J. Aquat. Plant Manage. 32: 33-36

Impact of Harvesting on Aquatic Plant Communities in Lake Wingra, Wisconsin

STANLEY A. NICHOLS[1] AND R. C. LATHROP[2]

ABSTRACT

An area in Lake Wingra with a history of mechanical harvesting was compared to other areas in the lake with no known management history. Although species diversity and taxa richness in three out of four unharvested areas were greater than in the harvested area, no differences in diversity or plant biomass could be attributed solely to the harvesting regime. Differences appeared to be more closely related to an increase in coontail (*Ceratophyllum demersum* L.) growth after the Eurasian watermilfoil (*Myriophyllum spicatum* L.) decline of the mid-1970s. Besides Eurasian watermilfoil and coontail, curlyleaf pondweed (*Potamogeton crispus* L.), northern watermilfoil (*M. sibiricum* Komarov), and sago pondweed (*P. pectinatus*) were important members of the vegetation.

Key words: Eurasian watermilfoil, coontail, biomass, and diversity change.

INTRODUCTION

The impact of harvesting on plant communities varies from a decrease in some species (Wile 1978, Nicholson 1981), to no change in species composition (Johnson and Bagwell 1979, Cottam and Nichols 1970), to an increase in diversity (Engel 1990, Rawls 1975). Harvesting may also promote higher plant biomass (Anonymous 1981). Generally, plants that emphasize sexual reproduction, regenerate poorly from cut parts, heal and regrow poorly when cut, and are tall are most vulnerable to harvesting (Nicholson 1981). These characteristics fit many native species, especially the pondweeds (*Potamogeton* spp.). Some aquatic nuisance species such as Eurasion watermilfoil (*Myriophyllum spicatum* L.) and coontail (*Ceratophyllum demersum* L.) do not have these characteristics and may be favored by a harvesting regime.

There is a long history of harvesting aquatic plants in the lakes around Madison, Wisconsin (Lathrop 1989), and some speculate that harvesting maintains the nuisance plant species in the lakes (Winkelman and Lathrop 1993 a and b). To study the long-term impact of mechanical harvesting, we compared the vegetation of unharvested regions (Areas 1, 3, 4, and 5, Figure 1) of Lake Wingra to that of an area of the lake along the Vilas Park shore (Area 2, Figure 1) that was regularly harvested during the late 1960s and early 1970s (Nichols and Mori 1971, Nichols 1971, Carpenter 1980) and in 1991. The Eurasian watermilfoil decline of the mid-1970s (Carpenter 1980) negated some need for harvesting along the park shoreline. Limited harvesting occurred during the late 1970s and the 1980s because Vilas Park is a high-use public recreational facility with shoreline fishing opportunities, a boat-launching area, and a swimming beach. The objective of this study was to compare the previously harvested and unhar-

[1]University of Wisconsin-Extension, Geological and Natural History Survey, 3817 Mineral Point Road, Madison, WI 53705, USA.

[2]Wisconsin Department of Natural Resources, 1350 Femrite Dr., Monona, WI 53713, USA. Received for publication May 27, 1993 and in revised form November 20, 1993.

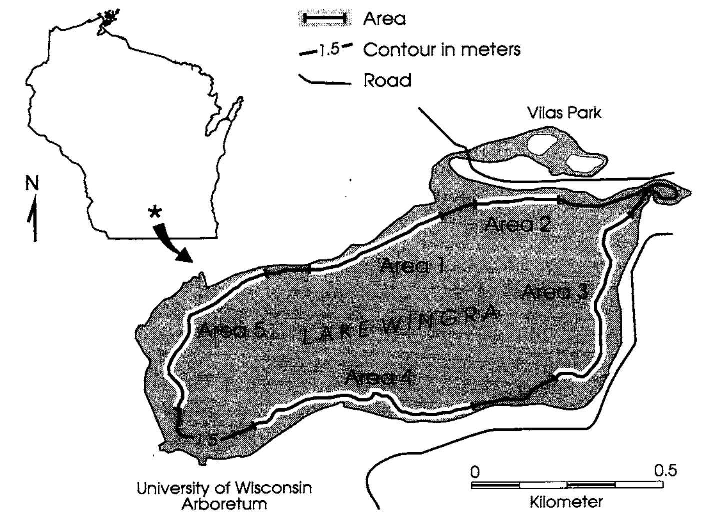

Figure 1. Locations of study areas in Lake Wingra, Madison, Wisconsin. Area 2 is the previously harvested area. Areas 1, 3, 4, and 5 had no previous management history.

vested areas of Lake Wingra to determine whether any difference in the present plant community structure or biomass might be attributed to past harvesting.

STUDY SITE

Lake Wingra, located in the Madison metropolitan area of Dane County, Wisconsin, U.S.A. (Figure 1), is a natural basin on an outwash terrace overlying a feeder stream of the preglacial Yahara River. It is the smallest and shallowest of the Madison area lakes; it has a surface area just under 140 ha, a maximum depth of 4.3 m, and a mean depth of 2.7 m. About one-third of the area is littoral zone, and the waters are alkaline and eutrophic. The shoreline is almost entirely within the University of Wisconsin Arboretum or in parks; much of the watershed is residential. The lake was intensively studied in the late 1960s and early 1970s as part of the International Biological Program - Lake Wingra site (Adams and Prentki 1982).

MATERIALS AND METHODS

We divided the lake shoreline into five areas (Figure 1) to provide good geographic coverage. On June 24 or 25, 1992, each area was sampled using 10 paired (i.e., 20 total), 0.1 m^2 quadrats placed randomly along the 1.5-m depth contour line. This is deep enough for the plant harvester to operate and is where the maximum impact to the plant community is likely to occur. Harvesting removes plants close to the substrate at this depth and previous studies (Nichols and Mori 1971, Trebitz et al. 1993) found that a more diverse plant community occurs in shallow than in deep water. We did not sample close to the swimming beach and the boat launch within the harvested area.

At each sampling location, a diver uprooted all the plant material within the quadrat. Plant material was brought to the surface, rinsed of foreign material, wrung dry, and placed in paper bags. Biomass samples were oven dried at 105° C for at least 48 hours and weighed to the nearest 0.1 g immediately after they were removed from the drying oven. A mean tare weight was subtracted for the bag. Dry plant material from each area was subsampled and analyzed for inorganic constituents by igniting at 550° C for six hours (American Public Health Association 1992). This percent ash correction factor was applied to all weights. Biomass results are reported as ash free dry weight (Figure 2). In addition, at each sampling point, rake tosses were used to sample four quadrants of an approximately 2-m radius circle for presence of plant species (Deppe and Lathrop 1992).

We used presence-absence data to develop frequency of occurrence information. We calculated diversity using a modified Simpson (1949) diversity index of $1-\Sigma$ (relative frequency)^2 and generated descriptive statistics with Minitab (1991). Biomass and community composition data from the summer of 1970 (Nichols 1971) were available for comparison between the two time periods. Biomass in the harvested area was altered by cutting in 1970; therefore, direct comparisons cannot be made between 1970 and 1992. However, 1970 was the height of the Eurasian watermilfoil invasion in Lake Wingra (Carpenter 1980) and the 1.5-m zone of the lake was essentially monotypic: 90 percent of the plants found (relative frequency, Table 1) were Eurasian watermilfoil. It would be hard to believe that any area was more or less diverse than other areas of the lake under these conditions.

RESULTS AND DISCUSSION

In 1992 Area 2 (harvested area) had only four species and was the least diverse (Table 1). Eurasian watermilfoil and coontail dominated. However, Area 3 had an equal paucity of species and a similar diversity, although native watermilfoil was much more important than coontail. Area 2 was geographically located between the area of highest species richness (Area 1) and the area of least species richness (Area 3) of the unharvested areas. Areas 4 and 5,

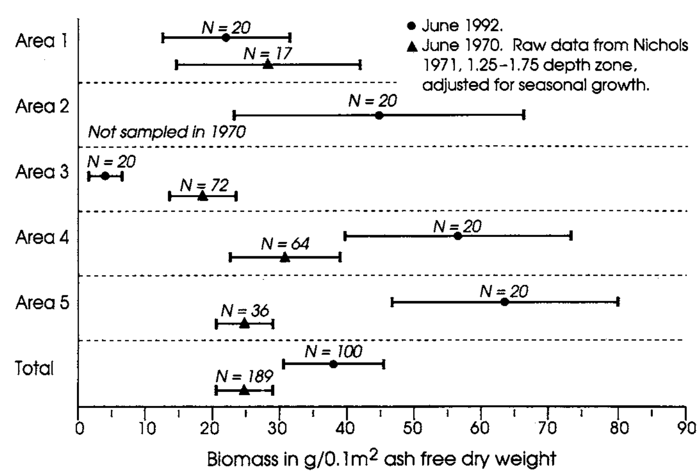

Figure 2. Comparison of 1970 and 1992 mean plant biomass in Lake Wingra. Error bars show 95 percent confidence interval. Area 2 is the previously harvested area. Areas 1, 3, 4, and 5 had no previous management history.

TABLE 1. RELATIVE FREQUENCY (%) OF PLANTS IN LAKE WINGRA[1]

Species	Area 1	Area 2[2]	Area 3	Area 4	Area 5	WHOLE LAKE	1970[3]
Myriophyllum spicatum L.	20	54	50	43	42	37	90
Ceratophyllum demersum L.	15	34	5	34	40	25	8
Potamogeton crispus L.	15	---[4]	9	8	2	9	---
M. sibiricum Komarov	8	8	36	3	1	9	---
P. pectinatus L.	12	---	---	9	---	6	<1
P. foliosus Raf.	9	---	---	---	1	4	---
Heteranthera dubia (Jacq.) Macm.	8	---	---	1	4	4	---
Najas flexilis (Willd.) Rostokov & Schmidt	4	---	---	---	---	2	---
P. illinoensis Morong	4	4	---	2	---	2	---
Chara sp.	2	---	---	---	---	1	---
Vallisneria americana Michx.	2	---	---	---	---	1	---
P. zosteriformis Fern.	1	---	---	---	---	1	---
Elodea canadensis Michx.	---	---	---	---	2	<1	---
Nymphaea odorata Aiton	---	---	---	---	2	<1	---
Nuphar variegata Durand	---	---	---	---	1	<1	---
P. natans L.	---	---	---	---	---	---	1
Taxa richness	12	4	4	7	9	15	4
Simpson diversity	0.88	0.59	0.61	0.69	0.66	0.78	0.18

[1]June 24 and 25, 1992 sampling date, 1.5-m depth contour, see figure 1 for areas sampled.
[2]Area 2 is the previously harvested area. Areas 1, 3, 4, and 5 have no previous management history.
[3]From data used in Nichols (1971), 1.25- to 1.75-m depth zone.
[4]Dash indicates that the species is not present.

which had diversities intermediate between Areas 2 and 3 and Area 1, also were dominated by Eurasian watermilfoil and coontail. All areas were more diverse than the whole lake diversity for the same depth zone in 1970 (Table 1). The trend of increasing coontail dominance in most areas was also noted in the other Madison lakes after the Eurasian watermilfoil decline of the mid-1970s (Nichols et al. 1992, Deppe and Lathrop 1993, Winkelman and Lathrop 1993 a and b).

Areas 4 and 5 produced the highest biomasses in 1992, but they were not significantly higher than Area 2 (Figure 2). Area 1 produced a moderate biomass. Area 3 had the lowest biomass, which was significantly lower than all other biomasses. Biomass is directly correlated with the relative frequency of coontail. The area of highest biomass also had the highest relative frequency of coontail and vice versa. Area 3, with the lowest biomass, had the highest combined frequency of milfoil species.

Total mean biomass for 1992 was slightly higher than for 1970 (Figure 2). However, the biomass of different areas varied considerably. In 1992, Areas 4 and 5 had significantly greater biomasses, Area 1 remained about the same, and Area 3 had less than in 1970. Again, this appears to be the result of differential dominance of coontail in these areas.

In conclusion, the Lake Wingra plant community, at the 1.5-m depth zone, increased in diversity and possibly biomass since 1970. Community composition and biomass varied among shoreline locations, but we do not know that these differences were caused by mechanical harvesting. Most differences between areas appear to be due to variation in coontail growth and not harvesting history. The most interesting question raised by this study is why Area 1 was more diverse and of moderate biomass when compared to other areas of the lake. This area contained plants, such as Illinois pondweed (*Potamogeton illinoensis* Morong.), sago pondweed, and wild celery (*Vallisneria americana* Michx.), that are valuable as fish and wildlife habitat (Nichols and Vennie 1991) and a community type that should be promoted. Yet the area is the same depth, appeared to have a similar substrate, and had a similar vegetative history as other areas of the lake.

ACKNOWLEDGMENTS

Susan Borman and Richard Lillie of the Wisconsin Department of Natural Resources are gratefully acknowledged for preliminary review of this manuscript. Jenny Winkelman and Carolyn Verage, Wisconsin Department of Natural Resources, assisted in field sampling and processing of plant material.

DISCLAIMER

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the Wisconsin Geological and Natural History Survey or the Wisconsin Department of Natural Resources.

LITERATURE CITED

Adams, M. S. and R. T. Prentki. 1982. Biology, metabolism, and function of littoral submersed weedbeds of Lake Wingra, Wisconsin, USA: A summary and review. Arch. Hydrobiol.-suppl. 62: 333-409.

American Public Health Association, 1992. Standard Methods for the Examination of Water and Wastewater (18th edition). American Public Health Association, Washington, D.C., Part 10400.

Anonymous. 1981. A summary of biological research on Eurasian milfoil in British Columbia. Vol XI. Inf. Bull. Aquat. Plant Manage. Program, British Columbia Ministry of Environment, Victoria. 18 pp.

Carpenter, S. R. 1980. The decline of *Myriophyllum spicatum* in a eutrophic Wisconsin USA lake. Can. J. Bot. 58: 527-535.

Cottam, G. and S. A. Nichols. 1970. Changes in water environments resulting from aquatic plant control. University of Wisconsin, Water Resources Center, Tech. Rep. OWRR-B-019-WIS, Madison. 24 pp.

Deppe, E. and R. C. Lathrop. 1992. A comparison of two rake sampling techniques for sampling aquatic macrophytes. Wis. Dept. Nat. Resour., Res. Manage. Find. No. 32, Madison. 4 pp.

Deppe, E. and R. C. Lathrop. 1993. The aquatic macrophyte community of Lake Mendota in 1989-91. Trans. Wis. Acad. Sci. Arts Lett. 81: 47-58.

Engel, S. 1990. Ecological impacts of harvesting macrophytes in Halverson Lake, Wisconsin. J. Aquat. Plant Manage. 28: 41-45.

Johnson, R. E. and M. R. Bagwell. 1979. Effects of mechanical cutting on submersed vegetation in a Louisiana lake. J. Aquat. Plant Manage. 17: 54-57.

Lathrop, R. C. 1989. The abundance of aquatic macrophytes in the Yahara Lakes. Wis. Dept. Nat. Resour., Res. Manage. Find. No. 22, Madison. 4 pp.

Minitab. 1991. Minitab statistical software, release 8. State College, PA.

Nichols, S. A. 1971. The distribution and control of macrophyte biomass in Lake Wingra. University of Wisconsin, Water Resources Center, Tech. Rep. OWRR B-019-WIS, Madison. 111 pp.

Nichols, S. A., R. C. Lathrop and S. R. Carpenter. 1992. Long-term vegetation trends—a history. In Kitchell, J. F. (Editor), Food Web Management: A Case Study of Lake Mendota. Springer-Verlag, New York. pp. 151-171.

Nichols, S. A. and S. Mori. 1971. The littoral macrophyte vegetation of Lake Wingra. Trans. Wis. Acad. Sci. Arts Lett. 59: 107-119.

Nichols, S. A. and J. G. Vennie. 1991. Attributes of Wisconsin lake plants. Wisconsin Geological and Natural History Survey, Inf. Circ. 73, Madison. 19 pp.

Nicholson, S. A. 1981. Changes in submersed macrophytes in Chautauqua Lake, 1937-1975. Freshwater Biol. 11: 523-530.

Rawls, C. K. 1975. Mechanical control of Eurasian watermilfoil in Maryland with and without 2,4-D application. Chesapeake Sci. 16: 226-281.

Simpson, W., 1949. Measurement of diversity. Nature. 16: 688.

Trebitz, A., S. A. Nichols, S. R. Carpenter and R. C. Lathrop. 1993. Patterns of vegetation change in Lake Wingra following a *Myriophyllum spicatum* decline. Aquat. Bot. 46: 325-340.

Wile, I. 1978. Environmental effects of mechanical harvesting. J. Aquat. Plant Manage. 16: 14-20.

Winkelman, J. and R. C. Lathrop. 1993a. Aquatic plants in Lake Monona: their status and implications for management. Wis. Dept. Nat. Resour., Bureau of Research, Madison. 64 pp.

Winkelman, J. and R. C. Lathrop. 1993b. Aquatic plants in Lake Waubesa: their status and implications for management. Wis. Dept. Nat. Resour., Bureau of Research, Madison. 62 pp.