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1996 Annual Status Report

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

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1996 Annual Status Report
A Summary of Aquatic Vegetation Monitoring at Fixed Transects in Pools 4, 8, 13, and 26 and La Grange Pool of the Upper Mississippi River System

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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 (EMTC). 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 and river managers 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 (U.S. Fish and Wildlife Service 1993).

This report presents the results of aquatic vegetation transect surveys conducted in 1996 by field station personnel under the direction of the EMTC. 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 1996, 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 distribution and abundance of submersed aquatic vegetation collected from the field stations for 1996. This report was developed with funding provided by the Long Term Resource Monitoring Program.

1996 Annual Status Report
A Summary of Aquatic Vegetation Monitoring at Fixed Transects in Pool 4, 8, 13, and 26 and La Grange Pool of the Upper Mississippi River System

by

Sara Rogers, Heidi Langrehr, J. Therese Dukerschein, Jenny Winkelman, John Nelson, Theresa Blackburn, and Thad Cook

Abstract

Distribution and frequency of submersed aquatic vegetation in the Upper Mississippi River System are monitored as part of the Long Term Resource Monitoring Program. This report summarizes results of sampling aquatic vegetation along fixed transects in Navigation Pools 4, 8, 13, and 26 in the Upper Mississippi River and La Grange Pool in the Illinois River in 1996. Plants were sampled at regular intervals along fixed transects using a modified rake technique. Sampling was conducted twice during the growing season (spring and summer). Twenty-four submersed and rooted floating-leaved species were found. Most species were found in Pools 4, 8, and 13. Pool 26 had the fewest (3) number of species and Pool 4 had the greatest (23), including most large-leaved pondweeds and the first LTRMP record of floating pondweed (*Potamogeton natans*). Sago pondweed (*P. pectinatus*) and coontail (*Ceratophyllum demersum*) were dominant in the contiguous backwaters sampled. Seasonal trends were observed in nine species, all of which, except sago pondweed, increased later in the season. Throughout the growing season, more sites were vegetated in Pools 8 and 13 and La Grange Pool (frequency of 50–73%) than in Pools 4 and 26 (<25%). Pool 26 was devoid of vegetation during the second sampling. Aquatic vegetation was generally rare in contiguous areas of Pool 26 and La Grange Pool, but more plentiful in the isolated, managed backwaters of La Grange 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 distribution and frequency of the vegetation are reported in annual status reports, and the data provides a baseline of information to which future observations can be compared and to help evaluate the trends. In combination with water quality, fish, and invertebrate monitoring, the overall mission of the Program is to provide scientifically sound and useful information for effective river management. The purpose of this report is to document the results of transect sampling at selected locations in 1996.

Historically, submersed aquatic vegetation (SAV) has played an important role in the UMRS ecosystem. These plant communities provide food for migratory waterfowl (Korschgen et. al. 1988) and improvement of water quality by stabilizing sediments, filtering out suspended materials, and taking up nutrients that can otherwise support nuisance algal growth (Barko et al. 1991). 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 within the UMRS, partly because few studies have adequately addressed these questions. Biologists have high interest and concern for this important resource, however, especially in view of the drastic decline of SAV in the Illinois River in the 1950s, of which only remnant populations survive (Talkington and Semonin 1991). Concern for SAV in the Upper Mississippi River escalated in the mid- to late-1980s when widespread and sudden declines in the abundance of wild celery (*Vallisneria americana*) were observed in Pools 5 to 19 (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).

Long-term monitoring can play a substantial role in increasing an 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?

This report documents the results of sampling of submersed and rooted floating-leaved vegetation along transects at selected locations in 1996. It provides baseline information to evaluate changing conditions. The 1996 growing season was the sixth year that we conducted field surveys in designated LTRMP study reaches. The objectives for monitoring aquatic vegetation in the UMRS are to

(1) document the distribution of SAV at selected locations of the UMRS,
(2) compare current distribution of SAV with past distribution, and
(3) identify environmental factors that may influence both long- and short-term changes in the distribution and abundance of SAV.

Fulfillment of these objectives requires research in addition to monitoring.

Study Areas

The LTRMP vegetation study area consists of five reaches within the UMRS, four on the Upper Mississippi River and one on the Illinois River (Figure 1). Study areas are herein referred to by the navigation pool designations according to the U.S. Army Corps of Engineers (USACE) lock and dam system. The Upper Mississippi River navigation pools studied are Pool 4 (Mississippi River mile [M] 752 to 797), Pool 8 (M 679 to 703), Pool 13 (M 523 to 557), Pool 26 (M 202 to 242), and La Grange Pool of the Illinois River (Illinois River mile [I] 80 to 158). Pool 26 includes 12 miles of the lower Illinois River upstream of its confluence (M 218) with the Upper Mississippi River. River miles for the Upper Mississippi River are measured from the confluence of the Mississippi and Ohio Rivers and for the Illinois River from the confluence of the Mississippi and Illinois Rivers.

These study areas were chosen, in part, to reflect important differences in geomorphology, floodplain land use, and water-level management strategies that exist within the UMRS. Pools 4, 8, and 13 are geomorphically complex with contiguous and isolated backwaters and numerous interconnected channels (Table 1). A relatively large proportion of the aquatic area in these pools comprise backwaters and impounded areas. The upper portions retain the most riverine character with braided channels, forested islands, and a relatively large range of water-level fluctuations (Peck and Smart 1986). In contrast, the lower portions of these pools provide a shallow, more lacustrine environment. Pool 26 has a greater proportion of main channel area. La Grange Pool has a high percentage of contiguous backwaters, but very little SAV has been observed. Consequently, SAV sampling effort is less intensive in the two southern pools.

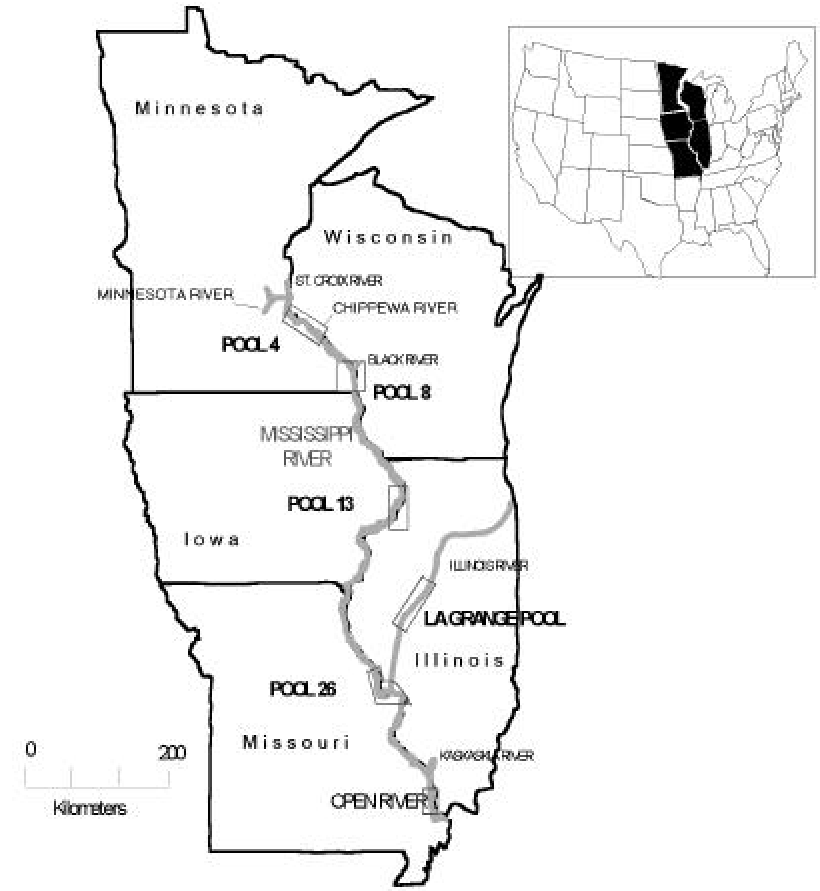

Figure 1. Location of Navigation Pools 4, 8, 13, and 26 and La Grange Pool in the Upper Mississippi River System where aquatic vegetation was surveyed, Long Term Resource Monitoring Program, 1996. The Open River Reach (Mississippi River mile 0 to 80), where water quality, fish, and invertebrates are sampled as part of the Long Term Resource Monitoring Program, is not monitored for vegetation because of the lack of habitat for submersed aquatic vegetation.

Table 1. Area and relative proportions of aquatic habitats (based on geomorphology) by navigation pool for select reaches of the Upper Mississippi River System studied as part of the Long Term Resource Monitoring Program.[a]

	Main channel		Side channel		Backwater		Lake		Impounded		Isolated		
Location	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Area (ha)**	**%**	**Total area (ha)**
Pool 4	1,240	8	721	5	2,300	16	9,764[b]	66	0	0	660	5	14,685
Pool 8	1,256	16	1,380	17	1,767	22	0	0	3,476	43	124	2	8,003
Pool 13	2,700	27	805	8	2,810	28	0	0	3,560	36	116	1	9,991
Pool 26	4,860	57	1,496	18	415	5	948[c]	11	176	2	580	7	8,475
La Grange Pool[d]	2,398	22	143	1	5,676	51	0	0	0	0	2,835	26	11,052

[a] Data for Pools 4, 8, 13, and 26 were based on the sampling strata coverage. Data for La Grange Pool were based on the aquatic areas coverage.

[b] Refers to Lake Pepin, a tributary delta lake.

[c] Refers to Swan Lake.

[d] La Grange Pool is located on the Illinois River.

In Pool 4, we surveyed contiguous backwaters where transects were established in 1991 (Figure 2). Transects were distributed in both the upper and lower portions of the pool, but not in Lake Pepin. Upper pool locations included Dead Slough Lake, Goose Lake, Upper Mud Lake, Mud Lake, and Catherine Pass (referred to as Bay City Flats in previous reports; Appendix A). Upper Mud Lake, which was added in 1993, was surveyed only during the spring sampling period. Transect sampling was discontinued in Upper Mud Lake because it is semi-isolated, atypical of backwaters in upper Pool 4, and access and sampling can be difficult. Instead, Upper Mud Lake was adopted as a fixed location for qualitative (informal) surveys. Lower pool locations (below Lake Pepin) included Robinson Lake and Peterson Lake, as well as three that are part of the Big Lake area, Big Lake, Rice Lake, and Big Lake Bay. In 1996, an additional transect was placed in upper Big Lake to capture dynamic changes in SAV. Data collected along this transect were excluded from analysis. A Habitat Rehabilitation and Enhancement Project (HREP), which involved dredging part of Big Lake Bay, was completed in spring 1993. The construction of a HREP in Peterson Lake in fall 1995 required relocating the first transect approximately 30 m downstream.

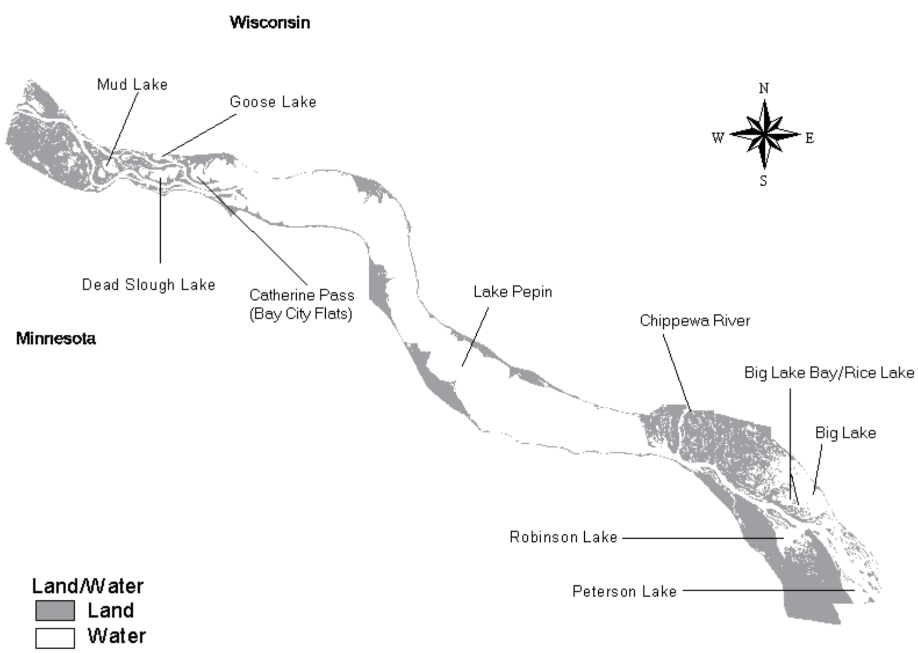

Figure 2. Backwater locations in Pool 4 (Upper Mississippi River) where transects were monitored for aquatic vegetation, Long Term Resource Monitoring Program, 1996.

In Pool 8, we sampled five backwaters where transects were established in 1991 (Figure 3). Locations included Target Lake, Lawrence Lake, a backwater area near Goose Island, Shady Maple, and the interior of Horseshoe Island (Appendix A). We added a backwater near Stoddard, Wisconsin, in 1992, and two backwaters, Blue Lake and the interior of Boomerang Island, in 1993. Horseshoe Island and Boomerang Island are part of the Pool 8 Islands HREP. Most backwaters were located in the lower two thirds of the pool.

In Pool 13, we monitored seven backwaters where transects were established in 1991 (Figure 4). Most of the backwaters were located in the middle and lower portions of the pool and included Brown's Lake, Savanna Bay, Spring Lake, Pomme de Terre, Potter's Marsh, Johnson Creek, and Johnson Creek Levee (Appendix A). Brown’s Lake and Potter’s Marsh are part of HREPs initiated in 1988 and 1994, respectively.

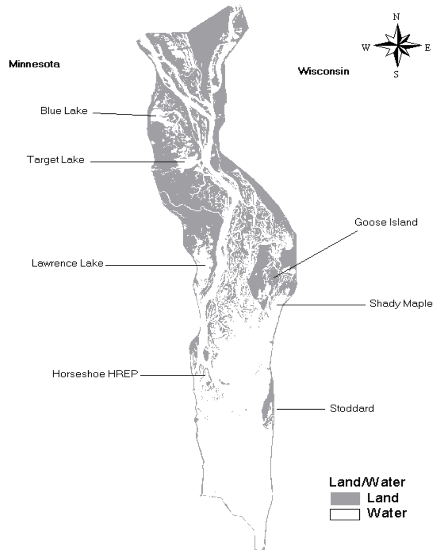

Figure 3. Backwater locations in Pool 8 (Upper Mississippi River) where transects were monitored for aquatic vegetation, Long Term Resource Monitoring Program, 1996.

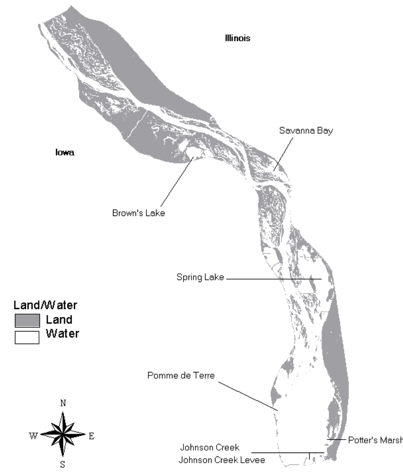

Figure 4. Backwater locations in Pool 13 (Upper Mississippi River) where transects were monitored for aquatic vegetation, Long Term Resource Monitoring Program, 1996.

In Pool 26, we surveyed two backwaters where transects were established in 1991 (Figure 5). These backwaters included Stump Lake and the Calhoun Point area, which consists of several backwater lakes, sloughs, and ephemeral ponds (Appendix A). We also surveyed Fuller Lake, which was added in 1992. The HREP construction in Swan Lake, which was sampled in previous years, prevented vegetation sampling in 1996. Before the HREP implementation, only Swan Lake was contiguous with the main river. The other transects were located in isolated backwaters that are intensively managed as moist soil units (namely, to mimic pre-impoundment hydrology). The reach known as Pool 26 includes portions of the Upper Mississippi River and lower Illinois River. All backwater locations sampled for vegetation were found in the lower 12 miles of the Illinois River.

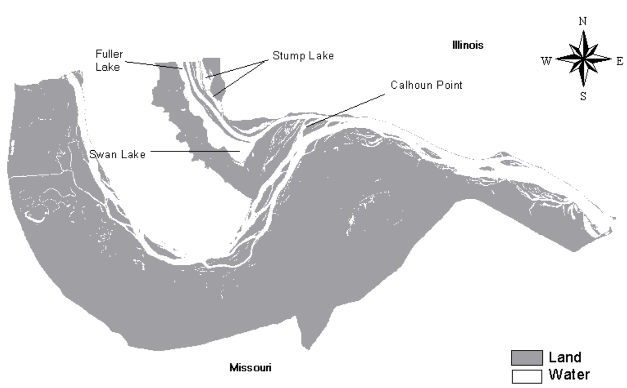

Figure 5. Backwater locations in Pool 26 (Upper Mississippi River) where transects were monitored for aquatic vegetation, Long Term Resource Monitoring Program, 1996.

In La Grange Pool, we have sampled three backwaters since 1991 (Figure 6); Bulrush Pond in the Banner Marsh State Fish and Wildlife Area, Point Lake, and Spring Lake (Appendix A). The Grape Island area, which was added in 1992, was sampled only in the summer in 1996. High water in the spring prevented sampling. Water levels in the main river influence the Grape Island area and Point Lake, but not Spring Lake and Banner Marsh, which are behind large drainage district levees.

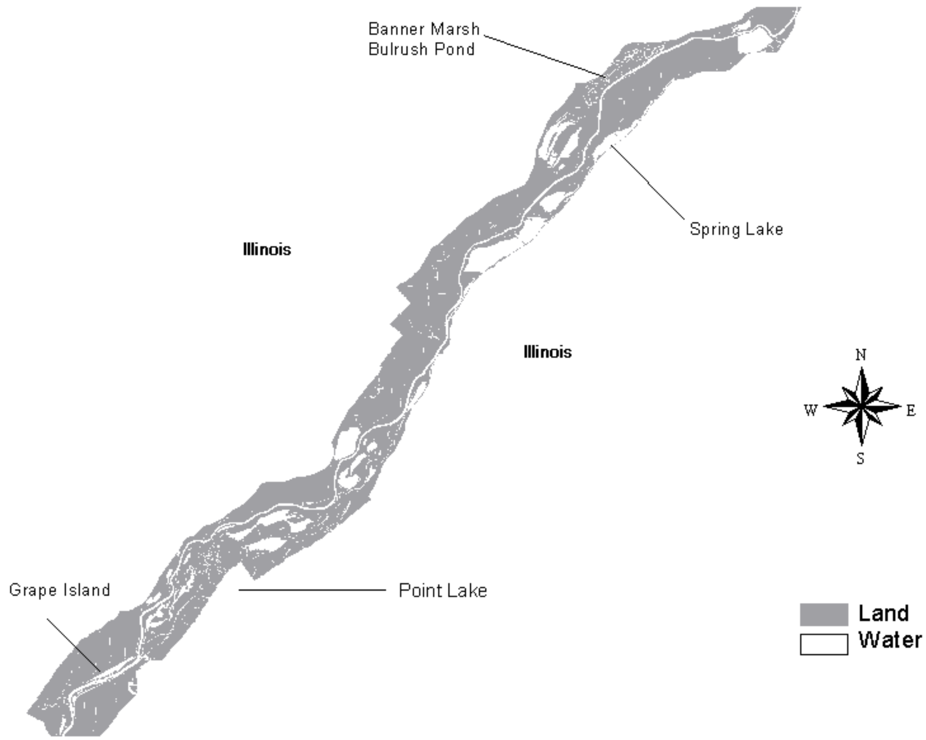

Figure 6. Backwater locations in La Grange Pool (Illinois River) where transects were monitored for aquatic vegetation, Long Term Resource Monitoring Program, 1996.

Methods

Transect Sampling

Transects were positioned perpendicular to shorelines at regular intervals, from 50 to 200 m apart depending on the size of the area. Transects typically traversed an entire backwater. Sampling was performed twice in most locations during the growing season in order to observe seasonal changes. In 1996, spring sampling began on May 20 and ended June 19. The summer sampling period extended from July 15 to August 21 (Appendix A). Two sites were sampled only once during 1996, Upper Mud Lake in Pool 4 (Upper Mississippi River) and Grape Island in La Grange Pool (Illinois River).

In 1996, we considered water temperature and calendar date in determining the onset of spring sampling. Ideally, sampling would proceed when temperatures in the backwaters reached 18E C, which exceeds the threshold for SAV growth and elongation (Barko and Smart 1981; Madsen and Adams 1988; Flint and

Madsen 1995). In fact, sampling was initiated before the threshold was reached due to the prolonged cool weather and the need to complete sampling by mid-June.

Sampling along the transects was conducted at regularly spaced intervals or sites. Sites were sampled every 15 m in Pools 8, 13, and 26 and La Grange Pool, and every 30 m in Pool 4 due to the large size of some backwaters. The sampling method was modified from a technique used by Jessen and Lound (1962). At each site along a transect, a sampling area extending approximately 2 m from the front of the boat was divided into thirds. We sampled plants once in each third by lowering a long-handled thatching rake to the bottom and twisting it. The thatching rake had a 38.1-cm (15-inch) head with 20, 12.7-cm-long (5-inch) teeth and sampled an area of approximately 0.1 m^2. The submersed species on the rake were identified and recorded. After all three twists were made, each species retrieved was assigned a rating of 1 to 4, based on the number of times it appeared on the rake. A rating of 4 was assigned only if a species completely covered the rake teeth on all three twists.

If rooted floating-leaved species were present, they were assigned a rating of 1 to 4 based on the amount of vegetative cover visible in the entire 2-m sampling area (1 = 1–25% cover, 2 = 26–50% cover, 3 = 51–75% cover, and 4 = 76–100% cover). Rooted floating-leaved species were not used in calculating relative frequency. Non-rooted floating species (e.g., Lemnaceae) were recorded if they exceeded 5% of the surface area, but were excluded from analysis.

Fassett (1957), Voss (1972, 1985), and Gleason and Cronquist (1991) were the primary keys used for plant identification. Scientific nomenclature and common names are based on those found in the U.S. Department of Agriculture Internet PLANTS Database (http://plants.usda.gov/plants/). Leafy pondweed (*Potamogeton foliosus*) and small pondweed (*P. pusillus*) were collectively referred to as "small and leafy pondweeds." They were not distinguished from each other during field sampling and were combined for analysis. Watermilfoil species were considered to be Eurasian watermilfoil (*Myriophyllum spicatum*) unless specifically recorded as short spike watermilfoil (*M. sibiricum*). Chara (*Chara* spp.), which is a macroalgae, was analyzed together with the vascular plants.

Since sampling began in 1991, examples of species found in each pool have been saved as voucher specimens. Voucher specimens have been pressed, dried, mounted, labeled, and stored at each field station. Rare species and unusual specimens have been saved for reference and sent to outside experts for verification. A list of submersed and floating-leaved species found during LTRMP monitoring since 1991 appears in Appendix B.

Informal Surveys

To gain perspective on the distribution and composition of SAV in habitats other than transect locations, we qualitatively surveyed many portions within each study pool. When vegetation was observed, visually or with the aid of a depth finder, we recorded species composition, relative abundance, approximate bed size, water depth, substrate type, and location information. Informal surveys have not been conducted in Pool 26 since 1992, when extensive surveys revealed that SAV was generally scarce.

Environmental Factors

Water depth was recorded at each site. The maximum rooting depth was calculated by averaging the deepest 10% of sites vegetated with SAV. Depths were not adjusted for water surface elevations (WSE), which fluctuate due to water-level management and natural events. A qualitative sediment assessment based on visual and tactile characteristics was recorded for each transect, but was excluded from analysis.

Daily WSE were measured by the USACE (Figure 7). Most backwaters with transects were in the middle to lower sections of the pools, therefore, select mid-pool gage readings were used to produce stage hydrographs for Pool 4 (Wabasha, Minnesota; M 760.4), Pool 8 (La Crosse, Wisconsin; M 696.8), Pool 26 (Grafton, Illinois; I 218.0), and La Grange Pool (Beardstown, Illinois; I 88.0). No mid-pool gage measurements for 1996 were available for Pool 13, so no WSE data were included for Pool 13. Mid-pool gages are preferred because most transects are located in that part of the pool. Similar stage hydrograph patterns are observed along the length of a pool and ultimately depend on discharge, which determines how pool level is controlled.

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 twists,
n = total number of sample sites.

Relative frequency of a species was defined as

$$rf_i = e_i/Ef$$

where

e_i = number of rake twists where species *I* was recorded,
Ef = sum of the total number of samples of each species present.

Frequency was calculated on a per site basis (a site was considered vegetated if at least one of three rake twists recovered plants); whereas, relative frequency calculations used each rake twist in order to assess the relative proportion of each species. Frequency and relative frequency are expressed as percent. Records of rooted floating-leaved species were omitted from the relative frequency calculations.

Chi-square tests were used to test for significant seasonal differences in the number of vegetated sites in each pool. To test for significant change in the frequency of individual species between sampling periods, a value for Z was calculated for each species in each backwater location using the following formula:

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

where

$p = (j_1 + j_2)/(n_1 + n_2)$,
$q = 1-p$,
$p_1 = j_1/n_1$,
$p_2 = j_2/n_2$,
n_1 and n_2 = 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.

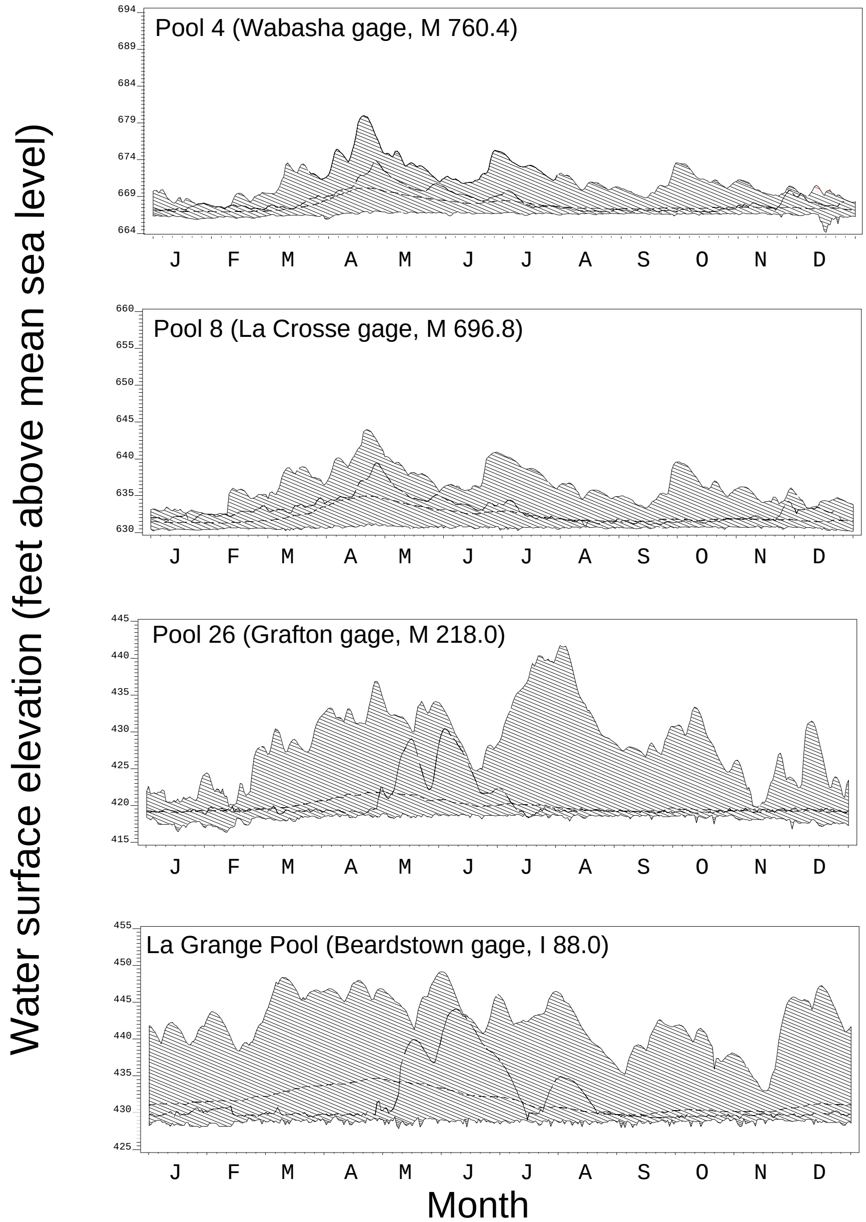

Figure 7. Daily water surface elevations for select navigation pools of the Upper Mississippi River System. Solid line shows 1996 stage hydrograph. Dotted line indicates mean annual stage hydrograph and shaded area shows minimum and maximum water surface elevations for the period of record from 1950–1996 (Mississippi River mile [M]; Illinois River mile [I]; U.S. Army Corps of Engineers data). Mid-pool gage data are not available for Pool 13.

Results and Discussion

All Pools

A total of 24 species of submersed and rooted floating-leaved plants were found in 1996 (21 and 3 species, respectively; Table 2). Of these, 16 submersed species were found along transects, and the remainder were recorded during informal surveys. Pool 4 was the most species rich (23, of which 20 were submersed) and Pool 26 the most depauperate (3, of which 2 were submersed). A total of 12 species, including 10 submersed, were recorded in La Grange Pool, Illinois River. As Peck and Smart (1986) noted, most species in the Upper Mississippi River were found upstream of Pool 14.

Table 2. Frequency (%) of aquatic plant species sampled in Pools 4, 8, 13, and 26 on the Upper Mississippi River and La Grange Pool (LG) of the Illinois River, 1996.

	Spring					Summer				
Species	**4**	**8**	**13**	**26**	**LG**	**4**	**8**	**13**	**26**	**LG**
Submersed species										
bladderwort, common (*Utricularia macrorhiza*)	IS[a]	2.0	–[b]	–	–	–	2.5	–	–	–
buttercup, longbeak (*Ranunculus longirostris*)	IS	–	–	–	–	–	–	–	–	–
chara (*Chara* spp.)	IS	–	–	–	–	–	–	0.2	–	10.3
coontail (*Ceratophyllum demersum*)	4.4	50.7	11.4	–	15.7	2.9	52.2	20.2	–	17.9
pondweed, alpine (*Potamogeton alpinus*)	IS	–	–	–	–	–	–	–	–	–
pondweed, curly (*P. crispus*)	8.6	17.0	1.2	–	12.4	1.3	10.0	1.7	–	18.8
pondweed, flatstem (*P. zosteriformis*)	–	3.6	0.2	–	–	0.1	4.4	1.1	–	–
pondweed, floating (*P. natans*)	IS	–	–	–	–	–	–	–	–	–
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	0.5	16.2	0.1	–	3.4	0.5	19.3	0.4	–	20.5
pondweed, longleaf (*P. nodosus*)	0.4	0.7	1.5	1.3	2.2	0.2	1.6	2.2	–	6.0
pondweed, ribbonleaf (*P. epihydrus*)	IS	–	–	–	–	–	–	–	–	–
pondweed, Richardson's (*P. richardsonii*)	IS	–	–	–	–	–	–	–	–	–
pondweed, sago (*P. pectinatus*)	14.3	29.6	40.0	11.6	6.7	4.8	29.6	32.1	–	6.8
pondweed, horned (*Zannichellia palustris*)	IS	0.2	–	–	–	–	0.2	–	–	8.5
water stargrass (*Heteranthera dubia*)	0.2	0.1	6.8	–	–	1.1	0.7	20.2	–	–
watermilfoil, Eurasian (*Myriophyllum spicatum*)	1.9	11.8	1.2	–	38.2	4.0	15.1	5.5	–	66.7
watermilfoil, shortspike (*M. sibiricum*)	0.2	–	–	–	–	–	–	–	–	–
waternymph, nodding (*N. flexilis*)	IS	0.1	–	–	–	–	4.8	1.7	–	2.6
waternymph, southern (*N. guadalupensis*)	–	–	–	–	–	–	–	2.2	–	–
waterweed, Canadian (*Elodea canadensis*)	0.4	2.8	2.8	–	–	1.5	4.0	3.9	–	3.4
wild celery (*Vallisneria americana*)	–	–	6.4	–	–	9.8	0.3	16.4	–	–

Table 2. Continued.

Species	Spring 4	Spring 8	Spring 13	Spring 26	Spring LG	Summer 4	Summer 8	Summer 13	Summer 26	Summer LG
Number of submersed species (transects)	**9**	**12**	**10**	**2**	**6**	**10**	**13**	**13**	**0**	**10**
Rooted floating-leaved species										
American lotus (*Nelumbo lutea*)	–	0.4	9.2	5.2	2.2	3.8	19.0	40.1	–	7.7
pondlily, yellow (*Nuphar lutea*)	IS	5.6	–	–	–	–	4.3	–	–	–
waterlily, white (*Nymphaea odorata*)	3.0	35.8	1.9	–	–	6.4	42.6	3.3	–	7.7
Number of rooted floating-leaved species (transects)	**1**	**3**	**2**	**1**	**1**	**2**	**3**	**2**	**0**	**2**
Total number of species per pool[c]	**23**	**16**	**15**	**3**	**12**					

[a] IS indicates a species was recorded during informal surveys but not during transect sampling.
[b] The symbol "–" indicates species was not found.
[c] Includes data from spring and summer transects and from informal surveys.

Sago pondweed (*Potamogeton pectinatus*), longleaf pondweed (*P. nodosus*), and American lotus (*Nelumbo lutea*) were the most cosmopolitan species present in all pools (Table 2). Coontail (*Ceratophyllum demersum*), curly pondweed (*P. crispus*), small and leafy pondweeds (*P. pusillus and P. foliosus)*, Eurasian watermilfoil (*Myriophyllum spicatum*), nodding waternymph (*Najas flexilis*), Canadian waterweed (*Elodea canadensis*), and white waterlily (*Nymphaea odorata*) were found in all LTRMP study reaches except Pool 26. Less common species were restricted in their distribution. Large-leaved pondweeds (*P. alpinus, P. epihydrus, P. richardsonii, and P. natans*), longbeak buttercup (*Ranunculus longirostris*), and shortspike watermilfoil (*M. sibiricum*) were recorded only in Pool 4, and southern waternymph (*Najas guadalupensis*) was found only in Pool 13.

Sago pondweed was the most frequently found species in Pools 4, 13, and 26. Coontail was dominant in Pool 8 transects, and Eurasian watermilfoil was most common in La Grange Pool. In general, sago pondweed growth peaked in the spring and subsequently declined. Other taxa, such as chara (*Chara* spp.), small and leafy pondweeds, water stargrass (*Heteranthera dubia*), Eurasian watermilfoil, waternymphs (*Najas* spp.), wild celery, American lotus, and white waterlily increased in frequency later in the season.

Approximately 50–73% of the sites sampled in Pools 8, 13, and La Grange Pool were vegetated during the 1996 growing season (Table 3). In comparison, vegetation was seen in <25% of the sites sampled in Pools 4 and 26. During summer sampling, the Pool 26 backwaters with transects were devoid of both submersed and floating-leaved vegetation.

In all pools, the percent of sites with SAV changed significantly between sampling periods, but the direction of change varied among pools (Table 3). Whether vegetation increased or decreased seasonally could usually be attributed to the regional phenology of the most dominant species. For example, in Pools 4 and 26, the general drop in the percent of SAV sites reflected a summer decline in sago pondweed, as well as in curly pondweed in Pool 4 (Table 2). Although wild celery later increased in Pool 4, it could not offset the decline of sago and curly pondweeds. Conversely, the increase in vegetated sites in La Grange Pool reflects the expansion of Eurasian watermilfoil.

Table 3. Frequency of vegetated sites with submersed aquatic plant species along transects in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool of the Illinois River during spring and summer sampling, 1996.

Pool	Spring (%)	*n*	Summer (%)	*n*	Significance[a]
4[b]	24.6	963	18.8	950	* $P < 0.002$
8	73.4	1,293	65.4	1,252	* $P < 0.001$
13	49.1	985	56.2	996	* $P < 0.002$
26	12.3	310	0.0	166	* $P < 0.001$
La Grange[c]	52.8	89	72.7	117	* $P < 0.003$

[a] Probability value is based on Chi-square test where % = 0.05. The symbol "*" indicates significant change.
[b] Upper Mud Lake was excluded from calculations.
[c] Grape Island was excluded from calculations.

In Pools 4, 8, and 13, the maximum rooting depth decreased from north to south (Table 4). Overall, the maximum rooting depth of SAV was deepest in Pool 26 (3.0 m, spring) and shallowest in Pool 13 (0.9 m, summer). In all study reaches, SAV grew deeper in the spring than in the summer. This trend reflects the natural hydrograph where seasonal precipitation typically swells WSE in the springtime (Figure 7). In Pools 4 and 8, the 1996 hydrographic pattern was characteristic, although higher than usual in the springtime. For the second consecutive year, spring flooding in the Illinois River resulted in unusually high water levels in Pool 26 and La Grange Pool. The hydrographic pattern indicates that water levels dropped during July. The relatively deep growth of plants in La Grange Pool reflects seasonal high water, as well as control of water levels for fish production. In Pool 26, the lack of SAV during summer sampling precluded determination of rooting depth.

Table 4. Maximum rooting depths (m) of submersed aquatic plant species in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool of the Illinois River during spring and summer sampling, 1996.[a]

Pool	Spring	*n*	Summer	*n*
4[b]	1.7 ± 0.03	24	1.3 ± 0.04	18
8	1.5 ± 0.01	95	1.0 ± 0.01	82
13	1.5 ± 0.01	49	0.9 ± 0.01	56
26	3.0 ± 0.05	4	–	0
La Grange[c]	2.6 ± 0.02	5	2.2 ± 0.10	9

[a] Maximum rooting depth was calculated by averaging the deepest 10% of sites with submersed vegetation.
[b] Upper Mud Lake was excluded from calculations.
[c] Grape Island was excluded from calculations.

Pool 4

In 1996, more species were found in Pool 4 than in the other LTRMP study reaches and grew in water up to 1.7 m deep (Tables 2 and 4); however, the overall frequency of vegetation was low in both the spring (25%) and summer (19%) sampling periods (Table 5). Of the 11 submersed species found along transects in Pool 4, 9 were recorded in the spring and 10 were recorded in the summer (Table 5). Shortspike watermilfoil was found only during spring sampling, whereas flatstem pondweed (*P. zosteriformis*) and wild celery were sampled only during the summer. Upstream of Lake Pepin, SAV was sparse and composed singularly of sago pondweed; whereas, many more species were found in backwaters downstream of Lake Pepin (Table 6). Lake Pepin is a 22-mile long tributary delta lake in the middle of Pool 4 that was created by the Chippewa River depositing vast amounts of sand at its confluence with the Mississippi River.

Table 5. Frequencies and relative frequencies of submersed aquatic plant species found along transects in Pool 4 of the Upper Mississippi River during spring (May 22–June 13) and summer (July 18–August 15) sampling periods, 1996.[a]

	Frequencies (%)		Relative frequencies (%)	
Species	**Spring *n* = 963**	**Summer *n* = 950**	**Spring**	**Summer**
coontail (*Ceratophyllum demersum*)	4.4	2.9	11.7	8.2
pondweed, curly (*Potamogeton crispus*)	8.6	1.3	24.6	4.0
pondweed, flatstem (*P. zosteriformis*)	0	0.1	0	0.3
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	0.5	0.5	1.2	1.3
pondweed, longleaf (*P. nodosus*)	0.4	0.2	0.9	1.3
pondweed, sago (*P. pectinatus*)	14.3	4.8	54.3	17.4
water stargrass (*Heteranthera dubia*)	0.2	1.1	0.5	2.6
watermilfoil, Eurasian (*Myriophyllum spicatum*)	1.9	4.0	5.4	13.5
watermilfoil, shortspike (*M. sibiricum*)	0.2	0	0.5	0
waterweed, Canadian (*Elodea canadensis*)	0.4	1.5	0.9	4.2
wild celery (*Vallisneria americana*)	0	9.8	0	47.2
Percent of vegetated sites[b]	**24.6**	**18.8**		

[a] Upper Mud Lake sites were monitored during spring only and were excluded from analysis.
[b] From Table 3.

Sago and curly pondweeds dominated the SAV community in spring (combined relative frequencies of 79%); however, they only grew in a small proportion of the sites sampled (14 and 9%, respectively; Table 5). During summer sampling only one species, wild celery, exceeded a frequency of 5%. Wild celery (relative frequency of 47%) replaced sago and curly pondweed as the dominant species.

Seasonal differences were indicated for particular species and in the upper versus the lower pool (Table 6). Sago pondweed was the only species found in the upper pool, where it declined significantly in two backwaters. Robinson Lake (lower pool) was the most dynamic area, where both sago and curly pondweeds decreased and three species (wild celery, water stargrass, and Canadian waterweed) increased. Wild celery also expanded in Big Lake. Low frequency values limit the detection of trends in all but the most commonly found species.

Table 6. Seasonality of submersed aquatic plant species sampled along transects in backwaters of Pool 4, Upper Mississippi River, 1996.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods	Increased between spring and summer sampling periods[a]
coontail (*Ceratophyllum demersum*)		Big Lake Big Lake Bay Lower Peterson Lake Peterson Lake Rice Lake Robinson Lake	
pondweed, curly (*Potamogeton crispus*)	Robinson Lake	Big Lake Big Lake Bay Lower Peterson Lake Peterson Lake Rice Lake	
pondweed, flatstem (*P. zosteriformis)*		Robinson Lake	
pondweeds, small and leafy (*P. pusillus, P. foliosus*)		Big Lake Bay Robinson Lake	
pondweed, longleaf (*P. nodosus*)		Rice Lake Robinson Lake	
pondweed, sago (*P. pectinatus*)	Bay City Flats[b] Dead Slough Lake[b] Robinson Lake	Big Lake Big Lake Bay Goose Lake[b] Lower Peterson Lake Mud Lake[b] Peterson Lake Rice Lake	
water stargrass (*Heteranthera dubia*)		Peterson Lake	Robinson Lake
watermilfoil, Eurasian (*Myriophyllum spicatum*)		Big Lake Big Lake Bay Lower Peterson Lake Peterson Lake Rice Lake Robinson Lake	
watermilfoil, shortspike (*M. sibiricum*)		Rice Lake	
waterweed, Canadian (*Elodea canadensis*)		Peterson Lake	Robinson Lake
wild celery (*Vallisneria americana*)		Big Lake Bay Lower Peterson Lake Peterson Lake Rice Lake	Big Lake Robinson Lake

[a] Changes in a species frequency were significant at $P < 0.05$.
[b] Upper Pool 4 locations.

Pool 8

Of the 13 submersed species found along transects in Pool 8, 12 were recorded in the spring and 13 were recorded in the summer, 1996 (Table 7). Wild celery was sampled only during the summer and at a very low frequency (<1%). The areas where transects are located may not be suitable habitat for wild celery as it was often observed in other areas of Pool 8 during the informal surveys. Water stargrass and horned pondweed (*Zannichellia palustris*) were also rarely recorded.

Coontail was the most frequently recorded species throughout the growing season (51% in spring and 52% in summer) followed by sago pondweed (30%, both periods). Small and leafy pondweeds were the third most common species in 1996. The small-leaved pondweed group, which would include sago and the small and leafy pondweeds in Pool 8, comprised approximately 32% of the SAV community, nearing that of coontail (43%) during both periods.

The percent of vegetated sites decreased between spring (73%) and summer (65%) sampling (Table 7). Even though the frequency increased for all species except curly and sago pondweeds, there was still a significant poolwide decline in vegetated areas. Overall, curly pondweed, which only declined by 7%, decreased significantly in only two backwaters and actually increased in another (Table 8). This suggests that most curly pondweed was found in Boomerang Island and Lawrence Lake and that following its senescence, these sites were not vegetated by other species.

Table 7. Frequencies and relative frequencies of submersed aquatic plant species found along transects in Pool 8 of the Upper Mississippi River during spring (May 20–June 13) and summer (July 15–August 12) sampling periods, 1996.

	Frequencies (%)		Relative frequencies (%)	
Species	**Spring** ***n*** **= 1,293**	**Summer** ***n*** **= 1,252**	**Spring**	**Summer**
bladderwort, common (*Utricularia macrorhiza*)	2.0	2.5	0.9	1.2
coontail (*Ceratophyllum demersum*)	50.7	52.2	43.7	43.4
pondweed, curly (*Potamogeton crispus*)	17.0	10.0	9.6	4.8
pondweed, flatstem (*P. zosteriformis*)	3.6	4.4	2.1	2.2
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	16.2	19.3	13.0	14.0
pondweed, longleaf (*P. nodosus*)	0.7	1.6	0.4	0.9
pondweed, sago (*P. pectinatus*)	29.6	29.6	20.4	17.9
pondweed, horned (*Zannichellia palustris*)	0.2	0.2	0.1	0.1
water stargrass (*Heteranthera dubia*)	0.1	0.7	<0.1	0.3
watermilfoil, Eurasian (*Myriophyllum spicatum*)	11.8	15.1	7.9	9.5
waternymph, nodding (*Najas flexilis*)	0.1	4.8	0.1	3.0
waterweed, Canadian (*Elodea canadensis*)	2.8	4.0	1.8	2.5
wild celery (*Vallisneria americana*)	0	0.3	0	0.2
Percent of vegetated sites[a]	**73.4**	**65.4**		

[a] From Table 3.

Only sago and curly pondweeds declined in any discrete locations (Table 8). In contrast, common bladderwort (*Utricularia macrorhiza*), coontail, small and leafy pondweeds, Eurasian watermilfoil, and nodding waternymph increased in at least one location. Lawrence and Blue Lakes were the most seasonally dynamic areas, and all 13 species recorded in Pool 8 were found in Lawrence Lake.

Table 8. Seasonality of submersed aquatic plant species sampled along transects in backwaters of Pool 8 of the Upper Mississippi River, 1996.

Species	Decreased between spring and summer sampling period[a]	No change between spring and summer sampling period	Increased between spring and summer sampling periods[a]
bladderwort, common (*Utricularia macrorhiza*)		Lawrence Lake Target Lake	Blue Lake
coontail (*Ceratophyllum demersum*)		Goose Island Lawrence Lake Shady Maple Stoddard, Wisconsin Target Lake	Blue Lake
pondweed, curly (*Potamogeton crispus*)	Boomerang Island Lawrence Lake	Goose Island Horseshoe Island Shady Maple Stoddard, Wisconsin Target Lake	Blue Lake
pondweed, flatstem (*P. zosteriformis*)		Blue Lake Goose Island Lawrence Lake Target Lake	
pondweeds, small and leafy (*P. pusillus, P. foliosus*)		Blue Lake Boomerang Island Horseshoe Island Stoddard, Wisconsin Target Lake	Goose Island Lawrence Lake
pondweed, longleaf (*P. nodosus*)		Goose Island Lawrence Lake Shady Maple Target Lake	
pondweed, sago (*P. pectinatus*)	Boomerang Island Goose Island Horseshoe Island	Blue Lake Lawrence Lake Shady Maple Stoddard, Wisconsin	Target Lake
pondweed, horned (*Zannichellia palustris*)		Goose Island Horseshoe Island Lawrence Lake	
water stargrass (*Heteranthera dubia*)		Goose Island Lawrence Lake Target Lake	
watermilfoil, Eurasian (*Myriophyllum spicatum*)		Goose Island Shady Maple Target Lake	Lawrence Lake
waternymph, nodding (*Najas flexilis*)		Target Lake	Blue Lake Lawrence Lake

Table 8. Continued.

Species	Decreased between spring and summer sampling period[a]	No change between spring and summer sampling period	Increased between spring and summer sampling periods[a]
waterweed, Canadian (*Elodea canadensis*)		Blue Lake Goose Island Horseshoe Island Lawrence Lake Stoddard, Wisconsin Target Lake	
wild celery (*Vallisneria americana*)		Boomerang Island Lawrence Lake	

[a] Changes in a species frequency were significant at $P < 0.05$.

Pool 13

Of the 13 submersed species found along transects in Pool 13 in 1996, 10 were found during the spring sampling period and 13 during the summer sampling period (Table 9). Chara, nodding waternymph, and southern waternymph were found only during the summer sampling.

The percent of sites with SAV increased in Pool 13 from spring (49%) to summer (56%). Sago pondweed was the most abundant species found during both sampling periods (40% and 32% in the spring and summer, respectively). In the spring, sago pondweed and coontail together comprised 77% of the SAV community. Despite an increase in coontail, their combined relative frequencies dropped to only 50% by late summer, because other species expanded. The frequencies of wild celery and water stargrass increased by >10% between sampling periods causing them to become the third most important species in Pool 13 by the summer (relative frequencies of 18%). Chara and small and leafy pondweeds were rarely recorded (<1%).

Table 9. Frequencies and relative frequencies of submersed aquatic plant species found along transects in Pool 13 of the Upper Mississippi River during spring (May 21–June 19) and summer (July 19–August 21) sampling period, 1996.

	Frequencies (%)		Relative frequencies (%)	
Species	**Spring** $n = 985$	**Summer** $n = 996$	**Spring**	**Summer**
chara (*Chara* spp.)	0	0.2	0	0.1
coontail (*Ceratophyllum demersum*)	11.4	20.2	13.6	18.8
pondweed, curly (*Potamogeton crispus*)	1.2	1.7	0.9	0.9
pondweed, flatstem (*P. zosteriformis*)	0.2	1.1	0.2	0.6
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	0.1	0.4	0.1	0.3
pondweed, longleaf (*P. nodosus*)	1.5	2.2	2.0	1.5
pondweed, sago (*P. pectinatus*)	40.0	32.1	63.6	31.3
water stargrass (*Heteranthera dubia*)	6.8	20.2	7.1	17.9

Table 9. Continued.

Species	Frequencies (%)		Relative frequencies (%)	
	Spring n = 985	Summer n = 996	Spring	Summer
watermilfoil, Eurasian (*Myriophyllum spicatum*)	1.2	5.5	1.3	3.7
waternymph, nodding (*Najas flexilis*)	0	1.7	0	1.5
waternymph, southern (*N. guadalupensis*)	0	2.2	0	2.0
waterweed, Canadian (*Elodea canadensis*)	2.8	3.9	3.7	3.6
wild celery (*Vallisneria americana*)	6.4	16.4	7.5	17.7
Percent of vegetated sites[a]	**49.1**	**56.2**		

[a] From Table 3.

Only sago pondweed declined between sampling periods in Pool 13 (Table 10). In comparison, five species increased in at least one location. Of these, water stargrass, Eurasian watermilfoil, and wild celery expanded in most of the backwaters where they were found. Johnson Creek, where five species increased, was the most dynamic area in Pool 13. In addition, all 13 species found in 1996 were recorded in Johnson Creek.

Table 10. Seasonality of submersed aquatic plant species sampled along transects in backwaters of Pool 13 of the Upper Mississippi River, 1996.

Species	Decreased between spring and summer sampling period[a]	No change between spring and summer sampling period	Increased between spring and summer sampling period[a]
chara (*Chara* spp.)		Johnson Creek	
coontail (*Ceratophyllum demersum*)		Johnson Creek Levee Pomme de Terre Savanna Bay Spring Lake	Brown’s Lake Johnson Creek
pondweed, curly (*Potamogeton crispus*)		Brown’s Lake Johnson Creek Johnson Creek Levee Potter’s Marsh Savanna Bay Spring Lake	
pondweed, flatstem (*P. zosteriformis*)		Johnson Creek Johnson Creek Levee Savannah Bay	
pondweeds, small and leafy (*P. pusillus, P. foliosus*)		Brown’s Lake Johnson Creek Spring Lake	

Table 10. Continued.

Species	Decreased between spring and summer sampling period[a]	No change between spring and summer sampling period	Increased between spring and summer sampling period[a]
pondweed, longleaf (*P. nodosus*)		Brown's Lake Johnson Creek Johnson Creek Levee Pomme de Terre Potter's Marsh Savanna Bay Spring Lake	
pondweed, sago (*P. pectinatus*)	Brown's Lake Johnson Creek Levee Potter's Marsh	Johnson Creek Pomme de Terre Savanna Bay Spring Lake	
water stargrass (*Heteranthera dubia*)		Savanna Bay Spring Lake	Johnson Creek Johnson Creek Levee Pomme de Terre Potter's Marsh
watermilfoil, Eurasian (*Myriophyllum spicatum*)		Spring Lake Potter's Marsh	Johnson Creek Johnson Creek Levee Pomme de Terre
waternymph, nodding (*Najas flexilis*)		Johnson Creek Johnson Creek Levee Savanna Bay Spring Lake	
waternymph, southern (*N. guadalupensis*)		Brown's Lake Johnson Creek Levee Pomme de Terre Spring Lake	Johnson Creek
waterweed, Canadian (*Elodea canadensis*)		Johnson Creek Johnson Creek Levee Pomme de Terre	
wild celery (*Vallisneria americana*)		Potter's Marsh Spring Lake	Johnson Creek Johnson Creek Levee Pomme de Terre

[a] Changes in a species frequency were significant at $P < 0.05$.

Pool 26

Overall, in Pool 26 vegetation was sparse and found only during spring sampling in Stump Lake in 1996 (12%; Tables 11 and 12). Sago and longleaf pondweeds were the only species recorded. Whereas both species disappeared between sampling periods, the low frequency of longleaf pondweed precluded significance. Swan Lake, a backwater sampled in previous years, was not sampled in 1996 because of construction of a HREP. The lack of vegetation in this river reach was possibly influenced by the second consecutive year of spring flooding by the Illinois River, shown by the elevated river stage and rooting depths exceeding 3 m (Figure 7; Table 4). It is also likely that the lack of vegetation is related to record flooding in 1993. Since that time, SAV has been absent from most of the backwaters of the lower Illinois River. This question has not been formally addressed in this study, but the data presented in Figure 7 and observations made during the monitoring and analysis phases of this study suggest a possible correlation between water depth and vegetation abundance.

Table 11. Frequencies and relative frequencies of submersed aquatic plant species found along transects in Pool 26 of the Upper Mississippi River during spring (June 5–13) and summer (August 2–8) sampling periods, 1996.

	Frequencies (%)		Relative frequencies (%)	
Species	Spring *n* = 310	Summer *n* = 166	Spring	Summer
pondweed, longleaf (*Potamogeton nodosus*)	1.3	0	10.0	0
pondweed, sago (*P. pectinatus*)	11.6	0	90.0	0
Percent of vegetated sites[a]	**12.3**	**0**		

[a] From Table 3.

Table 12. Seasonality of submersed aquatic plant species sampled along transects in backwaters of Pool 26 of the Upper Mississippi River, 1996.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods	Increased between spring and summer sampling periods[a]
pondweed, longleaf (*P. nodosus*)		Stump Lake	
pondweed, sago (*P. pectinatus*)	Stump Lake		

[a] Changes in a species frequency were significant at $P < 0.05$.

La Grange Pool

Ten submersed species were found along transects in La Grange Pool in 1996 (Table 13). Of these, 6 were recorded during spring sampling and 10 during summer sampling. Chara, horned pondweed, nodding waternymph, and Canadian waterweed were found only in the summer.

More than half of the sites were vegetated with SAV throughout the growing season (Table 13). Eurasian watermilfoil was more abundant than any other species during both sampling periods (frequencies of 38 and 67%). In the spring, Eurasian watermilfoil combined with coontail to account for >75% of the community. Coontail's frequency was comparable throughout the growing season (16 and 18%), however, its relative importance decreased from 31 to 11% because small and leafy pondweeds expanded later in the season.

Table 13. Frequencies and relative frequencies of submersed aquatic plant species found along transects in La Grange Pool of the Illinois River during spring (May 22–30) and summer (July 17–August 1) sampling periods, 1996.[a]

	Frequencies (%)		Relative frequencies (%)	
Species	Spring *n* = 89	Summer *n* = 117	Spring	Summer
chara (*Chara* spp.)	0	10.3	0	5.2
coontail (*Ceratophyllum demersum*)	15.7	17.9	30.9	11.2
pondweed, curly (*Potamogeton crispus*)	12.4	18.8	11.3	9.7

Table 13. Continued.

Species	Frequencies (%) Spring n = 89	Frequencies (%) Summer n = 117	Relative frequencies (%) Spring	Relative frequencies (%) Summer
pondweeds, small and leafy (*P. pusillus, P. foliosus*)	3.4	20.5	3.1	13.3
pondweed, longleaf (*P. nodosus*)	2.2	6.0	2.1	4.4
pondweed, sago (*P. pectinatus*)	6.7	6.8	6.2	2.3
pondweed, horned (*Zannichellia palustris*)	0	8.5	0	4.2
watermilfoil, Eurasian (*Myriophyllum spicatum*)	38.2	66.7	46.4	46.1
waternymph, nodding (*Najas flexilis*)	0	2.6	0	1.0
waterweed, Canadian (*Elodea canadensis*)	0	3.4	0	2.6
Percent of vegetated sites[b]	**52.8**	**72.7**		

[a] Grape Island sites were monitored during summer only and were excluded from analysis.
[b] From Table 3.

All 10 of the species recorded in La Grange Pool were found in Spring Lake. In addition, seasonal changes were significant only in Spring Lake, where curly pondweed, small and leafy pondweeds, and Eurasian watermilfoil increased (Table 14). Eurasian watermilfoil rebounded from its collapse in Spring Lake in 1995, and the species that appeared during Eurasian watermilfoil's nadir were sustained in 1996.

Coontail was the only species found in Point Lake, one of two backwaters with transects that are contiguous with the main stem of the Illinois River. The other backwater, Grape Island (sampled only in the summer due to high water in the spring), was devoid of vegetation. Unusually high water levels in the spring and again in mid-summer may explain the scarcity of plants in areas contiguous with the Illinois River. Elevated water levels would be less likely to affect Spring Lake and Banner Marsh because they are isolated from all but the highest river stages.

Table 14. Seasonality of submersed aquatic plant species sampled along transects in backwaters of La Grange Pool of the Illinois River, 1996.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods	Increased between spring and summer sampling periods[a]
chara (*Chara* spp.)		Spring Lake	
coontail (*Ceratophyllum demersum*)		Banner Marsh Point Lake Spring Lake	
pondweed, curly (*Potamogeton crispus*)		Banner Marsh	Spring Lake
pondweeds, small and leafy (*P. pusillus, P. foliosus*)		Banner Marsh	Spring Lake

Table 14. Continued.

Species	Decreased between spring and summer sampling periods[a]	No change between spring and summer sampling periods	Increased between spring and summer sampling periods[a]
pondweed, longleaf (*P. nodosus*)		Banner Marsh Spring Lake	
pondweed, sago (*P. pectinatus*)		Banner Marsh Spring Lake	
pondweed, horned (*Zannichellia palustris*)		Spring Lake	
watermilfoil, Eurasian (*Myriophyllum spicatum*)		Banner Marsh	Spring Lake
waternymph, nodding (*Najas flexilis*)		Spring Lake	
waterweed, Canadian (*Elodea canadensis*)		Spring Lake	

[a] Changes in a species frequency were significant at $P < 0.05$.

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Appendix A

Locations, Habitat, 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 1996 Sampling Season

Location (river mile)	Habitat[a]	Number of transects spring:summer	Number of sites spring	Number of sites summer	Dates sampled spring	Dates sampled summer	Distance between sites (m)
Pool 4							
Upper Mud Lake (M791.5)[b]	BWC	4:0	41	Not sampled	6/13	Not sampled	30
Mud Lake (M791.3)	BWC	3:3	63	55	6/12	8/13, 15	30
Dead Slough Lake (M789.2, M788.5, M788.0)	BWC	9:9	136	136	6/11–12	8/8–9, 13	30
Goose Lake (M788.G)[c]	BWC	3:3	30	28	6/10	8/8	30
Catherine Pass (Bay City Flats; M787.0)[d]	BWC	3:3	80	85	6/10	8/7	30
Robinson Lake (M758.R)[c]	BWC	9:9	228	225	5/24, 29–31; 6/4	7/24–26, 29–30	30
Big Lake Bay (M758.5)	BWC	3:3	46	45	6/5	8/5–6, 14	30
Rice Lake (M758.0)	BWC	3:3	39	35	6/7	7/30–31	30
Big Lake (M757.5)	BWC	5:5	182	160	6/5–7	7/31–8/2, 8/6	30
Peterson Lake (M754.8, M754.5)	BWC	6:6	55	53	5/22	7/18–19	30
Lower Peterson Lake (M753.5)	BWC	4:4	104	128	5/23	7/22–24	30
Total Pool 4		**52:48**	**1,004**	**950**	**14**	**20**	
Pool 8							
Blue Lake (M697.0)	BWI	3:3	126	118	6/4–5	7/24–25	15
Target Lake (M696.0)	BWC	11:11	293	279	5/20–24	7/15–18	15
Goose Island (M692.0)	BWC	5:5	112	114	5/31; 6/3	7/29	15
Lawrence Lake (M691.0)	BWC	10:10	421	417	6/7, 10–13	7/31–8/2, 6–9, 12	15
Shady Maple (M690.0)	BWC	3:3	102	90	6/3	7/26	15

Location (river mile)	Habitat[a]	Number of transects spring:summer	Number of sites spring	Number of sites summer	Dates sampled spring	Dates sampled summer	Distance between sites (m)
Horseshoe Island (Pool 8 Islands HREP; M687.0)[e]	BWC	5:5	85	82	6/6	7/30	15
Boomerang Island (Pool 8 Islands HREP; M686.0)[e]	IMP	4:4	104	104	5/28–29	7/19	15
Stoddard, Wisconsin (M684.0)	BWI	4:4	50	48	5/30	7/23	15
Total Pool 8		**45:45**	**1,293**	**1,252**	**18**	**19**	
Pool 13							
Brown's Lake (M545.1, M544.5)	BWC	15:15	338	357	6/5–6, 11–14	8/1–2, 5, 7–9, 12–13,	15
Savanna Bay (M541.5, M540.5, M539.5)	BWC	12:12	142	139	5/29–30	7/26, 29	15
Spring Lake (M534.8, M533.6, M532.0)	BWC	10:12	162	166	5/31; 6/3–4	7/30–31	15
Pomme de Terre (M526.0)	IMP	5:5	75	75	5/21	7/19, 22	15
Potter's Marsh (M524.0)	IMP	6:6	96	92	6/17	8/14–16	15
Johnson Creek Levee (M523.5)	IMP	4:4	113	102	6/18–19	8/20–21	15
Johnson Creek (M523.0)	IMP	2:2	59	65	5/22, 29	7/23–25	15
Total Pool 13		**54:56**	**985**	**996**	**16**	**22**	
Pool 26							
Calhoun Point (I003.0)[f]	BWI	18:3	156	27	6/13	8/8	15
Stump Lake (I010.0)	BWI	7:4	125	102	6/11–12	8/8	15
Fuller Lake (I011.5)	BWI	2:2	29	37	6/5, 12	8/2	15
Total Pool 26		**27:9**	**310**	**166**	**4**	**2**	
La Grange Pool							
Grape Island (I086.4)	SC	0:3	Not sampled	12	Not sampled	8/1	15
Point Lake (I100.0)	BWI	6:6	22	22	5/30	7/29	15
Spring Lake (I135.5)	IMP	5:5	51	78	5/24, 27, 30	7/18, 22, 24–25	15

Location (river mile)	Habitat[a]	Number of transects spring:summer	Number of sites spring	Number of sites summer	Dates sampled spring	Dates sampled summer	Distance between sites (m)
Banner Marsh (Bulrush Pond; I140.7)[d]	IMP	2:2	16	17	5/22–23	7/17	15
Total La Grange Pool		**13:16**	**89**	**129**	**5**	**7**	

[a] Type of habitats: BWC = Backwater contiguous, BWI = Backwater isolated, IMP = Impounded, SC = Side channel.
[b] Mississippi River miles, measured from the confluence of the Mississippi and Ohio Rivers.
[c] "G" and "R" to distinguish this lake from another lake with the same river mile.
[d] Locally recognized alternate name.
[e] Part of the Pool 8 Islands Habitat Rehabilitation and Enhancement Project.
[f] Illinois River miles, measured from the confluence of the Mississippi and Illinois Rivers. Pool 26 is located at the confluence of the Mississippi and Illinois Rivers and the portions named here extend up the Illinois River, are managed by the Illinois Department of Natural Resources, and are designated by Illinois River miles.

Appendix B

List of Submersed and Floating-leaved Aquatic Species Present at Transect Sites in Pools 4, 8, 13, and 26 of the Upper Mississippi River and La Grange Pool of the Illinois River During Monitoring for the Long Term Resource Monitoring Program, 1991–1996[a]

Family	Scientific name	Common name
Azollaceae (Salviniaceae)	*Azolla* spp.[b]	watervelvet, mosquitofern
Ceratophyllaceae	*Ceratophyllum demersum* L.	coon's tail, coontail
Characeae	*Chara* spp.	chara
Characeae	*Nitella* spp.	nitella
Haloragaceae	*Myriophyllum sibiricum* Komarov	northern watermilfoil, shortspike watermilfoil
Haloragaceae	*Myriophyllum spicatum* L.	Eurasian watermilfoil, spike watermilfoil
Hydrocharitaceae	*Elodea canadensis* Michx.	Canadian waterweed
Hydrocharitaceae	*Vallisneria americana* Michx.	wild celery, American eelgrass
Lemnaceae	*Lemna minor* L.[b]	lesser duckweed, small duckweed common duckweed
Lemnaceae	*Lemna trisulca* L.[b]	star duckweed
Lemnaceae	*Spirodela polyrhiza* (L.) Schleid.[b]	greater duckweed, big duckweed, common duckweed
Lemnaceae	*Wolffia braziliensis* Weddell[b] (*Wolffia papulifera* C. Thompson *Wolffia punctata* Griseb.)	Brazilian watermeal
Lemnaceae	*Wolffia columbiana* Karst.[b]	Columbian watermeal
Lentibulariaceae	*Utricularia macrorhiza* Le Conte (*Utricularia vulgaris* L.)	common bladderwort
Najadaceae	*Najas flexilis* (Willd.) Rostk. & Schmidt	bushy pondweed, slender naiad, nodding waternymph
Najadaceae	*Najas gracillima* (A. Braun ex Engelm.) Magnus	slender waternymph
Najadaceae	*Najas guadalupensis* (Spreng.) Magnus[c]	southern waternymph
Nymphaeaceae	*Nelumbo lutea* Willd.	American lotus
Nymphaeaceae	*Nuphar lutea* (L.) Sm	yellow pondlily
Nymphaeaceae	*Nymphaea odorata* Ait.	American white waterlily
Onagraceae	*Ludwigia decurrens* Walt. [b]	wingleaf primrosewillow
Pontederiaceae	*Heteranthera dubia* (Jacq.) MacM. (*Zosterella dubia* [Jacq.] Small)	water stargrass, grassleaf mudplantain
Potamogetonaceae	*Potamogeton alpinus* Balbis[d]	red pondweed, alpine pondweed
Potamogetonaceae	*Potamogeton crispus* L.	curly pondweed, curlyleaf pondweed
Potamogetonaceae	*Potamogeton epihydrus* Raf.	ribbonleaf pondweed
Potamogetonaceae	*Potamogeton foliosus* Raf.	leafy pondweed
Potamogetonaceae	*Potamogeton gramineus* L.	variableleaf pondweed
Potamogetonaceae	*Potamogeton illinoensis* Morong.[d]	Illinois pondweed
Potamogetonaceae	*Potamogeton natans* L.[d]	floating pondweed
Potamogetonaceae	*Potamogeton nodosus* Poir	river pondweed, American pondweed, longleaf pondweed
Potamogetonaceae	*Potamogeton pectinatus* L	sago pondweed

Family	Scientific name	Common name
Potamogetonaceae	*Potamogeton pusillus* L.	small pondweed, slender pondweed
Potamogetonaceae	*Potamogeton richardsonii* (Benn.) Rydb.	Richardson's pondweed
Potamogetonaceae	*Potamogeton zosteriformis* Fern.	flatstem pondweed
Ranunculaceae	*Ranunculus flabellaris* Raf.	yellow water buttercup
Ranunculaceae	*Ranunculus longirostris* Godr.[e]	longbeak buttercup, white water crowfoot
Zannichelliaceae	*Zannichellia palustris* L.	horned pondweed

[a] Scientific nomenclature and common names follow the U.S. Department of Agriculture Internet PLANTS Database (http://plants.usda.gov/plants/). Common names most often used by Upper Mississippi River managers are also included.
[b] Species excluded from analysis.
[c] Verified for Pool 13 by Dr. E. Cawley, Loras College, Iowa.
[d] Verified by Dr. C. B. Hellquist, North Adams State College, Massachusetts.
[e] *Ranunculus longirostris* and *R. trichophyllus* were combined (Voss 1985).

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Distribution and frequency of submersed aquatic vegetation in the Upper Mississippi River System are monitored as part of the Long Term Resource Monitoring Program. This report summarizes results of sampling aquatic vegetation along fixed transects in Navigation Pools 4, 8, 13, and 26 in the Upper Mississippi River and La Grange Pool in the Illinois River in 1996. Plants were sampled at regular intervals along fixed transects using a modified rake technique. Sampling was conducted twice during the growing season (spring and summer). Twenty-four submersed and rooted floating-leaved species were found. Most species were found in Pools 4, 8, and 13. Pool 26 had the fewest (3) number of species and Pool 4 had the greatest (23), including most large-leaved pondweeds and the first LTRMP record of floating pondweed (*Potamogeton natans*). Sago pondweed (*P. pectinatus*) and coontail (*Ceratophyllum demersum*) were dominant in the contiguous backwaters sampled. Seasonal trends were observed in 10 species, all of which increased later in the season. Throughout the growing season, more sites were vegetated in Pools 8 and 13 and La Grange Pool (frequency of 50–73%) than in Pools 4 and 26 (<25%). Pool 26 was devoid of vegetation during the second sampling. Aquatic vegetation was generally rare in contiguous areas of Pool 26 and La Grange Pool, but more plentiful in the isolated, managed backwaters of La Grange Pool.

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