CHAPTER 8

Submersed Aquatic Vegetation

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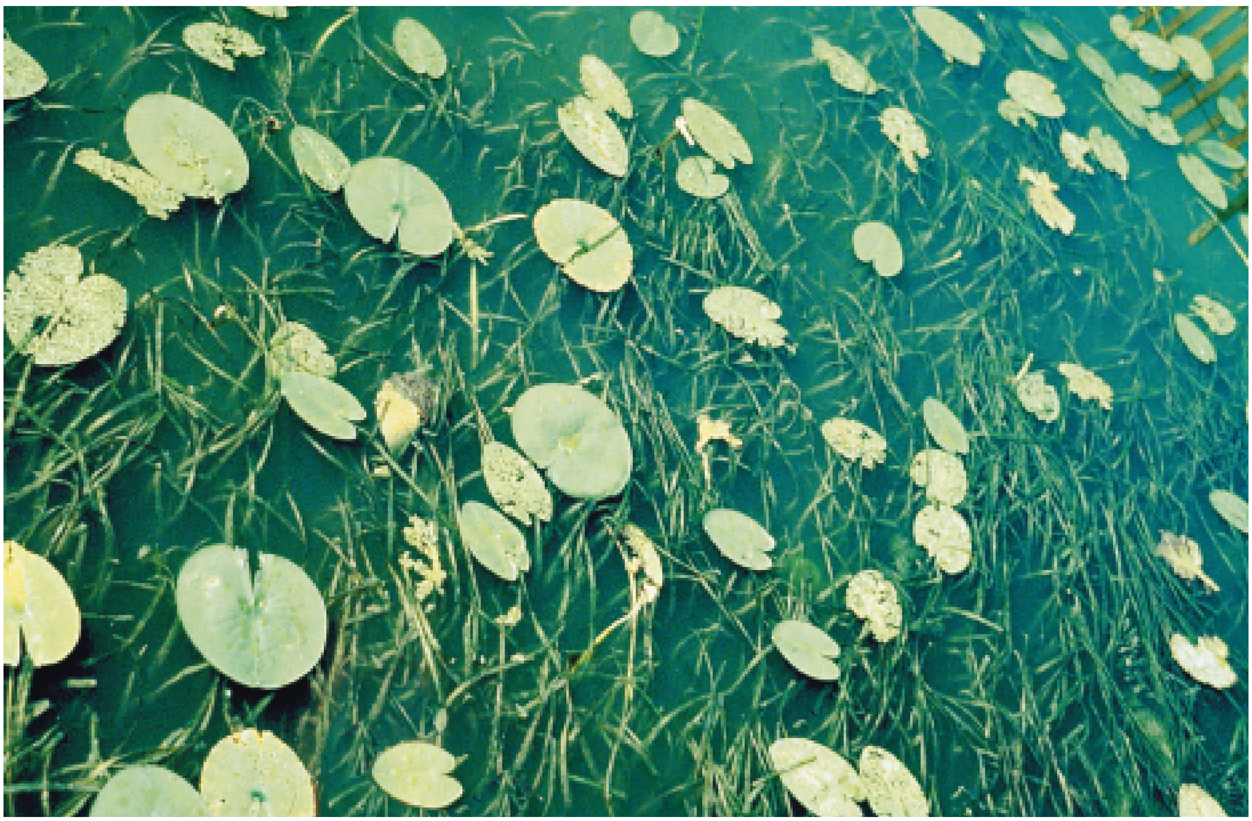

Figure 8-1. Diversity and abundance of submersed aquatic vegetation in the Upper Mississippi River System varies among reaches and years. Shown here is the submersed aquatic plant wildcelery and floating-leaved water lilies.

Submersed aquatic vegetation (SAV) includes plants with leaves and stems that grow on or under the surface of the water (Figure 8-1), usually found anchored to the sediment by their roots. This chapter covers what is known about the dynamics of these submersed vascular plants in the Upper Mississippi River System (UMRS). The discussion does not emphasize floating-leaved species and macroalgae.

Historically, submersed aquatic macrophytes have played several important roles in the Upper Impounded Reach of the UMRS (Green 1960). Plant communities generate dissolved oxygen, stabilize mucky sediments, filter suspended particulates, and take up nutrients that otherwise might support potentially nuisance algal growth (Carpenter and Lodge 1986; Korschgen 1990; Barko et al. 1991; James and Barko 1994). Their tubers and rootstocks provide food for a variety of aquatic animals and migrating waterfowl (Korschgen et al. 1988). Plant leaves provide surface area and shelter for invertebrate communities, an important food source for ducks and fish. Finally, beds of aquatic plants provide shelter for young and spawning fish (Crowder and Cooper 1982; Poe et al. 1986; Savino and Stein 1982, 1989).

Submersed aquatic vegetation exhibits an uneven longitudinal distribution throughout the UMRS. This is due, in part, to gradients of water clarity and water-level fluctuations.

Observations made on the Illinois River yield a valuable lesson on how the ecological quality of the Mississippi River reaches could decline if SAV is eliminated (see Chapter 14). When submersed aquatic vegetation died out in the Illinois River in the mid-1950s, several things occurred. Backwater substrates became easily disturbed, turbidity increased, fish communities became dominated by species tolerant of low dissolved oxygen and poorer habitat conditions, and waterfowl shifted their migrations away from the rivers (Sparks 1984). Continued evidence of declining SAV abundance in the Mississippi River is most notable in the Lower Impounded Reach, and during the drought of the late 1980s, in the Upper Impounded Reach.

Increasing the abundance and availability of SAV to migrating waterfowl is a common resource management objective of State and Federal conservation agencies along the Mississippi River. Many of the Federal Environmental Management Program Habitat Rehabilitation and Enhancement Projects focus on improving sediment conditions to promote the growth of emergent and submersed aquatic vegetation.

Current Status

Submersed aquatic vegetation exhibits an uneven longitudinal distribution throughout the UMRS. This is due, in part, to gradients of water clarity and water-level fluctuations (see Chapters 6 and 7). Gradients in floodplain geomorphology (e.g., depth, current velocity, and substrate type) lateral to the main channel determine which areas are suitable for SAV survival. The SAV generally grows best in areas of low water velocity, adequate light penetration, and relatively stable water levels. Backwaters are the most productive aquatic area type for aquatic vegetation because of their shallow water depths and relatively slow current velocities (Peck and Smart 1986).

Submersed aquatic vegetation in the Lower Impounded and Illinois River reaches have been affected greatly by reduced water clarity resulting from the deposition and resuspension of fine sediment. Upper Impounded Reach backwaters generally have good sediment quality, and although some are affected by high tributary-sediment delivery and island erosion (see Chapter 4), SAV is most abundant in the Upper Impounded Reach (Pools 4–13) of the Mississippi River (Lubinski 1993).

Historically, rather than using systematic surveys (Peck and Smart 1986), SAV surveys have been restricted to studies of small areas such as Pool 19 (Steffeck et al. 1985), Weaver Bottoms (Pool 5; McConville et al. 1994), and Pools 7 and 8 (Sohmer 1975; Swanson and Sohmer 1979; Carl Korschgen, USGS Upper Mississippi Science Center, La Crosse, Wisconsin, unpublished data). More recently, distribution of submersed aquatic plant communities in Pools 4, 8, 13, 26, and La Grange Pool of the Illinois River has been surveyed annually as part of the LTRMP trend analysis. The Unimpounded Reach does not support SAV and is not surveyed routinely.

Data collected along fixed-location transects in selected sites, from boat surveys, and aerial photography interpretation in LTRMP study reaches have provided information about the distribution of SAV. Between 1991 and 1994, 19 species have been recorded along fixed transects. Not surprisingly, SAV is most abundant in the three LTRMP study reaches in the Upper Impounded Reach. This trend does not compare directly with LTRMP water clarity data but appears to be related to increasing turbidity (see Figure 7-7) and to greater water-level fluctuations found in lower reaches of the rivers.

The average depth at which SAV occurs in the study reaches also supports the relationship to turbidity. Plants were found deepest in Pool 4 (3 feet.; 0.9 m), followed by Pools 8 and 13 (2.5 feet.; 0.75 m) and Pool 26 (1.75 feet.; 0.53 m). The number of species also declined downstream, with 17 species occurring in the Upper Impounded Reach and only seven in Pool 26.

Temporal change in the LTRMP study reaches differed among years and pools. Pool 4 plant beds experienced a steady decline in the frequency of species identified during the period from 1991 to 1994. The number of species also has declined from 16 to 11. The reason for this has not been determined, but turbidity has increased slightly in Pool 4 (see Figure 7-7). The decline resembles SAV declines that occurred between 1988 and 1991 in other pools in the Upper Impounded Reach but not exhibited in Pool 4 during the same period.

In Pool 8 SAV frequency-of-species gradually increased between 1991 and 1994, an apparent recovery from die-off experienced during the drought of 1987–89. The number of species increased from 10 to 14 during the same period. Increases were noted in both transect sampling and the occurrence of new plant beds found during boat surveys. This trend toward increases apparently corresponds to decreasing turbidity during the same period (see Figure 7-7).

The presence of submersed aquatic plants in Pool 13 was variable between 1991 and 1994, primarily in response to flooding during 1993. The frequency of SAV increased between 1991 and 1992, and SAV appeared to be growing well during the spring of 1993. But extreme flooding over a period of 54 days that year reduced total production. The plant community appears to have recovered well in 1994, with 13 species encountered. After the flood, species frequency shifted, with sago and curly pondweeds recovering well from the flood and coon's tail and Eurasian watermilfoil declining.

Aquatic plants in Pool 26 are largely restricted to a few backwaters, primarily those isolated from the river (except during floods) and managed with drawdowns to promote waterfowl habitat. In 1991 and 1992, six and seven species of aquatic plants, respectively, were present in the managed backwaters, contiguous backwaters, and channel border areas. The extreme flood in 1993 eliminated most SAV and, to date, there has not been a noticeable recovery. Plant growth in Pool 26 apparently is related to water-level fluctuations and turbidity because during the drought in 1988 and 1989 when water levels were stable and turbidity was low, aquatic plants were common and occurred in many areas.

Aquatic plants in the Illinois River are restricted primarily to backwaters isolated from the river by levees and managed to promote waterfowl habitat. Aquatic plants in these protected Illinois River backwaters occurred at average depths of over 4 feet (1.2 m), reflecting the difference in water clarity between the river and protected backwaters.

Species encountered during LTRMP sampling have been similar to those found in prior surveys. Notable exceptions are increased occurrence of the introduced species Eurasian watermilfoil and a decline of the native species spike watermilfoil, particularly in Pool 8. Coon's tail and sago pondweed were the most frequently found species in all pools during the period covering 1991 to 1994. Curly pondweed also frequently was found during spring transect

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sampling in Pools 4 and 8, whereas wildcelery was the most frequently found species during summer sampling in Pool 4.

The pattern of year-to-year SAV variability has been observed often along the river. The most common explanations link the response of the plants to water level, flow, turbidity, or nutrient differences associated with variable hydrographs among years (Haslam 1978). Annual variations in SAV frequency and distribution require repeated surveys over many climatic events to determine trends. However, long-term historical observations from specific sites on the UMRS make it possible to describe changes that have occurred since the river was impounded.

In the mid-1970s and again in the late 1980s, many biologists observed declines in the abundance of wildcelery and other submersed aquatic plants in the upper pools.

Long-Term Changes in Submersed Aquatic Vascular Plants

Before the lock and dam system was built, the UMRS floodplain consisted of river channels, wooded islands, deep sloughs, and many small lakes and ponds interspersed among forests, prairies, and marshes. Submersed vegetation was present, but not greatly abundant (Green 1960). Impoundment favored SAV by increasing shallow water surface area and stabilizing low-discharge water levels. Large open-water areas were created immediately upstream of the dams (Chen and Simons, 1986; also see Chapters 4 and 6). In mid-pool regions, large areas of flooded land conducive to marsh development were formed. In the upper pool reaches that most resembled pre-impoundment conditions, woody terrestrial vegetation continued to dominate the land cover.

Since early postimpoundment, water-surface area has declined slightly with the sedimentation and growth of emergent aquatic vegetation in midpool reaches. Many backwaters and impoundments have become habitats of uniform and shallow depth because sediment tends to accrete faster in deeper areas (Bellrose et al. 1983). Such bottom uniformity has limited the range of environmental conditions available for submersed aquatic plant species (Peck and Smart 1986).

Since the river was impounded, a succession of aquatic plant species has occurred in the upper pools of the Upper Mississippi River (UMR). Water smartweeds were the first species to occupy many newly created habitats where water depths were shallow. After about 5 years, smartweeds began to be replaced by species of pondweeds, coontail, elodea, water stargrass, and wildcelery (Green 1960). By the early 1960s, wildcelery was reported to be common and widespread in most of Pools 4 through 19 (Green 1960) where it was dominant until recently (Rogers 1994). In Lake Onalaska (Pool 7), for example, a plant community dominated by wildcelery covered half the surface area at depths less than 6 feet (2 m) deep until the late 1980s (Carl Korschgen, USGS Upper Mississippi Science Center, La Crosse, Wisconsin, unpublished data). This plant community was maintained from year to year by production of overwintering structures (tubers) that regrew each spring.

In the mid-1970s and again in the late 1980s, many biologists observed declines in the abundance of wildcelery and other submersed aquatic plants in the upper pools (Rogers 1994). Observations supported by Landsat images suggest that declines occurred primarily during a 1987–89 drought period (Figure 8-2). Observations by LTRMP staff members and other biologists suggest that many areas have shown a resurgence of SAV.

Little quantifiable information exists on aquatic plant communities south of Pool 19, but anecdotal information suggests that plants initially were abundant in shallow lakes created by the dams. Over time, sediment accumulation and resuspension, reduced water clarity, and other factors led

Figure 8-2. Changes in aquatic plant abundance during drought can be compared in these Landsat satellite images of Lake Onalaska (Pool 7). The image at left shows conditions in 1987 at the beginning of the drought; the one on the right is from 1989 when the drought was at its peak. Aquatic plants visible as dark green shaded areas in 1987 are noticeably absent in the same locations in 1989. Shading by algae and possible depletions of sediment nutrients are believed responsible for the decline. (Source: USGS Environmental Management Technical Center, Onalaska, Wisconsin).

to reduced plant abundance in most pools in the Lower Impounded Reach. Presently, SAV are not abundant in lakes connected to the river but sometimes flourish in isolated backwaters managed as waterfowl refuges and hunting areas.

The Illinois River provides a dramatic example of the decline of an entire plant community. Though discussed in more detail elsewhere in this report (Chapter 14), highlights of plant community change can be summarized here. Prior to flow augmentation for waste assimilation and water-level regulation for navigation on the Illinois River, aquatic plants occurred in backwater lakes and suitable channel areas. The large lakes, formed when water was diverted from Lake Michigan in 1900, initially flourished with aquatic plant life. By 1916, however, the plants were eliminated by impacts related to sewage pollution. Sewage treatment introduced in the 1920s improved water quality and by 1935 SAV had recolonized most of the Illinois River backwaters (Starrett 1972). In the 1950s, sediment-related factors eradicated Illinois River aquatic plants and to this day they have not recovered (Sparks et al. 1990).

Most SAV beds today on the Lower Illinois River are restricted to isolated waterfowl management areas. Aquatic vegetation is abundant in some parts of the upper river, for example, north of the Starved Rock Lock and Dam (K. D. Blodgett, Illinois Natural History Survey, Havana, Illinois, personal communication). Disappearance of submersed aquatic plants in the Illinois is attributed to pollution, sedimentation, and poor water clarity (Starrett 1972; Sparks 1984; Sparks et al. 1990). Some of these same factors have the potential to affect vegetation elsewhere in the river floodplain of the Upper Mississippi River (UMR).

Factors that Affect Submersed Aquatic Vascular Plants

Weather and Hydrology

Weather patterns and associated factors that affect water levels and water quality appear to have significant impacts on the abundance and distribution of submersed aquatic plants in the UMRS. For example, in 1985 water clarity in Pool 8 was noticeably better, apparently in response to reduced runoff from agricultural watersheds during that summer's drought (Wiener et al. 1998). In response to the increased availability of light, distribution

Concurrent with a widespread, extended drought that occurred from 1987 through 1989, submersed macrophyte populations declined within the Upper Impounded Reach of the UMR.

of submersed plants in Pool 8 also increased. Both wildcelery and Eurasian watermilfoil appeared that summer in areas where they had not occurred before. Similarly, aquatic plant bed expansion in a portion of Pool 19 during 1977 (near Keokuk, Iowa) coincided with a period of increased water clarity that resulted from low and stable water levels during spring and summer (Steffeck et al. 1985; Sparks et al. 1990).

Concurrent with a widespread, extended drought that occurred from 1987 through 1989, submersed macrophyte populations declined within the Upper Impounded Reach of the UMR. Although macrophyte data does not exist on conditions during the drought that bear directly on the declines, a number of factors likely were involved. Upper Mississippi River biologists have suggested that sediments and unusual nutrient changes in the water column were the product of reduced flows and higher-than-normal solar radiation which may have stimulated high algal and periphyton (algae on plant leaves) densities, thus reducing light availability at macrophyte leaf surfaces during that time (Rogers 1994). High ortho-phosphorus levels (detected at Locks and Dams 8 and 9 water-quality sample sites) during the summer of 1988 may have contributed to prolific algal “blooms” that colored the water green that year. Blooms were reported from Lake Pepin (Pool 4) to Pool 11 (John Sullivan, Wisconsin Department of Natural Resources, La Crosse, Wisconsin, personal communication). Thus, algal blooms during drought years may limit light availability to submersed macrophytes.

Another condition that may have been influenced by low flows during a drought was the availability of sediment nutrients (probably nitrogen). The input of sediments during high spring flow may provide nutrients important to the maintenance of submersed macrophyte beds (Barko et al. 1991). Possible depletion of sediment nutrients during the low flows of 1987, 1988, and 1989, in combination with above-normal water temperatures and possibly low-light conditions, may have influenced macrophyte growth and reproduction in some regions of the river (John Barko, U. S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi, personal communication).

During the drought in the late 1980s, SAV in Pool 26 responded differently than in the upper pools (Theiling et al. 1996). Water levels remained stable and water clarity was high for this river reach. The SAV was common in shallow backwaters, channel borders, and in the impounded area near the dam. When the drought ended and water-level fluctuations and water clarity returned to more typical levels, the aquatic vegetation that developed during the drought disappeared and was replaced by emergent species (Figure 8-3).

Flooding can affect submersed macrophyte beds in a variety of ways depending on the timing, duration, and magnitude of the event. Although flood waters may provide additional nutrients via suspended materials to rooted macrophytes, negative consequences such as burial of beds by sediments, reduced light availability, and uprooting from high velocities also can occur (Gent and Blackburn 1994; Langrehr and Dukerschein 1994; Redmond and Nelson 1994).

Sedimentation

When they were built, navigation dams increased the trapping efficiency of fine sediments in off-channel and impounded areas of the navigation pools (Peck and Smart 1986). In Pool 19, more than 50 years of sedimentation gradually raised the river bed into the photic zone (see Chapter 4, Figure 4-8). A large area on the Illinois side of the river

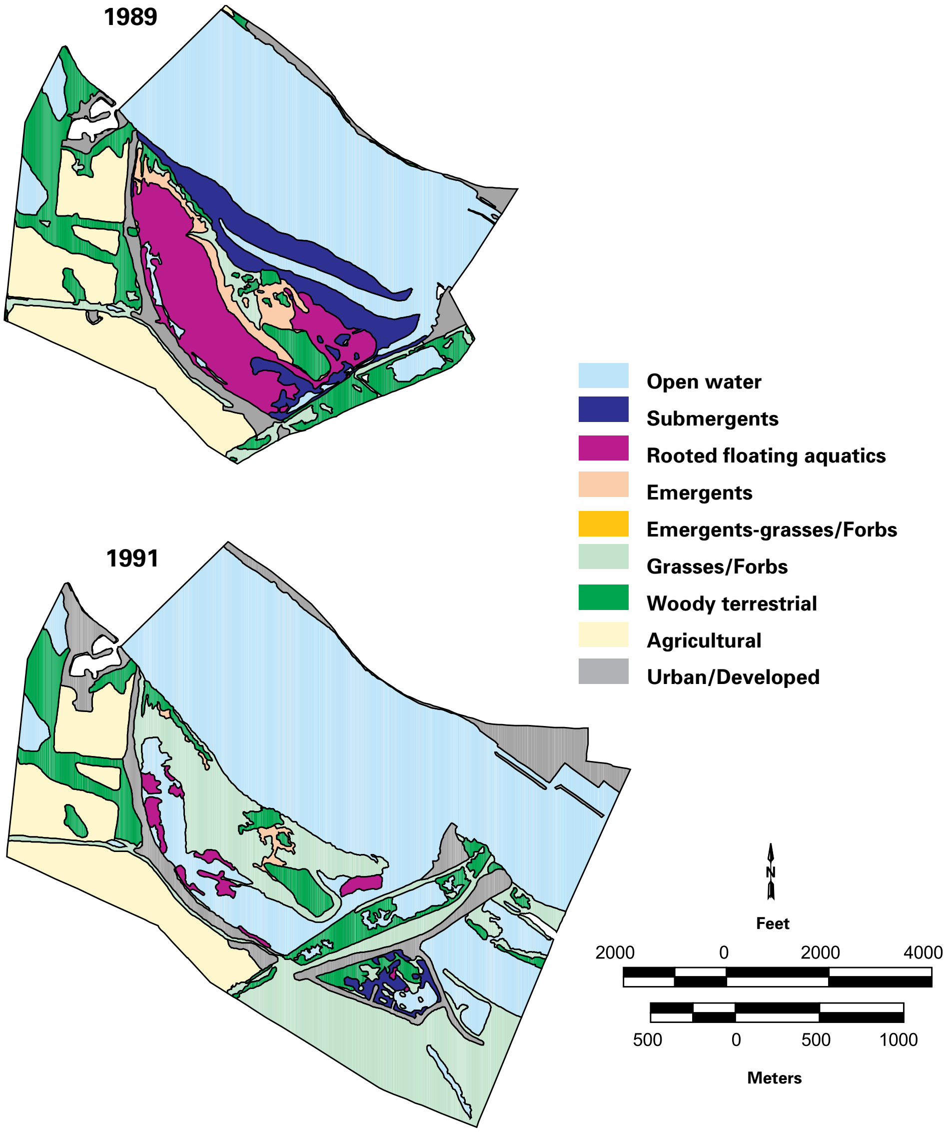
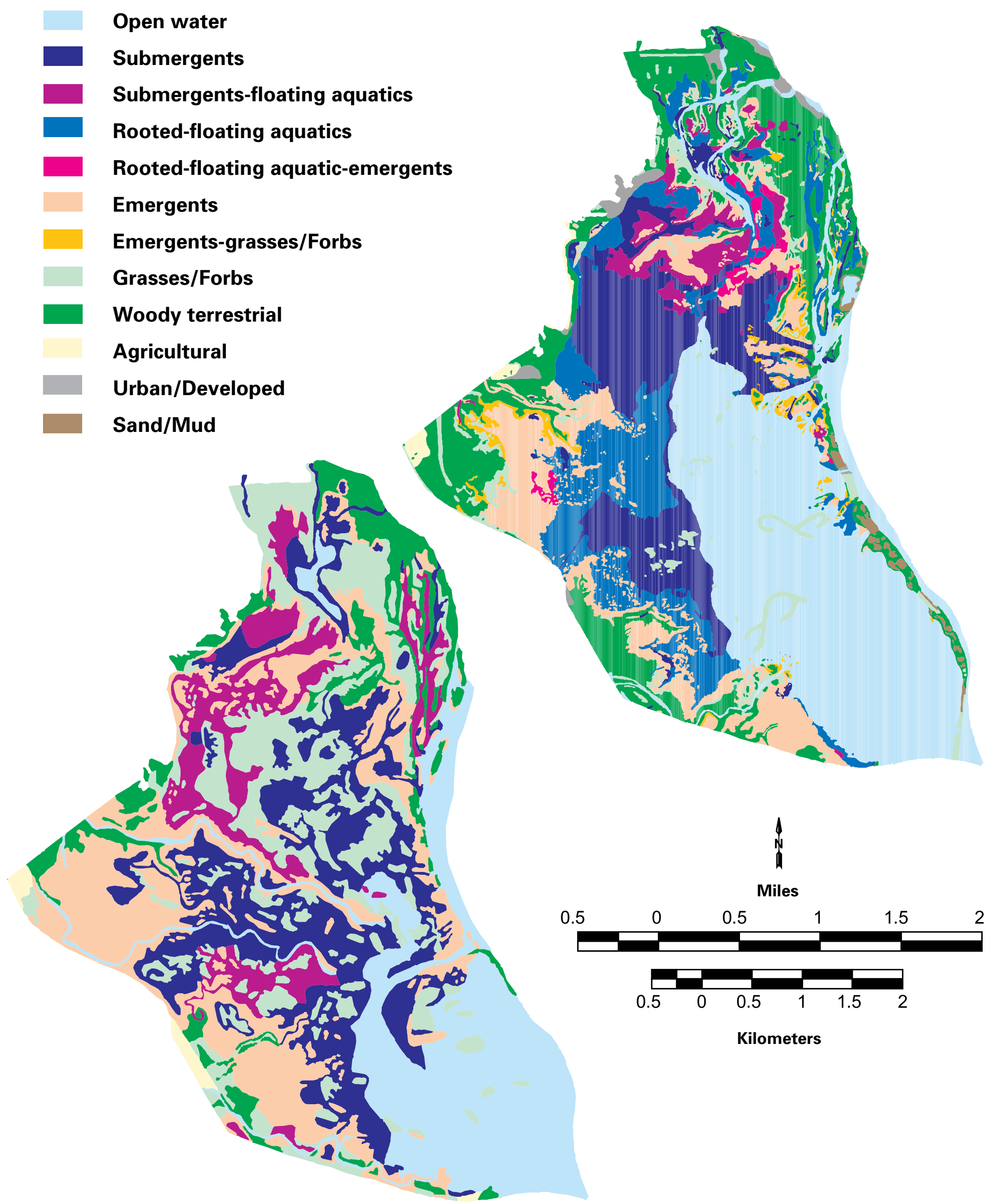


Figure 8-3. These computer-generated images illustrate the differing impact of weather on the Lower Impounded Reach vegetation in West Alton Bay (Pool 26) during a drought year (1989) and a year with more typical flow (1991). Aquatic plants (submergents and rooted floating aquatics) abundant during an unusually clear and stable water period in 1989 were eliminated in the more typical turbid and fluctuating water period in 1991 (Source: USGS Environmental Management Technical Center, Onalaska, Wisconsin).

was colonized eventually by SAV; floating-leaved and emergent vegetation has continued to persist (Bhowmik and Adams 1989).

Not all sedimentation is beneficial to submersed vegetation. Excessive sedimentation in nonchannel areas can lead to wide-ranging problems for aquatic macrophytes, including unfavorable light conditions and burial of plants (Sparks et al. 1990). An example from Pool 5 (Weaver Bottoms) indicates that even in the Upper Impounded Reach, generally considered more favorable for aquatic plant development, problem areas exist. Weaver Bottoms is a 5,000-acre (2,024-ha) backwater area that was subject to sedimentation from the Whitewater River and channel maintenance activities. Emergent and submersed aquatic plants that flourished prior to 1950 were eliminated (Figure 8-4). In the case of emergent vegetation, island erosion is responsible for eliminating essential habitat. Flocculent sediment accumulation, however, is suspected as contributing to submersed aquatic plant loss (McConville et. al 1994). It is predicted that at present sedimentation

Figyre 8-4. The Weaver Bottoms (Pool 5) was a complex mosaic of vegetation types interspersed with islands and marsh habitats in 1940 (below). But sediment introduced from tributaries and island erosion eliminated much of the marsh vegetation, leaving a larger open-water area and a greater proportion of submersed aquatic plants (Source: USGS Environmental Management Technical Center, Onalaska, Wsconsin).



rates, many backwater areas throughout the UMRS will convert to terrestrial areas within the next 50 to 100 years (Chen and Simons 1986).

Suspended Sediment and Water Clarity
Events such as high discharge and wind- or boat-generated waves contribute to high-suspended sediment concentrations. These sediments can shade plants by decreasing light penetration or they can settle and build up on leaf surfaces. The UMR experiences wide fluctuations in the concentration of suspended sediments, with variations in discharge accounting for most trends in the load of suspended matter (Dawson et al. 1984). Wind-generated waves can affect plant growth by resuspending sediments and decreasing water clarity during the sum-

mer's low-river stages when SAV production should be at its peak. Towboat passage and recreational boat traffic (Johnson 1994) also affect flow velocity distribution and wave patterns, which can increase the concentration of suspended sediments (Lubinski et al. 1981; USACE 1988). Resuspended sediments may be carried into main channel borders and side channels, affecting macrophyte beds in these habitats.

Consumption and Disturbance by Fish and Wildlife

Grazing by fish, particularly carp (or grass carp, Raibley et al. 1995), also should be considered a factor that can influence submersed aquatic macrophytes in the river. Feeding activity of carp and other bottom-feeding fish disturb bottom sediments, increasing turbidity and uprooting some submersed macrophytes, especially shallow-rooted species. Biologists in the LTRMP have observed carp in many submersed macrophyte beds; these observations offer circumstantial evidence about how aquatic plants may be affected by foraging activities. In a study to determine factors that influence wildcelery growth in backwaters of the Illinois River, Peitzmeier-Romano et al. (1992) discovered that grazing on unprotected plants reduced leaf growth and tuber production compared to caged plants which grew well. Grazing affected attempts to grow wildcelery in a similar study conducted by Carl Korschgen (USGS Upper Mississippi Science Center, La Crosse, Wisconsin, unpublished data) on the Mississippi River. Many plants grown in unprotected suspended buckets appeared to have been damaged by grazers. Aquatic-plant grazers include muskrats and waterfowl as well as fish that incidentally consume plants when feeding on invertebrates living on the plants.

Discussion

The UMR and its tributaries are affected continually by increased urban, industrial, and agricultural development (Jackson et al. 1984). Increased human activity and associated sediment and chemical impacts, industrial water discharges, and increased recreational pressures all place potential stress on submersed aquatic plant populations. Because stressors on the SAV community are widespread in space and time, their effect has been distributed differently throughout the basin. The Illinois River provides the strongest evidence of human activity, but the Lower Impounded Reach of the Upper Mississippi River also has been affected. The Upper Impounded Reach presently maintains the most SAV, but even within this reach widely fluctuating changes in abundance have been observed in recent years. In the future, excessive sedimentation and backwater filling may lead to declines similar to those in the other river reaches.

Information Needs

A great deal of information is needed for biologists to predict the fate of submersed aquatic vegetation within the UMRS. They will need to know where vegetation exists and the potential for unvegetated reaches to regain viable populations. Long-term monitoring of the distribution of plant beds is necessary to better understand the impact of various factors—whether they are anthropogenic in source or related to weather events such as droughts and floods. Additionally, studies are needed to determine the effects of the factors described above on the production and reproductive biology of macrophytes in the UMR. The impact from navigation and recreation traffic, sedimentation, turbidity, and physical aging of the system are especially important in Pools 4 through 13, where the majority of submersed plants

Events such as high discharge and wind- or boat-generated waves contribute to high-suspended sediment concentrations.

presently exist. In addition to submersed aquatic vegetation, monitoring and research concerned with emergent vegetation characteristic of marsh and wetland habitats should be initiated.

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