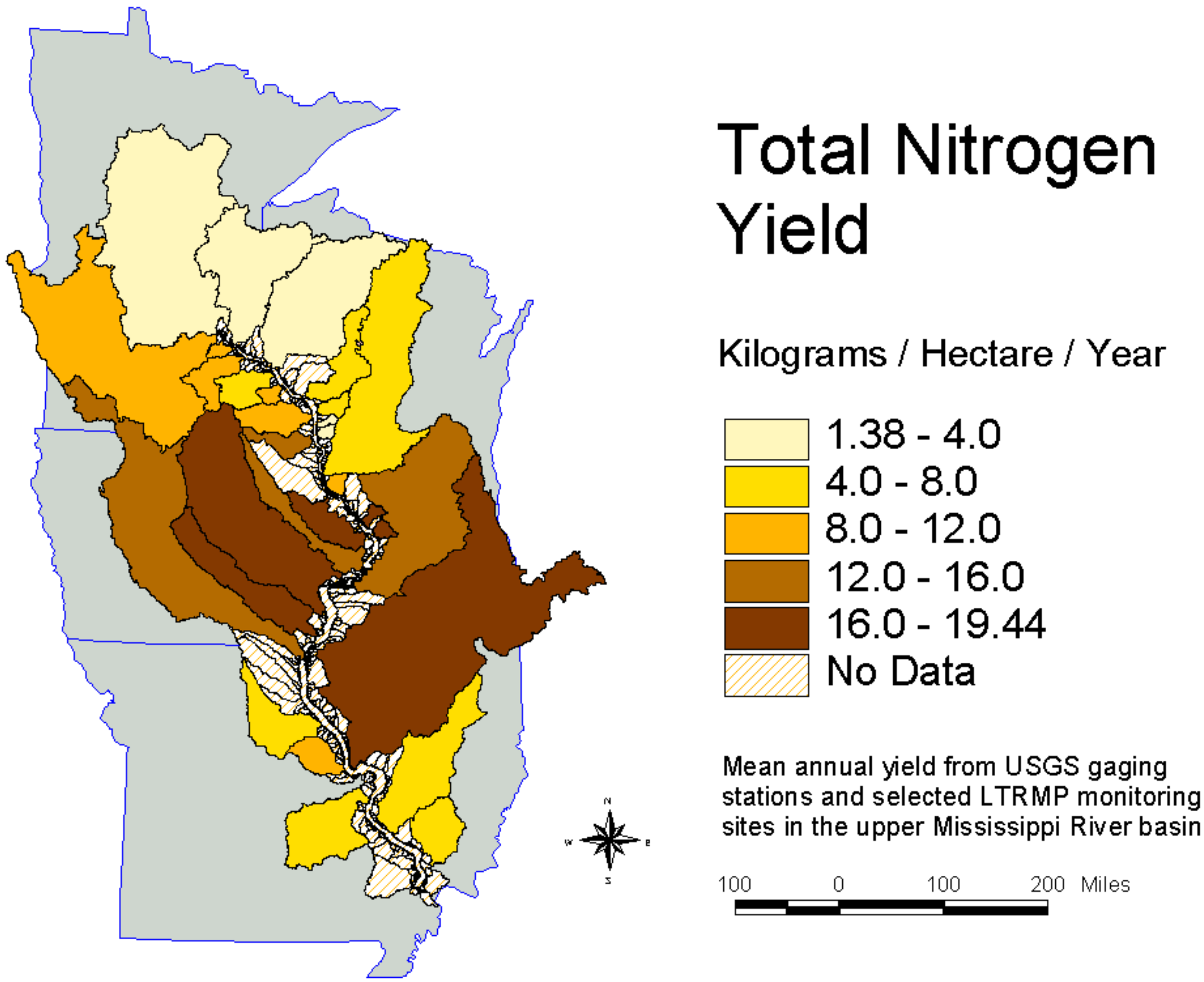


Figure 3-11: Average annual total nitrogen yield entering the UMRS from major tributaries.

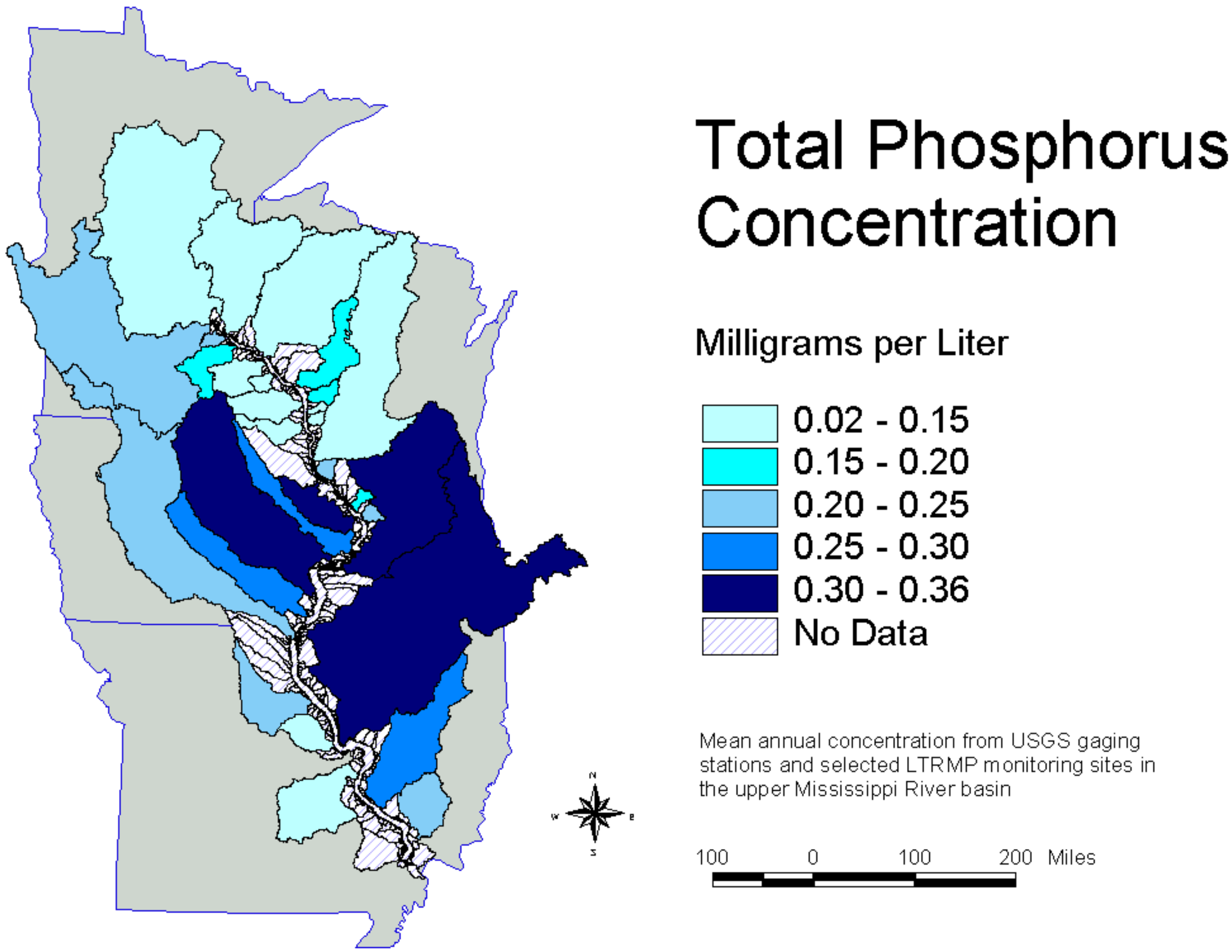


Figure 3-12: Average annual total phosphorus concentration in stream water of major UMRS tributaries.

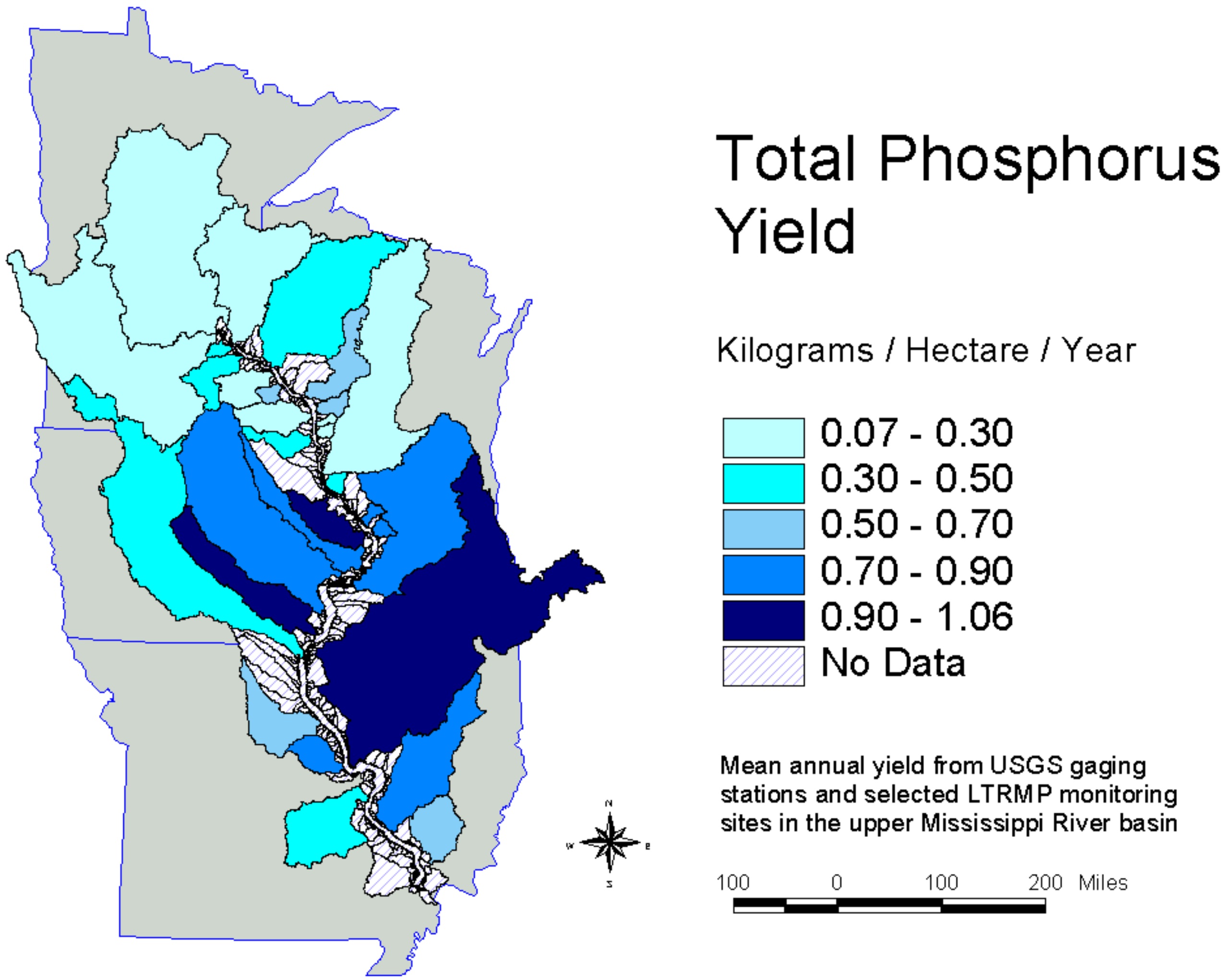


Figure 3-13: Average annual total nitrogen yield entering the UMRS from major tributaries.

3.1.12 Fish Entrainment and Impingement at Electrical Generating Plants

Entrainment is the withdrawal of water and organisms into river water intakes, cooling water systems, or hydropower turbines. Entrained organisms are small enough to pass through trash racks and intake screens, primarily planktonic forms such as phytoplankton, zooplankton, ichthyoplankton, and drifting benthic macroinvertebrates. This analysis focuses on larval fish that are entrained at power plants. Mortality of entrained organisms varies with the organisms and the characteristics of the system, from very low entrainment mortality on passage through low-head hydropower plants to 100% mortality of organisms entrained into the cooling systems of steam-electric power plants.

Impingement occurs when organisms too large to pass through trash racks or traveling screens on water intakes become trapped against the intake structure by the force of the current. Larger organisms are impinged, such as juvenile and adult fish, and amphibians such as frogs, newts, and mudpuppies. This analysis focuses on impinged fish. High fish impingement mortality occurs at power plant intakes during natural die-offs and during periods when fish are physiologically weakened by cold water temperatures (U.S. EPA 1976). Impingement of fish at hydropower plants can occur at the turbine intake trash racks and by fish striking any part of the draft tube, wicket gates, or turbine runner.

Section 316(b) of the Federal Water Pollution Control Act Amendments of 1972 (P.L. 92-500, Clean Water Act) requires industrial cooling water users to determine the biological effects of their intake systems and to demonstrate that the design, construction, and operation of the intake systems reflect the best technology available. States were given authority to administer Section 316(b) under the National Pollutant Discharge Elimination System (NPDES), Section 402 of P.L. 92-500. Utility companies and cooperatives complied with these requirements by monitoring and reporting impingement and entrainment rates, a series of Section 316(b) demonstration reports, and in some cases, modifications of power plant intake structures to reduce adverse biological effects.

Hydropower plants are not considered cooling water intakes under Section 316(b) of the Clean Water Act. Hydropower plants over 5-MW capacity are licensed by the Federal Energy Regulatory Commission (FERC) under the Federal Hydropower Act of 1920. States and other Federal agencies participate in the licensing of new hydropower projects and the periodic relicensing of existing projects. Depending on the characteristics of the project and the reservoir and river fisheries, states may require some determination of fish entrainment and impingement mortality at hydropower plants. These monitoring reports become part of the licensing/relicensing application to the FERC.

In this analysis, power plants (fossil fuel, nuclear, hydropower) that are in operation along the Upper Mississippi and Illinois Rivers were identified through examination of Internet information from the Electric Power Research Institute and other electrical utility industry sources. Utility companies and cooperatives owning the UMRS power plants were requested to provide information on normal power plant cooling system and hydropower plant river water entrainment rates and information available documenting annual fish entrainment and impingement rates. Some state agencies provided reports on Section 316(b)-related monitoring. Because of inter-state differences in implementing Section 316(b) and differences in fish entrainment and impingement rates among power plants, several utilities conducted detailed analyses of the biological effects of their cooling water intakes, while only minimal assessments were performed at other power plants. No previous cumulative effects analysis on fish entrainment and impingement losses at UMRS power plants has been reported for the UMR-IWW System. Table 3-1 summarizes the power plants located along the UMR and Illinois Rivers and the fish impingement and entrainment data available. Information on fish entrainment was obtained for only one of the six existing hydropower plants on the UMR.

Most of the available information on entrainment and impingement at power plants on the UMRS was collected during the 1970's and 1980's to meet Clean Water Act Section 316 requirements. Entrainment data collected during the 1970's from power plants that revised their operations during the 1980's (i.e., Prairie Island Nuclear Generating Plant, Quad Cities Nuclear Power Plant) were not included in this analysis because these data do not represent current operating conditions. However, impingement data from these power plants were included because fish are currently being impinged on the water intake structures.

To complete this assessment, the reported larval entrainment data were extrapolated to estimates of lost future adult fish. This was accomplished using the Equivalent Adults Lost (EAL) model (Horst 1975, Goodyear 1978). The EAL model simulates the numbers of lost future adult fish as the result of entrainment mortality suffered by larvae, employing estimates of larval-to-adult natural morality rates. The EAL estimates are made using the following equation:

$$\text{EAL} = L \cdot \{exp[-\sum_{i=1}^{2} Z_i\, t_i] - exp[-\sum_{i=1}^{2}(Z_i + T_i)]\}$$

where,

L = number of entrained and killed larvae,
t_i = duration of life stage (days),
Z_i = natural mortality rate of life stage i, and
T_i = power plant entrainment mortality rate of life stage i.

Calculation of EAL requires estimates of parameters used in the Conditional Entrainment Mortality (CEM) model (Boreman *et al.* 1981) along with estimates of larval-to-adult natural mortality rates. Natural mortality rates were estimated for larvae, young-of-year, and adults for 30 species of UMRS fishes for the Navigation Study (Bartell and Campbell 1998). These mortality rates were obtained from fisheries literature, obtained for fishes in other systems, and for some species, by professional judgment.

Results of the EAL model for larval fish entrained at power plants indicate the general magnitude of the lost future adults implied by entrainment mortality. In addition to the lack of complete and recent entrainment data and the variety of sampling and entrainment loss estimation methods employed for the various power plants, many of the parameters in the EAL and CEM models are estimated or obtained for fishes from other systems. The primary utility of the EAL model is to convert the reported power plant entrainment losses of larvae into more tangible terms (numbers of adult fish) that can be used in conjunction with entrainment loss estimates from towboats to assess significance and to develop mitigation alternatives. The EAL model provides a first approximation of the severity of annual power plant entrainment losses; it does not provide much insight into longer-term viability of fish populations.

Twenty one fossil fuel, two nuclear, and six hydropower electrical generating plants now operate on the UMR. Nine fossil fuel plants, one hydropower and two nuclear power plants are located on the Illinois River (Table 3-1). Annual fish egg and larvae entrainment and/or impingement estimates were available for nine of the steam-electric generating plants and two of the hydropower plants.

Table 3-12: Fish entrainment and impingement data availability at UMR/IWW power plants.

Pool	Power Plant	Type	Location	Owner	Reference	Year	Data Available
Upper St. A. Falls	Riverside	Coal	Minneapolis MN	Northern States Power	HDR 1976	1976	Predicted annual number (eggs and larvae) entrained
					Heberling *et al.* 1981	1980	Total number entrained (eggs and larvae) - 24 hour samples 4/17/80 - 8/14/80
							Total number entrained - larvae + adults
	Upper St. Anthony Falls	Hydro	Minneapolis MN	Northern States Power			
1	Lock and Dam 1	Hydro	St. Paul MN	Ford Motor			
2	High Bridge NSP	Coal	St. Paul MN	Northern States Power	HDR 1977a	1976	Predicted annual number (eggs and larvae) entrained
							Predicted annual number of fish impinged
						1974 - 1975	Total number impinged for sample dates 9/19/74 - 3/22/75
2	Lock and Dam 2	Hydro	Hastings MN	City of Hastings	FERC 1994	1993	Monthly entrainment rate - fish (eggs and larvae) entrained
3	Prairie Island	Nuclear	Red Wing MN	Northern States Power	Adams *et al.* 1979	1975	Total number entrained (larvae and juveniles)
							Estimated total number impinged
					Dahlberg *et al.* 1976	1975	Total number entrained (larvae and juveniles)
							Total number impinged
							Total number impinged by season
					Geise and Mueller 1996	1984	Estimated total number impinged (eggs, larvae, juveniles, adults - 6 sample days)
						1985	Estimated total number impinged (eggs, larvae, juveniles, adults - 6 sample days)
						1986	Estimated total number impinged (eggs, larvae, juveniles, adults - 6 sample days)
						1987	Estimated total number impinged (eggs, larvae, juveniles, adults - 6 sample days)
						1988	Estimated total number impinged (eggs, larvae, juveniles, adults) - whole season
						1989	Estimated total number impinged (eggs, larvae, juveniles, adults - 3 sample days)
						1992	Estimated total number impinged (eggs, larvae, juveniles, adults - 3 sample days)
						1993	Estimated total number impinged (eggs, larvae, juveniles, adults - 5 sample days)
						1994	Estimated total number impinged (eggs, larvae, juveniles, adults - 6 sample days)
						1995	Estimated total number impinged (eggs, larvae, juveniles, adults - 7 sample days)
						1996	Estimated total number impinged (eggs, larvae, juveniles, adults - 6 sample days)

Table 3-12 continued from previous page

Pool	Power Plant	Type	Location	Owner	Reference	Year	Data Available
					Kuhl & Mueller 1988	1988	Estimated total number impinged
4	Red Wing	Coal	Red Wing MN	Northern States Power	NUS Corp. 1975	1975	Estimated total number entrained (by month, multiple species[1.])
							Total number impinged (5 sample dates)
						1974 - 1975	Total number impinged (12 months)
5	John P. Madgett	Coal	Alma WI	Dairyland Power Cooperative	Kowalski *et al.* 1983	1981	Total number entrained per 24-hr. (larvae, juveniles, adults - 16 sample days)
							Total number impinged
					Kowalski *et al.* 1984	1982	Total number entrained per 24-hr. (larvae, juveniles, adults - 15 sample days)
							Projected annual entrainment + Actual number entrained[1]
							Total number impinged
5	Alma Station	Coal	Alma WI	Dairyland Power Cooperative			
8	LaCrosse (Black River)	Oil	LaCrosse WI	Northern States Power			
9	Genoa No. 3	Coal	Alma WI	Dairyland Power Cooperative	McInerny 1980	1979	Estimated total number entrained (eggs, larvae)
						1980	Estimated total number entrained (eggs, larvae)
						1978-1979	Estimated total number impinged
						1979 - 1980	Estimated total number impinged
					Kowalski *et al.* 1984	1982	Projected annual number entrained[1]
							Projected daily entrainment[1] (29 sampling dates)
10	Lansing Station	Coal	Lansing IA	Interstate Power			
11	Nelson Dewey	Coal	Cassville WI	Wisconsin Power and Light			
11	Stonemens	Coal	Cassville WI	Mid-American Power			
12	Dubuque	Coal	Dubuque IA	Interstate Power			
14	Quad Cities	Nuclear (2 Units)	Moline IL	Commonwealth Edison / Illinois Gas and Electric	LMSE 1985, 1986	1984	Total number entrained[1]
						1985	Total number entrained[1]
					LMSE 1995, LMSE 1996a	1973	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1974	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1975	Estimated number impinged

1. Available reports did not indicate life stages included in entrainment estimate.

Table 3-12 continued from previous page

Pool	Power Plant	Type	Location	Owner	Reference	Year	Data Available
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1976	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1977	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1978	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1979	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1980	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1981	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1982	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1983	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1984	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1985	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1986	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1987	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1988	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1989	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1990	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1991	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1992	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1993	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1995, LMSE 1996a	1994	Estimated number impinged
					LMSE 1996b, LMSE 1997b		Estimated number impinged (by month)
					LMSE 1996b	1995	Total number impinged (by month)
					LMSE 1996a		Estimated number impinged (by month)
					LMSE 1997a	1996	Estimated number impinged
					LMSE 1997b		Estimated number impinged (by month)

Table 3-12 continued from previous page

Pool	Power Plant	Type	Location	Owner	Reference	Year	Data Available
15	Riverside	Hydro	Rock Island IL	Mid American Energy	Mid American Energy	1974 - 1975	Total number impinged
15	Sylvan	Hydro	Rock Island IL	Rock Island Arsenal US DOD			
16	Fair Station	Coal	Montpelier IA	Central Iowa Power Cooperative			
17	Muscatine	Coal	Muscatine IA	Muscatine Power and Water	Wapora 1976b	1976	Total number impinged (10 sampling dates)
17	Louisa	Coal	Muscatine IA				
19	Burlington	Coal	Burlington IA	IES Utilities	Prill 1977	1975 - 1976	Total number impinged
19	Lock and Dam 19	Hydro	Keokuk IA	Union Electric			
26	Sioux	Coal	West Alton MO	Union Electric			
27	Wood River	Coal, Gas	East Alton IL	Illinois Power Company			
Open River	Grand Tower	Coal	Grand Tower IL	Central Illinois Public Service			
Open River	Venice	Gas, Oil	Venice IL	Union Electric			
Open River	Meramec	Coal, Gas	St. Louis MO	Union Electric			
Open River	Rush Island	Coal	Festus MO	Union Electric			
	Illinois River:						
Alton	Meredosia	Coal	Meredosia IL	Central Illinois Public Service Co.			
	Pearl Station	Coal	Pearl IL	Soyland Power Cooperative			
La Grange	Edwards	Coal	Near Peoria IL	Central Illinois Light Co.			
	Powerton	Coal	Pekin IL	Commonwealth Edison			
	Havana	Coal, Oil	Havana IL	Illinois Power Co.			

Table 3-12 continued from previous page

Pool	Power Plant	Type	Location	Owner	Reference	Year	Data Available
Peoria	Muni Light	Coal	Peoria IL	Central Illinois Light			
	Hennepin	Coal, Gas	Hennepin IL	Illinois Power Co.			
Lockport	Will County	Coal	Romeoville IL	Commonwealth Edison			
Starved Rock	Starved Rock	Hydro	Utica, IL	City of Peru			
Marseilles	LaSalle County	Nuclear (2 Units)	11 miles SE of Ottawa IL	Commonwealth Edison			
	Collins	Oil, Gas	Morris IL	Commonwealth Edison			
Dresden	Dresden	Nuclear	Morris IL	Commonwealth Edison			

3.1.12.1 Fish Entrainment Rates

Most of the data available from the studies on power plants is for fish impingement; however, entrainment data are available. Larval fish are entrained during those months (April through September) in which larval fish are present in the water column; the months and peak entrainment rate vary depending on the spawning season for the particular species. Annual entrainment rates were estimated for each species for each power plant where adequate data were available (Table 3-1). Annual entrainment rates for each power plant varied widely between each species, ranging from 45 for Ictaluridae and for rock bass for the E.D. Edwards Power Station located on the La Grange Pool of the IWW to 24,774,827 gizzard shad at the High Bridge Generating Plant on Pool 2. Annual entrainment rates for each fish species were combined to estimate annual losses due to entrainment for the UMR, the IWW, and the UMR-IWW System (Table 3-2).

Annual larval entrainment estimates were converted to equivalent numbers of adults lost for those species for which model parameter data sets have been developed (Bartell and Campbell 1998) using the EAL model (Horst 1975, Goodyear 1978) (Table 3-2). Lost future adults were estimated separately for the UMR and the IWW, as well as for the total UMR-IWW System (Table 3-2). The highest number of adults lost annually due to entrainment was for gizzard shad, in which 30,397,104 larvae represented 50,532 potentially lost future adult fish. Losses ranging in the thousands were also estimated for channel catfish (3,541), common carp (1,886), emerald shiner (1,452), and white bass (2,477). These projections based on annual estimates of entrainment by power plant intakes provide an existing impact which can be compared with fish losses estimated for entrainment through propellers of commercial traffic. These kinds of comparisons can be made for individual pools, where data permit, as well as for the UMR-IWW System (Bartell and Campbell 1998).

3.1.12.2 Fish Impingement Rates

The greater abundance and availability of impingement data provide a more comprehensive summary of fish losses resulting from power plant water intake structures. Depending on the life stage, fish are impinged during all months of the year; however, impingement of juvenile and adult fish occurs during those months (i.e., winter) when the fish are unable to escape from the current of the water intake structure. Annual impingement rates for each species were estimated for each power plant where adequate data were available (Table 3-3). Similar to annual entrainment rates, annual impingement rates varied widely across fish species, ranging from 1 to millions of fish. Annual impingement rates for the UMR, IWW, and the UMR-IWW System were calculated by combining annual pool impingement estimates (Table 3-3). Combined with the annual entrainment estimates, these data provide for the pool and system-wide cumulative effects of power plant water intake structures.

Table 3-13: Estimated annual number of fish entrained by power plant water intake structures.

	Power Plant (pool)						Totals		
Fish species	Riverside Generating Plant **(Upper St. Anthony Falls)**	High Bridge Generating Plant **(Pool 2)**	Hastings Hydro-electric Plant **(Pool 2)**	John P. Madgett Station **(Pool 5)**	Genoa #3 **(Pool 9)**	E.D. Edwards Power Station **(LaGrange Pool)**	**Upper Mississippi River**	**Illinois River/ Waterway**	**Upper Mississippi River/Illinois Waterway**
Black Bullhead							**0**	**0**	**0**
Black Crappie	34,440						**34,440**	**0**	**34,440**
Bluegill	38,150						**38,150**	**0**	**38,150**
Bluntnose Minnow							**0**	**0**	**0**
Brook Stickleback	32,970						**32,970**	**0**	**32,970**
Burbot							**0**	**0**	**0**
Catostomidae	876,440		298	478,632	278,121	255	**1,633,491**	**255**	**1,633,746**
Centrarchidae						160	**0**	**160**	**160**
Channel Catfish	455,350		4,427			98	**459,777**	**98**	**459,875**
Cisco							**0**	**0**	**0**
Clupeidae						36872	**0**	**36872**	**36,872**
Common Carp	110,646	3,352,761	360	410,263		2783	**3,874,030**	**2783**	**3,876,813**
Common Shiner							**0**	**0**	**0**
Common Sucker							**0**	**0**	**0**
Coregonus spp.	4,690						**4,690**	**0**	**4,690**
Cyprinidae	324,764			136,752	1,149,193	27267	**1,610,709**	**27267**	**1,637,976**
Emerald Shiner	8,120			2,000,026	857,850	319	**2,865,996**	**319**	**2,866,315**
Fathead Minnow	18,130						**18,130**	**0**	**18,130**
Flathead Catfish			3,646	17,094			**20,740**	**0**	**20,740**
Freshwater Drum			23,937	8,205,239	3,088,783	750	**11,317,959**	**750**	**11,318,709**
Gizzard Shad		24,774,827	33,324	4,632,537	956,149	267	**30,396,837**	**267**	**30,397,104**
Ichthyomyzon spp.				17,094			**17,094**	**0**	**17,094**
Ictaluridae						45	**0**	**45**	**45**
Johnny Darter	42,280						**42,280**	**0**	**42,280**
Largemouth Bass							**0**	**0**	**0**
Lepomis spp.				34,188	201,586		**235,774**	**0**	**235,774**
Logperch	331,246						**331,246**	**0**	**331,246**
Micropterus spp.	4,620			34,188			**38,808**	**0**	**38,808**
Mimic Shiner							**0**	**0**	**0**
Mooneye				17,094	55,047	55	**72,141**	**55**	**72,196**

Table 3-13 continued from previous page

Fish species	Power Plant (pool)						Totals		
	Riverside Generating Plant **(Upper St. Anthony Falls)**	High Bridge Generating Plant **(Pool 2)**	Hastings Hydro-electric Plant **(Pool 2)**	John P. Madgett Station **(Pool 5)**	Genoa #3 **(Pool 9)**	E.D. Edwards Power Station (**LaGrange Pool)**	**Upper Mississippi River**	**Illinois River/ Waterway**	**Upper Mississippi River/Illinois Waterway**
Morone spp.						147	**0**	**147**	**147**
Northern Pike							**0**	**0**	**0**
Notropis spp.						1515	**0**	**1515**	**1,515**
Percidae	441,207			940,184	135,618	77	**1,517,009**	**77**	**1,517,086**
Percina spp.						106	**0**	**106**	**106**
Pimephales spp.	4,620						**4,620**	**0**	**4,620**
Pomoxis spp.	14,140			17,094	100,000		**131,234**	**0**	**131,234**
Quillback			3,459		17,171		**20,630**	**0**	**20,630**
River Shiner				17,094	90,293		**107,387**	**0**	**107,387**
Rock Bass					21,364	45	**21,364**	**45**	**21,409**
Rosyface Shiner			34,332				**34,332**	**0**	**34,332**
Shorthead Redhorse	380,842						**380,842**	**0**	**380,842**
Silver Chub						53	**0**	**53**	**53**
Skipjack Herring						53	**0**	**53**	**53**
Smallmouth Bass	70,000						**70,000**	**0**	**70,000**
Spotfin Shiner					111,405		**111,405**	**0**	**111,405**
Spottail Shiner					19,838	72	**19,838**	**72**	**19,910**
Spotted Gar			3,459				**3,459**	**0**	**3,459**
Stizostedion spp.		6,812			197,259	55	**204,071**	**55**	**204,126**
Tadpole Madtom	12,460			17,094	102,242		**131,796**	**0**	**131,796**
Trout Perch	13,160						**13,160**	**0**	**13,160**
Walleye	3,360						**3,360**	**0**	**3,360**
Western Sand Darter					39,158		**39,158**	**0**	**39,158**
White Bass			13,907	6,538,553	1,872,644		**8,425,104**	**0**	**8,425,104**
Yellow Bass						72	**0**	**72**	**72**
Yellow Bullhead							**0**	**0**	**0**
Yellow Perch					19,320		**19,320**	**0**	**19,320**
Total	**3,221,635**	**28,134,400**	**121,149**	**23,513,126**	**9,313,041**	**71,066**	**64,303,351**	**71,066**	**64,374,417**

Table 3-14: Estimated annual number of adult fish lost due to entrainment by power plant water intake structures.

	Larvae		Young-of-the-year		Juvenile		Lost future adults		
Fish species	Life stage duration (d)	Mortality rate (1/d)	Life stage duration (d)	Mortality rate (1/d)	Life stage duration (d)	Mortality rate (1/d)	**Upper Mississippi River**	**Illinois River/ Waterway**	**Upper Mississippi River/Illinois Waterway**
Black Bullhead									
Black Crappie	47	0.0489	318	0.0092	365	0.0016	**103**		**103**
Bluegill	40	0.0576	325	0.0142	365	0.0016	**21**		**21**
Bluntnose Minnow									
Brook Stickleback									
Burbot									
Catostomidae									
Centrarchidae									
Channel Catfish	47	0.049	318	0.0051	1095	0.00086	**3,540**	**1**	**3,541**
Cisco									
Clupeidae									
Common Carp	44	0.1047	321	0.0093	365	0.000099	**1,885**	**1**	**1,886**
Common Shiner									
Common Sucker									
Coregonus spp.									
Cyprinidae									
Emerald Shiner	5	0.92	360	0.0083	0	0.0041	**1,452**	**0**	**1,452**
Fathead Minnow									
Flathead Catfish	47	0.049	318	0.0016	365	0.00086	**911**	**0**	**911**
Freshwater Drum	37	0.227	328	0.007	1460	0.0007	**92**	**0**	**92**
Gizzard Shad	40	0.0548	325	0.0107	365	0.002	**50,531**	**0**	**50,532**
Ichthyomyzon spp.									
Ictaluridae									
Johnny Darter									
Largemouth Bass	36	0.0895	329	0.0139	365	0.00084	**0**	**0**	**0**
Lepomis spp.	40	0.0576	325	0.0142	365	0.0016	**130**	**0**	**130**
Logperch									
Micropterus spp.	36	0.0895	329	0.0139	365	0.00084	**12**	**0**	**12**
Mimic Shiner									
Mooneye	35	0.1316	330	0.0069	730	0.00027	**61**	**0**	**61**

Table 3-14 continued from previous page

Fish species	Larvae		Young-of-the-year		Juvenile		Lost future adults		
	Life stage duration (d)	Mortality rate (1/d)	Life stage duration (d)	Mortality rate (1/d)	Life stage duration (d)	Mortality rate (1/d)	**Upper Mississippi River**	**Illinois River/ Waterway**	**Upper Mississippi River/Illinois Waterway**
Micropterus spp.	36	0.0895	329	0.0139	365	0.00084	**12**	**0**	**12**
Mimic Shiner									
Mooneye	35	0.1316	330	0.0069	730	0.00027	**61**	**0**	**61**
Morone spp.									
Northern Pike	44	0.1047	321	0.0049	730	0.00175	**0**	**0**	**0**
Notropis spp.									
Percidae									
Percina spp.									
Pimephales spp.									
Pomoxis spp.									
Quillback									
River Shiner									
Rock Bass									
Rosyface Shiner									
Shorthead Redhorse	60	0.0767	305	0.0098	730	0.0015	**64**	**0**	**64**
Silver Chub									
Skipjack Herring									
Smallmouth Bass	25	0.1287	348	0.0132	730	0.00084	**15**	**0**	**15**
Spotfin Shiner									
Spottail Shiner									
Spotted Gar									
Stizostedion spp.									
Tadpole Madtom									
Trout Perch									
Walleye	60	0.0767	305	0.0053	1095	0.00013	**6**	**0**	**6**
Western Sand Darter									
White Bass	30	0.1073	335	0.01375	365	0.00084	**2,477**	**0**	**2,477**
Yellow Bass									
Yellow Bullhead									
Yellow Perch									
Total	**673**		**5,540**		**9,855**		**61,301**	**3**	**61,303**

Table 3-15: Estimated annual number of fish impinged by power plant water intake structures.

	Power Plant (Pool)															Totals				
Fish species	Riverside Generating Plant **(Upper St. Anthony Falls)**	High Bridge Generating Plant **(Pool 2)**	Prairie Island Nuclear Generating Plant **(Pool 3)**	Red Wing Generating Plant **(Pool 4)**	John P. Madgett Station **(Pool 5)**	Genoa #3 **(Pool 9)**	Quad Cities Station **(Pool 14)**	Riverside Generating Station **(Pool 15)**	Burlington Generating Station **(Pool 19)**	Wood River Generating Plant **(Open River)**	New Madrid Power Plant **(Open River)**	Hennepin Power Station **(Peoria Pool)**	E.D. Edwards Power Station **(LaGrange Pool)**	Havana Power Station **(LaGrange Pool)**	Meredosia Power Station **(Alton Pool)**	**Pooled Mississippi River**	**Open Mississippi River**	**Mississippi River**	**Illinois River/ Waterway**	**Upper Mississippi River/ Illinois Waterway**
Alabama Shad											7					**0**	**7**	**7**	**0**	**7**
Alewife															2	**0**	**0**	**0**	**2**	**2**
Alligator Gar											7					**0**	**7**	**7**	**0**	**7**
American Eel											7		5			**0**	**7**	**7**	**5**	**12**
American Smelt											75					**0**	**75**	**75**	**0**	**75**
Bigmouth Buffalo							29			1	34	40	252	25	11	**29**	**35**	**64**	**328**	**392**
Black Buffalo															4	**0**	**0**	**0**	**4**	**4**
Black Bullhead		8			4		487	27	84	7		63	351	21	10	**610**	**7**	**617**	**445**	**1,062**
Black Crappie	1,060	35			17	1,680	840	10	70	15		181	3,697	397	224	**2,652**	**15**	**2,667**	**4,499**	**7,166**
Blue Catfish										2	3,212	4	110			**0**	**3,214**	**3,214**	**114**	**3,328**
Blue Sucker							3									**3**	**0**	**3**	**0**	**3**
Bluegill		2			83	7,688	10,657	55	427	100	78	622	3,431	478	161	**18,912**	**178**	**19,090**	**4,692**	**23,782**
Bluntnose Minnow		1							49				8		1	**50**	**0**	**50**	**9**	**59**
Bowfin							32						54		13	**32**	**0**	**32**	**67**	**99**
Brindled Madtom													4			**0**	**0**	**0**	**4**	**4**
Brook Silverside													4			**0**	**0**	**0**	**4**	**4**
Brown Bullhead												36	33		2	**0**	**0**	**0**	**71**	**71**
Burbot			23,072		1											**23,073**	**0**	**23,073**	**0**	**23,073**
Bullhead Minnow					1								5			**1**	**0**	**1**	**5**	**6**
Campostoma spp.														4		**0**	**0**	**0**	**4**	**4**
Carpiodes spp.		7					507		56				134			**570**	**0**	**570**	**134**	**704**
Catostomidae			162,176						7			236	824	4	2	**162,183**	**0**	**162,183**	**1,066**	**163,249**
Central Mudminnow					1		15				13					**16**	**13**	**29**	**0**	**29**
Central Stoneroller													15			**0**	**0**	**0**	**15**	**15**
Centrarchidae			18,144													**18,144**	**0**	**18,144**	**0**	**18,144**
Channel Catfish	31	163	129,472		27	2,568	5,103	612	2,632	26	4,058	555	6,155	608	79	**140,577**	**4,084**	**144,661**	**7,397**	**152,058**
Chesnut Lamprey					1					2						**1**	**2**	**3**	**0**	**3**
Cisco																**0**	**0**	**0**	**0**	**0**
Common Carp	248	457	1,088,640		31		145	21	28	7	157	468	3,981	183	47	**1,089,322**	**164**	**1,089,486**	**4,679**	**1,094,165**
Common Carp x Goldfish												8	174			**0**	**0**	**0**	**182**	**182**
Common Shiner		5										20		4		**5**	**0**	**5**	**24**	**29**
Common Sucker																**0**	**0**	**0**	**0**	**0**
Coregonus spp.			448													**448**	**0**	**448**	**0**	**448**
Creek Chub												4	41	4		**0**	**0**	**0**	**49**	**49**
Cyprinidae			14,659,456										4			**14,659,456**	**0**	**14,659,456**	**4**	**14,659,460**
Emerald Shiner					4	364	1,019	72				1,432	27,675	114	32	**1,459**	**0**	**1,459**	**29,253**	**30,712**
Fathead Minnow					3		19	29					42			**51**	**0**	**51**	**42**	**93**
Flathead Catfish			2,688		84	816	232	65	427	29	859	8	320	53	9	**4,312**	**888**	**5,200**	**390**	**5,590**
Freshwater Drum			32,478,880		97	6,310	126,610	1,965	3,500	3,733	6,627	653	157,261	7,304	1,980	**32,617,362**	**10,360**	**32,627,722**	**167,198**	**32,794,920**
Ghost Shiner								11								**11**	**0**	**11**	**0**	**11**
Gizzard Shad		33,728	3,382,848	71	1,430	2,936	481,957	15,076	4,949	34,084	1,358	52,228	664,648	95,739	10,430	**3,922,995**	**35,442**	**3,958,437**	**823,045**	**4,781,482**
Golden Redhorse							14						20		7	**14**	**0**	**14**	**27**	**41**
Golden Shiner							197	11	7				27		3	**215**	**0**	**215**	**30**	**245**
Goldeye										8		12	72	9	4	**0**	**8**	**8**	**97**	**105**
Goldfish												236	1,159		1	**0**	**0**	**0**	**1,396**	**1,396**

Table 3-15 continued from previous page

	Power Plant (Pool)															Totals				
Fish species	Riverside Generating Plant **(Upper St. Anthony Falls)**	High Bridge Generating Plant **(Pool 2)**	Prairie Island Nuclear Generating Plant **(Pool 3)**	Red Wing Generating Plant **(Pool 4)**	John P. Madgett Station **(Pool 5)**	Genoa #3 **(Pool 9)**	Quad Cities Station **(Pool 14)**	Riverside Generating Station **(Pool 15)**	Burlington Generating Station **(Pool 19)**	Wood River Generating Plant **(Open River)**	New Madrid Power Plant **(Open River)**	Hennepin Power Station **(Peoria Pool)**	E.D. Edwards Power Station **(LaGrange Pool)**	Havana Power Station **(LaGrange Pool)**	Meredosia Power Station **(Alton Pool)**	**Pooled Mississippi River**	**Open Mississippi River**	**Mississippi River**	**Illinois River/ Waterway**	**Upper Mississippi River/ Illinois Waterway**
Grass Pickerel							12			2					2	**12**	**2**	**14**	**2**	**16**
Green Sunfish					1		35				34	138	899	118	12	**36**	**34**	**70**	**1,167**	**1,237**
Highfin Carpsucker							18									**18**	**0**	**18**	**0**	**18**
Hybopsis spp.									105							**105**	**0**	**105**	**0**	**105**
Ictaluridae													19			**0**	**0**	**0**	**19**	**19**
Ictiobus spp.							34		35							**69**	**0**	**69**	**0**	**69**
Iowa Darter																**0**	**0**	**0**	**0**	**0**
Johnny Darter					1		3		7							**11**	**0**	**11**	**0**	**11**
Largemouth Bass					7		712		14	13		40	327	53	6	**733**	**13**	**746**	**426**	**1,172**
Lepomis spp.			1,306,368									52	28,044	77		**1,306,368**	**0**	**1,306,368**	**28,173**	**1,334,541**
Logperch		1			388	325	478					16	145		5	**1,192**	**0**	**1,192**	**166**	**1,358**
Longear Sunfish													3		1	**0**	**0**	**0**	**4**	**4**
Longnose Gar				20			303			2	34	8	48	9	7	**323**	**36**	**359**	**72**	**431**
Mimic Shiner													8			**0**	**0**	**0**	**8**	**8**
Mooneye			448			241	1,831	17	182	3			29		1	**2,719**	**3**	**2,722**	**30**	**2,752**
Morone spp.												20	3,650			**0**	**0**	**0**	**3,670**	**3,670**
Moxostoma spp.							36						7		3	**36**	**0**	**36**	**10**	**46**
Mud Darter					3		15									**18**	**0**	**18**	**0**	**18**
Northern Pike	96	149			1		88		7			44	51			**245**	**0**	**245**	**95**	**340**
Northern Hog Sucker													9			**0**	**0**	**0**	**9**	**9**
Notropis spp.									126	40	7		6	4	1	**126**	**47**	**173**	**11**	**184**
Noturus spp.												4	54			**0**	**0**	**0**	**58**	**58**
Orangespotted Sunfish							219	4				20	338	4		**223**	**0**	**223**	**362**	**585**
Paddlefish							4			4	42	4	31	4	2	**4**	**46**	**50**	**41**	**91**
Percidae			62,944										268			**62,944**	**0**	**62,944**	**268**	**63,212**
Pimephales spp.									7							**7**	**0**	**7**	**0**	**7**
Pirate Perch											34		5	4		**0**	**34**	**34**	**9**	**43**
Pomoxis spp.			67,648									48	1,525	575	141	**67,648**	**0**	**67,648**	**2,289**	**69,937**
Pumpkinseed							499									**499**	**0**	**499**	**0**	**499**
Quillback					1		21	4			40	12	35		9	**26**	**40**	**66**	**56**	**122**
Rainbow Smelt													4		1	**0**	**0**	**0**	**5**	**5**
Rainbow Trout													3			**0**	**0**	**0**	**3**	**3**
Red Shiner												8	21	4		**0**	**0**	**0**	**33**	**33**
Redear Sunfish														13		**0**	**0**	**0**	**13**	**13**
Redfin Shiner												4				**0**	**0**	**0**	**4**	**4**
River Carpsucker							138	3		2		95	270	45	10	**141**	**2**	**143**	**420**	**563**
River Darter					7	186	28									**221**	**0**	**221**	**0**	**221**
River Shiner	184				1		186				50		17			**187**	**50**	**237**	**17**	**254**
Rock Bass					7	145	19					4			6	**171**	**0**	**171**	**10**	**181**
Sand Shiner		72														**72**	**0**	**72**	**0**	**72**
Sauger			20,608		4	187	92			9	77	8	108		8	**20,891**	**86**	**20,977**	**124**	**21,101**
Shorthead Redhorse					22	186	371						16	4	3	**579**	**0**	**579**	**23**	**602**
Shortnose Gar					1		172			5	43	44	305	9	66	**173**	**48**	**221**	**424**	**645**
Shovelnose Sturgeon										1	7		5			**0**	**8**	**8**	**5**	**13**
Silver Chub						337	667					20	161	13	5	**1,004**	**0**	**1,004**	**199**	**1,203**
Silver Lamprey					1		7	4								**12**	**0**	**12**	**0**	**12**

Table 3-15 continued from previous page

	Power Plant (Pool)															Totals				
Fish species	Riverside Generating Plant **(Upper St. Anthony Falls)**	High Bridge Generating Plant **(Pool 2)**	Prairie Island Nuclear Generating Plant **(Pool 3)**	Red Wing Generating Plant **(Pool 4)**	John P. Madgett Station **(Pool 5)**	Genoa #3 **(Pool 9)**	Quad Cities Station **(Pool 14)**	Riverside Generating Station **(Pool 15)**	Burlington Generating Station **(Pool 19)**	Wood River Generating Plant **(Open River)**	New Madrid Power Plant **(Open River)**	Hennepin Power Station **(Peoria Pool)**	E.D. Edwards Power Station **(LaGrange Pool)**	Havana Power Station **(LaGrange Pool)**	Meredosia Power Station **(Alton Pool)**	**Pooled Mississippi River**	**Open Mississippi River**	**Mississippi River**	**Illinois River/ Waterway**	**Upper Mississippi River/ Illinois Waterway**
Silver Redhorse					2											**2**	**0**	**2**	**0**	**2**
Silver Shiner													4			**0**	**0**	**0**	**4**	**4**
Silverband Shiner											13					**0**	**13**	**13**	**0**	**13**
Silvery Minnow							283					4	56			**283**	**0**	**283**	**60**	**343**
Skipjack Herring										5	798	201	5,907	114	30	**0**	**803**	**803**	**6,252**	**7,055**
Slenderhead Darter							7									**7**	**0**	**7**	**0**	**7**
Smallmouth Bass	11	35						1	42			8	50	4	10	**78**	**0**	**78**	**72**	**150**
Smallmouth Buffalo							963	1		6	190	16	186	37	13	**964**	**196**	**1,160**	**252**	**1,412**
Speckled Chub											34		13			**0**	**34**	**34**	**13**	**47**
Spotfin Shiner					2		9					4		4		**11**	**0**	**11**	**8**	**19**
Spottail Shiner					10	394	318	1				95	275			**723**	**0**	**723**	**370**	**1,093**
Spotted Sucker					5		14						6			**19**	**0**	**19**	**6**	**25**
Steelcolor Shiner													4			**0**	**0**	**0**	**4**	**4**
Stizostedion spp.																**0**	**0**	**0**	**0**	**0**
Stonecat							76		91			4	13			**167**	**0**	**167**	**17**	**184**
Striped Bass							16				29					**16**	**29**	**45**	**0**	**45**
Suckermouth Minnow										1			31			**0**	**1**	**1**	**31**	**32**
Tadpole Madtom			1,344		1	135	18					28	76	37		**1,498**	**0**	**1,498**	**141**	**1,639**
Threadfin Shad											384					**0**	**384**	**384**	**0**	**384**
Threespine Stickleback												4				**0**	**0**	**0**	**4**	**4**
Trout Perch					13							260	175	17		**13**	**0**	**13**	**452**	**465**
Walleye			2,688		5	133	330		14		31	79	19		1	**3,170**	**31**	**3,201**	**99**	**3,300**
Warmouth							3			6		8	5			**3**	**6**	**9**	**13**	**22**
White Bass			1,122,240		22	1,042	16,986	149	476	18	128	335	1,496	142	130	**1,140,915**	**146**	**1,141,061**	**2,103**	**1,143,164**
White Crappie					4		139	7	112	16	25	99	713	134	147	**262**	**41**	**303**	**1,093**	**1,396**
White Sucker					3		35					4	20	4		**38**	**0**	**38**	**28**	**66**
Yellow Bass							547					87	114	57	10	**547**	**0**	**547**	**268**	**815**
Yellow Bullhead		1			3		7	21	14			36	260	17	5	**46**	**0**	**46**	**318**	**364**
Yellow Perch					324	559	50		21							**954**	**0**	**954**	**0**	**954**
Total	1,630	34,664	54,530,112	91	2,623	26,232	653,655	18,166	13,489	38,147	18,492	58,667	916,340	106,450	13,657	**55,279,032**	**56,639**	**55,335,671**	**1,095,114**	**56,430,785**

3.1.12.3 Power Plant Intake Modifications that Have Reduced Fish Entrainment and Impingement Losses

The Prairie Island (Pool 3) Nuclear Generating Plant was modified by Northern States Power Company in 1983 to reduce fish entrainment and impingement losses through installation of fine mesh traveling screens with low-pressure backwash. This system has effectively eliminated all fish entrainment and has greatly reduced impingement of adult fish. The 1984 through 1986 data on impingement includes fish eggs, larvae, and small fish impinged on the fine mesh screens. Studies conducted in 1987 on survival of impinged fish found that survival varies widely between fish species and life stage, and is adversely affected by debris load. Survival of impinged fish varied between 2.8% and 42.1%. Some taxa, such as freshwater drum larva, are apparently more fragile and susceptible to impingement mortality on the traveling screens at the Prairie Island Plant, while others, such as channel catfish larvae, are more robust and suffer lower impingement mortality.

The original discharge design for the Quad Cities Nuclear Station, which began commercial operation in 1972, was an on-shore side-jet discharge along the Illinois bank of the UMR in Pool 14. However, this design was only utilized for 8 months when a study determined that this type of discharge would violate thermal criteria. The Station discharge design was then modified to operate in an open-cycle mode (once through) from August 1972 through May 1974; entrainment of larval fish occurred during the operation in an open-cycle mode. In resolving a lawsuit filed concerning the possible adverse effects of once-through cooling on the river biota, Commonwealth Edison constructed an off-stream spray canal system for cooling the discharge water from the Station. The Station operated in a closed-cycle system from May 1974 through December 1983. The cooling capacity of the spray canal system was inadequate to allow normal plant operation, particularly during the summer months. Concurrent with the operational history of the Quad Cities Station, extensive biological monitoring of the river ecosystem has been conducted each year to assess the impacts of Station operation. Results of these studies have not demonstrated any measurable effects of Station operation on the aquatic communities of the river under either closed-cycle or open-cycle operation. Following a thorough review of the data, an agreement was reached where open-cycle cooling could occur, contingent upon continued monitoring of the fish community (including fish impingement monitoring). This agreement became effective in January 1984, and the Station continues to operate in accordance with the agreement. The inactive spray canal, which is no longer used for cooling purposes, has been converted into a game fish rearing facility (LMSE 1995).

3.1.12.4 Cumulative Effects of Power Plant Entrainment and Impingement Losses

The summary of annual estimates of losses of fish due to entrainment and impingement represents the cumulative effect of power plant water intake structures on both a pool and system-wide basis. Given the data limitations (much of the data are over 20 years old; data from some power plants are only for a single year, while many years of data are available for others; sampling and analysis was performed using different methods usually for each power plant; etc.), this summary is the first attempt that we know of to quantify the annual cumulative losses of fish due to power plant water intake structures on a pool and system-wide basis. The numbers of larval fish lost due to entrainment can be large for some species, such as common carp, gizzard shad, freshwater drum, and yellow perch, due to their life histories; however, they must be kept in perspective: most larval fish do not survive to become adults that recruit into the population. The conversion of larval fish losses to adults lost using the EAL model represents more useful data that could be compared to a particular fish population if the data are available (e.g., percent of total mortality). However, because adequate population data are not available, the cumulative effects of entrainment and impingement losses due to power plant water intake structures on a particular fish species is unknown.

If adequate population data were available, the effects of the cumulative losses of a particular species could be evaluated. For example, annual losses due to entrainment and impingement might be important in years of poor class size but may have no effect during years of large class size. In addition, evaluating the effect of many years of losses due to entrainment and impingement on population size could be estimated for some species if the data were available. Losses due to entrainment and/or impingement could be significant for a rare fish species or any species listed as threatened or endangered. Estimates of larval fish lost (and the adult equivalents) due to entrainment by commercial vessels can be compared to the annual entrainment losses from power plants estimated in this analysis, to assess the impact of fish losses from vessel entrainment in context of other sources of mortality.

3.1.13 Exotic and Nuisance Species

Human activity in the UMRS Basin has resulted in wholesale modification of the landscape and introductions of many species that have changed the UMRS ecosystem. Human activity has allowed some native species to increase their range and become abundant due to environmental conditions that are different than conditions before European settlement (e.g., grazing, fire, or creation of disturbed habitats).

Native Americans brought the domesticated dog with them from Asia to North America in the late Pleistocene. As Native American populations became agriculturists in the UMRS region about 5,000 years ago, they cleared land by burning, domesticated a number of native plant species, and introduced other plants such as maize, beans, and squashes native to other parts of North and Central America. Some plants probably introduced to the UMRS region by Native Americans persist in the wild today, such as several species of sunflowers (*Helianthus* spp.) and lotus (*Nelumbo lutea*).

Early European contacts introduced human pathogens which decimated the Native American populations. The greatly reduced Native American populations along the UMRS resulted in reduced incidence of fire and succession of fire-maintained prairie habitats into forest. With increased European settlement in the early 1800's, free-ranging elk and bison which were abundant in the UMRS floodplains were hunted nearly to extinction and replaced with cattle, horses, and other domesticated farm animals.

Nearly all of the prairie habitat in the UMR Basin has been converted to forest, pasture, and farmland. Nearly all of the original forests in the UMRS basin have been logged, and converted to agriculture, farm wood lots, or industrial forests. The entire landscape of the UMRS Basin has been altered by human activity. Now the landscape is dominated by and intentionally managed for non-native species such as a variety of ornamental plants in residential areas and corn and soybeans in agricultural areas. Many exotic species have invaded the basins and floodplains, ranging from trees to zooplankton. The following discussion does not address the full range of introduced species, but does address some of the species that have been recently introduced to the UMRS, some of their ecological effects, and a forecast of future effects.

3.1.13.1 Plants

Many non-native plant species were introduced as crops, many more were introduced as ornamentals, and many plant species and plant pathogens were unintentionally introduced.

Black locust (*Robinia pseudoacacia*), native to the eastern U.S., was brought by settlers and planted for use as fence posts. Black locust is now a pest tree on disturbed areas and in the remaining prairie areas within the UMRS floodplains. Black locust is a persistent problem in prairie restoration areas.

Dutch elm disease was first detected in 1917 in Holland from where it spread quickly to other European countries. It reached England in 1927 and invaded the U.S. around 1930. A second invasion of the North American continent occurred in 1944 in Quebec. The disease is caused by a fungus, (*Ceratocystis ulmi*) which enters the tree through holes made by bark beetles (*Scolytidae* spp.) and produces toxins that interfere with sap flow. Dutch elm disease is one of the most devastating tree diseases to invade North America, killing millions of the stately elm trees that were once common in the UMRS floodplains. Dutch elm disease has effectively eliminated American elms (*Ulmus americana*) from the UMRS floodplain forests. The floodplain forests are presently responding to the loss of elms. The many dead elms provided habitat for cavity-nesting birds such as woodpeckers and wood ducks, but the elm snags are rapidly falling and becoming scarce. Many areas of the UMRS floodplain where elms died out have been invaded by Reed canary grass (*Phalaris arundinacea*), which is preventing recruitment of seedling trees. The smaller introduced Chinese elm, (*Ulmus parviflora*) is resistant to Dutch elm disease, and has colonized many UMRS floodplain areas.

Butternut (*Juglans cinerea*) is a common tree in northern portions of the UMRS floodplains. Beginning in 1967, increasing mortality was observed and was found to be caused by a canker disease specific to butternut. Live butternut has decreased as much as 80% in much of its range. Most remaining trees are diseased. The disease is caused by a bacterium (*Sirococcus clavigignenti-juglandacearum)* which is suspected to be an introduced pathogen.

A European ecotype of the native reed canary grass (*Phalaris arundinacea*) was introduced for agricultural purposes and has invaded much of the lower elevation areas of the UMR floodplains, aggressively forming dense single species stands which effectively prevent growth of seedling trees. Like reed canary grass, a European ecotype of stinging nettle (*Urtica dioica var. dioica*) has colonized much of North America and is very abundant in the forested parts of the UMRS floodplain. A number of shrubs, including autumn olive (*Elaeganus umbellata*), Buckthorns (*Rhamnus* spp.), bush honeysuckles (*Lonicera* spp.), Japanese honeysuckle (*Lonicera japonica*), and multiflora rose (*Rosa multiflora*), have been introduced and now are common in the UMR floodplains.

Purple loosestrife (*Lythrum salicaria*) is a wet meadow plant from Europe and Asia. It was introduced as an ornamental to North America in the 1880's and now occurs in 40 U.S. states and all the Canadian border provinces. Purple loosestrife invades wetlands, replacing cattails and other species. Loosestrife forms dense stands that provide limited habitat value. Ready dispersal of seeds by birds and by water allows widespread distribution of loosestrife in the UMRS. Loosestrife has reached nuisance densities in many locations along the UMR. Mechanical and chemical control is difficult, and biological control measures are being actively researched. Extensive areas of wetland habitat on the UMRS have been invaded by purple loosestrife. Loosestrife will probably continue to expand in the UMRS wetland areas until some combination of effective biological control measures are found. Several beetles have been found to eat purple loosestrife; *Galerucella* spp. beetles show promise as a biological control.

Sweet clover (*Melilotus* sp.) is a tall (2.0 m) herbaceous plant native to Europe and Asia. It was introduced by the Spanish to North America in the 1500's and is now found throughout the U.S. Sweet clover rapidly colonizes disturbed areas if moisture is sufficient, including dredged material placement sites on the UMRS. As a legume, it does serve to fix nitrogen in the soil, improving conditions for succeeding vegetation on disturbed sites.

Curly-leaf pondweed (*Potamogeton crispus*) is a rooted submersed aquatic plant originally from Europe that is now widespread in North America. Curly-leaf pondweed grows rapidly early in the spring and can form nuisance surface mats. The plants usually go senescent by early July. Curly-leaf pondweed is common in the UMR, seems tolerant of somewhat turbid conditions, may be adapted to the river due to its early growth strategy, and provides submersed vegetation that is used by fish and macroinvertebrates.

Eurasian watermilfoil (*Myriophyllum spicatum*) is a rooted submersed aquatic plant introduced to North America between the late 1800's and 1940's. Eurasian watermilfoil can grow rapidly and out-compete native aquatic plants. Unlike in lakes, it does not form dense surface mats in the UMR backwaters. Eurasian watermilfoil provides substrate for macroinvertebrates and cover for fish. Eurasian watermilfoil has not been found to reproduce sexually in the UMR, but it has become widespread in the last decade. Further spread through fragmentation and vegetative reproduction in UMRS backwaters appears likely. Eurasian watermilfoil will probably remain a common submersed aquatic plant in low velocity, fine substrate, shallow aquatic habitat in the UMRS for the foreseeable future.

3.1.13.2 Mammals

In addition to the non-native animals that have been brought to North America for agricultural purposes, there are a several non-native mammals that inhabit the UMRS floodplains. The Norway rat (*Rattus norvegicus*) is a European rat that invaded North America by ship in the 1500's. Now widespread, the Norway rat occurs close to cities, farms, and port facilities along the UMRS where municipal waste and waste grain are available. The Common cat (*Felis catus*) was imported to North America as a pet animal in the 1600's. Feral cats are now widespread and cause considerable mortality to birds and small mammals. Dogs (*Canis familiaris*) also become feral and prey on small mammals and deer in the UMRS region.

3.1.13.3 Birds

House sparrows (*Passer domesticus*), house finches (*Carpodacus mexicanus*), and starlings (*Sturnus vulgarus*) are all birds that have been introduced to the UMRS region and are now very common. House sparrows and starlings are from Europe. House finches are native to the western U.S., but were introduced to Long Island, New York, as pets, from where they expanded throughout the eastern half of the continent. House sparrows and starlings compete with many native species of ground-feeding birds such as red-winged blackbirds and wood thrushes. House finches compete with the native goldfinch.

Ring-necked pheasants (*Phasianus colchicus*) are native to Asia and are a popular European sport hunting bird introduced to North America in the 1700's. Ring-necked pheasants are now common in the upper Midwest and occur in UMRS floodplain areas. Their populations fluctuate markedly with winter weather and predation pressure.

3.1.13.4 Fish

The UMRS supports 143 species of indigenous fish (Pitlo *et al.* 1995). Bull sharks (*Carcharhinus feucas*) and striped mullet (*Mugil cephalus*) are rare strays from the ocean. Rainbow smelt (*Osmerus mordax*) invaded the Great Lakes from the Atlantic through the Welland Canal and have become established in the Great Lakes. Smelt have been reported from the UMRS, but are probably only strays that entered through the Chicago Ship Canal or through angler introductions and have not established populations in the UMRS rivers. Rainbow trout (*Oncorhyncus mykiss*) are native to North Pacific Ocean tributaries and were introduced to may rivers and lakes in the UMRS and Great Lakes basins. Rainbow trout occur in the UMRS rivers only as strays. Brown trout (*Salmo trutta*) which originated in Europe, were also widely stocked in coldwater lakes and streams in the UMRS and Great Lakes basins; they also only occur in the UMRS rivers as strays. Lake trout (*Salvelinus namaycush*) are native to cold northern lakes and have occurred in the UMRS as strays from hatcheries.

The common carp (*Cyprinus carpio*) was intentionally introduced to North America from Europe in the 1800's and is now one of the most widely distributed and abundant fish in the UMRS. Carp is the primary species caught in UMRS commercial fisheries. Common carp heavily graze aquatic vegetation, increase turbidity by their rooting activity, and may be suppressing the extent of submersed aquatic plants in the UMRS. Carp feed on zebra mussels in the UMRS (Tucker *et al.* 1997). The goldfish (*Carassius auratus*) was introduced from Asia to North America in the 1700's as an ornamental pond fish and has spread through most of the UMRS.

Other carp species native to Asia have been introduced intentionally to the UMRS. The grass carp (*Cttenopharyngodon idella*) was introduced from Asia to North America in this century for aquatic plant control. Silver carp (*Hypophthalmichthys molitrix*) and the bighead carp (*Hypophthalmichthys nobilis*) are filter feeders from Asia introduced for use in polyculture (U.S. Geological Survey 1998). Grass carp and bighead carp have established populations and are occasionally caught in the southern reaches of the UMRS rivers. The grass carp brought an Asian tapeworm that infected native red shiners (*Cyprinella lutrensis*) in the Mississippi River. The grass carp appear to be expanding their range and may be becoming more abundant in the Mississippi and Illinois Rivers. Bighead and silver carp populations are thought to be rapidly increasing in the UMRS. Black carp (*Mylopharyngodon piceus*) escaped from a fish farm in Missouri into the Osage River in April 1994 and may now be established in the Mississippi River (Ken Brummet, Missouri Department of Conservation, personal communication, 1999). The black carp is a molluscivore, which may prey on zebra mussels and native Unionids.

White catfish (*Ameiurus catus*) is native to Atlantic and Gulf of Mexico drainages in North America and has been introduced outside its native range for food and sport fishing.

Striped bass (*Morone saxatilis*) is an Atlantic marine species that can adapt to fresh water. Striped bass have been widely stocked in the southern UMRS Basin reservoirs as a sport fish. In addition, wipers (a hybrid of striped bass and the native white bass) have been stocked in the UMRS. Both striped bass and wipers are occasionally caught in the southern reaches of the UMRS rivers. They do not naturally reproduce in the UMRS and their presence is maintained by stocking.

White perch (*Morone americana*) are native to Atlantic coastal rivers and have invaded the Great Lakes through the Erie and Welland canals. White perch are prolific and may compete directly with sport fish species such as yellow perch and walleye. White perch have invaded the UMRS through the Chicago Ship Canal and are now established in the Illinois River. The white perch will probably expand its range, much to the detriment of native UMRS fishes.

The European minnows rudd (*Scardinius erythrophthalmus*) and tench (*Tinca tinca*) have been introduced to the UMRS Basin (U.S. Geological Survey 1998) by intentional stocking, but have not yet become abundant in the mainstem UMRS.

A number of exotic tropical freshwater fishes such as pacu (*Colossoma* sp.), cichlids (*Cichlasoma* sp.), black-banded rainbowfish (*Melanotaenia nigrans*), and piranha (*Pygocentrus* spp.) have been released from aquaria into the UMRS (U.S. Geological Survey 1998). Although a few individuals have survived in thermal refuges near power plants, no populations have become established. Some populations of guppy (*Poecilia reticulata*) may persist in the wild within the UMRS Basin, but they have not become established in the UMRS.

Several fishes have invaded the Great Lakes and are poised to invade the UMRS through the Chicago Ship Canal and Calumet River (New York Sea Grant Program 1998). The round goby (*Neogobius melanostomus*) is a small (up to 25 cm long) bottom-dwelling fish native to Europe which was introduced to the Great Lakes in ship ballast water. Now established in Lakes Erie, Huron, Michigan, and Superior, round gobies have been already found in Calumet Harbor and the Calumet River. Round gobies can be prolific spawners, and may compete with native benthic fishes such as sculpins and darters. They are expected to be harmful to native fishes in the UMRS should they invade.

Tubenose gobies (*Proterorhynus marmoratus*) were apparently introduced from Europe into Lake St. Clair in the Great Lakes via ship ballast water along with the round goby. The tubenose goby has established a population in Lake St. Clair and the Detroit River, but it has not yet spread throughout the Great Lakes.

The ruffe (*Gymnocephalus cernuus*) is a small (10 cm long) fish native to Eurasia that was introduced into Lake Superior in ship ballast water in the mid-1980's. The ruffe is prolific, grows fast, and may disrupt native fish communities by eating eggs of other fishes and through competition for macroinvertebrate food. The ruffe has not yet spread into Lake Michigan or the UMRS.

Alternatives to prevent invasion of exotic fishes from the Great Lakes into the UMRS are being examined (Pam Theil, U.S. Fish and Wildlife Service, Onalaska, Wisconsin, personal communication, 1998). Some type of electrical barrier and other fish deterrent measures will be installed at the upper end of the Illinois River.

3.1.13.5 Macroinvertebrates

Rusty crayfish (*Orconectes rusticus*) are native to the Ohio and Tennessee River Basins. Rusty crayfish have been spread by releases from angler bait buckets into many lakes and rivers in the UMRS Basin. They are prolific, out-compete native crayfish, and graze heavily on submersed aquatic vegetation. Rusty crayfish have not yet established populations in the UMRS, but they do occur in a floodplain lake on the UMR in Pool 6 near Trempealeau, Wisconsin. Expansion of rusty crayfish into the UMRS may yet occur, and they may affect the abundance of submersed aquatic plants.

The zebra mussel (*Dreissena polymorpha*) is a small (2 cm long) mussel native to southern Russia. Zebra mussels are presently imposing significant ecological changes in the Great Lakes and in the UMRS. Zebra mussels were introduced into Lake St. Clair in 1985 or

1986 from ship ballast water (Ludyanskiy *et al.* 1993). Zebra mussels have a planktonic veliger larval stage that allows widespread distribution by currents, and the adults attach tenaciously to nearly any hard substrate. Zebra mussels have spread throughout the Great Lakes, entered the Mississippi River system via the Illinois River, and have been distributed by commercial vessels throughout the UMRS up to the head of navigation at Minneapolis, Minnesota (Cope *et al.* 1996).

Zebra mussels cause millions of dollars of added expense to industries and utilities because they foul intake pipes, water treatment systems, trash racks, debris screens, and cooling water systems on commercial vessels. Zebra mussels have severely affected native Unionid mussels by smothering their siphons, adding weight, preventing movement and burrowing, restricting shell gape, competing for food, and creating anaerobic conditions (Schlosser and Kovalak 1991). Zebra mussels have caused the nearly complete extirpation of Unionid mussels from Lake St. Clair (Nalepa 1996; Gillis and Mackie 1994). Most Unionid mussels in the UMR are now infested with zebra mussels (Tucker 1994, Theil 1998). Efforts are under way to find effective refugia from zebra mussels for native UMR Unionids (Naimo 1998).

Zebra mussels filter large quantities of particulate matter from the water and excrete feces, pseudofeces, and dissolved wastes (James *et al.* 1997). Zebra mussels have greatly increased water clarity in parts of the Great Lakes (Ludyanskiy *et al.* 1993). Zebra mussels are apparently exerting significant effects on water quality in the Illinois River (Whitney *et al.* 1995), the Seneca River in New York (Effler and Siegfried 1994; Effler *et al* 1996), and in parts of the UMR (Sullivan and Endris 1998). Unusually clear water conditions, accompanied by unusually low dissolved oxygen conditions, were noted in Pools 9 and 10 during low-flow periods in 1997 and 1998. An interagency investigation into the spatial distribution, population structure, and water quality effects of zebra mussels in the UMR is presently under way.

Zebra mussels have attained high densities in the Great Lakes and in the Illinois and Mississippi Rivers. Measured in tens of thousands per square meter, zebra mussels are now well established in the UMRS. Although zebra mussel densities have declined markedly in the Illinois River, veliger larvae from Lake Michigan will continue to contribute to zebra mussel populations in the Illinois River which may reach high densities again when water quality conditions allow (Whitney *et al.* 1995). The high density colonies of zebra mussels in Lake Pepin will probably continue to serve as a veliger source for downriver pools on the UMR. Adult zebra mussels will continue to be distributed by commercial and recreational vessels. Zebra mussels are probably a permanent component of the benthic fauna in the UMRS. Zebra mussel densities will probably vary from year to year as the populations are affected by water quality, disease, and predation. Zebra mussels will continue to exert some effects on water quality in areas where their density is high during periods of low river discharge. Although zebra mussels are expected to exert a devastating effect on the native Unionid mussels in the UMRS, the patchiness of their distribution within the river system may allow some habitats to function as refugia for the native mussel species (Tucker and Atwood 1995).

A close relative to the zebra mussel, the quagga mussel (*Dreissena bugensis*), also originated in eastern Europe near the Caspian sea and was introduced to the Great Lakes in ship ballast water. The quagga mussel now occurs throughout Lakes Erie and Ontario, and may eventually invade the UMRS. It has somewhat different environmental requirements (occurs in deeper, colder water) than the zebra mussel (Mills 1993) and may not pose an ecological threat to the UMRS.

The Asian clam (*Corbicula fluminea*) is another small (<1-cm) Asian mussel introduced to the Mississippi River system through ship ballast water. The Asian clam is intolerant of cold water temperatures and reaches highest densities in the Ohio River and southward. It persists in the UMRS in thermal refugia near power plants. Unlike zebra mussels, Asian clams do not attach to substrates and have apparently not had detrimental effects on native Unionid mussels (Payne and Miller 1998).

Several species of snails have been introduced to the UMRS Basin. The European faucet snail (*Bithynia tentaculata*) has invaded the Great Lakes and the Ohio River drainage where it has displaced native snails. The prosobranch faucet snail tends to be lacustrine but may become established in UMRS backwater areas. The pulmonate Asian big-ear radix (*Radix auricularia*) and the Chinese mysterysnail (*Cipangopaludina chinensis malleata*) have apparently escaped from aquaria. Their large size and quiet water habitat requirements indicate that they may not become abundant in the UMRS.

The spiny water flea (*Bythotrephes cederstroemi*) is a large planktonic crustacean (5 mm long) introduced from Europe to Lake Huron, probably through ship ballast water (Sea Grant 1998). It is now found throughout the Great Lakes and has been reported from the Illinois River. The spiny water flea has a long, sharp, barbed tail spine. It may compete with other native zooplankton for food, but it may be relatively unpalatable as food to young-of-year fish.

Another exotic planktonic crustacean, *Daphnia lumholtzi*, is native to Africa, Asia, and Australia. It appeared in Texas and Missouri in 1990 and 1991 and has since spread to reservoirs and lakes throughout the southern and eastern U.S. It has been reported from the Illinois River (Stoeckel *et al.* 1996). Like the spiny water flea, it has long spines, may compete with native zooplankton, and may not be edible by young-of-year fish.

3.2 Physical Habitat Change

Physical change was assessed in detail in Chapters 5 and 7 of this report (Volume 1), but plan form change data are presented here (Figure 3-1 and Figure 3-2) to help distinguish geographic trends where they are evident. Upstream-downstream changes in direction and rate of change and regional trends are important to assess broad-scale ecological change because the distribution of many species is strongly influenced by the availability of and access to specific habitats. Each of the major habitat classes will be discussed briefly to identify ecologically significant changes and trends.

In general, Pools 5 through 9 have experienced an increase in total open water area during the post-dam period. The trend is consistent with increases since impoundment, and this increase is projected to continue, at a slightly slower rate, to 2050. Pool 7 is unique in that it showed a large increase in secondary channel and contiguous backwater areas (2,368 acres) during the 1973 to 1989 period, but this trend is projected to reverse in the future because the backwater formed by delta formation is filling. Pools 4 and 10 through 26 (except 16) have either decreased in total open water area or have remained relatively stable during the post-dam period to the present. Pool 16 is unique in this group because open water area has increased slightly and is projected to continue to increase, probably due to its location in the Fulton-Rock Island gorge. Usually, future projections are for continued increases, but at reduced rates.

Main channel habitat decreased downstream from Pool 10 (except Pools 13, 16, 19 and 20), with Pools 11 and 18 showing the greatest loss of main channel area. There was also a loss of 1,343 acres (5.8%) in Pool 4. Future projections indicate downward trends or no change. The outlier pools (13, 16, and 20) show relatively small increases or no change in main channel area. Main channel area in Pool 19 reached a peak in 1940 and has been decreasing since then. Increases in main channel area in Pools 5 to 10 were minor in acreage, except Pools 8 and 9 where erosion of islands in the lower portions of the pools has continued through the post-dam period. Projections indicate continued increases in main channel area, but at much lower rates in Pools 8 and 9.

Secondary channel area has been reduced throughout the river except in Pools 6, 7, 10, 16, and 18, where their area has increased to various degrees. Loss of secondary channels is projected to continue at a lower rate except in Pools 5, 21, and 26 where the change will be greater than in the past. The river reaches between Pools 7 and 12 and Pools 18 and 19 are the most dynamic in terms of the amount of secondary channel change.

Contiguous backwater area has increased in Pools 5, 5a, 6, 7, and 11; the projected trend in these pools is the same, but at a lower rate. In contrast, Pool 12 is projected to experience contiguous backwater loss in the future. Pools 4, 8, 9, and 10 have experienced loss of contiguous backwaters, but the projections differ. Pools 4 and 10 are expected to continue to lose contiguous backwaters due to sediment transport from upstream (mainly the Minnesota River and the Wisconsin River, respectively). However, the projected trend in Pools 8 and 9 is for increases in contiguous backwater area as islands are dissected or as secondary channels are closed off at their upper ends. All pools south of Pool 12 have lost, and are expected to continue to lose, contiguous backwaters except for very minor increases in Pools 15, 20, 22, and 26.

Isolated backwater area has increased or remained stable in Pools 4 through 10, with major increases (1,225 acres) occurring in Pool 6. Projections are for stability or a reduced rate of change in the future. In Pools 11 through 26, the trend has been toward loss or stability of isolated backwaters, with Pools 13, 17, 19, and 26 showing the greatest change. Future projections indicate continued loss, but at reduced rates.

The area of islands has either increased, remained stable, or decreased very slightly in the majority of the river. Major exceptions occurred in Pools 5, 8, and 9 where islands have been eroded by wind- and boat-generated waves in the lower portions of these pools. Large increases in island area occurred in Pools 4, 5a, 7, 10, 13, 18, 19, and 21. Future projections indicate continued stability or change at lower rates.

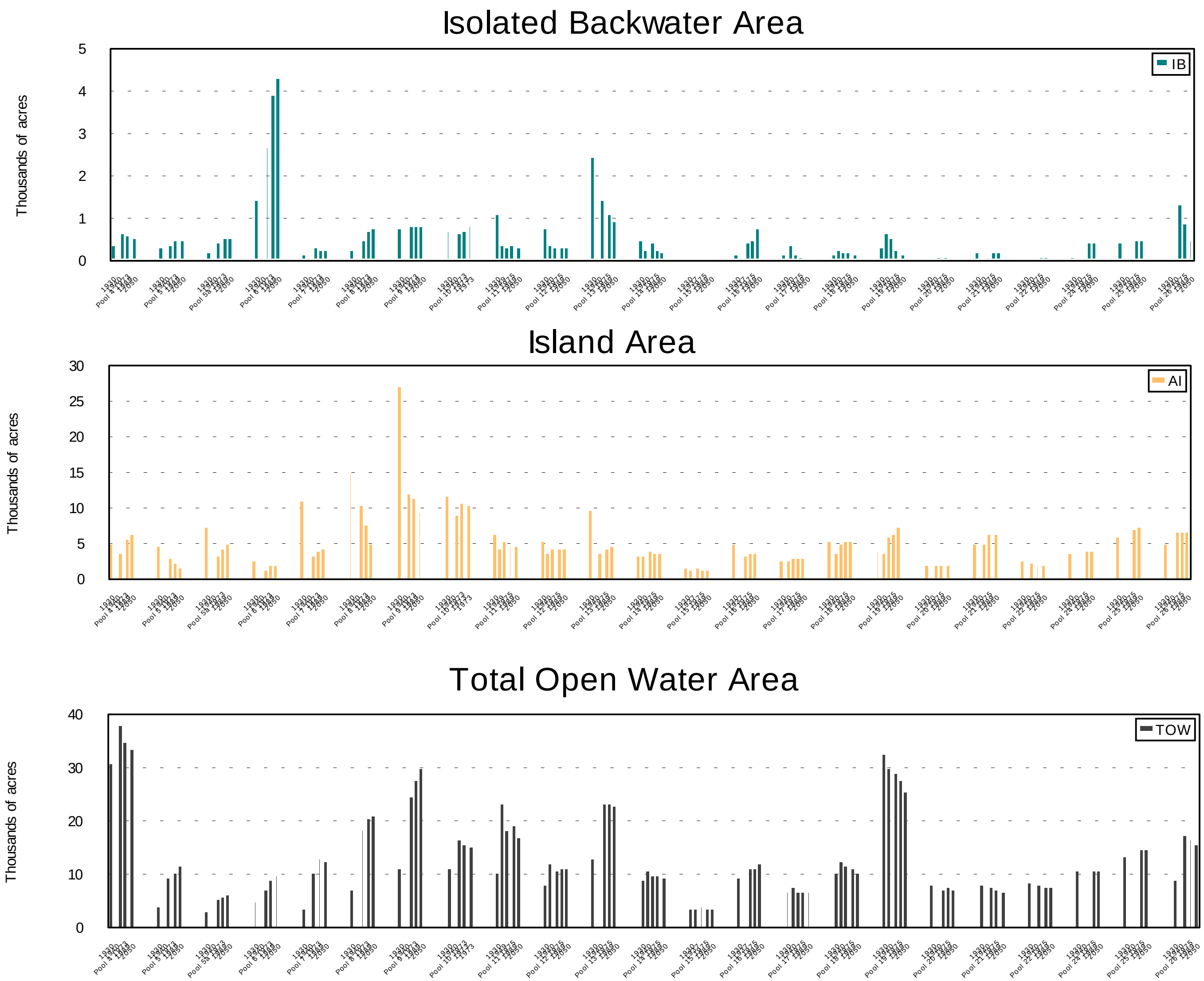


Figure 3-14: Areal change in Upper Mississippi River aquatic habitat classification units defined by the Cumulative Effects consultant team. The X axis order is years: 1930, 1940, 1975, 1989, and 2050; gaps within pools are periods for which data were missing.

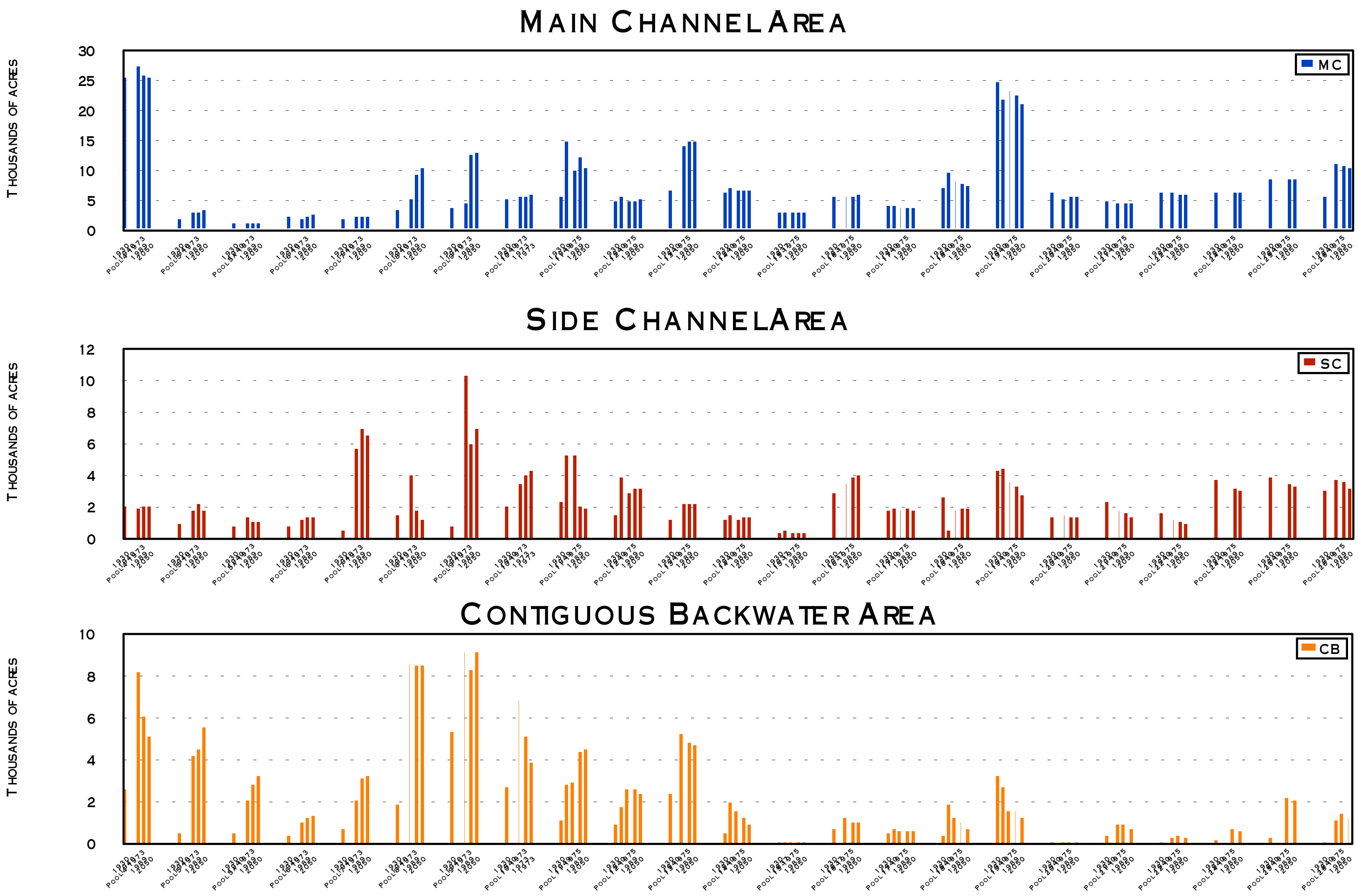


Figure 3-15: Areal change in Upper Mississippi River aquatic habitat classification units defined by the Cumulative Effects consultant team. The X axis order is years: 1930, 1940, 1975, 1989, and 2050; gaps within pools are periods for which data were missing.

3.2.1 A Pool-by-Pool Assessment of Ecological Changes

The plan form change analyses are used here to estimate change in the abundance of aquatic guilds. Plan form data were gathered from Brown's survey maps (ca. 1930), aerial photographs (1940 and 1973), and GIS maps (1989). All plan form data were gathered at summer, low-flow conditions. Estimates of change in abundance were assumed to be directly related to the percent and areal change in their preferred aquatic area because attributes of habitat quality could not be assessed. The general descriptions provided below are supported in more detail by tables and graphs of aquatic area change for each pool. Table 3-1 presents an example of the format that is repeated for each pool in Appendix S; analysis results are summarized in Table 3-2.

3.2.1.1 Pool 4

The most apparent change between 1973 and 1989 in Pool 4 has been the loss of 43% (1,546 acres) of upper pool backwaters due to the growth of the upper pool delta. There has also been an increase of 85% (1,712 acres) in island area and number (36%, 34 islands) in the lower pool. Contiguous backwater loss was evident in the lower pool where there was a 10% loss (479 acres); for the whole pool contiguous backwater loss was about 2,200 acres. Isolated backwater loss was less than 10% and estimated at approximately 60 acres. Channel habitats showed relatively little change.

Ecological impacts related to the plan form change are likely to be exhibited in backwater dependent guilds. The abundance of many backwater dependent species, such as the centrarchids, has probably declined concurrent with, and in proportion to, the loss of backwater habitat. The future projection indicates continued backwater loss, and it is anticipated that backwater species will continue to decline in abundance, though Upper Lake Pepin will continue to provide suitable habitat.

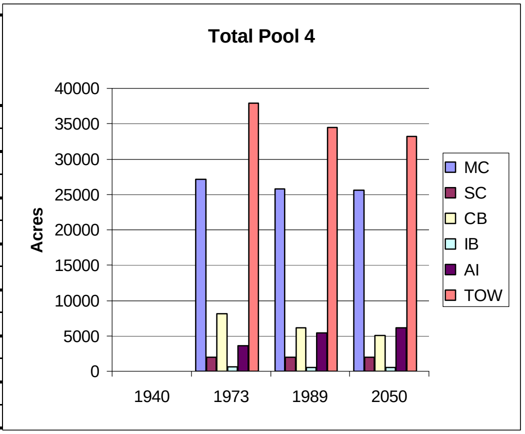
Of particular importance is the fact that many species of submersed aquatic vegetation no longer occur in most upper pool backwaters (EMTC 1999). The only species that occurs with regularity is sago pondweed which appears in the early spring and is gone by mid-summer, leaving macroinvertebrates and fish that require vegetation without the habitat they need. Foraging habitat for herbivorous reptiles, amphibians, and waterfowl has correspondingly declined since impoundment.

3.2.1.2 Pool 5

Two aquatic area classes have changed in Pool 5 between 1973 and 1989. Secondary channels have decreased by 15% (221 acres) in the upper pool, but increased 189% (552 acres) in the lower pool. Upper pool secondary channels apparently became contiguous backwaters because there were 22% (786 acres) and 33% (113 acres) increases in upper pool contiguous and isolated backwaters, respectively. Islands are becoming smaller and more numerous in the upper pool. Future change is projected to be slight, but indicates a continued transition of upper pool secondary channels to contiguous backwaters. A slight increase (250 acres) in main channel area is also anticipated.

Table 3-16: An example of results presented in Appendix S for UMRS navigation Pools 4-26.

Pool 4 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	23,562		24,963	23,600	-5.5%	23,364	-1.0%		
	Lower	2,011		2,210	2,230	0.9%	2,230	0.0%		
Secondary channel	Upper	1,421		1,324	1,323	-0.1%	1,323	0.0%		
	Lower	603		625	659	5.4%	659	0.0%		
Contiguous backwater area	Upper	2,033		3,612	2,066	-42.8%	1,653	-20.0%		
	Lower	604		4,533	4,054	-10.6%	3,446	-15.0%		
Isolated backwater area	Upper	193		420	384	-8.6%	346	-9.9%		
	Lower	151		201	189	-6.0%	180	-4.8%		
Island area	Upper	3,371		1,654	1,726	4.4%	1,726	0.0%		
	Lower	1,562		2,006	3,718	85.3%	4,462	20.0%		
Island perimeter	Upper	330,400		283,300	158,200	-44.2%	158,200	0.0%		
	Lower	204,750		463,350	768,400	65.8%	998,920	30.0%		
Island number	Upper	26		23	21	-8.7%				
	Lower	41		114	148	29.8%				



Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Unrooted Submersed Aquatics	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Floating Perennials	CB,IB	LOW,MED	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Floating Annuals	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Emergent Perennials	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Emergent Annuals	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	minor habitat loss in upper pool (MC) replaced by new habitat (SC) in lower pool
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	minor habitat loss in upper pool (MC) replaced by new habitat (SC) in lower pool
Lentic Limnetic (standing water)	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Lentic Profundal (standing water, basin)	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	minor habitat loss in upper pool (MC) replaced by new habitat (SC) in lower pool
Lentic	CB	MED,HIGH,LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Fish			
Rheophil	MC,SC	MED,HIGH	little change
Rheo-Limnophil	MC,SC,CB	MED,LOW	channels stable, impact from upper pool contiguous backwater loss
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	channels stable, impact from upper pool contiguous backwater loss
Limno-Rheophil	CB,SC,MC	LOW,MED	loss of habitat in upper and lower pool contiguous backwaters, channels stable
Limnophil	CB, IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Pelagic Limno-Rheophil	CB,SC,MC	LOW	loss of habitat in upper and lower pool contiguous backwaters, channels stable
Amphibians and Reptiles			
Lentic	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Lotic	MC,SC	LOW	minor habitat loss in upper pool (MC) replaced by new habitat (SC) in lower pool
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	channels stable, impact from upper pool contiguous backwater loss
Dabbling Ducks, Geese and Swans	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)

Table 3-17: The overall change (+ = increase, - = decrease, NC = no change) in habitat for a particular guild during the study period (1930 to 2050).

Guild/Pool	Pool 4	Pool 5	Pool 5a	Pool 6	Pool 7	Pool 8	Pool 9	Pool 10	Pool 11	Pool 12	Pool 13	Pool 14	Pool 15	Pool 16	Pool 17	Pool 18	Pool 19	Pool 20	Pool 21	Pool 22	Pool 24	Pool 25	Pool 26
Aquatic Vegetation																							
Rooted Submersed Aquatic Vegetation	-	+	+	+	+	+	+	-	-	-	-	-	NC	+	-	-	-	NC	-	-	NC	-	-
Unrooted Submersed Aquatic Vegetation	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Floating Leaved Perennial Aquatic Vegetation	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Floating Leaved Annual Aquatic Vegetation	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Emergent Perennial Aquatic Vegetation	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Emergent Annual Aquatic Vegetation	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Macroinvertebrates																							
Lotic Erosional Macroinvertebrates	-	+	NC	+	+	+	+	+	-	-	+	-	NC	+	-	-	-	+	-	-	-	-	-
Lotic Depositional Macroinvertebrates	-	+	NC	+	+	+	+	+	-	-	+	-	NC	+	-	-	-	+	-	-	-	-	-
Lentic Limnetic Macroinvertebrates	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Lentic Littoral Macroinvertebrates	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Lentic Profundal Macroinvertebrates	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Freshwater Mussels																							
Lotic Freshwater Mussels	-	+	NC	+	+	+	+	+	-	-	+	-	NC	+	-	-	-	+	-	-	-	-	-
Lentic Freshwater Mussels	-	+	+	+	+	+	NC	-	+	+	-	-	+	+	-	-	-	NC	-	+	-	-	-
Fish																							
Rheophilic Fish	-	+	NC	+	+	+	+	+	-	-	+	-	NC	+	-	-	-	NC	-	-	-	-	-
Rheo-Limnophilic Fish	-	+	+	+	+	+	+	-	-	-	+	-	NC	+	-	-	-	NC	-	-	-	-	-
Pelagic Rheo-Limnophilic Fish	-	+	+	+	+	+	+	-	-	-	+	-	NC	+	-	-	-	NC	-	-	-	-	-
Limno-Rheophilic Fish	-	+	+	+	+	+	+	-	-	-	+	-	NC	+	-	-	-	NC	-	-	-	-	-
Limnophilic Fish	-	+	+	+	+	+	NC	-	+	+	-	-	NC	+	-	-	-	NC	-	+	-	-	-
Pelagic Limno-Rheophilic Fish	-	+	+	+	+	+	+	-	-	-	+	-	NC	+	-	-	-	NC	-	+	-	-	-
Amphibians and Reptiles																							
Lentic Amphibians and Reptiles	-	+	+	+	+	+	NC	-	+	+	-	-	NC	+	-	-	-	NC	-	+	-	-	-
Lotic Amphibians and Reptiles	-	+	NC	+	+	+	+	+	-	-	+	-	NC	+	-	-	-	+	-	-	-	-	-
Waterfowl																							
Diving Ducks	-	+	+	+	+	+	NC	-	+	+	-	-	NC	+	-	-	-	NC	-	+	-	-	-
Dabbling Ducks	-	+	+	+	+	+	+	-	-	-	+	-	NC	+	-	-	-	NC	-	+	-	-	-

All guilds are expected to be slightly and equally impacted by habitat transition. In most cases, habitats being lost in the upper pool are being replaced in the lower pool for little net change in the whole pool. Because this is a short pool and the guilds are either mobile or have local populations that can expand (e.g., aquatic vegetation), little net change in the abundance of these guilds is expected.

3.2.1.3 Pool 5a

Little change has occurred in Pool 5a since 1973. The greatest change in aquatic area occurred in lower pool contiguous backwaters, and that was less than a 400-acre loss. Lower pool side channels decreased by 263 acres, indicating a shift from side channel to backwater. Total open water area increased 657 acres. In general, the slight increase in backwater area indicates that the backwater guilds should have increased habitat availability. Island development occurred in the upper pool where there were 47 more islands totaling 887 acres.

3.2.1.4 Pool 6

Two large changes have occurred in Pool 6 between 1973 and 1989. Upper pool secondary channels have expanded by more than 100% (141 acres), and a large isolated backwater area gained 1,074 acres (54%) of open water as islands and emergent vegetation were eroded by wind-generated waves similar to island loss occurring in several lower pool areas (Keith Beseke, USFWS Upper Mississippi Fish and Wildlife Refuge, Winona, Minnesota, personal communication, 1998). Upper pool main channel area has increased 26% (127 acres). Island area increased (122 acres), and their number also increased (13) due to island dissection. Lower pool main channel area has increased slightly (9%, 139 acres), as have contiguous backwaters (25%, 127 acres). In addition, the area (276 acres, 37%) and number of islands (86) have increased due to a combination of island dissection and growth of islands.

All open water guilds are presumed to have benefited from the increase in total open water area. Backwater guilds will benefit in the lower pool where backwaters have expanded. Channel dwellers will benefit more in the upper pool where secondary channel and backwater area has increased.

3.2.1.5 Pool 7

The largest change in Pool 7 between 1973 and 1989 has been a 25% increase (1,296 acres) in the area of lower pool secondary channels due to the growth of a channel delta into Lake Onalaska. Upper pool contiguous backwater area increased 83% (960 acres). Island area and number increased in both portions of the pool. Future projections indicate continued island growth and little change in the other aquatic area classes.

Because the geomorphologic changes affect secondary channels and contiguous backwaters, most guilds should be positively affected by the increase in total open water area (2,368 acres). Species dependent on the slower flow in backwaters (i.e., aquatic vegetation, lentic invertebrates, limnophilic fishes, and waterfowl) have increased habitat in the upper pool, while the more flow-adapted guilds (i.e., lotic invertebrates, mussels, rheophilic fishes, and diving ducks) have increased habitat in the lower pool. The projected change is unlikely to impact the guilds significantly.

3.2.1.6 Pool 8

The greatest change in Pool 8 between 1973 and 1989 is the erosion of 49 islands (1,685 acres) in the lower pool area (see Figure 5-50, Volume 1) and island dissection in the mid-pool area. Main channel area in the lower pool increased 119% (4,098 acres) due to the loss of islands, and 83% (2,582 acres) of the complex secondary channels that flowed between islands were lost. The resulting habitat is much less complex and provides uniform depth throughout much of the lower pool. The area is oriented such that it is subject to wind-generated waves that can resuspend fine sediments and cause a reduction in water clarity. Island dissection near the middle of the pool has created a 17% increase (166 acres) in secondary channels and 84 new islands in the upper pool. Although not of equal scale, some habitat lost in the lower pool has been replaced in the upper pool. The projected future condition indicates that similar changes will continue, although at a reduced rate.

The transition to open water in the lower pool was not favorable to aquatic vegetation because the area is too deep for rooted vegetation and unrooted vegetation drift in the low-flow area. Lotic-erosional macroinvertebrates lost the swift secondary channel habitat, and lentic littoral macroinvertebrates do not have the aquatic vegetation they need. The other macroinvertebrate guilds have increased habitat in the open water area. The lower pool currently provides poor lotic mussel habitat in the low-flow environment, but lentic mussel habitat has increased. Fishes generally have poorer habitat due to the reduced complexity, but the limno-rheophils are adapted to the low-flow environment. Amphibians are negatively impacted by the loss of habitat complexity and inability to support aquatic vegetation. Waterfowl are generally negatively impacted by reduced habitat complexity and loss of shelter, nesting islands, and emergent vegetation in the wind-swept area.

3.2.1.7 Pool 9

Habitat change in Pool 9 between 1973 and 1989 was very similar to that which has occurred in Pool 8. Main channel habitat in lower Pool 9 increased 402% (almost 8,100 acres), and 49% of islands (4,900 acres) and 85% of secondary channel and backwater habitat were lost (1,626 acres). The resulting habitat is much less complex and provides uniform depth throughout much of the lower pool. The area is subject to wind-generated waves that can resuspend sediments, causing a reduction in water clarity. Island dissection in the upper pool has created a 211% increase (640 acres) in secondary channels and 133 islands. Although not of equal scale, some habitat lost in the lower pool has been replaced in the upper pool. The projected future condition indicates that similar changes will continue at a reduced rate.

The transition to open water has not been favorable to aquatic vegetation because the area is slightly too deep for rooted vegetation, and unrooted vegetation drift in the low-flow area. Lotic-erosional macroinvertebrates lost the swift secondary channel habitat, and lentic littoral macroinvertebrates do not have the aquatic vegetation they need. The other macroinvertebrate guilds have increased habitat in the open water area, and recent studies show higher fingernail clam densities than in lower Pool 8 (Lara Hill, U.S. Fish and Wildlife Service, Onalaska, Wisconsin, personal communication, 1999). The lower pool currently provides poor lotic mussel habitat in the low-flow environment, but lentic mussel habitat increased. Fishes generally have poorer habitat due to the reduced complexity, but the limno-rheophils are adapted to the low-flow environment. Amphibians are negatively impacted by the loss of habitat complexity and inability to support aquatic vegetation. Waterfowl are generally negatively impacted by reduced habitat complexity and loss of shelter in the wind-swept area.

3.2.1.8 Pool 10

Contiguous backwater habitats have been lost (40%; 2,128 acres) in the upper reach of Pool 10 between 1973 and 1989. There has been a corresponding increase in island area (23%; 1,667 acres), secondary channels (22%; 385 acres), and isolated backwaters (7%; 35 acres). Island numbers have increased in the lower pool, which created more secondary channels and contiguous backwaters (30%; 444 acres). Future projections indicate change to continue at a slightly lower rate.

Habitat is quite complex in Pool 10, but the loss of upper pool backwaters will negatively impact aquatic vegetation, lentic macroinvertebrates, limnophilic fishes, amphibians, reptiles, and waterfowl. Rheophilic fish, lotic mussels, and lotic macroinvertebrate habitat increased with the formation of new secondary channels. Habitat transitions in the pool are somewhat balanced, with habitat lost in the upper pool being replaced by similar habitat in the lower pool.

3.2.1.9 Pool 11

Upper Pool 11 has lost total open water area. About 500 acres of main channel area, 500 acres of secondary channel area, and 300 acres of backwater area have been lost. Between 1940 and 1989 in the lower pool, a string of islands (54) formed from Wisconsin River sediments along the edge of the main channel to form a large contiguous backwater (1,800 acres). There has been a loss of about 2,000 acres of main channel area and 2,700 acres of secondary channel area in the lower pool.

Upper Pool 11 remains complex, but a trend, toward loss of aquatic area is evident, and further loss is projected for the future. The lower pool is currently a broad open water area, but island formation is increasing habitat complexity in the lower pool. The changes in habitat availability are somewhat balanced. Aquatic plant habitat has increased in the lower pool. Lotic macroinvertebrates have lost habitat in the upper pool, but the lentic macroinvertebrates have increased habitat availability in the lower pool.

Mussel habitat has been lost in the upper pool. Fishes have lost habitat in the upper pool, but limnophilic fish habitat has increased in the lower pool. Amphibian and reptile habitat has increased in the lower pool. Waterfowl have gained habitat in the lower pool.

3.2.1.10 Pool 12

Pool 12 has changed relatively little except in the lower pool reach where secondary channels have been lost, and contiguous backwaters were created as islands developed along the edge of the main channel. Since 1940, about 900 acres of secondary channel area were lost and 650 acres of backwaters were created in the lower pool. About 800 acres of main channel area have been lost throughout the pool. In addition, islands are eroding near the dam.

The trend toward backwater creation favors lentic species: aquatic vegetation, lentic macroinvertebrates, limnophilic fishes, amphibians, reptiles, and waterfowl. The loss of secondary channels reduces habitat for lotic species: lotic macroinvertebrates, mussels, and rheophilic fishes.

3.2.1.11 Pool 13

There has been little change in Pool 13 between 1973 and 1989, but upper pool habitats have transitioned from contiguous backwaters to secondary channels. Upper pool secondary channel area has increased 64% (127 acres), while upper pool contiguous backwaters decreased by 38% (384 acres). Isolated backwater loss is about 25%, representing almost 400 acres throughout the pool. Little areal change is projected, but isolated backwater and upper pool contiguous backwater loss will continue.

Submersed aquatic vegetation has less habitat throughout the pool. Lotic macroinvertebrate habitat has increased, but lentic macroinvertebrate habitat has decreased. Lotic mussels have more habitat in the upper pool, but lentic mussels have less throughout the pool. Rheophilic fishes gained secondary channel habitat in the upper pool, but isolated backwater habitat was lost. Amphibians and reptiles have lost upper pool contiguous backwaters and isolated backwaters. Waterfowl have lost backwaters throughout the pool, but lower Pool 13 supports very high densities of fingernail clams which are an important food source to diving ducks.

3.2.1.12 Pool 14

Pool 14 has lost 821 acres of backwater habitat between 1940 and 1989 and is projected to lose more in the future. There has been little change in the other aquatic area classes. The lower pool is very constricted and offers only main channel habitat.

Lentic species have lost aquatic area in the upper pool and that aquatic habitat has not been replaced. Aquatic vegetation, lentic macroinvertebrates, limnophilic fishes, amphibians, reptiles, and waterfowl have all lost about one-third of the habitat that was available in 1940.

3.2.1.13 Pool 15

Pool 15 is also very constricted and has changed very little except in the lower pool where about 100 acres of secondary channel habitat have been lost between 1940 and 1989. The ecological impact of the change is minor. This pool supports few fish and waterfowl benefits, but mussels thrive in the constricted channel (Scott Whitney, USCOE, Rock Island, Illinois, personal communication, 1998).

3.2.1.14 Pool 16

Pool 16 is more complex than Pools 14 and 15, but there has been relatively little plan form change since 1940. Contiguous backwaters (160 acres) have transitioned to secondary channels (230 acres) in the lower pool as islands were dissected to create channels. In the lower pool, main channel area is projected to increase about 200 acres, secondary channels are projected to increase by about 250 acres, and backwaters are expected to fill. In the upper pool, backwater area is projected to increase, while channels remain stable.

Aquatic vegetation, lentic macroinvertebrates, limnophilic fishes, amphibians, reptiles, and waterfowl have all lost habitat. Lotic macroinvertebrates, mussels, and rheophilic fishes have all gained a little habitat.

3.2.1.15 Pool 17

Pool 17 has experienced very little change since 1940. There has been some secondary channel loss in the upper pool due to filling between wing dams. Future change predictions anticipate loss of some lower pool secondary channels and almost all isolated backwaters. The acreage loss of isolated backwaters, however, is only 50 acres. Little ecological change is expected.

3.2.1.16 Pool 18

Island growth and/or dissection has contributed to the transition of main channel habitat to secondary channel habitat since 1940. Simultaneous changes occurred in the upper pool with the loss of 1,404 acres of main channel area and an increase of 1,403 acres of secondary channel area. There has also been a loss of 860 acres of contiguous backwater area in the upper pool. Backwater loss is expected to continue.

The loss of backwaters reduces habitat value for lentic species, but the transition from main channel to secondary channel habitat is not significant. Aquatic vegetation, lentic macroinvertebrates, limnophilic fishes, amphibians, reptiles, and waterfowl have all lost habitat in the upper pool. Lotic macroinvertebrate, mussel, and rheophilic fish habitat changed from main channel to secondary channel.

3.2.1.17 Pool 19

Pool 19 has lost secondary channels (1,121 acres), contiguous backwaters (1,882 acres), and isolated backwaters (437 acres) in the upper pool between 1940 and 1989. The main channel has expanded slightly, and the number of islands (15) has declined. The lower pool has remained relatively unchanged in plan form, though there has been significant loss of depth that has allowed for the establishment of submersed and floating aquatic vegetation in some areas.

Backwater dependent species may have been particularly impacted because they have lost 76% of their upper pool habitat since 1940. In addition, lotic species are impacted because they have lost about one-quarter of the secondary channel habitat since 1940. Aquatic vegetation, lentic macroinvertebrates, limnophilic fishes, amphibians, reptiles, and waterfowl have all lost backwater area in the upper pool. Lotic macroinvertebrates, mussels, and rheophilic fishes have also lost secondary channel habitat in the upper pool. Aquatic vegetation has increased in abundance in the lower pool, but the change in habitat is not apparent from the plan form analysis.

3.2.1.18 Pool 20

Pool 20 is not complex and consists mostly of main channel area. Although several areas of change were identified between 1973 and 1989, the areal change was relatively minor. Habitat for all lentic species is limited. In addition, lotic species have experienced little net change in habitat availability.

3.2.1.19 Pool 21

Pool 21 is a simple pool consisting mostly of main channel area and a couple of large secondary channels. Although several areas of change were identified between 1973 and 1989, the areal change was relatively minor. Habitat for all lentic species is limited, and lotic species have experienced little net change in habitat availability.

3.2.1.20 Pool 22

Pool 22 consists mostly of main channel area and a few large secondary channels. Although several areas of change were identified between 1973 and 1989, the areal change was relatively minor. Secondary channels were lost in the upper pool, but were gained in the lower pool. Habitat for all lentic species is limited. Lotic species have experienced little net change in habitat availability.

3.2.1.21 Pool 24

There was no post-dam time period for comparison Pool 24; however, it was assumed to be similar to Pools 20 through 22. Pool 24 consists mostly of main channel area and a few large secondary channels. Although several areas of change were suspected, the areal change was relatively minor. Habitat for all lentic species is limited. Lotic species have experienced little net change in habitat availability.

3.2.1.22 Pool 25

There was no post-dam time period for comparison for Pool 25, but it was assumed to be similar to Pools 20 through 22. Pool 25 consists mostly of main channel area and a few large secondary channels. Although several areas of change were suspected, the areal change was relatively minor. Habitat for all lentic species is limited. Lotic species have experienced little net change in habitat availability.

3.2.1.23 Pool 26

Pool 26 has experienced little areal change since 1973, but it has lost about 40% of the isolated backwater habitat. Contiguous backwaters have increased slightly (360 acres), leading to no net loss of backwaters but rather a transition from one class to the other. Lotic species have experienced little net change in habitat availability, but habitat for all lentic species is limited.

3.2.1.24 Illinois River

The plan form change over time was not assessed for the Illinois River, but available information indicates that there has been little plan form change in the river. Other impacts, such as levees, waste diversion from Chicago, sedimentation from a highly agricultural basin, and stabilized water levels, however, have caused significant change. In general, backwater lakes have trapped sediment, leading to uniformly shallow depths. Sediments are also easily resuspended by waves, which reduces water clarity below the level acceptable for aquatic plant growth. Backwater species have lost habitat area, but the degraded quality of the remaining habitat is also a negative factor affecting the abundance and distribution of lentic species.

3.2.1.25 Open River

The Open River plan form was not assessed in detail, but a summary of secondary channel loss was completed by examining maps available in Simons *et al.* (1974). The river reach below the Missouri River has always differed from the pooled river reaches. Almost the entire floodplain has been leveed, and about 30% of secondary channels has been lost (10 of 35 present in 1860). The remaining secondary channels have degraded and may be isolated from the river during low-flow periods. In addition to the loss of habitat in secondary channels, the river has many wing dams that concentrate flow in to the center of the channel. Low-flow river stages have decreased, and high-flow stages have increased due to river development. Backwater species are rare and have lost habitat. Channel-dwelling species contend with higher current velocities and reduced availability of low current velocity refugia because of the modified physical and hydraulic environments.

3.2.2 Guild-by-Guild Assessment

The plan form change analyses were used here to estimate change in abundance of aquatic guilds. Estimates of change in abundance were assumed to be directly related to the percent and areal change in their preferred aquatic area. The estimates are limited, however, to associate habitat requirements of adult-aged organisms with typical summer, low-flow conditions. Seasonal requirements, such as fish access to inundated floodplain areas or amount of exposed mudflat area for emergent aquatic plants, cannot be estimated because of the paucity of topographic data at a sufficient resolution to estimate the extent of inundation at different river stages.

The general descriptions of systemic change for aquatic guilds provided below are supported by graphs of aquatic area change for Pools 4 through 26. Figure 3-1 presents an example of the unrooted submersed aquatic vegetation format that is repeated for each guild in Appendix T.

3.2.2.1 Rooted Submersed Aquatic Vegetation

Rooted submersed aquatic vegetation can occur in all river habitats less than about 1 m deep with low to medium current. The histogram of potential habitat greatly overestimates the amount of habitat because the aquatic area classification used did not have the resolution to isolate shallow waters. Generally, more than 80% of main and secondary channel habitats provide medium to low flow but may be too deep. Other factors important to rooted submersed aquatic vegetation that could not be incorporated into this analysis include water clarity and substrate type.

UMR pools north of Pool 13 support the most rooted submersed aquatic vegetation because these pools have a large proportion of backwaters and high water clarity. Aquatic area suitable to rooted submersed aquatic vegetation has increased in Pools 5 through 9. However, due to the resolution of the data, we cannot give an accurate estimate. Also, factors other than total area, such as wind fetch, substrate type, and water clarity, may limit the actual distribution and abundance of these plants. Pool 4 is unique among the northern pools in that Lake Pepin is a large area that does not support rooted submersed aquatic vegetation except at its upper end and in shallow marginal areas; it is losing smaller backwater lakes that do support aquatic vegetation. Reports also indicate that the abundance of rooted submersed aquatic vegetation has declined in recent years in upper Pool 4. Navigation Pools 10 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 12, 13, 15, 17, and 20 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because ambient water clarity declines in the downstream direction, and pools, such as Pools 19, 25, and 26, actually provide very little habitat due to the dominance of deep main and secondary channel habitat. Pool 19 is interesting because, in some areas, sedimentation over time has raised the bottom of main channel borders into the zone of light penetration and plant beds have developed. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss is great because of their rarity.

Rooted submersed aquatic vegetation communities are very dynamic, expanding and contracting their distribution with different annual hydrologic patterns. Observations through time suggest they reach critical thresholds in which populations may crash and never recover (Sparks *et al.* 1990). Areas subject to high concentrations of suspended solids will likely experience declines in the future, especially where backwater area is being lost, but the upper pools (Pool 13 and north) will likely support rooted submersed aquatic vegetation for many years.

3.2.2.2 Unrooted Submersed Aquatic Vegetation

Coontail is the most common unrooted submersed aquatic plant in the river. Because these plants can be swept away by medium to high currents, coontail distribution is largely restricted to backwaters. As with other submersed aquatic vegetation, light penetration in the water column is an important factor affecting the distribution of unrooted submersed aquatic vegetation.

Navigation pools north of Pool 13 support the most unrooted submersed aquatic vegetation because they have a large proportion of backwaters and high water clarity. Aquatic area suitable to unrooted submersed aquatic vegetation has increased in Pools 5 through 12, but due to the resolution of the data, we cannot give an accurate estimate. Also, factors other than total area, such as wind fetch and water clarity, may limit their actual distribution and abundance. Pools 4 and 10 are unique among the northern pools in that they are losing habitats that support aquatic vegetation. Navigation Pools 13 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 15, 20, and 22 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because backwater abundance and ambient water clarity declines in the downstream direction. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss is relatively more important owing to the small acreage of this habitat.

Unrooted submersed aquatic vegetation communities are very dynamic, expanding and contracting their distribution with different annual hydrologic patterns. Observations through time suggest they reach critical thresholds in which populations may crash and never recover (Sparks *et al.* 1990). Areas subject to high concentrations of suspended solids will likely experience declines in the future, especially where backwater area is being lost, but the upper pools (Pool 13 and north) will likely support unrooted submersed aquatic vegetation for many years.

Unrooted Submersed Aquatic Plant Habitat

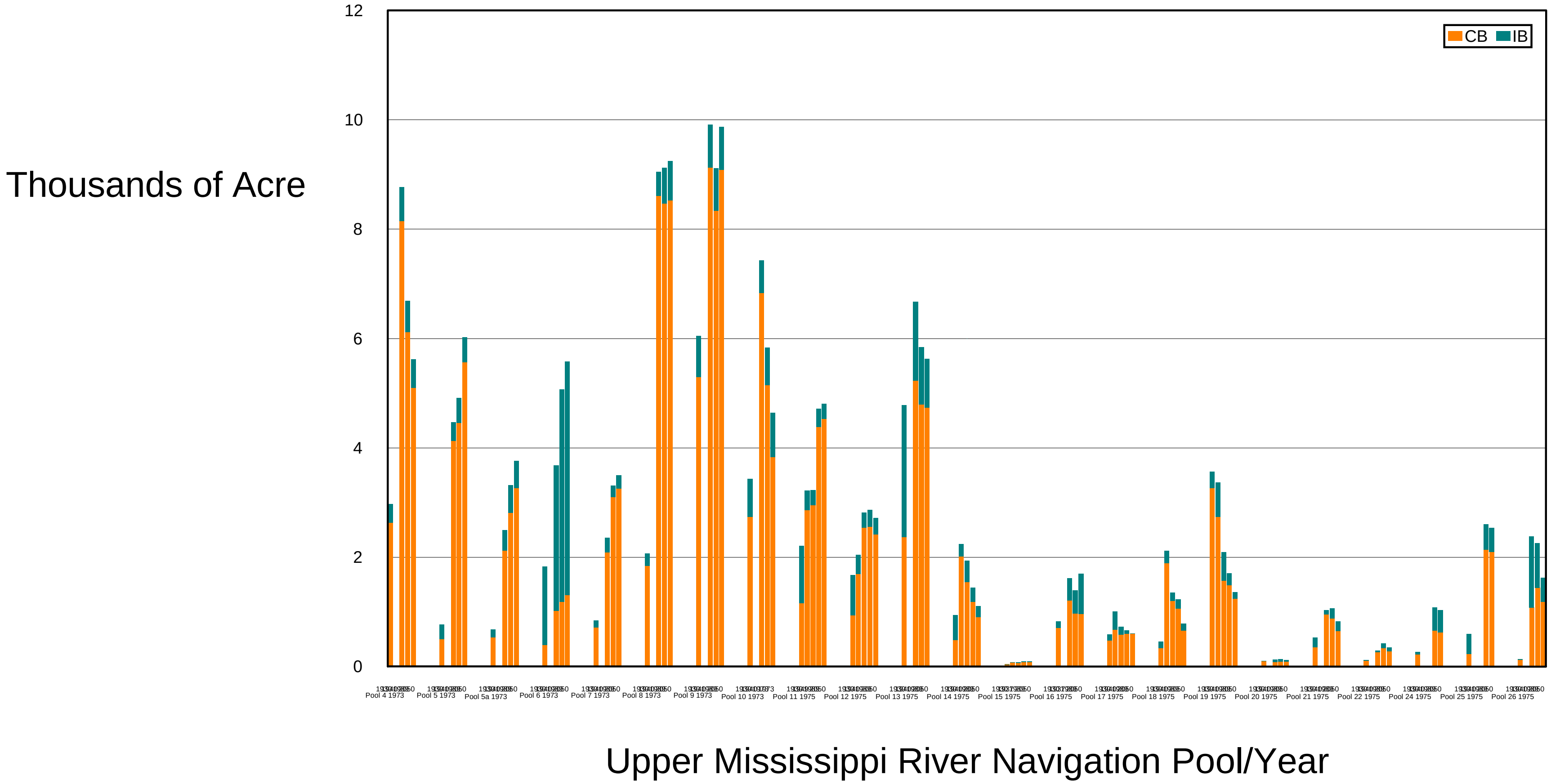


Figure 3-16: Example of summary figures to express areal change in available habitat for guilds used in the UMR/IWW Navigation Feasibility Studies - Cumulative Effects Study. The full set of figures is included in Appendix T. The X axis order is years: 1930, 1940, 1975, 1989, and 2050; gaps within pools are periods with missing data.

3.2.2.3 Floating Perennial Aquatic Vegetation

Water lilies and lotus are the most common floating perennial aquatic vegetation. They are generally restricted to low-flow backwater areas less than 1 m deep. Factors important to floating perennial aquatic vegetation that could not be incorporated into this analysis include depth, water clarity, and substrate type.

Navigation pools north of Pool 13 support the most floating perennial aquatic vegetation because they have a large proportion of backwaters and high water clarity. Aquatic area suitable to floating perennial aquatic vegetation has increased in Pools 5 through 12, but due to the resolution of the data, we cannot give an accurate estimate. Also, factors other than total area, such as wind fetch and water clarity, may limit their actual distribution and abundance. Pools 4 and 10 are unique among the northern pools in that they are losing habitats that support aquatic vegetation. Navigation Pools 13 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 15, 20, and 22 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because backwater abundance and water clarity declines in the downstream direction. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss is relatively more important owing to the small acreage of this habitat.

Floating perennial aquatic vegetation will likely track future changes in the submersed aquatic plant communities.

3.2.2.4 Floating Annual Aquatic Vegetation

Various species of duckweed make up the floating annual aquatic plant community. They float on the surface of backwaters with their roots dangling in the water. They are easily disturbed by wind and current and are sometimes swept out of backwaters. Water clarity and substrate type are not important factors affecting their distribution, but adequate nutrient concentrations must be available in the water.

Aquatic area suitable to floating annual aquatic vegetation has increased in Pools 5 through 12, but due to the resolution of the data, we cannot give an accurate estimate. Also, factors other than total area, such as wind fetch, may limit their actual distribution and abundance. Pools 4 and 10 are unique among the northern pools in that they are losing habitats that support aquatic vegetation. Navigation Pools 13 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 15, 20, and 22 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because backwater abundance declines in the downstream direction. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss is relatively more important owing to the small acreage of this habitat.

Floating annual aquatic plant populations will likely decline in the future with loss of isolated backwaters and sheltered contiguous backwaters. This community is highly variable.

3.2.2.5 Perennial Emergent Aquatic Vegetation

Perennial emergent aquatic vegetation is a diverse group of species that occur in and near the water's edge (<1 foot deep). Some species emerge in shallow waters, some grow after floodwaters recede, and others can tolerate moderate fluctuation. Emergent species occur in most aquatic marginal areas, but they are most abundant in open backwaters rather than forest fringed channels. Water level stability imposed by the dams decreases the potential distribution and abundance of emergent vegetation because water levels do not recede and expose backwater margins. Wind- and boat-generated waves can also prevent growth or shear plant stems.

UMR navigation pools north of Pool 13 support much of the emergent wetland area in the UMRS. The large area of backwater habitat and clear water provide favorable conditions for growth. Decreases in emergent plant marshes have been noticeable in recent years, especially in Pool 5 (Weaver Bottoms) and Pool 6 (Trempeleau Refuge). Aquatic area suitable to perennial emergent aquatic vegetation has increased in Pools 5 through 12, but due to the resolution of the data, we cannot give an accurate estimate. Also, factors other than total area, such as wind fetch and waves, may limit their actual distribution and abundance. Pools 4 and 10 are unique among the northern pools in that they are losing habitats that support aquatic vegetation. Navigation Pools 13 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 15, 20, and 22 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because backwater abundance declines in the downstream direction and water level fluctuations are greater and more frequent. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss is relatively more important owing to the small acreage of this habitat.

Perennial emergent aquatic vegetation has declined in the past and is likely to continue to decline in the future because of sediment degradation and wave action. Past change accounts for most of the area likely to be colonized by this community, so future change may be less than in the past.

3.2.2.6 Annual Emergent Aquatic Vegetation

Annual emergent aquatic vegetation is a diverse group of species that occurs in and near the water's edge (<1 foot deep). Most species grow after floodwaters recede, but many can tolerate moderate inundation and water level fluctuation. Emergent species occur in most aquatic marginal areas, but they are most abundant in open backwaters rather than forest fringed channels. Water level stability imposed by the dams decreases the potential distribution and abundance of emergent vegetation because water levels do not recede and expose backwater margins. Wind- and boat-generated waves can also prevent growth or erode plants.

UMR navigation pools north of Pool 13 support much of the emergent wetland area in the UMRS. The large area of backwater habitat and clear water provide favorable conditions for growth. Decreases in emergent plant marshes have been noticeable in recent years, especially in Pool 5 (Weaver Bottoms) and Pool 6 (Trempeleau Refuge).

Aquatic area suitable to annual emergent aquatic vegetation has increased in Pools 5 through 12, but due to the resolution of the data, we cannot give an accurate estimate. Also, factors other than total area, such as wind fetch and waves, may limit their actual distribution and abundance. Pools 4 and 10 are unique among the northern pools in that they are losing habitats that support aquatic vegetation. Navigation Pools 13 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 15, 20, and 22 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because backwater abundance declines in the downstream direction and water level fluctuations are greater and more frequent. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss is relatively more important owing to the small acreage of this habitat.

Annual emergent aquatic vegetation has declined in the past and is likely to continue to decline in the future because of sediment degradation and wave action. Past change accounts for most of the area likely to be colonized by this community, so future change may be less than in the past.

3.2.2.7 Lotic Erosional Macroinvertebrates

Lotic erosional macroinvertebrates are represented by a community of small insects, worms, scuds, crayfish, etc. that are found in high and medium flow areas of main and secondary channel habitats. They are found on rocks, snags, and freshwater mussels where they build nets, cling closely to the surface, or find refuge in the interstitial spaces between rocks. Wing dams provide optimal habitat for this guild, and very high densities of caddis flies have been documented in the few studies conducted.

Habitat has increased or remained stable north of Pool 14, except in Pool 11, where a large backwater is forming in the lower pool. Habitat has decreased or remained stable in the pools south of Pool 13. In all the pools with large proportions of main channel habitat, the amount of actual habitat is overestimated because these communities are generally restricted to riprap-armored banks and wing dams. Roots in undercut banks and downed tree snags in secondary channels may provide suitable habitat in some cases. Abundance of members in this guild may be related to the quality and quantity of food in the form of drifting organic matter.

No studies are available to track past change in lotic erosional macroinvertebrates, so future predictions of change are tenuous at best. Assuming riprap and wing dams will not be removed, habitat will remain except where dike fields fill with sediment. The quality of habitat may degrade as fine sediment fills interstitial spaces in the rocks. Zebra mussels may alter lotic macroinvertebrate habitat, because they can alter substrate, water quality, and compete for food. Zebra mussels are very patchy in distribution and highly variable in density.

3.2.2.8 Lotic Depositional Macroinvertebrates

Lotic depositional macroinvertebrates are found in the shifting sand and mud on the bottom of main and secondary channel areas. Very high flow may be unfavorable, but this is not yet supported by published data. High densities of small worms have been documented in shifting sands, but their distribution is patchy. Medium- and low-flow channel borders are better studied and frequently support high densities of fingernail clams and burrowing mayflies. A variety of fly larvae and worms are also common. Recent data demonstrate that high-density populations are distributed in patches, but the mechanisms determining their distribution are unknown (EMTC 1999). There is a trend of higher densities of this guild in northern versus southern pools, the Illinois River, and the Open River; however, in the northern pools there is also wide variation.

Habitat has increased or remained stable north of Pool 14, except in Pool 11, where a large backwater is forming in the lower pool. Habitat has decreased or remained stable south of Pool 13.

Lotic depositional macroinvertebrates are the best known aquatic macroinvertebrates in the UMRS, but long-term studies are rare. One monitoring site in Pool 19 has shown stable burrowing mayfly populations for 25 years, whereas, fingernail clam populations have declined and are very erratic. Sediment quality is likely to be an important factor controlling this community, but such factors as food availability, ammonia toxicity, and other contaminants can impact the community. Sediment accretion in lower pools and near tributary inflows will likely be the biggest factor in the future. Populations may decline in the future.

3.2.2.9 Lentic Limnetic Macroinvertebrates

Lentic limnetic macroinvertebrates include small invertebrate fauna (zooplankton and phantom midges) that inhabit the open water of backwater lakes. Zooplankton float at the mercy of currents, maneuvering enough to capture and consume algae and protozoa. Phantom midges migrate from the bottom into the water column at night. Zooplankton are an important food source for many larval and adult fish. This guild is little studied in the UMR.

Aquatic area suitable to lentic limnetic macroinvertebrates has increased in Pools 5 through 12. Pools 4 and 10 are unique among the northern pools in that they are losing habitats that support lentic limnetic macroinvertebrates. Navigation Pools 13 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 15, 20, and 22 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because backwater abundance declines in the downstream direction. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss is relatively more important owing to the small acreage of this habitat.

Because this group is little known, future predictions are difficult to make. Populations are likely to decline proportionately with loss of backwater area. Zebra mussel feeding may reduce the availability of lentic limnetic macroinvertebrates to other guilds. This potential effect may only occur in Lake Pepin and other larger lentic areas where zebra mussel densities are high enough to have an effect on zooplankton. Only smaller zooplanton are vulnerable. *Chaoborus* sp. and other larger zooplankters are not vulnerable to zebra mussel predation. Although zooplankton occur in the water column of channel areas, they may be 'lost' washouts from lentic areas and constitute part of the flowing POM.

3.2.2.10 Lentic Littoral Macroinvertebrates

Lentic littoral macroinvertebrates are represented by small invertebrate fauna (scuds, fly larvae, beetles, damselflies, zooplankton, worms, etc.) found in and around aquatic vegetation. This is a complex and diverse community of scavengers, grazers, and predators that has received little attention in the UMR. Because of their association with vegetation, they are distributed similarly and impacted by similar factors.

Navigation pools north of Pool 13 likely support the most lentic littoral macroinvertebrates because of the abundance of submersed aquatic vegetation and large proportion of backwaters. Aquatic area suitable to submersed aquatic vegetation and, therefore, lentic littoral macroinvertebrates, has increased in Pools 5 through 9, but due to the resolution of the data, we cannot give an accurate estimate. Pool 4 is unique among the northern pools in that Lake Pepin is a large area that does not support rooted submersed aquatic vegetation or lentic littoral macroinvertebrates throughout the lake, and it is losing smaller backwater lakes that support aquatic vegetation. Navigation pools 10 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 12, 13, 15, 17, and 20 are relatively stable. Pools south of Pool 14 generally have little favorable habitat, and submersed aquatic plant abundance declines in the downstream direction. In addition, pools, such as 19, 25, and 26, actually provide very little habitat due to the dominance of deep main and secondary channel habitat. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss is relatively more important owing to the small acreage of this habitat.

Lentic littoral macroinvertebrate populations will fluctuate with aquatic vegetation in the future. Their overall abundance will likely decline systemically where plants are lost in southern river reaches and near tributary inflows.

3.2.2.11 Lentic Profundal Macroinvertebrates

Lentic profundal macroinvertebrates include the community of fly larvae and worms found in the mud and silt at the bottom of backwater lakes. They are generally detritivores that can occur in high densities. The community is ubiquitous in backwaters, but high densities may be distributed in patches. It is likely that this community is more important in southern pools, where aquatic vegetation is less common and in areas where aquatic vegetation has been lost.

Aquatic area suitable to lentic profundal macroinvertebrates has increased in Pools 5 through 12. Open water areas created due to the erosion of islands and large backwater lakes are typical habitat. Pools 4 and 10 are unique among the northern pools in that they are losing habitats that support lentic profundal macroinvertebrates. Navigation Pools 13 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 15, 20, and 22 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because backwater abundance declines in the downstream direction. However, the large unvegetated lakes provide suitable habitat. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss to lentic profundal macroinvertebrates is relatively more important owing to the small acreage of this habitat.

Lentic profundal macroinvertebrates will likely fluctuate opposite of aquatic plants. Where plants are lost, this community will colonize and increase their populations. This guild has many species, each adapted to different conditions. Species composition may shift rather than total numbers of individuals lost.

3.2.2.12 Lotic Mussels

Lotic mussels are, by far, the most common group of freshwater mussels in UMR. They occur in main channel and secondary channel habitats in clumped distributions called beds. They prefer gravel and firm mud substrates where they bury themselves and siphon river water to collect organic particles. Many species are highly sensitive to silt, and some species' reproduction has been impacted by blocked host fish migrations. Some mussel beds have been carefully studied, but there has never been a systemic, comprehensive assessment throughout the river. Mussels do not occur in abundance in the Mississippi River below the Missouri River.

Habitat has increased or remained stable north of Pool 14, except in Pool 11 where a large backwater is forming in the lower pool. Habitat has decreased or remained stable in the pools south of Pool 13. The impact of wing dam construction on this immobile community cannot be readily assessed, but it is likely that some beds were buried during wing dam construction; others may be impacted by the modified hydraulic environment. The impact of dredging has not been assessed completely, but it is likely that dredging disrupted some beds. Changes in sediment composition and delivery rate may affect mussels differently in northern and southern river reaches. Abundance of members in this guild may also be related to the quality and quantity of food in the form of drifting organic matter. Many changes in the mussel fauna have been caused by commercial harvest and the exotic zebra mussels.

The future for lotic mussels is difficult to estimate because of the many factors affecting their survival. If they can withstand the impacts of zebra mussels, they should generally maintain their current populations. The ebony shell mussel is likely to be extirpated north of Lock and Dam 19 which blocks the migration of its host fish, skipjack herring.

3.2.2.13 Lentic Mussels

Lentic mussels include a group of species called floaters. They are adapted to the low flow and silty environment of backwaters. They are relatively adaptable and insignificant in the commercial harvest. Their distribution is similar to that of the lentic profundal macroinvertebrate guild.

Aquatic area suitable to lentic mussels has increased in Pools 5 through 12. Pools 4 and 10 are unique among the northern pools in that they are losing habitats that support lentic mussels. Navigation Pools 13 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 15, 20, and 22 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because backwater abundance declines in the downstream direction. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss to lentic mussels is relatively more important owing to the small acreage of this habitat.

The future for lentic mussels is linked to the loss of backwater area and sediment quality. Lentic mussels will likely decline in areas subject to high rates of sedimentation and backwater filling.

3.2.2.14 Rheophilic Fish

Rheophilic fishes are represented by species found in the high-flow main and secondary channel environment. They exhibit streamlined shapes and/or bottom dwelling behavior that allows them to survive in the high-flow environment. Many species are also migratory and may have reduced opportunity to move throughout the river because of the dams. Although information on main channel fishes is largely lacking, recent results from a year-long sampling program indicate that species adapted to the highest flows (shovelnose sturgeon and blue suckers) are concentrated in the upper pool reaches. Other rheophils such as blue catfish were more common in the channel of the impounded lower pool reaches. Seasonal changes in species composition and abundance also were noted (John Dettmers, Illinois Natural History Survey, Zion, Illinois, and Steve Gutreuter, USGS Upper Midwest Environmental Science Center, La Crosse, Wisconsin, personal communication, 1998).

Main channel habitat has increased or remained stable north of Pool 14, except in Pool 11, where a large backwater is forming in the lower pool. Secondary channels have been converting to backwaters in some areas. Habitat has decreased or remained stable in the pools south of Pool 13. The greatest proportion of rheophilic fish habitat occurs in the southern pools, but species that require backwaters for some portion of their life history are likely to be limited by the lack of backwaters. The amount of suitable habitat available is likely overestimated in Pools 4 and 19 because of the large main channel area.

Rheophilic fish habitat is unlikely to decline greatly in the future because the main channel will always be maintained. They will likely maintain stable populations in the future unless channel maintenance activities are greatly modified. Entrainment/ impingement in commercial towboat propellers is a source of adult fish mortality, impacts should be considered in combination with power plant impingement, losses due to recreational boat propellers, and sport and commercial exploitation.

3.2.2.15 Rheo-Limnophilic Fish

Rheo-limnophilic fish are channel-dwelling species that are adapted to medium- and low-flow areas of the main channel and secondary channels. They are similar to the rheophilic fishes in their behavior and physical adaptations. Although information on channel-dwelling fishes is lacking for most areas, recent results indicate that these species are found more commonly in the lower reaches of the navigation pools (John Dettmers, Illinois Natural History Survey, Zion, Illinois, personal communication, 1998).

Rheo-limnophilic fish are a ubiquitous group whose habitat has been increasing in Pools 5 through 9 and decreasing in Pool 4. Pools 10 through 26 have lost rheo-limnophilic fish habitat or remained stable.

Rheo-limnophilic fish habitat is very general, so most will find appropriate areas in the future. Population declines may occur in species that require backwaters for part of their life history where backwaters are lost or degraded. Entrainment/impingement in commercial towboat propellers is a source of adult fish mortality; impacts should be considered in combination with power plant impingement, losses due to recreational boat propellers, and sport and commercial exploitation.

3.2.2.16 Pelagic Rheo-Limnophilic Fish

Pelagic rheo-limnophilic fish are schooling species found in main channel, secondary channel, and contiguous backwaters. They are streamlined fishes that seek flow refugia in channel habitats. They are wide ranging, exploit a variety of habitats, and tend to move upstream in the spring.

Pelagic rheo-limnophilic fish habitat has been increasing in Pools 5 through 9 and decreasing in Pool 4. Pools 10 through 26 have lost pelagic rheo-limnophilic fish habitat or remained stable.

Pelagic rheo-limnophilic fish habitat is similar to rheophilic fish habitat and will likely remain stable in the future. Entrainment/impingement in commercial towboat propellers is a source of adult fish mortality; impacts should be considered in combination with power plant impingement, losses due to recreational boat propellers, and sport and commercial exploitation.

3.2.2.17 Limno-Rheophilic Fish

Limno-rheophilic fishes are similar to rheo-limnophils, but with a preference for lower current velocities. Many members of the guild are bottom-oriented fishes, and others are streamlined and seek flow refugia.

Habitat for limno-rheophilic fish has been decreasing in Pool 4 and increasing in Pools 5 through 9. Pools 10 through 26 have lost limno-rheophilic fish habitat or remained stable. The relative lack of backwaters in the southern pools limits habitat for these species.

Limno-rheophilic fish habitat is very general, so most will find appropriate areas in the future. Population declines may occur in species that require backwaters for part of their life history where backwaters are lost or degraded. Entrainment/impingement in commercial towboat propellers is a source of adult fish mortality; impacts should be considered in combination with power plant impingement, losses due to recreational boat propellers, and sport and commercial exploitation.

3.2.2.18 Pelagic Limno-Rheophilic Fish

Pelagic limno-rheophilic fish are species found in the water column of backwaters and low velocity areas of channel habitats. They feed on zooplankton that drift in the water column and invertebrates in non-vegetated low-flow areas. Some members of the guild are migratory, and their movements are impeded by dams.

Habitat has been increasing in pools 5 through 9 and decreasing in Pool 4. Pools 10 through 26 have lost habitat or remained stable. The relative lack of backwaters in the southern pools limits habitat for these species. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss to pelagic limno-rheophilic fish is relatively more important owing to the small acreage of this habitat.

Pelagic limno-rheophilic fish populations will be reduced in the future in areas where backwaters are degrading or being lost. High densities of zebra mussels in backwaters may compete for small zooplankton food items, but pelagic limno-rheophilic fish can consume much larger food items than zebra mussels.

3.2.2.19 Limnophilic Fish

Limnophilic fish are most commonly found in contiguous and isolated backwaters, though they can also be found in channel habitats. They are not adapted to high-flow conditions, and some species require still waters for spawning. Many species are associated with aquatic vegetation where they feed on macroinvertebrate fauna. Recent results indicate that some members of this guild are distributed in relation to the abundance of backwaters in specific pools, with fewer backwater species present in southern river reaches and especially the Open River (EMTC 1999).

Limnophilic fish habitat has been increasing in Pools 5 through 11, except in Pools 4 and 10 where it is decreasing. Pools 12 through 26 have lost habitat or remained stable. The relative lack of backwaters in the southern pools limits habitat for these species. Lower abundance of submersed aquatic vegetation in southern pools is also unfavorable to these species. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss to limnophilic fish is relatively more important owing to the small acreage of this habitat.

Limnophilic fish populations will decline in the future in areas where backwaters are degrading or being lost.

3.2.2.20 Lotic Amphibians and Reptiles

Amphibians and reptiles use most river habitats, but some species of turtles are more abundant in flowing waters. Some are adapted to sand substrates, while others prefer silty/mud substrates. Dredged material placement in terrestrial areas may impact the nesting success of some species if eggs are buried during their incubation period, but the sand placement has also created nesting habitat. Little emphasis has been placed on studying reptiles and amphibians. Lotic amphibian and reptile habitat has been increasing in Pools 5 through 9 and decreasing in Pool 4. Pools 10 through 26 have lost habitat or remained stable.

Lotic amphibian and reptile populations will likely remain stable in the future, but changes in dredged material placement may affect their reproduction.

3.2.2.21 Lentic Amphibians and Reptiles

Lentic amphibians and reptiles are more common than their lotic counterparts. They include various frogs, toads, snakes, and turtles that inhabit contiguous and isolated backwaters. Some frogs and toads have better reproductive success when small isolated pools and lakes without fish are present. Turtle nesting success is dependent on undisturbed terrestrial habitats above the flood stage.

Navigation pools north of Pool 13 provide a large proportion of backwaters. Aquatic area suitable to amphibians and reptiles has increased in Pools 5 through 12. Pools 4 and 10 are unique among the northern pools in that they are losing habitats that support amphibians and reptiles. Navigation Pools 13 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 15, 20, and 22 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because backwater abundance declines in the downstream direction. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss to lentic amphibians and reptiles is relatively more important owing to the small acreage of this habitat.

Lentic amphibians and reptile populations are likely to decline in areas where backwaters are being lost or degraded.

3.2.2.22 Diving Ducks

Diving ducks are generally associated with concentrations of their preferred foods (fingernail clams and aquatic plant tubers) during spring and fall migrations. Because their food sources can be distributed in all river habitats, diving ducks are also widely distributed. Particularly high densities of diving ducks occur in Pools 7, 8, 9, and 19 during spring and fall migrations. Many factors beyond the river can affect diving duck populations, and in some years, they may occur in low numbers if food resources are scarce (EMTC, in press).

Navigation pools north of Pool 13 support the most rooted submersed aquatic vegetation and macroinvertebrates favored by diving ducks because they have a large proportion of backwaters and high water clarity. Aquatic area suitable to diving duck food resources has increased in Pools 5 through 10. Pool 4 is unique among the northern pools in that Lake Pepin is a large area that does not support diving ducks, and it is losing upper pool backwaters that do support them. Navigation Pools 10 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 12, 13, 15, 17, and 20 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because aquatic vegetation and preferred macroinvertebrate foods decline in the downstream direction; pools such as 19, 25, and 26 actually provide very little habitat due to the dominance of deep main and secondary channel habitat. Pool 19 is interesting, however, because there are some unique locations that have supported large concentrations of fingernail clams and diving ducks that feed on them. Although the actual areal loss of backwaters in the lower pools (Pools 21 to 26) is slight, the impact of any loss to diving ducks is relatively more important owing to the small acreage of this habitat.

Diving duck populations are difficult to predict because factors outside of the UMRS can affect their populations also. UMRS migratory habitat, and therefore duck use, will decline in areas where lotic depositional macroinvertebrates and rooted submersed aquatic vegetation decline. Changes in the main channel impounded area appear to impact diving duck distribution.

3.2.2.23 Dabbling Ducks

Dabbling ducks loaf and feed on emergent vegetation and invertebrates in the still waters provided by contiguous and isolated backwater lakes. They do occur in channel areas, but backwaters provide better food supplies and resting habitat. Habitat is generally abundant in the northern pools, but declines downstream. In southern pools, wildlife managers manipulate water levels to increase plant production in refuge and hunting areas.

Navigation pools north of Pool 13 provide a large proportion of backwaters. Aquatic area suitable to dabbling ducks has increased in Pools 5 through 12. Pools 4 and 10 are unique among the northern pools in that they are losing habitats that support dabbling ducks. Navigation Pools 13 through 26 have been losing habitat or have remained relatively stable during the post-dam era. Pools 15, 20, and 22 are relatively stable. Pools south of Pool 14 generally have little favorable habitat because backwater abundance declines in the downstream direction.

Dabbling duck populations are difficult to predict because factors outside of the UMRS can affect their populations also. UMRS migratory habitat, and therefore duck use, will decline in areas where backwaters and aquatic vegetation are being lost.

4 Conclusions and Recommendations

4.1 Conclusions

4.1.1 Physical Habitat Change and Ecological Implications

- **Geomorphic Reach 2** - Pool 4 stands out as unique among northern pools because it receives significant tributary sediments from upstream and the Chippewa River. Loss of area in all aquatic classes, both upstream and downstream of Lake Pepin, suggests that sedimentation has affected all guilds. This loss of aquatic habitat is a result of delta formation at the head of Lake Pepin and in the Chippewa River delta entering the Big Lake area.

- **Geomorphic Reach 3** - Pools 5 to 9 generally show a loss of islands to erosion and dissection, and the corresponding increase in main channel and secondary channel area. This is attributable to loss of islands to erosion and dissection, and the corresponding increase in main channel and secondary channel area. Backwaters do not show significant decreases except where deltas encroach into them. Increases in the area necessary for aquatic guilds do not necessarily translate to increases in abundance of aquatic populations because some transitions in habitat do not provide the highest quality habitat. The loss of islands in lower Pool 8, for example, has resulted in extensive areas of shallow, windswept aquatic habitat that is frequently turbid due to sediment resuspension.

- **Geomorphic Reaches 4 and 5** - Pools 10 to 15 generally lost contiguous and isolated backwaters and gained main channel and secondary channels. Guilds with strict backwater habitat requirements lost habitat area, but habitat generalists and lotic species that use secondary and main channel habitat gained habitat.

- **Geomorphic Reaches 6 through 8** - Pools 16 to 26 show decreasing trends in habitat for all guilds, with the exception of Pools 20 and 22, which show little change. There is a general loss of total open water in these reaches. Losses of backwater and side channel area, though small in acreage, represent significant impacts to lentic species because backwaters are a small proportion of total aquatic area. Pool 16 stands out as unique because it shows positive trends in available habitat among all the guilds, perhaps due to deposition downstream from the bedrock gap through Pools 14 and 15.

- **Geomorphic Reaches 9 and 10** - River miles 0-201 have lost aquatic habitat for species requiring slower current velocities due to the loss of side channels. Channel training structures have closed off many side channels, the main channel has incised over time, which isolates side channels at low flow, and island and sand bars have been lost. The result is a uniform, swift current, and deep channel with dike fields providing most sheltered habitat. Lotic guilds dominate the two reaches.

- **Illinois River Geomorphic Reaches** - The upper Illinois River reach has been much changed by dams and urban influences. The channel and floodplain are small and constrained by banks and bluffs, and water impounded by dams fills much of the valley. The lower Illinois River reach is more similar to the Mississippi River, with broad floodplains and seasonal flood pulses. Lentic guilds once flourished because there is a high proportion of backwaters, but their populations have declined through time due to the interaction between navigation and other impacts. Water level regulation has increased and stabilized water levels to form large open backwaters. High sediment loads entering from the highly agricultural basin are trapped in the large backwater lakes and not allowed to dry and compact during summer low flows. Many lakes have been filled completely and the remaining ones are expected to fill in the next 100 years. The quality of the lake habitat is degraded because sediments remain silty and are easily resuspended, thus reducing water clarity and limiting plant growth. Sewage pollution had significant impacts earlier this century.

4.1.2 Other Human Activities

Impoundment

- Impoundment and river regulation has transformed a free-flowing river to a series of regulated pools. Water levels are most variable and correspond closely with discharge in the upper portions of the navigation pools and show the greatest effects of regulation closer to the dam where they are most stable. Some pools are regulated with mid-pool control points and have drawdowns of water surface near the dams at moderate flow. Water level regulation does not impede floods, but it does prevent low river stages and the drying of inundated floodplains. This study did not address seasonal habitat requirements.

- Pools in the upstream reaches exhibit an island braided form and provide diverse aquatic habitat conditions. Pools south of Pool 13 are simpler, with larger islands and a greater proportion of aquatic area represented by main channel and secondary channel habitat. Loss of aquatic area generally increases in the downstream direction due to the influences of water level regulation and increased sedimentation.

- Habitats created by impoundment have shown significant changes exemplified by the loss of islands in the lower pool, filling of backwaters created by the dams, and terrestrial encroachment between wing dams. Many backwaters created by the dams remain but they have been degraded by sedimentation that tends to create homogenous, shallow backwaters and impounded areas.

Structures

- Impacts of channel training structures are most evident in the southern pools and the Open River. They tend to cut off flow and increase sedimentation in side channels and speed terrestrial encroachment into channel areas. Bank revetments prevent erosion and maintain a stable channel; they have largely arrested new habitat creation. Wing dams also provide flow refugia and may support large concentrations of fish adapted to moderate flow. The rock revetment provides structure for dense aggregation of macroinvertebrates.

Dredging

- Dredging usually affects small areas (1.6% of main channel in St. Paul and Rock Island Districts) and it is episodic in nature. While impacts are severe for fauna within dredge cuts, the effects do not appear to be long lasting for macroinvertebrates or fish. Dredging destroys mussel beds, and frequently dredged sites cannot support mussels**.** Most dredging occurs in cuts that have been repeatedly dredged over time. The volume and frequency of dredging has declined markedly over the last two decades in the St. Paul and Rock Island Districts reaches of the UMR. Most of the material dredged in the Upper Mississippi River is primarily sand. Dredging is now closely coordinated with state and federal natural resources management agencies, and impacts of dredging have been reduced from historic levels.

- Dredged material placement has been a major resource problem in the past, but changes through time have reduced the impact. The St. Paul District transports most dredged material out of the floodplain for beneficial uses. The Rock Island District places dredged material in the floodplain, along levees and in agricultural fields outside the floodplain, and in the main channel. The St. Louis District places all dredged material in the main channel. Terrestrial placement sites eventually become colonized with vegetation and may become indistinguishable from other floodplain areas. Revegetation is accelerated by placement of fine-grained material and through plantings. Aquatic placement areas probably recover quickly unless mussels are disturbed.

Restoration

- Environmental management projects are being constructed to rehabilitate and enhance river habitats. To the degree they are successful, they can counteract some of the losses of habitat exhibited in the past. The 24 projects implemented to date affect about 28,000 acres of aquatic and floodplain habitat. The 26 projects presently under construction and in general design will increase the total affected area to about 97,000 acres, approximately 11% of the total UMRS floodplain and aquatic habitat area, not counting agricultural and urban areas. The HREP projects incorporate a variety of habitat protection and restoration features.

Connectivity

- Fish movement throughout the river is restricted by navigation dams. Locks and Dams 1 and 19 on the Mississippi River impose complete barriers to upstream fish migrations, but the other dams go to open river conditions at some time during almost every year. The timing between when dams are open and fish are migrating may not correspond and usually only the strongest-swimming species can pass through the navigation dams. The consequences of restricted upriver fish passage include disruption of migration behavior, reproductive activity, access to foraging and wintering areas, and may combine to limit growth, recruitment, overwinter survival, and population size if access to essential habitat is denied. On the Illinois River, the wicket gate dams at Peoria and La Grange allow open river passage to fish most of the time. The dam at Starved Rock, however, rarely goes to an open river condition and presents a barrier to upriver fish passage most of the time. The upper Illinois River dams (Starved Rock, Marseilles, Dresden, Brandon Road, and O'Brien) all present complete barriers to upriver fish passage.

- Levees have decreased the connectivity between the river and its floodplain. The impact is quite small in the pools north of Pool 16, but the rest of the system is between 50% and 85% leveed. Levees reduce organic matter transport and assimilation, restrict fish that spawn in flooded environments, and limit the availability of isolated floodplain pools beneficial to invertebrates, reptiles, amphibians, and birds. Levees also contribute to sedimentation by limiting the area over which sediment can be deposited during floods. Finally, levees have increased flood stages by constricting flood flows.

Pollution

- Point source discharges have largely been controlled by regulations initiated in the 1970's. In the past, municipal discharges contributed to the loss of aquatic fauna downstream of large cities, but most of those impacts have been eliminated and the pollution assimilated. Industrial pollution is better controlled now than in the past, but past contamination is still stored in sediment and affects aquatic fauna.

- Non-point source pollutants are a major problem in the UMRS. High loads of sediment, fertilizers and pesticides are washed in from agricultural areas. Urban runoff supplies a variety of household fertilizers, pesticides, vehicle wastes, and sediment from construction activities. Some urban areas are upgrading storm sewage treatment capabilities, and agricultural runoff has been reduced in the last two decades.

- Fish entrainment and impingement is high at some power plants, but the impact of such fish losses is unknown. Some of the largest facilities have implemented measures to reduce fish mortality. The Quad Cities nuclear plant stocks walleye to mitigate losses.

Exotic Species

- Exotic and nuisance species have been introduced to the UMRS, and some have caused significant changes. Common carp were introduced in the late 1800's and have become one of the most abundant fish species in the river. Zebra mussels were introduced from Europe via the Great Lakes and Illinois River in the early 1990's and have become widespread. In some locations, where populations get large, they colonize native mussels and degrade water quality.

4.1.3 Data Limitations

Geomorphic data

- Visual conceptualization of plan form data is difficult because there is only one complete set of the 1:24,000 scale maps and photos used in the plan form analysis, and they are large and difficult to work with compared to maps of smaller scale. Conversely, the 1:24,000 maps lacked the spatial resolution to detect small changes. Also missing were physical attributes affecting the quality of habitat: depth profiles were limited to main channel areas only; bathymetry of off-channel habitat areas was limited to selected navigation pools; data on sediment types was limited; changes in water quality could only be generally assessed; and the effects of wind-generated waves were not assessed. The Illinois River, Open River, and some navigation pools lacked a full series of mapping or photographs for time series change analysis.

Biological data

- Biological data limitations are also apparent. No pre-dam estimates of population sizes are available for any part of the river, so it is difficult to quantify change. The best quantified guilds are waterfowl, and their counts were initiated in the 1950's. Life histories of many species are little known, which makes assessing impacts difficult. Some guilds show cyclical patterns of abundance, which may take multiple observations over time to understand and quantify.

Navigation data

- The interaction of navigation-induced stress and other stressors is difficult to identify. In many cases, barges moving in the river may not impact UMRS guilds, but the infrastructure of dams, channel training structures, and operations and maintenance activities such as river regulation and dredging, needed to support navigation does induce or increase the rate of various environmental impacts. Assessment of guilds that require seasonal flooding and drying to complete their life histories was limited because of the inability to estimate the extent and seasonal availability of flooded areas.

4.2 Recommendations

- This retrospective analysis provides a coarse level estimate of change over a very large geographic area. We do not recommend that further refinement of our estimate of change focus on large river reaches; rather, we suggest that future studies focus on areas exhibiting the most rapid change due to the nine geomorphic processes identified.

- The nine geomorphic processes identified in Chapter 5 (Volume 1) should be further studied to identify rates and end points of change. Given the current amount of data available and the ability to increase the historic perspective through geomorphic analysis, sediment transport models should be refined and calibrated for use on the UMRS. Backwaters and floodplain overbank areas should be included in sediment budgets.

- Future efforts should try to separate the influences of human activities throughout the basin from those specifically related to commercial traffic.

- Where basin and navigation impacts intersect, such as dam-induced sediment retention in pooled reaches, the relative contribution of each factor should be estimated.

- Biological resources need to be better quantified. Population sizes need to be estimated with confidence so impacts can be quantified. Also, the degree of impact on populations needs to be estimated and any critical thresholds need to be identified. The importance of seasonal flooding must be better understood.

- When the multiple stressors affecting the UMRS are better quantified, a formal risk assessment should be completed.

- The results of these analyses should be used to help guide future habitat management. The physical processes identified should be integral factors in the engineering design of restoration projects. Dynamic areas identified in this study may help identify sites suitable for restoration.

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APPENDICES

Appendix L
Upper Mississippi River System Plant Species
(CD ROM)

Appendix M
Upper Mississippi River System Macroinvertebrate Species
(CD ROM)

Appendix N
Upper Mississippi River System Freshwater Mussel Species
(CD ROM)

Appendix O
Upper Mississippi River System Fish Species
(CD ROM)

Appendix P
Upper Mississippi River System Reptile and Amphibian Species
(CD ROM)

Appendix Q
Upper Mississippi River Bird Species
(CD ROM)

Appendix R
Upper Mississippi River System Mammal Species
(CD ROM)

Appendix S
Assessment of Change through Time for Selected Upper Mississippi River System Aquatic Guilds
(CD ROM and hard copy)

Appendix T
Graphical Presentation of Aerial Change in Habitat for Selected Upper Mississippi River System Aquatic Guilds
(CD ROM and hard copy)

Appendix U
Dredging Summary for the UMRS
(CD ROM)

Appendix L

Upper Mississippi River System Plant Species

Guild assignment after:

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Key to Plant Guilds:

	Woody Plant Guilds
FTPT	Flood-Tolerant Pioneering Trees
FIPT	Flood-Intolerant Pioneering Trees
SF	Swamp Forest Trees
SFT	Softwood Floodplain Trees
BHT	Bottomland Hardwood Trees
FTPS	Flood-Tolerant Pioneering Shrubs
FTSS	Flood-Intolerant Pioneering Shrubs
WS	Woodland Shrubs
	Semi-Aquatic and Terrestrial Herbaceous guilds
SE	Spring Ephemerals
AWF	Autumnal Woodland Forbs
WG	Woodland Graminoids
V	Vines
MF	Meadow Forbs
MG	Meadow Graminoids
SAF	Semi-Aquatic Annual Forbs
SAG	Semi-Aquatic Annual Grasses
TAF	Terrestrial Annual Forbs
TAG	Terrestrial Annual Grasses
PP	Parasitic Plants
	Aquatic Guilds
EP	Emergent Perennials
EA	Emergent Annuals
RSA	Rooted Submersed Aquatics
USA	Unrooted Submersed Aquatics
FP	Floating Perennials
FA	Floating Annuals

* = non-indigenous species

Common Name	Scientific Name	Family	Distribution	Guild
Bitter cress	*Cardamine pennsylvanica Muhl.*	Brassicaceae	Ubiquitous	AWF
Blunt-lobed woodsia	*Woodsia obtusa (Spreng.) Torr.*	Polypodiaceae	Ubiquitous	AWF
Bog-hemp	*Boehmeria cylindrica (L.) Sw.*	Urticaceae	Ubiquitous	AWF
Bottomland aster	*Aster ontarionis Wieg.*	Asteraceae	Ubiquitous	AWF
Bulbet-bladder fern	*Cystopteris bulbifera (L.)Bernh.*	Polypodiaceae	Ubiquitous	AWF
Cardinal flower	*Lobelia cardinalis L.*	Campanulaceae	Ubiquitous	AWF
Clammy ground cherry	*Physalis heterophylla Nees.*	Solanaceae	Ubiquitous	AWF
Cluster-leaf tick trefoil	*Desmodium glutinosum (Muhl.) Wood.*	Fabaceae	Ubiquitous	AWF
Elegant bedstraw	*Galium concinnum T. & G.*	Rubiaceae	Ubiquitous	AWF
Enchanter's nightshade	*Circaea lutetiana L.*	Onagraceae	Ubiquitous	AWF
False petunia	*Ruellia strepens L.*	Acanthaceae	Ubiquitous	AWF
Fancy wood fern	*Dryopteris intermedia (Muhl.) A. Gray*	Polypodiaceae	Ubiquitous	AWF
Forest pea	*Lathyrus venosus Muhl. var. intonsus Butters and St. John*	Fabaceae	Ubiquitous	AWF
Frog orchid	*Habenaria viridis (L.) Br. var. bracteata (Muhl.) A. Gray*	Orchidaceae	Ubiquitous	AWF
Grape fern	*Botrychium dissectum Sprengel var. obliquum Clute*	Ophioglossaceae	Ubiquitous	AWF
Ground nut	*Apios americana Medic.*	Fabaceae	Ubiquitous	AWF
Hedge nettle	*Stachys tenuifolia Willd.*	Lamiaceae	Ubiquitous	AWF
Hog peanut	*Amphicarpa bracteata (L.) Fern.*	Fabaceae	Ubiquitous	AWF
Honewort	*Cryptotaenia canadensis (L.) DC.*	Apiaceae	Ubiquitous	AWF
Horse-gentian	*Triosteum perfoliatum L.*	Caprifoliaceae	Ubiquitous	AWF
Jumpseed	*Polygonum virginianum L.*	Polygonaceae	Ubiquitous	AWF
Late boneset	*Eupatorium serotinum Michx.*	Asteraceae	Ubiquitous	AWF
Mist flower	*Eupatorium coelestinum L.*	Asteraceae	Ubiquitous	AWF
Moneywort	*Lysimachia nummularia L.**	Primulaceae	Ubiquitous	AWF
Ostrich fern	*Matteuccia struthiopteris (L.) Todaro*	Polypodiaceae	Ubiquitous	AWF
Purple giant hyssop	*Agastache scrophulariaefolia (Willd.) Kuntze*	Lamiaceae	Ubiquitous	AWF
Rattlesnake fern	*Botrychium virginianum (L.) Sw.*	Ophioglossaceae	Ubiquitous	AWF
Red baneberry	*Actaea rubra (Aiton) Willd.*	Ranunculaceae	Ubiquitous	AWF
Robin's plantain	*Erigeron pulchellus Michx.*	Asteraceae	Ubiquitous	AWF
Rose turtlehead	*Chelone obliqua L.*	Scrophulariaceae	Ubiquitous	AWF
Sharp-winged monkey flower	*Mimulus alatus Ait.*	Scrophulariaceae	Ubiquitous	AWF
Southern agrimony	*Agrimonia parviflora Ait.*	Rosaceae	Ubiquitous	AWF
Spikenard	*Aralia racemosa L.*	Araliaceae	Ubiquitous	AWF
Tall bellflower	*Campanula americana L.*	Campanulaceae	Ubiquitous	AWF
Three-lobed coneflower	*Rudbeckia triloba L.*	Asteraceae	Ubiquitous	AWF
Two-leaved miterwort	*Mitella diphylla L.*	Saxifragaceae	Ubiquitous	AWF

Common Name	Scientific Name	Family	Distribution	Guild
Virginia water leaf	*Hydrophyllum virginianum L.*	Hydrophyllaceae	Ubiquitous	AWF
White avens	*Geum canadense Jacq.*	Rosaceae	Ubiquitous	AWF
White baneberry	*Actaea alba (L.) Miller*	Ranunculaceae	Ubiquitous	AWF
White snake root	*Eupatorium rugosum Houttuyn.*	Asteraceae	Ubiquitous	AWF
White turtlehead	*Chelone glabra L.*	Scrophulariaceae	Ubiquitous	AWF
Wild leek	*Allium tricoccum Ait.*	Liliaceae	Ubiquitous	AWF
Wild lily of the valley	*Maianthemum canadense Desf.*	Liliaceae	Ubiquitous	AWF
Wild sasparilla	*Aralia nudicaulis L.*	Araliaceae	Ubiquitous	AWF
Winged-stem	*Verbesina alternifolia (L.) Britt.*	Asteraceae	Ubiquitous	AWF
Wood nettle	*Laportea canadensis (L.) Wedd.*	Urticaceae	Ubiquitous	AWF
Woodland lettuce	*Lactuca floridana (L.) Gaertner*	Asteraceae	Ubiquitous	AWF
Yellowtop	*Senecio glabellus Poir.*	Asteraceae	Ubiquitous	AWF
Yerba de tajo	*Eclipta prostrata L.*	Asteraceae	Ubiquitous	AWF
Basswood	*Tilia americana L.*	Tiliaceae	Ubiquitous	BHT
Bitternut hickory	*Carya cordiformis (Wang.) K.Koch*	Juglandaceae	Ubiquitous	BHT
Black cherry	*Prunus serotina Ehrh.*	Rosaceae	Ubiquitous	BHT
Black jack oak	*Quercus marilandica Muench.*	Fagaceae	Ubiquitous	BHT
Black locust	*Robinia pseudo-acacia L.**	Fabaceae	Ubiquitous	BHT
Black oak	*Quercus velutina Lam.*	Fagaceae	Ubiquitous	BHT
Black walnut	*Juglans nigra L.*	Juglandaceae	Ubiquitous	BHT
Butternut	*Juglans cinerea L.*	Juglandaceae	Ubiquitous	BHT
Chinquapin oak	*Quercus prinoides Willd.*	Fagaceae	Ubiquitous	BHT
Kentucky coffee tree	*Gymnocladus dioica (L.) K.Koch*	Fabaceae	Ubiquitous	BHT
Mockernut hickory	*Carya tomentosa Nutt.*	Juglandaceae	Ubiquitous	BHT
Northern catalpa	*Catalpa speciosa Warder**	Bignoniaceae	Ubiquitous	BHT
Pecan	*Carya illinoensis (Wang.) K.Koch*	Juglandaceae	Ubiquitous	BHT
Pin oak	*Quercus palustris Muench.*	Fagaceae	Ubiquitous	BHT
Red oak	*Quercus rubra L.*	Fagaceae	Ubiquitous	BHT
Redbud	*Cercis canadensis L.*	Fabaceae	Ubiquitous	BHT
Sand Post Oak	*Quercus stellata Wang.*	Fagaceae	Ubiquitous	BHT
Shagbark hickory	*Carya ovata (Mill.) K.Koch.*	Juglandaceae	Ubiquitous	BHT
Shellbark hickory	*Carya laciniosa (Michx.) Loud.*	Juglandaceae	Ubiquitous	BHT
Shingle oak	*Quercus imbricaria Michx.*	Fagaceae	Ubiquitous	BHT
Shumard oak	*Quercus shumardii Buckl.*	Fagaceae	Ubiquitous	BHT
Sugar maple	*Acer saccharum Marsh.*	Aceraceae	Ubiquitous	BHT
Swamp white oak	*Quercus bicolor Willd.*	Fagaceae	Ubiquitous	BHT
Sweet gum	*Liquidambar styraciflua L.*	Hamamelidaceae	Southern	BHT

Common Name	Scientific Name	Family	Distribution	Guild
Mississippi arrowhead	*Sagittaria calycina Engelm.*	Alismataceae	Ubiquitous	EA
Wild rice	*Zizania palustris L. var. interior Fassett*	Poaceae	Ubiquitous	EA
Arrow arum	*Peltandra virginica (L.) schott & Endl.*	Araceae	Ubiquitous	EP
Blue flag	*Iris virginica L. var. shrevei (Small) E. Anders.*	Iridaceae	Ubiquitous	EP
Broad-leaved arrowhead	*Sagittaria latifolia Willd.*	Alismataceae	Ubiquitous	EP
Burhead	*Echinodorus cordifolius (L.) Griseb.*	Alismataceae	Ubiquitous	EP
Burhead	*Sparganium americanum Nutt.*	Sparganiaceae	Ubiquitous	EP
Burreed	*Sparganium chlorocarpum Rydb.*	Sparganiaceae	Northern	EP
Common burreed	*Sparganium eurycarpum Engelm.*	Sparganiaceae	Ubiquitous	EP
Common cattail	*Typha latifolia L.*	Typhaceae	Ubiquitous	EP
Common reed	*Phragmites australis (Cav.) Trin.*	Poaceae	Ubiquitous	EP
Grass-leaved arrowhead	*Sagittaria graminea Michx.*	Alismataceae	Ubiquitous	EP
Grass-leaved water plantain	*Alisma gramineum Lej.*	Alismataceae	Northern	EP
Hardstem bulrush	*Scirpus acutus Muhl.*	Cyperaceae	Ubiquitous	EP
Narrow-leaved cattail	*Typha angustifolia L.*	Typhaceae	Ubiquitous	EP
Northern arrowhead	*Sagittaria cuneata Sheldon*	Alismataceae	Ubiquitous	EP
Northern water plantain	*Alisma triviale Pursh*	Alismataceae	Ubiquitous	EP
Pickerelweed	*Pontederia cordata L.*	Pontederiaceae	Ubiquitous	EP
River bulrush	*Scirpus fluviatilis Torr. & Gray*	Cyperaceae	Ubiquitous	EP
Sessile-fruited arrowhead	*Sagittaria rigida Pursh*	Alismataceae	Ubiquitous	EP
Short-beaked arrowhead	*Sagittaria brevirostra Mack. & Bush*	Alismataceae	Ubiquitous	EP
Slender bulrush	*Scirpus heterochaetus Chase*	Cyperaceae	Ubiquitous	EP
Softstem bulrush	*Scirpus validus Vahl.*	Cyperaceae	Ubiquitous	EP
Southern water plantain	*Alisma subcordatum Raf*	Alismataceae	Ubiquitous	EP
Spotted cowbane	*Cicuta maculata L.*	Apiaceae	Ubiquitous	EP
Square-stemmed spikerush	*Eleocharis quadrangulata (Michx.) Roem. & Schultes*	Cyperaceae	Ubiquitous	EP
Sweet flag	*Acorus calamus L.*	Araceae	Ubiquitous	EP
Water hemlock	*Cicuta bulbifera L.*	Apiaceae	Ubiquitous	EP
Water parsnip	*Sium suave Walt.*	Apiaceae	Ubiquitous	EP
Water Smartweed	*Polygonum amphibium L.*	Polygonaceae	Ubiquitous	EP
Aquatic liverwort	*Riccia fluitans*	Ricciaceae	Ubiquitous	FA
Common ricciocarpus	*Ricciocarpus natans*	Ricciaceae	Ubiquitous	FA
Dotted water meal	*Wolffia punctata Griseb.*	Lemnaceae	Ubiquitous	FA
Duckweed	*Lemna obscura (Austin) Daubs*	Lemnaceae	Ubiquitous	FA
Duckweed	*Lemna perpusilla Torr.*	Lemnaceae	Ubiquitous	FA
Duckweed	*Lemna trinervis (Austin) Small*	Lemnaceae	Ubiquitous	FA
Duckweed	*Lemna valdiviana Phil.*	Lemnaceae	Ubiquitous	FA

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Greaterduckweed	*Spirodela polyrhiza (L.) Schleiden*	Lemnaceae	Ubiquitous	FA
Lesser duckweed	*Lemna minor L.*	Lemnaceae	Ubiquitous	FA
Mosquito fern	*Azolla mexicana Presl*	Salviniaceae	Ubiquitous	FA
Star duckweed	*Lemna trisulca L.*	Lemnaceae	Ubiquitous	FA
Water meal	*Wolffia columbiana Karst.*	Lemnaceae	Ubiquitous	FA
Water meal	*Wolffia papulifera Thompson*	Lemnaceae	Ubiquitous	FA
Water meal	*Wolffiella floridana (J.D. Smith) Thompson*	Lemnaceae	Ubiquitous	FA
Choke-cherry	*Prunus virginiana L.*	Rosaceae	Ubiquitous	FIPT
Persimmon	*Diospyros virginiana L.*	Ebenaceae	Ubiquitous	FIPT
Red cedar	*Juniperus virginiana L.*	Cuppressaceae	Ubiquitous	FIPT
Wild Plum	*Prunus americana Marsh.*	Rosaceae	Ubiquitous	FIPT
Spatter dock	*Nuphar advena Aiton*	Nymphaceae	Ubiquitous	FP
Water lily	*Nymphaea adorata Aiton*	Nymphaceae	Ubiquitous	FP
Water lotus	*Nelumbo lutea (Willd.) Pers.*	Nelumbonaceae	Ubiquitous	FP
Diamond willow	*Salix eriocephala Michx.*	Salicaceae	Ubiquitous	FTPS
Sandbar willow	*Salix interior Rowlee*	Salicaceae	Ubiquitous	FTPS
Black willow	*Salix nigra Marsh.*	Salicaceae	Ubiquitous	FTPT
Box elder	*Acer negundo L.*	Aceraceae	Ubiquitous	FTPT
Cottonwood	*Populus deltoides Marsh.*	Salicaceae	Ubiquitous	FTPT
Green ash	*Fraxinus pennsylvanica Marsh.*	Oleaceae	Ubiquitous	FTPT
Peach-leaved willow	*Salix amygdaloides Anderss.*	Salicaceae	Ubiquitous	FTPT
Silver maple	*Acer saccharinum L.*	Aceraceae	Ubiquitous	FTPT
Alder	*Alnus serrulata (Ait.) Willd.*	Betulaceae	Ubiquitous	FTSS
Alder buckthorn	*Rhamnus frangula L.**	Rhamnaceae	Ubiquitous	FTSS
Buttonbush	*Cephalanthus occidentalis L.*	Rubiaceae	Ubiquitous	FTSS
Canada anemone	*Anemone canadensis L.*	Ranunculaceae	Ubiquitous	FTSS
Dotted hawthorne	*Crategus punctata Jacq.*	Rosaceae	Ubiquitous	FTSS
Eastern serviceberry	*Amelanchier canadensis (L.) Medikus*	Rosaceae	Ubiquitous	FTSS
Northern swamp dogwood	*Cornus racemosa Lam.*	Cornaceae	Ubiquitous	FTSS
Pale dogwood	*Cornus amomum Mill.*	Cornaceae	Ubiquitous	FTSS
Possum haw	*Ilex decidua Walt.*	Aquilfoliaceae	Ubiquitous	FTSS
Red mulberry	*Morus rubra L.*	Moraceae	Ubiquitous	FTSS
Red-osier dogwood	*Cornus stolonifera Michx.*	Cornaceae	Ubiquitous	FTSS
Rough-leaved dogwood	*Cornus drummondii Meyer*	Cornaceae	Ubiquitous	FTSS
Swamp privet	*Forestiera acuminata (Michx.) Poiret.*	Oleaceae	Ubiquitous	FTSS
American bugleweed	*Lycopus americanus Muhl.*	Lamiaceae	Ubiquitous	MF

Common Name	Scientific Name	Family	Distribution	Guild
American fever-few	*Parthenium integrifolium L.*	Asteraceae	Ubiquitous	MF
American germander	*Teucrium canadense L.*	Lamiaceae	Ubiquitous	MF
Arrow-leaved violet	*Viola sagittata Ait.*	Violaceae	Ubiquitous	MF
Bitter cress	*Cardamine hirsuta L.*	Brassicaceae	Ubiquitous	MF
Bittersweet	*Solanum dulcamara L.*	Solanaceae	Ubiquitous	MF
Black-eyed susan	*Rudbeckia hirta L.*	Asteraceae	Ubiquitous	MF
Blackberry lily	*Belamcanda chinensis (L.) DC.**	Iridaceae	Ubiquitous	MF
Blue vervain	*Verbena hastata L.*	Verbenaceae	Ubiquitous	MF
Bluntleaf bedstraw	*Galium obtusum bigel.*	Rubiaceae	Ubiquitous	MF
Boneset	*Eupatorium perfoliatum L.*	Asteraceae	Ubiquitous	MF
Buttonweed	*Spermacoce glabra Michx.*	Rubiaceae	Ubiquitous	MF
Canada goldenrod	*Solidago canadensis L.*	Asteraceae	Ubiquitous	MF
Canada thistle	*Cirsium arvense (L.) Scop.**	Asteraceae	Ubiquitous	MF
Canada tick-trefoil	*Desmodium canadense (L.) DC.*	Fabaceae	Ubiquitous	MF
Cannabis	*Cannabis sativa L.*	Cannabaceae	Ubiquitous	MF
Chickweed	*Cerastium vulgatum L.*	Caryophyllaceae	Ubiquitous	MF
Cinnamon fern	*Osmunda cinnamonea L.*	Osmundaceae	Ubiquitous	MF
Cinnamon willow-herb	*Epilobium coloratum Biehler.*	Onagraceae	Ubiquitous	MF
Clasping dogbane	*Apocynum sibiricum Jacq.*	Araliaceae	Ubiquitous	MF
Common horsetail	*Equisetum arvense L.*	Equisataceae	Ubiquitous	MF
Common plantain	*Plantago major L.**	Plantaginaceae	Ubiquitous	MF
Common purslane	*Portulaca oleracea L.*	Portulaceae	Ubiquitous	MF
Common skullcap	*Scutellaria galericulata L.*	Lamiaceae	Ubiquitous	MF
Common tansy	*Tanacetum vulgare L.**	Asteraceae	Ubiquitous	MF
Cow-parsnip	*Heracleum lanatum Michx.*	Apiaceae	Ubiquitous	MF
Crested wood fern	*Dryopteris cristata (L.) Gray*	Polypodiaceae	Ubiquitous	MF
Culver's root	*Veronicastrum virginicum (L.) Farw.*	Scrophulariaceae	Ubiquitous	MF
Curly dock	*Rumex crispus L.**	Polygonaceae	Ubiquitous	MF
Cutleaf coneflower	*Rudbeckia laciniata L.*	Asteraceae	Ubiquitous	MF
Dandelion	*Taraxacum officinale Weber.*	Asteraceae	Ubiquitous	MF
Ditch-stonecrop	*Penthorum sedoides L.*	Saxifragaceae	Ubiquitous	MF
Dock	*Rumex salicifolius J.A. Weinm.*	Polygonaceae	Ubiquitous	MF
Downy phlox	*Phlox pilosa L.*	Polemoniaceae	Ubiquitous	MF
Drummond's aster	*Aster drummondii Lindl.*	Asteraceae	Ubiquitous	MF
Dwarf St. John's-wort	*Hypericum mutilum L.*	Clusiaceae	Ubiquitous	MF
Dye bedstraw	*Galium tinctorium L.*	Rubiaceae	Ubiquitous	MF
Evening primrose	*Oenothera biennis L.*	Onagraceae	Ubiquitous	MF

Common Name	Scientific Name	Family	Distribution	Guild
False buckwheat	*Polygonum scandens L.*	Polygonaceae	Ubiquitous	MF
False dragonhead	*Physostegia virginiana (L.) Benth.**	Lamiaceae	Ubiquitous	MF
False indigo	*Amorpha fruticosa L.*	Fabaceae	Ubiquitous	MF
False starwort	*Boltonia asteroides (L.) L.Her.*	Asteraceae	Ubiquitous	MF
Field mint	*Mentha arvensis L.*	Lamiaceae	Ubiquitous	MF
Figwort	*Scrophularia marilandica L.*	Scrophulariaceae	Ubiquitous	MF
Fleabane	*Erigeron philadelphicus L.*	Asteraceae	Ubiquitous	MF
Floating primrose willow	*Ludwigia peploides (HBK) Raven*	Onagraceae	Ubiquitous	MF
Fog fruit	*Phyla lanceolata Michx. (Green)*	Verbenaceae	Ubiquitous	MF
Fringed loosestrife	*Lysimachia ciliata L.*	Primulaceae	Ubiquitous	MF
Fringeleaf ruellia	*Ruellia humilis Nutt.*	Acanthaceae	Ubiquitous	MF
Garden asparagus	*Asparagus officinalis L.**	Liliaceae	Ubiquitous	MF
Giant chickweed	*Stellaria aquatica (L.) Scop.*	Caryophyllaceae	Ubiquitous	MF
Golden alexander	*Zizia aurea (L.) W.D. J. Koch.*	Apiaceae	Ubiquitous	MF
Grass of parnassus	*Parnassia glauca Raf.*	Saxifragaceae	Northern	MF
Grass-leaved golden aster	*Chrysopsis graminifolia (Michx.) Elliot var. latifolia Fern.*	Asteraceae	Ubiquitous	MF
Gray-headed coneflower	*Ratibida pinnata (Vent.) Barnh.*	Asteraceae	Ubiquitous	MF
Great lobelia	*Lobelia siphilitica L.*	Campanulaceae	Ubiquitous	MF
Great St. John's-wort	*Hypericum pyramidatum Ait.*	Clusiaceae	Ubiquitous	MF
Ground ivy	*Glechoma hederacea L.*	Lamiaceae	Ubiquitous	MF
Horsenettle	*Solanum caroliniense L.*	Solanaceae	Ubiquitous	MF
Indian hemp	*Apocynum cannabinum L.*	Araliaceae	Ubiquitous	MF
Indian plantain	*Cacalia suaveolens L.*	Asteraceae	Ubiquitous	MF
Interrupted fern	*Osmunda claytoniana L.*	Osmundaceae	Ubiquitous	MF
Joe-pye-weed	*Eupatorium maculatum L.*	Asteraceae	Ubiquitous	MF
Lance-leaved loosestrife	*Lysimachia lanceolata Walt.*	Primulaceae	Ubiquitous	MF
Large purple agalinis	*Agalinis purpurea (L.) Penn.*	Scrophulariaceae	Ubiquitous	MF
Long-leaved ground cherry	*Physalis longifolia Nutt.*	Solanaceae	Ubiquitous	MF
Mad-dog skullcap	*Scutellaria lateriflora L.*	Lamiaceae	Ubiquitous	MF
Marsh fern	*Thelypteris palustris Schott.*	Polypodiaceae	Ubiquitous	MF
Marsh marigold	*Caltha palustris L.*	Ranunculaceae	Ubiquitous	MF
Marsh pea	*Lathyrus palustris L.*	Fabaceae	Ubiquitous	MF
Marsh speedwell	*Veronica scutellata L.*	Asteraceae	Ubiquitous	MF
Michigan lily	*Lilium michiganense Farw.*	Liliaceae	Ubiquitous	MF
Mississippi Valley loosestrife	*Lysimachia hybrida Michx.*	Primulaceae	Ubiquitous	MF
Missouri ironweed	*Vernonia missurica Raf.*	Asteraceae	Southern	MF

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Missouri violet	*Viola sororia Willd.*	Violaceae	Ubiquitous	MF
Motherwort	*Leonurus cardiaca L.**	Lamiaceae	Ubiquitous	MF
Mud plantain	*Heteranthera limosa (Sw,) Willd.*	Pontederiaceae	Ubiquitous	MF
Northern bugleweed	*Lycopus uniflorus Michx.*	Lamiaceae	Ubiquitous	MF
Northern St. John's-wort	*Hypericum boreale (Britt.) Bick.*	Clusiaceae	Ubiquitous	MF
Northern three-lobed bedstraw	*Galium trifidum L.*	Rubiaceae	Ubiquitous	MF
Pale dock	*Rumex altissimus Wood.*	Polygonaceae	Ubiquitous	MF
Pale-spike lobelia	*Lobelia spicata Lam.*	Campanulaceae	Ubiquitous	MF
Plains yellow primrose	*Calylophus serrulatus (Nutt.) Raven*	Onagraceae	Ubiquitous	MF
Pokeweed	*Phytolacca americana L.*	Phtolaccaceae	Ubiquitous	MF
Prairie blue-eyed grass	*Sisyrinchium campestre E. Bickn.*	Iridaceae	Ubiquitous	MF
Prairie fringed orchid	*Habenaria leucophaea (Nutt.) A. Gray*	Orchidaceae	Ubiquitous	MF
Prairie milkweed	*Asclepias hirtella (Pennell) Woodson*	Asclepiadaceae	Ubiquitous	MF
Prairietick-trefoil	*Desmanthus illinoensis (Michx.) MacM.*	Mimosaceae	Ubiquitous	MF
Purple fringed orchid	*Habenaria psycodes (L.) Sprengel.*	Orchidaceae	Ubiquitous	MF
Purple joe-pye-weed	*Eupatorium purpureum L.*	Asteraceae	Ubiquitous	MF
Purple loosestrife	*Lythrum salicaria L.**	Lythraceae	Ubiquitous	MF
Purple milkweed	*Asclepias purpurascens L.*	Asclepiadaceae	Ubiquitous	MF
Red-stemmed plantain	*Plantago rugelii Dene.*	Plantaginaceae	Ubiquitous	MF
Rough avens	*Geum laciniatum Murr.*	Rosaceae	Ubiquitous	MF
Roundfruit St. John's wort	*Hypericum sphaerocarpum Michx.*	Clusiaceae	Ubiquitous	MF
Royal fern	*Osmunda regalis L.*	Osmundaceae	Ubiquitous	MF
Sawtooth sunflower	*Helianthus grosseserratus Martens*	Asteraceae	Ubiquitous	MF
Scouring rush	*Equisetum hyemale L. var. affine (Engelm.)*	Equisataceae	Ubiquitous	MF
Seedbox	*Ludwigia alternifolia L.*	Onagraceae	Ubiquitous	MF
Self heal	*Prunella vulgaris L.*	Lamiaceae	Ubiquitous	MF
Sensitive fern	*Onoclea sensibilis L.*	Polypodiaceae	Ubiquitous	MF
Sheep sorrel	*Rumex acetosella L.**	Polygonaceae	Ubiquitous	MF
Shooting star	*Dodecatheon meadia L.*	Primulaceae	Ubiquitous	MF
Showy lady's slipper	*Cypripedium reginae Walter*	Orchidaceae	Ubiquitous	MF
Showy milkweed	*Asclepias speciosa Torr.*	Asclepiadaceae	Ubiquitous	MF
Shrubby St. John's-wort	*Hypericum prolificum L.*	Clusiaceae	Ubiquitous	MF
Small-headed aster	*Aster racemosus Elliott..*	Asteraceae	Ubiquitous	MF
Smooth rose mallow	*Hibiscus laevis All.*	Malvaceae	Ubiquitous	MF
Smooth scouring rush	*Equisetum laevigatum A.Br.*	Equisataceae	Ubiquitous	MF
Sneezeweed	*Helenium autumnale L.*	Asteraceae	Ubiquitous	MF

Common Name	Scientific Name	Family	Distribution	Guild
Spectacle-weed	*Triodanis perfoliata (L.) Nieuwl.*	Campanulaceae	Ubiquitous	MF
Spiderwort	*Tradescantia virginiana L.*	Commelinaceae	Ubiquitous	MF
Spotted St. John's-wort	*Hypericum punctatum L.*	Clusiaceae	Ubiquitous	MF
Spurge	*Euphorbia humistrata (Engelm.)*	Euphorbiaceae	Ubiquitous	MF
Square-stemmed monkey flower	*Mimulus ringens L.*	Scrophulariaceae	Ubiquitous	MF
Stalked water horehound	*Lycopus rubellus Moench*	Lamiaceae	Ubiquitous	MF
Stinging nettle	*Urtica dioica L. **	Urticaceae	Ubiquitous	MF
Sulfur cinquefoil	*Potentilla recta L.**	Rosaceae	Ubiquitous	MF
Swamp buttercup	*Ranunculus hispidus Michx.*	Ranunculaceae	Ubiquitous	MF
Swamp candles	*Lysimachia terrestris (L.) BSP.*	Primulaceae	Ubiquitous	MF
Swamp dock	*Rumex verticillatus L.*	Polygonaceae	Ubiquitous	MF
Swamp loosestrife	*Lysimachia thyrsiflora L.*	Primulaceae	Ubiquitous	MF
Swamp milkweed	*Asclepias incarnata L.*	Asclepiadaceae	Ubiquitous	MF
Swamp rosemallow	*Hibiscus muscheutos L.*	Malvaceae	Ubiquitous	MF
Swamp saxifrage	*Saxifraga pensylvanica L.*	Saxifragaceae	Ubiquitous	MF
Sweet ox-eye	*Heliopsis helianthoides (L.) Sweet.*	Asteraceae	Ubiquitous	MF
Tall ironweed	*Vernonia gigantea (Walter) Trel.*	Asteraceae	Southern	MF
Tall meadow rue	*Thalictrum dasycarpum Fisch. and Lall.*	Ranunculaceae	Ubiquitous	MF
Tall white aster	*Aster lanceolatus Willd.*	Asteraceae	Ubiquitous	MF
Water dock	*Rumex orbiculatus Gray*	Polygonaceae	Ubiquitous	MF
Water horehound	*Lycopus virginicus L.*	Lamiaceae	Ubiquitous	MF
Water horsetail	*Equisetum fluviatile L.*	Equisataceae	Northern	MF
Water primrose	*Ludwigia polycarpa Short & Peter*	Onagraceae	Ubiquitous	MF
Water smartweed	*Polygonum punctatum Ell.*	Polygonaceae	Ubiquitous	MF
Water speedwell	*Veronica anagallis-aquatics L.*	Asteraceae	Ubiquitous	MF
Waxy meadow rue	*Thalictrum revolutum DC.*	Ranunculaceae	Ubiquitous	MF
Western ironweed	*Vernonia baldwini Torr.*	Asteraceae	Southern	MF
White vervain	*Verbena urticifolia L.*	Verbenaceae	Ubiquitous	MF
White wild indigo	*Baptisia lactea (Raf.) Thieret*	Fabaceae	Ubiquitous	MF
Wild garlic	*Allium canadense L.*	Liliaceae	Ubiquitous	MF
Wild strawberry	*Fragaria virginiana Duchn.*	Rosaceae	Ubiquitous	MF
Wild water pepper	*Polygonum hydropiperoides Michx.*	Polygonaceae	Ubiquitous	MF
Wild yellow lily	*Lilium canadense L.*	Liliaceae	Ubiquitous	MF
Winged loosestrife	*Lythrum alatum Pursh.*	Lythraceae	Ubiquitous	MF
Wood betony	*Pedicularis canadensis L.*	Scrophulariaceae	Ubiquitous	MF
Wood-sorrel	*Oxalis stricta L.*	Oxalaceae	Ubiquitous	MF
Woundwort	*Stachys palustris L.*	Lamiaceae	Ubiquitous	MF

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Wrinkled goldenrod	*Solidago rugosa Miller*	Asteraceae	Ubiquitous	MF
Yellow star grass	*Hypoxis hirsuta (L.) Cov.*	Liliaceae	Ubiquitous	MF
bald spike rush	*Eleocharis erythropoda Steud.*	Cyperaceae	Ubiquitous	MG
Bead grass	*Paspalum fluitans (Elliott) Kunth.*	Poaceae	Ubiquitous	MG
Beaked sedge	*Carex rostrata Stokes.*	Cyperaceae	Northern	MG
Bebb's sedge	*Carex bebbii Olney*	Cyperaceae	Ubiquitous	MG
Bicknell's sedge	*Carex bicknellii Britt.*	Cyperaceae	Ubiquitous	MG
Big bluestem	*Andropogon gerardii Vitman*	Poaceae	Ubiquitous	MG
Black bulrush	*Scirpus atrovirens Willd.*	Cyperaceae	Ubiquitous	MG
Blue-joint	*Calamagrostis canadensis (Michx.) Nutt.*	Poaceae	Ubiquitous	MG
Blunt broom sedge	*Carex tribuloides Wahl.*	Cyperaceae	Ubiquitous	MG
Bottlebrush sedge	*Carex hystericina Muhl.*	Cyperaceae	Ubiquitous	MG
Brevior's sedge	*Carex brevior (Dew.) Mackens.*	Cyperaceae	Ubiquitous	MG
Canada wild rye	*Elymus canadensis L.*	Poaceae	Ubiquitous	MG
Catchfly grass	*Leersia lenticularis Michx.*	Poaceae	Ubiquitous	MG
Cattail sedge	*Carex typhina Michx.*	Cyperaceae	Ubiquitous	MG
Crab grass	*Digitaria sanguinalis (L.) Scop.**	Poaceae	Ubiquitous	MG
Crested sedge	*Carex cristatella Britt.*	Cyperaceae	Ubiquitous	MG
Emory's sedge	*Carex emoryi Dew.*	Cyperaceae	Ubiquitous	MG
Flatstem spike rush	*Eleocharis compressa Sullivant*	Cyperaceae	Ubiquitous	MG
Fowl meadow grass	*Glyceria striata (Lam.) A. Hitchc.*	Poaceae	Ubiquitous	MG
Fox sedge	*Carex vulpinoidea Michx.*	Cyperaceae	Ubiquitous	MG
Foxtail sedge	*Carex alopecoidea Tuckerm.*	Cyperaceae	Ubiquitous	MG
Green muhly	*Muhlenbergia racemosa (Michx.) BSP*	Poaceae	Ubiquitous	MG
Hart Wright's sedge	*Carex hyalinolepis Steud.*	Cyperaceae	Southern	MG
Hayden's sedge	*Carex haydenii Dew.*	Cyperaceae	Ubiquitous	MG
Hop sedge	*Carex lupulina Willd.*	Cyperaceae	Ubiquitous	MG
Indian grass	*Sorghastrum nutans (L.) Nash*	Poaceae	Ubiquitous	MG
Joint rush	*Juncus nodosus L.*	Juncaceae	Ubiquitous	MG
Kentucky bluegrass	*Poa pratensis L.*	Poaceae	Ubiquitous	MG
Knotty-leaved rush	*Juncus acuminatus Michx.*	Juncaceae	Ubiquitous	MG
Lake sedge	*Carex lacustris Willd.*	Cyperaceae	Ubiquitous	MG
Marsh foxtail	*Alopecurus geniculatus L.*	Poaceae	Ubiquitous	MG
Marsh spikerush	*Eleocharis palustris (L.) Roem. & Schultes*	Cyperaceae	Ubiquitous	MG
Meadow sedge	*Carex granularis Muhl. ex Willd.*	Cyperaceae	Ubiquitous	MG
Muskingum sedge	*Carex muskingumensis Schwein.*	Cyperaceae	Ubiquitous	MG
Necklace sedge	*Carex projecta Mack.*	Cyperaceae	Ubiquitous	MG

Common Name	Scientific Name	Family	Distribution	Guild
Needle spikerush	*Eleocharis acicularis (L.) Roem. & Schultes*	Cyperaceae	Ubiquitous	MG
Nimbleweed	*Muhlenbergia schreberi J.F. Gmelin*	Poaceae	Ubiquitous	MG
Nodding bulrush	*Scirpus pendulus Muhl.*	Cyperaceae	Ubiquitous	MG
Northern manna grass	*Glyceria borealis Nash.*	Poaceae	Ubiquitous	MG
Nutsedge	*Cyperus esculentus L.**	Cyperaceae	Ubiquitous	MG
Olney-three square	*Scirpus americanus Pers.*	Cyperaceae	Ubiquitous	MG
Path rush	*Juncus tenuis Willd. var. dudleyi (Wieg.)*	Juncaceae	Ubiquitous	MG
Pointed broom sedge	*Carex scoparia Schkuhr ex Willd.*	Cyperaceae	Ubiquitous	MG
Prairie cord grass	*Spartina pectinata Link.*	Poaceae	Ubiquitous	MG
Purple lovegrass	*Eragrostis spectabilis (Pursh) Seud.*	Poaceae	Ubiquitous	MG
Raven's foot sedge	*Carex crus-corvi Shuttlew ex O. Ktze*	Cyperaceae	Ubiquitous	MG
Red sprangletop	*Leptochloa filiformis P.(Lam.) Beauv.*	Poaceae	Ubiquitous	MG
Red Top	*Agrostis gigantea Roth.*	Poaceae	Ubiquitous	MG
Red-top panicum	*Panicum rigidulum Bosc.*	Poaceae	Ubiquitous	MG
Reed canary grass	*Phalaris arundinacea L.**	Poaceae	Ubiquitous	MG
Reed meadow grass	*Glyceria grandis S. Wats.*	Poaceae	Ubiquitous	MG
Retrorse sedge	*Carex retrorsa Schwein.*	Cyperaceae	Northern	MG
Rice cutgrass	*Leersia oryzoides (L.) Sw.*	Poaceae	Ubiquitous	MG
Sallow sedge	*Carex lurida Wahl.*	Cyperaceae	Ubiquitous	MG
Satin grass	*Muhlenbergia frondosa (Poir.) Fernald*	Poaceae	Ubiquitous	MG
Sedge	*Carex brunnescens (Pers.)Poir.*	Cyperaceae	Ubiquitous	MG
Sedge	*Carex comosa f. boott.*	Cyperaceae	Ubiquitous	MG
Sedge	*Carex echinata Murray*	Cyperaceae	Ubiquitous	MG
Sedge	*Carex laeviconica Dewey.*	Cyperaceae	Ubiquitous	MG
Sedge	*Carex normalis Mackenz.*	Cyperaceae	Ubiquitous	MG
Sedge	*Carex stipata Muhl.*	Cyperaceae	Ubiquitous	MG
Sedge	*Carex trichocarpa Muhl.*	Cyperaceae	Ubiquitous	MG
Short's sedge	*Carex shortinana Dew.*	Cyperaceae	Ubiquitous	MG
Slender sedge	*Carex tenera Dewey*	Cyperaceae	Ubiquitous	MG
Soft rush	*Juncus effusus L.*	Juncaceae	Northern	MG
Switchgrass	*Panicum virgatum L.*	Poaceae	Ubiquitous	MG
Tall dropseed	*Sporobolus asper (Michx.) Kunth.*	Poaceae	Ubiquitous	MG
Three-way sedge	*Dulichium arundinaceum (L.) Britt.*	Cyperaceae	Ubiquitous	MG
Torrey's rush	*Juncus torreyi Cov.*	Juncaceae	Ubiquitous	MG
Tuckerman's sedge	*Carex tuckermanii F. Boott.*	Cyperaceae	Ubiquitous	MG
Tussock sedge	*Carex stricta Lam.*	Cyperaceae	Ubiquitous	MG
Virginiana wild rye	*Elymus virginicus L.*	Poaceae	Ubiquitous	MG

Common Name	Scientific Name	Family	Distribution	Guild
Wire sedge	*Carex lasiocarpa Ehrh.*	Cyperaceae	Ubiquitous	MG
Woolly bulrush	*Scirpus cyperinus (L.) Kunth*	Cyperaceae	Ubiquitous	MG
Woolly sedge	*Carex lanuginosa Michx.*	Cyperaceae	Ubiquitous	MG
Wooly panicum	*Panicum lanigunosum Ell.*	Poaceae	Ubiquitous	MG
Buttonbush dodder	*Cuscuta cephalanthi Engelm.*	Cuscutaceae	Ubiquitous	PP
Common dodder	*Cuscuta gronovii Willd.*	Cuscutaceae	Ubiquitous	PP
Dodder	*Cuscuta compacta A.L. Juss*	Cuscutaceae	Ubiquitous	PP
Dodder	*Cuscuta cuspidata Engelm.*	Cuscutaceae	Ubiquitous	PP
Rope dodder	*Cuscuta glomerata Choisy.*	Cuscutaceae	Ubiquitous	PP
Smartweed-dodder	*Cuscuta polygonorum Engelm.*	Cuscutaceae	Ubiquitous	PP
Bigleaf pondweed	*Potamogeton amplifolius Tuckerm.*	Potamogetonaceae	Ubiquitous	RSA
Common water weed	*Elodea canadensis Michx*	Hydrophyllaceae	Ubiquitous	RSA
Curly-leaved pondweed	*Potamogeton crispus L.**	Potamogetonaceae	Ubiquitous	RSA
Eurasian milfoil	*Myriophyllum spicatum L. var. exalbescens (Fern.) Jepson**	Halogaraceae	Ubiquitous	RSA
Eutrophic water nymph	*Najas minor All.**	Najadaceae	Ubiquitous	RSA
Flat-stem pondweed	*Potamogeton zosteriformis Fern.*	Potamogetonaceae	Ubiquitous	RSA
Floating pondweed	*Potamogeton natans L.*	Potamogetonaceae	Northern	RSA
Horned pondweed	*Zannichellia palustris L.*	Zannichelliaceae	Ubiquitous	RSA
Illinois pondweed	*Potamogeton illinoensis Morong*	Potamogetonaceae	Ubiquitous	RSA
Leafy pondweed	*Potamogeton foliosus Raf.*	Potamogetonaceae	Ubiquitous	RSA
Long-leaved pondweed	*Potamogeton nodosus Poir.*	Potamogetonaceae	Ubiquitous	RSA
Mermaid-weed	*Proserpinaca palustris L.*	Halogaraceae	Ubiquitous	RSA
Milfoil	*Myriophyllum heterophyllum Michx.*	Halogaraceae	Ubiquitous	RSA
Milfoil	*Myriophyllum pinnatum (Walt.) BSP.*	Halogaraceae	Ubiquitous	RSA
Northern water nymph	*Najas flexilis (Willd.) rostk. & Schmidt*	Najadaceae	Northern	RSA
Quillwort	*Isoetes melanpoda Gay and Dur.*	Isoetaceae	Northern	RSA
Red-head pondweed	*Potamogeton richardsonii (Benn.) Rydb.*	Potamogetonaceae	Ubiquitous	RSA
Ribbon-flowered pondweed	*Potamogeton epihydrus Raf.*	Potamogetonaceae	Ubiquitous	RSA
Sago pondweed	*Potamogeton pectinatus L.*	Potamogetonaceae	Ubiquitous	RSA
Slender pondweed	*Potamogeton pusillus L.*	Potamogetonaceae	Ubiquitous	RSA
Snailseed pondweed	*Potamogeton diversifolius L.*	Potamogetonaceae	Ubiquitous	RSA
Southern water nymph	*Najas guadalupensis (Spreng.) Morong*	Najadaceae	Ubiquitous	RSA
Spotted pondweed	*Potamogeton pulcher Tuckerm.*	Potamogetonaceae	Ubiquitous	RSA
Straight-leaved pondweed	*Potamogeton strictifolius Benn.*	Potamogetonaceae	Northern	RSA
Vernal water starwort	*Callitriche verna L.*	Callitrichaceae	Ubiquitous	RSA
Water celery	*Vallisneria americana Michx.*	Hydrophyllaceae	Ubiquitous	RSA
Water stargrass	*Zosterella dubia (Jacq.) Small*	Pontederiaceae	Ubiquitous	RSA

Common Name	Scientific Name	Family	Distribution	Guild
Water starwort	*Callitriche heterophylla Pursh.*	Callitrichaceae	Ubiquitous	RSA
Water weed	*Elodea nuttallii (Planch.) St. John*	Hydrophyllaceae	Ubiquitous	RSA
White water crowfoot	*Ranunculus subrigidus W. Drew*	Ranunculaceae	Northern	RSA
White water crowfoot	*Ranunculus longirostris Godr.*	Ranunculaceae	Ubiquitous	RSA
Whorled milfoil	*Myriophyllum verticillatum L.*	Halogaraceae	Northern	RSA
Yellow water crowfoot	*Ranunculus flabellaris Raf.*	Ranunculaceae	Ubiquitous	RSA
Bristly crowfoot	*Ranunculus pensylvanicus L.*	Ranunculaceae	Ubiquitous	SAF
Brook cinquefoil	*Potentilla rivalis Nutt.*	Rosaceae	Ubiquitous	SAF
Bur marigold	*Bidens laevis (L.) BSP.*	Asteraceae	Ubiquitous	SAF
Bushy knotweed	*Polygonum ramosissimum Michx.*	Polygonaceae	Ubiquitous	SAF
Creeping burhead	*Echinodorus berteroi (Sprengel) Fassett*	Alismataceae	Ubiquitous	SAF
Cursed crowfoot	*Ranunculus scleratus L.*	Ranunculaceae	Ubiquitous	SAF
Devil's beggar's ticks	*Bidens frondosa L.*	Asteraceae	Ubiquitous	SAF
False pimpernel	*Lindernia dubia (L.) Pennell.*	Scrophulariaceae	Ubiquitous	SAF
Golden dock	*Rumex maritimus L.*	Polygonaceae	Ubiquitous	SAF
Hedge hyssop	*Gratiola neglecta Torr.*	Scrophulariaceae	Ubiquitous	SAF
Lady's thumb	*Polygonum persicaria L.*	Polygonaceae	Ubiquitous	SAF
Lizard's tail	*Saururus cernuus L.*	Saururaceae	Ubiquitous	SAF
Long-bracted tickseed	*Bidens polylepis S.F. Blake*	Asteraceae	Ubiquitous	SAF
Low cudweed	*Gnaphalium uliginosum L.*	Asteraceae	Ubiquitous	SAF
Marsh cress	*Rorripa palustris (L.) Bess.*	Brassicaceae	Ubiquitous	SAF
Nodding smartweed	*Polygonum lapathifolium L.*	Polygonaceae	Ubiquitous	SAF
Pinkweed	*Polygonum pensylvanicum L.*	Polygonaceae	Ubiquitous	SAF
Purple-stemmed beggar's tick	*Bidens connata Muhl.*	Asteraceae	Ubiquitous	SAF
Round-leaved spurge	*Euphorbia serpens HBK.*	Euphorbiaceae	Ubiquitous	SAF
Sessile-flowered cress	*Rorripa sessiliflora (Nutt.) Hitchc.*	Brassicaceae	Ubiquitous	SAF
Stick-tight	*Bidens cernua L.*	Asteraceae	Ubiquitous	SAF
Tall beggar's ticks	*Bidens vulgata Greene.*	Asteraceae	Ubiquitous	SAF
Toothcup	*Ammania coccinea Rottb.*	Lythraceae	Ubiquitous	SAF
Water cress	*Rorripa nasturtium-aquaticum (L.) Hayek**	Brassicaceae	Ubiquitous	SAF
Water pepper	*Polygonum hydropiper L.*	Polygonaceae	Ubiquitous	SAF
Awned cyperus	*Cyperus squarrosus L.*	Cyperaceae	Ubiquitous	SAG
Barnyard grass	*Echinochloa crusgalli (L.) Beauv.*	Poaceae	Ubiquitous	SAG
Barnyard grass	*Echinochloa muricata (Beauv.) Fern.*	Poaceae	Ubiquitous	SAG
Brook sedge	*Cyperus bipartitus Torr.*	Cyperaceae	Ubiquitous	SAG
Coarse cyperus	*Cyperus odoratus L.*	Cyperaceae	Ubiquitous	SAG
Creeping lovegrass	*Eragrostis hypnoides (Lam.) BSP.*	Poaceae	Ubiquitous	SAG

Common Name	Scientific Name	Family	Distribution	Guild
Dwarf bulrush	*Hemicarpha micrantha (Vahl) Pax*	Cyperaceae	Ubiquitous	SAG
Low cyperus	*Cyperus diandrus Torr.*	Cyperaceae	Ubiquitous	SAG
Red-rooted sedge	*Cyperus erythrorhizos Muhl.*	Cyperaceae	Ubiquitous	SAG
Sandbar lovegrass	*Eragrostis frankii C.A. Mey*	Poaceae	Ubiquitous	SAG
Small lovegrass	*Eragrostis pectinacea (Michx.) Ness.*	Poaceae	Ubiquitous	SAG
Spike rush	*Eleocharis ovata (Roth) R. & S.*	Cyperaceae	Ubiquitous	SAG
Straw-colored cyperus	*Cyperus strigosus L.*	Cyperaceae	Ubiquitous	SAG
Swamp barnyard grass	*Echinochloa walteri (Pursh) Heller*	Poaceae	Ubiquitous	SAG
Taper-leaf sedge	*Cyperus acuminatus Torr. & Hook*	Cyperaceae	Ubiquitous	SAG
Wedge grass	*Sphenopholis obtusata (Michx.) scribn.*	Poaceae	Ubiquitous	SAG
Bellwort	*Uvularia grandiflora J.E. Smith*	Liliaceae	Ubiquitous	SE
Blank sweet cicely	*Osmorhiza claytonii (Michx.)*	Apiaceae	Ubiquitous	SE
Bloodroot	*Sanguinaria canadensis L.*	Papaveraceae	Ubiquitous	SE
Early meadow rue	*Thalictrum dioicum L.*	Ranunculaceae	Ubiquitous	SE
Forest phlox	*Phlox divaricata L.*	Polemoniaceae	Ubiquitous	SE
Green dragon	*Arisaema dracontium (L.) Schott.*	Araceae	Ubiquitous	SE
May apple	*Podophyllum peltatum L.*	Berberidaceae	Ubiquitous	SE
Nodding trillium	*Trillium cernuum L.*	Liliaceae	Northern	SE
Sharp-lobed lobelia	*Hepatica acutiloba DC.*	Ranunculaceae	Ubiquitous	SE
Skunk cabbage	*Symplocarpus foetidus (L.) Nutt.*	Araceae	Northern	SE
White dog-tooth violet	*Erythronium albidum Nutt.*	Liliaceae	Ubiquitous	SE
Wild geranium	*Geranium maculatum L.*	Geraniaceae	Ubiquitous	SE
Wild ginger	*Asarum canadense L.*	Aristolochiaceae	Ubiquitous	SE
Wood anemone	*Anemone quinquefolia L.*	Ranunculaceae	Ubiquitous	SE
Bald cypress	*Taxodium distichum (L.) Rich.*	Taxodiaceae	Ubiquitous	SF
Water tupelo	*Nyssa aquatica (L.)*	Cornaceae	Ubiquitous	SF
American elm	*Ulmus americana L.*	Ulmaceae	Ubiquitous	SFT
Black Ash	*Fraxinus nigra Marsh.*	Oleaceae	Northern	SFT
Hackberry	*Celtis occidentalis L.*	Ulmaceae	Ubiquitous	SFT
Honey locust	*Gleditsia triacanthos L.*	Fabaceae	Ubiquitous	SFT
Red elm	*Ulmus rubra Muhl.*	Ulmaceae	Ubiquitous	SFT
Red maple	*Acer rubrum L.*	Aceraceae	Ubiquitous	SFT
River birch	*Betula nigra L.*	Betulaceae	Ubiquitous	SFT
Siberian elm	*Ulmus pumila L.**	Ulmaceae	Ubiquitous	SFT
Sugarberry	*Celtis laevigata Willd.*	Ulmaceae	Ubiquitous	SFT
Sycamore	*Platanus occidentalis L.*	Plantanaceae	Ubiquitous	SFT
Asiatic dayflower	*Commelina communis L.*	Commelinaceae	Ubiquitous	TAF

Common Name	Scientific Name	Family	Distribution	Guild
Biennial gaura	*Gaura biennis D.*	Onagraceae	Ubiquitous	TAF
Black mustard	*Brassica nigra L.*	Brassicaceae	Ubiquitous	TAF
Black nightshade	*Solanum nigrum L.*	Solanaceae	Ubiquitous	TAF
Blood polygala	*Polygala sanguinea L.*	Polygonaceae	Ubiquitous	TAF
Bull thistle	*Cirsium vulgare (Savi) Tenore.**	Asteraceae	Ubiquitous	TAF
Carpetweed	*Mollugo verticillata L.*	Molluginaceae	Ubiquitous	TAF
common chickweed	*Stellaria media (L.) Cyrillo*	Caryophyllaceae	Ubiquitous	TAF
Common cocklebur	*Xanthium strumarium L.**	Asteraceae	Ubiquitous	TAF
Common ragweed	*Ambrosia artemisiifolia L.*	Asteraceae	Ubiquitous	TAF
Creeping dayflower	*Commelina diffusa Burman*	Commelinaceae	Ubiquitous	TAF
Daisy fleabane	*Erigeron annuus (L.) Pers.*	Asteraceae	Ubiquitous	TAF
Field thistle	*Cirsium discolor (Muhl.) Spreng.*	Asteraceae	Ubiquitous	TAF
Fireweed	*Erechtites hieracifolia (L.) Raf.*	Asteraceae	Ubiquitous	TAF
Fringed quickweed	*Galinsoga quadriradiata Ruiz & Pavon*	Asteraceae	Ubiquitous	TAF
Golden coreopsis	*Coreopsis tinctoria Nutt.*	Asteraceae	Ubiquitous	TAF
Goosefoot	*Chenopodium album L.**	Chenopodiaceae	Ubiquitous	TAF
Great ragweed	*Ambrosia trifida L.*	Asteraceae	Ubiquitous	TAF
Green amaranth	*Amaranthus hybridus L.*	Amaranthaceae	Ubiquitous	TAF
Hairy spurge	*Euphorbia vermiculata Raf.*	Euphorbiaceae	Ubiquitous	TAF
Horseweed	*Conyza canadensis (L.) Cronq.*	Asteraceae	Ubiquitous	TAF
Marsh elder	*Iva annua L.*	Asteraceae	Ubiquitous	TAF
Motherwort	*Leonurus marrubiastrum L.**	Lamiaceae	Ubiquitous	TAF
Pale touch-me-not	*Impatiens pallida Nutt.*	Balsaminaceae	Ubiquitous	TAF
Partridge pea	*Chamaecrista fasciculata Michx.*	Fabaceae	Ubiquitous	TAF
Prickly sida	*Sida spinosa L.*	Malvaceae	Ubiquitous	TAF
Purslane-speedwell	*Veronica peregrina L.*	Scrophulariaceae	Ubiquitous	TAF
Rough fleabane	*Erigeron strigosus Muhl.*	Asteraceae	Ubiquitous	TAF
Shepherd's purse	*Capsella bursa-pastoris (L.) Medic.*	Brassicaceae	Ubiquitous	TAF
Spanish needles	*Bidens bipinnata L.*	Asteraceae	Ubiquitous	TAF
Spiny pigweed	*Amaranthus spinosus L.*	Amaranthaceae	Ubiquitous	TAF
Spotted spurge	*Euphorbia maculata L.*	Euphorbiaceae	Ubiquitous	TAF
Spotted touch-me -not	*Impatiens capensis Meerb.*	Balsaminaceae	Ubiquitous	TAF
Spreading chervil	*Chaerophyllum procumbens (L.) Crantz*	Apiaceae	Ubiquitous	TAF
Spring-cleavers	*Galium aparine L.*	Rubiaceae	Ubiquitous	TAF
Stickseed	*Hackelia virginiana (L.) Johnston.*	Boraginaceae	Ubiquitous	TAF
Straw-stem beggar's ticks	*Bidens comosa (Gray) Wiegand.*	Asteraceae	Ubiquitous	TAF
Strawberry weed	*Potentilla norvegica L.*	Rosaceae	Ubiquitous	TAF

Common Name	Scientific Name	Family	Distribution	Guild
Three-seeded mercury	*Acalypha rhomboidea Raf.*	Euphorbiaceae	Ubiquitous	TAF
Tomato	*Lycopersicon esculentum Miller*	Solanaceae	Ubiquitous	TAF
Toothed spurge	*Euphorbia dentata Michx.*	Euphorbiaceae	Ubiquitous	TAF
Turnsole	*Heliotropium indicum L.**	Boraginaceae	Ubiquitous	TAF
Velvetleaf	*Abutilon theophrasti Medikus.**	Malvaceae	Ubiquitous	TAF
Water hemp	*Amaranthus rudis Sauer*	Amaranthaceae	Ubiquitous	TAF
Water hemp	*Amaranthus tuberculatus (Nutt.) Moq.*	Amaranthaceae	Ubiquitous	TAF
Water Smartweed	*Polygonum aviculare L.*	Polygonaceae	Ubiquitous	TAF
White morning glory	*Ipomoea lacunosa L.*	Convolvulaceae	Ubiquitous	TAF
Willowleaf lettuce	*Lactuca saligna L.*	Asteraceae	Ubiquitous	TAF
Clearweed	*Pilea pumila (l.) Gray.*	Urticaceae	Ubiquitous	TAG
Deer-tongue grass	*Panicum clandestinum L.*	Poaceae	Ubiquitous	TAG
Fall panic grass	*Panicum dichotomiflorum Michx.*	Poaceae	Ubiquitous	TAG
Giant foxtail	*Setaria faberi Herrm.*	Poaceae	Ubiquitous	TAG
Green foxtail	*Setaria viridis (L.) Beauv.*	Poaceae	Ubiquitous	TAG
Old witch grass	*Panicum capillare L.*	Poaceae	Ubiquitous	TAG
Prairie three-awn	*Aristida oligantha Michx.*	Poaceae	Ubiquitous	TAG
Sand bur	*Cenchrus longispinus (Hack.) Fern.*	Poaceae	Ubiquitous	TAG
Yellow foxtail	*Setaria glauca (L.) P. Beauv.*	Poaceae	Ubiquitous	TAG
Common bladderwort	*Utricularia vulgaris L.*	Lentibulariaceae	Ubiquitous	USA
Coontail	*Ceratophyllum demersum L.*	Ceratophyllaceae	Ubiquitous	USA
Coontail	*Ceratophyllum echinatum Gray*	Ceratophyllaceae	Ubiquitous	USA
American bindweed	*Convolvulus arvensis L.**	Convolvulaceae	Ubiquitous	V
Bristly greenbrier	*Smilax hispida Muhl.*	Smilacaceae	Ubiquitous	V
Bur cucumber	*Sicyos angulatus L.*	Curcurbitaceae	Ubiquitous	V
Carrion flower	*Smilax herbacea L.*	Smilacaceae	Ubiquitous	V
Climbing milkweed	*Ampelamus albidus (Nutt.) Britton*	Asclepiadaceae	Ubiquitous	V
Common poison ivy	*Toxicodendron radicans ssp. negundo (Greene)Gillis*	Anacardiaceae	Ubiquitous	V
Frost grape	*Vitis vulpina L.*	Vitaceae	Ubiquitous	V
Grape woodvine	*Parthenocissus vitacea (Knerr.) A. Hitchc.*	Vitaceae	Ubiquitous	V
Grayback grape	*Vitis cinerea Engelm.*	Vitaceae	Ubiquitous	V
Hops	*Humulus lupulus L.*	Cannabaceae	Ubiquitous	V
Moonseed	*Menispermum canadense L.*	Menisperimaceae	Ubiquitous	V
Prickly cucumber	*Echinocystis lobata (Michx.) T. & G.*	Curcurbitaceae	Ubiquitous	V
Red grape	*Vitis palmata Vahl.*	Vitaceae	Ubiquitous	V
Riverbank grape	*Vitis riparia Michx.*	Vitaceae	Ubiquitous	V
Sandvine	*Ampelopsis cordata Michx.*	Asclepiadaceae	Ubiquitous	V

Common Name	Scientific Name	Family	Distribution	Guild
Summer grape	*Vitis aestivalis var. argentinfolia*	Vitaceae	Ubiquitous	V
Trumpet flower	*Campsis radicans (L.) Seem.**	Bignoniaceae	Ubiquitous	V
Upright carrion flower	*Smilax ecirrhata (Engelm.) S. Wats.*	Smilacaceae	Ubiquitous	V
Virginia creeper	*Parthenocissus quinquefolia (L.) Planch*	Vitaceae	Ubiquitous	V
Westren poison ivy	*Toxicodendron rydbergii (Small ex Rydb.) Greene.*	Anacardiaceae	Ubiquitous	V
Wild pumpkin	*Cucurbita foetidissima HBK*	Curcurbitaceae	Ubiquitous	V
Yam	*Dioscorea villosa L.*	Dioscoreaeceae	Ubiquitous	V
Frank's sedge	*Carex frankii Kunth*	Cyperaceae	Ubiquitous	WG
Gray sedge	*Carex amphibola Steud. var. turgida Fern.*	Cyperaceae	Ubiquitous	WG
Gray's sedge	*Carex grayi Carey.*	Cyperaceae	Ubiquitous	WG
Sedge	*Carex rosea Schk.*	Cyperaceae	Ubiquitous	WG
Soft fox sedge	*Carex conjuncta E. Boott.*	Cyperaceae	Ubiquitous	WG
Squarrose sedge	*Carex squarrosa L.*	Cyperaceae	Ubiquitous	WG
White grass	*Leersia virginica Willd.*	Poaceae	Ubiquitous	WG
Wild oats	*Chasmanthium latifolium (Michx.) Yates.*	Poaceae	Ubiquitous	WG
Wood reed grass	*Cinna arundinacea L.*	Poaceae	Ubiquitous	WG
Black raspberry	*Rubus occidentalis L.*	Rosaceae	Ubiquitous	WS
Bladdernut	*Staphylea trifolia l.*	Staphyleaceae	Ubiquitous	WS
Common blackberrry	*Rubus allegheniensis Porter.*	Rosaceae	Ubiquitous	WS
Common buckthorn	*Rhamnus cathartica L.**	Rhamnaceae	Ubiquitous	WS
common juniper	*Juniperus communis L.*	Cuppressaceae	Ubiquitous	WS
Dwarf hackberry	*Celtis tenuifolia Nutt.*	Ulmaceae	Ubiquitous	WS
Early wild rose	*Rosa blanda Ait.*	Rosaceae	Ubiquitous	WS
Elderberry	*Sambucus canadensis L.*	Caprifoliaceae	Ubiquitous	WS
Flowering dogwood	*Cornus florida L.*	Cornaceae	Ubiquitous	WS
Gooseberry	*Ribes hirtellum Michx.*	Saxifragaceae	Ubiquitous	WS
Hazelnut	*Corylus americana Walter.*	Betulaceae	Ubiquitous	WS
Honeysuckle	*Lonicera x bella Zabel.**	Caprifoliaceae	Ubiquitous	WS
Missouri gooseberry	*Ribes missouriense Nutt.*	Saxifragaceae	Ubiquitous	WS
Nannyberry	*Viburnum lentago L.*	Caprifoliaceae	Ubiquitous	WS
Northern dewberry	*Rubus flagellaris L.*	Rosaceae	Ubiquitous	WS
Prairie rose	*Rosa setigera Michx.*	Rosaceae	Ubiquitous	WS
Prickly ash	*Xanthoxylum americanum Mill.*	Rutaceae	Ubiquitous	WS
Red raspberry	*Rubus strigosus Michx.*	Rosaceae	Ubiquitous	WS
Round-leaved dogwood	*Cornus rugosa Lam.*	Cornaceae	Ubiquitous	WS
Sassafras	*Sassafras albidum (Nutt.) Nees.*	Lauraceae	Ubiquitous	WS
Wahoo	*Euonymus atropurpureus Jacq.*	Celastraceae	Ubiquitous	WS

Common Name	Scientific Name	Family	Distribution	Guild
White mulberry	*Morus alba L.**	Moraceae	Ubiquitous	WS
Wild black currant	*Ribes americanum Mill.*	Saxifragaceae	Ubiquitous	WS
Wild honeysuckle	*Lonicera dioca L.*	Caprifoliaceae	Ubiquitous	WS

Appendix M

Upper Mississippi River System Macroinvertebrate Species

Species list compiled from:

Ecological Specialists, Inc. 1996. Macroinvertebrates associated with chevron dikes in Pool 24 of the Mississippi River – Seasonal comparisons, 1995. Report Prepared for US Army Corps of Engineers – St. Louis District, Ecological Specialists, Inc. Report No. 95-006, St. Peters, Missouri.
(Pool 24 in location column)

Chilton, E. W. 1990. Macroinvertebrate communities associated with three aquatic macrophytes (*Ceratophyllum demersum*, *Myriophyllum spictatum*, and *Vallisneria americana*) in Lake Onalaska, Wisconsin. Journal of Freshwater Ecology 5:455 – 466.
(LkOnplant in location column)

Elstad, C.A. 1986. Macrobenthic distribution and community structure in the upper navigation pools of the Mississippi River. Hydrobiologia 136:85 – 100.
(Pool 7,8 in location column)

Gale, W.F. 1975. Bottom fauna of a segment of the Mississippi River above Dam 19, Keokuk, Iowa. Ecology 49:162 – 168.
(Pool 19 in location column)

Guild assignments after:

Merritt, R.W. and K.W. Cummins. 1996. An introduction to the aquatic insects of North America. Kendall/Hunt Publishing Company, Dubuque, Iowa. 862pp.
(M&C in Source Column)

Pennak, R.W. 1978. Freshwater invertebrates of the United States. John Wiley & sons, Inc., New York, New York. 803pp.
(Pennak in Source column)

Phylum	Class	Order	Family	Species	Guild: Habitat	Guild: Feeding	Guild: Existence	Source	Location
Annelida	Aelosomatida	Aelosomatida	Aeolosomatidae	*Spp.*	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
	Hirudinea	Rhynchobdellida	Erpobdellidae	*Erpobdella punctata*					Pool 19
				Illinoibdella sp.					Pool 19,G
			Glossiphoniidae	*Alboglossiphonia heteroclita*					LkOnplant
				Batracobdella paludosa					LkOnplant
				Batracobdella phalera					LkOnplant
				Batracobdella picta					LkOnplant
				Helobdella elongata					LkOnplant
				H. fusca					Pool 19,G
				H. nepheloidea					Pool 24
				H. stagnalis					Pool 19
				H. transversa					LkOnplant
				H. triserialis					LkOnplant
				Glossophonia complanata					Pool 19
				Placobdella montifera					Pool 19
				P. parasitica					Pool 19
				P. translucens					LkOnplant
	Oligochaeta	Haplotaxida	Enchytraeidae	*Barbidrilus paucisetus*	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
			Enchytraeidae	*Spp.*	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
			Naididae	*Aelosoma spp.*					LkOnplant
				Chaetogaster diaphanus	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Chaetogaster diastrophus	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
				Dero digitata	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Nais behningi	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
				Nais bretscheri	Lotic-Erosional	Parasite	Burrower	Pennak	Pool 24
				Nais communis	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
				Nais elinguis	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
				Nais pardalis	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
				Nais pseudobtusa	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
				Nais simplex	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Nais variabilis	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Ophidonais serpentina	Lotic-Erosional	Parasite	Burrower	Pennak	Pool 24
				Paranais frici	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Piguetiella michiganensis	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
				Pristina aequiseta	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Pristina breviseta	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
				Pristina leidyi	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
				Pristinella osborni	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
				Pristinella sima	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24

Phylum	Class	Order	Family	Species	Guild: Habitat	Guild: Feeding	Guild: Existence	Source	Location
				Slavina appendiculata	Lotic-Erosional	Collector	Burrower	Pennak	Pool 24
				Stephensoniana trivandrana	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Stylaria lacustris	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
			Tubificidae	*Aulodrilus limnobius*	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Aulodrilus pigueti	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Branchiura sowerbyi	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				immature w/o capilliform setae	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Limnodrilus hoffmeisteri	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Limnodrilus maumeensis	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
				Limnodrilus udekemianus	Lotic-Depositional	Collector	Burrower	Pennak	Pool 24
Arthropoda	Arachnida	Acarina		*Spp.*	Lotic-Depositional	Predator	Burrower	Pennak	Pool 24
	Decapoda		Palaemonidae	*Palaemonetes spp.*					LkOnplant
	Insecta	Collembola	Poduridae						LkOnplant
			Isotomidae	*Semicerura spp.*	Lotic-Depositional	Collector		M&C	Pool 24
		Coleoptera	Chrysomelidae	*Donacia*	Aq. Plants			M&C	Pool 7,8
			Dytiscidae	*Bidessonatus spp.*	Lotic Depositional	Predator	Swimmer, Climer	M&C	LkOnplant
				Hydroporus spp.	Lotic Depositional	Predator	Swimmer, Climer	M&C	LkOnplant
				Laccophilus proximus	Lotic Depositional		Swimmer, Climer	M&C	LkOnplant
				Laccophilus spp.	Lotic Depositional		Swimmer, Diver	M&C	LkOnplant
				Liodessus spp.	Lotic	Predator	Swimmer, Diver	M&C	LkOnplant
			Elmidae	*Dubiraphia spp.*	Lotic Erosional - plants		Clinger	M&C	Pool 7,8
				Macronynchus glabratus	Lotic	Collector	Clinger	M&C	LkOnplant
				Stenelmis spp.	Lotic Erosional	Scrapers	Clinger	M&C	Pool 19
				Stenopelmus spp.				M&C	LkOnplant
			Gyrinidae	*Dineutus spp.*	Lotic Depositional	Predators	Swimmer, Diver	M&C	Pool 7,8
				Gyrinus spp.	Lotic Depositional	Predators	Swimmer, Diver	M&C	Pool 7,8
			Haliplidae	*Haliplus spp.*	Aq. Plants	Macrophyte Piercer	Climbers	M&C	LkOnplant
			Helophoridae	*Helophorus spp.*	Lentic and Lotic Erosional	Shredders	Climbers	M&C	Pool 7,8
		Diptera		*Spp. (pupa)*				M&C	Pool 24
			Ceratopogonidae	*Bezzia spp.*	Lotic-Depositional	Predator	Burrower	M&C	Pool 24
			Ceratopogonidae	*Atrichopogon spp.*	Lotic-Depositional	Predator	Burrower	M&C	Pool 24
				Culicoides spp.	Lotic-Depositional	Predator	Burrower	M&C	Pool 24
				Nilobezzia spp.	Lotic-Depositional	Predator	Burrower	M&C	Pool 24
				Palpomyia spp.	Lotic-Depositional	Predator	Burrower	M&C	Pool 19
			Chironomidae	*Spp.*				M&C	Pool 24
				Spp. (pupa)				M&C	Pool 24
				Ablabesmyia annulata	Lotic-Depositional	Predator	Sprawler	M&C	Pool 24
				Axarus spp.	Lotic-Depositional	Collector Gatherer	Sprawler Burrower	M&C	Pool 24
				Chernovskiia spp.	Lotic Depositional			M&C	Pool 24
				Chironomus spp.	Lotic Depositional	Collector	Burrower	M&C	Pool 24
				Cladotanytarsus spp.	Lotic Depositional	Collector		M&C	Pool 24

Phylum	Class	Order	Family	Species	Guild: Habitat	Guild: Feeding	Guild: Existence	Source	Location
				Coelotanypus sp.	Lentic	Predator	Buttrower	M&C	Pool 19
				Cricotopus bicinctus group	Varied	Varied	Varied	M&C	Pool 24
				Cricotopus intersectus	Varied	Varied	Varied	M&C	LkOnplant
				Cricotopus sylvestris group	Varied	Varied	Varied	M&C	Pool 24
				Cryptochironomus spp.	Lotic Depositional	Sprawler Burrower	Predator	M&C	Pool 24
				C. digitatus	Lotic Depositional	Sprawler Burrower	Predator	M&C	Pool 19
				Dicrotendipes neomodestus	Lotic Erosional	Collector	Burrower	M&C	Pool 24
				Dicrotendipes nervosus	Lotic Erosional	Collector	Burrower	M&C	LkOnplant
				Dicrotendipes spp.	Lotic Erosional	Collector	Burrower	M&C	Pool 24
				Endochironomus sp.	Lentic	Shredder	Clinger	M&C	Pool 7,8
				Endochironomus nigricans	Lentic	Shredder	Clinger	M&C	LkOnplant
				Endochironomus subtendeus	Lentic	Shredder	Clinger	M&C	LkOnplant
				Glyptotendipes spp.	Lotic Depositional	Burrower, Clinger	Shredder, Collector	M&C	Pool 24
				Glyptotendipes lobiferus	Lotic Depositional	Burrower, Clinger	Shredder, Collector	M&C	LkOnplant
				Hydrobaenus spp.	Lotic Erosional	Scraper, Collector	Sprawler	M&C	Pool 24
				Lipiniella spp.	Lentic	?	?	M&C	Pool 24
				Lopescladius spp.	Lotic Erosional	Collector	Sprawler	M&C	Pool 24
				Micropsectra spp.	Lotic Depositional	Collector	Climber, Sprawler	M&C	Pool 24
				Microtendipes	Lotic Depositional	Collectors-filterer	Clinger	M&C	Pool 19
				Nanocladius spp.	Lotic Erosional	Collector	Sprawler	M&C	Pool 24
				Nanocladius distinctus	Lotic Erosional	Collector	Sprawler	M&C	LkOnplant
				Nanocladius spiniplenus	Lotic Erosional	Collector	Sprawler	M&C	LkOnplant
				Nilothaume babiyi	Lotic Depositional			M&C	LkOnplant
				Orthocladius sp.	Lotic Erosional	Collectors	Sprawler, Burrower	M&C	LkOnplant
				Parachironomus spp.	Lentic	Preator, Collector	Sprawler	M&C	Pool 24
				Parachironomus abortivus	Lentic-Litoral	Predator	Sprawler	M&C	LkOnplant
				Parachironomus frequeus	Lentic-Litoral	Predator	Sprawler	M&C	LkOnplant
				Parakiefferiella spp.	Lotic Erosional	Collector -gatherer	Sprawler	M&C	Pool 24
				Paralauterborniella spp.	Lentic	Collector-gatherer	Clinger	M&C	Pool 24
				Paratanytarsus spp.	Lotic Erosional	?	Sprawler	M&C	Pool 24
				Paratendipes spp.	Lotic Depositional	Collector-gatherer	Burrower	M&C	Pool 24
				Pelopia sp.				M&C	Pool 19
				Pentaneura sp.				M&C	Pool 19
				Phaenospectra spp.	Lentic-littoral	Scraper	Clingers-tubes	M&C	LkOnplant
				Polypedilum convictum	Lotic Erosional	Shredder	Climber	M&C	Pool 24
				Polypedilum illinoense	Lotic Depositional	Shredder	Climber	M&C	Pool 24
				Polypedilum scalaenum	Lotic Depositional	Shredder	Climber	M&C	Pool 24
				Polypedilum spp.	Lotic Depositional	Shredder	Climber	M&C	Pool 24
				Procladius (Holotanypus)	Lotic Depositional	Predator	Sprawler	M&C	Pool 24
				Psectrocladius psilopterus	Lotic Depositional	Collectors	Sprawler	M&C	LkOnplant
				Pseudosmittia spp.	Lotic			M&C	Pool 24

Phylum	Class	Order	Family	Species	Guild: Habitat	Guild: Feeding	Guild: Existence	Source	Location
				Rheocricotopus robacki	Lotic Erosional	Sprawler	Clinger	M&C	LkOnplant
				Rheotanytarsus spp.	Lotic Erosional	Collector-filterers	Clinger	M&C	Pool 24
				Rheotanytarsus exiguus group	Lotic Erosional	Collector-filterers	Clinger	M&C	LkOnplant
				Robackia spp.	Lotic Erosional	Collector-gatherer	Burrower	M&C	Pool 24
				Stenochironomus spp.	Lentic-aq. plants	Collector	Burrower-miner	M&C	Pool 19
				Tanytarsus guerlus group	Lotic Depositional	Collector	Burrower	M&C	Pool 24
				Tanytarsus spp.	Lotic Depositional	Collector	Burrower	M&C	Pool 24
				Tendipes plumosus				M&C	Pool 19
				Thienemanniella spp.	Lotic Erosional	Collector	Sprawler	M&C	Pool 24
				Thienemanniella fusca	Lotic Erosional	Collector	Sprawler	M&C	LkOnplant
				Thienemannimyia spp.	Lotic Erosional	Predator	Sprawler	M&C	Pool 24
			Culicidae	*Chaoborus spp.*	Lentic-limnetic	Predator	Sprawler, Swimmer	M&C	Pool 19
			Ephydridae	*Hyrellia spp.*				M&C	LkOnplant
				Notiphila spp.				M&C	LkOnplant
				Neoscatella spp.				M&C	LkOnplant
			Empididae	*Hemerodromia spp.*	Lotic Erosional	Predator	Sprawler	M&C	Pool 24
			Psychodidae	*Psychoda spp.*	Lotic Depositional	Collector	Burrower	M&C	LkOnplant
			Simuliidae	*Simulium spp.*				M&C	Pool 7,8
			Stratiomyidae	*Euparyphus spp.*	Lotic	Collector	Sprawler	M&C	Pool 7,8
				Odontomyia spp.	Lentic-aq. plants	Collector	Sprawler	M&C	LkOnplant
			Tabanidae	*Chrysops sp.*	Lotic Depositional	Predator	Sprawler, Burrower	M&C	Pool 19
			Tipulidae	*Spp.*	Lotic	Predator	Sprawler	M&C	Pool 24
		Ephemeroptera	Baetidae	*Baetis spp.*	Lotic-hydrophytes	Collector	Swimmer, Climber, Clinger	M&C	LkOnplant
			Isonichiidae	*Isonychia sp.*	Lotic Erosional	Collector-filterer	Swimmer, Clinger	M&C	Pool 19
			Caenidae	*Brachycerus*	Lotic Depositional	Collector	Sprawler	M&C	Pool 7,8
				Caenis spp.	Lotic Depositional	Collector	Sprawler, Climber	M&C	Pool 24
			Ephemerelidae	*Ephemerella spp.*	Lotic	Collector	Clinger	M&C	LkOnplant
				Ephemerella stenuata	Lotic	Collector	Clinger	M&C	LkOnplant
			Ephemeridae	*Hexagenia Bilineata*	Lotic Depositional	Collector	Burrower	M&C	Pool 24
				H. limbata	Lotic Depositional	Collector	Burrower	M&C	Pool 7,8
				Pentagenia vittigera	Lotic Depositional	Collector	Burrower	M&C	Pool 19
			Heptageniidae	*Spp.*				M&C	Pool 24
				Stenacron spp.	Lotic	Collector	Clinger	M&C	Pool 24
				Stenonema integrum	Lotic	Scraper	Clinger	M&C	Pool 24
				Stenonema spp.	Lotic	Scraper	Clinger	M&C	Pool 24
			Polymitarcidae	*Ephoron sp.*	Lotic	Collector	Burrower	M&C	Pool 7,8
			Siphlonuridae	*Siphlonurus*	Lotic Depositional	Collector	Swimmer, Climber	M&C	Pool 7,8
			Tricorythidae	*Tricorythodes*	Lotic Depositional	Collector	Sprawler, Clinger	M&C	Pool 7,8
		Hemiptera	Belostomatidae	*Belostoma spp.*	Lotic Depositional	Predator	Climber-swimmer	M&C	LkOnplant
			Corixidae	*Trichocorixa spp. (adult)*	Lentic	Predator	Swimmer	M&C	Pool 24
			Gerridae	*Gerris spp.*	Lotic Depositional	Predator	Skater	M&C	LkOnplant

Phylum	Class	Order	Family	Species	Guild: Habitat	Guild: Feeding	Guild: Existence	Source	Location
			Mesoveliidae	*Mesovelia spp.*	Lentic-aq. plants	Predator	Skater	M&C	LkOnplant
			Nepidae	*Ranatra spp.*	Lotic Depositional-aq. plants	Predator	Climber	M&C	LkOnplant
			Pleidae	*Plea striola*	Lentic-aq. plants	Predator	Swimmer-climber	M&C	LkOnplant
			Veliidae	*Microvelis spp.*	Lotic Depositional	Predator	Skater	M&C	LkOnplant
		Lepidoptera	Pyralidae	*Neocataclysta spp.*	Aquatic Plants	Shredder	Climber	M&C	LkOnplant
				Nymphula	Aquatic Plants	Shredder	Climber	M&C	Pool 7,8
				Paragyractis spp.	Aquatic Plants	Shredder	Climber	M&C	LkOnplant
				Paraponyx	Aquatic Plants	Shredder	Climber	M&C	Pool 7,8
		Megaloptera	Corydalidae	*Chauliodes sp.*	Lentic-littoral	Predator	Clinger-climber	M&C	Pool 7,8
				Nigronia spp.	Lotic	Predator	Clinger-climber	M&C	LkOnplant
				Protochauliodes spp.	Lotic	Predator	Clinger-climber	M&C	LkOnplant
			Sialidae	*Sialis sp.*	Lotic	Predator	Burrower-climber	M&C	Pool 19
		Neuroptera	Sisyridae					M&C	LkOnplant
		Odonata	Coenagrionidae	*Spp.*				M&C	Pool 24
			Coenagrionidae	*Argia spp.*	Lotic Erosional	Predator	Clinger	M&C	Pool 24
				Enallagma sp.	Lotic Depositional-aq. plants	Predator	Climber	M&C	Pool 7,8
				Ischnura sp.	Lotic Depositional-aq. plants	Predator	Climber	M&C	Pool 19
				Nehalennia spp.	Lentic	Predator	Climber	M&C	LkOnplant
			Aeschnidae	*Anax junius*	Lentic	Predator	Climber	M&C	LkOnplant
			Gomphidae	*Gomphus sp.*	Lotic Depositional	Predator	Burrower	M&C	Pool 19
				Ophiogomphus sp.	Lotic	Predator	Burrower	M&C	Pool 7,8
		Plecoptera		*Spp.*				M&C	Pool 24
			Chloroperlidae	*spp.*	Lotic Erosional	Predator	Clinger	M&C	Pool 24
				Haploperla brevis	Lotic Erosional	Predator	Clinger	M&C	Pool 24
			Perlidae	*Acroneuria spp.*	Lotic	Predator	Clinger	M&C	Pool 24
				Perlesta placida	Lotic	Predator	Clinger	M&C	Pool 7,8
			Perlodidae	*Spp.*	Lotic	Predator	Clinger	M&C	Pool 24
				Isoperla spp.	Lotic	Predator	Clinger	M&C	Pool 24
			Taeniopterygidae	*Taeniopteryx spp.*	Lotic Erosional	Shredder	Sprawler	M&C	Pool 24
		Tricoptera	Brachycentridae	*Brachycentrus americanus*	Lotic Erosional	Collector	Clinger-case	M&C	LkOnplant
			Hydropsychidae	*Spp.*				M&C	Pool 24
				Cheumatopsyche spp.	Lotic Erosional	Collector-filterer	Clinger-nets	M&C	Pool 24
				Hydropsyche orris	Lotic Erosional	Collector-filterer	Clinger-nets	M&C	Pool 24
				Hydropsyche simulans	Lotic Erosional	Collector-filterer	Clinger-nets	M&C	Pool 24
				Hydropsyche spp.	Lotic Erosional	Collector-filterer	Clinger-nets	M&C	Pool 24
				Potamyia flava	Lotic Erosional	Collector-filterer	Clinger-nets	M&C	Pool 24
			Hydroptilidae	*Spp.*	Lotic	Piercer	Clinger	M&C	Pool 24
				Agraylea multipuncta	Lentic	Piercer	Climber	M&C	LkOnplant
				Agraylea spp.	Lentic	Piercer	Climber	M&C	LkOnplant
				Hydroptila spp.	Lotic	Piercer	Clinger	M&C	Pool 24
				Hydroptila albicorni	Lotic	Piercer	Clinger	M&C	LkOnplant
				Hydroptila armata	Lotic	Piercer	Clinger	M&C	LkOnplant

Phylum	Class	Order	Family	Species	Guild			Source	Location
					Habitat	Feeding	Existence		
				H. waubesiana	Lotic	Piercer	Clinger	M&C	Pool 12
				Stactobiella sp.	Lotic	Piercer	Clinger	M&C	Pool 7,8
				Oxyethira	Lotic	Piercer	Clinger	M&C	LkOnplant
			Leptoceridae	*Ceraclea spp.*	Lotic, Lentic	Collector	Sprawler	M&C	LkOnplant
				Oecetis sp.	Lotic	Predator	Clinger-climber	M&C	LkOnplant
				Oecetis cinerascens	Lotic	Predator	Clinger-climber	M&C	Pool 19
				Leptocerus americana	Lentic-aq. plants	Shredder	Swimmer-climber	M&C	LkOnplant
				Nectopsyche spp.	Lotic	Shredder	Climber	M&C	Pool 24
				Nectopsyche candida	Lotic-Aq. plants	Shredder	Climber-swimmer	M&C	LkOnplant
				Nectopsyche dianrina	Lotic-Aq. plants	Shredder	Climber-swimmer	M&C	LkOnplant
				Nectopsyche pavida	Lotic-Aq. plants	Shredder	Climber-swimmer	M&C	LkOnplant
				Triaenodes spp.	Lotic Depositional	Shredder	Swimmer	M&C	Pool 24
			Philopotamidae	*Dolophilides spp.*	Lotic Erosional	Collector	Clinger-nets	M&C	Pool 24
			Polycentropodidae	*Cyrnellus spp.*	Lotic	Collector-filterer	Clinger	M&C	Pool 24
				Neureclipsis spp.	Lotic Erosional	Collector-filterer	Clinger	M&C	Pool 24
				Polycentropus spp.	Lotic Erosional	Predator	Clinger	M&C	LkOnplant
				Polycentropus centralis	Lotic Erosional	Predator	Clinger	M&C	LkOnplant
				Polycentropus cinerus	Lotic Erosional	Predator	Clinger	M&C	LkOnplant
				Polycentropus gracialis	Lotic Erosional	Predator	Clinger	M&C	LkOnplant
	Malacostraca	Amphipoda	Crangonyctidae	*Spp.*	Widespread	Collector	Crawler	Pennak	Pool 24
			Gammaridae	*Gammarus fasciatus*	Widespread	Collector	Crawler	Pennak	Pool 24
				G. lacustris	Widespread	Collector	Crawler	Pennak	Pool 7,8
				G. minus	Widespread	Collector	Crawler	Pennak	Pool 24
			Taltridae	*Hyalella azteca*	Widespread	Collector	Crawler	Pennak	Pool 24
		Decapoda		*Orconectes virilis*	Widespread	Collector	Crawler	Pennak	Pool 19
		Isopoda	Asellidae	*Spp.*	Widespread	Collector	Crawler	Pennak	Pool 24
				Asellus brevicaudus	Widespread	Collector	Crawler	Pennak	Pool 19
				A. communis	Widespread	Collector	Crawler	Pennak	LkOnplant
				A. militaris	Widespread	Collector	Crawler	Pennak	Pool 7,8
				Caecidotea spp.	Widespread	Collector	Crawler	Pennak	Pool 24
									Pool 12
									Pool 12
Mollusca	Bivalvia	Veneroida	Corbiculidae	*Corbicula fluminea*					Pool 24
			Dreissenidae	*Dreissena bugensis*					Pool 24
				Dreissena polymorpha					Pool 24
			Sphaeriidae	*Musculium sp.*					Pool 7,8
				Pisidium sp.					Pool 7,8
				Sphaerium transversum					Pool 19
				S. striatinum					Pool 19

Phylum	Class	Order	Family	Species	Guild: Habitat	Guild: Feeding	Guild: Existence	Source	Location
	Gastropoda	Lymnophila	Amnicolidae	*Amnicola lustrica*					LkOnplant
				A. sayana					LkOnplant
				Fontigens nickliniana					LkOnplant
				Stomatogyrus depressus					LkOnplant
				Stomatogyrus isogonus					Pool 19
			Ancylidae	*Ferrissia sp.*					LkOnplant
			Hydrobiidae	*Amnicola spp.*					LkOnplant
			Lymnaeidae	*Pseudosuccinea spp.*					Pool 19
			Physidae	*Physa spp.*					Pool 24
				Physella spp.					Pool 24
			Planorbidae	*Gyraulus spp.*					LkOnplant
				Helosoma spp.					LkOnplant
			Pleuroceridae	*Pleurocera sp.*					Pool 19
				Pleurocera acuta					Pool 19,G
			Valvatidae	*Valvata tricarinata*					Pool 19,G
			Viviparidae	*Campeloma sp.*					Pool 19
				C. crassula					Pool 19,G
				C. decisum					Pool 19
				Lioplax subcarinata					Pool 19
				Lioplax subculosa					Pool 19,G
				Viviparus intertextus					Pool 19
				Viviparus georgianus					LkOnplant
Nematoda				*spp.*					
Platyhelminthes	Turbellaria	Macrostomida		*spp.*					
		Tricladida	Planariidae	*Dugesia tigrina*					

Appendix N

Upper Mississippi River System Freshwater Mussel Species

Species list and habitat and substrate preferences compiled from:

Cummings, K.S. and C.A. Mayer. 1992. Field guide to freshwater mussels of the Midwest. Illinois Natural History Survey, Manual 5, Champaign, Illinois 194pp.

Fish hosts after:

Watters, T.G. 1994. An annotated bibliography of the reproduction and propagation of the Unionacea. Ohio Biological Survey, The Ohio State University, Columbus, Ohio. 158 pp.

Upper Mississippi River System Mussel Species

Common Name	Subfamily	Species	Habitat	Substrate	Fish Host
Spectaclecase	Cumberlandinae	*Cumberlandia monodonta*	Swift lotic	Boulder; gravel, cobble	American eel
					black bullhead
					black crappie
					bluegill
					bowfin
					brown bullhead
					channel catfish
					flathead catfish
					freshwater drum
					gizzard shad
					green sunfish
					tadpole madtom
					white bass
					white crappie
Washboard	Ambleminae	*Megalonaias nervosa*	Lotic	Mud, sand, gravel	
Pistolgrip		*Tritogonia verrucosa*	Lotic	Mud, sand, gravel	
Winged mapleleaf		*Quadrula fragosa*	Lotic	Mud, sand, gravel	
Mapleleaf		*Quadrula quadrula*	Lotic	Mud, sand, gravel	flathead catfish
Monkeyface		*Quadrula metanevra*	Lotic	Mixed sand and gravel	bluegill
					green sunfish
					sauger
Wartyback		*Quadrula nodulata*	Lotic	Sand, fine gravel	black crappie
					bluegill
					channel catfish

Common Name	Subfamily	Species	Habitat	Substrate	Fish Host
					largemouth bass
					white crappie
Pimpleback		*Quadrula pustulosa*	Lotic	Mud, sand, gravel	black bullhead
					brown bullhead
					channel catfish
					flathead catfish
					white crappie
Threeridge		*Amblema plicata*	Lotic-Lentic	Mud, sand, gravel	black crappie
					bluegill
					flathead catfish
					green sunfish
					largemouth bass
					northern pike
					pumpkinseed
					rock bass
					sauger
					shortnose gar
					white bass
					white crappie
					yellow perch
Ebonyshell		*Fusconaia ebena*	Lotic	Sand, gravel	black crappie
					largemouth bass
					skipjack herring
					white crappie
Wabash pigtoe		*Fusconaia flava*	Lotic	Mud, sand, gravel	black crappie
					bluegill

Common Name	Subfamily	Species	Habitat	Substrate	Fish Host
					white crappie
Purple wartyback		*Cyclonaias tuberculata*	Lotic	Gravel, mixed sand and gravel	
Sheepnose		*Plethobasus cyphyus*	Lotic	Gravel, mixed sand and gravel	sauger
Round pigtoe		*Pleurobema coccineum*	Lotic	Mud, sand, gravel	bluegill
Elephant-ear		*Elliptio crassidens*			skipjack herring
Spike		*Elliptio dilatata*	Lotic-Lentic	Mud, gravel	black crappie
					flathead catfish
					gizzard shad
					sauger
					white crappie
					yellow perch
Pondhorn		*Uniomerus tetralasmus*	Lentic	Mud, sand	golden shiner
Paper pondshell	Anodontinae	*Utterbackia imbecillis*	Lentic	Mud	
Flat floater		*Anodonta suborbiculata*	Lentic	Mud	
Giant floater		*Pyganodon grandis*	Lentic	Mud	banded killifish
					blackchin shiner
					black crappie
					blacknose dace
					blacknose shiner
					bluegill
					bluntnose minnow
					brook silverside
					brook stickleback
					carp
					central stoneroller
					common shiner

Common Name	Subfamily	Species	Habitat	Substrate	Fish Host
					creek chub
					freshwater drum
					gizzard shad
					golden shiner
					golden topminnow
					green sunfish
					Iowa darter
					johnny darter
					largemouth bass
					lonear sunfish
					longnose gar
					Notropis sp.
					orangespotted sunfish
					pearl dace
					pumkinseed
					rainbow darter
					redfin shiner
					river carpsucker
					rock bass
					skipjack herring
					white bass
					white crappie
					white sucker
					yellow bullhead
					yellow perch
Squawfoot		*Strophitus undulatus*	Lotic	Mud, sand, gravel	none needed

Common Name	Subfamily	Species	Habitat	Substrate	Fish Host
					"several fishes"
					facultative parasite
					creek chub
					largemouth bass
Elktoe		*Alasmidonta marginata*	Lotic	Gravel, mixed sand and gravel	northern hog sucker
					rock bass
					shorthead redhorse
					warmouth
					white sucker
Rock-pocketbook		*Arcidens confragosus*	Lotic-Lentic	Mud, sand	American eel
					freshwater drum
					gizzard shad
					rock bass
					white crappie
Salamander mussel		*Simpsonaias ambigua*	Lotic	Mud, gravel, under stones	mudpuppy
White heelsplitter		*Lasmigona complanata*	Lotic	Mud, sand, fine gravel	banded killifish
					carp
					green sunfish
					largemouth bass
					orangespotted sunfish
					white crappie
Fluted-shell		*Lasmigona costata*	Lotic	Mud, sand, fine gravel	carp
Creek heelsplitter		*Lasmigona compressa*	Lotic	Fine gravel, sand	guppy
Threehorn wartyback	Lampsilinae	*Obliquaria reflexa*	Lotic-Lentic	Sand, gravel	
Mucket		*Actinonaias ligamentina*	Lotic	Gravel, mixed sand and gravel	banded killifish
					black crappie
					bluegill

Common Name	Subfamily	Species	Habitat	Substrate	Fish Host
					green sunfish
					largemouth bass
					orangespotted sunfish
					rock bass
					sauger
					smallmouth bass
					white bass
					white crappie
					yellow perch
Butterfly		*Ellipsaria lineolata*	Lotic	Sand, gravel	freshwater drum
					green sunfish
					sauger
Hickorynut		*Obovaria olivaria*	Lotic	Gravel, mixed sand and gravel	shovelnose sturgeon
Deertoe		*Truncilla truncata*	Lotic	Mud, sand, gravel	freshwater drum
					sauger
Fawnsfoot		*Truncilla donaciformis*	Lotic	Sand, gravel	freshwater drum
					sauger
Scaleshell		*Leptodea leptodon*	Lotic	Mud	
Fragile papershell		*Leptodea fragilis*	Lotic	Mud, sand, gravel	freshwater drum
Pink papershell		*Potamilus ohiensis*	Lotic	Silt, mud, sand	freshwater drum
					white crappie
Pink heelsplitter		*Potamilus alatus*	Lotic	Mixed mud, sand, and gravel	freshwater drum
Fat pocketbook		*Potamilus capax*	Lotic-Lentic	Mud, sand	freshwater drum
Lilliput		*Toxolasma parvus*	Lentic	Mud, sand, gravel	bluegill
					green sunfish
					orangespotted sunfish
					warmouth

Common Name	Subfamily	Species	Habitat	Substrate	Fish Host
					white crappie
Black sandshell		*Ligumia recta*	Lotic	Gravel, firm sand	banded killifish
					black bass
					bluegill
					"crappie"
					green sunfish
					largemouth bass
					orangespotted sunfish
					sauger
					white crappie
Rayed bean		*Villosa fabalis*	Lotic	Sand, gravel	
Yellow sandshell		*Lampsilis teres*	Lotic	Fine gravel, sand	alligator gar
					black crappie
					green sunfish
					largemouth bass
					longnose gar
					orangespotted sunfish
					shortnose gar
					shovelnose sturgeon
					warmouth
					white crappie
Fat mucket		*Lampsilis siliquoidea*	Lotic	Mud, sand, gravel	black crappie
					bluegill
					common shiner
					largemouth bass
					orangespotted sunfish
					pumpkinseed

Common Name	Subfamily	Species	Habitat	Substrate	Fish Host
					rock bass
					sauger
					smallmouth bass
					walleye
					white bass
					white crappie
					white sucker
					yellow perch
Higgins eye		*Lampsilis higginsi*	Lotic	Gravel, sand	bluegill
					freshwater drum
					green sunfish
					largemouth bass
					northern pike
					sauger
					smallmouth bass
					sauger
					yellow perch
Pink mucket		*Lampsilis abrupta*	Lotic	Gravel, sand	
Plain pocketbook		*Lampsilis cardium*	Lotic	Mud, sand, gravel	
Snuffbox		*Epioblasma triquetra*	Lotic	Clear riffle	banded sculpin
					log perch

Appendix O

Upper Mississippi River System Fish Species

Species list from:

Pitlo, J. A. VanVooren, and J. Rasmussen. 1995. Distribution and relative abundance of Upper Mississippi River fishes. Upper Mississippi River Conservation committee, Rock Island, Illinois. 20pp.

Guild associations after:

Habitat,

Poddubny, L.P. and D.L. Galat. 1995. Habitat associations of upper Volga River fishes: Effects of reservoirs. Regulated Rivers 11:76 – 84.

Robert Hrabik, Missouri Department of Conservation, Cape Girardeau, Missouri.

Feeding,

Becker, G.C. 1983. Fishes of Wisconsin. The University of Wisconsin Press, Madison, Wisconsin. 1052pp.

Pflieger, W.L. 1975. The fishes of Missouri. Missouri Department of Conservation. Jefferson City, Missouri. 34pp.

Reproduction,

Balon, E.K. 1975. Reproductive guilds of fishes: a proposal and definition. Journal of the Fisheries Research Board of Canada. 32:821 – 864.

Upper Mississippi River System fish guilds

Species	Guild: Habitat	Feeding	Reproduction
PETROMYZONTIDAE			
Chestnut lamprey (*Ichthyomyzon castaneus*)	Rheo-Limnophil		
Silver lamprey (*Ichtyomyzon unicuspi*s)			
American brook lamprey (*Lamperta appendix*)			
CARCHARHINIDAE			
Bull shark (*Carcharhinus leucas*)			
ACIPENSERIDAE			
Lake sturgeon (*Acipenser fulvescens*)	Rheo-Rheophil		
Pallid sturgeon (*Scaphirhynchus albus*)	Rheophil		
Shovelnose sturgeon (*Scaphirhynchus platorynchus*)	Rheophil	Benthophage	Lithophyl
POLYDONTIDAE			
Paddlefish (*Polyodon spathula*)	Pelagic Limno-Rheophil	Planktophage	Pelago-Lithophyl
LEPISOSTEIDAE			
Spotted gar (*Lepisosteus oculatus*)	Limno-Rheophil		
Longnose gar (*Lepisosteus osseus*)	Rheo-Limnophil	Juvenile - Planktophage; Adult - ichtyophage	Phytophyl; Lithophyl
Shortnose gar (*Lepisosteus platostomus*)	Rheo-Limnophil	Juvenile - Planktophage; Adult - Ichtyophage	Phytophyl
Alligator gar (*Lepisosteus spa*tula)			
AMIIDAE			
Bowfin (*Amia calva*)		Juvenile - Bentho-Planktophage; Adult - Ichtyophage	Gaurder-Nesting-Phytophyl
ANGUILLIDAE			
American eel (*Anguilla rostrata*)	Rheo-Limnophil	Ichthyo-Benthophage	Catadromous - Marine

Species	Guild: Habitat	Feeding	Reproduction
CLUPEIDAE			
Alabama shad (*Alosa alabamae*)			
Skipjack herring (*Alosa chrysochloris*)	Rheo-Limnophil	Plankto-Ichtyophage	
Gizzard shad (*Dorosoma cepedianum*)	Limnophil	Planktophage	Litho-Pelagophyls
Threadfin shad (*Dorosoma pet*enense)	Limnophil		
HIODONTIDAE			
Goldeye (*Hiodon alosoides*)	Rheo-Limnophil		
Mooneye (*Hiodon tergisus*)	Rheo-Limnophil	Plankto-Ichtyophage	Litho-pelagophyl
CYPRINIDAE			
Central stoneroller (*Campostoma anomalum*)			
Common carp (*Cyprinus carpio*)	Limno-Rheophil	Benthophage	Phytophyl
Goldfish (*Carassius auratus*)			
Grass carp (*Ctenopharyngodon idella*)			
Silverjaw minnow (*Notropis buccatus*)			
Western silvery minnow (*Hybognathus argyritis*)			
Brassy minnow (*Hybognathus hankinsoni*)			
Mississippi silvery minnow (*Hybognathus nuchalis*)	Rheo-Limnophil		
Plains minnow (*Hybognathus placitus*)	Rheophil		
Bighead carp (*Hypophthalmichthys nobilis*)			
Speckled chub (*Macrhybopsis aestivalis*)	Rheophil	Benthophage	Pelagophyl
Sturgeon chub (*Macrhybopsis gelida*)	Rheophil		
Flathead chub (*Platygobio gracilis*)	Rheophil		
Sicklefin chub (*Macrhybopsis meeki*)	Rheophil		
Silver chub (*Macrhybopsis storeriana*)	Rheophil	Benthophage	Pelagophyl
Gravel chub (*Erimystax x-punctatus*)			
Hornyhead chub (*Nocomis biguttatus*)			
Golden shiner (*Notemigonus crysoleucas*)		Planktophyle	Phytophyl
Pallid shiner (*Notropis amnis*)			
Pugnose shiner (*Notropis anogenus*)	Limno-Rheophil		
Emerald shiner (*Notropis atherinoides*)	Rheo-Limnophil	Planktophyle	Lithophyl

	Guild		
Species	Habitat	Feeding	Reproduction
River shiner (*Notropis blennius*)	Rheo-Limnophil	Plankto-Benthophyle	?
Bigeye shiner (*Notropis boops*)			
Ghost shiner (*Notropis buchanani*)	Rheo-Limnophil		
Striped shiner (*Luxilus chrysocephalus*)			
Common shiner (*Luxilus cornutus*)			
Bigmouth shiner (*Notropis dorsalis*)			
Pugnose minnow (*Opsopoeodus emiliae*)			
Spottail shiner (*Notropis hudsonius*)	Limno-Rheophil	Benthophage	Psammophyl
Red shiner (*Cyprinella lutrensis*)	Rheo-Limnophil	Phyto-Planktophage	Nest Spawner- Lithophyl
Ozark minnow (*Notropis nubilus*)			
Rosyface shiner (*Notropis rubellus*)			
Silverband shiner (*Notropis shumardi*)	Rheo-Limnophil		
Spotfin shiner (*Cyprinella spiloptera*)		Benthophage	Phyto-Lithophyl
Sand shiner (*Notropis stramineus*)	Rheo-Limnophil	Euryphage	?
Weed shiner (*Notropis texanus*)	Limno-Rheophil		
Redfin shiner (*Lythrurus umbratilis*)			
Blacktail shiner (*Cyprinella venusta*)	Rheo-Limnophil		
Mimic shiner (*Notropis volucellus*)		Planktophyle	Phytophyl ?
Channel shiner (*Notropis wickliffi*)	Rheo-Limnophil		
Suckermouth minnow (*Phenacobius mirabilis*)			
Northern redbelly dace (*Phoxinus eos*)			
Southern redbelly dace (*Phoxinus erythrogaster*)			
Bluntnose minnow (*Pimephales notatus*)			
Fathead minnow (*Pimephales promelas*)			
Bullhead minnow (*Pimephales vigilax*)	Rheo-Limnophil	Euryphage	Phyto-Lithophyl
Creek chub (*Semotilus atromaculatus*)			
Pearl dace (*Margariscus margarita*)			
Blacknose dace (*Rhinichthys atratulus*)			
CATOSTOMIDAE			
River carpsucker (*Carpiodes carpio*)	Limno-Rheophil	Benthophage - Euryphage	Lithophyl, open bottom varied
Quillback (*Carpiodes cyprinus*)	Limno-Rheophil	Benthophage - Euryphage	Lithophyl, open bottom varied
Highfin carpsucker (*Carpiodes velifer*)	Limno-Rheophil		

Species	Guild: Habitat	Guild: Feeding	Guild: Reproduction
Longnose sucker (*Catostomus catostomus*)			
White sucker (*Catostomus commersoni*)		Benthophage - Euryphage	Lithophyl
Blue sucker (*Cycleptus elongatus*)	Rheophil		
Northern hog sucker (*Hypentelium nigricans*)			
Smallmouth buffalo (*Ictiobus bubalus*)	Pelagic Limno-Rheophil		
Bigmouth buffalo (*Ictiobus cyprinellus*)	Pelagic Limno-Rheophil	Benthophage - Euryphage	Phytophyl
Black buffalo (*Ictiobus niger*)	Rheo-Limnophil	Benthophage - Euryphage	Phytophyl (needs flood)
Spotted sucker (*Minytrema melanops*)	Limno-Rheophil	Benthophage - Euryphage	Lithophyl
Silver redhorse (*Moxostoma anisurum*)	Limno-Rheophil	Benthophage	Lithophyl
Black redhorse (*Moxostoma dequesnei*)			
River redhorse (*Moxostoma carinatum*)	Rheo-Limnophil		
Golden redhorse (*Moxostoma erythrurum*)	Limno-Rheophil		
Shorthead redhorse (*Moxostoma macrolepidotum*)	Rheo-Limnophil		
Greater redhorse (*Moxostoma valenciennesi*)			
ICTALURIDAE			
White catfish (*Ameiurus catus*)			
Black bullhead (*Ameiurus melas*)	Limnophil		
Yellow bullhead (*Ameiurus natalis*)	Limnophil		
Brown bullhead (*Ameiurus nebulosus*)			
Blue catfish (*Ictalurus furcatus*)	Rheophil		
Channel catfish (*Ictalurus punctatus*)	Rheophil	Euryphage	Gaurder - Lithophyl, Cavity
Stonecat (*Noturus flavus*)	Rheophil		
Tadpole madtom (*Noturus gyrinus*)	Limnophil		
Freckled madtom (*Noturus nocturnus*)	Rheophil		
Flathead catfish (*Pylodictis olivaris*)	Rheo-Limnophil	Ichthyophage	Gaurder - Lithophyl, Cavity
ESOCIDAE			
Grass pickeral (*Esox americanus vermiculatus*)			
Northern pike (*Esox lucius*)	Limnophil	Ichthyophage	Phytophyl
Muskellunge (*Esox ma*squinongy)			

Species	Guild: Habitat	Guild: Feeding	Guild: Reproduction
UMBRIDAE			
Central mudminnow (*Umbra limi*)	Limnophil		
OSMERIDAE			
Rainbow smelt (*Osmerus mordax*)			
SALMONIDAE			
Rainbow trout (*Oncorhynchus mykiss*)			
Brown trout (*Salmo trutta*)			
Brook trout (*Salvelinus fontinalis*)			
Lake trout (*Salvelinus namaycush*)			
PERCOPSIDAE			
Trout-perch (*Percopsis omiscomaycus*)			
GADIDAE			
Pirate perch (*Aphredoderus sayanus*)			
Burbot (*Lota lota*)			
CYPRINODONTIDAE			
Northern studfish (*Fundulus catenatus*)			
Starhead topminnow (*Fundulus dispar*)			
Blackstripe topminnow (*Fundulus notatus*)			
Blackspotted topminnow (*Fundulus olivaceus*)			
POECILIIDAE			
Western mosquitofish (*Gambusia affinis*)		Planktophage	Viviporous
ATHERINIDAE			
Brook silverside (*Labidesthes sicculus*)	Rheo-Limnophil		
Inland silverside (*Menidia beryllina*)			
GASTEROSTEIDAE			
Brook stickleback (*Culaea inconstans*)			
COTTIDAE			
Banded sculpin (*Cottus carolinae*)			

Species	Guild: Habitat	Guild: Feeding	Guild: Reproduction
MORONIDAE			
White bass (*Morone chrysops*)	Pelagic Rheo-Limnophil	Planktophage/Ichthyophage	Pelagophyl
Yellow bass (*Morone mississippiensis*)			
Striped bass (*Morone saxatilis*)			
Hybrid striped bass			
CENTRARCHIDAE			
Shadow bass (*Ambloplites ariommus*)			
Rock bass (*Ambliplites rupestris*)		Benthophage	Gaurder, Nest builder, Lithophyl
Flier (*Centrarchus macropterus*)			
Green sunfish (*Lepomis cyanellus*)	Limnophil		
Pumpkinseed (*Lepomis gibbosus*)			
Warmouth (*Lepomis gulosus*)	Limnophil		
Orangespotted sunfish (*Lepomis humilis*)	Limnophil	Benthophage	Gaurder, Nest builder, Lithophyl
Bluegill (*Lepomis macrochirus*)	Limnophil	Benthophage	Gaurder, Nest builder, Lithophyl
Longear sunfish (*Lepomis megalotis*)			
Redear sunfish (*Lepomis microlophus*)			
Smallmouth bass (*Micropterus dolomieu*)	Limno-Rheophil	Ichthyophage	Gaurder, Nest builder, Lithophyl
Spotted bass (*Micropterus punctulatus*)			
Largemouth bass (*Micropterus salmoides*)	Limnophil	Ichthyophage	Gaurder, Nest builder, Lithophyl
White crappie (*Pomoxis annularis*)	Limnophil	Benthophage/Ichthyophage	Gaurder, Nest builder, Lithophyl
Black crappie (*Pomoxis nigromaculatus*)	Limnophil	Benthophage/Ichthyophage	Gaurder, Nest builder, Lithophyl
PERCIDAE			
Crystal darter (*Ammocrypta asperella*)	Rheophil		
Western sand darter (*Ammocrypta clara*)	Rheophil		
Mud darter (*Etheostoma asprigene*)	Limno-Rheophil		
Rainbow darter (*Etheostoma caeruleum*)			
Bluntnose darter (*Etheostoma chlorosomum*)	Limno-Rheophil		
Iowa darter (*Etheostoma exile*)			
Fantail darter (*Etheostoma flabellare*)			
Johnny darter (*Etheostoma nigrum*)	Limno-Rheophil		
Orangethroat darter (*Etheostoma spectabile*)			

Species	Guild		
	Habitat	Feeding	Reproduction
Banded darter (*Etheostoma zonale*)			
Yellow perch (*Perca flavescens*)	Limno-Rheophil	Benthophage/Ichthyophage	Phyto-Lithophyl
Logperch (*Percina caprodes*)		Benthophage	Lithophyl
Blackside darter (*Percina maculata*)			
Slenderhead darter (*Percina phoxocephala*)			
Dusky darter (*Percina sciera*)			
River darter (*Percina shumardi*)	Rheo-Limnophil	Benthophage	Lithophyl
Sauger (*Stizostedion canadense*)	Rheo-Limnophil	Ichthyophage	Lithophyl
Walleye (*Stizostedion vitreum*)	Limno-Rheophil	Ichthyophage	Lithophyl
SCIAENIDAE			
Freshwater drum (*Aplodinotus grunniens*)	Limno-Rheophil	Benthophage	Pelagophyl
MUGILIDAE			
Striped mullet (*Mugil cephalus*)			

Appendix P

Upper Mississippi River System Reptile and Amphibian Species

Compiled from US Fish and Wildlife Service Mississippi River refuges and reviewed by:

John K. Tucker, Illinois Department of Natural Resources, Natural History Survey, Alton, Illinois.

Reptiles and amphibians are most common in contiguous backwaters and isolated backwaters except where denoted "aquatic – lotic" for riverine turtle species.

Order	Family	Scientific Name	Common Name	Habitat Guild
Amphibia				
Cordata	Sirenidae	*Siren intermedia nettingi*	western lesser siren	Aquatic
	Ambystomatidae	*Ambystoma laterale*	blue-spotted salamander	Terrestrial
		Ambystoma texanum	smallmouth salamander	Terrestrial
		Ambystoma tigrinum	eastern tiger salamander	Terrestrial
	Salamandridae	*Notophthalmus viridescens*	central newt	Aquatic
	Plethodontidae	*Eurycea longicauda*	dark-sided salamander	Terrestrial
		Hemidactylium scutatum	four-toed salamander	Aquatic
	Proteidae	*Necturus maculosus*	mudpuppy	Aquatic
Salientia	Bufonidae	*Bufo americanus*	American toad	Terrestrial
		Bufo woodhousei fowleri	Fowler's toad	Terrestrial
	Hylidae	*Acris crepitans blanchardi*	northern Blanchard's cricket frog	Aquatic
		Hyla chrysoscelis	Cope's gray tree frog	Arboreal
		Pseudacriscrucifer	spring peeper	Arboreal
		Hyla versicolor	gray tree frog	Arboreal
		Pseudacris triseriata triseriata	western chorus frog	Widespread
	Ranidae	*Rana areolata circulosa*	northern crawfish toad	Terrestrial
		Rana catesbeiana	bullfrog	Aquatic
		Rana clamitans melanota	green frog	Terrestrial
		Rana palustris	pickerel frog	Aquatic
		Rana pipiens	northern leopard frog	Aquatic
		Rana sphenocephala	southern leopard frog	Aquatic
		Rana sylvatica	wood frog	Terrestrial
Reptilia				
Testudines	Chelydridae	*Chelydra serpentina*	snapping turtle	Aquatic
		Macroclemys temminicki	alligator snapping turtle	Aquatic
	Kenosternidae	*Kinosternon flavescens*	yellow (Illinois) mud turtle	Aquatic
		Sternotherus odoratus	stinkpot	Aquatic

Order	Family	Scientific Name	Common Name	Habitat Guild
	Empydidae	*Chysemys picta*	painted turtle	Aquatic
		Emydoidea blandingi	Blanding's turtle	Aquatic
		Graptemys geographica	map turtle	Aquatic
		Graptemys pseudogeographica	false map turtle	Aquatic
		Terrapene ornata ornata	ornate box turtle	Terrestrial
		Terrapene carolina carolina	eastern box turtle	Terrestrial
		Clemmys insculpta	wood turtle	Terrestrial
		Chrysemys scripta	red-eared slider	Aquatic
	Trionychidae	*Trionyx muticus*	smooth softshell turtle	Aquatic - Lotic
		Trionyx spiniferus spiniferus	eastern spiny softshell turtle	Aquatic - Lotic
		Trionyx spiniferus haertwegi	western spiny softshell turtle	Aquatic - Lotic
Squamata				
Sauria	Iguanidae	*Eumeces fasciatus*	five-lined skink	Terrestrial
		Eumeces laticeps	broadhead skink	Terrestrial
	Scincidae	*Cnemidophorus sexlineatus sexlineatus*	six-lined racerunner	Terrestrial
	Anguidae	*Ophisaurus attenuatus*	slender glass lizard	Terrestrial
Serpentes	Colubridae	*Carphosis ameonus vermis*	western worm snake	Terrestrial
		Coluber constrictor foxi	blue racer	Terrestrial
		Diadophis punctatus arnyi	prairie ringneck snake	Terrestrial
		Diadophis punctatus	ringneck snake	Terrestrial
		Elaphe obsoleta obsoleta	black rat snake	Terrestrial
		Elaphe vulpina	fox snake	Terrestrial
		Heterodon nasicus	plains hognose snake	Terrestrial
		Heterodon platyrhinos	eastern hognose snake	Terrestrial
		Lampropeltis calligaster calligaster	prairie kingsnake	Terrestrial
		Lampropeltis getulus	speckled kingsnake	Terrestrial
		Lampropeltis triangulum syspila	red milk snake	Terrestrial
		Nerodia rhombifera rhombifera	diamondback water snake	Aquatic

Order	Family	Scientific Name	Common Name	Habitat Guild
		Nerodia erythrogaster	copperbelly water snake	Aquatic
		Opheodrys vernalis blanchardi	western smooth green snake	Terrestrial
		Pituophis melanoleucus sayi	bullsnake	Terrestrial
		Regina grahami	Graham's crayfish snake	Aquatic
		Storeria dekayi	Brown snake	Terrestrial
		Storeria dekayi wrightorium	midland brown snake	Terrestrial
		Storeria occipitomaculata	northern red-bellied snake	Terrestrial
		Thamnophis proximus	western ribbon snake	Terrestrial
		Thamnophis sauritus	eastern ribbon snake	Terrestrial
		Thamnophis radix radix	eastern plains garter snake	Terrestrial
		Thamnophis sirtalis perietalis	red-sided garter snake	Terrestrial
		Thamnophis sirtalis sirtalis	eastern garter snake	Terrestrial
		Lampropeltis triangulum triangulum	eastern milk snake	Terrestrial
	Viperidae	*Agkistrodon contortrix*	copperhead	Terrestrial
		Crotalus horridus horridus	timber rattlesnake	Terrestrial
		Sistrurus catenatus catenatus	massasauga	Terrestrial

Appendix Q

Upper Mississippi River Bird Species

Species list from:

Lowenberg, C.D. 1997. Geographic information system modeling procedures for the Upper Mississippi River System migratory bird pilot project. Long Term Resource Monitoring Program, Technical Report 97-T001. U.S. Geological Survey, Environmental Management Technical Center, Onalaska, Wisconsin. 46pp. +appendices.

EMTC generalized land cover/use classification codes

100	Open water
200	Submergent plants
300	Submergent and rooted floating aquatic plants
400	Submergent, rooted floating, and emergent aquatic plants
500	Rooted floating aquatic plants
600	Rooted floating and emergent aquatic plants
700	Emergent aquatic plants
800	Emergent aquatic plants and terrestrial grasses and forbs
900	Grasses and Forbs
1000	Woody terrestrial
1100	Agriculture
1200	Urban developed
1300	Sand and/or mud

Upper Mississippi River System Bird species

Family	Common name	Species name	EMTC generalized land cover/use classification codes												
			100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Gaviidae	Common loon	*Gavia immer*	X												
Podicipedidae	Pied-billed grebe	*Podilymbus podiceps*	X	X					X						
	Horned grebe	*Podiceps auritus*	X	X											
	Red-necked grebe	*Podiceps grisegena*	X	X											
Pelicanidae	American white pelican	*Pelecanus erythrothynchos*	X	X											X
Phalacrocoracidae	Double-crested cormorant	*Phalacrocorax auritus*	X	X	X							X			
Aredeidae	American bittern	*Botaurus lentiginosus*							X	X	X				
	Least bittern	*Ixobrychus exilis*							X	X					
	Great blue heron	*Ardea herodias*							X	X	X	X	X		X
	Great egret	*Casmerodius albus*							X	X	X	X	X		X
	Snowy egret	*Egretta thula*													
	Little blue heron	*Egretta caerulea*													
	Green-backed heron	*Butorides striatus*							X	X		X			
	Black-crowned night-heron	*Nycticorax nycticorax*							X	X		X			
	Yellow-crowned night-heron	*Nycticorax violaceus*							X	X	X	X			
Gruidae	Sandhill crane	*Grus canadensis*							X	X	X	X	X		
Anatidae	Tundra swan	*Cygnus columbianus*	X	X	X	X	X	X	X				X		X
	Trumpeter swan	*Cygnus buccinator*	X	X	X	X	X	X	X				X		X
	Greater white-fronted goose	*Anser albifrons*													
	Snow goose	*Chen caerulescens*	X	X	X	X	X	X	X		X		X		X
	Canada goose	*Branta canadensis*	X	X	X	X	X	X	X		X		X		X
	Wood duck	*Aix sponsa*	X	X	X	X	X	X	X	X	X	X			
	Green-winged teal	*Anas crecca*	X	X	X	X	X	X	X	X	X	X	X		
	American black duck	*Anas rubripes*	X	X	X	X	X	X	X	X	X	X	X		
	Mallard	*Anas platyrhynchos*	X	X	X	X	X	X	X	X	X	X	X		
	Northern pintail	*Anas acuta*	X	X	X	X	X	X	X	X	X	X	X		
	Blue-winged teal	*Anas discors*	X	X	X	X	X	X	X	X	X	X	X		
	Northern shoveler	*Anas clypeata*	X	X	X	X	X	X	X	X	X	X	X		
	Gadwall	*Anas strepera*	X	X	X	X	X	X	X	X	X	X	X		

Family	Common name	Species name	EMTC generalized land cover/use classification codes												
			100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
	American wigeon	*Anas americana*	X	X	X	X	X	X	X	X	X	X	X		
	Canvasback	*Aythya valisineria*	X	X	X	X	X	X	X	X					
	Redhead	*Aythya americana*	X	X	X	X	X	X	X	X					
	Ring-necked duck	*Aythya collaris*	X	X	X	X	X	X	X	X	X	X	X		
	Greater scaup	*Aythya marila*	X	X	X	X	X	X	X	X					
	Lesser scaup	*Aythya affinis*	X	X	X	X	X	X	X	X					
	Oldsquaw	*Clangula hyemalis*													
	Black scoter	*Melanitta nigra*													
	White-winged scoter	*Melanitta fusca*													
	Common goldeneye	*Bucephala clangula*	X	X	X	X									
	Bufflehead	*Bucephala albeola*	X	X	X	X									
	Hooded merganser	*Lophodytes cucullatus*	X	X	X	X	X	X	X	X	X	X	X		
	Common merganser	*Mergus merganser*	X	X	X	X									
	Red-breasted merganser	*Mergus serrator*	X	X	X	X									
	Ruddy duck	*Oxyura jamaicensis*	X	X	X	X	X	X	X	X					
Rallidae	King rail	*Rallus elegans*			X	X	X	X	X	X	X				
	Virginia rail	*Rallus limicola*			X	X	X	X	X	X					
	Sora	*Porzana carolina*			X	X	X	X	X	X	X				
	Common moorhen	*Gallinula chloropus*	X	X	X	X	X	X	X	X	X				
	American coot	*Fulica americana*	X	X	X	X	X	X	X	X	X				
Recurvirostridae	American avocet *	*Recurvirostra americana*									X		X		X
Charadriidae	Black-bellied plover *	*Pluvialis squatarola*									X		X		X
	Lesser golden-plover *	*Pluvialis dominica*									X		X		X
	Semipalmated plover *	*Gharadrius semipalmatus*									X		X		X
	Killdeer	*Charadrius vociferus*									X		X	X	X
Scolopacidae	Greater yellowlegs *	*Tinga melanoleuca*									X		X		X
	Lesser yellowlegs *	*Tringa flavipes*									X		X		X
	Solitary sandpiper *	*Tringa solitaria*									X		X		X
	Willet *	*Catoptophorus semipalatus*									X		X		X
	Spotted sandpiper	*Actitis macularia*									X	X	X		X
	Upland sandpiper	*Bartramia longicauda*									X		X		

Family	Common name	Species name	EMTC generalized land cover/use classification codes												
			100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
	Hudsonian godwit *	*Limosa haemastica*									X		X		X
	Marbled godwit *	*Limosa fedoa*									X		X		X
	Ruddy turnstone *	*Arenaria interpres*											X		X
	Sanderling *	*Calidris alba*									X		X		X
	Semipalmated sandpiper*	*Calidris pusilla*									X		X		X
	Least sandpiper *	*Calidris minutilla*									X		X		X
	White-rumped sandpiper*	*Calidris fuscicollis*									X		X		X
	Baird's sandpiper *	*Calidris bairdii*									X		X		X
	Pectoral sandpiper *	*Calidris melanotos*									X		X		X
	Dunlin *	*Calidris alpina*									X		X		X
	Stilt sandpiper *	*Calidris himantopus*									X		X		X
	Short-billed dowitcher *	*Limnodromus griseus*									X		X		X
	Long-billed dowitcher *	*Limnodromus scolopaceus*									X		X		X
	Common snipe	*Gallinago gallinago*							X	X	X		X		
	American woodcock	*Scolopax minor*									X	X	X		
	Wilson's phalarope	*Phalaropus tricolor*	X	X	X	X					X		X		
	Red-necked phalarope	*Phalaropus lobatus*	X	X	X	X					X		X		
Laridae	Franklin's gull	*Larus pipixcan*	X	X									X	X	X
	Bonaparte's gull	*Larus philadelphia*	X	X									X	X	X
	Ring-billed gull	*Larus delawarensis*	X	X									X	X	X
	Herring gull	*Larus argentatus*	X	X									X	X	X
	Gulls	*Larus*	X	X									X	X	X
	Caspian tern	*Sterna caspia*	X	X											X
	Common tern	*Sterna hirundo*	X	X											X
	Forster's tern	*Sterna forsteri*	X	X	X	X	X	X	X	X	X				
	Least tern	*Sterna antillarum*	X	X	X										X
	Black tern	*Chlidonias niger*	X	X	X	X	X	X	X	X	X				
Cathartidae	Turkey vulture	*Cathartes aura*									X	X	X	X	X
Accipitridae	Osprey	*Panion haliaetus*	X	X	X	X						X			
	Bald eagle	*Haliaeetus leucocephalus*	X	X	X	X						X	X		X

Family	Common name	Species name	EMTC generalized land cover/use classification codes												
			100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
	Northern harrier	*Circus cyaneus*							X	X	X		X		
	Sharp-shinned hawk	*Accipiter striatus*										X		X	
	Cooper's hawk	*Accipiter cooperii*										X		X	
	Northern goshawk	*Accipiter gentilis*										X			
	Red-shouldered hawk	*Buteo lineatus*							X	X	X	X			
	Broad-winged hawk	*Buteo platypterus*										X			
	Swainson's hawk	*Buteo swainsoni*													
	Red-tailed hawk	*Buteo Jamaicensis*									X	X	X	X	
	Rough-legged hawk	*Buteo lagopus*								X	X		X		
	Golden eagle	*Aquila chrysaetos*									X	X	X		
Falconidae	American kestrel	*Falco sparverius*									X		X	X	
	Merlin	*Falco columbarius*										X	X		
	Peregrine falcon	*Falco peregrinus*							X	X	X			X	X
Phasianidae	Ring-necked pheasant	*Phasianus colchicus*							X	X	X	X	X		
	Ruffed grouse	*Bonasa umbellus*										X	X		
	Wild turkey	*Meleagris gallopavo*									X	X	X		
	Northern bobwhite	*Clinus virginianus*									X	X	X		
Columbidae	Gray partridge	*Perdix perdix*									X		X		
	Rock dove	*Columba livia*											X	X	X
	Mourning dove	*Zenaida macroura*									X	X	X	X	
Cuculidae	Black-billed cuckoo	*Coccyzus erythropthalmus*										X			
	Yellow-billed cuckoo	*coccyzus americanus*										X			
Strigidae	Eastern screech-owl	*Otus asio*										X	X		
	Great horned owl	*Bubo virginianus*							X	X	X	X	X	X	
	Snowy owl	*Nyctea scandiaca*													
	Barred owl	*Strix varia*									X	X	X		
	Long-eared owl	*Asio otus*									X	X	X		
	Short-eared owl	*Asio flammeus*									X		X		
	Northern saw-whet owl	*Aegolius acadicus*										X			
Caprimulgidae	Common nighthawk	*Chordeiles minor*											X	X	
	Whip-poor-will	*Caprimulgus vociferus*									X	X	X		

Family	Common name	Species name	EMTC generalized land cover/use classification codes												
			100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Apodidae	Chimney swift	*Chaetura vauxi*									X	X	X	X	
Trochilidae	Ruby-throated hummingbird	*Archilochus colubris*									X	X	X	X	
Alcedinidae	Belted kingfisher	*Ceryle alcyon*	X	X	X	X	X	X						X	X
Picidae	Red-headed woodpecker	*Melaneres erythrocephalus*									X	X	X		
	Red-bellied woodpecker	*Melaneres carolinus*										X		X	
	Yellow-bellied sapsucker	*Sphyrapicus varius*										X		X	
	Downy woodpecker	*Picoides pubescens*										X		X	
	Hairy woodpecker	*Picoides villosus*										X		X	
	Northern flicker	*Colaptes auratus*									X	X	X	X	
	Pileated woodpecker	*Dryocopus pileatus*										X			
Tyrannidae	Olive-sided flycatcher	*Contopus borealis*													
	Eastern wood-peewee	*Contopus virens*										X			
	Yellow-bellied flycatcher	*Empidonax flaviventris*													
	Alder flycatcher	*Empdonax alnorum*										X			
	Willow flycatcher	*Empidonax traillii*										X			
	Least flycatcher	*Empidonax minimus*										X			
	Eastern phoebe	*Sayornis phoebe*									X	X	X	X	
	Great crested flycatcher	*Myiarchus crinitus*									X	X			
	Eastern kingbird	*Tyrannus tyrannus*									X	X	X	X	
Alaudidae	Horned lark	*Eremophila alpestris*									X		X	X	
Hirundinidae	Purple martin	*Progne subis*									X		X	X	
	Tree swallow	*Tachycineta bicolor*									X		X		
	Northern rough-winged swallow	*Stelgidopteryx serripennis*											X	X	
	Bank swallow	*Riparia riparia*											X	X	
	Cliff swallow	*Hirundo pyrrhonota*											X	X	
	Barn swallow	*Hirundo rustica*											X	X	
Corvidae	Blue jay	*Cyanocitta cristata*									X	X	X	X	
	American crow	*Corvus brachyrhynchos*							X	X	X	X	X	X	X
Paridae	Black-capped chickadee	*Parus atricapillus*										X		X	
	Tufted titmouse	*Parus bicolor*										X			
Certhiidae	Red-breasted nuthatch	*Sitta canadensis*										X		X	

Family	Common name	Species name	EMTC generalized land cover/use classification codes												
			100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
Sittidae	White-breasted nuthatch	*Sitta carolinensis*										X		X	
	Brown creeper	*Certhia americana*										X			
Troglodytidae	Carolina wren	*Thryothorus ludovicianus*										X			
	Bewick's wren	*Thryomanes bewickii*										X			
	House wren	*Troglodytes aedon*									X	X	X	X	
	Winter wren	*Troglodytes troglodytes*										X			
	Sedge wren	*Cistothorus platensis*							X	X	X				
	Marsh wren	*Cistothrous palustris*							X	X					
Muscicapidae	Golden-crowned kinglet	*Regulas satrapa*										X		X	
	Ruby-crowned kinglet	*Regulas calendula*										X		X	
	Blue-gray gnatcatcher	*Plioptila caerulea*										X			
	Eastern bluebird	*Sialia sialis*									X	X	X	X	
	Veery	*Catharus fuscescens*										X			
	Gray-cheeked thrush	*Catharus minimus*										X			
	Swainson's thrush	*Catharus ustulatus*										X			
	Hermit thrush	*Catharus guttatus*										X			
	Wood thrush	*Hylocichla mustelina*										X			
	American robin	*Turdus migratorius*									X	X	X	X	
Laniidae	Grey catbird	*Dumetella carolinensis*									X	X	X	X	
	Northern mockingbird	*Mimus polyglottos*									X	X	X	X	
Mimidae	Brown thrasher	*Toxostoma rufum*									X	X	X	X	
	American pipit	*Anthus*													
	Bohemian waxwing	*Bombycilla garrulus*													
Motacillidae	Cedar waxwing	*Bonbycilla cedrorum*							X	X	X	X	X	X	
Bombycillidae	Northern shrike	*Lanius excubitor*									X		X	X	
	Loggerhead shrike	*Lanius ludovicianus*									X	X	X	X	
Sturnidae	European starling	*Strunus vulgaris*									X	X	X	X	
Vireonidae	White-eyed vireo	*Vireo griseus*										X			
	Bell's vireo	*Vireo bellii*									X	X			
	Solitary vireo	*Vireo solitarius*										X			
	Yellow-throated vireo	*Vireo flavifrons*										X			

Family	Common name	Species name	EMTC generalized land cover/use classification codes												
			100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
	Warbling vireo	*Vireo gilvus*									X	X			
	Philadelphia vireo	*Vireo philadelphicus*										X			
	Red-eyed vireo	*Vireo olivaceus*										X			
Emberizidae	Blue-winged warbler *	*Vermivora pius*									X	X			
	Golden-winged warbler *	*Vermivora chrysoptera*									X	X			
	Tennessee warbler *	*Vermivora peregrina*									X	X			
	Orange-crowned warbler*	*Vermivora celata*									X	X			
	Nashville warbler *	*Vermivora ruficapilla*									X	X			
	Northern parula *	*Parula americana*									X	X			
	Yellow warbler	*Dendroica petechia*							X		X	X			
	Chestnut-sided warbler *	*Dendroica pensylvanica*									X	X			
	Magnolia warbler *	*Dendroica magnolia*									X	X			
	Cape May warbler *	*Dendroica tigrina*									X	X			
	Black-throated blue warbler *	*Dnedroica caeruulescens*									X	X			
	Yellow-rumped warbler*	*Dendroica coronata*									X	X			
	Black-throated green warbler *	*Dendroicqa virens*									X	X			
	Blackburnian warbler *	*Dendroica fusca*									X	X			
	Pine warbler *	*Dendroica pinus*									X	X			
	Palm warbler *	*Dendroica palmarum*									X	X			
	Bay-breasted warbler *	*Dendroica castanea*									X	X			
	Blackpoll warbler *	*Dendroica striata*									X	X			
	Cerulean warbler *	*Dendroica cerulea*									X	X			
	Black-and-white warbler*	*Mniotilta varia*									X	X			
	American redstart *	*Setophaga ruticilla*									X	X			
	Prothonotary warbler *	*Protonotaria citrea*									X	X			
	Worm-eating warbler *	*Helmitheros vermivorous*										X			
	Ovenbird *	*Seiurus aruocapillus*									X	X			
	Northern waterthrush *	*Seiurus noveboracensis*									X	X			
	Louisiana waterthrush *	*Seiurus motacilla*									X	X			

Family	Common name	Species name	EMTC generalized land cover/use classification codes												
			100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
	Kentucky warbler *	*Oporornis formosus*									X	X			
	Connecticut warbler *	*Oporornis agilis*									X	X			
	Mourning warbler *	*Oporornis philadelphia*									X	X			
	Common yellowthroat	*Geothlypis trichas*							X	X	X	X			
	Hooded warbler *	*Wilsonia citrina*									X	X			
	Wilson's warbler *	*Wilsonia pusilla*									X	X			
	Canada warbler *	*Wilsonia canadensis*									X	X			
	Yellow-breasted chat *	*Icteria virens*									X	X			
	Scarlet tanager	*Piranga olivacea*										X			
	Northern cardinal	*Cardinalis cardinalis*									X	X	X	X	
	Rose-breasted grosbeak	*Pheucticus ludovicianus*									X	X		X	
	Indigo bunting	*passerina cyanea*									X	X			
	Dickcissel	*Spiza americana*									X		X		
	Rufous-sided towhee	*Pipilo erythrophtlalmus*									X	X		X	
	American tree sparrow	*Spizella arborea*									X	X	X	X	
	Chipping sparrow	*Spizella passerina*									X	X	X	X	
	Clay-colored sparrow	*Spizella pallida*									X	X			
	Field sparrow	*Spizella pusilla*									X		X		
	Vesper sparrow	*Pooecetes gramineus*									X		X		
	Lark sparrow	*Chondestes grammacus*									X		X		
	Savannah sparrow	*Passerculus sandwichensis*									X		X		
	Grasshopper sparrow	*Ammodramus savannarum*									X		X		
	Henslow's sparrow	*Ammodramus henslowii*									X		X		
	Le Conte's sparrow	*Ammodramus leconteii*							X	X	X				
	Fox sparrow	*Passerella iliaca*									X	X		X	
	Song sparrow	*Melospiza melodia*							X	X	X	X	X	X	
	Lincoln's sparrow	*Melospiza lincolnii*									X	X			
	Swamp sparrow	*Melospiza georgiana*							X	X	X	X			
	White-throated sparrow	*Zonotrichia albicollis*									X	X	X	X	
	White-crowned sparrow	*Zonotrichia leucophrys*									X	X	X	X	
	Harris sparrow	*Zonotrichia querula*									X	X	X	X	

			EMTC generalized land cover/use classification codes												
Family	Common name	Species name	100	200	300	400	500	600	700	800	900	1000	1100	1200	1300
	Dark-eyed junco	*Junco hyemalis*									X	X	X	X	
	Lapland longspur	*Calcarius lapponicus*													
	Snow bunting	*Plectrophenax nivalis*													
	Bobolink	*Dolichonyx oryzivorus*									X		X		
	Red-winged blackbird	*Agelaius phoeniceus*			X	X	X	X	X	X	X	X	X	X	
	Eastern meadowlark	*Sturnella magna*									X		X	X	
	Western meadowlark	*Strunella neglecta*									X		X	X	
	Yellow-headed blackbird	*Xanthocephalus xanthocephalus*			X	X	X	X	X	X	X				
	Rusty blackbird	*Euphagus carolinus*							X	X	X	X	X		
	Brewer's blackbird	*Euphagus cyanocephalus*							X	X	X	X	X		
	Common grackle	*Quiscalus quiscula*							X	X	X	X	X	X	
	Brown-headed cowbird	*Molothrus ater*							X	X	X	X	X	X	
	Orchard oriole	*Icterus spurius*									X	X			
	Northern oriole	*Icterus galbula*									X	X		X	
Passeridae	House sparrow	*Passer domesticus*											X	X	
Fringilidae	Pine grosbeak	*Pinicola enucleator*													
	Purple finch	*Carpodacus purpureus*									X	X		X	
	House finch	*Carpodacus mexocanus*										X		X	
	Red crossbill	*Loxia curvirostra*										X			
	White-winged crossbill	*Loxia leucoptera*										X			
	Common redpoll	*Carduelis flammea*									X		X	X	
	Hoary redpoll	*Carduelis hornemmani*													
	Pine siskin	*Carduelis pinus*										X		X	
	American goldfinch	*Gcaruelis tristis*									X	X	X	X	
	Evening grosbeak	*Coccothraustes verpertinus*										X		X	

Appendix R

Upper Mississippi River System Mammal Species

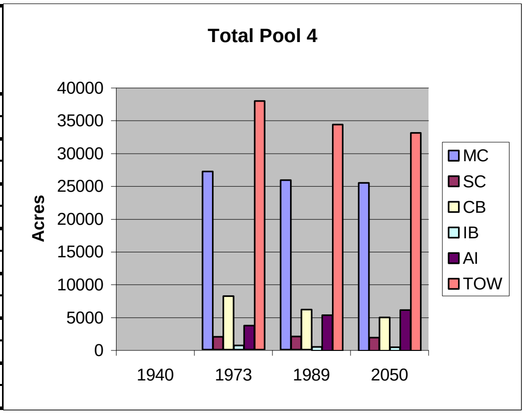
Compiled from U.S. Fish and Wildlife Service, Mississippi River Refuges

Upper Mississippi River System mammal species

Family	Species name	Common name	Gulid
Marsupialia			
Didelphiidae	Didelphis marsupialis	Virginia opossum	Small Mammal
Insectivora			
Soricidae	Sorex longirostris	southeastern shrew	Small Mammal
	Sorex cinereus	masked shrew	Small Mammal
	Cryptotis parva	least shrew	Small Mammal
	Blarina brevicauda	short-tailed shrew	Small Mammal
Talpidae	Scalophus aquaticus	eastern mole	Small Mammal
Chiroptera			
Vespertilionidae	Myotis lucifugus	little brown bat	Bat
	Myotis keenii	keen's bat	Bat
	Myotis sodalis	Indiana bat	Bat
	Myotis grisescens	gray bat	Bat
	Lasionycteris noctivagans	silver-haired bat	Bat
	Pipistrellus subflavus	eastern pipistrel (bat)	Bat
	Eptescius fuscus	big brown bat	Bat
	Nycteris borealis	red bat	Bat
	Nycteris cinerus	hoary bat	Bat
	Nicticeus humeralis	evening bat	Bat
Logomorpha			
Lepus	Sylvilagus floridanus	eastern cottontail rabbit	Small Mammal
	Lepus townsendii	white-tailed jackrabbit	Small Mammal
Rodentia			
Sciuridae	Mormota monax	woodchuck	Small Mammal
	Spermophilis tridecemlineatus	Thirteen-lined ground squirrel	Small Mammal
	Spermophilis franklinii	Franklin's ground squirrel	Small Mammal
	Tamias striatus	eastern chipmunk	Small Mammal
	Sciurus carolinensus	eastern gray squirrel	Small Mammal
	Sciurus niger	eastern fox squirrel	Small Mammal
	Glaucomys volans	southern flying squirrel	Small Mammal
Geomyidae	Peromyscus leucopus	white-footed mouse	Small Mammal
Cricetidae	Geomys bursarius	plains pocket gopher	Small Mammal
	Reithrodontomy megalotis	western harvest mouse	Small Mammal
	Peromyscus maniculatus	deer mouse	Small Mammal
	Castor canadensis	beaver	Small Mammal
	Synaptomys cooperi	southern bog lemming	Small Mammal
	Microtus pennsylvanicus	meadow vole	Small Mammal
	Microtus ochrogastor	prairie vole	Small Mammal
	Microtus pinetorum	pine vole	Small Mammal
Muridae	Ondatra zibethicus	muskrat	Aquatic Furbearer
	Rattus norvegicus	norway rat	Small Mammal
Zapodidae	Mus musculus	house mouse	Small Mammal
Capromyidae	Zapus hudsonius	meadow jumping mouse	Small Mammal
Carnivora	Myocastor coypus	nutria	Aquatic Furbearer
Canidae			
	Canis latrans	coyote	Terrestrial Furbearer
	Vulpes fluva	red fox	Terrestrial Furbearer

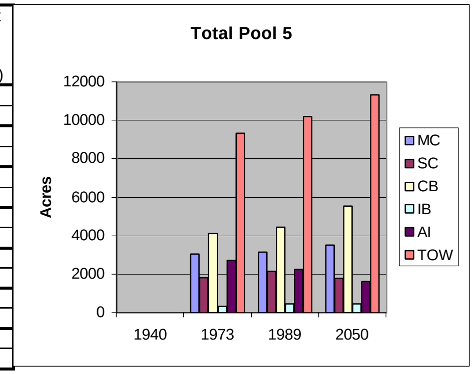
Family	Species name	Common name	Gulid
Procyonidae	Urocyon cineroargenteus	gray fox	Terrestrial Furbearer
Mustelidae	Procyon lotor	raccoon	Terrestrial Furbearer
	Mustela ermina	short-tailed weasel	Terrestrial Furbearer
	Mustela vison	mink	Terrestrial Furbearer
	Mustela nivalis	least weasel	Terrestrial Furbearer
	Mustela frenata	long-tailed weasel	Terrestrial Furbearer
	Taxida taxus	badger	Terrestrial Furbearer
	Spilogale putorius	spotted skunk	Small Mammal
	Mephitis mephitis	striped skunk	Small Mammal
Felidae	Lutra canadensis	river otter	Aquatic Furbearer
Artiodactyla	Lynx rufus	bobcat	Terrestrial Furbearer
	Odocoileus virginianus	white-tailed deer	Ungulate

Pool 4 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	23,562		24,963	23,600	-5.5%	23,364	-1.0%		
	Lower	2,011		2,210	2,230	0.9%	2,230	0.0%		
Secondary channel	Upper	1,421		1,324	1,323	-0.1%	1,323	0.0%		
	Lower	603		625	659	5.4%	659	0.0%		
Contiguous backwater area	Upper	2,033		3,612	2,066	-42.8%	1,653	-20.0%		
	Lower	604		4,533	4,054	-10.6%	3,446	-15.0%		
Isolated backwater area	Upper	193		420	384	-8.6%	346	-9.9%		
	Lower	151		201	189	-6.0%	180	-4.8%		
Island area	Upper	3,371		1,654	1,726	4.4%	1,726	0.0%		
	Lower	1,562		2,006	3,718	85.3%	4,462	20.0%		
Island perimeter	Upper	330,400		283,300	158,200	-44.2%	158,200	0.0%		
	Lower	204,750		463,350	768,400	65.8%	998,920	30.0%		
Island number	Upper	26		23	21	-8.7%				
	Lower	41		114	148	29.8%				



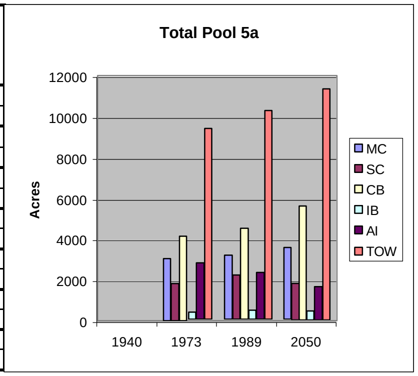
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Unrooted Submersed Aquatics	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Floating Perennials	CB,IB	LOW,MED	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Floating Annuals	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Emergent Perennials	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Emergent Annuals	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	minor habitat loss in upper pool (MC) replaced by new habitat (SC) in lower pool
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	minor habitat loss in upper pool (MC) replaced by new habitat (SC) in lower pool
Lentic Limnetic (standing water)	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Lentic Profundal (standing water, basin)	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	minor habitat loss in upper pool (MC) replaced by new habitat (SC) in lower pool
Lentic	CB	MED,HIGH,LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Fish			
Rheophil	MC,SC	MED,HIGH	little change
Rheo-Limnophil	MC,SC,CB	MED,LOW	channels stable, impact from upper pool contiguous backwater loss
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	channels stable, impact from upper pool contiguous backwater loss
Limno-Rheophil	CB,SC,MC	LOW,MED	loss of habitat in upper and lower pool contiguous backwaters, channels stable
Limnophil	CB, IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Pelagic Limno-Rheophil	CB,SC,MC	LOW	loss of habitat in upper and lower pool contiguous backwaters, channels stable
Amphibians and Reptiles			
Lentic	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)
Lotic	MC,SC	LOW	minor habitat loss in upper pool (MC) replaced by new habitat (SC) in lower pool
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	channels stable, impact from upper pool contiguous backwater loss
Dabbling Ducks, Geese and Swans	CB,IB	LOW	loss of habitat in upper and lower pool contiguous backwaters (approx. 2,000 acres)

Pool 5 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	1,332		1,159		1,221	5.3%	1,470	20.4%		
	Lower	710		1,887		1,927	2.1%	2,040	5.9%		
Secondary channel	Upper	585		1,515		1,294	-14.6%	934	-27.8%		
	Lower	327		308		860	179.2%	860	0.0%		
Contiguous backwater area	Upper	318		3,591		4,377	21.9%	5,559	27.0%		
	Lower	187		543		82	-84.9%	8	-90.2%		
Isolated backwater area	Upper	265		339		452	33.3%	452	0.0%		
	Lower	4		0		0		0	0.0%		
Island area	Upper	3,481		2,606		2,234	-14.3%	1,626	-27.2%		
	Lower	899		136		43	-68.4%	4	-90.7%		
Island perimeter	Upper	300,600		556,500		692,500	24.4%	588,625	-15.0%		
	Lower	126,500		65,500		28,300	-56.8%	8,949	-68.4%		
Island number	Upper	41		106		197	85.8%				
	Lower	18		17		14	-17.6%				



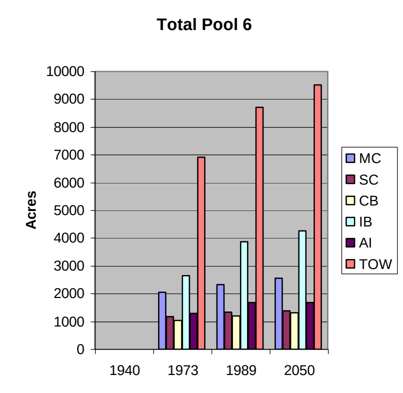
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	loss of upper pool SC replaced by CB; loss of lower pool CB
Unrooted Submersed Aquatics	CB,IB	LOW	Iincreased upper pool CB; loss of lower pool CB
Floating Perennials	CB,IB	LOW,MED	Iincreased upper pool CB; loss of lower pool CB
Floating Annuals	CB,IB	LOW	Iincreased upper pool CB; loss of lower pool CB
Emergent Perennials	CB,IB	LOW	Iincreased upper pool CB; loss of lower pool CB
Emergent Annuals	CB,IB	LOW	Iincreased upper pool CB; loss of lower pool CB
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	loss of upper pool SC, gain lower pool SC
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	loss of upper pool SC, gain lower pool SC
Lentic Limnetic (standing water)	CB,IB	LOW	Iincreased upper pool CB; loss of lower pool CB
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	Iincreased upper pool CB; loss of lower pool CB
Lentic Profundal (standing water, basin)	CB,IB	LOW	some upper pool IB gain
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	loss of upper pool SC, gain lower pool SC
Lentic	CB	MED,HIGH,LOW	Iincreased upper pool CB; loss of lower pool CB
Fish			
Rheophil	MC,SC	MED,HIGH	loss of upper pool SC, gain lower pool SC
Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of upper pool SC replaced by CB; loss of lower pool CB
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of upper pool SC replaced by CB; loss of lower pool CB
Limno-Rheophil	CB,SC,MC	LOW,MED	loss of upper pool SC replaced by CB; loss of lower pool CB
Limnophil	CB, IB	LOW	Iincreased upper pool CB; loss of lower pool CB
Pelagic Limno-Rheophil	CB,SC,MC	LOW	loss of upper pool SC replaced by CB; loss of lower pool CB
Amphibians and Reptiles			
Lentic	CB,IB	LOW	Iincreased upper pool CB; loss of lower pool CB
Lotic	MC,SC	LOW	loss of upper pool SC, gain lower pool SC
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	loss of upper pool SC replaced by CB; loss of lower pool CB
Dabbling Ducks, Geese and Swans	CB,IB	LOW	Iincreased upper pool CB; loss of lower pool CB

Pool 5A Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	989		773		839	8.5%	923	10.0%		
	Lower	333		341		396	16.1%	396	0.0%		
Secondary channel	Upper	527		412		391	-5.1%	391	0.0%		
	Lower	326		945		682	-27.8%	614	-10.0%		
Contiguous backwater area	Upper	337		1,591		1,889	18.7%	2,229	18.0%		
	Lower	204		529		922	74.3%	1,041	12.9%		
Isolated backwater area	Upper	9		347		472	36.0%	472	0.0%		
	Lower	133		27		31	14.8%	28	-9.7%		
Island area	Upper	4,866		2,733		3,620	32.5%	4,272	18.0%		
	Lower	2,362		526		596	13.3%	477	-20.0%		
Island perimeter	Upper	262,200		391,250		673,350	72.1%	731,445	8.6%		
	Lower	169,500		159,600		204,600	28.2%	182,094	-11.0%		
Island number	Upper	26		42		89	111.9%				
	Lower	18		48		58	20.8%				



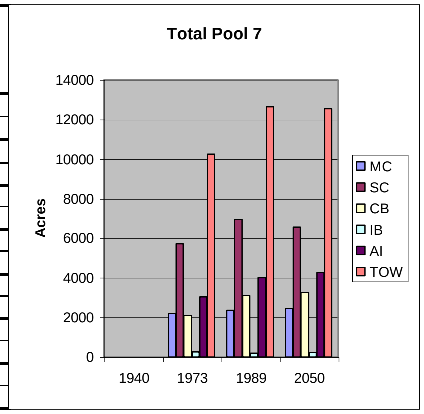
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	little change
Unrooted Submersed Aquatics	CB,IB	LOW	little change
Floating Perennials	CB,IB	LOW,MED	little change
Floating Annuals	CB,IB	LOW	little change
Emergent Perennials	CB,IB	LOW	Iincreased upper pool CB; loss of lower pool CB
Emergent Annuals	CB,IB	LOW	Iincreased upper pool CB; loss of lower pool CB
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	little change
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	little change
Lentic Limnetic (standing water)	CB,IB	LOW	little change
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	little change
Lentic Profundal (standing water, basin)	CB,IB	LOW	little change
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	little change
Lentic	CB	MED,HIGH,LOW	little change
Fish			
Rheophil	MC,SC	MED,HIGH	little change
Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Limno-Rheophil	CB,SC,MC	LOW,MED	little change
Limnophil	CB, IB	LOW	little change
Pelagic Limno-Rheophil	CB,SC,MC	LOW	little change
Amphibians and Reptiles			
Lentic	CB,IB	LOW	little change
Lotic	MC,SC	LOW	little change
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	little change
Dabbling Ducks, Geese and Swans	CB,IB	LOW	little change

Pool 6 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	655		485		612	26.2%	673	10.0%		
	Lower	1,605		1,565		1,704	8.9%	1,874	10.0%		
Secondary channel	Upper	326		137		278	102.9%	334	20.1%		
	Lower	441		1,044		1,050	0.6%	1,050	0.0%		
Contiguous backwater area	Upper	258		513		548	6.8%	603	10.0%		
	Lower	139		517		644	24.6%	708	9.9%		
Isolated backwater area	Upper	418		696		847	21.7%	932	10.0%		
	Lower	1,019		1,956		3,030	54.9%	3,333	10.0%		
Island area	Upper	737		539		661	22.6%	661	0.0%		
	Lower	1,655		746		1,022	37.0%	1,022	0.0%		
Island perimeter	Upper	109,600		136,500		180,800	32.5%	180,800	0.0%		
	Lower	265,500		236,400		382,050	61.6%	382,050	0.0%		
Island number	Upper	16		22		35	59.1%				
	Lower	44		49		135	175.5%				



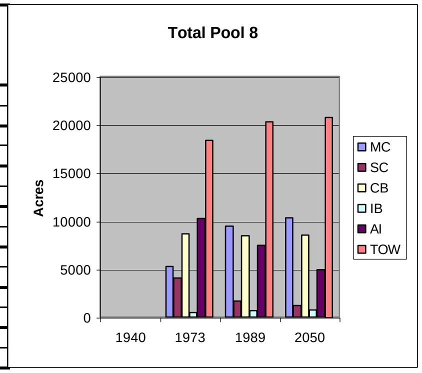
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	increased lower pool contiguous and isolated backwater
Unrooted Submersed Aquatics	CB,IB	LOW	increased lower pool contiguous and isolated backwater
Floating Perennials	CB,IB	LOW,MED	increased lower pool contiguous and isolated backwater
Floating Annuals	CB,IB	LOW	increased lower pool contiguous and isolated backwater
Emergent Perennials	CB,IB	LOW	increased lower pool contiguous and isolated backwater
Emergent Annuals	CB,IB	LOW	increased lower pool contiguous and isolated backwater
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	Increased main and side channel
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	Increased main and side channel
Lentic Limnetic (standing water)	CB,IB	LOW	increased lower pool contiguous and isolated backwater
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	increased lower pool contiguous and isolated backwater
Lentic Profundal (standing water, basin)	CB,IB	LOW	increased lower pool contiguous and isolated backwater
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	Increased main and side channel
Lentic	CB	MED,HIGH,LOW	increased lower pool contiguous and isolated backwater
Fish			
Rheophil	MC,SC	MED,HIGH	Increased main and side channel
Rheo-Limnophil	MC,SC,CB	MED,LOW	Increased main and side channel, and lower pool backwaters
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	Increased main and side channel, and lower pool backwaters
Limno-Rheophil	CB,SC,MC	LOW,MED	Increased main and side channel, and lower pool backwaters
Limnophil	CB, IB	LOW	increased lower pool contiguous and isolated backwater
Pelagic Limno-Rheophil	CB,SC,MC	LOW	Increased main and side channel, and lower pool backwaters
Amphibians and Reptiles			
Lentic	CB,IB	LOW	increased lower pool contiguous and isolated backwater
Lotic	MC,SC	LOW	Increased main and side channel
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	Increased main and side channel, increased backwaters
Dabbling Ducks, Geese and Swans	CB,IB	LOW	increased lower pool contiguous and isolated backwater

Pool 7 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	1,525		1,430		1,481	3.6%	1,481	0.0%		
	Lower	580		758		881	16.2%	969	10.0%		
Secondary channel	Upper	322		474		410	-13.5%	369	-10.0%		
	Lower	213		5,246		6,542	24.7%	6,210	-5.1%		
Contiguous backwater area	Upper	438		1,162		2,122	82.6%	2,228	5.0%		
	Lower	279		931		984	5.7%	1,033	5.0%		
Isolated backwater area	Upper	89		251		160	-36.3%	192	20.0%		
	Lower	42		9		49	444.4%	49	0.0%		
Island area	Upper	2,888		1,902		2,107	10.8%	2,107	0.0%		
	Lower	7,965		1,145		1,888	64.9%	2,171	15.0%		
Island perimeter	Upper	210,700		323,900		570,000	76.0%	570,000	0.0%		
	Lower	208,100		202,850		356,200	75.6%	381,134	7.0%		
Island number	Upper	25		55		115	109.1%				
	Lower	14		44		87	97.7%				



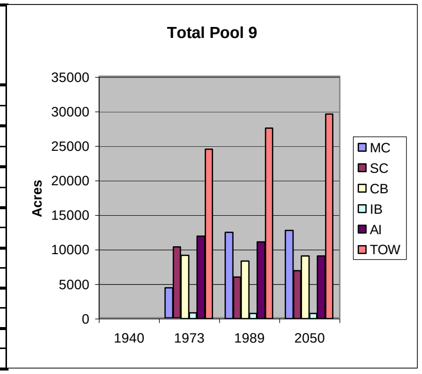
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	increased upper pool CB and lower pool SC
Unrooted Submersed Aquatics	CB,IB	LOW	increased upper pool CB
Floating Perennials	CB,IB	LOW,MED	increased upper pool CB
Floating Annuals	CB,IB	LOW	increased upper pool CB
Emergent Perennials	CB,IB	LOW	increased upper pool CB
Emergent Annuals	CB,IB	LOW	increased upper pool CB
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	increased lower pool SC
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	increased lower pool SC
Lentic Limnetic (standing water)	CB,IB	LOW	increased upper pool CB
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	increased upper pool CB
Lentic Profundal (standing water, basin)	CB,IB	LOW	increased upper pool CB
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	increased lower pool SC
Lentic	CB	MED,HIGH,LOW	increased upper pool CB
Fish			
Rheophil	MC,SC	MED,HIGH	increased MC and SC area
Rheo-Limnophil	MC,SC,CB	MED,LOW	increased upper pool MC, SC, and CB
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	increased upper pool MC, SC, and CB
Limno-Rheophil	CB,SC,MC	LOW,MED	increased upper pool CB, SC, and MC
Limnophil	CB, IB	LOW	increased CB
Pelagic Limno-Rheophil	CB,SC,MC	LOW	increased upper pool CB, SC, and MC
Amphibians and Reptiles			
Lentic	CB,IB	LOW	increased upper pool CB
Lotic	MC,SC	LOW	increased lower pool SC
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	increased upper pool CB and lower pool SC
Dabbling Ducks, Geese and Swans	CB,IB	LOW	increased upper pool CB

Pool 8 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	2,063		1,810		1,875	3.6%	2,025	8.0%		
	Lower	1,172		3,456		7,554	118.6%	8,293	9.8%		
Secondary channel	Upper	808		1,009		1,175	16.5%	1,175	0.0%		
	Lower	664		3,021		519	-82.8%	52	-90.0%		
Contiguous backwater area	Upper	981		4,439		4,339	-2.3%	4,122	-5.0%		
	Lower	863		4,174		4,134	-1.0%	4,406	6.6%		
Isolated backwater area	Upper	191		393		637	62.1%	701	10.0%		
	Lower	31		44		18	-59.1%	18	0.0%		
Island area	Upper	6,845		7,755		6,657	-14.2%	4,660	-30.0%		
	Lower	8,111		2,462		777	-68.4%	233	-70.0%		
Island perimeter	Upper	403,100		1,053,606		1,189,700	12.9%	999,348	-16.0%		
	Lower	458,900		735,038		307,400	-58.2%	168,370	-45.2%		
Island number	Upper	31		132		216	63.6%				
	Lower	33		155		106	-31.6%				



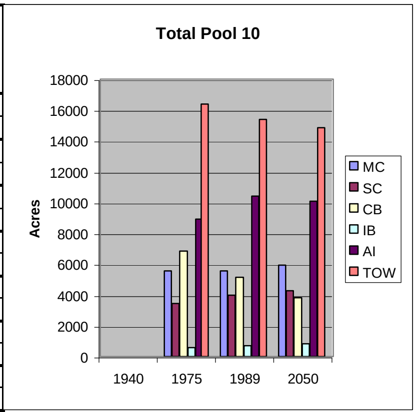
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	lower pool habitat transition to open water, too deep
Unrooted Submersed Aquatics	CB,IB	LOW	lower pool habitat transition to open water, too much flow
Floating Perennials	CB,IB	LOW,MED	lower pool habitat transition to open water, too deep
Floating Annuals	CB,IB	LOW	lower pool habitat transition to open water, too much flow
Emergent Perennials	CB,IB	LOW	lower pool habitat transition to open water, too much flow
Emergent Annuals	CB,IB	LOW	lower pool habitat transition to open water, too much flow
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	loss of lower pool side channel
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	increased habitat in lower pool island erosion zone
Lentic Limnetic (standing water)	CB,IB	LOW	increased habitat in lower pool island erosion zone
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	lower pool habitat transition to open water, too deep, no plants
Lentic Profundal (standing water, basin)	CB,IB	LOW	increased habitat in lower pool island erosion zone
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	loss of lower pool side channel
Lentic	CB	MED,HIGH,LOW	increased habitat in lower pool island erosion zone
Fish			
Rheophil	MC,SC	MED,HIGH	loss of lower pool side channel, MC increase low quality
Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of lower pool side channel, MC increase low quality
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of lower pool side channel, MC increase low quality
Limno-Rheophil	CB,SC,MC	LOW,MED	loss of lower pool side channel, MC increase low quality
Limnophil	CB, IB	LOW	loss of lower pool side channel, MC increase low quality
Pelagic Limno-Rheophil	CB,SC,MC	LOW	loss of lower pool side channel, MC increase low quality
Amphibians and Reptiles			
Lentic	CB,IB	LOW	lower pool habitat transition to open water, too deep
Lotic	MC,SC	LOW	loss of lower pool side channel
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	lower pool habitat transition to open water, too deep
Dabbling Ducks, Geese and Swans	CB,IB	LOW	lower pool habitat transition to open water, too deep

Pool 9 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	2,419		2,348		2,390	1.8%	2,390	0.0%		
	Lower	1,474		2,007		10,081	402.3%	10,421	3.4%		
Secondary channel	Upper	319		303		943	211.2%	1,535	62.8%		
	Lower	510		9,970		5,067	-49.2%	5,407	6.7%		
Contiguous backwater area	Upper	2,862		7,223		8,051	11.5%	9,057	12.5%		
	Lower	2,434		1,907		281	-85.3%	28	-90.0%		
Isolated backwater area	Upper	513		749		779	4.0%	779	0.0%		
	Lower	235		40		3	-92.5%	3	0.0%		
Island area	Upper	17,152		10,054		10,655	6.0%	9,057	-15.0%		
	Lower	9,953		1,877		474	-74.7%	47	-90.1%		
Island perimeter	Upper	1,257,800		1,903,499		2,037,921	7.1%	2,037,921	0.0%		
	Lower	1,129,600		568,611		231,850	-59.2%	74,192	-68.0%		
Island number	Upper	77		244		377	54.5%				
	Lower	98		127		81	-36.2%				



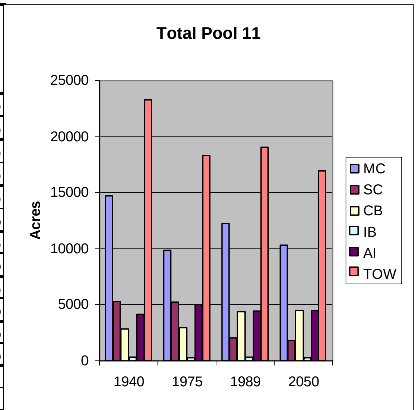
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	lower pool habitat transition to open water, too deep
Unrooted Submersed Aquatics	CB,IB	LOW	lower pool habitat transition to open water, too much flow
Floating Perennials	CB,IB	LOW,MED	lower pool habitat transition to open water, too deep
Floating Annuals	CB,IB	LOW	lower pool habitat transition to open water, too much flow
Emergent Perennials	CB,IB	LOW	lower pool habitat transition to open water, too much flow
Emergent Annuals	CB,IB	LOW	lower pool habitat transition to open water, too much flow
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	loss of lower pool side channel
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	increased habitat in lower pool island erosion zone
Lentic Limnetic (standing water)	CB,IB	LOW	increased habitat in lower pool island erosion zone
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	lower pool habitat transition to open water, too deep, no plants
Lentic Profundal (standing water, basin)	CB,IB	LOW	increased habitat in lower pool island erosion zone
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	loss of lower pool side channel
Lentic	CB	MED,HIGH,LOW	increased habitat in lower pool island erosion zone
Fish			
Rheophil	MC,SC	MED,HIGH	loss of lower pool side channel, MC increase low quality, increase upper pool SC
Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of lower pool side channel, MC increase low quality, increased upper pool SC and CB
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of lower pool side channel, MC increase low quality, increased upper pool SC and CB
Limno-Rheophil	CB,SC,MC	LOW,MED	loss of lower pool side channel, MC increase low quality, increased upper pool SC and CB
Limnophil	CB, IB	LOW	increased upper pool CB
Pelagic Limno-Rheophil	CB,SC,MC	LOW	loss of lower pool side channel, MC increase low quality, increased upper pool SC and CB
Amphibians and Reptiles			
Lentic	CB,IB	LOW	lower pool habitat transition to open water, too deep
Lotic	MC,SC	LOW	loss of lower pool side channel
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	lower pool habitat transition to open water, too deep
Dabbling Ducks, Geese and Swans	CB,IB	LOW	lower pool habitat transition to open water, too deep

Pool 10 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	3,967		3,759		3,832	1.9%	4,100	7.0%		
	Lower	1,410		1,789		1,726	-3.5%	1,847	7.0%		
Secondary channel	Upper	1,270		1,744		2,129	22.1%	2,278	7.0%		
	Lower	825		1,678		1,859	10.8%	1,989	7.0%		
Contiguous backwater area	Upper	2,164		5,361		3,233	-39.7%	1,617	-50.0%		
	Lower	574		1,471		1,915	30.2%	2,215	15.7%		
Isolated backwater area	Upper	507		486		521	7.2%	594	14.0%		
	Lower	187		113		167	47.8%	217	29.9%		
Island area	Upper	8,921		7,187		8,854	23.2%	8,854	0.0%		
	Lower	2,502		1,727		1,556	-9.9%	1,245	-20.0%		
Island perimeter	Upper	875,300		1,215,828		1,162,100	-4.4%	1,045,890	-10.0%		
	Lower	274,450		447,851		565,300	26.2%	503,117	-11.0%		
Island number	Upper	64		115		114	-0.9%				
	Lower	29		85		138	62.4%				



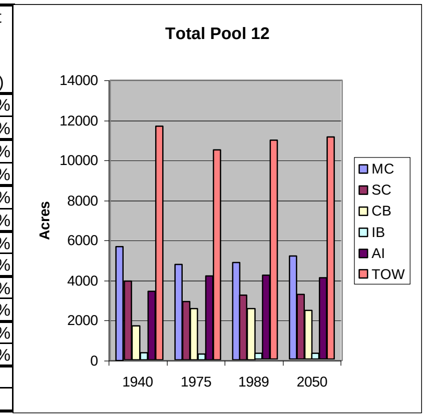
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	loss of upper pool contiguous backwater habitat
Unrooted Submersed Aquatics	CB,IB	LOW	loss of upper pool contiguous backwater habitat
Floating Perennials	CB,IB	LOW,MED	loss of upper pool contiguous backwater habitat
Floating Annuals	CB,IB	LOW	loss of upper pool contiguous backwater habitat
Emergent Perennials	CB,IB	LOW	loss of upper pool contiguous backwater habitat
Emergent Annuals	CB,IB	LOW	loss of upper pool contiguous backwater habitat
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	little change
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	little change
Lentic Limnetic (standing water)	CB,IB	LOW	loss of upper pool contiguous backwater habitat
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	loss of upper pool contiguous backwater habitat
Lentic Profundal (standing water, basin)	CB,IB	LOW	loss of upper pool contiguous backwater habitat
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	little change
Lentic	CB	MED,HIGH,LOW	loss of upper pool contiguous backwater habitat
Fish			
Rheophil	MC,SC	MED,HIGH	little change
Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of upper pool contiguous backwater habitat
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of upper pool contiguous backwater habitat
Limno-Rheophil	CB,SC,MC	LOW,MED	loss of upper pool contiguous backwater habitat
Limnophil	CB, IB	LOW	loss of upper pool contiguous backwater habitat
Pelagic Limno-Rheophil	CB,SC,MC	LOW	loss of upper pool contiguous backwater habitat
Amphibians and Reptiles			
Lentic	CB,IB	LOW	loss of upper pool contiguous backwater habitat
Lotic	MC,SC	LOW	little change
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	loss of upper pool contiguous backwater habitat
Dabbling Ducks, Geese and Swans	CB,IB	LOW	loss of upper pool contiguous backwater habitat

Pool 11 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	2,744	2888	2,392	-17.2%	2,411	0.8%	2,411	0.0%	-16.5%	-16.5%
	Lower	2,743	11848	7,455	-37.1%	9,866	32.3%	7,893	-20.0%	-16.7%	-33.4%
Secondary channel	Upper	1,013	1753	1,447	-17.5%	1,264	-12.6%	1,071	-15.3%	-27.9%	-38.9%
	Lower	1,336	3554	3,817	7.4%	777	-79.6%	777	0.0%	-78.1%	-78.1%
Contiguous backwater area	Upper	408	2121	1,615	-23.9%	1,836	13.7%	1,469	-20.0%	-13.4%	-30.7%
	Lower	756	740	1,342	81.4%	2,554	90.3%	3,065	20.0%	245.1%	314.2%
Isolated backwater area	Upper	589	336	246	-26.8%	263	6.9%	210	-20.2%	-21.7%	-37.5%
	Lower	463	26	30	15.4%	67	123.3%	67	0.0%	157.7%	157.7%
Island area	Upper	3,219	3556	3,856	8.4%	3,431	-11.0%	3,240	-5.6%	-3.5%	-8.9%
	Lower	3,104	623	1,171	88.0%	1,006	-14.1%	1,257	25.0%	61.5%	101.8%
Island perimeter	Upper	233,750	454900	571,600	25.7%	556,700	-2.6%	528,865	-5.0%	22.4%	16.3%
	Lower	297,450	247800	317,300	28.0%	308,500	-2.8%	308,500	0.0%	24.5%	24.5%
Island number	Upper	26	48	65	35.4%	79	21.5%			64.6%	
	Lower	29	31	89	187.1%	85	-4.5%			174.2%	



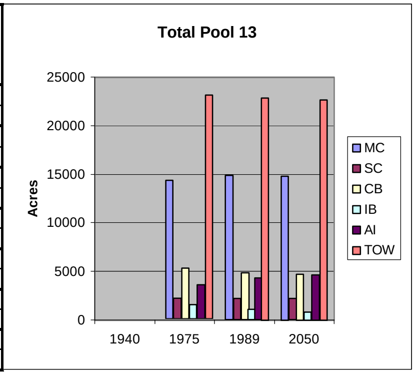
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	increase in lower pool contiguous backwater habitat
Unrooted Submersed Aquatics	CB,IB	LOW	increase in lower pool contiguous backwater habitat
Floating Perennials	CB,IB	LOW,MED	increase in lower pool contiguous backwater habitat
Floating Annuals	CB,IB	LOW	increase in lower pool contiguous backwater habitat
Emergent Perennials	CB,IB	LOW	increase in lower pool contiguous backwater habitat
Emergent Annuals	CB,IB	LOW	increase in lower pool contiguous backwater habitat
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	loss of main channel and secondary channel habitat
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	loss of main channel and secondary channel habitat
Lentic Limnetic (standing water)	CB,IB	LOW	increase in lower pool contiguous backwater habitat
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	increase in lower pool contiguous backwater habitat
Lentic Profundal (standing water, basin)	CB,IB	LOW	increase in lower pool contiguous backwater habitat
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	loss of main channel and secondary channel habitat
Lentic	CB	MED,HIGH,LOW	increase in lower pool contiguous backwater habitat
Fish			
Rheophil	MC,SC	MED,HIGH	loss of MC and SC
Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of MC and SC, increased CB and IB
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of MC and SC, increased CB and IB
Limno-Rheophil	CB,SC,MC	LOW,MED	loss of MC and SC, increased CB and IB
Limnophil	CB, IB	LOW	increased CB and lower pool IB
Pelagic Limno-Rheophil	CB,SC,MC	LOW	loss of MC and SC, increased CB and IB
Amphibians and Reptiles			
Lentic	CB,IB	LOW	increase in lower pool contiguous backwater habitat
Lotic	MC,SC	LOW	loss of main channel and secondary channel habitat
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	increase in lower pool contiguous backwater habitat
Dabbling Ducks, Geese and Swans	CB,IB	LOW	increase in lower pool contiguous backwater habitat

Pool 12 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	3,622	3814	3,419	-10.4%	3,443	0.7%	3,443	0.0%	-9.7%	-9.7%
	Lower	1,175	1879	1,341	-28.6%	1,405	4.8%	1,700	21.0%	-25.2%	-9.5%
Secondary channel	Upper	1,043	1204	1,345	11.7%	1,385	3.0%	1,385	0.0%	15.0%	15.0%
	Lower	460	2720	1,561	-42.6%	1,835	17.6%	1,835	0.0%	-32.5%	-32.5%
Contiguous backwater area	Upper	720	1403	1,496	6.6%	1,620	8.3%	1,620	0.0%	15.5%	15.5%
	Lower	225	300	1,049	249.7%	945	-9.9%	800	-15.3%	215.0%	166.7%
Isolated backwater area	Upper	385	336	273	-18.8%	272	-0.4%	272	0.0%	-19.0%	-19.0%
	Lower	348	7	0	-100.0%	29	NA	25	-13.8%	314.3%	257.1%
Island area	Upper	3,363	2758	3,039	10.2%	3,072	1.1%	3,072	0.0%	11.4%	11.4%
	Lower	1,666	674	1,159	72.0%	1,124	-3.0%	972	-13.5%	66.8%	44.2%
Island perimeter	Upper	282,750	501300	620,500	23.8%	631,900	1.8%	631,900	0.0%	26.1%	26.1%
	Lower	127,500	183200	281,400	53.6%	283,800	0.9%	283,800	0.0%	54.9%	54.9%
Island number	Upper	33	65	75	15.4%	83	10.7%			27.7%	
	Lower	10	39	41	5.1%	59	43.9%			51.3%	



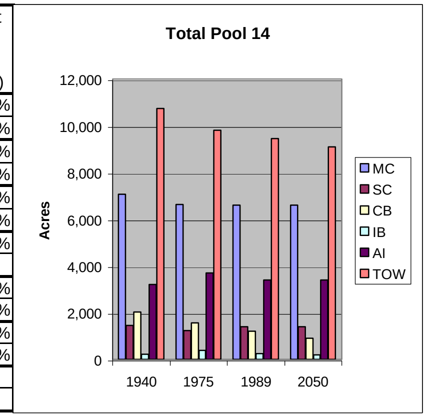
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	increased contiguous backwater
Unrooted Submersed Aquatics	CB,IB	LOW	increased contiguous backwater
Floating Perennials	CB,IB	LOW,MED	increased contiguous backwater
Floating Annuals	CB,IB	LOW	increased contiguous backwater
Emergent Perennials	CB,IB	LOW	increased contiguous backwater
Emergent Annuals	CB,IB	LOW	increased contiguous backwater
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	loss of main and secondary channels
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	loss of main and secondary channels
Lentic Limnetic (standing water)	CB,IB	LOW	increased contiguous backwater
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	increased contiguous backwater
Lentic Profundal (standing water, basin)	CB,IB	LOW	increased contiguous backwater
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	loss of main and secondary channels
Lentic	CB	MED,HIGH,LOW	increased contiguous backwater
Fish			
Rheophil	MC,SC	MED,HIGH	loss of main and secondary channels
Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of main and secondary channels, increased CB
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of main and secondary channels, increased CB
Limno-Rheophil	CB,SC,MC	LOW,MED	loss of main and secondary channels, increased CB
Limnophil	CB, IB	LOW	increased CB
Pelagic Limno-Rheophil	CB,SC,MC	LOW	loss of main and secondary channels, increased CB
Amphibians and Reptiles			
Lentic	CB,IB	LOW	increased contiguous backwater
Lotic	MC,SC	LOW	loss of main and secondary channels
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	increased contiguous backwater
Dabbling Ducks, Geese and Swans	CB,IB	LOW	increased contiguous backwater

Pool 13 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	2,295		2,118		2,080	-1.8%	2,080	0.0%		
	Lower	4,553		12,129		12,781	5.4%	12,781	0.0%		
Secondary channel	Upper	207		199		326	63.8%	326	0.0%		
	Lower	987		1,927		1,873	-2.8%	1,873	0.0%		
Contiguous backwater area	Upper	490		1,007		620	-38.4%	558	-10.0%		
	Lower	1,882		4,227		4,179	-1.1%	4,179	0.0%		
Isolated backwater area	Upper	740		684		508	-25.7%	457	-10.0%		
	Lower	1,673		752		540	-28.2%	432	-20.0%		
Island area	Upper	633		660		626	-5.2%	626	0.0%		
	Lower	8,814		2,804		3,671	30.9%	4,038	10.0%		
Island perimeter	Upper	182,800		122,800		102,900	-16.2%	102,900	0.0%		
	Lower	833,300		540,100		634,400	17.5%	634,400	0.0%		
Island number	Upper	21		29		21	-27.6%				
	Lower	78		131		138	5.3%				



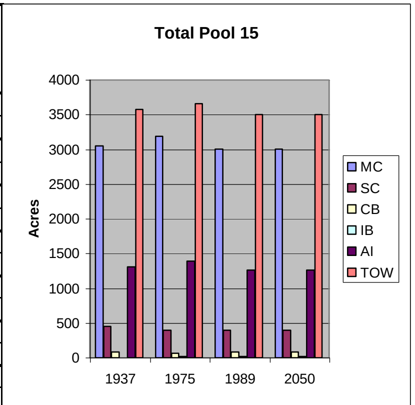
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	loss of upper pool contiguous backwaters and isolated backwaters throughout
Unrooted Submersed Aquatics	CB,IB	LOW	loss of upper pool contiguous backwaters and isolated backwaters throughout
Floating Perennials	CB,IB	LOW,MED	loss of upper pool contiguous backwaters and isolated backwaters throughout
Floating Annuals	CB,IB	LOW	loss of upper pool contiguous backwaters and isolated backwaters throughout
Emergent Perennials	CB,IB	LOW	loss of upper pool contiguous backwaters and isolated backwaters throughout
Emergent Annuals	CB,IB	LOW	loss of upper pool contiguous backwaters and isolated backwaters throughout
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	gain in upper pool side channels
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	gain in upper pool side channels
Lentic Limnetic (standing water)	CB,IB	LOW	loss of upper pool contiguous backwaters and isolated backwaters throughout
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	loss of upper pool contiguous backwaters and isolated backwaters throughout
Lentic Profundal (standing water, basin)	CB,IB	LOW	loss of upper pool contiguous backwaters and isolated backwaters throughout
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	gain in upper pool side channels
Lentic	CB	MED,HIGH,LOW	loss of upper pool contiguous backwaters and isolated backwaters throughout
Fish			
Rheophil	MC,SC	MED,HIGH	gain in upper pool side channels
Rheo-Limnophil	MC,SC,CB	MED,LOW	gain in upper pool side channels, loss of uuper pool CB
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	gain in upper pool side channels, loss of uuper pool CB
Limno-Rheophil	CB,SC,MC	LOW,MED	gain in upper pool side channels, loss of uuper pool CB
Limnophil	CB, IB	LOW	loss of upper pool CB and IB throughout pool
Pelagic Limno-Rheophil	CB,SC,MC	LOW	gain in upper pool side channels, loss of uuper pool CB
Amphibians and Reptiles			
Lentic	CB,IB	LOW	loss of upper pool contiguous backwaters and isolated backwaters throughout
Lotic	MC,SC	LOW	gain in upper pool side channels
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	loss of upper pool contiguous backwaters and isolated backwaters throughout
Dabbling Ducks, Geese and Swans	CB,IB	LOW	loss of upper pool contiguous backwaters and isolated backwaters throughout

Pool 14 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	4,309	3904	3,722	-4.7%	3,743	0.6%	3,743	0.0%	-4.1%	-4.1%
	Lower	2,146	3151	2,915	-7.5%	2,854	-2.1%	2,854	0.0%	-9.4%	-9.4%
Secondary channel	Upper	904	1303	1,150	-11.7%	1,319	14.7%	1,319	0.0%	1.2%	1.2%
	Lower	359	142	75	-47.2%	77	2.7%	77	0.0%	-45.8%	-45.8%
Contiguous backwater area	Upper	460	1971	1,504	-23.7%	1,150	-23.5%	863	-25.0%	-41.7%	-56.2%
	Lower	30	45	45	0.0%	45	0.0%	45	0.0%	0.0%	0.0%
Isolated backwater area	Upper	459	226	390	72.6%	235	-39.7%	176	-25.1%	4.0%	-22.1%
	Lower	0	0	0		19	NA	19	0.0%		
Island area	Upper	3,290	3158	3,600	14.0%	3,354	-6.8%	3,354	0.0%	6.2%	6.2%
	Lower	57	50	89	78.0%	54	-39.3%	54	0.0%	8.0%	8.0%
Island perimeter	Upper	246,000	568200	472,700	-16.8%	418,850	-11.4%	281,795	-32.7%	-26.3%	-50.4%
	Lower	20,200	21000	10,000	-52.4%	13,700	37.0%	13,700	0.0%	-34.8%	-34.8%
Island number	Upper	43	77	55	-28.6%	56	1.8%			-27.3%	
	Lower	7	4	1	-75.0%	3	200.0%			-25.0%	



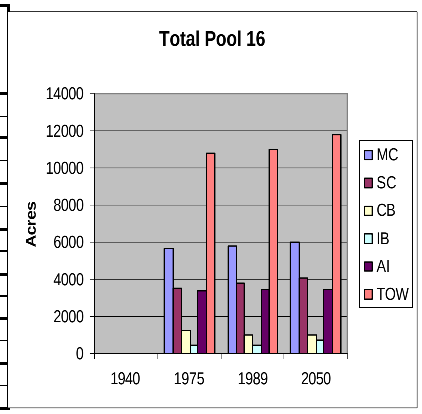
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	loss of upper pool backwater
Unrooted Submersed Aquatics	CB,IB	LOW	loss of upper pool backwater
Floating Perennials	CB,IB	LOW,MED	loss of upper pool backwater
Floating Annuals	CB,IB	LOW	loss of upper pool backwater
Emergent Perennials	CB,IB	LOW	loss of upper pool backwater
Emergent Annuals	CB,IB	LOW	loss of upper pool backwater
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	little change
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	little change
Lentic Limnetic (standing water)	CB,IB	LOW	loss of upper pool backwater
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	loss of upper pool backwater
Lentic Profundal (standing water, basin)	CB,IB	LOW	loss of upper pool backwater
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	little change
Lentic	CB	MED,HIGH,LOW	loss of upper pool backwater
Fish			
Rheophil	MC,SC	MED,HIGH	little change
Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of upper pool backwater
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of upper pool backwater
Limno-Rheophil	CB,SC,MC	LOW,MED	loss of upper pool backwater
Limnophil	CB, IB	LOW	loss of upper pool backwater
Pelagic Limno-Rheophil	CB,SC,MC	LOW	loss of upper pool backwater
Amphibians and Reptiles			
Lentic	CB,IB	LOW	loss of upper pool backwater
Lotic	MC,SC	LOW	little change
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	loss of upper pool backwater
Dabbling Ducks, Geese and Swans	CB,IB	LOW	loss of upper pool backwater

Pool 15 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	1,756	1,713	1,800	5.1%	1,672	-7.1%	1,672	0.0%	-2.4%	-2.4%
	Lower	1,314	1,340	1,385	3.4%	1,333	-3.8%	1,333	0.0%	-0.5%	-0.5%
Secondary channel	Upper	210	182	230	26.4%	233	1.3%	233	0.0%	28.0%	28.0%
	Lower	203	266	163	-38.7%	165	1.2%	165	0.0%	-38.0%	-38.0%
Contiguous backwater area	Upper	0	5	14	180.0%	23	64.3%	23	0.0%	360.0%	360.0%
	Lower	40	74	52	-29.7%	61	17.3%	61	0.0%	-17.6%	-17.6%
Isolated backwater area	Upper	0	0	15		10	-33.3%	10	0.0%		
	Lower	3	0	0		6		6	0.0%		
Island area	Upper	302	283	321	13.4%	306	-4.7%	306	0.0%	8.1%	8.1%
	Lower	1,065	1,027	1,074	4.6%	953	-11.3%	953	0.0%	-7.2%	-7.2%
Island perimeter	Upper	22,300	21,100	22,900	8.5%	26,700	16.6%	26,700	0.0%	26.5%	26.5%
	Lower	52,400	37,600	51,700	37.5%	49,700	-3.9%	49,700	0.0%	32.2%	32.2%
Island number	Upper	3	3	4	33.3%	6	50.0%			100.0%	
	Lower	4	2	4	100.0%	4	0.0%			100.0%	



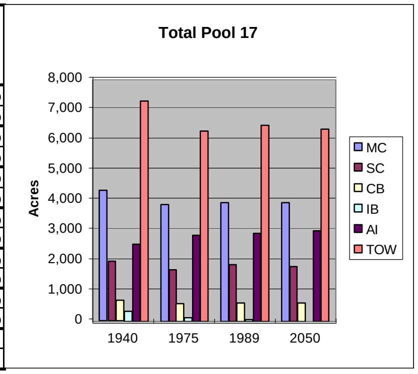
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	little change
Unrooted Submersed Aquatics	CB,IB	LOW	little change
Floating Perennials	CB,IB	LOW,MED	little change
Floating Annuals	CB,IB	LOW	little change
Emergent Perennials	CB,IB	LOW	little change
Emergent Annuals	CB,IB	LOW	little change
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	lower pool side channel loss
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	lower pool side channel loss
Lentic Limnetic (standing water)	CB,IB	LOW	little change
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	little change
Lentic Profundal (standing water, basin)	CB,IB	LOW	little change
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	lower pool side channel loss
Lentic	CB	MED,HIGH,LOW	little change
Fish			
Rheophil	MC,SC	MED,HIGH	little change
Rheo-Limnophil	MC,SC,CB	MED,LOW	lower pool side channel loss
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	lower pool side channel loss
Limno-Rheophil	CB,SC,MC	LOW,MED	lower pool side channel loss
Limnophil	CB, IB	LOW	little change
Pelagic Limno-Rheophil	CB,SC,MC	LOW	lower pool side channel loss
Amphibians and Reptiles			
Lentic	CB,IB	LOW	little change
Lotic	MC,SC	LOW	lower pool side channel loss
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	little change
Dabbling Ducks, Geese and Swans	CB,IB	LOW	little change

Pool 16 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	3,344		3,207		3,272	2.0%	3,272	0.0%		
	Lower	2,160		2,434		2,515	3.3%	2,707	7.6%		
Secondary channel	Upper	1,305		1,328		1,386	4.4%	1,386	0.0%		
	Lower	1,618		2,181		2,419	10.9%	2,685	11.0%		
Contiguous backwater area	Upper	451		333		255	-23.4%	393	54.1%		
	Lower	261		876		718	-18.0%	574	-20.1%		
Isolated backwater area	Upper	81		329		369	12.2%	728	97.3%		
	Lower	34		79		56	-29.1%	6	-89.3%		
Island area	Upper	1,733		1,337		1,442	7.9%	1,442	0.0%		
	Lower	3,115		1,999		1,991	-0.4%	1,991	0.0%		
Island perimeter	Upper	180,700		185,700		187,600	1.0%	187,600	0.0%		
	Lower	306,100		338,900		400,700	18.2%	440,770	10.0%		
Island number	Upper	26		19		22	15.8%				
	Lower	33		47		70	48.9%				



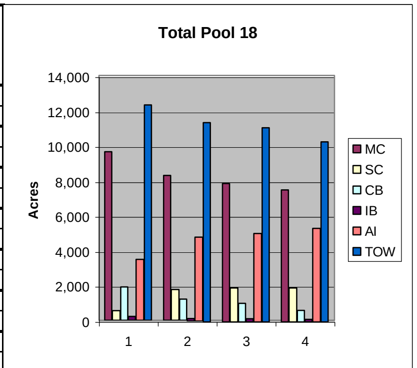
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	loss of lower pool backwaters
Unrooted Submersed Aquatics	CB,IB	LOW	loss of lower pool backwaters
Floating Perennials	CB,IB	LOW,MED	loss of lower pool backwaters
Floating Annuals	CB,IB	LOW	loss of lower pool backwaters
Emergent Perennials	CB,IB	LOW	loss of lower pool backwaters
Emergent Annuals	CB,IB	LOW	loss of lower pool backwaters
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	gain lower pool side channel
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	gain lower pool side channel
Lentic Limnetic (standing water)	CB,IB	LOW	loss of lower pool backwaters
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	loss of lower pool backwaters
Lentic Profundal (standing water, basin)	CB,IB	LOW	loss of lower pool backwaters
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	gain lower pool side channel
Lentic	CB	MED,HIGH,LOW	loss of lower pool backwaters
Fish			
Rheophil	MC,SC	MED,HIGH	gain lower pool side channel
Rheo-Limnophil	MC,SC,CB	MED,LOW	gain lower pool SC, loss of lower pool CB
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	gain lower pool SC, loss of lower pool CB
Limno-Rheophil	CB,SC,MC	LOW,MED	gain lower pool SC, loss of lower pool CB
Limnophil	CB, IB	LOW	loss of lower pool CB
Pelagic Limno-Rheophil	CB,SC,MC	LOW	gain lower pool SC, loss of lower pool CB
Amphibians and Reptiles			
Lentic	CB,IB	LOW	loss of lower pool backwaters
Lotic	MC,SC	LOW	gain lower pool side channel
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	loss of lower pool backwaters
Dabbling Ducks, Geese and Swans	CB,IB	LOW	loss of lower pool backwaters

Pool 17 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	2,462	2284	2,108	-7.7%	2,063	-2.1%	2,063	0.0%	-9.7%	-9.7%
	Lower	1,821	2039	1,758	-13.8%	1,864	6.0%	1,864	0.0%	-8.6%	-8.6%
Secondary channel	Upper	922	810	724	-10.6%	962	32.9%	962	0.0%	18.8%	18.8%
	Lower	854	1150	981	-14.7%	932	-5.0%	863	-7.4%	-19.0%	-25.0%
Contiguous backwater area	Upper	13	166	76	-54.2%	95	25.0%	95	0.0%	-42.8%	-42.8%
	Lower	471	509	518	1.8%	512	-1.2%	512	0.0%	0.6%	0.6%
Isolated backwater area	Upper	17	38	30	-21.1%	9	-70.0%	1	-88.9%	-76.3%	-97.4%
	Lower	88	298	106	-64.4%	50	-52.8%	5	-90.0%	-83.2%	-98.3%
Island area	Upper	865	1046	1,211	15.8%	1,262	4.2%	1,339	6.1%	20.7%	28.0%
	Lower	1,798	1508	1,650	9.4%	1,660	0.6%	1,660	0.0%	10.1%	10.1%
Island perimeter	Upper	89,700	142400	132,900	-6.7%	142,150	7.0%	146,350	3.0%	-0.2%	2.8%
	Lower	194,700	185500	215,800	16.3%	221,100	2.5%	221,100	0.0%	19.2%	19.2%
Island number	Upper	7	27	19	-29.6%	24	26.3%			-11.1%	
	Lower	18	12	19	58.3%	21	10.5%			75.0%	



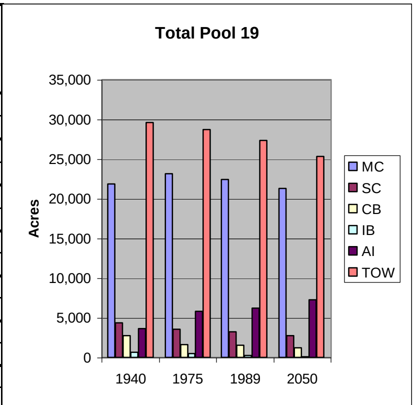
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	little change
Unrooted Submersed Aquatics	CB,IB	LOW	little change
Floating Perennials	CB,IB	LOW,MED	little change
Floating Annuals	CB,IB	LOW	little change
Emergent Perennials	CB,IB	LOW	little change
Emergent Annuals	CB,IB	LOW	little change
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	little change
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	little change
Lentic Limnetic (standing water)	CB,IB	LOW	little change
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	little change
Lentic Profundal (standing water, basin)	CB,IB	LOW	little change
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	little change
Lentic	CB	MED,HIGH,LOW	little change
Fish			
Rheophil	MC,SC	MED,HIGH	little change
Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Limno-Rheophil	CB,SC,MC	LOW,MED	little change
Limnophil	CB, IB	LOW	little change
Pelagic Limno-Rheophil	CB,SC,MC	LOW	little change
Amphibians and Reptiles			
Lentic	CB,IB	LOW	little change
Lotic	MC,SC	LOW	little change
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	little change
Dabbling Ducks, Geese and Swans	CB,IB	LOW	little change

Pool 18 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	5,057	5508	4,240	-23.0%	4,104	-3.2%	3,858	-6.0%	-25.5%	-30.0%
	Lower	1,856	4121	4,043	-1.9%	3,819	-5.5%	3,704	-3.0%	-7.3%	-10.1%
Secondary channel	Upper	1,662	507	1,770	249.1%	1,910	7.9%	1,910	0.0%	276.7%	276.7%
	Lower	908	46	0	-100.0%	24	#DIV/0!	24	0.0%	-47.8%	-47.8%
Contiguous backwater area	Upper	284	1766	1,061	-39.9%	905	-14.7%	499	-44.9%	-48.8%	-71.7%
	Lower	62	131	138	5.3%	162	17.4%	162	0.0%	23.7%	23.7%
Isolated backwater area	Upper	110	222	152	-31.5%	164	7.9%	126	-23.2%	-26.1%	-43.2%
	Lower	7	0	0		3	#DIV/0!	3	0.0%		
Island area	Upper	4,408	3303	4,680	41.7%	4,804	2.6%	4,948	3.0%	45.4%	49.8%
	Lower	908	165	115	-30.3%	243	111.3%	386	58.8%	47.3%	133.9%
Island perimeter	Upper	280,000	402500	474,500	17.9%	628,850	32.5%	638,213	1.5%	56.2%	58.6%
	Lower	99,200	37100	48,300	30.2%	71,950	49.0%	90,657	26.0%	93.9%	144.4%
Island number	Upper	39	55	57	3.6%	85	49.1%			54.5%	
	Lower	14	8	17	112.5%	21	23.5%			162.5%	



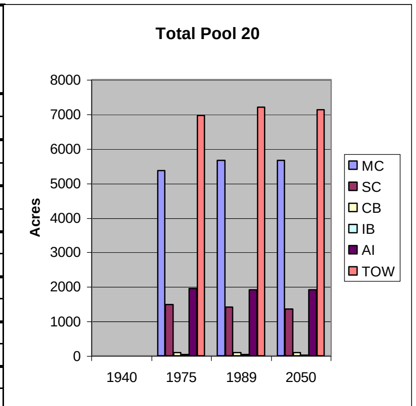
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	loss of upper pool contiguous backwaters
Unrooted Submersed Aquatics	CB,IB	LOW	loss of upper pool contiguous backwaters
Floating Perennials	CB,IB	LOW,MED	loss of upper pool contiguous backwaters
Floating Annuals	CB,IB	LOW	loss of upper pool contiguous backwaters
Emergent Perennials	CB,IB	LOW	loss of upper pool contiguous backwaters
Emergent Annuals	CB,IB	LOW	loss of upper pool contiguous backwaters
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	transition upper pool main channel to side channel
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	transition upper pool main channel to side channel
Lentic Limnetic (standing water)	CB,IB	LOW	loss of upper pool contiguous backwaters
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	loss of upper pool contiguous backwaters
Lentic Profundal (standing water, basin)	CB,IB	LOW	loss of upper pool contiguous backwaters
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	transition upper pool main channel to side channel
Lentic	CB	MED,HIGH,LOW	loss of upper pool contiguous backwaters
Fish			
Rheophil	MC,SC	MED,HIGH	transition upper pool main channel to side channel
Rheo-Limnophil	MC,SC,CB	MED,LOW	transition upper pool MC to SC, loss of upper pool CB
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	transition upper pool MC to SC, loss of upper pool CB
Limno-Rheophil	CB,SC,MC	LOW,MED	transition upper pool MC to SC, loss of upper pool CB
Limnophil	CB, IB	LOW	loss of upper pool CB
Pelagic Limno-Rheophil	CB,SC,MC	LOW	transition upper pool MC to SC, loss of upper pool CB
Amphibians and Reptiles			
Lentic	CB,IB	LOW	loss of upper pool contiguous backwaters
Lotic	MC,SC	LOW	transition upper pool main channel to side channel
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	loss of upper pool contiguous backwaters
Dabbling Ducks, Geese and Swans	CB,IB	LOW	loss of upper pool contiguous backwaters

Pool 19 Aquatic areas	Within Pool	Post-Dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	9,460	7522	8,445	12.3%	8,153	-3.5%	6,988	-14.3%	8.4%	-7.1%
	Lower	15,280	14365	14,667	2.1%	14,263	-2.8%	14,263	0.0%	-0.7%	-0.7%
Secondary channel	Upper	3,870	4370	3,514	-19.6%	3,249	-7.5%	2,710	-16.6%	-25.7%	-38.0%
	Lower	344	0	0		0	0.0%	0	0.0%		
Contiguous backwater area	Upper	2,978	2487	1,005	-59.6%	605	-39.8%	355	-41.3%	-75.7%	-85.7%
	Lower	288	258	571	121.3%	889	55.7%	889	0.0%	244.6%	244.6%
Isolated backwater area	Upper	224	543	400	-26.3%	106	-73.5%	11	-89.6%	-80.5%	-98.0%
	Lower	74	85	119	40.0%	109	-8.4%	109	0.0%	28.2%	28.2%
Island area	Upper	3,780	3564	5,700	59.9%	6,170	8.2%	7,281	18.0%	73.1%	104.3%
	Lower	135	94	75	-20.2%	25	-66.7%	3	-88.0%	-73.4%	-96.8%
Island perimeter	Upper	613,000	687480	685,200	-0.3%	588,500	-14.1%	529,650	-10.0%	-14.4%	-23.0%
	Lower	26,100	19800	14,600	-26.3%	12,600	-13.7%	0	-100.0%	-36.4%	-100.0%
Island number	Upper	83	138	86	-37.7%	71	-17.4%			-48.6%	
	Lower	4	3	4	33.3%	6	50.0%			100.0%	



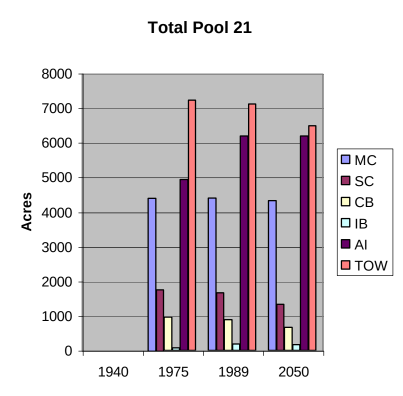
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	loss of upper pool contiguous and isolated backwaters
Unrooted Submersed Aquatics	CB,IB	LOW	loss of upper pool contiguous and isolated backwaters
Floating Perennials	CB,IB	LOW,MED	loss of upper pool contiguous and isolated backwaters
Floating Annuals	CB,IB	LOW	loss of upper pool contiguous and isolated backwaters
Emergent Perennials	CB,IB	LOW	loss of upper pool contiguous and isolated backwaters
Emergent Annuals	CB,IB	LOW	loss of upper pool contiguous and isolated backwaters
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	loss of upper pool secondary channels
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	loss of upper pool secondary channels
Lentic Limnetic (standing water)	CB,IB	LOW	loss of upper pool contiguous and isolated backwaters
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	loss of upper pool contiguous and isolated backwaters
Lentic Profundal (standing water, basin)	CB,IB	LOW	loss of upper pool contiguous and isolated backwaters
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	loss of upper pool secondary channels
Lentic	CB	MED,HIGH,LOW	loss of upper pool contiguous and isolated backwaters
Fish			
Rheophil	MC,SC	MED,HIGH	loss of upper pool secondary channels
Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of upper pool SC and CB
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	loss of upper pool SC and CB
Limno-Rheophil	CB,SC,MC	LOW,MED	loss of upper pool SC and CB
Limnophil	CB, IB	LOW	loss of upper pool contiguous and isolated backwaters
Pelagic Limno-Rheophil	CB,SC,MC	LOW	loss of upper pool SC and CB
Amphibians and Reptiles			
Lentic	CB,IB	LOW	loss of upper pool contiguous and isolated backwaters
Lotic	MC,SC	LOW	loss of upper pool secondary channels
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	loss of upper pool contiguous and isolated backwaters
Dabbling Ducks, Geese and Swans	CB,IB	LOW	loss of upper pool contiguous and isolated backwaters

Pool 20 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	3,922		3,382		3,543	4.8%	3,543	0.0%		
	Lower	2,313		1,983		2,113	6.6%	2,113	0.0%		
Secondary channel	Upper	528		604		459	-24.0%	404	-12.0%		
	Lower	755		874		943	7.9%	943	0.0%		
Contiguous backwater area	Upper	77		59		89	50.8%	89	0.0%		
	Lower	23		29		10	-65.5%	10	0.0%		
Isolated backwater area	Upper	0		20		26	30.0%	20	-23.1%		
	Lower	7		18		13	-27.8%	7	-46.2%		
Island area	Upper	1,148		1,043		980	-6.0%	980	0.0%		
	Lower	760		904		927	2.5%	927	0.0%		
Island perimeter	Upper	151,100		138,750		124,900	-10.0%	124,900	0.0%		
	Lower	89,800		98,500		88,000	-10.7%	88,000	0.0%		
Island number	Upper	16		15		12	-20.0%				
	Lower	15		17		16	-5.9%				



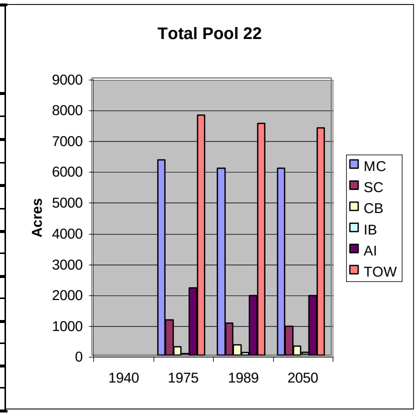
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	little change
Unrooted Submersed Aquatics	CB,IB	LOW	little change
Floating Perennials	CB,IB	LOW,MED	little change
Floating Annuals	CB,IB	LOW	little change
Emergent Perennials	CB,IB	LOW	little change
Emergent Annuals	CB,IB	LOW	little change
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	little change
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	little change
Lentic Limnetic (standing water)	CB,IB	LOW	little change
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	little change
Lentic Profundal (standing water, basin)	CB,IB	LOW	little change
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	little change
Lentic	CB	MED,HIGH,LOW	little change
Fish			
Rheophil	MC,SC	MED,HIGH	little change
Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Limno-Rheophil	CB,SC,MC	LOW,MED	little change
Limnophil	CB, IB	LOW	little change
Pelagic Limno-Rheophil	CB,SC,MC	LOW	little change
Amphibians and Reptiles			
Lentic	CB,IB	LOW	little change
Lotic	MC,SC	LOW	little change
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	little change
Dabbling Ducks, Geese and Swans	CB,IB	LOW	little change

Pool 21 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	2,876		2,513		2,475	-1.5%	2,401	-3.0%		
	Lower	1,980		1,909		1,923	0.7%	1,923	0.0%		
Secondary channel	Upper	2,242		1,779		1,614	-9.3%	1,291	-20.0%		
	Lower	26		0		40	NA	40	0.0%		
Contiguous backwater area	Upper	53		284		226	-20.4%	26	-88.5%		
	Lower	307		671		658	-1.9%	632	-4.0%		
Isolated backwater area	Upper	66		51		158	209.8%	148	-6.3%		
	Lower	110		24		24	0.0%	23	-4.2%		
Island area	Upper	4,720		4,403		5,856	33.0%	5,856	0.0%		
	Lower	298		539		338	-37.3%	338	0.0%		
Island perimeter	Upper	227,600		200,980		299,100	48.8%	299,100	0.0%		
	Lower	25,300		76,200		56,500	-25.9%	56,500	0.0%		
Island number	Upper	29		33		28	-15.2%				
	Lower	3		20		12	-40.0%				



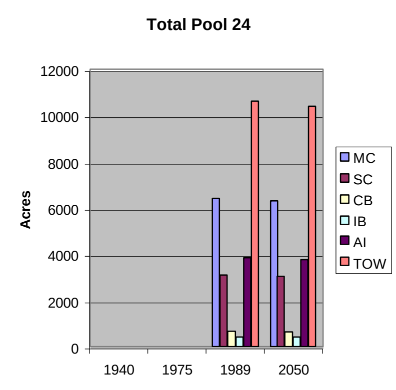
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	little change
Unrooted Submersed Aquatics	CB,IB	LOW	little change
Floating Perennials	CB,IB	LOW,MED	little change
Floating Annuals	CB,IB	LOW	little change
Emergent Perennials	CB,IB	LOW	little change
Emergent Annuals	CB,IB	LOW	little change
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	little change
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	little change
Lentic Limnetic (standing water)	CB,IB	LOW	little change
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	little change
Lentic Profundal (standing water, basin)	CB,IB	LOW	little change
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	little change
Lentic	CB	MED,HIGH,LOW	little change
Fish			
Rheophil	MC,SC	MED,HIGH	little change
Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Limno-Rheophil	CB,SC,MC	LOW,MED	little change
Limnophil	CB, IB	LOW	little change
Pelagic Limno-Rheophil	CB,SC,MC	LOW	little change
Amphibians and Reptiles			
Lentic	CB,IB	LOW	little change
Lotic	MC,SC	LOW	little change
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	little change
Dabbling Ducks, Geese and Swans	CB,IB	LOW	little change

Pool 22 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	4,040		3,646		3,607	-1.1%	3,607	0.0%		
	Lower	2,368		2,701		2,466	-8.7%	2,466	0.0%		
Secondary channel	Upper	1,223		895		610	-31.8%	519	-14.9%		
	Lower	408		257		425	65.4%	425	0.0%		
Contiguous backwater area	Upper	114		159		205	28.9%	164	-20.0%		
	Lower	0		105		135	28.6%	122	-9.6%		
Isolated backwater area	Upper	9		19		56	194.7%	45	-19.6%		
	Lower	0		8		26	225.0%	23	-11.5%		
Island area	Upper	2,287		1,897		1,630	-14.1%	1,630	0.0%		
	Lower	248		293		294	0.3%	294	0.0%		
Island perimeter	Upper	202,500		200,750		168,200	-16.2%	168,200	0.0%		
	Lower	42,750		60,000		76,700	27.8%	76,700	0.0%		
Island number	Upper	26		30		18	-40.0%				
	Lower	7		9		17	88.9%				



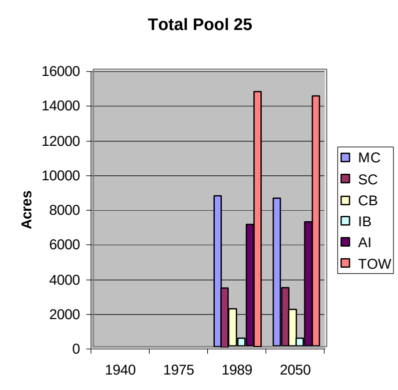
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	little change
Unrooted Submersed Aquatics	CB,IB	LOW	little change
Floating Perennials	CB,IB	LOW,MED	little change
Floating Annuals	CB,IB	LOW	little change
Emergent Perennials	CB,IB	LOW	little change
Emergent Annuals	CB,IB	LOW	little change
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	little change
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	little change
Lentic Limnetic (standing water)	CB,IB	LOW	little change
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	little change
Lentic Profundal (standing water, basin)	CB,IB	LOW	little change
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	little change
Lentic	CB	MED,HIGH,LOW	little change
Fish			
Rheophil	MC,SC	MED,HIGH	little change
Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Limno-Rheophil	CB,SC,MC	LOW,MED	little change
Limnophil	CB, IB	LOW	little change
Pelagic Limno-Rheophil	CB,SC,MC	LOW	little change
Amphibians and Reptiles			
Lentic	CB,IB	LOW	little change
Lotic	MC,SC	LOW	little change
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	little change
Dabbling Ducks, Geese and Swans	CB,IB	LOW	little change

Pool 24 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	4,264				4,098		4,016	-2.0%		
	Lower	2,184				2,322		2,299	-1.0%		
Secondary channel	Upper	2,529				1,667		1,634	-2.0%		
	Lower	1,130				1,440		1,411	-2.0%		
Contiguous backwater area	Upper	187				340		323	-5.0%		
	Lower	38				323		307	-5.0%		
Isolated backwater area	Upper	16				348		331	-4.9%		
	Lower	29				76		72	-5.3%		
Island area	Upper	2,612				3,089		3,027	-2.0%		
	Lower	876				766		728	-5.0%		
Island perimeter	Upper	265,900				269,200		266,508	-1.0%		
	Lower	93,800				174,750		178,245	2.0%		
Island number	Upper	38				42					
	Lower	15				25					



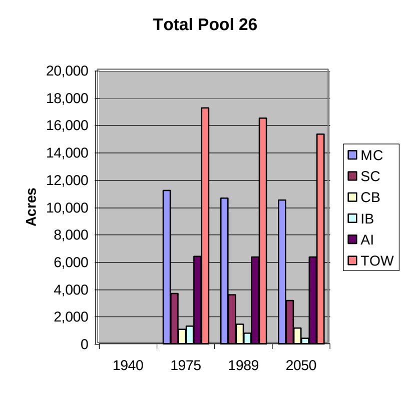
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	
Unrooted Submersed Aquatics	CB,IB	LOW	
Floating Perennials	CB,IB	LOW,MED	
Floating Annuals	CB,IB	LOW	
Emergent Perennials	CB,IB	LOW	
Emergent Annuals	CB,IB	LOW	
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	
Lentic Limnetic (standing water)	CB,IB	LOW	
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	
Lentic Profundal (standing water, basin)	CB,IB	LOW	
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	
Lentic	CB	MED,HIGH,LOW	
Fish			
Rheophil	MC,SC	MED,HIGH	
Rheo-Limnophil	MC,SC,CB	MED,LOW	
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	
Limno-Rheophil	CB,SC,MC	LOW,MED	
Limnophil	CB, IB	LOW	
Pelagic Limno-Rheophil	CB,SC,MC	LOW	
Amphibians and Reptiles			
Lentic	CB,IB	LOW	
Lotic	MC,SC	LOW	
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	
Dabbling Ducks, Geese and Swans	CB,IB	LOW	

Pool 25 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	5,958				5,278		5,172	-2.0%		
	Lower	2,674				3,415		3,347	-2.0%		
Secondary channel	Upper	3,155				2,869		2,811	-2.0%		
	Lower	712				548		537	-2.0%		
Contiguous backwater area	Upper	174				423		415	-1.9%		
	Lower	57				1,721		1,687	-2.0%		
Isolated backwater area	Upper	220				399		379	-5.0%		
	Lower	148				60		57	-5.0%		
Island area	Upper	4,786				5,638		5,751	2.0%		
	Lower	1,249				1,373		1,400	2.0%		
Island perimeter	Upper	374,500				464,300		468,943	1.0%		
	Lower	113,500				306,160		309,222	1.0%		
Island number	Upper	51				63					
	Lower	14				52					



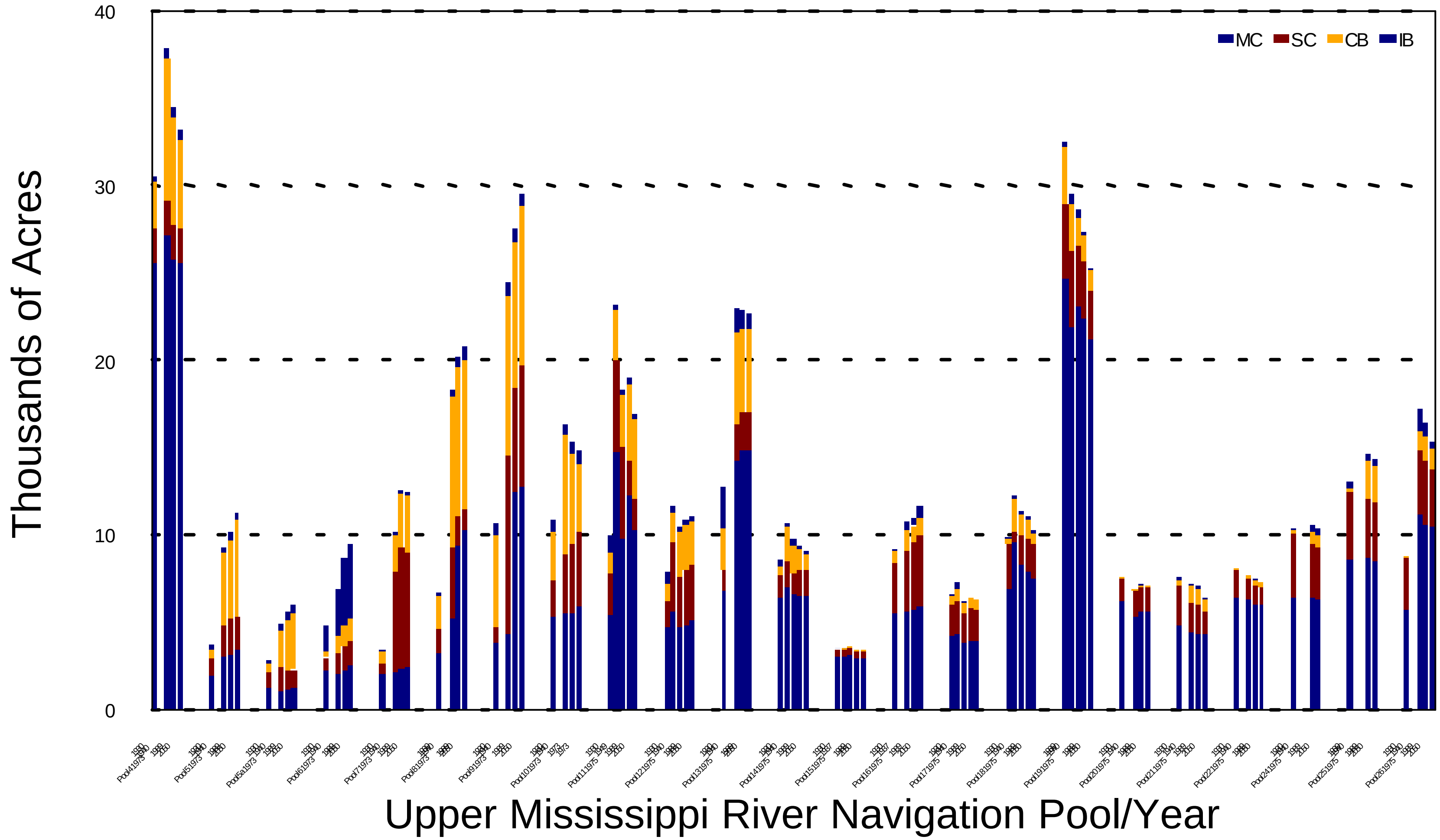
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	
Unrooted Submersed Aquatics	CB,IB	LOW	
Floating Perennials	CB,IB	LOW,MED	
Floating Annuals	CB,IB	LOW	
Emergent Perennials	CB,IB	LOW	
Emergent Annuals	CB,IB	LOW	
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	
Lentic Limnetic (standing water)	CB,IB	LOW	
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	
Lentic Profundal (standing water, basin)	CB,IB	LOW	
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	
Lentic	CB	MED,HIGH,LOW	
Fish			
Rheophil	MC,SC	MED,HIGH	
Rheo-Limnophil	MC,SC,CB	MED,LOW	
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	
Limno-Rheophil	CB,SC,MC	LOW,MED	
Limnophil	CB, IB	LOW	
Pelagic Limno-Rheophil	CB,SC,MC	LOW	
Amphibians and Reptiles			
Lentic	CB,IB	LOW	
Lotic	MC,SC	LOW	
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	
Dabbling Ducks, Geese and Swans	CB,IB	LOW	

Pool 26 Aquatic areas	Within Pool	Pre-dam (1930) (acre)	Post-Dam (1940's) (acre) (1)	Recent year ('73) (acre) (2)	Percent change % (1) to (2)	Present year (1989) (acre) (3)	Percent change % (2) to (3)	Future 2050 (acre) (4)	Percent change % (3) to (4)	Percent change % (1) to (3)	Percent change % (1) to (4)
Main channel area	Upper	5,722		5,587		5,245	-6.1%	5,140	-2.0%		
	Lower			5,631		5,422	-3.7%	5,422	0.0%		
Secondary channel	Upper	2,962		2,890		2,695	-6.7%	2,291	-15.0%		
	Lower			787		894	13.6%	894	0.0%		
Contiguous backwater area	Upper	124		350		402	14.9%	362	-10.0%		
	Lower			731		1,038	42.0%	830	-20.0%		
Isolated backwater area	Upper	18		654		514	-21.4%	272	-47.1%		
	Lower			644		305	-52.6%	162	-46.9%		
Island area	Upper	4,908		5,104		5,268	3.2%	5,268	0.0%		
	Lower			1,303		1,118	-14.2%	1,118	0.0%		
Island perimeter	Upper	350,900		422,300		385,500	-8.7%	385,500	0.0%		
	Lower			181,600		208,000	14.5%	208,000	0.0%		
Island number	Upper	43		44		40	-9.1%				
	Lower			18		20	11.1%				



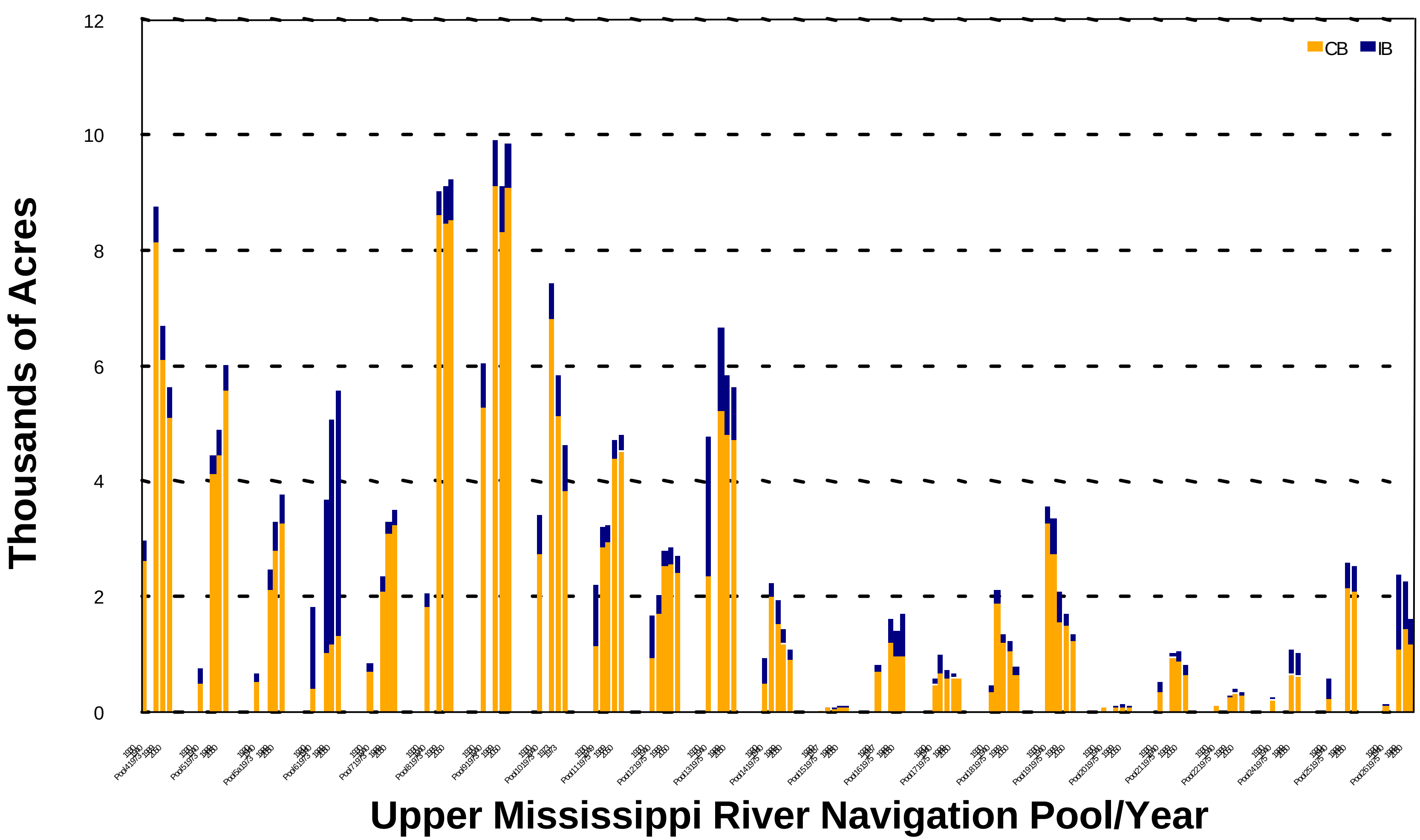
Biological Community/Guild	Habitat Requirements	Velocity Preference	Impact of change
Aquatic Plants			
Rooted Submersed Aquatics	MC,SC,CB,IB	LOW, MED	little change
Unrooted Submersed Aquatics	CB,IB	LOW	little change
Floating Perennials	CB,IB	LOW,MED	little change
Floating Annuals	CB,IB	LOW	little change
Emergent Perennials	CB,IB	LOW	little change
Emergent Annuals	CB,IB	LOW	little change
Macroinvertebrates			
Lotic-Erosional (running-water riffles)	MC,SC	MED,HIGH	little change
Lotic Depositional (running-water pools and margins)	MC,SC	LOW	little change
Lentic Limnetic (standing water)	CB,IB	LOW	little change
Lentic-Littoral (standing water, shallow shore area)	CB,IB	LOW	little change
Lentic Profundal (standing water, basin)	CB,IB	LOW	little change
Freshwater Mussels			
Lotic	MC,SC	MED,HIGH,LOW	little change
Lentic	CB	MED,HIGH,LOW	little change
Fish			
Rheophil	MC,SC	MED,HIGH	little change
Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Pelagic Rheo-Limnophil	MC,SC,CB	MED,LOW	little change
Limno-Rheophil	CB,SC,MC	LOW,MED	little change
Limnophil	CB, IB	LOW	loss of isolated backwaters
Pelagic Limno-Rheophil	CB,SC,MC	LOW	little change
Amphibians and Reptiles			
Lentic	CB,IB	LOW	little change
Lotic	MC,SC	LOW	little change
Waterfowl			
Diving Ducks	MC,SC,CB	MED,LOW	little change
Dabbling Ducks, Geese and Swans	CB,IB	LOW	little change

Rooted Submersed Aquatic Plant Habitat



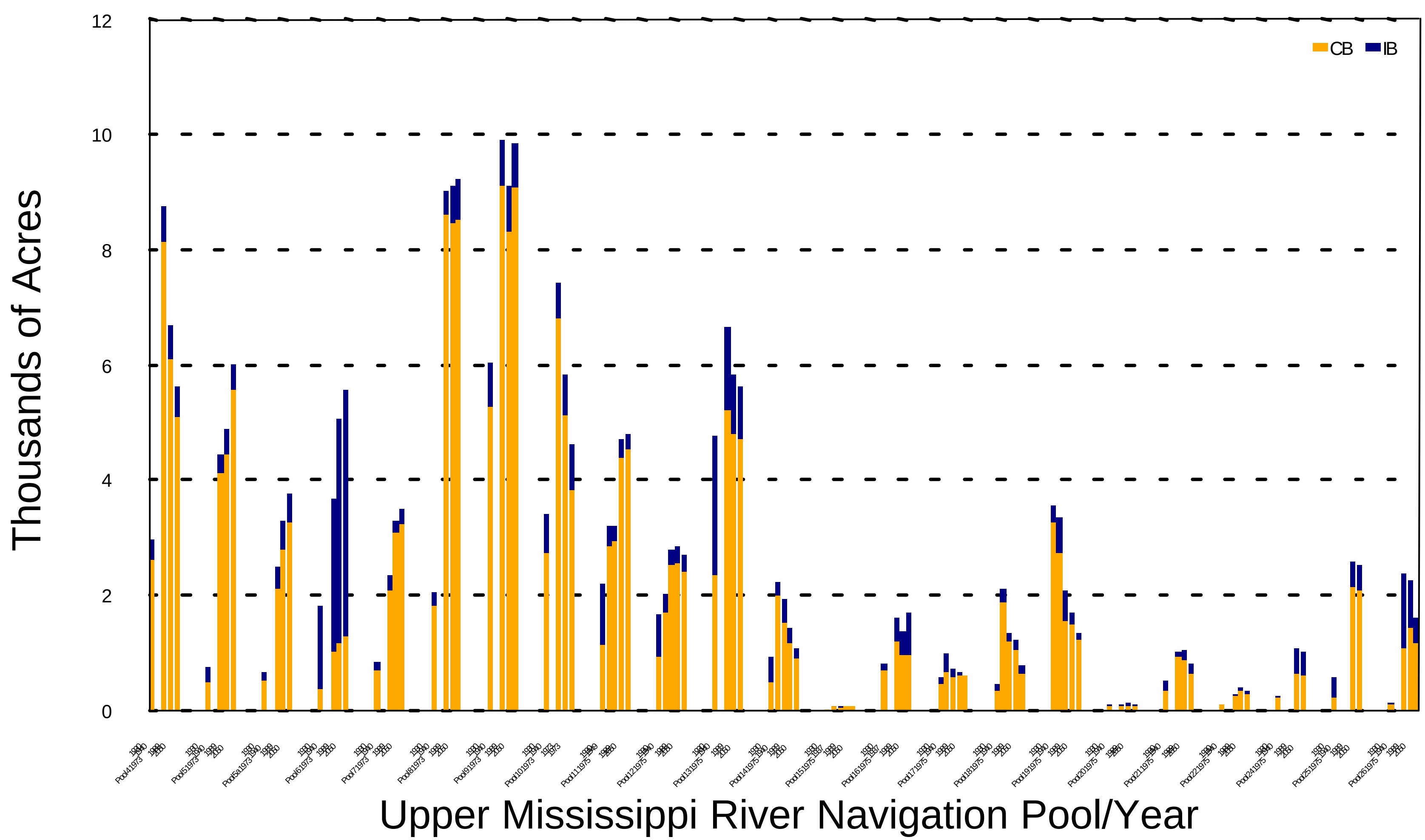
X-axis order is years: 1930, 1940, 173/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Un-Rooted Submersed Aquatic Plant Habitat



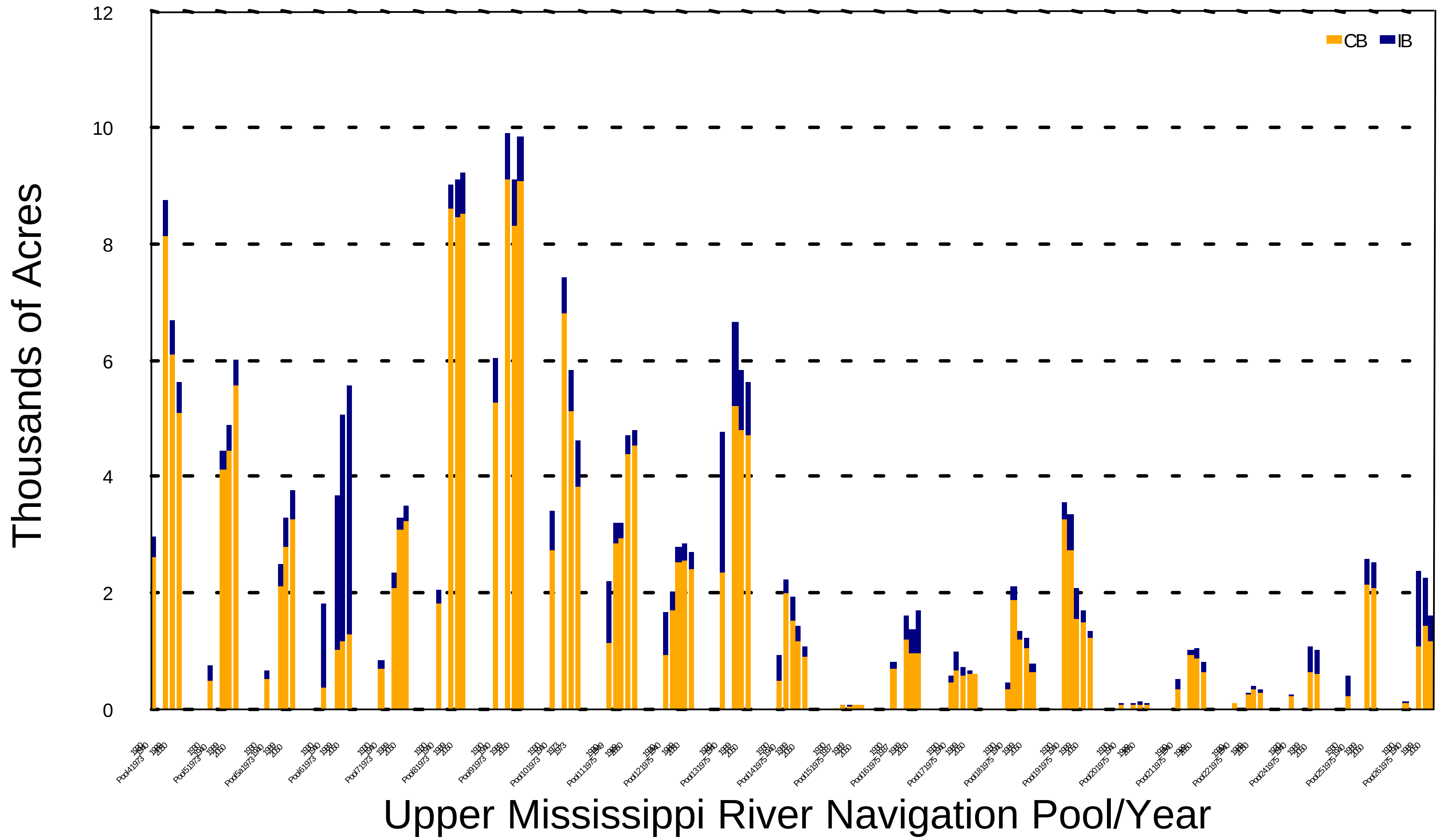
X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Floating Leaved Perennial Aquatic Plant Habitat



X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

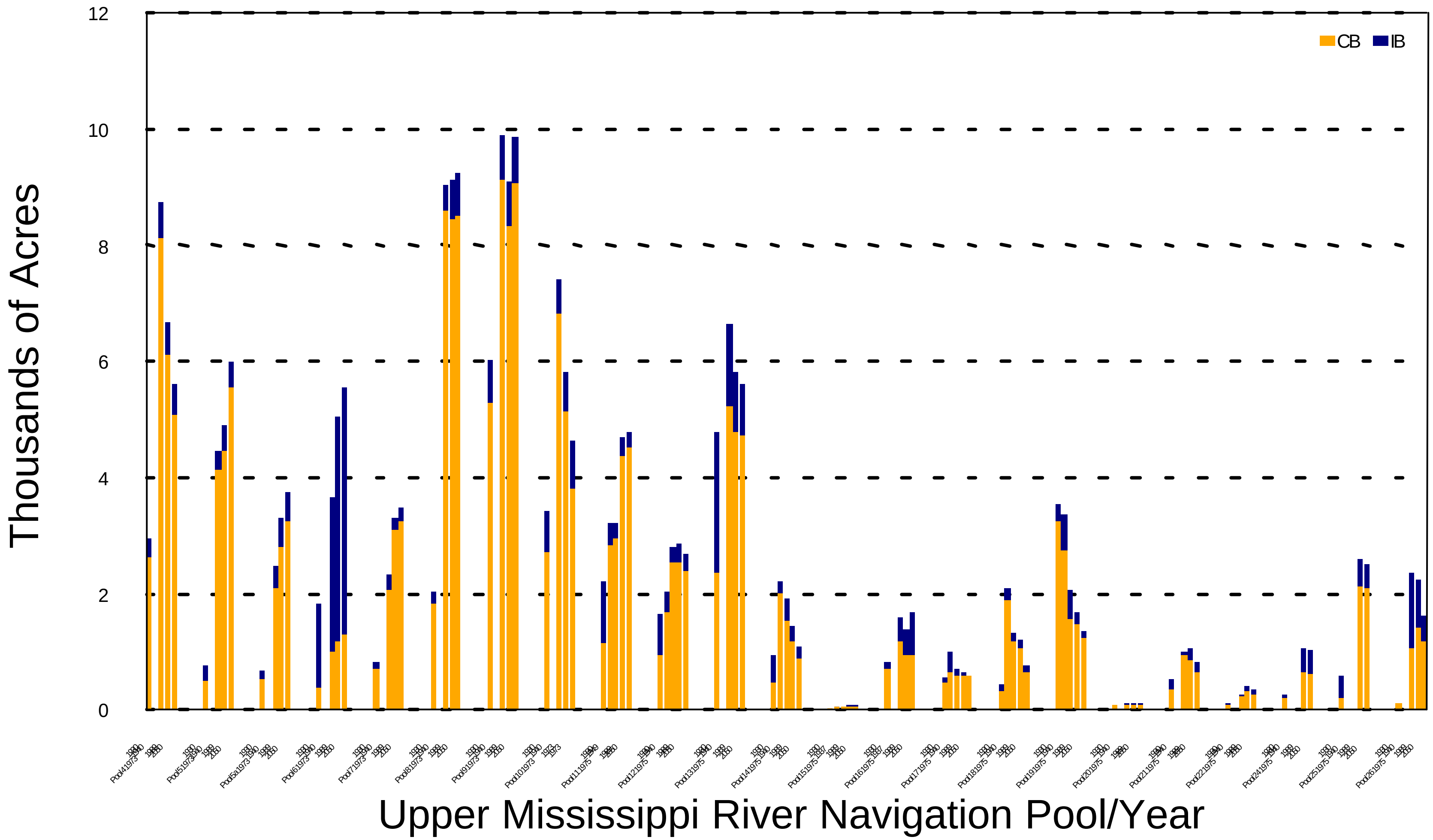
Floating Leaved Annual Aquatic Plant Habitat



T-4

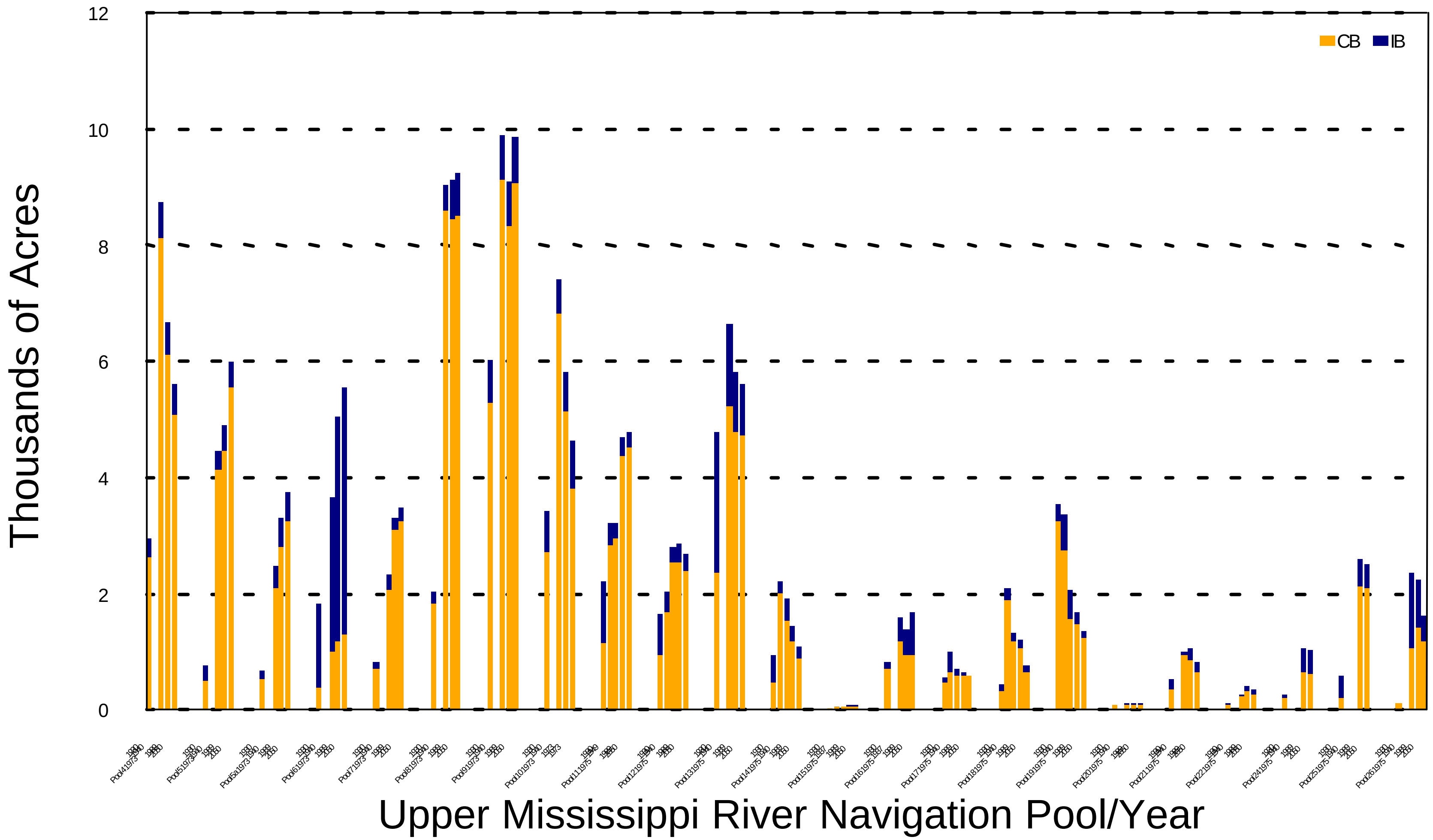
X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Perennial Emergent Aquatic Plant Habitat



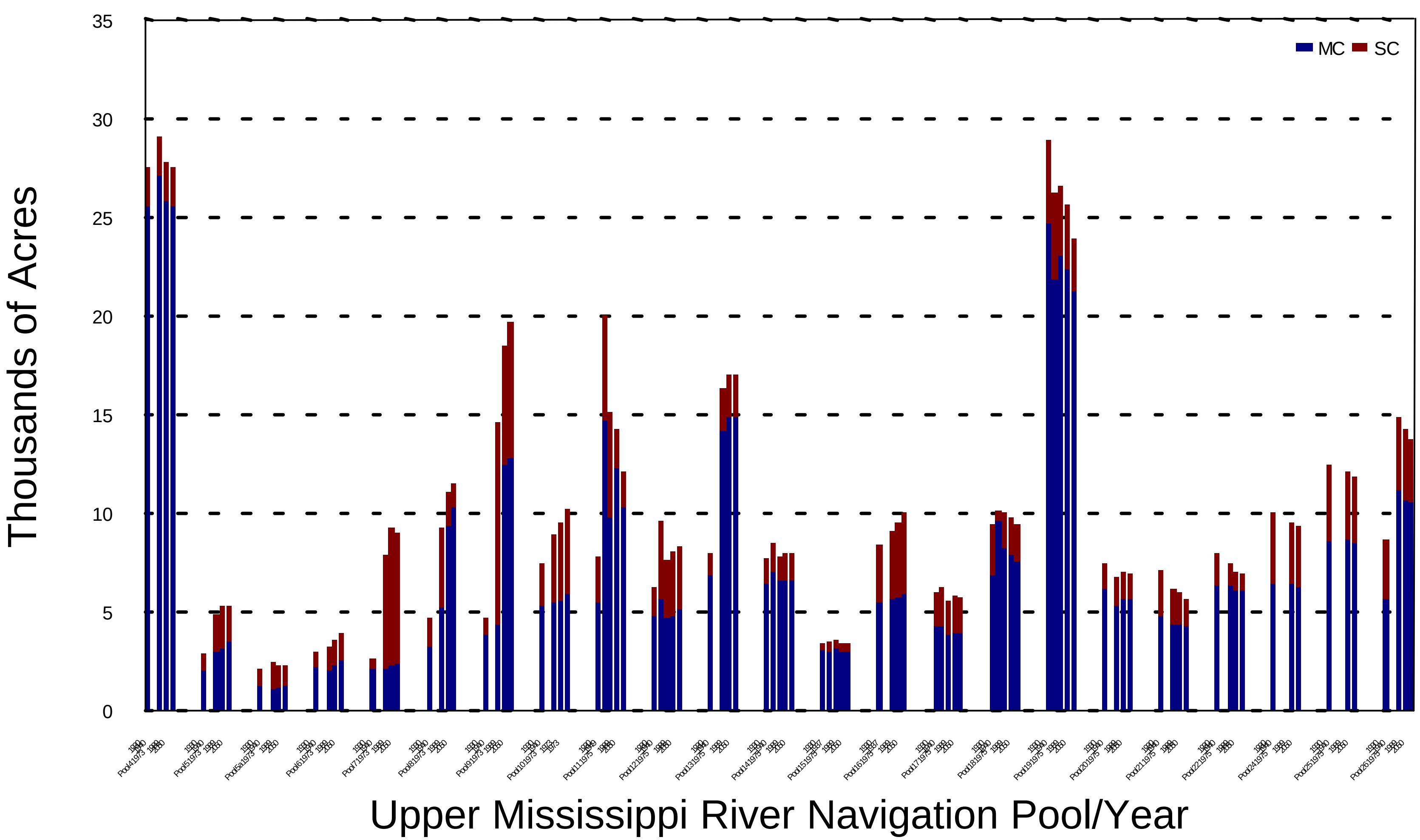
X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Annual Emergent Aquatic Plant Habitat



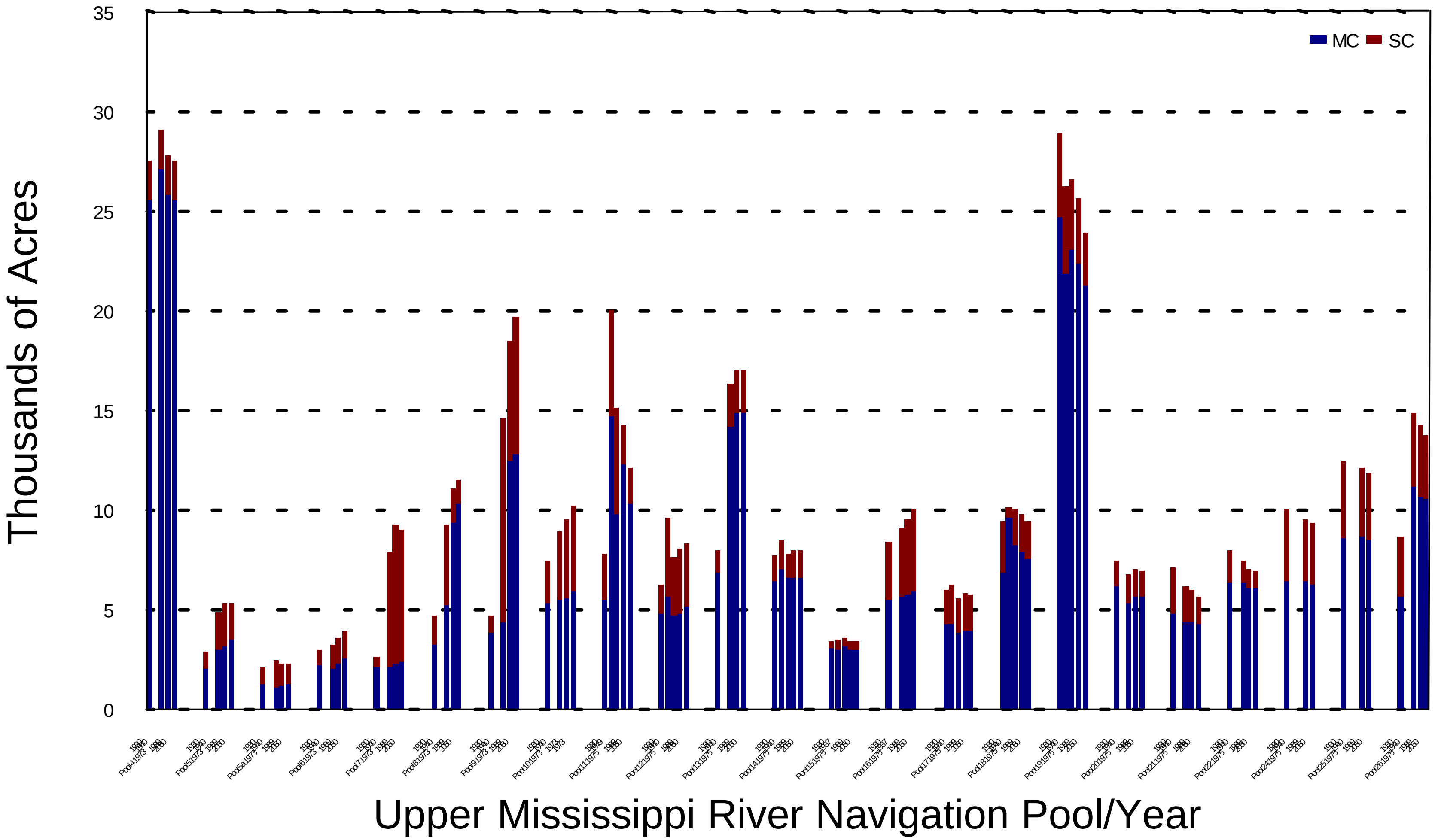
X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Lotic Erosional Macroinvertebrate Habitat



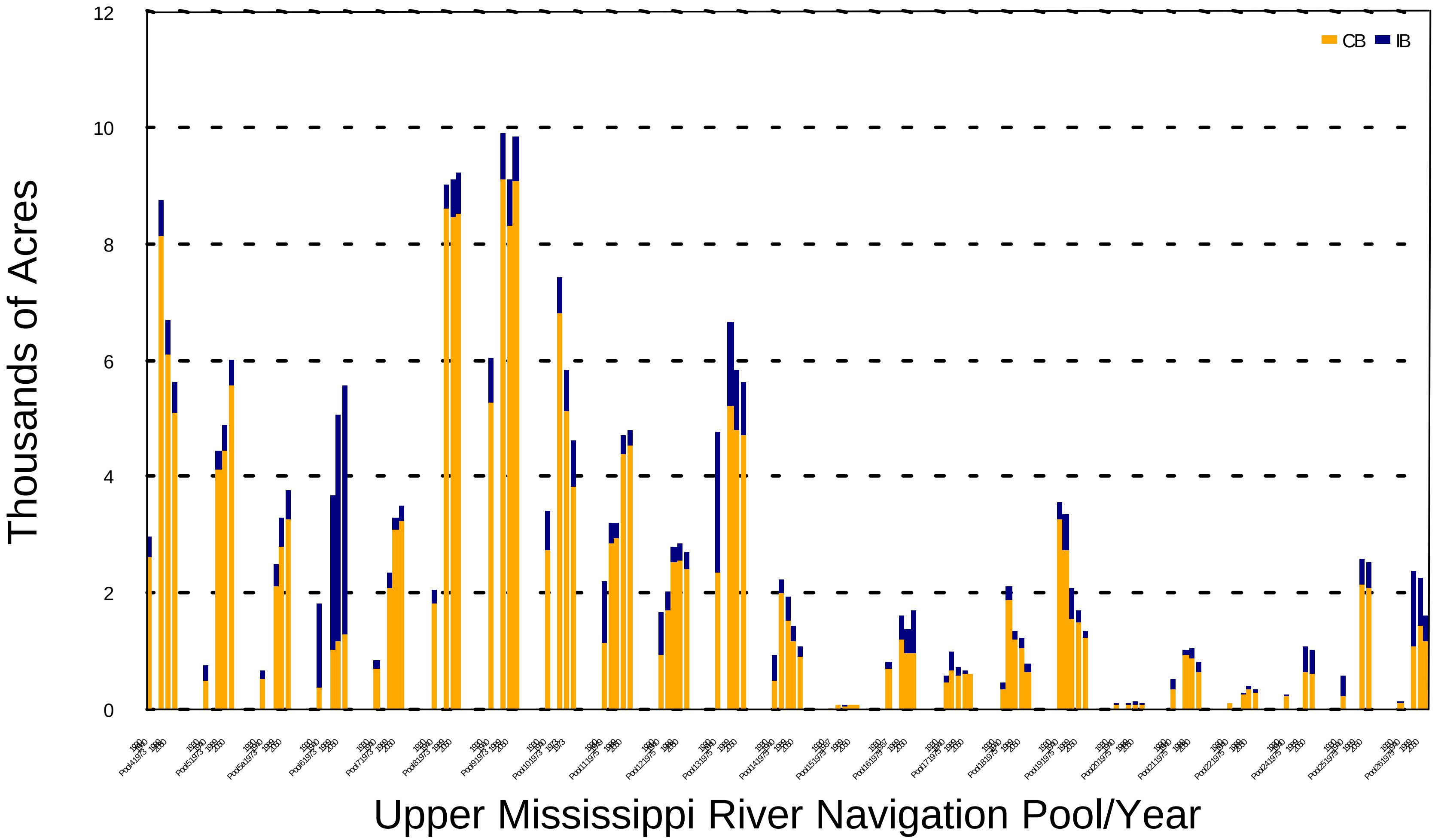
X-axis order is years: 1930, 1940, 197375, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Lotic Depositional Macroinvertebrate Habitat



X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

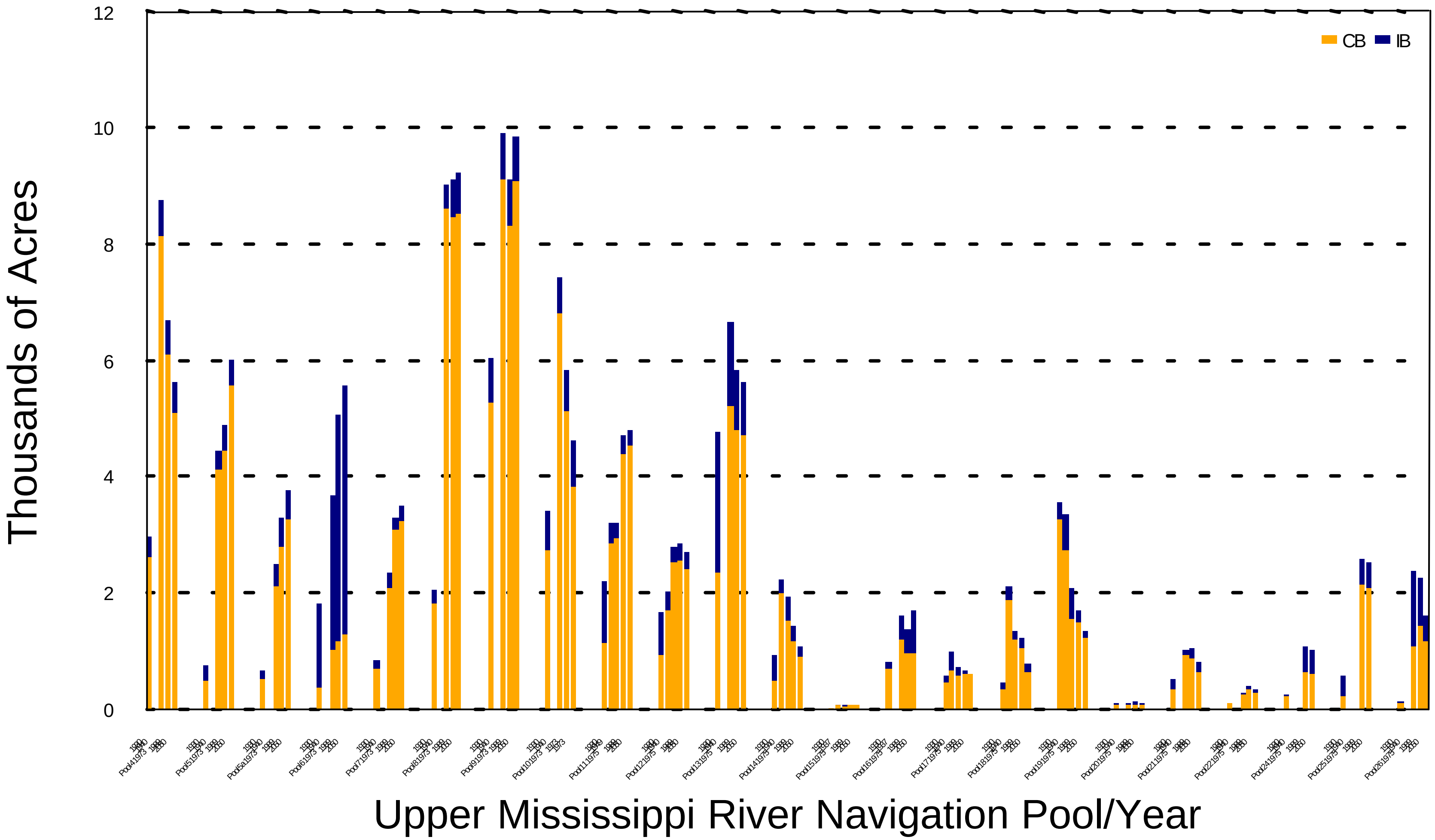
Lentic Limnetic Macroinvertebrate Habitat



X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.

MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

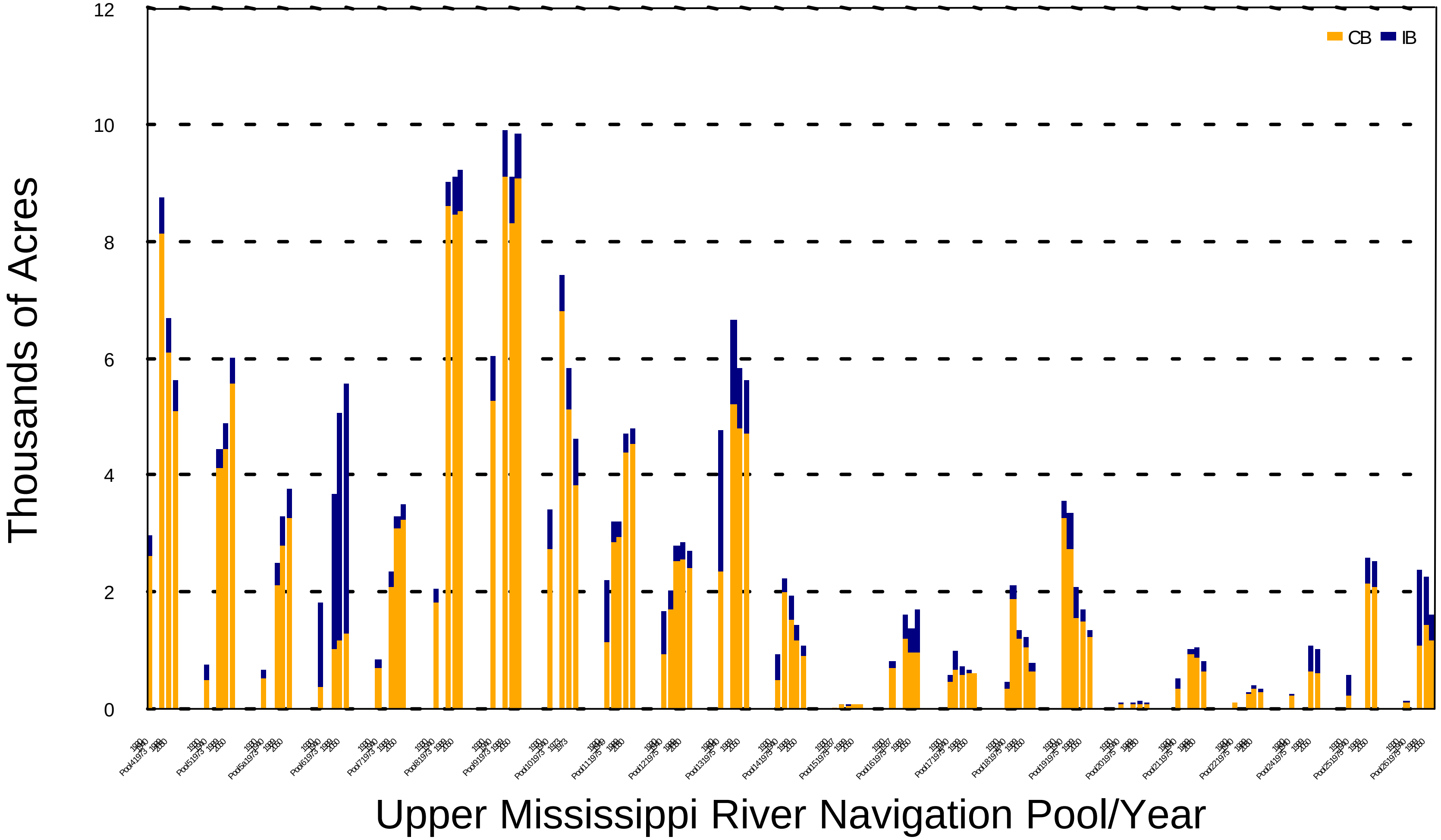
Lentic Littoral Macroinvertebrate Habitat



T-10

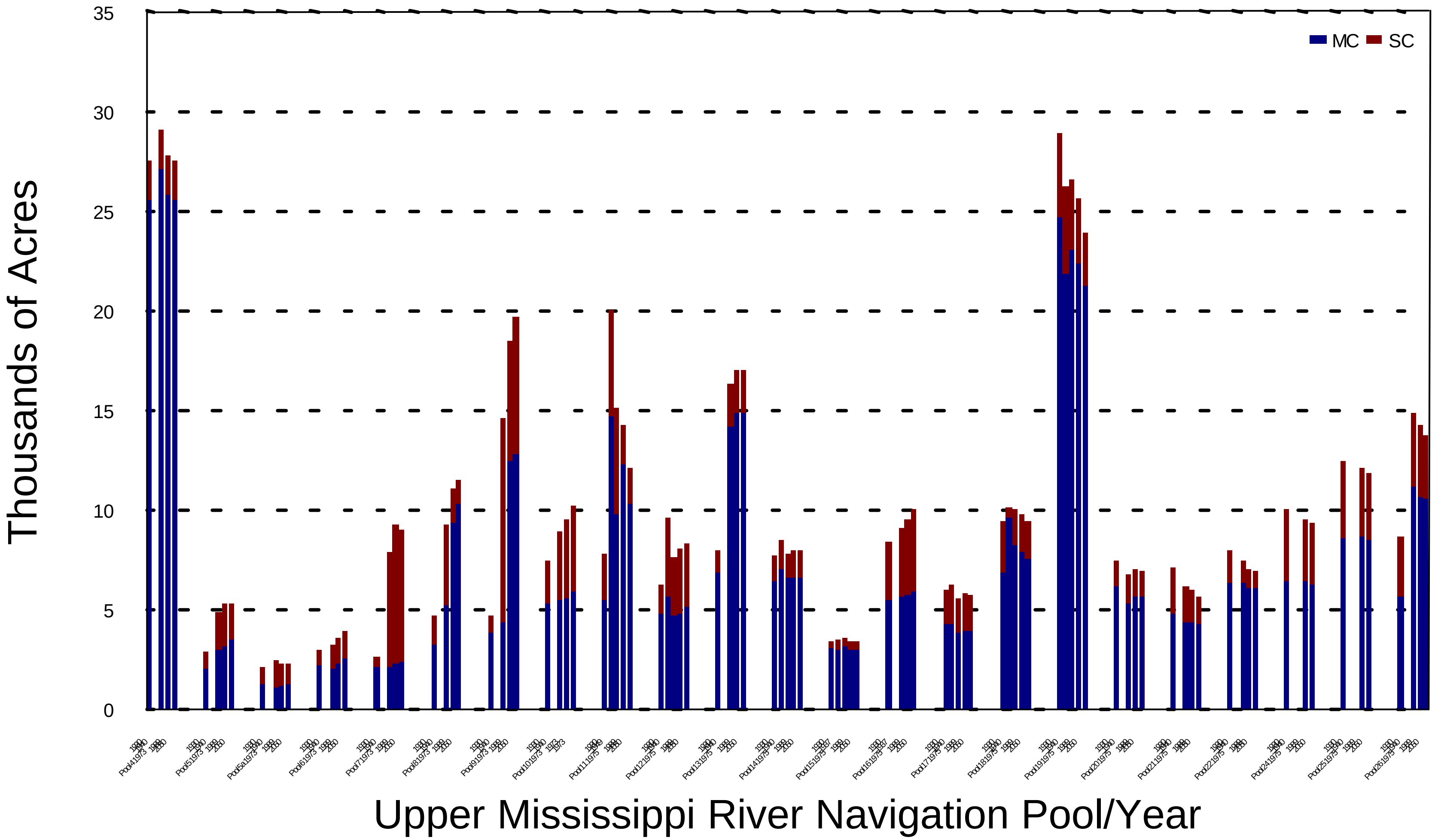
X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Lentic Profundal Macroinvertebrate Habitat



X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

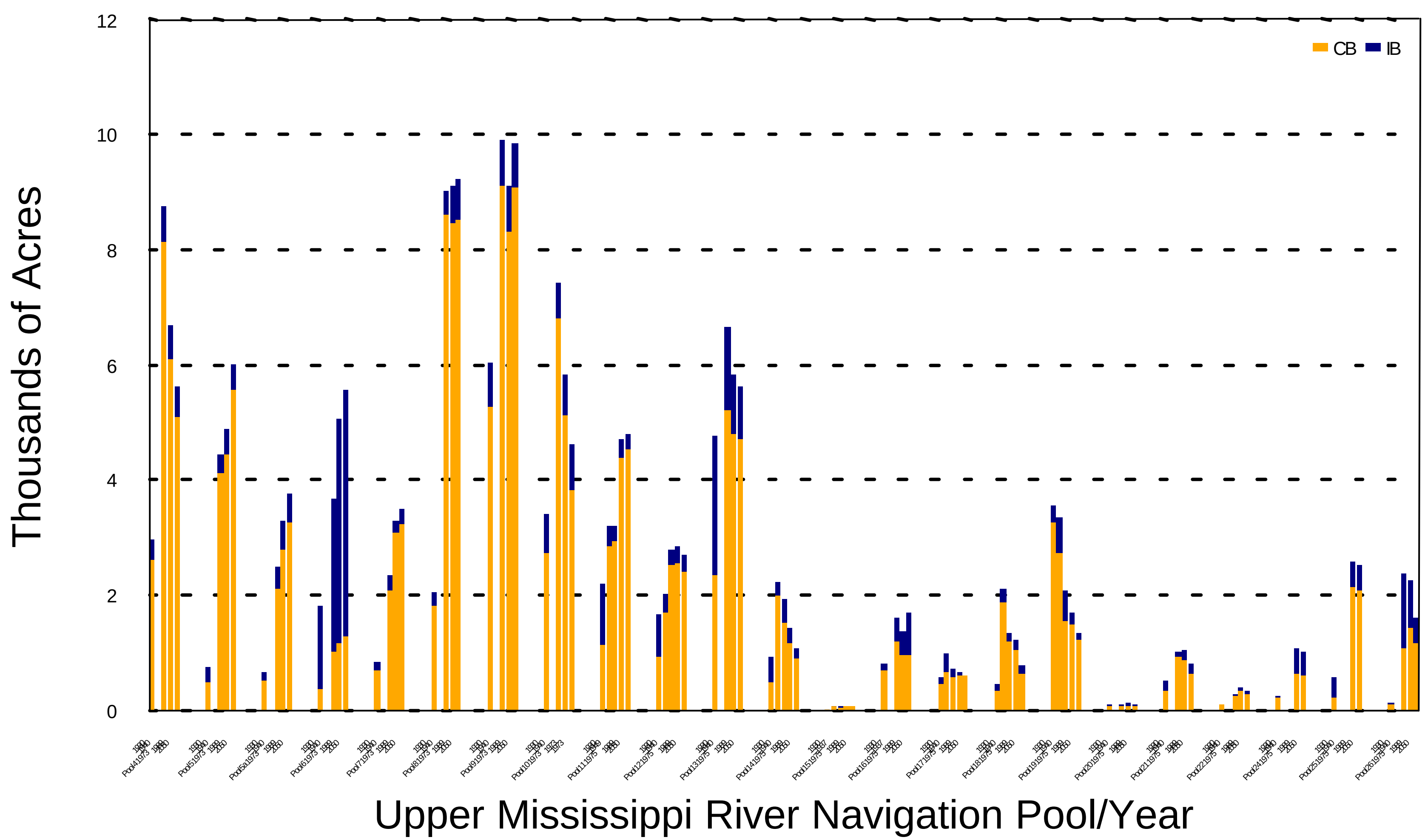
Lotic Mussel Habitat



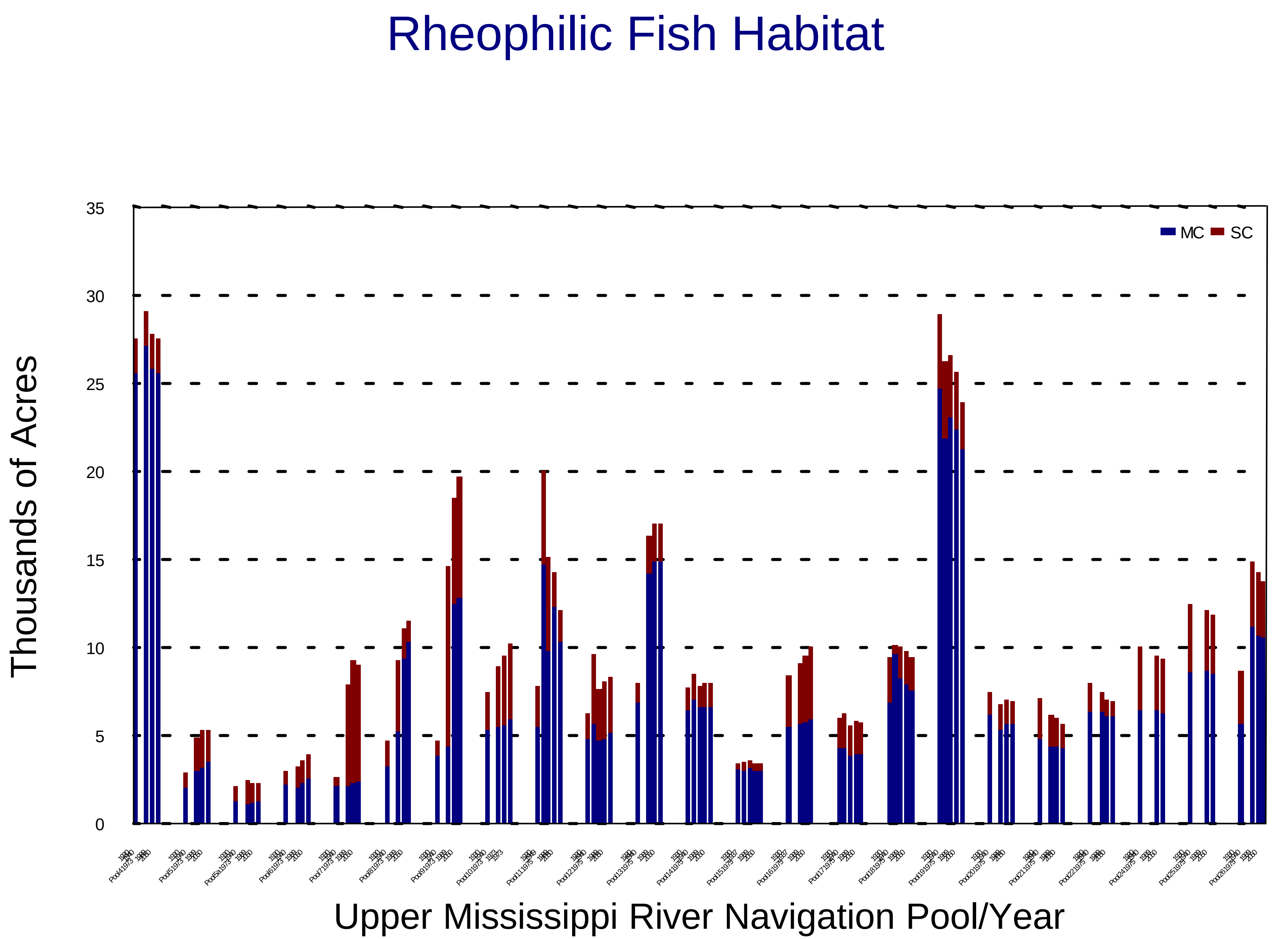
T-12

X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Lentic Mussel Habitat

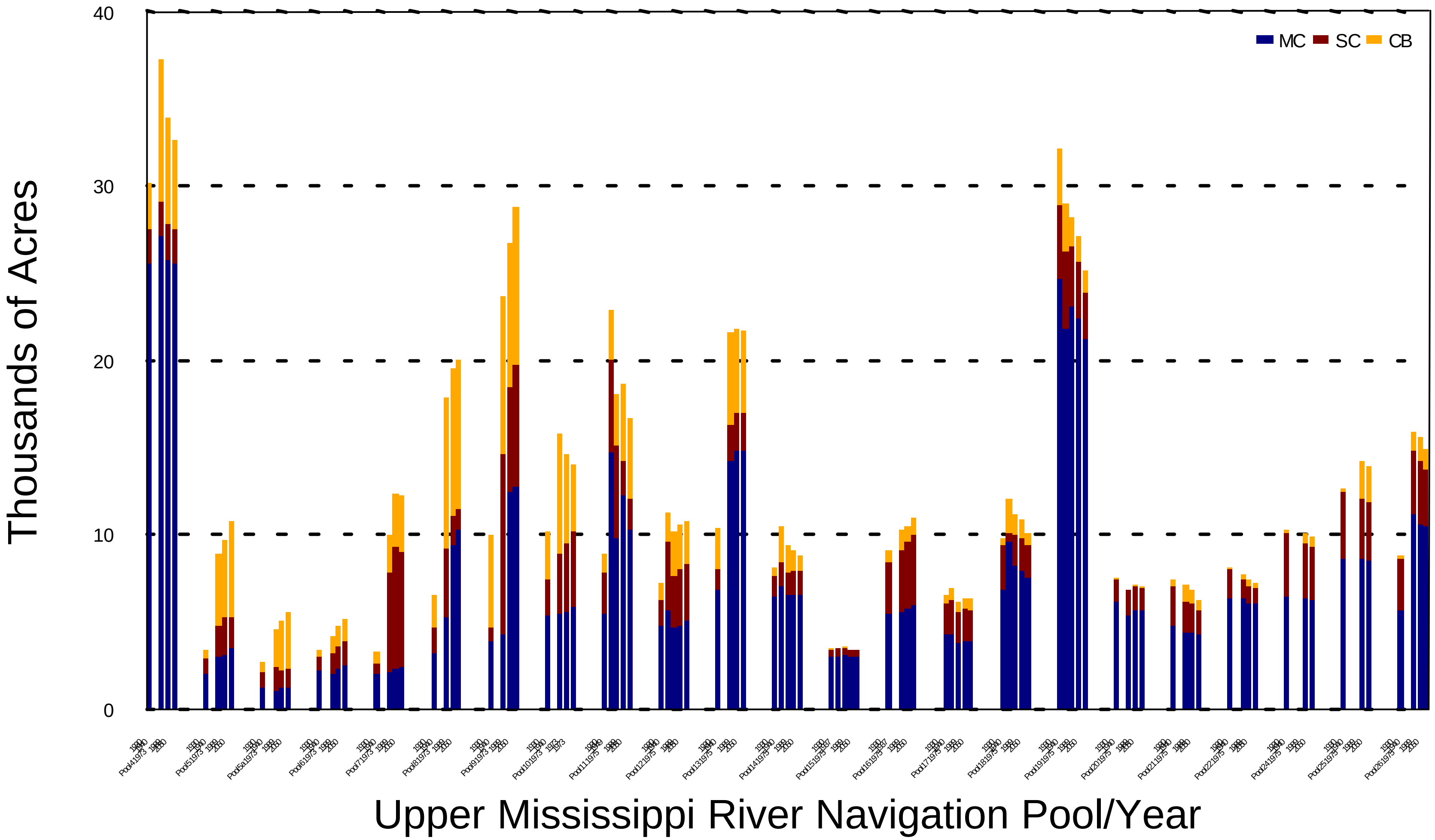


X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.



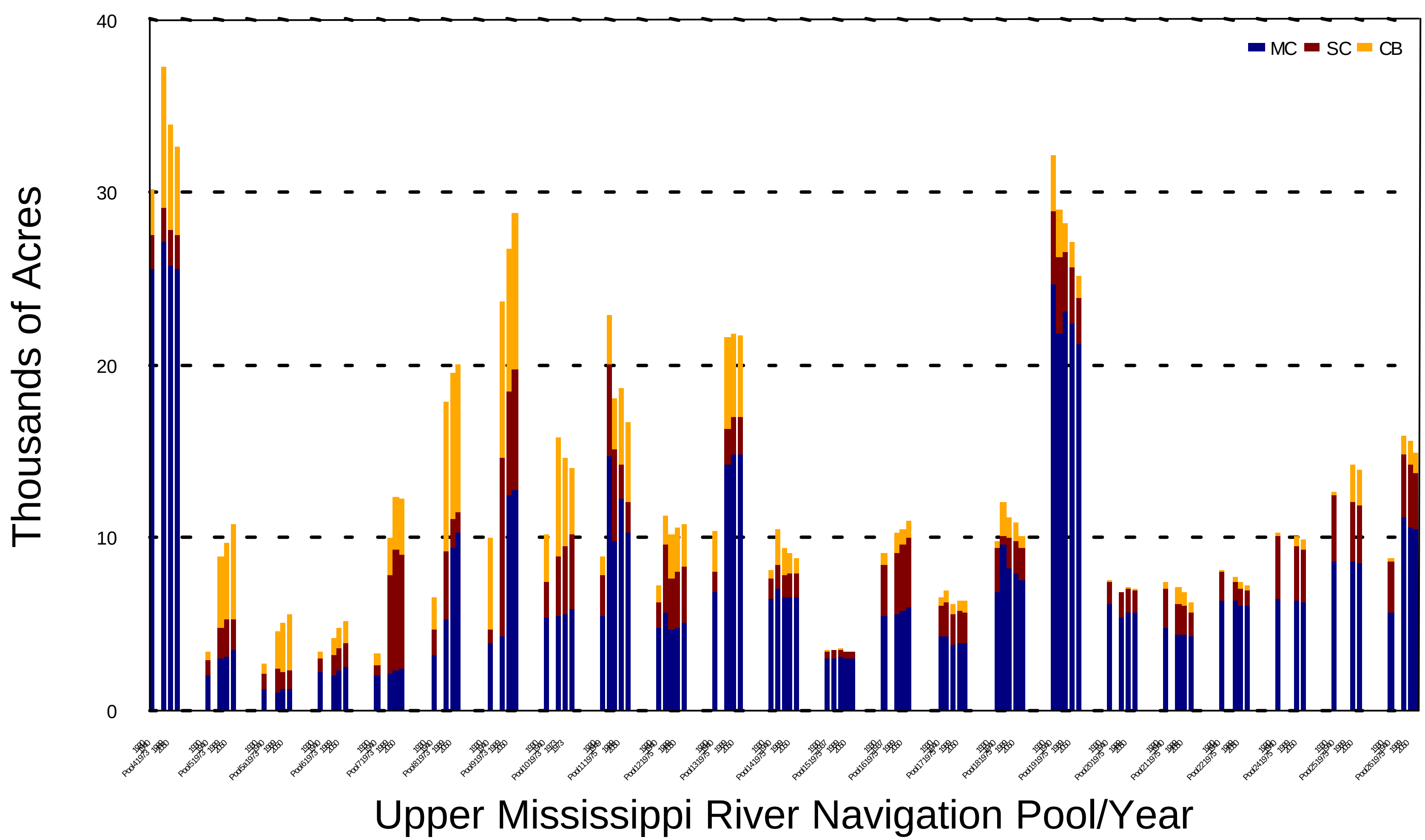
X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Rheo-Limnophilic Fish Habitat



X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

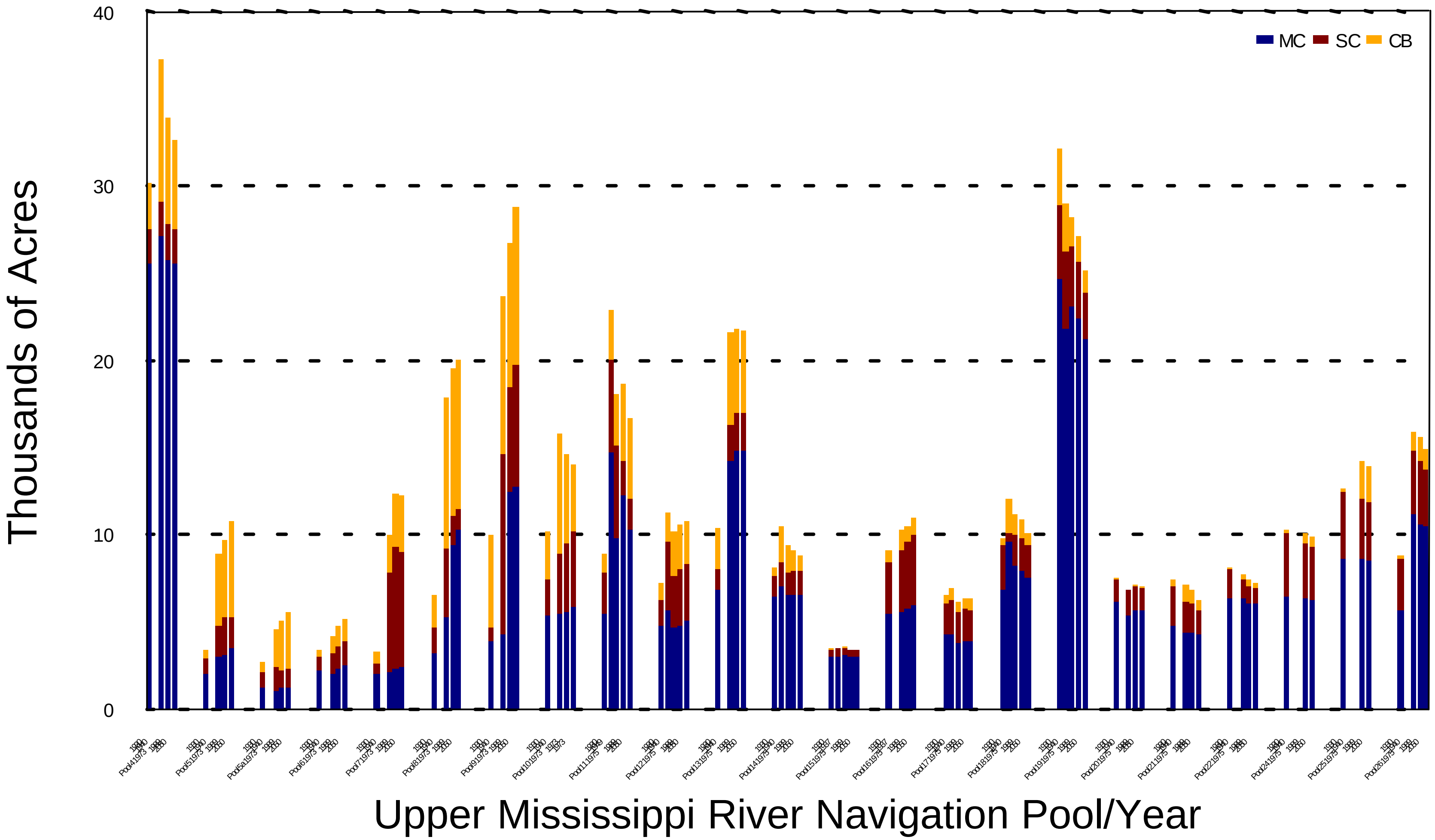
Pelagic Rheo-Limnophilic Fish Habitat



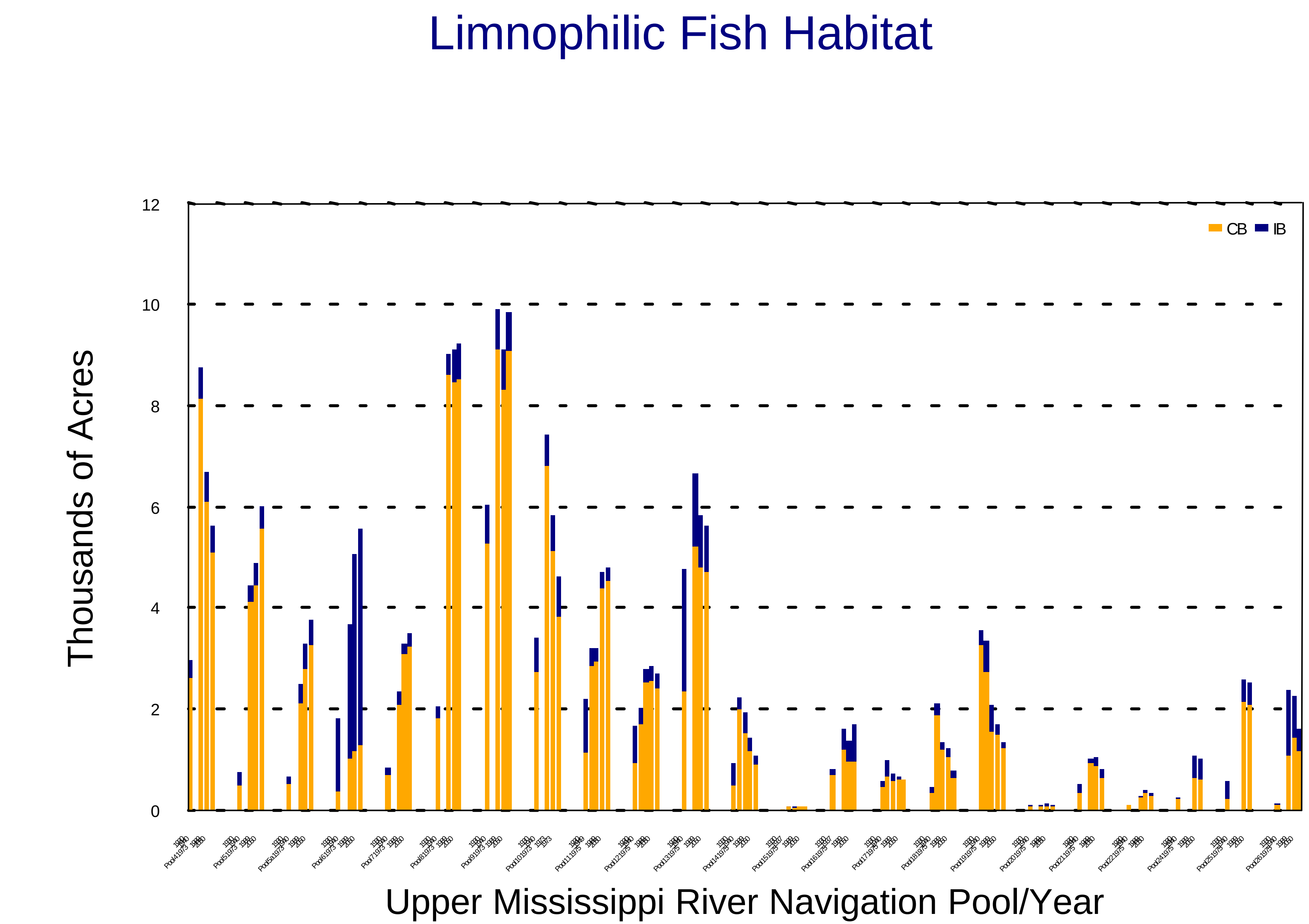
X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.

MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Limno-Rheophilic Fish Habitat

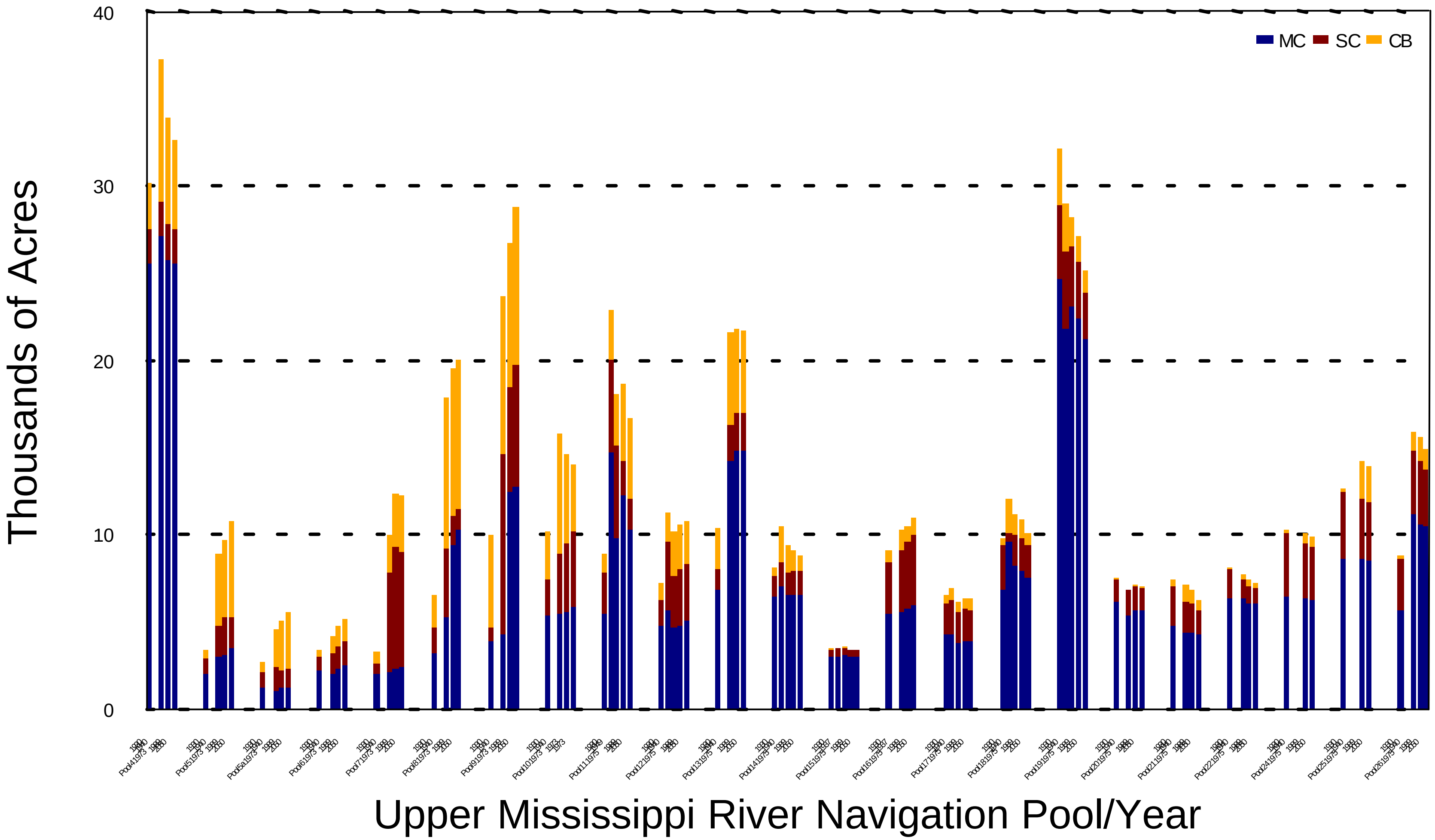


X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.



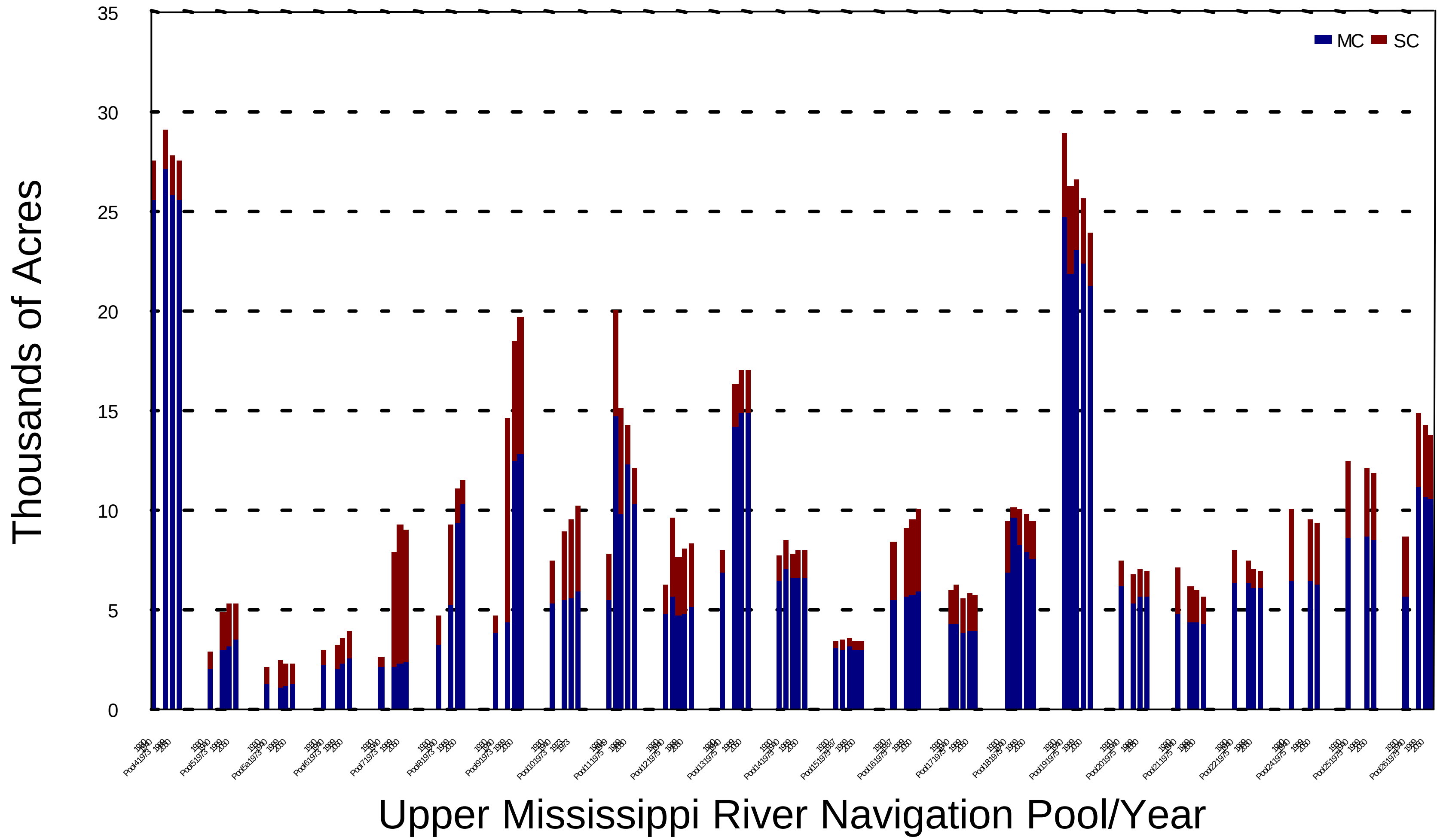
X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Pelagic Limno-Rheophilic Fish Habitat



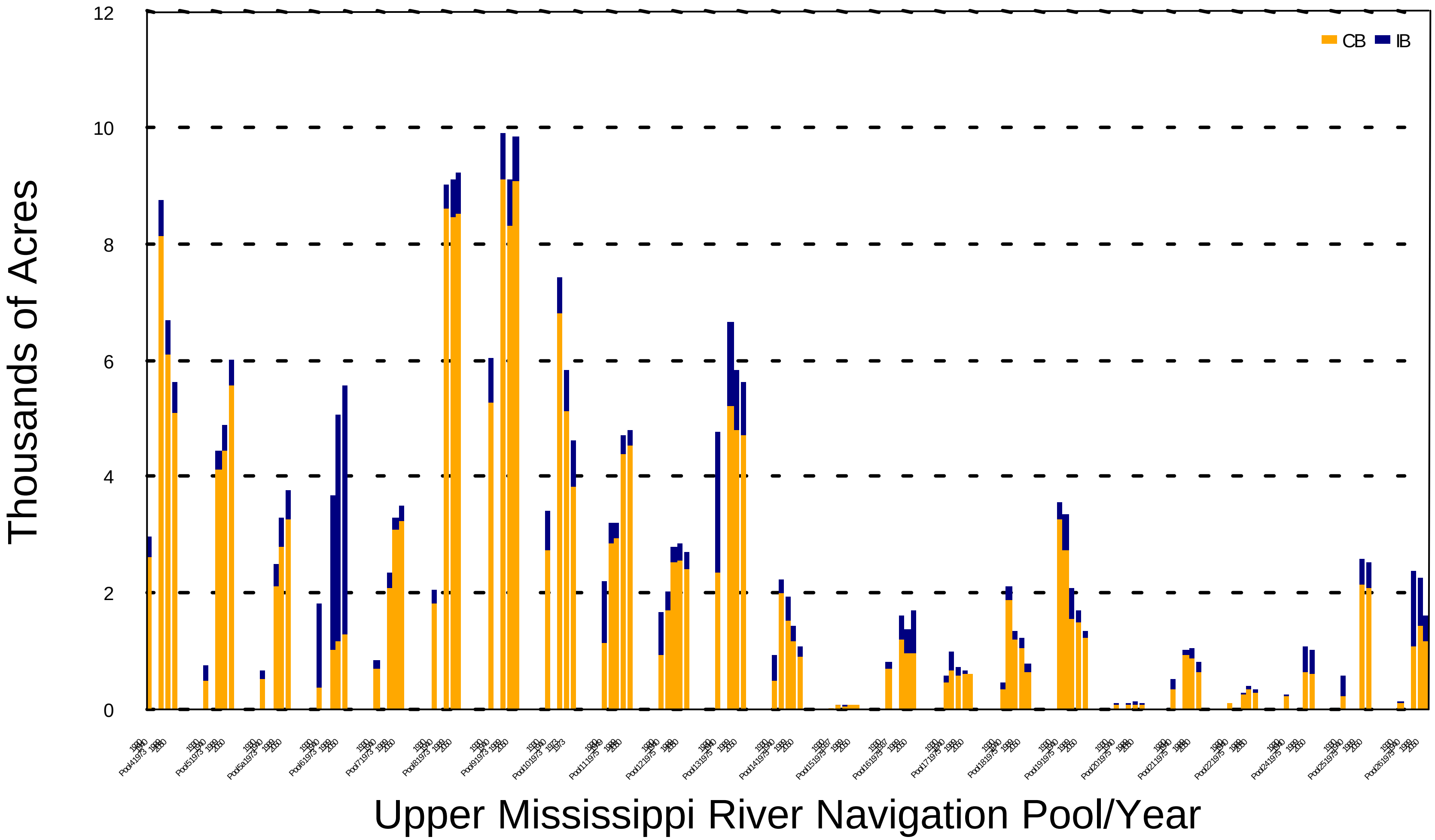
X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Lotic Amphibian and Reptile Habitat



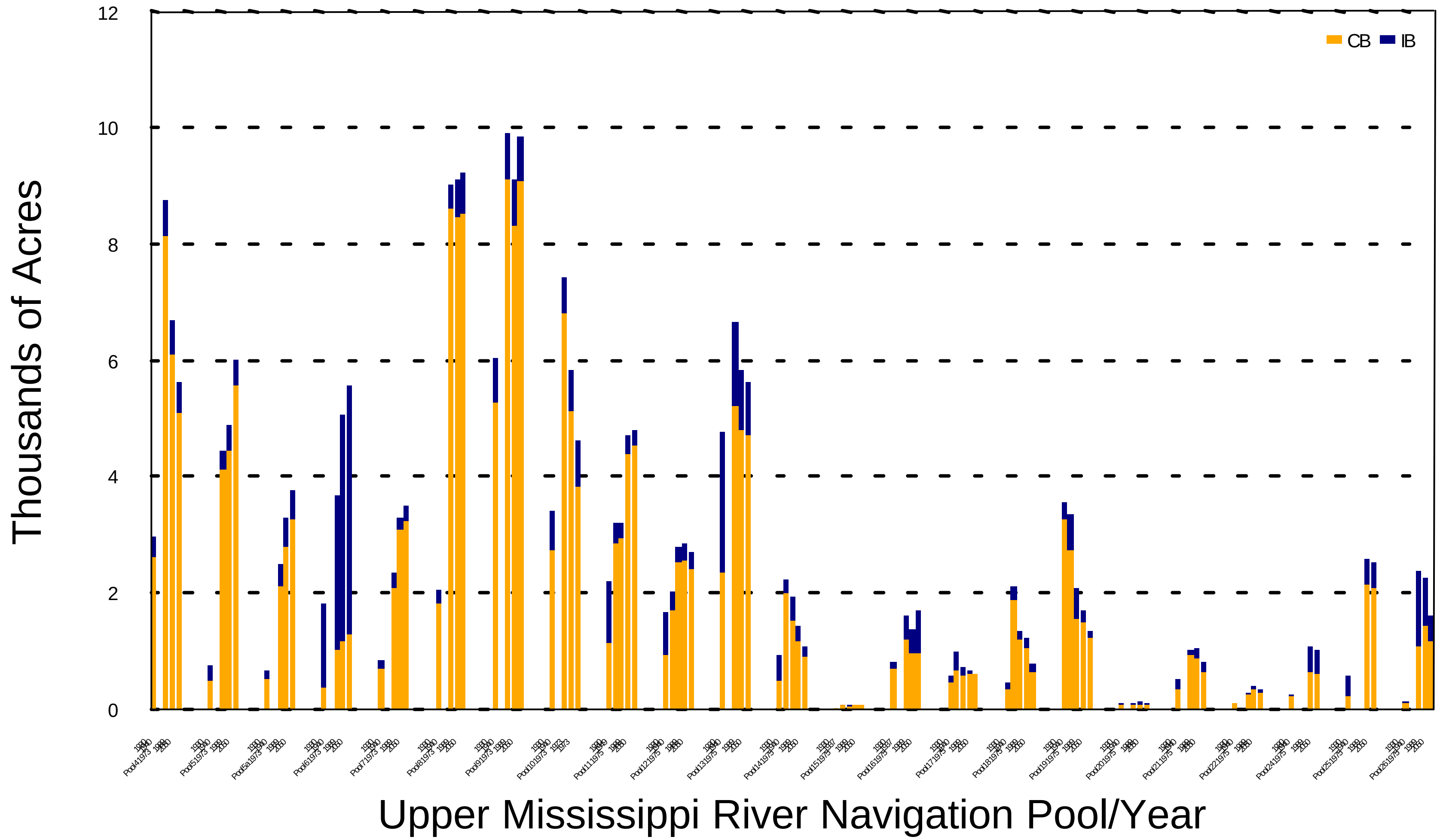
X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Lentic Amphibian and Reptile Habitat



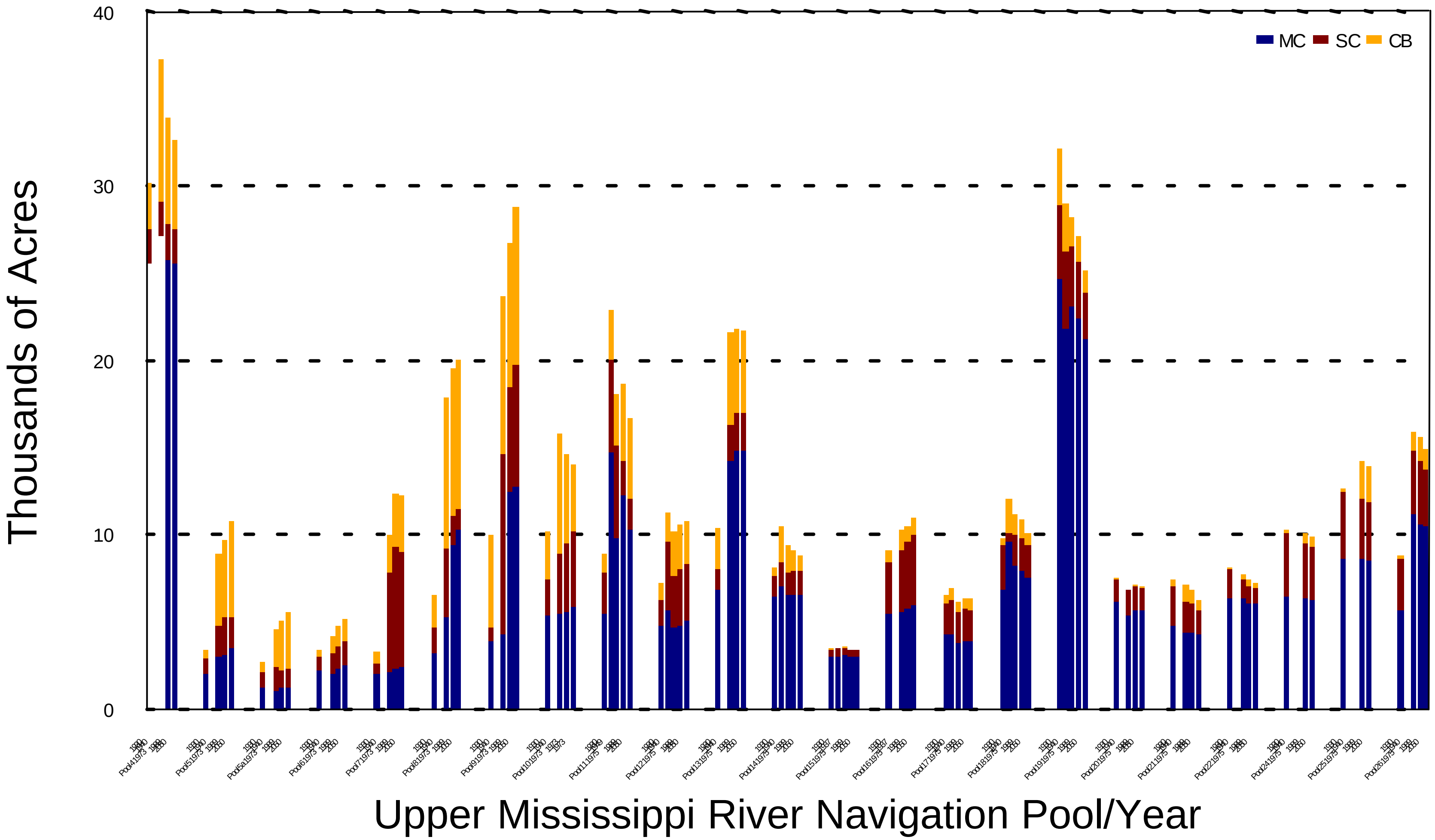
X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Dabbling Duck Habitat



X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Diving Duck Habitat



T-23

X-axis order is years: 1930, 1940, 1973/75, 1989, and 2050 by pool; gaps within pools are periods with missing data.
MC = Main Channel, SC = Secondary Channel, CB = Contiguous Backwater, IB = Impounded Backwater.

Appendix U

Dredging Summary for the UMRS

Appendix U-1: Dredging summary for the USACE St. Paul District navigation pools (SAF = St. Anthony falls dam).

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
SAF	MPLS. TURNING BASIN	857.0	-	857.6	15	1964	1996	346,355	10	0.59
	ABOVE LOWRY AVE. BR.	855.4	-	857.6	25	1965	1996	774,002	14	0.82
	BROADWAY AVE. BR.	855.1	-	856.4	16	1966	1996	232,118	8	0.47
	ABOVE PLYMOUTH AVE. BR.	854.8	-	855.4	9	1970	1996	181,068	3	0.18
	BELOW BROADWAY BR.	854.8	-	857.6	1	1964	1964	7,214	0	0.00
	UPPER SAF	854.8	-	857.6	1	1963	1963	5,338	0	0.00
1	INTERMEDIATE POOL	853.6	-	853.7	1	1964	1964	3,312	0	0.00
	LOWER APPROACH LSAF	853.2	-	853.5	6	1960	1988	15,919	3	0.18
	WASHINGTON AVE. BR.	852.5	-	853.0	16	1957	1987	334,495	1	0.06
	ABOVE FRANKLIN AVE. BR.	851.3	-	852.4	13	1957	1991	235,882	2	0.12
	BELOW FRANKLIN AVE. BR.	850.1	-	851.5	11	1958	1992	225,971	1	0.06
	ABOVE LAKE ST. BRIDGE	849.9	-	851.0	25	1958	1958	664,375	7	0.41
	BELOW LAKE STREET BR.	848.8	-	849.9	16	1957	1996	385,996	4	0.24
	BELOW ST. PAUL DAYMARK	848.0	-	849.0	11	1965	1988	198,440	3	0.18
	UPPER APPROACH L/D #1	847.8	-	848.4	9	1965	1978	203,679	0	0.00
	L/D #1 CHAMBER	847.6	-	847.6	1	1990	1990	40	1	0.06
2	LOWER APPROACH L/D 1	847.4	-	847.5	1	1994	1994	1,880	1	0.06
	UPPER MOUTH - MN R.	845.3	-	845.4	1	1968	1968	9,435	0	0.00
	PIKE ISLAND	844.4	-	845.3	3	1968	1968	143,175	0	0.00
	LOWER MOUTH MINNESOTA RIVER	844.1	-	844.5	1	1968	1968	36,851	0	0.00
	CLIFF STATION DAYMARK	843.3	-	843.7	2	1959	1960	92,187	0	0.00
	ABOVE & BELOW SMITH AVE.	840.0	-	841.0	21	1957	1984	330,658	3	0.18
	ABOVE WABASHA BR.	839.5	-	839.6	1	1994	1994	660	1	0.06
	HARRIET ISLAND	839.5	-	839.7	2	1960	1965	35,820	0	0.00
	SBH - ST. PAUL	839.5	-	840.0	15	1959	1996	127,175	10	0.59
	BELOW ROBERT STREET BRIDGE	838.4	-	838.8	1	1963	1963	30,710	0	0.00
	ST. PAUL BARGE	836.5	-	837.8	20	1957	1996	3,005,077	8	0.47

	TERMINAL									
	BELOW CUDAHY	831.1	-	832.3	4	1960	1965	120,117	0	0.00

Appendix U-1: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	ST. PAUL PARK	829.8	-	830.3	1	1957	1957	38,970	0	0.00
	GREY CLOUD SLOUGH	827.3	-	828.2	8	1965	1995	188,751	5	0.29
	GREY CLOUD LANDING	822.7	-	823.4	1	1971	1971	45,323	0	0.00
	PINE BEND	822.7	-	824.6	13	1958	1995	657,017	7	0.41
	BOULANGER BEND	819.6	-	821.5	4	1974	1995	400,255	3	0.18
	BOULANGER BEND LOWER LIGHT	818.5	-	820.2	3	1972	1995	251,938	1	0.06
	FREEBORN LIGHT	818.4	-	819.0	2	1992	1995	64,953	2	0.12
	UPPER APPROACH L/D 2	815.6	-	815.9	1	1964	1964	12,349	0	0.00
	HARRIET ISLAND SBH	815.2	-	847.5	1	1969	1969	21,308	0	0.00
	HARRIET ISLAND SBH 2	815.2	-	847.5	1	1968	1968	5,462	0	0.00
3	LOWER APPROACH L/D 2	814.8	-	815.1	2	1989	1992	29,564	2	0.12
	SBH-HASTINGS	813.2	-	813.2	3	1963	1970	13,514	0	0.00
	POINT DOUGLAS	811.6	-	811.7	1	1958	1958	21,852	0	0.00
	PRESCOTT	810.2	-	811.7	5	1964	1972	218,682	0	0.00
	PINE COULEE	809.5	-	809.8	2	1957	1967	112,371	0	0.00
	TRUEDALE SLOUGH	808.2	-	808.7	1	1963	1972	123,115	0	0.00
	FOUR MILE ISLAND	806.9	-	807.4	5	1957	1972	265,774	0	0.00
	SMITH BAR UPPER LIGHT	805.1	-	806.1	5	1962	1995	84,655	3	0.18
	BIG RIVER	804.2	-	804.9	6	1957	1972	255,407	0	0.00
	MORGANS COULEE	802.3	-	802.6	5	1958	1992	125,526	1	0.06
	COULTERS ISLAND	801.3	-	801.6	11	1962	1995	333,895	8	0.47
	DIAMOND BLUFF	798.9	-	800.6	13	1964	1995	611,233	9	0.53
4	LOWER APPROACH L/D 3	796.0	-	796.3	1	1957	1957	55,983	0	0.00
	TRENTON	794.1	-	794.5	3	1962	1975	171,355	0	0.00
	CANNON RIVER	792.4	-	793.7	9	1958	1996	386,587	5	0.29
	COMM. HARBOR-RED WING	791.5	-	791.5	3	1974	1996	7,190	1	0.06
	RED WING SMALL BOAT HARBOR	791.1	-	791.1	1	1963	1963	5,605	1	0.06
	ABOVE RED WING HWY. BR.	790.7	-	791.0	1	1972	1972	58,538	0	0.00

Appendix U-1: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	BELOW RED WING HWY. BR.	789.5	-	790.3	4	1956	1967	221,530	0	0.00
	HEAD OF LAKE PEPIN	785.2	-	785.4	1	1990	1990	11,532	1	0.06
	WACOUTA POINT	783.0	-	785.4	2	1966	1969	517,222	0	0.00
	LAKE CITY SBH	772.5	-	772.5	1	1965	1965	243	0	0.00
	SBH-PEPIN	767.0	-	767.0	2	1977	1980	2,292	1	0.06
	CHIPPEWA DELTA	763.3	-	763.8	6	1965	1992	1,604,259	5	0.29
	BELOW READS BRIDGE	761.8	-	762.2	1	1964	1964	36,307	0	0.00
	READS LANDING	761.7	-	763.9	27	1957	1993	2,301,367	9	0.53
	ABOVE CRATS ISLAND	758.4	-	759.5	36	1957	1996	2,531,830	16	0.94
	ABOVE TEEPEOTA POINT	757.0	-	759.7	28	1957	1996	1,317,750	10	0.59
	GRAND ENCAMPMENT	755.7	-	756.9	22	1958	1996	913,757	13	0.76
	ALMA S.B.H.	754.0	-	754.0	2	1965	1965	10,712	0	0.00
	SBH-ALMA	754.0	-	754.0	1	1970	1970	3,104	1	0.06
	BEEF SLOUGH	753.1	-	754.4	15	1957	1995	297,094	5	0.29
	L/D #4 AUX LOCK/GATE BAYS	752.8	-	752.8	1	1996	1996	6,300	1	0.06
5	LOWER APPROACH L/D 4	752.6	-	752.7	5	1959	1974	46,219	0	0.00
	MULE BEND	747.5	-	749.7	11	1960	1996	402,576	4	0.24
	WEST NEWTON	746.5	-	748.2	13	1958	1995	575,303	4	0.24
	BELOW WEST NEWTON	746.0	-	746.8	24	1957	1996	735,716	10	0.59
	FISHER ISLAND	744.5	-	745.9	28	1957	1996	1,685,822	10	0.59
	LOWER ZUMBRO	743.5	-	744.8	23	1958	1996	1,011,526	10	0.59
	SOMMERFIELD ISLAND	742.3	-	743.8	15	1957	1996	432,755	11	0.65
	MT. VERNON LIGHT	741.3	-	741.6	1	1974	1974	62,849	0	0.00
	ABOVE MT. VERNON LIGHT	741.2	-	741.7	3	1960	1996	94,893	1	0.06
5a	LOWER APPROACH L/D 5	737.7	-	738.0	1	1968	1968	33,869	0	0.00
	BOX DAM	735.1	-	735.2	1	1960	1960	15,777	0	0.00
	ISLAND 58	733.4	-	735.2	12	1957	1979	657,981	0	0.00
	FOUNTAIN CITY	733.3	-	733.7	2	1968	1972	123,119	0	0.00

Appendix U-1: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	BETSY SLOUGH	731.0	-	732.2	22	1960	1994	510,583	14	0.82
	WILDS BEND	729.8	-	730.7	17	1957	1994	452,209	8	0.47
	UPPER APPROACH L/D 5A	728.5	-	729.5	5	1957	1968	269,872	0	0.00
6	LOWER APPROACH L/D 5A	728.1	-	728.3	7	1960	1969	81,378	0	0.00
	COMM. HARBOR-WINONA	726.3	-	726.3	1	1996	1996	2,000	1	0.06
	SBH-WINONA	726.0	-	726.3	12	1961	1996	51,913	4	0.24
	ISLAND 71	725.9	-	726.7	3	1962	1968	44,819	0	0.00
	ABOVE LOWER WINONA R.R. BR	723.9	-	724.2	1	1970	1970	26,403	0	0.00
	LOWER WINONA	723.2	-	724.2	13	1960	1995	419,592	3	0.18
	GRAVEL POINT	721.9	-	722.9	4	1957	1972	117,532	0	0.00
	HOMER	719.8	-	721.3	8	1957	1991	344,582	2	0.12
	BLACKSMITH SLOUGH	719.0	-	719.2	1	1958	1958	35,028	0	0.00
7	L/D #6 AUX LOCK/GATE BAYS	714.1	-	714.2	1	1992	1992	300	1	0.06
	LOWER APPROACH L/D 6	713.6	-	714.2	4	1964	1993	62,667	2	0.12
	HEAD OF RICHMOND ISLAND	712.3	-	712.9	3	1958	1965	83,627	0	0.00
	RICHMOND ISLAND	711.3	-	712.4	8	1963	1982	474,794	1	0.06
	BELOW QUEENS BLUFF	710.4	-	710.6	1	1957	1957	30,843	0	0.00
	QUEENS BLUFF	710.3	-	710.6	1	1964	1964	38,480	0	0.00
	ABOVE WINTER'S LANDING	708.6	-	709.3	1	1970	1970	64,921	0	0.00
	WINTERS LANDING	707.8	-	709.3	22	1961	1996	808,186	14	0.82
	DAKOTA	705.7	-	708.0	19	1960	1996	371,008	6	0.35
	HEAD OF DRESBACH CUT	704.1	-	705.5	16	1962	1996	301,006	10	0.59
	UPPER APPROACH L/D 7	703.4	-	703.7	3	1964	1989	48,180	2	0.12
	LOWER DRESBACH ISLAND	703.1	-	703.7	6	1990	1996	89,972	6	0.35
8	ABOVE LACROSSE RR BRIDGE	700.1	-	700.3	2	1957	1962		0	0.00
	LACROSSE R.R. BR.	698.7	-	700.4	9	1970	1992		5	0.29
	LACROSSE	698.6	-	698.7	1	1989	1989	8,113	1	0.06

Appendix U-1: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	SAND SLOUGH	694.3	-	695.0	4	1962	1970		0	0.00
	ROOT RIVER	693.0	-	693.4	1	1960	1960	45,332	0	0.00
	PICAYUNE ISLAND	691.4	-	692.6	4	1965	1973		0	0.00
	ABOVE BROWNSVILLE	690.0	-	691.6	23	1959	1996		8	0.47
	BROWNSVILLE	688.0	-	690.1	27	1958	1996		15	0.88
	HEAD OF RAFT CHANNEL	686.8	-	688.7	25	1960	1996		10	0.59
	BELOW HEAD OF RAFT CHANNEL	686.4	-	687.4	2	1963	1967		0	0.00
	CROSBY SLOUGH	684.7	-	685.1	1	1963	1963		0	0.00
	WARNERS LANDING	683.4	-	683.8	1	1963	1963		0	0.00
9	BEHIND LOWER GUIDEWALL L/D	679.0	-	679.0	2	1992	1992	2,645	2	0.12
	LOWER APPROACH L/D #8	678.8	-	679.1	3	1967	1988	43,329	2	0.12
	ISLAND 126	677.4	-	677.9	6	1958	1989	390,397	1	0.06
	TWIN ISLAND	676.7	-	676.7	1	1976	1976		0	0.00
	TWIN ISLAND	676.0	-	676.5	7	1958	1969	244,497	0	0.00
	BATTLE ISLAND	671.6	-	671.8	2	1972	1973		0	0.00
	HEAD OF BATTLE ISLAND	670.9	-	671.9	4	1958	1968		0	0.00
	DE SOTO	667.4	-	668.5	2	1958	1958	156,864	0	0.00
	INDIAN CAMP LIGHT	664.9	-	666.2	19	1963	1996		12	0.71
	ABOVE & BELOW LANSING HIGH	663.7	-	664.2	1	1966	1966		0	0.00
	LANSING UPPER LIGHT	663.7	-	664.8	31	1958	1996		16	0.94
	ABOVE ATCHAFALAYA BLUFF	660.3	-	660.8	1	1970	1970		0	0.00
	ABOVE CROOKED SLOUGH	653.6	-	654.1	1	1964	1964		0	0.00
10	LOWER APPROACH L/D 9	647.7	-	647.7	1	1959	1959		0	0.00
	HAY POINT	646.0	-	646.7	6	1958	1972		0	0.00
	JACKSON ISLAND	643.4	-	644.8	6	1960	1975		0	0.00
	MISSISSIPPI GARDENS	642.7	-	643.4	3	1959	1976		0	0.00
	EAST CHANNEL	635.0	-	635.0	1	1976	1976		0	0.00
	MCGREGOR	633.2	-	633.5	2	1964	1964		0	0.00

Appendix U-1: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	WYALUSING	627.2	-	628.0	8	1965	1978		0	0.00
	MCMILLAN ISLAND	617.8	-	619.2	15	1964	1996		11	0.65
	UPPER APPROACH L/D 10	615.6	-	615.8	1	1973	1973		0	0.00
	* THROUGH 1996									

Appendix U-2: Dredging summary for the USACE Rock Island District navigation pools.

Pool	Dredge Cut	Approximate River Mile	Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
11	LOCK #10 LOWER	613.7 - 614.9	4	1941	1950	169,937	0	0.00
	SWIFT SLOUGH	612.7 - 613.5	8	1940	1974	496,837	0	0.00
	GOETZ ISLAND	612.1 - 612.7	3	1941	1974	127,945	0	0.00
	ST. LOUIS WOODYARD	610.0 - 612.1	18	1940	1978	1,039,123	0	0.00
	TURKEY RIVER	608.8 - 610.0	30	1940	1990	1,372,468	3	0.18
	TURKEY RIVER LOWER	607.8 - 608.8	7	1942	1955	405,356	0	0.00
	CASSVILLE	605.7 - 606.3	7	1941	1948	458,594	0	0.00
	ISLAND 195	604.6 - 605.3	2	1958	1965	187,644	0	0.00
	BUENA VISTA UPPER	603.8 - 604.6	3	1952	1958	191,427	0	0.00
	BUENA VISTA	602.9 - 603.4	3	1955	1965	184,223	0	0.00
	HURRICANE ISLAND	598.7 - 599.1	7	1968	1995	214,951	3	0.18
	FINLEY'S LANDING	595.5 - 596.5	6	1974	1994	241,097	5	0.29
12	DUBUQUE	581.3 - 581.6	1	1962	1962	64,033	0	0.00
	CATFISH CREEK	579.2 - 580.1	9	1941	1965	549,123	0	0.00
	CATFISH CROSSING	574.3 - 574.8	1	1942	1942	38,421	0	0.00
	NINE MILE ISLAND	572.6 - 572.9	1	1968	1968	43,415	0	0.00
	DEADMAN'S LIGHT	568.5 - 568.8	2	1958	1969	128,507	0	0.00
	DEADMAN'S LIGHT LOWER	566.8 - 568.0	2	1940	1969	239,226	0	0.00
	GORDON'S FERRY	565.1 - 565.8	5	1940	1981	319,928	1	0.06
	ISLAND 241 LIGHT	561.8 - 562.5	5	1940	1995	318,488	3	0.18
	BELLEVUE SLOUGH	560.4 - 561.1	3	1940	1958	120,665	0	0.00
13	LOCK #12 LOWER	555.0 - 555.4	4	1945	1956	123,796	0	0.00
	DUCK CREEK	554.1 - 555.0	11	1940	1962	596,759	0	0.00
	PLEASANT CREEK	552.7 - 553.8	3	1962	1983	98,649	1	0.06
	SAND PRAIRIE	549.9 - 550.8	7	1941	1976	396,262	0	0.00
	MAQUOKETA RIVER	547.0 - 548.6	15	1950	1987	1,297,786	2	0.12

Appendix U-2: Cont.

Pool	Dredge Cut	Approximate River Mile	Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	APPLE RIVER ISLAND	546.1 - 547.0	2	1946	1974	56,495	0	0.00
	ISLAND 527	544.1 - 545.9	3	1956	1973	221,538	0	0.00
	LAINSVILLE LOWER	540.5 - 541.0	2	1958	1970	124,130	0	0.00
	SAVANNA BAY	538.8 - 539.6	7	1958	1995	447,654	4	0.24
	SABULA LOWER	532.5 - 533.9	5	1961	1977	417,312	0	0.00
	DARK SLOUGH	531.0 - 531.3	3	1971	1991	251,033	1	0.06
	ELK RIVER	528.7 - 529.9	2	1940	1954	409,418	0	0.00
	POMME DE TERRE	525.1 - 525.6	2	1961	1972	165,184	0	0.00
14	LOCK #13 LOWER	521.1 - 522.4	4	1940	1943	111,468	0	0.00
	JOYCE'S ISLAND	518.5 - 519.9	16	1940	1971	1,013,176	0	0.00
	BEAVER ISLAND	515.8 - 517.6	9	1940	1991	334,043	2	0.12
	BEAVER SLOUGH	513.0 - 517.6	14	1942	1975	569,315	0	0.00
	ALBANY LOWER	513.4 - 514.4	3	1956	1972	197,481	0	0.00
	MARAIS D'OSIER SLOUGH	509.6 - 510.0	3	1940	1968	195,531	0	0.00
	ADAMS ISLAND UPPER	508.4 - 509.1	3	1950	1968	200,629	0	0.00
	WAPSIPINICON RIVER	505.6 - 506.0	1	1972	1972	50,200	0	0.00
	STEAMBOAT SLOUGH	503.3 - 504.0	10	1961	1995	630,394	6	0.35
	LE CLAIRE CANAL	496.1 - 496.6	1	1941	1941	111,129	0	0.00
	LOCK #14 UPPER	493.7 - 494.8	6	1952	1971	529,222	0	0.00
15	LOCK #14 LOWER	492.0 - 492.2	1	1941	1941	20,538	0	0.00
	CAMPBELL'S ISLAND	490.7 - 491.6	7	1941	1969	247,218	0	0.00
	WINNEBAGO ISLAND	489.2 - 490.5	9	1941	1985	161,537	2	0.12
	LOCK #15 UPPER	483.2 - 483.3	2	1954	1967	53,832	0	0.00
16	LOCK #15 LOWER	482.2 - 482.9	20	1940	1994	495,386	9	0.53
	MOUTH OF ROCK RIVER	478.5 - 479.3	1	1939	1939	88,869	0	0.00
	CENTENNIAL BRIDGE	481.2 - 482.2	12	1940	1995	256,649	3	0.18
	OFFERMAN ISLAND	478.9 - 479.1	2	1942	1946	28,020	0	0.00

Appendix U-2: Cont.

Pool	Dredge Cut	Approximate River Mile	Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	BUFFALO	472.0 - 473.2	12	1944	1993	618,402	7	0.41
	MONTPELIER	469.1 - 469.7	2	1966	1970	176,234	0	0.00
	FAIRPORT	463.7 - 464.5	1	1947	1947	93,019	0	0.00
	HERSHEY CHUTE	460.7 - 461.7	8	1962	1995	421,326	5	0.29
	HERSHEY CHUTE LOWER	457.6 - 458.8	1	1941	1941	30,956	0	0.00
17	LOCK # 16 LOWER	456.2 - 457.0	2	1940	1944	154,359	0	0.00
	MUSCATINE ISLAND	452.9 - 454.5	8	1943	1968	642,274	0	0.00
	MUSCATINE PRAIRIE	451.5 - 451.8	1	1971	1971	46,102	0	0.00
	BASS ISLAND	447.2 - 448.2	19	1941	1994	1,297,760	4	0.24
	BARKIS ISLAND	446.1 - 446.2	1	1969	1969	10,000	0	0.00
	LAKE ODESSA	441.1	1	1994	1994	40,425	1	0.06
	LOCK #17 UPPER	437.7 - 438.7	1	1941	1941	193,352	0	0.00
18	LOCK #17 LOWER	436.7 - 437.0	2	1945	1970	46,587	0	0.00
	KEG ISLAND	435.2 - 436.2	9	1940	1955	797,056	0	0.00
	NEW BOSTON UPPER	432.9 - 434.2	14	1947	1981	625,026	1	0.06
	EDWARDS RIVER	431.0 - 432.0	15	1940	1977	488,317	0	0.00
	KEITHSBURG	428.3 - 429.0	1	1949	1949	9,162	0	0.00
	KEITHSBURG UPPER	426.8 - 427.5	16	1941	1993	1,064,902	1	0.06
	KEITHSBURG LOWER	425.1 - 426.7	34	1941	1993	1,575,020	11	0.65
	HURON ISLAND	423.5 - 424.7	9	1951	1993	456,563	4	0.24
	JOHNSON ISLAND	420.5 - 421.9	4	1948	1992	271,105	2	0.12
	BENTON ISLAND	418.5 - 420.5	15	1941	1995	953,163	4	0.24
	OQUAWKA	414.7 - 415.2	1	1961	1961	66,470	0	0.00
	LOCK #18 UPPER	411.0 - 412.4	5	1941	1983	360,593	2	0.12
19	LOCK #18 LOWER	408.5 - 410.3	4	1940	1943	147,747	0	0.00
	DREW CHUTE	407.0 - 408.5	19	1940	1963	1,490,244	0	0.00
	RUSH ISLAND	405.9 - 407.0	19	1940	1973	1,946,555	0	0.00

Appendix U-2: Cont.

Pool	Dredge Cut	Approximate River Mile	Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	RUSH ISLAND LOWER	404.8 - 405.9	8	1945	1972	529,759	0	0.00
	BURLINGTON BRIDGE	404.3 - 404.6	2	1971	1972	90,710	0	0.00
	BURLINGTON BLUFF	401.1 - 401.6	3	1957	1968	162,962	0	0.00
	CRAIGEL ISLAND	399.1 - 400.5	22	1940	1995	1,091,535	5	0.29
	KEMP'S LANDING	397.9 - 399.1	14	1940	1994	545,016	5	0.29
	KEMP'S LANDING LOWER	397.0 - 397.5	1	1991	1991	43,149	1	0.06
	SHOKOKON SLOUGH	394.2 - 395.0	6	1944	1969	620,504	0	0.00
	DALLAS CITY	390.2 - 391.0	1	1955	1955	182,708	0	0.00
	LOCK #19 UPPER	364.2 - 364.5	2	1944	1968	104,565	0	0.00
20	LOCK #19 LOWER	361.2 - 363.9	4	1971	1982	120,101	1	0.06
	FOX ISLAND UPPER	358.3 - 358.8	2	1964	1965	127,835	0	0.00
	FOX ISLAND TOWHEAD	356.4 - 357.6	4	1945	1948	555,946	0	0.00
	FOX ISLAND	354.4 - 356.0	17	1955	1975	1,977,411	0	0.00
	FOX RIVER	352.6 - 353.4	8	1942	1948	551,722	0	0.00
	GREGORY LOWER	351.1 - 352.0	7	1961	1974	328,618	0	0.00
	BUZZARD ISLAND	348.5 - 349.6	22	1959	1996	1,620,620	11	0.65
	BROWNSVILLE ISLAND	345.1 - 345.4	1	1964	1964	47,398	0	0.00
	LOCK #20 UPPER	343.2 - 344.3	6	1942	1967	440,268	0	0.00
21	LOCK #20 LOWER	342.2 - 343.2	15	1940	1988	561,261	1	0.06
	CANTON	341.4 - 341.9	1	1946	1946	44,189	0	0.00
	HOWARD’S CROSSING	336.9 - 339.5	23	1944	1995	1,513,367	7	0.41
	LAGRANGE	335.9 - 336.9	32	1944	1991	1,408,257	8	0.47
	WILLOW ISLAND	332.5 - 333.9	15	1947	1991	848,823	7	0.41
	HOGBACK/LONE TREE	330.9 - 332.6	27	1951	1996	1,674,146	14	0.82
	BAY ISLAND	328.0 - 329.2	5	1945	1968	792,845	0	0.00
	QUINCY BRIDGE	326.5 - 327.9	7	1963	1970	617,881	0	0.00
22	LOCK #21 LOWER	323.3 - 324.7	14	1940	1987	791,070	1	0.06

Appendix U-2: Cont.

Pool	Dredge Cut	Approximate River Mile	Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	NE MISSOURI POWER	319.7 - 321.2	27	1940	1994	2,248,681	5	0.29
	BEEBE ISLAND UPPER	317.2 - 319.3	7	1940	1948	476,976	0	0.00
	BEEBE ISLAND	316.0 - 316.9	13	1940	1993	1,197,335	4	0.24
	WHITNEY LIGHT	312.8 - 314.9	29	1944	1995	1,578,871	8	0.47
	TURTLE ISLAND	311.5 - 312.1	10	1941	1973	559,659	0	0.00
	HANNIBAL	308.7 - 308.8	1	1941	1941	20,640	0	0.00
	CAVE HOLLOW LIGHT	306.0 - 306.5	1	1961	1961	85,810	0	0.00
	WING DAM #17	304	1	1982	1982	39,445	1	0.06
	LOCK #22 UPPER	301.5 - 303.4	13	1944	1994	943,549	6	0.35
24	LOCK #22 LOWER	300.3 - 300.9	14	1944	1994	545,886	5	0.29

* THROUGH 1996

Appendix U-3: Dredging summary for the USACE St. Louis District navigation pools and Open River.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
24	LD 22 LWR APPROACH	300.0	-	300.0	1	1990	1990	26,444	1	0.06
	TURNER ISLAND	299.6	-	299.6	1	1997	1997	51,659	1	0.06
	GILBERT ISLAND	294.0	-	299.0	11	1964	1997	784,396	6	0.35
	TAYLOR CROSSING	297.0	-	298.5	10	1963	1993	963,295	1	0.06
	CINCINNATI LANDING	298.2	-	298.2	1	1991	1991	24,444	1	0.06
	SLIM ISLAND	294.3	-	294.3	1	1969	1969	70,100	0	0.00
	MUNDY LANDING	293.2	-	293.2	1	1964	1964	105,800	0	0.00
	COTTONWOOD ISLAND	289.5	-	291.8	11	1965	1989	1,933,424	7	0.41
	ATLAS ISLAND	290.8	-	290.8	1	1974	1974	59,200	0	0.00
	COPPERFIELD	289.7	-	290.0	2	1991	1992	306,832	2	0.12
	NORTH FRITZ	289.0	-	290.0	5	1975	1997	935,259	3	0.18
	TWO RIVER	283.0	-	283.2	3	1979	1984	67,600	2	0.12
	PIKE STATION	283.2	-	283.2	1	1968	1968	405,700	0	0.00
	BUFFALO ISLAND	281.0	-	281.0	1	1972	1972	30,500	0	0.00
	L&D 24 UPPER	273.4	-	275.5	8	1968	1992	591,895	3	0.18
	MIDDLETON	275.0	-	275.0	1	1995	1995	64,533	1	0.06
25	L&D 24 LOWER	273.0	-	273.4	12	1964	1997	720,239	7	0.41
	LOWER FRITZ	273.0	-	273.0	1	1976	1976	23,700	0	0.00
	AMARANTH ISLAND	268.8	-	270.0	16	1965	1997	2,706,395	8	0.47
	CARROLL ISLAND	268.5	-	269.0	3	1963	1980	556,200	1	0.06
	COON ISLAND	265.8	-	267.5	28	1963	1997	2,865,889	10	0.59
	SLIM ISLAND	265.0	-	267.0	10	1966	1985	838,300	2	0.12
	RIP RAP LANDING	265.0	-	266.2	7	1972	1997	538,416	4	0.24
	GRIMES ISLAND	265.6	-	265.6	2	1966	1967	123,900	0	0.00
	TISDALE ISLAND	264.5	-	264.5	1	1971	1971	56,800	0	0.00
	DAGO POINT	263.6	-	264.5	6	1967	1996	450,243	2	0.12

Appendix U-3: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	MCCOY ISLAND	263.3	-	264.4	13	1965	1997	1,147,461	6	0.35
	TISDALE ISLAND	262.4	-	262.9	8	1967	1996	401,833	2	0.12
	MOSIER ISLAND	261.0	-	261.5	2	1969	1997	160,458	1	0.06
	THOMAS CHUTE	261.5	-	261.5	2	1993	1993	48,529	2	0.12
	KELLY ISLAND	255.8	-	258.0	20	1965	1997	2,163,505	11	0.65
	WESTPORT ISLAND	255.0	-	256.8	12	1966	1997	1,409,223	8	0.47
	REDS LANDING	253.5	-	256.0	13	1971	1997	1,447,095	7	0.41
	BURR OAKS	255.9	-	255.9	1	1974	1974	116,900	0	0.00
	WILDWOOD LANDING	255.6	-	255.6	1	1969	1969	86,000	0	0.00
	STERLING ISLAND	249.0	-	255.5	33	1963	1993	3,807,987	14	0.82
	BOLTERS BAR	255.0	-	255.0	1	1992	1992	143,270	1	0.06
	EAGLE ISLAND	253.0	-	253.5	6	1978	1997	471,612	4	0.24
	WESTPOINT IL	253.5	-	253.5	1	1969	1969	65,800	0	0.00
	HAMBURG	251.0	-	251.0	1	1993	1993	215,451	1	0.06
	MAPLE ISLAND	249.5	-	249.5	1	1993	1993	34,837	1	0.06
	CHURCH CREEK	248.0	-	249.0	3	1995	1997	222,528	3	0.18
	L&D 25 UPPER	241.4	-	243.9	8	1966	1993	787,196	3	0.18
	WINFIELD LGT	243.5	-	243.5	1	1989	1989	25,000	1	0.06
	SANDY ISLAND	242.0	-	243.0	8	1978	1995	1,060,257	5	0.29
	SARAH ANN	242.3	-	243.0	3	1967	1975	319,200	0	0.00
26	L&D 25 LOWER	241.0	-	241.2	5	1970	1995	182,582	1	0.06
	TURKEY ISLAND	236.8	-	237.1	5	1963	1997	619,822	1	0.06
	HAT ISLAND	235.3	-	236.5	2	1977	1992	59,235	1	0.06
	CUIVRE ISLAND	234.6	-	235.5	2	1965	1996	100,299	1	0.06
	MARTINS TWHD	234.2	-	235.0	13	1965	1994	1,269,736	3	0.18
	MARTUB THD	235.0	-	235.0	1	1978	1978	57,200	0	0.00
	CRIMINAL ISLAND	232.5	-	234.0	8	1963	1974	1,353,900	0	0.00

Appendix U-3: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	POPPLETON	232.7	-	234.0	2	1967	1968	79,600	0	0.00
	PERUQUE ISLAND	232.0	-	233.0	3	1987	1996	170,777	3	0.18
	TWO BRANCH ISLAND	229.3	-	232.5	6	1973	1991	425,617	4	0.24
	APPLE ISLAND	229.3	-	229.6	3	1963	1997	195,386	2	0.12
	GOLDEN EAGLE	228.5	-	229.0	2	1995	1996	67,039	2	0.12
	JOHNSON LANDING	227.8	-	227.8	1	1970	1970	81,800	0	0.00
	BOLTERS ISLAND	225.0	-	227.5	48	1967	1997	6,733,190	39	2.29
	MACKERS LANDING	227.0	-	227.5	5	1975	1993	449,087	2	0.12
	BROCK LANDING	226.0	-	226.2	2	1972	1975	331,400	0	0.00
	MILAN LANDING	226.2	-	226.2	1	1974	1974	19,000	0	0.00
	MIDLAND LANDING	225.5	-	225.5	1	1974	1974	73,100	0	0.00
	CALHOUN UPPER	225.4	-	225.4	1	1996	1996	98,736	1	0.06
	IOWA ISLAND	224.1	-	225.4	10	1963	1994	1,054,033	4	0.24
	POINT LANDING	225.0	-	225.0	1	1975	1975	76,200	0	0.00
	CALHOUN LANDING	223.8	-	224.5	6	1968	1996	615,151	5	0.29
	ROYAL LANDING	222.2	-	224.0	19	1966	1997	3,210,724	10	0.59
	SQUAW ISLAND	220.5	-	222.7	18	1963	1997	1,548,552	12	0.71
	ENTERPRISE ISLAND	222.5	-	222.5	1	1995	1995	85,405	1	0.06
	PERRY ISLAND	220.8	-	220.8	1	1992	1992	33,019	1	0.06
	GRAFTON FE	218.2	-	219.0	2	1967	1969	273,200	0	0.00
	SHERWOOD HARBOR	218.5	-	218.5	1	1997	1997	365,415	1	0.06
	PIASA ISLAND	208.0	-	209.0	5	1965	1969	518,400	0	0.00
	YOUNGBLOOD	207.7	-	207.7	1	1965	1965	260,200	0	0.00
	LOCK 26 UPPER	202.9	-	202.9	1	1982	1982	19,800	1	0.06
	L&D 26 LOWER	202.0	-	202.7	17	1975	1989	1,594,971	11	0.65
OPEN	L&D 26 REPL	201.0	-	201.0	1	1971	1971	114,000	0	0.00
RIVER	MPL&D AUX LR	200.6	-	200.6	1	1996	1996	58,808	1	0.06

Appendix U-3: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	MOBILE ISLAND	195.6	-	196.0	2	1993	1996	162,275	2	0.12
	CANAL UPPER	195.7	-	195.7	1	1988	1988	43,583	1	0.06
	MOUTH MO RIVER	195.1	-	195.3	2	1977	1978	172,000	0	0.00
	CHEROKEE DK	195.1	-	195.1	1	1996	1996	25,483	1	0.06
	MOBILE ISLAND	194.9	-	195.0	2	1994	1997	185,381	2	0.12
	MOUTH OF MO	195.0	-	195.0	1	1987	1987	115,139	1	0.06
	CAHOKIA CREEK	195.0	-	195.0	1	1966	1966	141,300	0	0.00
	UPPER CANAL	190.8	-	194.0	20	1964	1996	2,976,479	10	0.59
	HUMBOLT ST	187.0	-	187.0	1	1981	1981	88,700	1	0.06
	MOSENTHIEN	186.1	-	186.1	2	1977	1977	302,300	0	0.00
	OLD RIVER CH	184.3	-	185.0	2	1978	1979	69,600	0	0.00
	LOWER CANAL	182.0	-	185.0	61	1964	1997	8,601,066	25	1.47
	MERCHANTS BR	182.1	-	184.0	34	1970	1997	3,709,503	21	1.24
	CONT. GRAIN	184.0	-	184.0	1	1976	1976	79,600	0	0.00
	MSD DOCK	183.4	-	183.4	1	1988	1988	78,333	1	0.06
	NORTH MARKET	180.0	-	182.5	10	1969	1982	1,487,800	3	0.18
	MUNICIPAL DK	181.5	-	182.8	16	1964	1996	2,201,202	13	0.76
	UE DOCK LGHT	182.3	-	182.3	2	1990	1990	641,973	2	0.12
	MCKINLEY BR	182.0	-	182.0	1	1989	1989	73,223	1	0.06
	CITY DOCK	181.7	-	181.7	1	1984	1984	217,100	1	0.06
	ST LOUIS TER	181.3	-	181.7	4	1976	1992	576,647	2	0.12
	VET BRIDGE	180.4	-	181.5	2	1968	1977	59,400	0	0.00
	ML KING BRIDGE	180.2	-	180.2	1	1990	1990	53,111	1	0.06
	EADS BRIDGE	180.0	-	180.1	2	1968	1984	50,300	1	0.06
	POPLAR ST.	179.1	-	179.1	2	1968	1968	211,600	0	0.00
	CHOTOA AVE	179.0	-	179.0	1	1971	1971	126,700	0	0.00
	COE SER BASE	176.8	-	177.0	8	1967	1990	790,708	4	0.24

Appendix U-3: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	FOX TERMINAL	177.0	-	177.0	1	1990	1990	118,334	1	0.06
	ARSENAL ISLAND	173.0	-	175.5	12	1977	1997	1,923,117	10	0.59
	USCG BASE	173.4	-	175.0	5	1976	1995	425,136	4	0.24
	REIDY TERMINAL	175.0	-	175.0	1	1989	1989	296,525	1	0.06
	MARQUETT DKS	173.2	-	173.5	2	1990	1995	147,540	2	0.12
	PETRO-CHEM	173.3	-	173.3	1	1995	1995	67,897	1	0.06
	RIVERWAYS DK	171.5	-	173.0	3	1988	1990	347,145	3	0.18
	NATL LEAD DK	171.5	-	171.8	2	1989	1992	521,423	2	0.12
	EAST IVORY	171.6	-	171.8	2	1918	1981	214,200	1	0.06
	R DES PERES	172.0	-	172.0	2	1971	1990	670,641	1	0.06
	NATL LEAD DK	171.5	-	172.0	2	1991	1996	395,153	2	0.12
	IVORY LANDING	169.5	-	171.5	22	1966	1990	1,479,858	9	0.53
	CARL BAHR	171.5	-	171.5	1	1980	1980	99,000	1	0.06
	NOTRE DAME	171.1	-	171.1	1	1967	1967	181,400	0	0.00
	DES PERES	171.0	-	171.0	2	1981	1981	118,100	2	0.12
	JEFF BRKS BR	160.3	-	169.5	14	1974	1997	1,774,375	13	0.76
	STREETT OIL	169.5	-	169.5	1	1984	1984	284,300	1	0.06
	BUSSEN QUARRY	167.5	-	168.5	5	1980	1996	159,042	5	0.29
	CLIFF CAVE	166.2	-	168.0	23	1975	1997	2,851,509	10	0.59
	CARROLL ISLAND	168.0	-	168.0	1	1964	1964	277,000	0	0.00
	TWIN HOLLOW	166.0	-	166.6	7	1967	1978	1,036,600	0	0.00
	MERAMEC RIVER	160.2	-	166.0	21	1965	1995	2,233,717	13	0.76
	PULLTIGHT LT	164.4	-	165.8	3	1972	1989	311,512	2	0.12
	CARL BAER	163.9	-	163.9	1	1989	1989	107,222	1	0.06
	DREDGING D	163.9	-	163.9	1	1966	1966	50,600	0	0.00
	FINES BLUFF	161.4	-	162.9	2	1988	1989	219,446	2	0.12
	UNION ELECTRIC	161.5	-	161.5	1	1991	1991	61,667	1	0.06

Appendix U-3: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	CHESLEY ISLAND	158.9	-	160.5	4	1964	1996	311,035	1	0.06
	SULPHER SPRINGS	155.0	-	159.7	6	1964	1970	684,400	0	0.00
	WATERS POINT	157.4	-	159.5	5	1966	1989	470,381	4	0.24
	KIMMSWICK MO	158.0	-	159.5	3	1968	1988	406,144	1	0.06
	FOSTER LIGHT	158.0	-	158.2	6	1987	1991	910,745	6	0.35
	GLEN PARK	156.4	-	156.5	3	1971	1989	241,488	1	0.06
	BUSHBERG LGT	153.8	-	154.0	4	1966	1989	477,282	2	0.12
	RIVERSIDE	153.4	-	153.4	1	1965	1965	203,600	0	0.00
	HARRISONVILL	153.1	-	153.1	1	1967	1967	63,300	0	0.00
	HERCULANEUM	151.6	-	152.9	5	1967	1989	431,868	2	0.12
	LUCAS BLUFF	152.7	-	152.7	1	1967	1967	69,200	0	0.00
	PLATTIN ROCK	149.0	-	149.0	1	1990	1990	93,529	1	0.06
	MCCOYS	148.0	-	148.0	1	1966	1966	170,100	0	0.00
	PLATTIN CREEK	148.0	-	148.0	2	1964	1965	269,200	0	0.00
	ST NICHOLAS	147.5	-	147.5	1	1967	1967	86,800	0	0.00
	RIVER CEMENT	145.5	-	145.5	1	1989	1989	202,415	1	0.06
	JAMES BAR	145.0	-	145.5	3	1964	1965	242,100	0	0.00
	MICHAELS THD	144.6	-	144.8	2	1964	1979	189,100	0	0.00
	LOWERY LANDING	143.2	-	144.0	3	1966	1967	322,800	0	0.00
	DANBY LANDING	138.0	-	142.3	9	1964	1988	1,192,655	1	0.06
	FULTS DOCK	142.0	-	142.0	1	1989	1989	51,966	1	0.06
	RUSH ISLAND	141.2	-	141.3	3	1965	1967	206,200	0	0.00
	AMES ISLAND	138.0	-	139.5	9	1968	1989	1,317,358	7	0.41
	LEE ISLAND	138.6	-	138.6	1	1972	1972	173,800	0	0.00
	BRICKEYS LANDING	134.0	-	137.1	14	1964	1989	2,001,422	2	0.12
	SYCAMORE	136.5	-	136.5	1	1973	1973	98,000	0	0.00

Appendix U-3: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	SNELL HOLLOW	135.6	-	135.6	1	1967	1967	105,700	0	0.00
	ESTABLISH IL	134.0	-	134.0	1	1972	1972	125,900	0	0.00
	DICKEY F	134.0	-	134.0	1	1971	1971	187,400	0	0.00
	ESTABLISH CREEK	129.0	-	133.9	3	1979	1990	403,407	2	0.12
	FT CHAR BEND	129.7	-	132.4	10	1971	1995	1,194,851	4	0.24
	CROOK LIGHT	130.0	-	131.4	2	1986	1991	345,289	2	0.12
	TURKEY ISLAND	129.2	-	129.2	1	1976	1976	127,900	0	0.00
	TOWER ROCK QUARRY	127.0	-	127.0	1	1989	1989	108,370	1	0.06
	WHITE SAND	127.0	-	127.0	1	1979	1979	216,200	0	0.00
	MIDWEST TOWING	126.8	-	126.8	1	1990	1990	109,444	1	0.06
	RUBICON	126.5	-	126.5	1	1976	1976	93,000	0	0.00
	LTL ROCK LANDING	124.9	-	126.0	20	1967	1997	2,578,761	14	0.82
	KELLOGGS LANDING	125.0	-	125.6	7	1966	1980	1,094,900	1	0.06
	MUD HURDLE	123.4	-	124.5	3	1964	1990	420,339	1	0.06
	STE GEN BEND	119.5	-	123.0	4	1976	1991	538,953	2	0.12
	BAUMSTARDS	123.0	-	123.0	1	1969	1969	187,500	0	0.00
	JIM KENNEDY	122.0	-	122.6	4	1964	1976	437,600	0	0.00
	MORO ISLAND	118.5	-	122.5	7	1964	1990	926,775	5	0.29
	S GABOURI CREEK	122.4	-	122.5	2	1964	1994	110,547	1	0.06
	STANTON TWHD	122.0	-	122.0	1	1972	1972	158,900	0	0.00
	BIG FIELD LT	121.2	-	121.3	2	1987	1991	279,906	2	0.12
	OKAW RIVER	118.0	-	118.0	1	1977	1977	166,700	0	0.00
	MO KSKSKIA R	117.0	-	117.5	19	1974	1997	1,074,731	13	0.76
	RILEY LAKE	117.5	-	117.5	1	1979	1979	102,200	0	0.00
	ELLIS GROVE	116.0	-	117.5	13	1965	1989	2,578,356	4	0.24
	OKAW	117.0	-	117.0	1	1973	1973	155,800	0	0.00
	REILY LAKE	116.9	-	116.9	2	1978	1982	608,300	1	0.06

Appendix U-3: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	FARMERS LANDING	114.5	-	115.5	3	1980	1994	436,834	3	0.18
	CHEROKEE LANDING	112.5	-	113.2	5	1978	1995	700,036	4	0.24
	CHESTER IL	111.5	-	111.5	1	1970	1970	258,600	0	0.00
	CHESTER BRIDGE	109.0	-	110.5	13	1965	1996	1,877,661	7	0.41
	HORSE ISLAND	110.5	-	110.5	1	1968	1968	228,700	0	0.00
	CLARYVILLE	109.0	-	109.0	1	1989	1989	136,110	1	0.06
	BLOCKS LANDING	107.9	-	108.0	2	1966	1975	143,900	0	0.00
	SO IL SAND C	107.8	-	107.8	1	1989	1989	210,277	1	0.06
	FORD COAL DK	105.0	-	106.5	7	1981	1994	1,239,644	7	0.41
	KIRKS LANDING	103.5	-	104.4	3	1972	1973	796,700	0	0.00
	MANSKER LANDING	103.5	-	104.0	7	1974	1996	1,172,065	4	0.24
	WATERS LANDING	103.0	-	103.0	1	1995	1995	199,351	1	0.06
	ANCHORS LANDING	101.0	-	103.0	5	1967	1994	625,120	1	0.06
	BISHOP LIGHT	100.7	-	100.7	1	1976	1976	254,400	0	0.00
	LIBERTY ISLAND	96.6	-	100.0	12	1966	1994	1,929,151	10	0.59
	JONES TOWHD	96.4	-	98.8	5	1964	1996	1,116,806	1	0.06
	CORA DOCK	98.2	-	98.2	1	1976	1976	357,900	0	0.00
	WAGNERS LANDING	95.3	-	97.5	15	1964	1991	2,572,138	4	0.24
	ROMAN LANDING	95.5	-	96.5	12	1964	1990	1,616,436	2	0.12
	BACKBONE	94.0	-	94.8	11	1964	1994	1,683,239	6	0.35
	RED ROCK	94.0	-	94.5	3	1975	1981	567,500	2	0.12
	ROWLAND LIGHT	93.0	-	93.0	1	1992	1992	68,361	1	0.06
	76 TOWHEAD	90.7	-	92.0	14	1964	1992	2,516,716	4	0.24
	WILKERSON	91.4	-	91.6	2	1972	1973	356,200	0	0.00
	LINNHOFF L	91.6	-	91.6	1	1965	1965	217,200	0	0.00
	JONES TOWHED	91.4	-	91.4	1	1977	1977	8,900	0	0.00
	GILLS POINT	85.5	-	85.5	1	1974	1974	190,000	0	0.00

Appendix U-3: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	BRUNKHORST	84.5	-	84.7	6	1964	1976	1,464,300	0	0.00
	FOUNT BLUFF	82.8	-	84.0	4	1977	1986	751,800	3	0.18
	WHITTENBERG	81.3	-	81.5	4	1980	1995	336,580	4	0.24
	TUCKER POINT	81.0	-	81.1	2	1989	1990	298,431	2	0.12
	GRAND TOWER	77.0	-	80.4	10	1987	1996	1,074,546	10	0.59
	APPLE CREEK	74.5	-	76.0	7	1975	1989	1,801,490	2	0.12
	HINES LANDING	73.7	-	75.0	4	1974	1996	401,265	3	0.18
	CRAWFORD THD	73.0	-	73.0	1	1991	1991	119,112	1	0.06
	HANGING DOG	71.0	-	71.6	5	1971	1989	983,598	2	0.12
	SWIFTSU LWR	69.8	-	69.8	1	1968	1968	191,400	0	0.00
	TEATABLE LT	69.0	-	69.6	5	1988	1995	597,494	5	0.29
	MOCCASIN SPR	65.0	-	67.5	23	1965	1994	5,159,677	10	0.59
	TRAIL OF TRS	66.0	-	66.3	4	1970	1974	405,800	0	0.00
	WILLARDS LANDING	62.5	-	66.5	6	1964	1968	340,100	0	0.00
	BEE BAR LIGHT	63.5	-	65.8	11	1964	1990	1,557,822	3	0.18
	SHEPPARD POINT	62.8	-	64.4	9	1966	1991	931,217	3	0.18
	HAMBURG LANDING	60.8	-	64.3	14	1965	1990	1,753,668	1	0.06
	SCHENIMANS	60.0	-	62.3	4	1966	1969	350,000	0	0.00
	POE LANDING	57.9	-	61.7	10	1966	1977	1,248,900	0	0.00
	DUSTY BAR	59.5	-	61.0	3	1973	1977	342,100	0	0.00
	SWIFTS UPPER	60.2	-	60.2	1	1968	1968	169,200	0	0.00
	DEVILS ISLAND	54.8	-	60.0	14	1964	1995	1,885,311	2	0.12
	LOWER SWIFT	58.8	-	59.5	3	1966	1977	272,400	0	0.00
	PICAYUNE LIGHT	56.9	-	59.0	15	1966	1995	2,924,547	7	0.41
	FLORA CREEK	55.2	-	55.5	5	1964	1995	595,603	4	0.24
	CAPE ROCK	54.2	-	54.2	1	1970	1970	52,600	0	0.00
	WAHOO PILING	52.6	-	54.0	7	1978	1997	1,671,336	6	0.35

Appendix U-3: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	CAPE GIRARDU	52.0	-	53.0	8	1970	1991	2,459,869	2	0.12
	SLOAN CREEK	52.7	-	52.7	1	1976	1976	56,500	0	0.00
	DIAMOND SAND	52.0	-	52.0	1	1980	1980	29,400	1	0.06
	CAPE BEND	47.4	-	50.5	17	1965	1990	5,110,091	4	0.24
	CITY LIMIT LIGHT	50.4	-	50.4	2	1976	1976	942,100	0	0.00
	MARQUETTE LIGHT	49.4	-	50.2	7	1966	1990	2,726,278	3	0.18
	LONE STAR LIGHT	50.0	-	50.0	3	1990	1991	478,898	3	0.18
	CAPE LACROIX	47.4	-	50.0	5	1964	1997	1,718,091	2	0.12
	MOUTH SEMO POINT	48.0	-	48.0	1	1991	1991	19,999	1	0.06
	GRAYS POINT	45.5	-	47.6	27	1966	1995	4,517,748	14	0.82
	GRAYSBORO	47.4	-	47.4	1	1966	1966	33,000	0	0.00
	WEST LAKE QUARRY	47.0	-	47.0	3	1989	1991	501,284	3	0.18
	GALE LIGHT	46.0	-	46.0	1	1988	1988	121,658	1	0.06
	THEBES LIGHT	44.8	-	44.8	1	1977	1977	160,200	0	0.00
	DORRITY CREEK	44.0	-	44.5	8	1987	1997	708,985	8	0.47
	THEBES BRIDGE	43.5	-	44.0	5	1976	1990	1,106,326	4	0.24
	UNCLE JOE LIGHT	41.5	-	43.0	8	1982	1997	1,777,702	8	0.47
	COUNTERFEIT	41.0	-	43.0	20	1976	1991	4,546,595	13	0.76
	HANCOCK LIGHT	41.5	-	41.5	1	1994	1994	100,120	1	0.06
	COMMERCE MO	39.0	-	41.5	8	1977	1988	1,620,506	6	0.35
	BURNHAM ISLAND	38.0	-	39.0	10	1967	1997	2,341,227	6	0.35
	ALLEN TOWHED	37.2	-	38.0	7	1964	1988	872,765	1	0.06
	COMMERCE	38.0	-	38.0	1	1981	1981	93,500	1	0.06
	BEAVER DAM	37.5	-	37.5	1	1966	1966	45,200	0	0.00
	COMMERCIAL POINT	31.0	-	32.5	6	1988	1997	1,221,430	6	0.35
	DANIELS LIGHT	30.5	-	31.5	10	1964	1997	2,373,319	8	0.47
	PRICE LANDING	30.0	-	30.0	4	1975	1987	681,100	3	0.18

Appendix U-3: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	BUFFALO ISLAND	27.0	-	28.5	12	1968	1995	2,561,008	7	0.41
	SEMO GRAIN	28.5	-	28.5	1	1989	1989	268,074	1	0.06
	HACKERS TOWHED	26.5	-	27.5	4	1964	1967	1,164,100	0	0.00
	BROOKS POINT	25.8	-	27.0	3	1989	1991	962,236	3	0.18
	SLIDING TOWHED	23.4	-	24.6	15	1966	1995	2,897,637	8	0.47
	BROWNS BAR	24.5	-	24.5	1	1964	1964	79,000	0	0.00
	DOGTOOTH BEND	21.8	-	21.8	1	1981	1981	213,000	1	0.06
	THOMPSON LIGHT	18.0	-	21.0	10	1975	1997	2,293,642	6	0.35
	SCUDDERS	16.0	-	19.0	17	1970	1997	5,506,663	16	0.94
	PRICE LANDING	19.6	-	19.6	1	1989	1989	166,446	1	0.06
	GRAND LAKE	14.0	-	15.0	13	1980	1992	5,016,537	13	0.76
	GREENLEAF	14.5	-	14.5	1	1975	1975	256,400	0	0.00
	BEECHRIDGE	13.0	-	14.0	5	1964	1987	620,847	2	0.12
	HURRICANE	10.8	-	12.0	4	1964	1992	588,126	3	0.18
	ANTELOPE	8.0	-	11.5	2	1982	1997	192,804	2	0.12
	ELK ISLAND	8.5	-	9.0	6	1980	1997	1,236,094	6	0.35
	BOSTON BAR	8.5	-	8.5	1	1975	1975	98,400	0	0.00
	I-57 BRIDGE	6.5	-	7.5	6	1978	1991	2,083,094	5	0.29
	ELIZA POINT	6.4	-	7.0	7	1980	1987	1,787,195	7	0.41
	GREENFIELD	3.2	-	4.5	9	1965	1995	4,060,698	6	0.35
	STEVENSON LIGHT	3.8	-	4.5	12	1976	1997	3,520,463	11	0.65
	BIRDS POINT	2.0	-	2.0	1	1997	1997	299,028	1	0.06
	CAIRO POINT	0.8	-	1.0	2	1991	1997	480,162	2	0.12

* THROUGH 1997

Appendix U-4: Dredging summary for the USACE Rock Island District Illinois River navigation pools.

Pool	Dredge Cut	Approximate River Mile	Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
LAGRANGE	ABOVE LAGRANGE LOCK	80.0 - 81.0	3	1940	1992	302,111	1	0.06
	BRIGG'S LANDING	83.7 - 84.4	1	1943	1943	99,360	0	0.00
	GRAPE ISLAND	86.8 - 87.2	1	1996	1996	20,173	1	0.06
	BEARDSTOWN	87.5 - 89.5	10	1947	1996	334,990	8	0.47
	SUGAR ISLAND	94.0 - 95.2	4	1940	1962	112,134	0	0.00
	BROWNING LANDING	97.0 - 98.0	3	1943	1963	93,662	0	0.00
	ELM CREEK	102.4 - 102.8	1	1943	1943	17,678	0	0.00
	HOLMES LANDING	108.1 - 108.3	1	1943	1943	8,733	0	0.00
	ANDERSON LAKE	109.0 - 109.7	3	1951	1996	72,607	2	0.12
	GRAND ISLAND	109.7 - 110.7	2	1951	1990	63,097	1	0.06
	OTTER CREEK	110.6 - 112.5	3	1941	1962	247,717	1	0.06
	GRAND ISLAND HEAD	112.4 - 114.0	5	1943	1995	270,447	2	0.12
	MATANZAS BAY	114.0 - 116.0	3	1962	1994	181,389	2	0.12
	DEVIL'S ELBOW	116.2 - 117.2	4	1984	1995	202,302	4	0.24
	HISTORICAL CUT	117.6 - 118.8	1	1941	1941	37,333	0	0.00
	QUIVER ISLAND	120.0 - 123.0	15	1941	1996	1,755,707	4	0.24
	BIG SISTER CREEK	125.5 - 126.1	1	1962	1962	22,997	0	0.00
	SENATE ISLAND	132.0 - 135.0	9	1953	1996	542,738	7	0.41
	DUCK ISLAND	135.0 - 136.0	5	1953	1995	237,203	4	0.24
	COPPERAS CREEK	136.0 - 137.5	10	1942	1994	1,065,906	2	0.12
	LANCASTER LANDING	142.0 - 145.0	7	1946	1995	569,357	4	0.24
	KINGSTON MINES	145.0 - 146.7	17	1946	1996	882,806	12	0.71
	MACKINAW RIVER	146.7 - 148.0	33	1941	1996	2,734,867	17	1.00
	LAMARSHCRK/PEKIN BEND	148.0 - 153.1	16	1942	1992	1,211,002	4	0.24
	LICK CREEK	153.1 - 156.6	16	1944	1991	758,305	3	0.18
	BARTONVILLE	154.6 - 157.7	1	1996	1996	unknown	1	0.06

Appendix U-4: Cont.

Pool	Dredge Cut	Approximate River Mile	Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	KEYSTONE CREEK	157.0 - 157.5	1	1991	1991	21,302	1	0.06
	BELOW PEORIA LOCK	156.6 - 157.7	10	1941	1991	435,424	2	0.12
PEORIA	ABOVE PEORIA LOCK	157.9 - 158.1	4	1940	1979	60,936	0	0.00
	KICKAPOO CREEK	159.0 - 160.0	7	1940	1962	1,003,212	0	0.00
	PEORIA BRIDGES/FARM CREEK	161.0 - 163.0	7	1942	1979	313,964	0	0.00
	TEN MILE CREEK	166.0 - 168.4	3	1946	1969	260,121	0	0.00
	BLUE CREEK/ROME LIGHT	173.0 - 178.0	5	1944	1959	1,065,550	0	0.00
	SENACHWINE CREEK	180.8 - 181.8	5	1966	1992	198,255	1	0.06
	HENRY	193.3 - 196.3	4	1942	1992	82,490	1	0.06
	ILLINOIS POWER	212.0 - 213.7	1	1946	1946	94,739	0	0.00
	CLARK ISLAND	214.5 - 215.7	5	1987	1995	94,560	5	0.29
	SPRING VALLEY	215.9 - 218.4	7	1942	1996	274,960	4	0.24
	SPRING CREEK/HUSE SLOUGH	218.5 - 221.1	9	1942	1996	578,816	2	0.12
	PERU BEND	223.3 - 224.2	3	1944	1952	103,364	0	0.00
	LA SALLE BEND	225.4 - 225.7	1	1991	1991	8,637	1	0.06
	VERMILLION RIVER	226.2 - 226.9	3	1944	1994	602,619	1	0.06
	DEER PARK LIGHT	227.7 - 228.5	1	1992	1992	36,288	1	0.06
	HISTORICAL CUT	228.8 - 229.4	1	1946	1946	77,631	0	0.00
	BELOW STARVED ROCK	230.2 - 230.8	6	1990	1995	25,848	6	0.35
STARVED ROCK	ABOVE STARVED ROCK LOCK	231.2 - 231.5	2	1990	1994	7,286	2	0.12
	BULLS ISLAND	240.5 - 241.5	6	1987	1996	75,718	6	0.35
	BELOW MARSEILLES LOCK	244.0 - 244.5	5	1990	1994	9,112	5	0.29
MARSEILLES	MARSEILLES CANAL	244.7 - 247.0	5	1990	1996	19,110	5	0.29

Appendix U-4: Cont.

Pool	Dredge Cut	Approximate River Mile	Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	GRIST ISLAND	258.6 - 259.3	3	1987	1995	35,294	3	0.18
	BELOW DRESDEN ISLAND LOCK	270.8 - 271.4	6	1988	1994	63,114	6	0.35
DRESDEN ISLAND	ABOVE DRESDEN ISLAND LOCK	271.5 - 272.0	1	1995	1995	16,200	1	0.06
	BONNEL BEND	273.7 - 274.3	1	1987	1987	unknown	1	0.06
	TREATS ISLAND	278.8 - 279.5	1	1993	1993	2,771	1	0.06
	BELOW BRANDON ROAD LOCK	285.2 - 285.8	6	1988	1994	18,748	6	0.35
BRANDON ROAD	BELOW LOCKPORT LOCK	290.0 - 291.0	6	1988	1994	650	6	0.35

Appendix U-5: Dredging summary for the USACE St. Louis District Illinois River navigation pools.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
IWW -	LAGRANGE ISLAND	80.1	-	80.1	1	1990	1990	104,722	1	0.06
ALTON	LAGRANGE LOWER	79.5	-	80.0	8	1976	1989	612,867	5	0.29
	INDIAN CREEK	71.4	-	79.7	19	1963	1997	2,599,298	12	0.71
	OLD LAGRANGE LAKE	76.9	-	78.4	7	1976	1994	1,097,284	2	0.12
	MOORE ISLAND	76.3	-	76.4	2	1966	1981	121,900	1	0.06
	KAMP CREEK	74.5	-	76.0	9	1967	1997	1,369,026	6	0.35
	WILSON ISLAND	73.5	-	73.5	1	1977	1977	21,300	0	0.00
	MEREDOSIA	70.5	-	71.0	7	1969	1987	1,289,723	2	0.12
	MCGEE CREEK	66.9	-	67.5	7	1966	1984	1,206,200	1	0.06
	NAPLES	64.0	-	65.9	8	1966	1986	1,254,500	1	0.06
	VALLEY CITY	61.3	-	63.0	6	1976	1997	551,089	2	0.12
	MAUVAISTER	62.6	-	62.6	1	1975	1975	254,400	0	0.00
	BIG BLUE CREEK	57.8	-	59.0	4	1975	1986	120,300	2	0.12
	FLORENCE	57.8	-	55.8	4	1965	1995	620,439	2	0.12
	LITTLE BLUE	54.0	-	54.0	2	1975	1979	162,200	0	0.00
	BIG SWAN	52.3	-	52.8	2	1995	1995	153,141	2	0.12
	MONTEZUMA	51.0	-	51.3	2	1967	1997	172,324	1	0.06
	ROCK CREEK	51.0	-	51.0	1	1976	1976	48,000	0	0.00
	PILOT PEAK	46.5	-	47.8	3	1974	1979	178,900	0	0.00
	BUCKHORN ISLAND	46.1	-	47.0	3	1975	1987	343,487	1	0.06
	PEARL GA	46.9	-	46.9	1	1974	1974	71,600	0	0.00
	HILLVIEW	46.5	-	46.5	1	1977	1977	55,300	0	0.00
	VAN GEASON ISLAND	45.0	-	45.3	2	1977	1987	99,199	1	0.06
	GRAND PASS BEND	44.1	-	44.1	1	1976	1976	227,100	0	0.00
	PEARL LANDING	41.4	-	43.9	5	1965	1994	668,855	1	0.06
	PEARL ISLAND	40.5	-	41.4	2	1976	1987	120,956	1	0.06
	SAND CREEK	41.5	-	41.5	1	1972	1972	382,200	0	0.00

Appendix U-5: Cont.

Pool	Dredge Cut	Approximate River Mile			Number of Dredging Events	Earliest Recorded Dredging Event	Most Recent Dredging Event*	Total Volume Dredged (yd^3)	Number of Recent Dredging Events (1980-1996)	Recent Dredging Frequency (1980-1996) cuts/year
	WING ISLAND	40.5	-	40.5	1	1984	1984	192,800	1	0.06
	SPAR ISLAND	39.0	-	39.0	1	1996	1996	67,217	1	0.06
	TWIN ISLAND	38.7	-	38.7	1	1972	1972	315,900	0	0.00
	FISHER ISLAND	38.0	-	38.0	1	1987	1987	78,140	1	0.06
	APPLE CREEK	37.3	-	37.3	1	1976	1976	61,900	0	0.00
	PANTHER CREEK	36.3	-	37.0	5	1969	1996	904,651	4	0.24
	KAMPSVILLE	31.0	-	32.0	4	1971	1976	176,500	0	0.00
	WILLOW ISLAND	31.0	-	31.0	2	1986	1987	109,700	2	0.12
KAS-KASKIA	KAS RIVER MOUTH	000.1	-	000.5	17	1978	1995	1,828,811	15	0.88
RIVER	COAL DOCK	024.8	-	024.8	1	1986	1986	11,500	1	0.06

* THROUGH 1997

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The methods and results of a detailed evaluation of the cumulative ecological effects resulting from select physical and biological changes that have occurred since construction of the 9-foot Channel Project are presented. Predictions of changes between the present and 2050, given current management protocols and planned or anticipated habitat enhancement projects, are also made. Physical habitat changes evaluated include plan form, current velocity, sediment types and water depths. Twenty-three guilds of aquatic organisms are identified and used in this analysis. The analyses are generally representative of summer low-flow habitat conditions and adult aged organisms. To evaluate changes in the guilds, their major habitat requirements are compared with the amount of increase or decrease in suitable habitat. The percent change in the area of available habitats is assumed to proportionally affect the abundance of individuals within each guild. Best professional judgment is used to account for changes due to contamination, sedimentation, harvest and other stressors. Lack of data precluded analysis of certain habitats, such as floodplains and a formal risk assessment is not made because of the limitations of both physical and ecological information.

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