

**BFS Technical Report # 15
AQUATIC MACROPHYTE
MANAGEMENT PLAN FACILITATION
LAKE MORaine, MADISON COUNTY, NY
2002**

- 1. MACROPHYTE BIOMASS MONITORING**
- 2. MONITORING EFFECTS OF SELECTIVE HERBICIDE
SONAR[®]**
- 3. WATER QUALITY ANALYSIS**

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EXECUTIVE SUMMARY

The SUNY Biological Field Station has been involved in monitoring aquatic macrophyte communities in Lake Moraine, continuously since summer, 1997. This work has focused upon efforts to control the nuisance, non-native Eurasian water-milfoil (*Myriophyllum spicatum*). After a long history of using mechanical harvesting and non-selective herbicides (i.e., copper sulfate; Simazine[®]), the Lake Moraine Association opted to pursue more selective, environmentally friendly options. Sonar[®], a selective herbicide, was first applied during the spring of 1996. While research by others and by the BFS could not empirically demonstrate success because of methodological problems, anecdotal observations suggested that water-milfoil was reduced. In 1998 and again in 2000, after any effects of that treatment would have been exhausted, the north basin was stocked with *Euhrychiopsis lecontei*, a weevil known to feed upon the apical regions of water-milfoil, in hopes of establishing a long-term means of controlling that plant. Monitoring since then has not shown a sustained increase in that insect's population, nor increased evidence of milfoil damage by it. Sonar[®] was again applied in May 2001, this time throughout the entire littoral area of the south basin. Monitoring throughout that summer documented the near-eradication of water-milfoil there. Additionally, curly leaved pondweed (*Potamogeton crispus*), another nuisance exotic, suffered severe mortality. Some native plants also were impacted, but most rebounded over the course of that summer.

Monitoring throughout the summer of 2002 demonstrated the continued trend of milfoil decimation in the south basin; however, *Elodea canadensis*, a native macrophyte damaged by the Sonar[®] application has not rebounded as well as previous research suggested. Also, 2002 research found no obvious sustained impact on the exotic *Potamogeton crispus*.

INTRODUCTION (from Harman et al., 1999)

The role of aquatic plants in freshwater lakes:

The diversity of large aquatic plants attached to the substrate, known as benthic macrophytes, play an important role in maintaining the potable, recreational and aesthetic characteristics, as well as the ecological functioning of most waters in the Northeastern United States (Anon., 1990). These aquatic macrophytes protect shorelines from erosion and stabilize deeper substrates, limiting turbidity by disturbed silts and clays. The resuspension of sediments, which have nutrients adsorbed in them, is prevented by direct competition between the benthic macrophytes and algae in the water column. This competition maintains water clarity and limits algal growth. (Wetzel, 1983).

Macrophytes provide cover for all of the organisms that make up shallow water (littoral) aquatic communities. They are the basis of aquatic food webs in these areas, providing indispensable links between the sun's energy and animals that eat plants and are, in turn, eaten by predators (Hutchinson, 1975). In these ways, plants regulate the size and character of game fish and waterfowl populations as well as impact other biotic resources we cherish.

In our region there are a few introduced plant species (e.g., Eurasian water-milfoil, curly leaved pondweed, water chestnut) that aggressively out-compete our native flora under conditions of excess nutrient loading, destroying biodiversity and causing the loss of some of the abovementioned benefits. The dense beds commonly formed by these introduced exotics often reduce the recreational quality of lakes and are responsible for the great majority of the complaints heard from recreational lake users.

Aquatic plant management in the northeast:

Modern managers recognize the benefits of our native plant communities and therefore, under all but emergency conditions, use techniques to control the aggressive introductions while attempting to restore native plant diversity for its inherent values. Techniques can be divided into two types:

1. Those that improve the environment by minimizing nutrient loading, reducing littoral disturbance and preventing further introductions, and:
2. Those that directly impact plant populations.

Even aggressive exotics can become innocuous if cultural pollution (nutrient loading) is minimized. Whole-lake and watershed management techniques to control runoff are expensive, often politically charged and must be seen as long-term investments. Nevertheless, they must be addressed to assure unqualified success over time.

Introductions tend to be most aggressive when native plants or substrates are disturbed. It is harder for exotics to achieve dominance if healthy natives already occupy a lake's bottom. Disturbance of lakeside lands also directly impacts littoral areas to the benefit of aggressive exotics by sediment deposition, which reduces populations of native plants, and also by supplying associated nutrients. All things being equal, the fewer nutrients available for plant growth, the less plants will grow, reducing management problems. However, competitive interactions between planktonic algae and benthic plants may result in multifaceted situations complicating management. Efforts to manage non-native plants must be selective. The more exotic species present, the more extensive, and costly, are the management strategies required. By far, most introductions to inland lakes have been traced to the activities of recreational navigation. Lakes with public access should have some mechanism in place to minimize the chances of new introductions.

Strategies directly impacting plant populations are normally categorized as: physical (e.g., harvesting, barriers placed on the bottom or water level manipulation), biological (utilization of other organisms, usually herbivores) or chemical (use of various herbicides). Based on the above discussion, it is assumed that management activities normally are directed at selected target species. It is neither feasible nor desirable to remove all plants from a body of water. If necessary, small areas such as channels and spaces around docks can be treated physically for the convenience of individuals. In even more problematic situations mechanical harvesting on a larger scale may be necessary.

Several problems result from harvesting and other means of physical removal of nuisance plants. Since the majority of exotic species are more competitive in disturbed situations, harvesting enhances growth. Because harvesting is non-selective, native plants competing with the target species are also removed allowing exotics to grow even more vigorously. Existing herbivores, which potentially serve as natural biocontrol agents, are removed compounding the problem. Expenses increase since the more an area is harvested, the more it will need harvesting to assure trouble-free utilization of the site.

Biological control protocols for aquatic plant management are now being developed. These control agents have the potential for ecologically friendly plant management. There is still more to learn, as agents become available for utilization. There are at least three native insect herbivores that may help control water-milfoil in our lakes. *Euhrychiopsis lecontei*, the milfoil weevil, is present in many lakes and has been stocked to augment local populations in an attempt to control water-milfoil (Sheldon, 1997). *Acentria ephemerella*, an aquatic moth, is being tested for similar use (Johnson, et al., 1998). Herbivorous midges (Chironomidae) (Fagnani and Harman, 1987), namely *Cricotopus myriophylli*, the milfoil midge, which may attack water-milfoil in some situations, have also been documented (Harman et al., 2000). These organisms may have a role in the reduction of water-milfoil as a serious pest in the Northern tier of the United States and Canada. Other organisms, such as East Asian grass carp, have been used to good effect in some situations, particularly further south.

Introductions of non-native herbivores often require permits in New York State. It should be recognized that in regulated wetlands, plant management activities of any kind require a permit from the NYS Department of Environmental Conservation and the US Army Corps of Engineers. Plans for introduction of the non-native herbivores, to attempt biocontrol, should be preceded by intensive monitoring over a long period of time. Native herbivore damage and population densities need to be ascertained prior to management decisions. To date the evidence is tenuous that native herbivore populations, augmented or introduced, control target species successfully.

The use of herbicides has historically been an important tool in macrophyte control. The greatest concerns with herbicides relate to their toxicity. They are poisons. Many can kill non-target plants as well as animals and can cause health problems to lake-users. There are also a host of poorly understood, subtle and indirect effects on the biota, nutrient flow and food web relationships. Herbicides are available today that allow selective targeting of nuisance species. Contact herbicides cause parts of the plant in contact with the herbicide to die back. Systemic herbicides are capable of killing an entire plant. Non-selective herbicides will generally affect all plants in a target area, whereas selective herbicides will only affect one or a few plant species. Fluridone sold as Sonar[®] and Avast![®] (1-methyl-3-phenyl-5-[3-(trifluoromethyl)phenyl]-4(1H)-pyridinone), is an example of a systemic herbicide which is selective in low concentrations. This product is best used to control water-milfoil while permitting most other plants to recolonize, re-establishing a nearly complete native plant community. This, and similar products, must be carefully handled by professional permitted applicators **with an understanding of aquatic ecosystems**. Also, clearly specified targets should be part of plans developed with the involvement of affected stakeholders. There are still many problems to solve regarding

maintenance of appropriate herbicide concentrations over time to attain control without negatively impacting non-target species.

Efforts to manage aquatic macrophytes should be part of a coherent plan, no matter how formally documented. Involved groups need to precisely articulate goals and coordinate various activities. Physical control, biocontrol and chemical control procedures are often incompatible and should not be used concurrently except under professional guidance.

AQUATIC MACROPHYTE MANAGEMENT IN LAKE MORAINE

Lake Moraine (42° 50' 47" N, 75° 31' 39" W), Madison County, New York, is an artificially raised impoundment originally formed by the damming of a valley by the deposition of glacial moraine. This 261 acre (106 ha) body of water (Figure 1) comprises two distinct basins separated by a causeway and interconnected by a submerged culvert. The northern basin occupies 79 acres (32 ha), has a maximum depth of approximately 12.0 feet (3.7 m) and a mean depth of 3.7 feet (1.1 m). Most human activity focuses upon the southern basin, which occupies 182 acres (74 ha), has a maximum depth of approximately 45 feet (13.7 m) and a mean depth of 17.7 feet (5.4 m). Recreational activities associated with the lake include boating, skiing, swimming, and fishing (Anon., 1991).

Investigations into Moraine and its watershed have led to a detailed description, as well as suggestions regarding management (Hohenstein et al., 1997). The lake is generally regarded as being meso-eutrophic, as reflected by high productivity of algae and macrophytic plants and hypolimnetic oxygen depletion during summer stratification. Our findings with total phosphorus and nitrite+ nitrate ratios make it unclear as to whether the lake is phosphorus or nitrogen limited (Harman and Albright, 1997; Harman et al., 1998; 1999; 2000; 2001). Agricultural activities and residential development are believed to be primarily responsible for the bulk of the nutrient loading to the northern and southern basins, respectively (Anon., 1991). Nutrient introduction by septic leachate seems particularly problematic. Soils throughout the watershed are considered severely limited in their ability to assimilate pollutants associated with septic systems due to poor percolation rates, excessive slope, shallow depth to bedrock, and fractured bedrock (Anon., 1991). Of 237 dwellings in the watershed, approximately 200 are on parcels adjacent to the lake. A survey conducted in 1988 (Anon., 1988) indicated that the average septic system tended to be outdated (22 years old at that time), undersized (581 gallons), and extremely close to the lake (80 feet). Because nutrients associated with sewage are in a form readily available to plant uptake (Brown et al., 1983), it is unlikely that significant improvements in water clarity and oxygen depletion rates, as a result of decreased algal productivity, will be realized unless septic problems are addressed. Recently, nutrient controls in the watershed have been implemented by the Lake association.

Of the factors affecting lake use, excessive submergent macrophyte growth is considered to most impair the recreational use of Lake Moraine. Reportedly as much as 45% of the Lake's surface can be covered by aquatic macrophytes (Anon., 1991). *Myriophyllum spicatum* (Eurasian water-milfoil), a non-native macrophyte encountered sometime before 1990

(Hohenstein et al., 1997), is now abundant. This plant is especially pestiferous in that it is able to form dense, monospecific beds whose canopy reaches the surface while rooted in 3-5 meters of water (Coffey and McNabb, 1974). Controlling this species is the primary intent of the Lake Moraine aquatic macrophyte management plan (Welch, 1997).

The cover provided by most macrophytes creates distinct habitats due to differences in leaf structure as well as height of growth in the water column. When an aggressive exotic macrophyte enters a littoral community, the biodiversity of this area will decrease due to the extreme growth patterns the plant has. Native macrophytes in Moraine, for example, *Elodea canadensis*, *Valisneria americana*, and *Chara vulgaris*, do not grow profusely at the surface, whereas Eurasian water-milfoil does, often forming a dense canopy. This canopy shades out the area beneath it and therefore decreases the growth of native plants that otherwise would compete with it. The milfoil canopy creates a monotypic habitat in which the surface water becomes extremely hot and stratification occurs beneath (Uumuth et al., 2000).

Mechanical harvesting of macrophytes has been used regularly in an attempt to reduce plant densities throughout the lake, particularly in areas adjacent to lakeside property owners. This strategy provides immediate recreational access, but requires an ongoing effort. Harvesting may aid in the dispersal of undesirable species through the propagation of fragments while removing insects that may aid in the control of those plants (see below).

Populations of native herbivores, including the milfoil weevil, macrophyte moth and milfoil midge, were noted in Lake Moraine in the fall of 1997 (Johnson, 1998). As their names imply, these organisms are known to feed on milfoil. The milfoil weevil prefers water-milfoil (Sheldon, 1997). The weevil, *Euhrychiopsis lecontei*, has the potential to serve as an effective tool in managing milfoil. Between 30 June 1998 and 18 July 2000, 13,000 weevils were released at three sites in the north basin of Lake Moraine in a cooperative effort by the Lake Moraine Association, the Madison County Planning Department, EnviroScience, Inc., the Biological Field Station and the NYSDEC.

There are some questions regarding the ability of these herbivores to control water-milfoil effectively. They tend to live in new growth, feeding primarily upon apical meristems of plants. These insects “over-winter” on shore close to the water’s edge. Any flooding or early drawdown of the area may result in loss of these herbivores. Mechanical harvesting, such as historically occurred in Lake Moraine, has severe negative impacts on their populations. Harvesting has not been used on the North basin since 1999. The release of biocontrol agents for plant management must be considered experimental. The BFS has previously collected information on weevil population densities and damage to milfoil in order to ascertain the effectiveness of *Euhrychiopsis* for water-milfoil control (Harman et. al., 1999, 2000, 2001)

Copper sulfate, a broad-spectrum toxic herbicide, has periodically been used to control phytoplankton and macrophytes. As an alternate approach to more specifically limit the more problematic plants (i.e., water-milfoil), and to potentially manage the problem in a more cost-effective manner, Sonar[®] (fluridone) was applied throughout much of the littoral zone in both basins in May, 1996 (Figure 2) and throughout the entire littoral area of the south basin only on 13 May 2001. This product, advertised as being non-toxic, carries a “caution” warning, which is

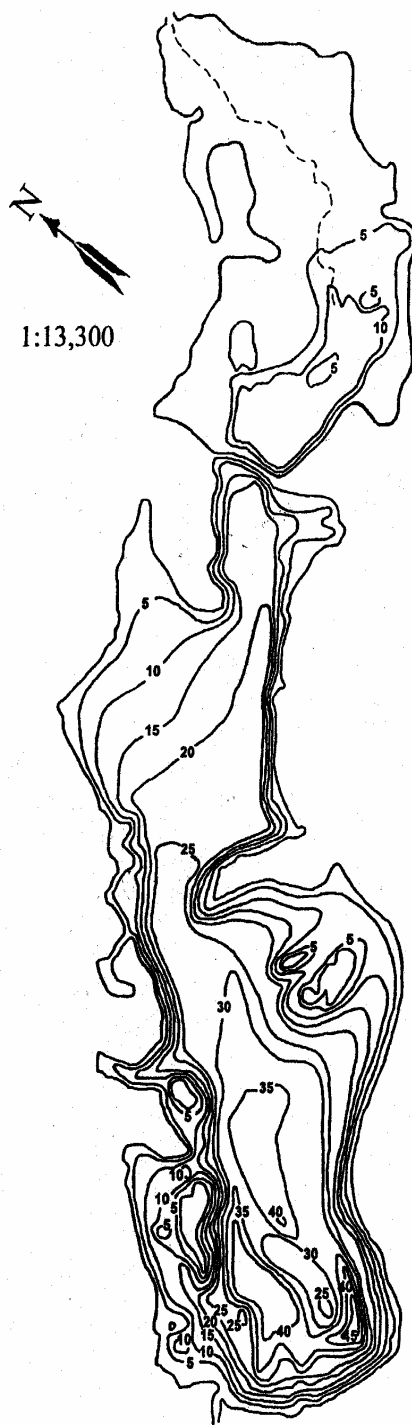


Figure 1. Bathymetric map of Moraine Lake, Madison County, New York (from Harman and Albright, 1997). Contours in feet, scale = 1:13,300.

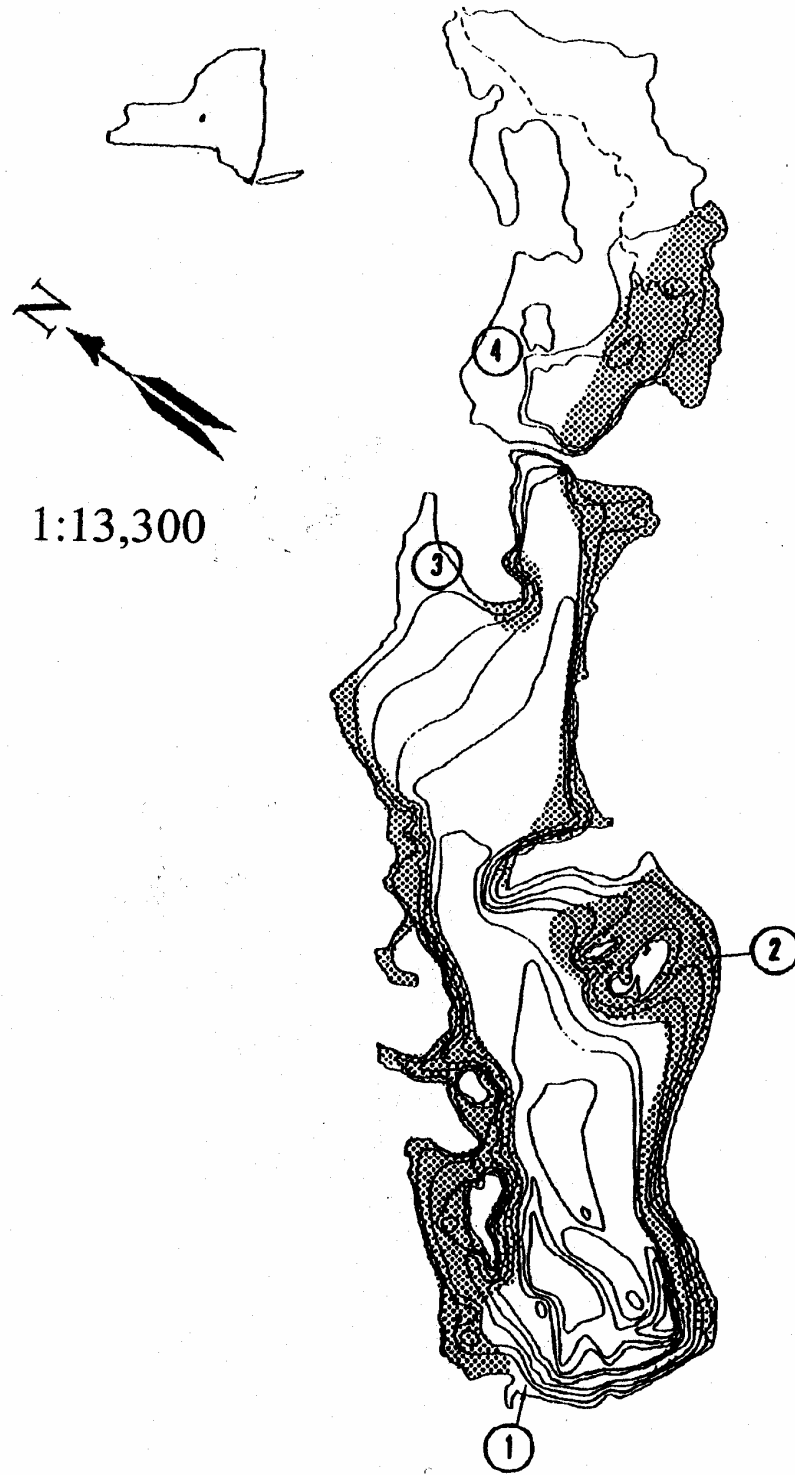


Figure 2. Moraine Lake, Madison County, identifying Sonar® sample sites and approximate areas of Sonar® application in May, 1996 (Harman and Albright, 1997).

the lowest warning assigned by the EPA. Sonar[®] prevents plant growth by disrupting chlorophyll metabolism, affecting the entire plant. Target plants can be controlled with some specificity, based upon application rates, and control may last for over a year (SePRO, 1999). Sonar works slowly to control weeds so there is limited oxygen deprivation, which otherwise can result in fish kills (SePRO, 1999). Lake Moraine became the first lake in New York State to receive a second application of Sonar[®].

In order to evaluate the effectiveness of Sonar[®] in controlling milfoil in Moraine, a sampling protocol was initiated in June 1996 (Fuller, 1997). Three sites in the lower basin, where Sonar[®] was applied, were sampled over the course of that summer. A fourth site, on the upper basin in an area not receiving Sonar[®] application, was sampled once as the control site (Figure 2). Macrophytes collected from quadrats were separated by species, dried and weighed for biomass determination. Since 1997, the Biological Field Station (BFS) has been provided resources to continue monitoring using similar methodologies. This work later attempted to evaluate the effects of biocontrol efforts by *Euhrychiopsis*, and, most recently, to monitor following the 2001 application of Sonar[®].

METHODS

Macrophyte biomass monitoring

Sonar[®] was applied over the entire littoral area of Lake Moraine's south basin on 13 May 2001 (Maier, 2002). The application was timely, as no precipitation occurred for the first 40 days after initial treatment. Sonar[®] concentration levels were evaluated five consecutive weeks following treatment. The concentration level of Sonar remained at a consistent level between 5.0 and 6.0ppb ($\mu\text{g/l}$) throughout that interval. On 10 June a second application was applied to ensure that the concentration remain between 5-6 ppb for 45 days, which is the target believed needed to achieve selective success. Ten gal (37.8 l) was initially applied and 2 gal (3.8 l) were later added (Maier, 2002).

Plant biomass was monitored throughout the summer of 2002 in order to evaluate the effects of the 2001 Sonar[®] application. Samples of aquatic macrophyte biomass were collected from the south basin (where Sonar[®] was applied; collection at sites #1-3) at monthly intervals during the summer of 2002 (29 May, 24 June, 30 July, (UNKNOWN) August and (UNKNOWN) September). Samples were collected from the north basin (site #4, serving as the control) the same dates. Figure 2 identifies the sample sites used in 2002 research (R1-R4) and outlines where the herbicide was applied in 1996. Two additional sites (R5, R6) were added in the north basin to facilitate research with *Euhrychiopsis* in 1998, but have since been removed from collection protocol, as 2002 research deals solely with Sonar[®] application. Mid-basin profiles of water quality were collected in both the north (mean depth = 4 m) (site WQ2) and the south basin (mean depth = 12 m) (site WQ1) on each collection date.

At each site on each collection date, five replicate plant samples were taken. To provide unbiased samples, a weighted line, marked in one-meter intervals, was randomly tossed from the boat; the line then allowed to settle over the substrate. Samples were taken at meter marks along

the line, each replicate being at a different mark. Collection was made by a diver, outfitted with mask and snorkel, using a mesh net secured to a 0.32 m diameter ring (surface area = .08 m²). The net was lowered over the macrophytes to the substrate collecting all the plants within the aperture. In cases where plants reached the surface forming masses of material in excess of the diameter of the opening of the net, the net was taken to just above the bottom, the stems from the sample area were removed from the substrate and pulled down by winding around the diver's forearm, whereupon they were inserted into the net. No attempt was made to include root tissue or dead or senescent plants, but that included in field samples was processed. Samples were transferred to labeled plastic bags and were stored on ice until processed. Following the first collection date in 1998, data were evaluated to ensure that a statistically adequate number of replicates were collected (Madsen & Bloomfield, 1993).

Samples were returned to the lab, rinsed and separated by species according to Crow and Hellquist (2000a; 2000b). To achieve constant weight, the macrophytes were dried at 105°C in a convection oven for approximately 24 hours, and reported as species dry weight/m². Macrophytes were weighed to the hundredths of a gram. If a sample weighed less than 0.01g it was recorded as "*" to indicate its presence in the sample. The information gathered during this study was compared to that collected in 1996 by Fuller (1997), 1997 (Harman and Albright, 1997), 1998 (Harman et al., 1998), 1999 (Harman et al., 2000) and 2000 (Harman et al., 2001).

Water Quality Analysis

Routine water quality analyses (temperature, pH, conductivity, dissolved oxygen) were collected in profile at sites WQ1 and WQ2 (Figure 3) on each sample date (**excepting 30 July as no properly functioning Hydrolab[®] was available for use**). Secchi transparency readings were also recorded. Samples were collected from each site and analyzed for total phosphorus using ascorbic acid method following persulfate digestion (APHA, 1989) and nitrite + nitrate by cadmium reduction (APHA, 1989).

<u>Site</u>	<u>Location</u>
WQ1	N 42°50.79' W 75°31.47'
WQ2	N 42°51.61' W 75°30.73'
R1	N 42°50.85' W 75°31.60'
R2	N 42°51.11' W 75°31.09'
R3	N 42°51.51' W 75°31.03'
R4	N 42°51.67' W 75°30.73'

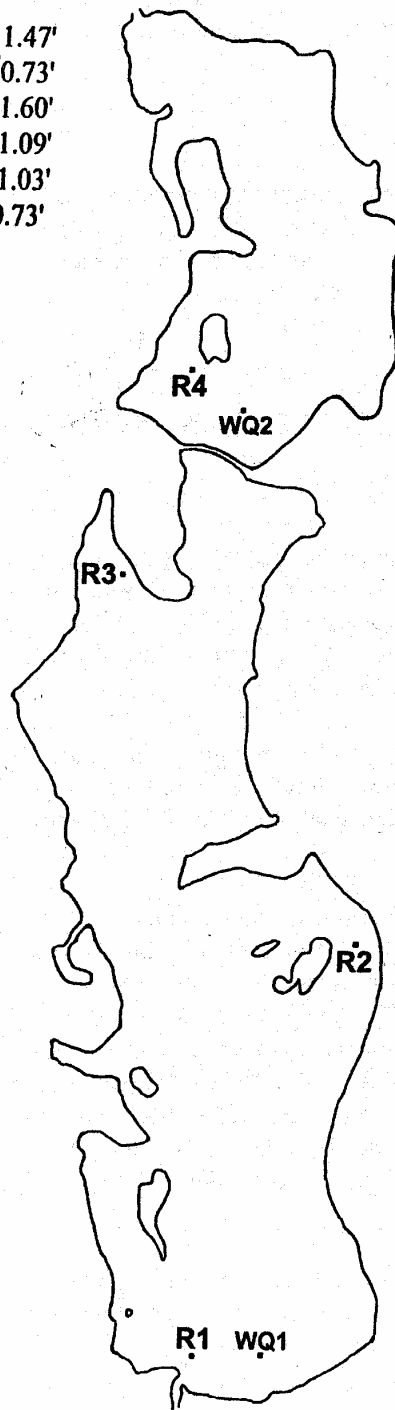


Figure 3. Moraine Lake site description. R1-R6 = macrophyte and herbivore monitoring, WQ1-WQ2 = water quality monitoring (from Harman and Albright, 1997).

RESULTS AND DISCUSSION

Macrophyte biomass analysis

A complete outline of the macrophyte biomass data collected in 2002 is provided in Tables 1-21 (see Figure 3 for site locations). These data, along with those of 1996 (Fuller, 1997), 1997 (Harman and Albright, 1997), 1998 (Harman et al., 1998), 1999 (Harman et al., 2000) 2000 (Harman et al., 2001) and 2001 (Harman et al., 2002) are graphically presented in Figures 4-9. Because the intent of the Moraine aquatic management strategy has focused upon the control of water-milfoil, these graphs have been simplified to compare its biomass to other aquatic plants combined. These data are even more broadly generalized in Figure 10. Here, the mean biomass of water-milfoil and “other” plants are plotted for the experimental sites (areas subjected to Sonar[®] application in May 1996 and May 2001 i.e., R1-R3) and the control sites (i.e., R4) throughout the summers of 1996-2002.

The data collected between 1996-98 on plant biomass in Lake Moraine indicate that macrophyte density had, in general, increased throughout the lake and that water-milfoil was significantly more abundant in areas not subject to Sonar[®] in May 1996 (i.e., site R4). In 1997, it became evident that regular water level draw-down was affecting plant growth in the areas sampled. In order to sample in areas more reflective of lake wide conditions, sampling stations were moved to deeper water beginning in 1998 (Harman et al., 1999). It is believed that this is at least in part responsible for the increased incidence of milfoil first noticed in 1998. The few differences in milfoil biomass between years at any given site imply that any effects by Sonar[®] were exhausted by 1999 (which is consistent with product claims related to duration of effectiveness).

Evaluating plant management strategies in years immediately following the initial Sonar[®] application is difficult because of the above situation. However, since shortcomings in the methodologies have been corrected, the effects of the 1998 and 2000 *Euhrychiopsis* augmentations and the 2001 Sonar[®] application will be better understood. Changes in plant distributions since 1998 can be more confidently attributed to management efforts rather than methodological variability.

At no time during the summer of 2002 was water-milfoil encountered in a sample taken from the south basin (Figures 4-6, 10). Overall, plant biomass was considerably lower at all sites in both basins throughout the summer. By 26 September, a significant resurgence of *C. demersum* and, to a lesser extent milfoil, occurred in the north basin (Figure 10). The earlier response by milfoil in that basin suggests that Sonar[®] had flowed into it because alterations in water flow due to the extremely dry weather conditions that prevailed in 2001.

Other species affected in varying degrees by the herbicide include *Potamogeton crispus*, which had a resurgence in 2002, expected because of the presence of turions from previous years. Other native plants that were affected in 2001 seem to have recovered well with the exception of *Elodea canadensis*, which was not collected in the south basin this summer.

WHEN DATA COLLECTION IS COMPLETE ALL GRAPHS (FROM EXCEL) WILL BE INSERTED HERE (SEVERAL PAGES OF DATA)

Water quality analysis

Water quality data were collected at sites WQ1 and WQ2 (Figure 3), the deepest parts of the lower and upper basins, respectively. Information collected fell within the range of values provided by CSLAP data provided by the Lake Moraine Association (Hohenstein et al., 1997). Transparency in the lower basin ranged from 2.0 to 3.6 meters (AS OF 12 AUGUST, WILL NEED TO BE UPDATED AS DATA COLLECTION CLOSES). The hypolimnion (from 10 meters down) was anoxic by 29 May. In the upper basin transparency ranged from 2.0 to 3.3 (AS OF 12 AUGUST, WILL NEED TO BE UPDATED AS DATA COLLECTION CLOSES) meters. Oxygen levels in this shallower basin were variable, presumably due to extreme daily swings resulting from plant photosynthesis/respiration and intermittent mixing.

MANAGEMENT CONCERNS

Work conducted since 1997 (Harman and Albright., 1998) suggests that Lake Moraine has a mix of 13 species of submerged aquatic macrophytes that create a diverse littoral community with a structure (physiognomy) analogous in many ways to the groundcover, understory and canopies typical of forest ecosystems. Unlike a forest, these communities go through successional changes over the growing season (phenology), providing a constantly varying environment. In our opinion, this mix of species is close to ideal for lakes the size and shape of Moraine.

There are two aggressive exotic plants present in Lake Moraine: water-milfoil and curly-leaved pondweed. By June, both plants typically are present in noxious densities in the upper basin, the latter forming large beds in the vicinity of site R3 in the lower basin. For the rest of the growing season dense beds of water-milfoil cover much of the upper basin. In 1999 a few isolated small colonies of milfoil reached the surface of the lower basin along the northwestern shore near the causeway and in the area near site R3. In 2000, a large bed of milfoil was present near site R3 extending south along the western shore and other smaller beds around the lower basin. Results from 2002 indicate that the 2001 Sonar[®] application successfully reduced water-milfoil to a vestigial state in the south basin. *Potamogeton crispus* rebounded, apparently from turions present prior to 2001. Other native species were initially affected, but most recovered over the growing season.

In the majority of the littoral area, waters less than 2 meters deep are dominated by *Valisneria* (eel grass) in the summer and by *Zosterella* (yellow star flower) in the late summer and fall. *Stuckenia pectinata* (thin-leaved pondweed) formed dense beds in one isolated area near R2 in the early summer of 1997 (Harman et al., 1998). In 1998-99 plants were present but did not become dense enough to pose a problem for recreational users. These species have been regarded as problematic in the past, and are undoubtedly considered troublesome by some who must traverse shallow water to satisfy their recreational goals. The extent of shallow-water plant species attaining the surface varies from year to year, apparently with lake level fluctuations.

These changes are normal and should be expected. If lake users are not satisfied with the current situation regarding *Vallisneria*, *Zosterella* and *S. pectinata*, we recommend physical removal, by hand, of problem plants around docks and in swimming areas. The use of tightly woven synthetic fiber barriers may also be effective in these situations. Care should be taken to minimize substrate disturbance. Attempts to bury shallow water plants by introducing sand in beach areas are fruitless and, in the long run, will worsen the situation. Non-specific herbicides are, in our opinion, potentially dangerous to the stability of the condition of the littoral community as it now exists and are not recommended. Water-milfoil generally colonizes new sites through the spreading of vegetative fragments (Aiken et al., 1979). During the growing season, fragmented tips, released either by physical disturbances (i.e., boat propellers or harvesting activities) or by some natural process, float to the surface and invest available resources into growing new roots. Once completed, the fragments descend to the bottom and commence growing. Interestingly, our earlier observations suggest that spontaneous “autofragmentation”, described by Aiken et al. (1979) could, in part, result from *Euhrychiopsis* mining.

The augmentation of the populations of *Euhrychiopsis* into the upper basin should be experimental. Monitoring did not suggest that stocking yielded significant benefits. Any potential for biocontrol by that, or other, species to control water-milfoil will probably take at least several years of not exercising mechanical or chemical control measures in that basin, and may require the management of predatory fish populations (Cornwell, 2001; Johnson, 2002).

Educational programs and other preventative measures are recommended to assure that stakeholder expectations equal realistic plant management goals. Such programs can help prevent further introductions of noxious plants. These same strategies may minimize the chances of introducing exotic zooplankton (e.g., spiny water fleas [*Bythotrephes cederstroemi*]), zoobenthos (e.g., zebra mussels [*Dreissena polymorpha*]) and fish (nekton) (e.g., alewives [*Alosa pseudoharengus*]), all of which are present in nearby lakes including Oneida, and could create serious problems both ecologically and recreationally. Techniques vary from simple signage at launch sites to boat washing facilities and boat registration schemes.

Changes in the distribution of emergent plants along shorelines and increasing layers of mud over sandy bottoms are indicative of gradual increases of nutrient enrichment. Long term planning should involve land use regulations to minimize nutrient (phosphorous and nitrogen) runoff from the watershed from compacted surfaces (roofs, roads, driveways, patios, etc.) near the lake and its tributaries. Sewage problems have been documented and to some extent mitigated. However, soils throughout the watershed are considered severely limited in their ability to assimilate pollutants associated with septic leachate. A survey conducted in 1988 (Anon., 1998) indicated that the average septic system tended to be outdated, undersized, and in close proximity to the lake. Short of employing sewage holding tanks, lakeside homes, especially those on islands, can be expected to contribute substantially to nutrient loading. And plants flourish with nutrients.

We stand ready to assist with whatever follow up monitoring, education or other activity the Lake Moraine Association, Madison County Planning Department, or other partners in the management of Lake Moraine desire.

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