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THE ABUNDANCE OF AQUATIC MACROPHYTES IN THE YAHARA LAKES

by Richard C. Lathrop

The 4 Yahara lakes (Mendota, Monona, Waubesa, and Kegonsa) are located near Madison in southern Wisconsin. They vary in size and maximum depth, but all have large areas of shallow water (Table 1). The lakes are eutrophic and often have dense aquatic macrophyte growth and/or blue-green algal blooms during the summer. While anglers recognize the importance of submersed macrophytes as fish habitat, many people complain that the "weeds" are excessive and restrict swimming and boating. Complaints have prompted macrophyte eradication and control programs that have raised environmental concerns about the use of chemicals and have strained governmental budgets for mechanical cutting and harvesting.

My objective in this article is to provide a long-term picture of macrophyte abundance in the Yahara lakes to promote a greater understanding of current weed management issues. This account draws primarily on the following reports: Forbes (1890), Juday (1914), Denniston (1922), Rickett (1922), Domogalla (1935), Frey (1940), Andrews (1946), Threinen (1949), Threinen and Helm (1952), Lind (1967), Andrews (1980), and Vander Zouwen (1982). I also used surveys from the Wisconsin Conservation Department (WCD) and its successor the Department of Natural Resources (DNR), City of Madison weed cutting records, and Dane County weed harvesting records.

Early Accounts

Early accounts indicate that all the Yahara lakes except for Kegonsa had abundant macrophytes. Mendota during 1884-85 was described by Forbes as having "a large area [of] weedy shallows." Juday later noted that the whole bay at the Yahara River inlet was "filled with dense growths of vegetation." Detailed surveys by Denniston in 1912 and Rickett in 1920 recorded abundant macrophytes of many species growing to maximum water depths of about 5.0-5.5 m. Wild celery (*Vallisneria americana*) and pondweeds (*Potamogeton* spp.) were most abundant.

Monona's Turville Bay was described by Juday as "filled with dense growths of vegetation" and Monona Bay as "filled with a large amount of vegetation" prior to being dredged. In another account of Monona's macrophytes, the lake around 1920 had a "practically continuous belt" of weeds to a depth of about 3.0 m. For Waubesa, Juday wrote: "abundant growths of the larger aquatic plants [occur] in the

TABLE 1. Physical characteristics of the Yahara Lakes.

Characteristic	Men	Mon	Wau	Keg
Area (ha)				
Total	3,985	1,326	843	1,299
Percent <3 m	17%	26%	40%	28%
Depth (m)				
Maximum	25.3	22.2	11.6	9.8
Mean	12.7	8.3	4.7	5.1

shoal water [along the west shoreline]. In fact, a fairly large amount of vegetation is found in the shallow water all along the edge of the lake...." Kegonsa, however, did not have dense macrophyte beds. Juday noted that "the lake is free from bays...[which] permits a freer circulation of the water and tends to prevent the growth of vegetation in the shallow water."

The 1920s through the Early 1960s

Mendota's macrophytes did not significantly change during the 1920s through the late 1950s. Andrews' surveys (1939-41, 1946) on Mendota's University Bay showed that wild celery and numerous pondweeds were still most abundant. Threinen and Helm also found dense wild celery and pondweed beds throughout Mendota in the summers of 1948 and 1951 although coontail (*Ceratophyllum demersum*) and native milfoil species (*Myriophyllum* spp.) were common. Maximum depth of plant growth was about 4.8 m.

In 1925, Monona was still "infested with rooted weeds" when surveyed by Domogalla. Because of citizen complaints, the City of Madison began chemical treatments of shore areas. However, by the mid 1930s macrophytes flourished in deeper water (3.0-5.5 m) because of good water clarity brought about by massive copper sulfate treatments that began in 1925 to control the obnoxious summer algal blooms. Domogalla wrote: "This finding pleases the fisherman, who first thought the chemical treatments through these years would kill every weed in the lake." Copper sulfate treatments declined after 1946. When Threinen and Helm surveyed Monona in 1948 and 1951, they found aquatic macrophytes restricted to depths <1.8 m because of decreased light penetration caused by algal blooms. However, "the vegetation within this zone grew luxuriantly." Sago pondweed (*P. pectinatus*) predominated; other pondweeds, wild celery, and coontail were also present. The situation was similar in 1960-61 except that sago pondweed was less abundant while native milfoil was more abundant.

In Waubesa, macrophyte beds declined after about 1936 because of massive algal blooms caused by the new discharge of Madison's sewage effluent to the lake. In 1939, Frey found macrophytes growing in isolated areas to a depth of only 0.6-1.5 m. Sago pondweed predominated whereas wild celery had been abundant a few years earlier. Frey recounted that fishermen until about 1936 "sometimes had difficulty rowing through the weed beds." In 1948 and 1951, Threinen and Helm found sago pondweed still only moderately abundant (other species were sparse), with growth generally restricted to depths <1.2 m. Surveys in 1955 and 1960-61 also recorded very little macrophyte growth in Waubesa. In Kegonsa, macrophytes were sparse in 1939 with sago pondweed the main species. Algal blooms were severe during this time. Macrophytes were also sparse in 1948 and 1951, growing to depths of only 1.6-1.8 m. Sago pondweed and coontail were the principal species. Surveys in 1955 and 1961-62 also noted sparse macrophytes.

The Milfoil Era: Mid-1960s to the Present

The macrophyte community in Mendota and Monona changed dramatically during the 1960s as indicated by the sharp increase in amount of weeds cut (Fig. 1). Lind's 1966 survey of Mendota's University Bay showed that the exotic Eurasian milfoil (*Myriophyllum spicatum*) accounted for 98% of the plant biomass. The maximum depth of plant growth had decreased to <4.0 m. The milfoil also became very dense in Waubesa and moderately dense in Kegonsa after the mid-1960s. Madison's sewage effluent had been diverted from these lakes in 1958, and algal blooms subsequently declined.

Eurasian milfoil continued to be very dense in the Yahara lakes until about 1975-76, when the amount of weeds harvested decreased dramatically in all 4 lakes (Fig. 1). Between 1978-79, Andrews (1980) found a "precipitous general decline" of species and plant densities in University Bay, which he attributed to "unusually turbid water." Few macrophytes were harvested in Monona, Waubesa, and Kegonsa during the late 1970s. Poor water clarity from dense summer algal blooms restricted plant growth.

The macrophytes in Mendota for most years during the 1980s have been only moderately dense. In the summer of 1980, Vander

Zouwen (1982) found that Eurasian milfoil in University Bay was not extensive; the depth of maximum plant growth was only about 3.0 m with the densest growth <2.0 m. Dense growth of filamentous algae was on the milfoil. In late July 1984, I recorded conditions similar to Vander Zouwen's, except that coontail was more abundant. However, macrophyte growth (mostly Eurasian milfoil) in Mendota has increased in 1988, a year of exceptionally good spring and summer water clarity.

Beginning in the early 1980s, milfoil growth has been resurgent in Monona and Waubesa because of improved water clarity, particularly in 1987-88 (Fig. 1). In 1984 in Monona's Turville Bay, I found Eurasian milfoil to be very dense from the shore to 1.5 m and then gradually declining out to about 3.0 m, the limit of all plant growth. Coontail was also dense, particularly in 1.5-2.1 m of water. Very little filamentous algae was growing among the macrophytes, but filamentous algae have been a major problem in Lake Monona in 1986-88. In Kegonsa algal blooms have continued to restrict macrophyte growth through the 1980s.

Summary and Future Management

Two principal factors have dramatically affected the macrophytes in the Yahara lakes since the early 1900s: (1) extremely dense algal blooms that reduced light penetration needed for macrophyte growth in deeper water, and (2) the dominance of Eurasian water milfoil beginning in the mid-1960s. Dense algal blooms stimulated by the sewage effluent nutrients severely reduced macrophyte growth and limited the macrophyte community to mostly sago pondweed in the lower 3 lakes for decades prior to the early 1960s. Only when the algal blooms in Monona were controlled by massive applications of copper sulfate (1925-46) was light penetration sufficient

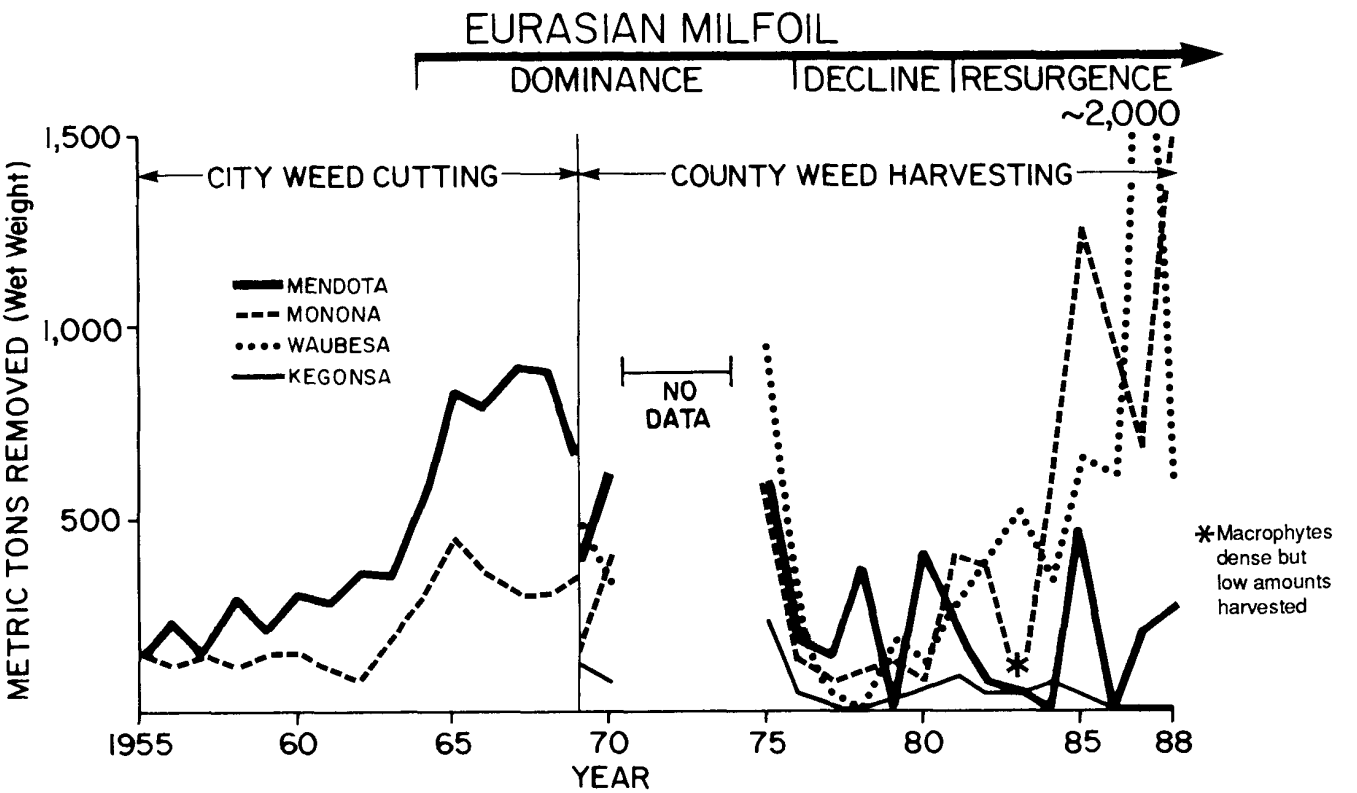

FIGURE 2. Trends in macrophyte abundance in the Yahara lakes based on City of Madison weed cutting records and Dane County weed harvesting records. Both the county and city were involved in weed control in 1969. Although no data are available for the early 1970s, accounts by county personnel indicate that large amounts of weeds were removed.

to allow a deep-water macrophyte community to grow. Lake Mendota's diverse macrophyte community did not change much during these years because severe algal blooms were less frequent. The explosion of overabundant Eurasian milfoil during the mid-1960s drastically changed the character of the Yahara lakes' macrophytes. The decline of milfoil in the late 1970s in the Yahara lakes and its resurgence in the 1980s in Monona and Waubesa seem to be related to changes in water clarity during those periods (summarized in "Findings" No. 17).

Because the Yahara lakes' sediments contain vast quantities of nutrients, milfoil growth should continue to be a problem for the foreseeable future, particularly if water clarity improvements continue. Good water clarity in Mendota and Monona should allow either the spread of milfoil to deeper water or the slow establishment of deep-water native macrophyte species that are valuable as fish habitat and less likely to restrict swimming and boating. Managers may want to consider macrophyte plantings to speed up the recolonization of native species, particularly because too few plants exist in these lakes to provide an extensive seed source. Modest improvements in water clarity in Lake Kegonsa would also allow limited growth of macrophytes, which would benefit the fishery. If healthy, balanced macrophyte communities are to return to the Yahara lakes, then eradication and control programs should not be applied indiscriminately.

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Dick Lathrop is a limnologist with the Wisconsin DNR Bureau of Research. Dick has conducted research on the Yahara lakes since 1976. Address: 3911 Fish Hatchery Rd, Madison WI 53711. Telephone: (608)275-3221.

Edited by Betty Les

Bureau of Research
Wisconsin Department of Natural Resources
P.O. Box 7921
Madison, WI 53707

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