Long Term Resource Monitoring Program

Program Report

98-P005

1991 Annual Status Report

A Summary of Aquatic Vegetation Monitoring at Selected Locations in Pools 4, 8, 13, and 26 and La Grange Pool of the Upper Mississippi River System

June 1998

The Environmental Management Technical Center issues LTRMP Program Reports to provide Long Term Resource Monitoring Program partners with programmatic documentation, procedures manuals, and annual status reports.

Cover graphic by Mi Ae Lipe-Butterbrodt

1991 Annual Status Report
A Summary of Aquatic Vegetation Monitoring at Selected Locations in Pools 4, 8, 13, and 26 and La Grange Pool of the Upper Mississippi River System

by

Sara Rogers
U.S. Geological Survey
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

Theresa Blackburn
Iowa Department of Natural Resources
Mississippi River Monitoring Station
206 Rose Street
Bellevue, Iowa 52031

Daniel Dieterman
Minnesota Department of Natural Resources
1801 S. Oak Street
Lake City, Minnesota 55041

Heidi Langrehr
Wisconsin Department of Natural Resources
Onalaska Field Station
575 Lester Avenue
Onalaska, Wisconsin 54650

John Nelson and Susan Romano-Peitzmeyer
Illinois Natural History Survey
Havana Field Station
704 N. Schrader Avenue
Havana, Illinois 62644

June 1998

Suggested citation:

Rogers, S., T. Blackburn, D. Dieterman, H. Langrehr, J. Nelson, and S. Romano-Peitzmeyer. 1998. 1991 annual status report: A summary of aquatic vegetation monitoring at selected locations in Pools 4, 8, 13, and 26 and La Grange Pool of the Upper Mississippi River System. U.S. Geological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, June 1998. LTRMP 98-P005. 21 pp. + Appendixes A–B

Additional copies of this report may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (1-800-553-6847 or 703-487-4650). Also available to registered users from the Defense Technical Information Center, Attn: Help Desk, 8725 Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218 (1-800-225-3842 or 703-767-9050).

Contents

Tables

Figures

Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers' Environmental Management Program. The LTRMP is being implemented by the Environmental Management Technical Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This report presents the results of aquatic vegetation surveys conducted by field station personnel under direction of the Environmental Management Technical Center during the 1991 growing season. Selected areas in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool on the Illinois River were surveyed. This report satisfies, for 1991, Task 2.2.4.6, *Evaluate and Summarize Annual Present-day Results* under Goal 2, *Monitor Resource Change* of the Operating Plan (U.S. Fish and Wildlife Service 1993). The purpose of this report is to provide a summary of data regarding the presence and distribution of submersed aquatic vegetation collected from the field stations for 1991. This report was developed with funding provided by the Long Term Resource Monitoring Program.

1991 Annual Status Report
A Summary of Aquatic Vegetation Monitoring at Selected Locations in Pools 4, 8, 13, and 26 and La Grange Pool of the Upper Mississippi River System

by

Sara Rogers, Theresa Blackburn, Daniel Dieterman, Heidi Langrehr,
John Nelson, and Susan Romano-Peitzmeier

Abstract

Aquatic vegetation of the Upper Mississippi River System is monitored as part of the Long Term Resource Monitoring Program. This report summarizes the 1991 effort of monitoring submersed aquatic vegetation (SAV) along transects permanently established in vegetated locations in four navigation pools of the Upper Mississippi River and one navigation pool of the Illinois River. Seventeen species of submersed aquatic plants were found along transects in Pools 4, 8, 13, 26, and La Grange Pool. The highest number of submersed aquatic plant species found in any one pool was 16 in Pool 4 and the lowest number was 6 in La Grange Pool. Coon's tail (*Ceratophyllum demersum*) and sago pondweed (*Potamogeton pectinatus*) were the only two species found in every study pool during both spring and summer sampling. Decreases in pondweed species noticeably affected the number of transect sites with SAV in Pools 4 and 13. In Pool 8, nearly all species declined between sampling periods and the proportion of sites with SAV dropped to less than 10% by August, the most decline of any pool.

Introduction

Aquatic vegetation of the Upper Mississippi River System (UMRS) is monitored as part of the Long Term Resource Monitoring Program (LTRMP; U.S. Fish and Wildlife Service 1993). The trends in the status of the vegetation are reported in annual status reports, and the data provides a baseline of information to which future observations can be compared. In combination with other monitoring conducted for the LTRMP, the overall mission is to provide decision makers with scientifically sound and useful information for effective river management. The purpose of this report is to document sampling along transects at selected locations in 1991. This report also provides an initial indication of features of submersed aquatic vegetation (SAV) that can be compared to future monitoring efforts.

Submersed macrophytes have always played an important role in the UMRS ecosystem. These plant communities provide food for migratory waterfowl (Korschgen et al. 1988) and improve the water quality by stabilizing sediments, filtering out suspended materials, and taking up nutrients that can otherwise support nuisance algal growth (Barko et al. 1991). Submersed aquatic macrophytes also provide nursery areas for young fish, serve as spawning habitat, and support invertebrate populations by providing structure and surface area (Engel 1990).

We have been unable to understand or anticipate many changes in the distribution of SAV in the UMRS, partly because few studies have adequately addressed the questions. Biologists have high interest and concern for this important component, however, especially following the mid- to late-1980s when widespread and sudden declines in the abundance of wild celery (*Vallisneria americana*) from Pools 5 to 19 were observed (E. Nelson and C. Cheap, U.S. Fish and Wildlife Service, Winona, Minnesota, unpublished data; C. Korschgen, Northern Prairie Wildlife Research Center, Jamestown, North Dakota, unpublished data; J. Lyons, U.S. Fish and Wildlife Service, McGregor, Iowa, personal communication; R. Anderson, Western Illinois University, Macomb, personal communication; W. Thrune, U.S. Fish and Wildlife Service, La Crosse, Wisconsin, personal communication). Among those especially concerned were biologists familiar with the history of the Illinois River. Submersed aquatic vegetation in much of the river rapidly disappeared during the 1950s and only remnant populations now survive (Talkington and Semonin 1991).

Long-term monitoring can have a substantial role in increasing our understanding of trends in this resource by addressing the following questions:

(1) How temporally and spatially dynamic is SAV in the UMRS?
(2) Are we observing short-term fluctuations in one or more species or is SAV becoming irreparably lost?
(3) Based on patterns observed, what factors most likely contribute to the observed changes?

The 1991 growing season was the first year we conducted field surveys for the LTRMP specifically to collect data on the distribution and relative abundance of SAV throughout each resource trend analysis pool. The objectives for monitoring aquatic vegetation in the UMRS are to

(1) document the presence and distribution of SAV in selected locations of the UMRS,
(2) compare present and future distribution of SAV, and
(3) identify environmental factors potentially responsible for long- and short-term changes in the distribution of SAV.

This report partially fulfills the first objective. Fulfillment of the second objective will be accomplished over the course of the LTRMP beginning in the second year and gaining significance each year. Fulfillment of the third objective requires research in addition to monitoring. Measuring the effect of the environment on abundance and distribution requires focused initiatives to explore plant response to key factors, singly or in combination with one another.

Study Areas

The LTRMP vegetation study areas include river reaches in the UMRS, four on the Mississippi River and one on the Illinois River (Figure 1). Study areas are referred to herein by the navigation pool designations according to the U.S. Army Corps of Engineers lock and dam system. Mississippi River navigation pools studied are Pool 4 (Mississippi River mile [M] 752 to 797), Pool 8 (M679 to 703), Pool 13 (M523 to 557), Pool 26 (M202 to 242), and La Grange Pool of the Illinois River (Illinois River mile [I] 80 to 158). River miles for the Mississippi are measured from the confluence of the Mississippi and Ohio Rivers and for the Illinois from the confluence of the Mississippi and Illinois Rivers.

These study pools were chosen, in part, to reflect important differences in geomorphology, floodplain land use, and water level management strategies that exist with the UMRS. Pools 4, 8, and 13 are located in an upper impounded reach characterized by high percentages of open water and aquatic vegetation and low agricultural use. Relatively high percentages of the total aquatic area in these study reaches are composed of contiguous (to the main channel) backwaters, and relatively low percentages are composed of main channel (Table 1). Qualitatively, Pools 4, 8, and 13 are geomorphically complex and richly braided by side channels and backwaters. Pool 26, in a lower impounded reach, is characterized by relatively low percentages of open water and aquatic vegetation and a high percentage of agriculture in the floodplain. The main channel and main channel border habitats make up the greater proportion of the water surface (Table 1) and habitats suitable for aquatic vegetation make up a very small proportion of the total area (Peck and Smart 1986). La Grange Pool is similar to Pool 26 in floodplain composition, but is similar to Pools 8 and 13 in composition of the aquatic area. In fact, La Grange Pool has the greatest percentage (52.2%) of contiguous backwaters among the LTRMP study areas, but aquatic vegetation is not present in most of them.

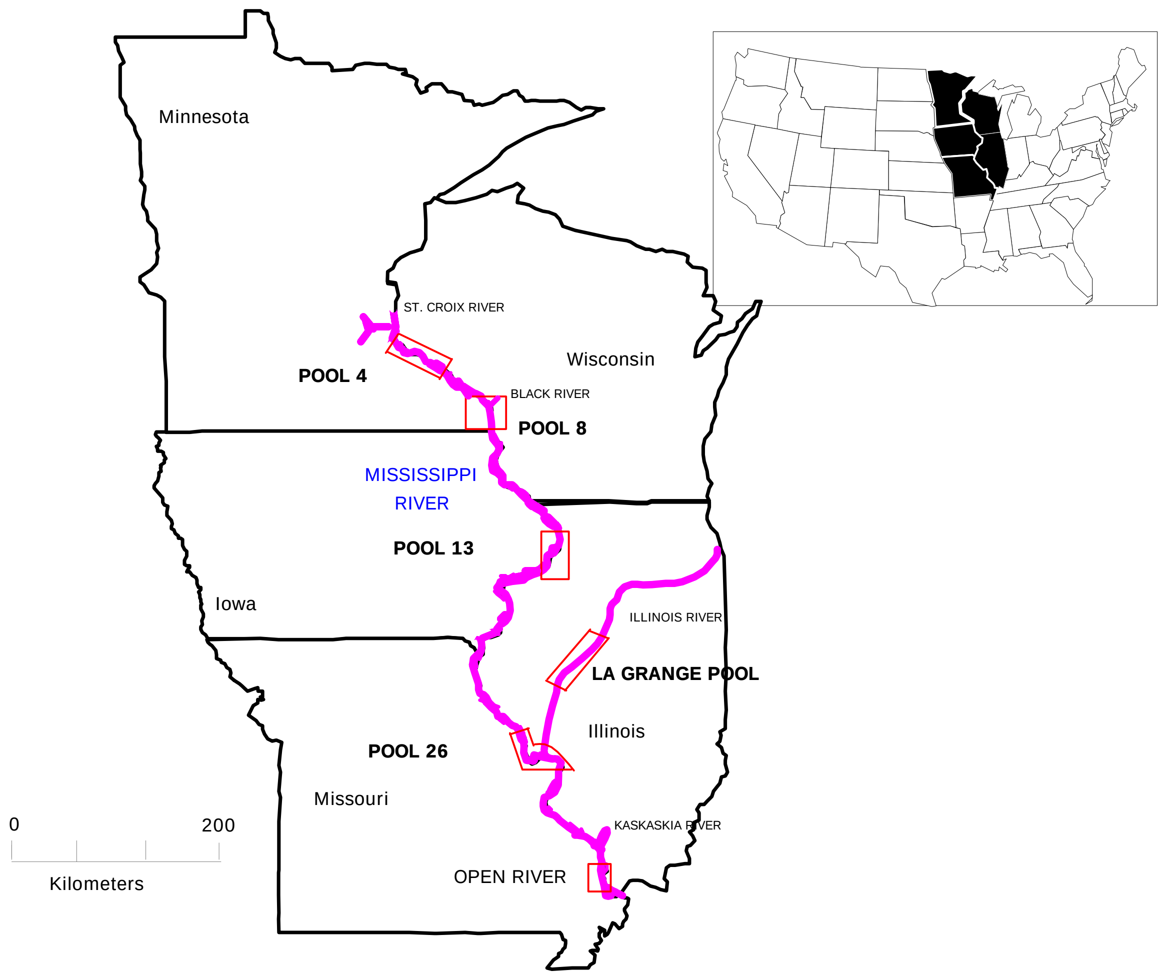

Figure 1. Main stem of the Upper Mississippi River System with the study reaches in the Long Term Resource Monitoring Program submersed vegetation surveys of 1991 (Pools 4, 8, 13, 26, and La Grange Pool). The Open River reach was not selected as a study site because of the lack of habitat for submersed vegetation.

To locate vegetated areas to monitor, we conducted field reconnaissance and used historical reports, conversations with biologists familiar with the river, and 1989 aerial photographs and land cover vegetation maps. Depending on the size of the backwater and the extent of the vegetation, transects either traversed all or a portion of the backwater or, if bordering a channel or large expanse of open water, extended to the edge of a vegetated bed.

In Pool 4, we selected 10 contiguous backwater lakes for placement of permanent transects (Figure 2). The transect locations were distributed in both the upper and lower portions of the pool, but not in Lake Pepin (Appendix A). Upper pool locations included Dead Slough Lake, Goose Lake, Mud Lake, and Bay City Flats. Lower pool locations (below Lake Pepin) included Big Lake, Robinson Lake, Peterson Lake, Lower Peterson Lake, Rice Lake, and Big Lake Bay.

Table 1. Key features of the floodplain and aquatic area compositions of the five Mississippi and Illinois River study reaches monitored for aquatic vegetation in 1991 for the Long Term Resource Monitoring Program.[a]

		Floodplain composition (%)[b]			Aquatic area composition (%)[c]	
Study reach	**Floodplain area (ha)**	**Open water[d]**	**Aquatic vegetation[e]**	**Agriculture**	**Contiguous backwater**	**Main channel**
Pool 4	28,358	50.5	10.0	12.1	21.3	10.5
Pool 8	19,068	40.1	14.4	0.9	30.6	14.2
Pool 13	34,528	29.7	8.6	27.9	28.5	24.7
Pool 26	51,688	13.4	1.4	65.4	17.3	54.4
La Grange Pool, Illinois River	89,554	15.7	2.2	59.6	52.2	21.3

[a] Table from Gutreuter et al. (1997).

[b] Data on floodplain composition are from Laustrup and Lowenberg (1994).

[c] Aquatic area is that portion of the floodplain that is inundated at normal water elevations. Data on the composition of aquatic areas are from the Long Term Resource Monitoring Program aquatic areas spatial database.

[d] Submersed vegetation, when detectable, was merged with the open water class. Main channel includes area in the navigation channel and main channel border areas.

[e] Aquatic vegetation includes rooted floating aquatics and emergents only.

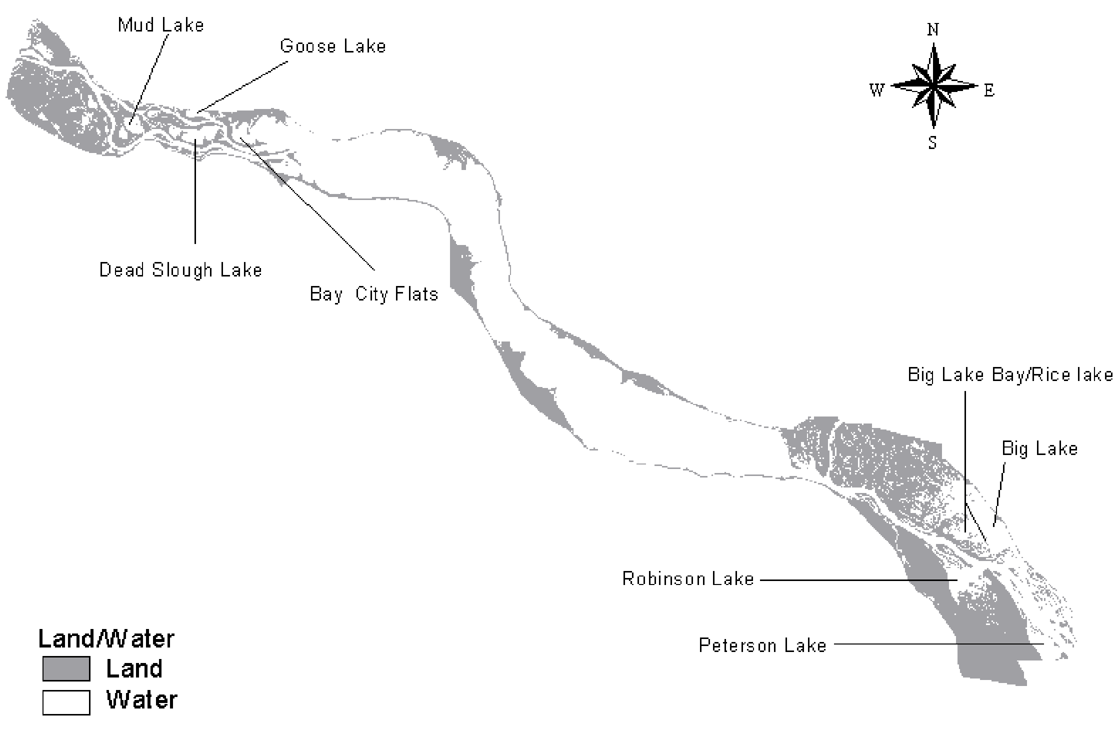

Figure 2. Pool 4, Upper Mississippi River, transect locations for the 1991 monitoring of submersed aquatic vegetation for the Long Term Resource Monitoring Program.

In Pool 8, we selected five locations for placement of permanent transects including Target Lake, Lawrence Lake, Shady Maple, the interior of Horseshoe Island, and a backwater area near Goose Island, (Figure 3). These locations were primarily in the lower two thirds of the pool.

In Pool 13, we selected seven locations with SAV for placement of permanent transects (Figure 4). The transect locations were distributed primarily in the middle and lower portions of the pool and included backwater habitats and impounded areas. Locations chosen were Brown's Lake, Savanna Bay, Spring Lake, Pomme de Terre, Potter's Marsh, Lower Johnson Creek, and Johnson Creek Levee (Appendix A).

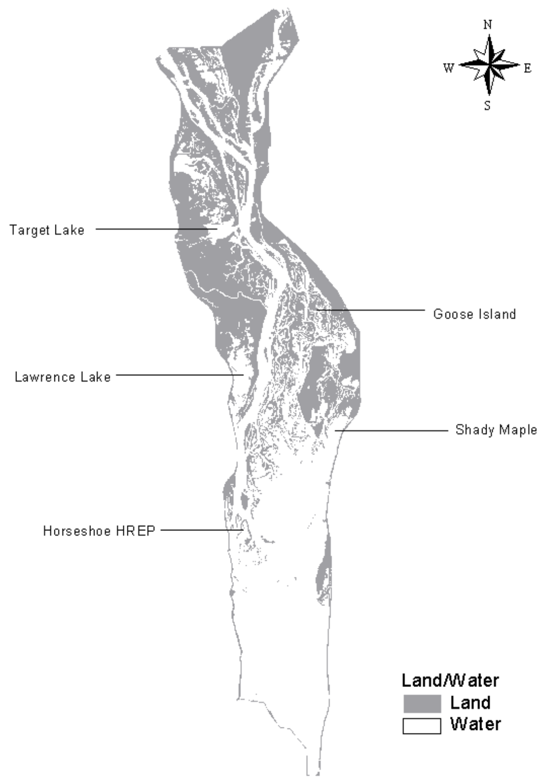

Figure 3. Pool 8, Upper Mississippi River, transect locations for the 1991 monitoring of submersed aquatic vegetation for the Long Term Resource Monitoring Program.

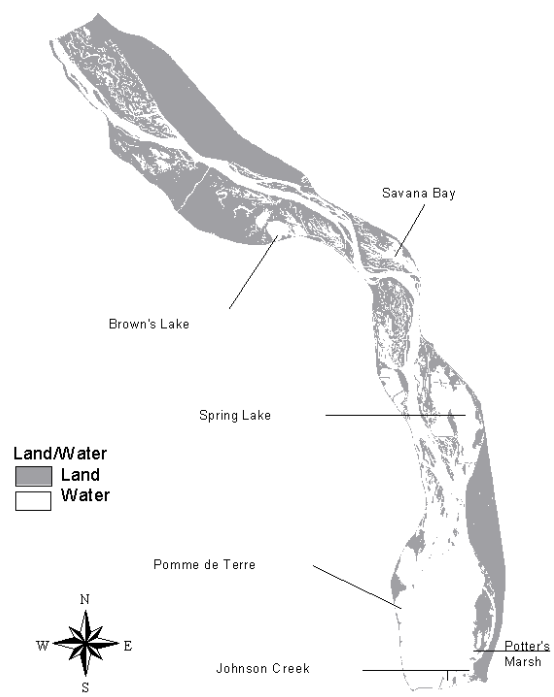

Figure 4. Pool 13, Upper Mississippi River, transect locations for the 1991 monitoring of submersed aquatic vegetation for the Long Term Resource Monitoring Program.

In Pool 26, we selected three vegetated backwater sites for placement of permanent transects (Figure 5). Transect locations were distributed in the Calhoun Point area, which consists of several backwater lakes, sloughs, and wet-weather (temporary) ponds, and in Swan Lake and Stump Lake (Appendix A). The selected areas are actually managed backwaters of the lower Illinois River. Using control structures and pumping, the Illinois Department of Natural Resources seasonally drains these areas for waterfowl management.

In La Grange Pool, we selected three backwaters for transect locations including Point Lake, Spring Lake, and Banner Marsh (Figure 6). The three are among the few locations where submersed vegetation are still found in this river reach. These backwaters are classified as isolated and are protected from the main stem of the Illinois River by agricultural levees. Point Lake, however, often receives overflow water from the main channel of the Illinois River. Banner Marsh (Bulrush Pond) and Spring Lake are actively managed for fishing and are completely isolated.

Methods

Transect Sampling

We positioned transects at regular intervals, from 50 to 200 m apart depending on the size of the area, and perpendicular to shorelines. In some large backwaters, we positioned transects in groups of three or four and placed several groups throughout the backwater. Peterson Lake (Pool 4), for example, has three transects in the upper portion, three in the middle portion, and four in the lower portion. No sampling was performed in the areas between the groups.

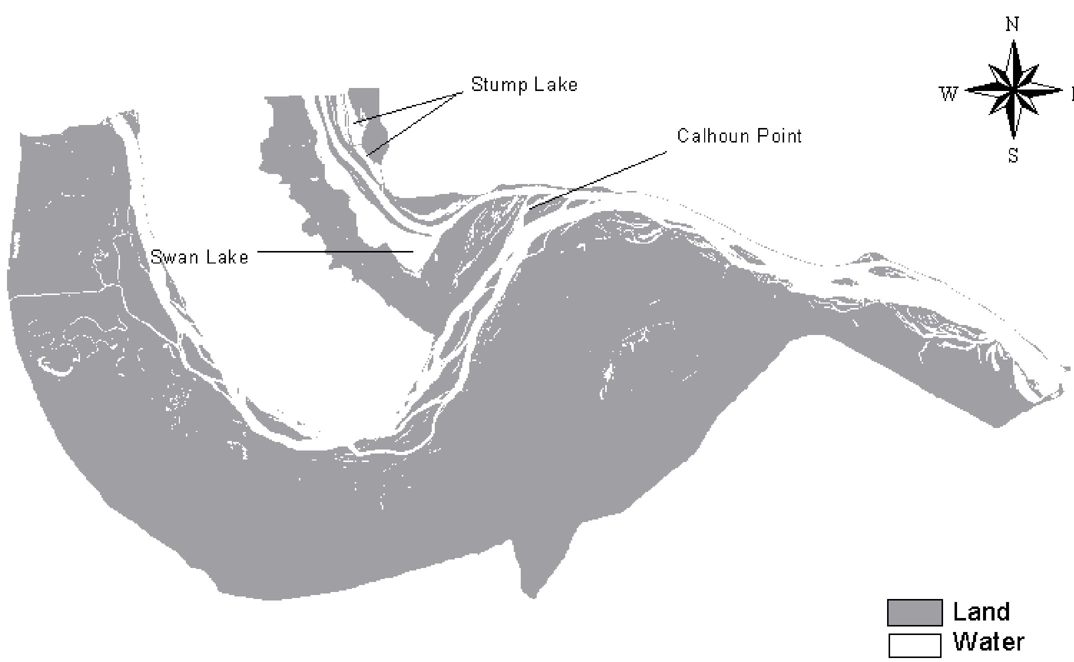

Figure 5. Pool 26, Upper Mississippi River, transect locations for the 1991 monitoring of submersed aquatic vegetation for the Long Term Resource Monitoring Program.

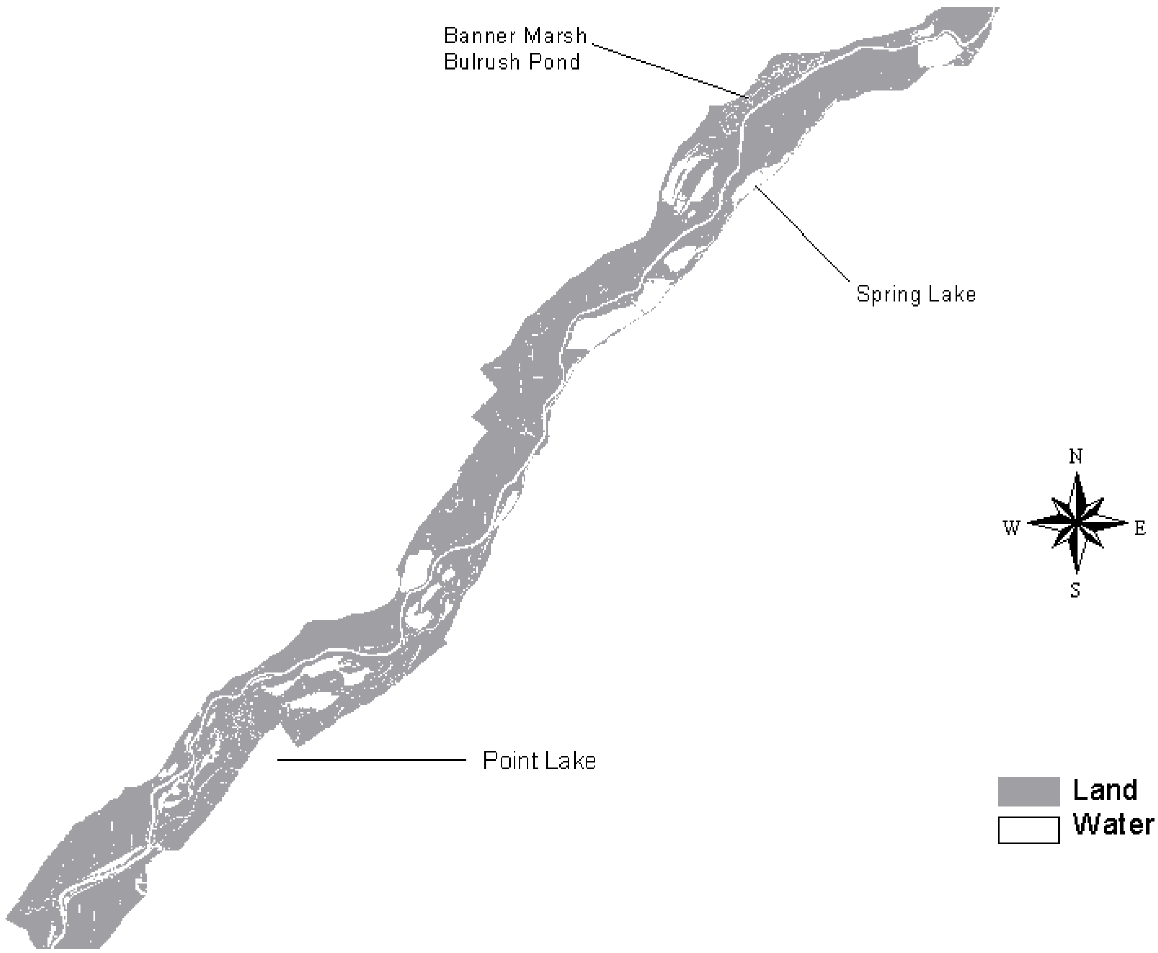

Figure 6. La Grange Pool, Illinois River, transect locations for the 1991 monitoring of submersed aquatic vegetation for the Long Term Resource Monitoring Program.

In most transect locations, sampling was performed twice during the growing season to observe seasonal changes in species composition and relative frequencies. Several transect locations were not chosen until the summer sampling period, thus, sampling was performed only once at those locations. Locations sampled only during the summer included Horseshoe Island and the Goose Island backwater (Pool 8), Savanna Bay and Spring Lake (Pool 13), and Banner Marsh (La Grange Pool). Sampling was done at only every other site in Swan Lake (Pool 26) during the summer sampling period after preliminary survey work revealed that the vegetated area had been uprooted. Also, Stump Lake (Pool 26) was drained in the summer and sampling could not be conducted there. We began sampling late in the spring sampling window (which was to run from May 15 through June 15) because time was taken at the beginning of the season to select locations and mark transect starting points. Sampling, therefore, began in late May or early June and continued into the first week of July. Sampling dates for each pool location and for each sampling period are listed in Appendix A.

Sampling along the transects was at regularly spaced intervals (sites) such that a grid-like sampling scheme of evenly distributed sampling sites was imposed over a backwater or vegetated area. Sites were 15 m apart in Pools 8, 13, and 26 and in La Grange Pool, but 30 m apart in Pool 4 because several of the backwaters were too large to sample at the 15-m interval (Appendix A). The sampling technique was modified from a technique used by Jessen and Lound (1962). At each site along a transect, a 2-m diameter sampling area was divided into three equal portions. We sampled plants once in each of the three portions by casting a long-handled thatching rake to the bottom and twisting it to snag plants—instead of dragging it as did Jessen and Lound. (In Pool 4, the rake was dragged over a distance extending up to 0.6 m along the sediment surface.) The thatching rake has a 15-inch head with 20, 5-inch-long teeth and samples about 0.1 m^2. The submersed species on the rake were identified and recorded. After all three casts were made, each species recovered was assigned a rating of from 1 to 4—instead of from 1 to 5 as did Jessen and Lound—based on the number of times each species appeared on the rake at each sampling site. A rating of 4 was assigned only if a species completely covered the rake teeth on all three casts.

If floating-leaved species were present, they were recorded and assigned a rating based on four cover classes (1–25% visible vegetative cover within the sample area, 26–50%, 51–75%, and 76–100%). Floating-leaved species are listed in the taxa list (Appendix B) but were not used in analysis of data because our focus was on submersed species.

Fassett (1966) and Gleason and Cronquist (1991) were the primary keys used for plant identification. Scientific nomenclature and common names were taken from the U.S. Department of Agriculture PLANTS Database on the Internet (www.itis.usda.gov/). A list of common and scientific names of plants is found in Table 2.

Table 2. Submersed and floating-leaved aquatic vegetation most likely to be found in the area covered by the Long Term Resource Monitoring Program, arranged alphabetically by common name within family.

Family	Common name[a,b]	Scientific name[a]
Ceratophyllaceae	Coon's tail, coontail	*Ceratophyllum demersum*
Characeae	Chara	*Chara* spp.
Characeae	Nitella	*Nitella* spp.
Haloragaceae	Northern watermilfoil[b], shortspike watermilfoil	*Myriophyllum sibiricum* Komarov
Haloragaceae	Eurasian watermilfoil[b], spike watermilfoil	*Myriophyllum spicatum* L.
Hydrocharitaceae	Canadian waterweed	*Elodea canadensis*
Hydrocharitaceae	Western waterweed	*Elodea nuttallii* Planch.
Hydrocharitaceae	Wild celery[b], American eelgrass	*Vallisneria americana* Michx.
Lentibulariaceae	Common bladderwort	*Utricularia macrorhiza* Le Conte
Najadaceae	Brittle waternymph	*Najas minor* All.
Najadaceae	Nodding waternymph, bushy pondweed	*Najas flexilis* (Willd.) Rostk. & Schmidt
Najadaceae	Slender waternymph	*Najas gracillima* (A. Braun ex Engelm.) Magnus
Najadaceae	Southern waternymph	*Najas guadalupensis* (Spreng.) Magnus
Nymphaeaceae	American lotus	*Nelumbo lutea* (Willd.) Pers.
Nymphaeaceae	Yellow pondlily	*Nuphar lutea* (L.) Sm.
Nymphaeaceae	White waterlily	*Nymphaea odorata* Ait.
Onagraceae	Floating primrosewillow	*Jussiaea repens* L.

Table 2. Continued.

Family	Common name[a,b]	Scientific name[a]
Pontederiaceae	Water stargrass, grassleaf mudplantain	*Heteranthera dubia* (Jacq.) MacM.
Potamogetonaceae	Curly pondweed, curlyleaf pondweed	*Potamogeton crispus* L.
Potamogetonaceae	Flatstem pondweed	*Potamogeton zosteriformis* Fern.
Potamogetonaceae	Illinois pondweed	*Potamogeton illinoisensis* Morong.
Potamogetonaceae	River pondweed[b], longleaf pondweed	*Potamogeton nodosus* Poir
Potamogetonaceae	Leafy pondweed	*Potamogeton foliosus* Raf.
Potamogetonaceae	Variableleaf pondweed	*Potamogeton gramineus* L.
Potamogetonaceae	Ribbonleaf pondweed	*Potamogeton epihydrus* Raf.
Potamogetonaceae	Richardson's pondweed	*Potamogeton richardsonii* (Benn.) Rydb.
Potamogetonaceae	Small pondweed	*Potamogeton pusillus* L.
Potamogetonaceae	Sago pondweed	*Potamogeton pectinatus* L.
Ranunculaceae	Longbeak buttercup	*Ranunculus longirostris* Godron.
Ranunculaceae	White water-crowfoot	*Ranunculus trichophyllus* Chauix.
Zannichelliaceae	Horned pondweed	*Zannichellia palustris* L.

[a] Scientific nomenclature and common names follow the U.S. Department of Agriculture PLANTS Database on the Internet (www.itis.usda.gov/).

[b] Common names most often used by Upper Mississippi River managers are also included if different from the common names listed in the U.S. Department of Agriculture PLANTS Database on the Internet.

At least one sample of each species found was collected for reference and archiving. After drying, pressing, mounting, and labeling, specimens were stored at each field station. Two species of narrow-leaved pondweeds, small pondweed (*Potamogeton pusillus*) and leafy pondweed (*P. foliosus*), collectively referred to as small and leafy pondweeds, were not distinguished from each other during sampling in the field and were combined during analysis. Two species of macroalgae, chara (*Chara* spp.) and nitella (*Nitella* spp.), were included in the analysis with the vascular plants.

Environmental Factors

Sediments

To acquire information on the relation between macrophyte presence and sediment composition, sediments at transect sites were cataloged subjectively into five broad categories (muck-organic, silt-clay, sand-silt, sand, and sand-clay) based on visual and tactile characteristics. About 10% of the sites along transects were randomly selected for collecting sediment cores. The cores were collected with a Wildco sediment corer with a 5-cm ID acrylic core liner (Wildlife Supply Company, Saginaw, Michigan) to a depth of approximately 10 cm. Cores were frozen for later analysis. Measured volumes of the sediment were dried at 105 °C for about 12 h to determine sediment moisture content and bulk density. Dried samples were combusted in a muffle furnace at 550 °C for estimations of organic matter content from loss of mass following ignition (Allen et al. 1974).

Nutrients

Aboveground plant tissues of several common species of SAV were collected from a few randomly selected transect sites to determine nitrogen and phosphorus content. Tissue concentrations have been considered reliable indicators of the availability of an element in the environment (Gerloff and Krombholz 1966). Forty samples from all pools, except Pool 4, were collected and analyzed. Dried above-ground plant tissue samples were ground (<0.7 mm diameter) in a Wiley Mill and digested with sulfuric acid and hydrogen peroxide (Allen et al. 1974). Both N and P concentrations were determined colorimetrically with a Technicon Autoanalyzer II (Bran + Luebbe Analyzing Technology Inc., Elmsford, New York).

Statistical Analysis

The frequency of a species is defined as $f_i = j_i/n$ where j_i = number of sample sites containing species *i* on at least one of the three rake casts, and *n* = total number of sample sites. Relative frequency of a species is defined as $rf_i = e_i/Ef$ where e_i = the number of rake casts for species *i*, and Ef = number of rake grabs for all species. Species of floating-leaved vegetation were omitted from the calculations because the life form is better documented using a geographic information system. To test for significant changes in frequencies for a species between the two sampling periods, a value for Z was calculated with the following formula:

$$Z = p_1 - p_2 / \surd pq[(1/n_1)+(1/n_2)]$$

where

$p = j_1 + j_2/n_1 + n_2$;

$q = 1 - p$;

p_1 and p_2 are the spring and summer proportions, respectively;

n_1 and n_2 equal the number of sampling sites, spring and summer, respectively;

j_1 and j_2 = number of times species *j* was found during the spring and summer sampling periods, respectively; and

Z-values were calculated for each species and for each location within a pool.

Chi-square tests were used to test for significant changes in the proportion of sites with SAV to the total number of sampling sites between sampling periods. All analysis was done using the Statistical Analysis System (SAS; SAS Institute Inc., Cary, North Carolina).

Species richness is defined as the number of different species found through rake grabs. This provides an observed count for each pool but does not mean these are all the species present within a pool or even within a transect location. Determination of species richness in an exact sense is not possible (Greig-Smith 1983) because species richness is a function of sample size. The focus in this report, therefore, is a simple qualitative assessment of trends in observed species numbers.

Informal Surveys

To gain perspective on the distribution and composition of SAV in habitats other than transect locations, we began to establish protocols for conducting surveys throughout each pool. Aerial photographs and bathymetry maps were used to locate sites supporting or likely to support SAV. Surveys were conducted by boating along channel border habitats and through other areas most likely to support vegetation but not covered by sampling along transects. If vegetated areas or patches of vegetation were seen at or near the surface, samples were gathered using a rake. An estimate of abundance (rare, common, abundant) was given to each species. Species composition, approximate bed size, water depth, substrate type, and location of the vegetated areas and patches were recorded.

Informal surveys during 1991 did not cover as many areas as we would have preferred in a given pool because of time constraints. Selection of and sampling along transect locations left less time than needed for informal surveys before the second sampling period was scheduled to begin.

Results

All Pools

We found 15 species of submersed vascular aquatic plants and two species of macroalgae of the muskgrass family (Characeae) along transects in Pools 4, 8, 13, and 26 and La Grange Pool in 1991. We also found four species of floating-leaved plants and have included them in our species list (Appendix B). Across the study pools, the greatest number of submersed aquatic species found at transect sites in a single pool was 16 (Pool 4 in spring), and the fewest was 5 (La Grange Pool in spring and Pool 26 in summer). Only one additional species, northern watermilfoil, was found during informal surveys (in Pool 4) that was not found along the transects.

Coon’s tail and sago pondweed were the only two species found in every study pool during both spring and summer sampling. Relative frequencies of coon’s tail increased in all pools except Pool 8 between spring and summer and relative frequencies of sago pondweed declined in all pools except La Grange Pool between the two sampling periods (Table 3). Spring relative frequencies for coon’s tail were from 7.0% in La Grange Pool to 65.6% in Pool 8 and summer relative frequencies were from 14.6% in Pool 13 to 83.9% in Pool 26. Spring relative frequencies for sago pondweed were from 0.3% in La Grange Pool to 73.1% in Pool 13. Summer relative frequencies for sago pondweed were from 0.7% in La Grange Pool to 60.3% in Pool 13. Eurasian watermilfoil was present in all pools except Pool 26, reaching highest relative frequencies during spring in La Grange Pool (82.7%) and during summer in Pool 8 (62.1%) and La Grange Pool (68.9%). In all other pools, the relative frequency of Eurasian watermilfoil remained less than 10.0% (Table 2).

Relative frequencies of most other species remained less than 5.0%. Species reaching relative frequencies greater than 5.0% during at least one sampling period were Canadian waterweed (Pool 4), chara (La Grange Pool), curly pondweed (Pools 4 and 8), longleaf pondweed (Pools 8 and 26), small and leafy pondweeds (Pool 4), water stargrass (Pool 4), and wild celery (Pools 4 and 13; Table 3).

Horned pondweed, nitella, and Richardson’s pondweed were found rarely in Pool 4, but were not found in other pools. Chara was found in Pool 4 and in La Grange Pool in spring and summer. Western waterweed was found only in La Grange Pool (positive identification still pending verification by an outside source).

Table 3. Relative frequencies (%) of species in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool (LG) of the Illinois River in 1991 spring and summer sampling periods.[a]

	Spring					Summer				
Species	**4**	**8**	**13**	**26**	**LG**	**4**	**8**	**13**	**26**	**LG**
Canadian waterweed	8.9	1.6	–[b]	0.3	–	10.4	–	–	–	–
Chara	0.2	–	–	–	9.6	p[c]	–	–	–	8.6
Common bladderwort	0.1	0.1	–	–	–	–	–	–	–	–
Coon's tail	19.3	65.6	9.1	30.9	7.0	23.6	12.5	14.6	83.9	23.5

Table 3. Continued.

Species	Spring 4	Spring 8	Spring 13	Spring 26	Spring LG	Summer 4	Summer 8	Summer 13	Summer 26	Summer LG
Curly pondweed	7.0	2.8	1.6	0.4	–	0.6	37.5	0.9	1.6	–
Eurasian watermilfoil	2.6	0.5	6.9	–	80.7	5.5	18.7	9.1	–	66.7
Flatstem pondweed	3.4	4.6	0.2[d]	–	–	4.3	–	–	–	–
Horned pondweed	0.2	–	–	–	–	p	–	–	–	–
Longleaf pondweed	0.7	–	2.6	8.1	–	1.5	–	4.1	0.4	–
Nitella	0.1	–	–	–	–	0.2	–	–	–	–
Nodding waternymph	0.9	–	–	–	–	1.2	–	0.5	–	–
Richardson's pondweed	p	–	–	–	–	p	–	–	–	–
Sago pondweed	15.4	24.3	73.1	55.4	0.3	6.7	31.2	60.3	13.8	0.3
Small and leafy pondweeds	16.6	–	0.2	4.8	–	4.2	–	–	0.4	–
Water stargrass	7.3	–	?[d]	–	–	12.9	–	–	–	–
Western waterweed[e]	–	–	–	–	0.3	–	–	–	–	0.9
Wild celery	17.2	0.4	6.3	–	–	28.8	–	10.5	–	–

[a] Relative frequencies are based on all transect locations within a pool. Rounding may cause relative frequency columns to not total 100%.
[b] The symbol "–" indicates the species was not found.
[c] p=Relative frequency less than 0.1.
[d] Flatstem pondweed relative frequency may also include water stargrass in Pool 13.
[e] Verification of specimen needed for positive identification.

The proportion of sites with SAV to the total number of sampling sites declined significantly between spring and summer sampling periods (based on Chi-square tests) in Pools 4, 8, and 13, but not in Pool 26 or La Grange Pool. Species of pondweeds that declined between sampling periods were the primary contributors to changes in the proportion of SAV sites. Our spring sampling period was conducted later than planned (mostly in mid- to late-June), thus, we may have sampled at the time of peak growth of sago pondweed, curly pondweed, and small and leafy pondweeds. In Pool 8, however, loss of several other species, especially in Lawrence Lake, also contributed to the change within the pool. In Pool 26, loss of sago pondweed was balanced by an increase in coon's tail, thus the proportion of SAV sites remained relatively unchanged. In La Grange Pool, pondweeds made up a very small portion of the total number of SAV and fluctuations in other species were not great enough to cause a significant change (Table 4).

Table 4. Proportion of sites with submersed aquatic vegetation to total number of sites sampled at transect locations during the 1991 spring and summer sampling periods.

Location	Spring	Summer
Pool 4	67.8	54.0 (0.001)[a]
Pool 8	75.0	6.8 (0.001)
Pool 13	38.7	28.2 (0.001)
Pool 26	46.2	48.5 (0.542)
La Grange Pool	88.6	84.0 (0.326)

[a] Probability values for differences between sampling periods are given in parentheses. P-values are based on Chi-square tests with a 0.05 level of significance.

The proportion of sites with submersed vegetation at our transect locations in La Grange Pool was relatively high compared to other pools. This was probably because these backwaters were small and sheltered from wind turbulence and high turbidity associated with the main channel of the Illinois River. Thus, SAV tends to cover the surfaces of these backwaters.

Submersed aquatic species were present mostly on sandy silts throughout all pools. Laboratory analysis of sediment cores taken at 10% of the transect sites revealed mean bulk densities were from 0.91 g/mL in Pool 13 to 0.53 g/mL in Pool 8 (n = 156, standard error [SE] = 0.02). Bulk density, which closely parallels sand content, suggests that sediments at transect sites contained relatively high sand fractions. Mean percent moisture content were from 39.01 in Pool 13 to 58.31 in Pool 8. Percent organic matter were from 6.36 in Pool 13 to 10.91 in Pool 8 (Table 5).

Table 5. Means and standard errors for percent moisture, bulk density, and percent organic matter collected in 1991 at randomly selected sites along transects in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool of the Illinois River.

Pool and *n*[a]	Mean % moisture	Standard error	Mean % bulk density	Standard error	Mean % organic	Standard error
Pool 4 *n* = 165	43.84	1.08	0.80	0.02	8.19	0.64
Pool 8 *n* = 156	58.31	1.04	0.53	0.01	10.91	0.42
Pool 13 *n* = 119	39.01	0.99	0.91	0.02	6.36	0.28
Pool 26 *n* = 57	52.94	1.13	0.63	0.02	8.32	0.29
La Grange Pool *n* = 57	45.05	2.45	0.84	0.01	8.60	0.91

[a] Number of samples taken in each study area.

Multiple comparison procedures (ANOVAs) revealed the average phosphorus content and nitrogen content of plant tissues were not significantly different between pools. Phosphorus content mean was of 3.45 mg/g (n = 37, SE = 0.21) and nitrogen content mean was 26.5 mg/g (n = 37, SE = 0.96). These levels are well above critical levels for growth suggested by Gerloff and Krombolz (1966).

Pool 4

We found 16 species of SAV along Pool 4 transects during the spring sampling period and 15 during the summer sampling period. More species were found along transects in lower Pool 4 (below Lake Pepin) than in the upper pool (above Lake Pepin; Appendix B). Species with the highest frequencies during both sampling periods were coon's tail, wild celery, water stargrass, and Canadian waterweed. These four species made up more than 50% of the relative frequencies. Sago pondweed, curly pondweed, and the small and leafy pondweeds all declined in frequency and relative frequency between sampling periods (Table 6).

Table 6. Frequencies and relative frequencies (%) of species found in Pool 4 during 1991 spring and summer sampling periods.

Species	Frequencies[a]		Relative frequencies[a]	
	Spring	Summer	Spring	Summer
Coon's tail	33.5	29.4	19.3	23.6
Curly pondweed	14.9	1.3	7.0	0.6
Canadian waterweed	17.0	14.2	8.9	10.4
Eurasian watermilfoil	6.8	9.3	2.6	5.5
Flatstem pondweed	9.1	7.8	3.4	4.3
Longleaf pondweed	1.6	2.3	0.7	1.5
Nodding waternymph	2.0	1.7	0.9	1.2
Sago pondweed	28.1	11.9	15.4	6.7
Small and leafy pondweeds	27.9	6.7	16.6	4.2
Water stargrass	15.7	18.6	7.3	12.9
Wild celery	27.5	30.5	17.2	28.8
Other species	1.3[b]	1.0[c]	0.6[b]	0.3[c]

[a] Frequencies and relative frequencies are based collectively on all transect locations where sampling was performed twice during the growing season. Rounding may cause relative frequency columns to not total 100%.

[b] Other species include Richardson's pondweed, horned pondweed, common bladderwort, chara, and nitella.

[c] Other species include Richardson's pondweed, horned pondweed, chara, and nitella.

Three species, sago, small and leafy, and curly pondweeds declined in most locations where present between the spring and summer sampling periods. Because spring sampling was done later than planned (early to mid-June in Pool 4), we probably caught peak growth for the pondweeds. If sampling had been done earlier, before the pondweeds had reached their peak, the change may not have been so apparent. No other species revealed significant change between sampling periods at locations where present. Only three species, coon’s tail, curly pondweed, and sago pondweed, were found in transect locations above Lake Pepin. Most other species were distributed throughout transect locations within the lower pool. Nitella and chara were found only in the Big Lake area, whereas Richardson’s pondweed was found only in Robinson Lake (Table 7).

Pool 8

We found eight species along Pool 8 transects during the spring sampling period and four of the eight species at the same transect locations during the summer sampling period. One additional species, longleaf pondweed, was found at Goose Island, which was surveyed only during the summer sampling period (Appendix B). Coon's tail and sago pondweed were the only two species with frequencies greater than 10% and they accounted for nearly 90% of the relative frequencies during the spring sampling period. As in Pool 4, sago pondweed dropped in frequency and relative frequency by the summer sampling period. Wild celery and common bladderwort were rarely encountered in the spring and not found during the summer sampling period (Table 8). No additional species were encountered during informal surveys that were not found along transects.

Table 7. Pool 4 transect locations where species were present in the 1991 showing increase or decrease in species between spring and summer sampling periods.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods[b]	Increased between spring and summer sampling periods[a]
Canadian waterweed		Peterson Lake Lower Peterson Lake Big Lake Big Lake Bay Robinson Lake Rice Lake	
Chara		Big Lake Rice Lake	
Common bladderwort		Big Lake	
Coon's tail		Peterson Lake Lower Peterson Lake Big Lake Big Lake Bay Robinson Lake Bay City Flats Dead Slough Lake Mud Lake Goose Lake Rice Lake	
Curly pondweed	Lower Peterson Lake Peterson Lake Big Lake Robinson Lake	Big Lake Bay Mud Lake Bay City Flats Goose Lake	
Eurasian watermilfoil		Big Lake Peterson Lake Lower Peterson Lake Robinson Lake Rice Lake	
Flatstem pondweed		Big Lake Big Lake Bay Robinson Lake Peterson Lake Lower Peterson Lake	
Horned pondweed		Robinson Lake Peterson Lake Lower Peterson Lake Big Lake	
Longleaf pondweed		Big Lake Robinson Lake Rice Lake	
Nitella		Big Lake	
Nodding waternymph		Big Lake Bay Robinson Lake Big Lake Rice Lake	
Richardson’s pondweed		Robinson Lake	
Sago pondweed	Peterson Lake Lower Peterson Lake Robinson Lake Bay City Flats Dead Slough Lake Goose Lake	Big Lake Mud Lake Rice Lake	

Table 7. Continued.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods[b]	Increased between spring and summer sampling periods[a]
Small and leafy pondweeds	Peterson Lake Lower Peterson Lake Big Lake Big Lake Bay Robinson Lake	Rice Lake	
Water stargrass		Peterson Lake Lower Peterson Lake Big Lake Big Lake Bay Robinson Lake Rice Lake	
Wild celery		Big Lake Big Lake Bay Peterson Lake Lower Peterson Lake	Robinson Lake

[a] Species that increased or decreased in frequency at a location are significant at the 0.05 probability level (based on z-tests).
[b] Species that did not change significantly may have been untestable due to small sample size during one or both periods.

Table 8. Frequencies and relative frequencies (%) of species at transect locations in Pool 8 during the 1991 spring and summer sampling periods.

	Frequencies[a]		Relative frequencies[a]	
Species	**Spring**	**Summer**	**Spring**	**Summer**
Canadian waterweed	2.1	–[b]	1.6	–
Coon's tail	59.9	0.6	65.6	12.5
Common bladderwort	0.3	–	0.1	–
Curly pondweed	3.1	1.3	2.8	37.5
Eurasian watermilfoil	0.8	1.0	0.5	18.7
Flatstem pondweed	6.2	–	4.6	–
Sago pondweed	29.4	1.6	24.3	31.2
Wild celery	0.3	–	0.4	–

[a] Frequencies and relative frequencies are based collectively on all transect locations where sampling was performed twice during the growing season. Rounding may cause relative frequency columns to not total 100%.
[b] The symbol "–" indicates the species was not found.

Whereas no species significantly increased between sampling periods at any one location, several species decreased. Sago pondweed, flatstem pondweed, and coon's tail all decreased significantly in Lawrence Lake. Sago pondweed and coon's tail decreased in Target Lake and curly pondweed decreased at Shady Maple. Common bladderwort and wild celery were found only in Target Lake, whereas flatstem pondweed was found only in Lawrence Lake (Table 9).

Table 9. Pool 8 transect locations where species were present in 1991 showing increase or decrease in species between spring and summer sampling periods.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods[b]	Increased between spring and summer sampling periods[a]
		Target Lake	
Canadian waterweed		Lawrence Lake	
Common bladderwort		Target Lake	
	Lawrence Lake	Shady Maple	
Coon's tail	Target Lake		
Curly pondweed	Shady Maple	Lawrence Lake	
		Shady Maple	
		Target Lake	
		Lawrence Lake	
Eurasian watermilfoil			
Flatstem pondweed	Lawrence Lake		
Sago pondweed			
	Lawrence Lake		
	Target Lake	Shady Maple	
Wild celery		Target Lake	

[a] Species that increased or decreased in frequency at a location are significant at the 0.05 probability level (based on z-tests).
[b] Species that did not change significantly may have been untestable due to small sample size during one or both sampling periods.

Pool 13

We found eight species along Pool 13 transects during the 1991 spring sampling period and seven of those species were found during the summer sampling period. Water stargrass was probably present, which would add one species to the count for each sampling period, but a distinction between water stargrass and flatstem pondweed was not made while in the field. Sago pondweed was the most frequently found species during both the spring and summer sampling periods, but as in Pools 4 and 8, it decreased in frequency between periods (Table 10). The remaining species were present at frequencies less than 10% during both the spring and summer sampling periods.

Table 10. Frequencies and relative frequencies (%) of species in Pool 13 during the 1991 spring and summer sampling periods.

	Frequencies[a]		Relative frequencies[a]	
Species	Spring	Summer	Spring	Summer
Coon's tail	9.4	4.8	9.1	14.6
Curly pondweed	2.0	0.5	1.6	0.9
Eurasian watermilfoil	8.0	4.3	6.9	9.1
Longleaf pondweed	3.1	1.6	2.6	4.1
Nodding waternymph	–[b]	0.3	–	0.5
Sago pondweed	55.4	23.2	73.1	60.3
Small and leafy pondweeds	0.3	–	0.2	–
Wild celery	7.4	3.7	6.3	10.5
Other species[c]	0.3	–	0.2	–

[a] Frequencies and relative frequencies are based collectively on all transect locations where sampling was performed twice during the growing season.
[b] The symbol "–" indicates the species was not found.
[c] Other species include flatstem pondweed and possibly water stargrass.

Sago pondweed decreased at four of the eight locations where it was present. Coon's tail decreased at one of the six locations where it was found in the spring. No other species changed significantly (Table 11).

Table 11. Pool 13 transect locations where species were present in the 1991 showing increase or decrease in species between spring and summer sampling periods.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods[b]	Increased between spring and summer sampling periods[a]
Coon's tail	Johnson Creek Levee	Potter's Marsh Pomme de Terre Brown's Lake	
Curly pondweed		Potter's Marsh Pomme de Terre Brown's Lake	
Eurasian watermilfoil		Johnson Creek Levee Potter's Marsh Pomme de Terre	
Flatstem pondweed		Johnson Creek Levee Potter's Marsh Pomme de Terre	
Longleaf pondweed		Pomme de Terre Brown's Lake Johnson Creek Levee	
Nodding waternymph		Pomme de Terre	
Sago pondweed	Johnson Creek Levee Potter's Marsh Pomme de Terre Brown's Lake		
Small and leafy pondweeds		Pomme de Terre	
Wild celery		Johnson Creek Levee Potter's Marsh Pomme de Terre	

[a] Species that increased or decreased in frequency at a location are significant at the 0.05 probability level (based on z-tests).

[b] Species that did not change significantly may have been untestable due to small sample size during one or both sampling periods.

Pool 26

We found six species of SAV along Pool 26 transects during the spring sampling period and five of those species during the summer sampling period. During the summer sampling period, we sampled along only 3 of the 11 transects in Swan Lake after discovering the bed of sago pondweed had disappeared between sampling periods. Also, sampling was limited in Stump Lake during the summer because of low water levels. Frequency and relative frequency analysis include only those locations (and transects) that were monitored twice.

Relative frequencies were dominated by coon's tail and sago pondweed. Sago pondweed had the highest relative frequency during the spring sampling period and coon's tail had the highest relative frequency during the summer sampling period. By the summer sampling period, the frequency of sago pondweed had decreased and that of coon's tail had increased to the highest of all species found (Table 12). Informal surveys conducted in July revealed no additional species that were not found along transects.

Table 12. Frequencies and relative frequencies (%) of species in Pool 26 during the 1991 spring and summer sampling periods.

	Frequencies[a]		Relative frequencies[a]	
Species	**Spring**	**Summer**	**Spring**	**Summer**
Canadian waterweed	0.4	–[b]	0.3	–
Coon's tail	17.3	44.8	30.9	83.9
Curly pondweed	0.5	1.6	0.4	1.6
Longleaf pondweed	4.2	0.4	8.1	0.4
Sago pondweed	33.5	5.8	55.4	13.8
Small and leafy pondweeds	8.1	0.4	4.8	0.4

[a] Frequencies and relative frequencies are based collectively on all transect locations where sampling was performed twice during the growing season. Rounding may cause relative frequency columns to not total 100%.

[b] The symbol "–" indicates the species was not found.

Sago pondweed decreased significantly during the growing season (z-test; Table 13). Sago pondweed was found uprooted and laying on the shoreline of Swan Lake. Coon's tail was the only species that increased.

Table 13. Pool 26 transect locations where species were present in the 1991 showing increase or decrease in species between spring and summer sampling periods.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods[b]	Increased between spring and summer sampling periods[a]
Canadian waterweed		Calhoun Point	
Coon's tail			Calhoun Point
Curly pondweed		Calhoun Point	
Longleaf pondweed		Stump Lake	
Sago pondweed	Swan Lake		
Small and leafy pondweeds	Calhoun Point		

[a] Species that increased or decreased in frequency at a location are significant at the 0.05 probability level (based on z-tests).

[b] Species that did not change significantly may have been untestable due to small sample size during one or both sampling periods.

La Grange Pool

We found five species of submersed aquatic macrophytes along La Grange Pool transects during the 1991 spring and summer sampling periods. (One additional species, longleaf pondweed, was found in Banner Marsh, which was sampled only during the summer sampling period.) Species frequencies in La Grange Pool were dominated by Eurasian watermilfoil and coon's tail. Eurasian watermilfoil has been a problem species in Spring Lake, covering most the water surface in the lower half of the lake where transects are located. In that location, frequencies of Eurasian watermilfoil occupied at least 79% of sites where sampling was performed (Table 14). Coon's tail dominated at Point Lake, a location where Eurasian watermilfoil has not been found. Relative frequencies reflect the high frequencies of Eurasian watermilfoil and coon's tail. La Grange Pool backwaters are the only locations within our study areas where we found western waterweed.

Table 14. Frequencies and relative frequencies (%) of species in La Grange Pool, Illinois River, during 1991 spring and summer sampling periods.

Species	Frequencies[a]		Relative frequencies[a]	
	Spring	Summer	Spring	Summer
Chara	11.4	9.1	9.6	8.6
Coon's tail	11.4	31.8	7.0	23.5
Eurasian watermilfoil	80.7	79.5	82.7	66.6
Sago pondweed	0.8	2.3	0.3	0.3
Western waterweed[b]	0.9	0.7	0.3	0.9

[a] Frequencies and relative frequencies are based collectively on all transect locations where sampling was performed twice during the growing season. Rounding may cause relative frequency columns to not total 100%.
[b] Pending identification.

Coon's tail was the only species that revealed a seasonal increase at La Grange Pool. Eurasian watermilfoil remained stable in Spring Lake. The less frequently found sago pondweed and western waterweed also did not change (Table 15).

Submersed aquatic macrophytes are rare in La Grange Pool, except in isolated backwaters. We found, however, a few small patches of sago pondweed on the southeast side of Grape Island. These patches were on fine sands with clay in water less than 0.10 m deep.

Table 15. La Grange Pool, Illinois River, transect locations where species were present in 1991 showing increase or decrease in species between spring and summer sampling periods.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods[b]	Increased between spring and summer sampling periods[a]
Chara		Spring Lake Banner Marsh	
Coon's tail		Point Lake	Spring Lake
Eurasian watermilfoil		Spring Lake	
Longleaf pondweed		Banner Marsh	
Sago pondweed		Point Lake Banner Marsh	
Western waterweed[c]		Spring Lake Banner Marsh	

[a] Species that increased or decreased in frequency at a location are significant at the 0.05 probability level (based on z-tests).
[b] Species that did not change significantly may have been untestable due to small sample size during one or both sampling periods.
[c] Pending identification.

Acknowledgments

The authors acknowledge J. Winkelman and T. Cook for their helpful comments to the manuscript. We also thank the team leaders and staff at the participating agencies: Illinois Natural History Survey, Alton; Illinois Natural History Survey, Havana; Iowa Department of Natural Resources, Bellevue; Minnesota Department of Natural Resources, Lake City; and Wisconsin Department of Natural Resources, Onalaska.

References

Allen, S. E., H. M. Grimshaw, J. A. Parkinson, and C. Quarmby. 1974. Chemical analysis of ecological Materials. John Wiley and Sons, New York. 565 pp.

Barko, J. W., D. Gunnison, and S. R. Carpenter. 1991. Sediment interactions with submersed macrophyte growth and community dynamics. Aquatic Botany 41:41–65.

Engel, S. 1990. Ecosystem responses to growth and control of submerged macrophytes: A literature review. Technical Bulletin 170. Wisconsin Department of Natural Resources, Madison. 20 pp.

Fassett, N. C. 1966. A manual of aquatic plants. University of Wisconsin Press, Madison. 405 pp.

Gerloff, G. C., and P. H. Krombholz. 1966. Tissue analysis as a measure of nutrient availability for the growth of angiosperm aquatic plants. Limnology and Oceanography 11:529–537.

Gleason, H. A., and A. Cronquist. 1991. A manual of vascular plants of northeastern United States and adjacent Canada. 2nd edition. The New York Botanical Garden, Bronx. 910 pp.

Gutreuter, S., R. W. Burkhardt, M. Stopyro, A. Bartels, E. Kramer, M. C. Bowler, F. A. Cronin, D. W. Soergel, M. D. Petersen, D. P. Herzog, P. T. Raibley, K. S. Irons, and T. M. O'Hara. 1997. 1994 Annual Status Report: A summary of fish data in six reaches of the Upper Mississippi River System. U.S. Geological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, July 1997. LTRMP 97-P007. 15 pp. + Chapters 1–6. (NTIS #PB97-198923)

Greig-Smith, P. 1983. Quantitative plant ecology. University of California Press, Berkeley. 359 pp.

Jessen, R., and R. Lound. 1962. An evaluation of survey techniques for submerged aquatic plants. Game Investigational Report 6. Minnesota Department of Conservation, St. Paul. 10 pp.

Korschgen, C. E., L. S. George, and W. L. Green. 1988. Feeding ecology of canvasbacks staging on Pool 7 of the Upper Mississippi River. Pages 237–249 *in* M. W. Weller, editor. Waterfowl in winter. University Minnesota Press, Minneapolis.

Laustrup, M. S., and C. D. Lowenberg. 1994. Development of a systemic land cover/land use database for the Upper Mississippi River system derived from Landsat Thematic Mapper satellite data. National Biological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, May 1994. LTRMP 94-T001. 103 pp. (NTIS #PN97-155543)

Peck, J. H., and M. M. Smart. 1986. An assessment of the aquatic and wetland vegetation of the Upper Mississippi River. Hydrobiologia 136:57–76.

Talkington, L. M., and R. G. Semonin. 1991. The Illinois River: Working for our state. Miscellaneous Publication 128. Illinois State Water Survey, Champaign. 51 pp.

U.S. Fish and Wildlife Service. 1993. Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program. Environmental Management Technical Center, Onalaska, Wisconsin, Revised September 1993. EMTC 91-P002R. 179 pp. (NTIS #PB94-160199)

Appendix A

Locations, Number of Transects and Sites, Sampling Dates, and Distances Between Sites Sampled in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool of the Illinois River During the 1991 Sampling Season

Location	Number of transects	Number of sites in spring	Number of sites in summer	Dates sampled in spring	Dates sampled in summer	Distance between sites (m)
Pool 4						
Dead Slough Lake (M789.2, M788.5, M788.0)[a]	9	98	93	6/17–18	8/7–8	30
Goose Lake (M788.G)[b]	3	25	25	6/20	8/6	30
Mud Lake (M791.3)	3	63	58	6/11	8/6	30
Bay City Flats (M788.0; Catherine Pass)[c]	3	77	74	6/20–21	8/9	30
Robinson Lake (M788.R)[b]	9	199	180	6/27–28; 7/1–2	8/14–16	30
Big Lake Bay (M788.5)	3	22	48	7/3	8/19	30
Rice Lake (M758.0)	3	27	24	7/3	8/19	30
Big Lake (M757.5)	5	182	177	7/5, 8–10	8/20–21	30
Peterson Lake (M754.8, M754.5)	6	70	61	6/24–25	8/12	30
Lower Peterson Lake (M753.5)	4	94	119	6/24	8/13	30
Total Pool 4	**48**	**857**	**859**	**19**	**14**	
Pool 8						
Target Lake (M696.0)	8	79	79	6/4–6	8/5, 7	15
Goose Island (M692.0)	5 (summer)	not sampled	80	not sampled	8/21–22	15
Lawrence Lake (M691.0)	13 (spring) 10 (summer)	195	195	5/30; 6/3, 11–13, 20, 24	8/9, 12–14	15
Shady Maple (M690.0)	3	24	30	6/17	8/20, 30	15

Location	Number of transects	Number of sites in spring	Number of sites in summer	Dates sampled in spring	Dates sampled in summer	Distance between sites (m)
Horseshoe HREP[d] (M687.0)	5 (summer)	not sampled	40	not sampled	8/15	15
Total Pool 8	**24 (spring) 31 (summer)**	**298**	**424**	**10**	**11**	
Pool 13						
Brown's Lake (M545.1, M544.5)	25	194	235	6/24–26; 7/1–2	8/5, 15, 26–27	15 or 30[a]
Savanna Bay (M541.5, M540.5, M539.5)	12 (summer)	not sampled	120	not sampled	8/28; 9/4	15
Spring Lake (M534.8, M533.6, M532.0)	12 (summer)	not sampled	99	not sampled	8/8, 28	15
Pomme de Terre (M526.0)	5	52	59	7/3	8/6	15
Potter's Marsh (M524.0)	6	41	41	7/9–10	8/21	15
Johnson Creek Levee (M523.5)	4	55	40	7/10	8/22	15
Lower Johnson Creek (M523.0)	2 (summer)	not sampled	30	not sampled	8/22	15
Total Pool 13	**60 (spring) 94 (summer)**	**342**	**624**	**9**	**12**	
Pool 26						
Calhoun Point (I003.0)[e,f]	21	137	137	6/10–13, 17–18	8/8	15
Swan Lake (I005.5)	11 (spring) 3 (summer)	308	80	6/25, 28; 7/1, 3, 8, 10–12	8/12	15
Stump Lake (I010.0)	8 (spring)	172	24	7/16–17, 20	not sampled	15
Total Pool 26	**40 (spring) 32 (summer)**	**617**	**241**	**15**	**12**	
La Grange Pool						
Point Lake (I100.0)	6	9	20	7/17, 24	8/21	15

Location	Number of transects	Number of sites in spring	Number of sites in summer	Dates sampled in spring	Dates sampled in summer	Distance between sites (m)
Spring Lake (I135.5)	5	105	99	6/13, 19–20, 26–28; 7/11–12	8/8–9, 16, 20	15
Banner Marsh (I140.7; Bulrush Pond[c])	2	13	13	7/31	8/19	15
Total La Grange Pool	**13**	**127**	**132**	**10**	**6**	

[a] Mississippi River miles, measured from the confluence of the Mississippi and Ohio Rivers.

[b] "G" and "R" to distinguish this lake from another lake with the same river mile.

[c] Locally recognized name.

[d] Habitat Rehabilitation and Enhancement Project.

[e] Illinois River miles, measured from the confluence of the Mississippi and Illinois Rivers.

[f] Pool 26 is located at the confluence of the Illinois and Mississippi Rivers and the portions named here extent up the Illinois River, are managed by the Illinois Department of Natural Resources, and are designated by Illinois River miles.

Appendix B

Species of Submersed and Floating-leaved Aquatic Macrophytes Occurring at Transect Sites in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool of the Illinois River

Species	Pool 4[a]	Pool 8	Pool 13	Pool 26	La Grange Pool
Submersed Aquatic Species					
Canadian waterweed (*Elodea canadensis* L.)	x[b]	x	–[c]	x	–
Chara (*Chara* spp.)	x	–	–	–	x
Common bladderwort (*Utricularia macrorhiza* L.)	x	x	–	–	–
Coon's tail (*Ceratophyllum demersum* L.)	x	x	x	x	x
Curly pondweed (*Potamogeton crispus* L.)	x	x	x	x	–
Eurasian watermilfoil (*Myriophyllum spicatum* L.)	lower pool x	x	x	–	x
Horned pondweed (*Zannichellia palustris* L.)	lower pool x	–	–	–	–
Flatstem pondweed (*Potamogeton zosteriformis* Fern)	lower pool x	x	x	–	–
Longleaf pondweed (*Potamogeton nodosus* Poiret.)	x	x	x	x	x
Nitella (*Nitella* spp.)	x	–	–	–	–
Nodding waternymph (*Najas flexilis* [Willd.] Rostke. & Schmidt)	lower pool x	–	x	–	–
Richardson's pondweed (*Potamogeton richardsonii* [Benn] Rydb.)	lower pool x	–	–	–	–
Sago pondweed (*Potamogeton pectinatus* L.)	x	x	x	x	x
Small and leafy pondweeds (*Potamogeton pusillus and P. foliosus* L.)	lower pool x	–	x	x	–
Water stargrass (*Heteranthera dubia* L.)	lower pool x	–	?[d] –	–	–
Western waterweed (*Elodea Nuttallii* [Planch.] St. John)	–	–	–	–	x
Wild celery, American eelgrass (*Vallisneria americana* Michx.)	lower pool x	x	x	–	–

Species	Pool 4[a]	Pool 8	Pool 13	Pool 26	La Grange Pool
Floating-leaved Species					
American lotus (*Nelumbo lutea* [Willd.] Pers.)	x	x	x	–	–
White waterlily (*Nymphaea odorata* Ait.)	x	x	–	–	–
Yellow pondlily (*Nuphar lutea* [L.] Sm.)	–	–	–	–	–
Species of submersed plants found during informal surveys but not found along transects					
Northern watermilfoil (*Myriophyllum sibericum* Komarov)	x				
Total per pool	**19**	**11**	**10**	**6**	**6**

[a] Found in lower Pool 4 (below Lake Pepin) only when so indicated.
[b] The symbol "x" indicates the species was present.
[c] The symbol "–" indicates the species was not found.
[d] Water stargrass was probably present in Pool 13, but was not distinguished from flatstem pondweed.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE June 1998	3. REPORT TYPE AND DATES COVERED

4. TITLE AND SUBTITLE

1991 Annual Status Report: A summary of vegetation monitoring at selected locations in Pools 4, 8, 13, and 26 and La Grange Pool of the Upper Mississippi River System

5. FUNDING NUMBERS

6. AUTHOR(S)

Sara Rogers[1], Theresa Blackburn[2], Daniel Dieterman[3], Heidi Langrehr[4], John Nelson[5], and Susan Romano-Peitzmerer[5]

7. PERFORMING ORGANIZATION NAME AND ADDRESS

[1]U.S. Geological Survey, Environmental Management Technical Center, 575 Lester Avenue, Onalaska, Wisconsin 54650;
[2]Iowa Department of Natural Resources, Mississippi River Monitoring Station, 206 Rose Street, Bellevue, Iowa 52031;
[3]Minnesota Department of Natural Resources, 1801 S. Oak Street, Lake City, Minnesota 55041;
[4]Wisconsin Department of Natural Resources, Onalaska Field Station, 575 Lester Avenue, Onalaska, Wisconsin 54650; and
[5]Illinois Natural History Survey, Havana Field Station, 704 N. Schrader Avenue, Havana, Illinois 62644

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

U.S. Geological Survey
Environmental Management Technical Center
575 Lester Avenue
Onalaska, Wisconsin 54650

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

98-P005

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

Release unlimited. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (1-800-553-6847 or 703-487-4650). Also available to registered users from the Defense Technical Information Center, Attn: Help Desk, 8725 Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218 (1-800-225-3842 or 703-767-9050).

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

The Long Term Resource Monitoring Program (LTRMP) of the Upper Mississippi River System (UMRS) authorizes monitoring of submersed aquatic vegetation (SAV) in the river system. This report summarizes the 1991 effort of monitoring SAV along transects permanently established in vegetated locations in four navigation pools of the Upper Mississippi River and one navigation pool of the Illinois River. Seventeen species of submersed aquatic plants were found along transects in Pools 4, 8, 13, and 26 and La Grange Pool. The highest number of submersed aquatic plant species found in any one pool was 16 in Pool 4 and the lowest number was 6 in La Grange Pool. Coon's tail (*Ceratophyllum demersum*) and sago pondweed (*Potamogeton pectinatus*) were the only two species found in every study pool during both spring and summer sampling. Decreases in pondweed species noticeably affected the number of transect sites with SAV in Pools 4 and 13. In Pool 8, nearly all species declined between sampling periods and the proportion of sites with SAV dropped to less than 10% by August, the most decline of any pool.

14. SUBJECT TERMS

1991 annual report, aquatic, Illinois River, LTRMP, Mississippi River, monitoring, plant, submersed, vegetation

15. NUMBER OF PAGES

21 pp. + Appendixes A–B

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	

The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information for maintaining the Upper Mississippi River System as a sustainable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.