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The Decline of Native Vegetation Under Dense Eurasian Watermilfoil Canopies[1]

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ABSTRACT

A dense bed of Eurasian watermilfoil in Northwest Bay, Lake George, NY grew consistently and expansively from 1987 through 1989, suppressing native plant species. The total number of species found within the 3 m^2 grid system in the Eurasian watermilfoil beds decreased from 20 in 1987 to 9 in 1989. Average number of species per quadrat declined from 5.5 in 1987 to 2.2 in 1989. This study is possibly the first to quantitatively document the suppression of native submersed macrophyte species by Eurasian watermilfoil after its establishment at a given site.

Key words: Myriophyllum spicatum, submersed aquatic macrophytes, exotic species, invasive species, aquatic plant communities.

INTRODUCTION

Eurasian watermilfoil (*Myriophyllum spicatum* L.), a native of Eurasia, may have been introduced to the North American continent at Chesapeake Bay in the 1880's (Reed, 1977), although Couch and Nelson (1985) present evidence that it was first observed as late as the 1940's. Eurasian watermilfoil has since spread throughout much of North America, creating nuisance growths and suppressing native plant populations (Smith *et al.*, 1966; Blackburn and Weldon, 1957; Coffey and McNabb, 1974; Aiken *et al.*, 1979; Newroth, 1985). At the present time, it is found from Florida to Quebec in the east, and California to British Columbia in the west (Couch and Nelson, 1985).

The impact of Eurasian watermilfoil nuisance growths on human utilization of water resources is well known (Newroth, 1985). In addition, the proliferation of this species adversely impacts aquatic ecosystems. Dense canopies formed by Eurasian watermilfoil often shade out native vegetation (Newroth, 1985; Aiken *et al.*, 1979). The invasion of Eurasian watermilfoil may alter the community composition of aquatic macroinvertebrates, and may impair the ability of some fish species to spawn in the littoral zone (Newroth, 1985). The significant rates of plant sloughing and leaf turnover, as well as the decomposition of high biomass at the end of the growing season, significantiy increase the internal loading of phosphorus and nitrogen to the water column (Newroth, 1985; Nichols and Shaw, 1986).

The rapid domination of littoral zone vegetation by Eurasan watermilfoil, and suppression of native plants, has been noted in several localities, but generally not studied while plant community changes were occurring. For instance, Coffey and McNabb (1974) noted that Water Celery *(Vallisneria americana* Michx.) appeared to survive under a canopy of Eurasian watermilfoil, but other native species already were absent from dense stands of the exotic. Studies in British Columbia noted that approximately 2 to 3 years were required for Eurasian watermilfoil to dominate a given area of littoral zone (Newroth, 1985; Aiken *et al.*, 1979). In Devil's Lake, Wisconsin, Eurasian watermilfoil was not noted in a 1974 survey, but was widespread by 1984 (Lillie, 1986). Eurasian watermilfoil had clearly displaced some species noted in 1974, such as Elodea (*Elodea canadensis* Michx.) but other species were able to coexist at lower densities, such as Robbins Pondweed (*Potamogeton robbinsii* Oakes).

The puirpose of our study is to quantitatively document the decline of a native plant in conjunction with the expansion of a dense Eurasian watermilfoil bed. Previous studies have not observed, much less quantatively documented, this process while it was occurring.

STUDY SITE DESCRIPTION

Lake George is located in northeastern New York State, on the southeastern edge of the Adirondack Mountains and the Adirondack Park (Figure 1). Lake George is large (114 km^2) and deep (18 m z_{mean}, 58 m z_{max}), and is the subject of ongoing water quality monitoring[7]. Eurasian watermilfoil was first observed in Lake George in 1985 when 3 sites were discovered[8]. Lakewide surveys found 19

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[7]Eichler, L. W. and C. W. Boylen. 1989. Report on the Lake George Chemical Montioring Program, January 1988 - December 1988. Rensselaer Fresh Water Institute Report #89-3, Rensselaer Polytechnic Institute, Troy, NY. February 1989. 18pp.

[8]Rensselaer Fresh Water Institute. 1986. A survey of Eurasian watermilfoil in Lake George. Rensselaer Fresh Water Institute Report #86-3, Rensselaer Polytechnic Institute, Troy, NY; Rensselaer Fresh Water Institute, New York State Department of Environmental Conservation, and Adirondack Park Agency. 1988. Lake George Aquatic Plant Survey. Interim Report. New York State Department of Environmental Conservation, Albany, NY. March 1988.

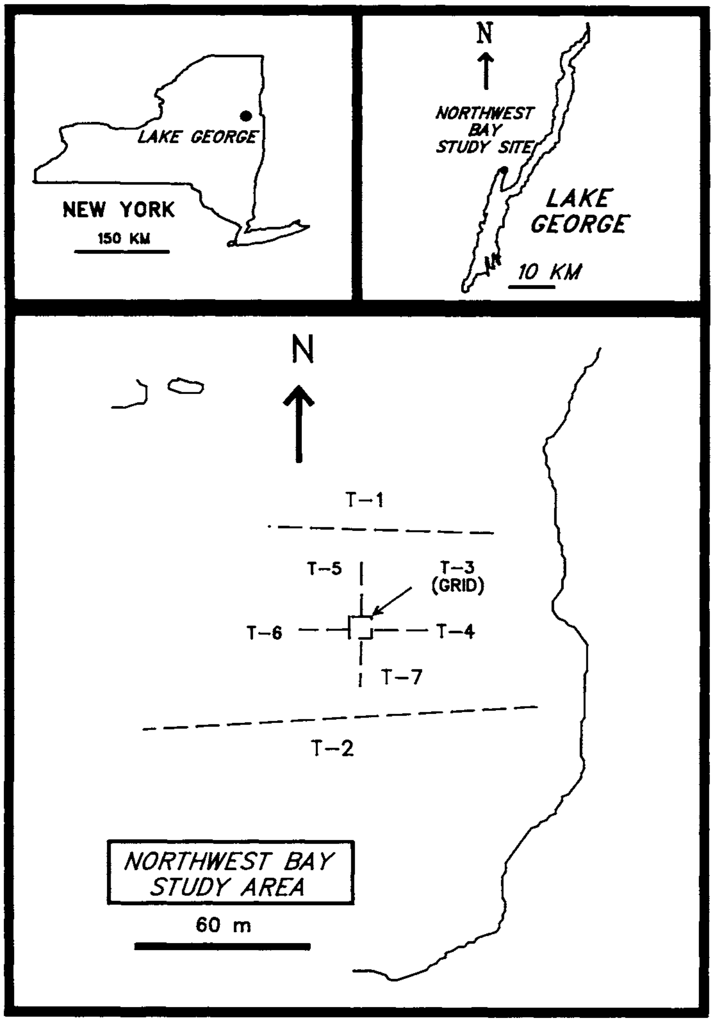

Figure 1. The location of Lake George in New York State (top left), Northwest Bay study site location on Lake George (top right), and the layout of the grid and seven transects at the Northwest Bay study site.

additional sites in 1986, 21 new sites in 1987, and 12 more sites in 1988. By 1989, a total of 66 different sites were found to have Eurasian watermilfoil, but only 41 sites had active populations due to the removal of isolated scattered plants and an active hand-harvesting effort[9]. In several localities, dense beds had formed, but the overall lake population was still predominantly scattered individuals.

The Northwest Bay study site is located at the northernmost end of Northwest Bay, where Northwest Bay Brook enters Lake George (Figure 1). Ten isolated plants were found at this site in 1986. During the 1987 survey, a small bed was found. Because of the small size of the population and particular characteristics of the site (e.g., depth range, silty sediments and dense native plant community) conducive to the growth of Eurasian watermilfoil, it was selected as an intensive sampling site for a survey initiated in 1987. Quantitative surveys were done in late July and early August in 1987, 1988 and 1989.

METHODS

Two long transects were installed on the bottom both to the north and south of the dense bed (Figure 1). These transects were divided into 1-meter depth intervals, and 25 equally-spaced markers were placed on the transect in each depth interval and served as locations to estimate percent cover. In addition, a permanently-fixed grid was placed on the bottom around the dense bed location. The grid was a 6 m by 6 m frame of PVC pipe, with nylon rope stretched across the frame ever 0.5 m, creating a grid-work of 144 contiguous quadrats, each with an area of 0.25 m^2.

Four radiating transects were set up from the central grid system, deployed along the four cardinal axes of the compass (N, W, E, S). Each transect was 25 m long, with a marker every meter.

Percent cover was estimated by a SCUBA diver using the Daubenmire scale of percent cover classifying the leaf canopy coverage ofer the bottom within the quadrat (Daubenmire, 1959, 1968). For the grid system, percent cover was estimated for each species within each quadrat of 0.25 m^2. For all transects, a portable 0.1 m^2 quadrat was placed at each marker on the transect, and the Daubenmire scale estimate recorded for each species in the quadrat.

Data was managed using the Oracle[tm] database system, with Daubenmire values converted to the centroid of each cover range for calculations[10]. Data summaries included average percent cover of species (where total cover could exceed 100%), percent of community — percent cover relativized to total coverage of all plants (relative cover of all species adds to 100% for each quadrat), and percent frequency (percent of quadrats containing a given species in entire sample).

During the 1987 and 1988 surveys, the size of the dense bed in Northwest Bay was mapped by professional surveyors. Surveying was not done during 1989, so the size of the dense bed was estimated using the distance covered along the four radiating transects as two diameters, which were then averaged. The average diameter was then used to calculate the area and perimeter of the bed using a circle as an approximation.

RESULTS AND DISCUSSION

As of 1989, Eurasian watermilfoil had not spread northward to Transect 1 or southward to Transect 2 (Figure 2). Average percent coverage of Eurasian watermilfoil was much less than 10% for all depth intervals, and percent frequency (percentage of quadrats in which Eurasian watermilfoil appears) was only 5 to 20%. However,

[9]Madsen, J. D., L. J. Taggett, R. Bombard and C. W. Boylen. 1990. Lake George Eurasian watermilfoil survey 1989 report. Rensselaer Fresh Water Institute Report #90-11, Rensselaer Polytechnic Institute, Troy, NY, May 1990; Madsen, J. D., J. W. Sutherland and L. W. Eichler. 1989. Hand harvesting of Eurasian watermilfoil in Lake George. 1989 Interim Report. Rensselaer Fresh Water Institute Report #89-8, Rensselaer Polytechnic Institute, Troy, NY. December, 1989.

[10]Madsen, J. D., J. W. Sutherland, J. A. Bloomfield, K. M. Roy, L. W. Eichler, and C. W. Boylen. 1989. Lake George Aquatic Plant Survey. Final Report. New York State Department of Environmental Conservation, Albany, NY. May 1989.

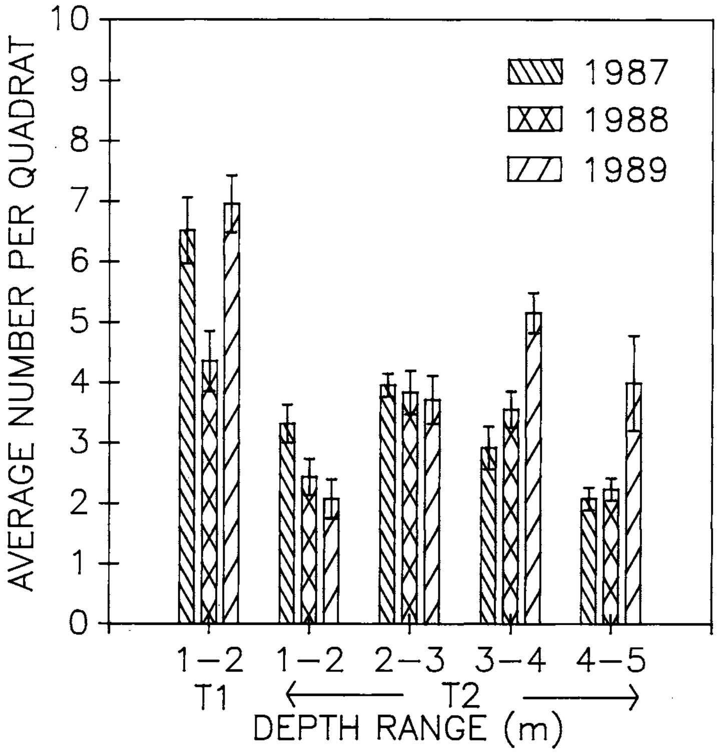

Figure 2. Average number of species per quadrat for transects 1 (one depth interval) and 2 (depth intervals from 1 to 5 meters). Bars indicate ± 1 standard error of the mean.

there was a trend towards increased occurrence of Eurasian watermilfoil in most depth intervals. Percent community (relative cover of Eurasian watermilfoil) was also low, due to the scarcity of Eurasian watermilfoil along these two transects. The average number of species per quadrat was highly variable from one year to the next in these depth intervals, possibly indicating that the macrophyte community is dynamic, rather than stable or fixed.

This was in marked contrast to the central grid (grid) and the four radiating transects (N, S, E and W), which showed consistent increases in the presence and abundance of Eurasian watermilfoil (Figure 3). The Eurasian watermilfoil population "dense bed", where percent cover was greater than 50%, began in the grid, and had spread outward. By 1987, almost all quadrats in the grid had some Eurasian watermilfoil, with percent cover under 30%. By 1988, percent cover in the grid was almose 80%, and approaching 100% by 1989. Eurasian watermilfoil went from being only 15% of the community in 1987 in the grid, to the overwhelming dominant species in 1989 in excess of 95%. By 1989, the formerly dense native communities were reduced to only a few stems of native plants under a dense canopy of Eurasian watermilfoil. Species richness went from an average of 5.5 per quadrat to slightly over 2 in 1989 (of which one species was always Eurasian watermilfoil). Eurasian watermilfoil had significantly suppressed native vegetation in this locality, in three years' time.

The total number of species found in the grid had decreased linearly over time, from 20 in 1987 to 14 in 1988 and to 9 in 1989. Given additional time further loss of species can be expected. However, it is likely that two species in particular, Water Celery and Robbins Pondweed, will continue to survive at reduced abundances under the dense Eurasian watermilfoil canopy, as has been observed in Huddle Bay[10]. Similar tolerance of low light levels under a Eurasian watermilfoil canopy have been reported for these two species in other lakes (Coffey and McNabb, 1974; Lillie, 1986).

Eurasian watermilfoil continues to spread along the four radiating transects. The east and south transects contained Eurasian watermilfoil in only 10% of the quadrats in 1987, but had Eurasian watermilfoil in over 80% in 1989. Eurasian watermilfoil also spread along the north and west transects, but to a lesser extent. This may be due in part to the physical topography/bathymetry of the site, which is shallow along the north transect, and drops off sharply at the far end of the west transect towards the center of a boat channel. Percent cover increased from almost zero in 1987, to 30 percent on the north and west transects, to almost 50% of the east and south transects. Negative impacts on species richness were observed once a dense bed is formed along the east transect, so that density of Eurasian watermilfoil may be one key element in the suppression of native plants. On these two transects, percent cover was approaching 50%, indicating the development of a dense bed.

In 1987, only a small segment of the north-south transect had Eurasian watermilfoil densities above the 50% value for a dense bed (Figure 4). The Eurasian watermilfoil dense bed continued to increase in size during 1988 and 1989 along this 60 m long transect. As the dense bed increased in size, the number of species per quadrat decreased under the dense bed area. Note along the "edge effect", where quadrats near the edge of the dense bed tended to exhibit higher numbers of species than those in the middle of the dense bed. This phenomenon may have been due to light penetrating the edges of the beds, and the young age of the bed at these locations. Native macro phytes along the edges of dense beds also may have survived through utilizing stored carbohydrates despite inadequate light for maintaining a daily positive carbon balance (Madsen *et al.*, 1991). A similar pattern was exhibited by the east-west transect system, with the grid at its core (Figure 5).

Some Eurasian watermilfoil dense beds in Lake George appear to have stopped expanding for no obvious reason (e.g., upper or lower depth limits or discontinuities in sediment type), while others only expand within the allowable environmental restraints until further growth is prevented by upper or lower depth limits. The growth of dense beds is primarily through the growth of root crowns and stolons and secondarily through the "seeding ahead" of small patches from fragments (Madsen *et al.*, 1988). Seed production is not a significant form of propagation in Lake George (Madsen and Boylen, 1989).

Some controversy has occurred as to whether disturb ance must occur before Eurasian watermilfoil will invade a given area of the littoral zone (see Smith and Barko, 1990). Some even suggest that a decline or degradation in native plant communities occurs before the establishment of dense stands of Eurasian watermilfoil. While we do not dispute the possible role of disturbance in increasing the

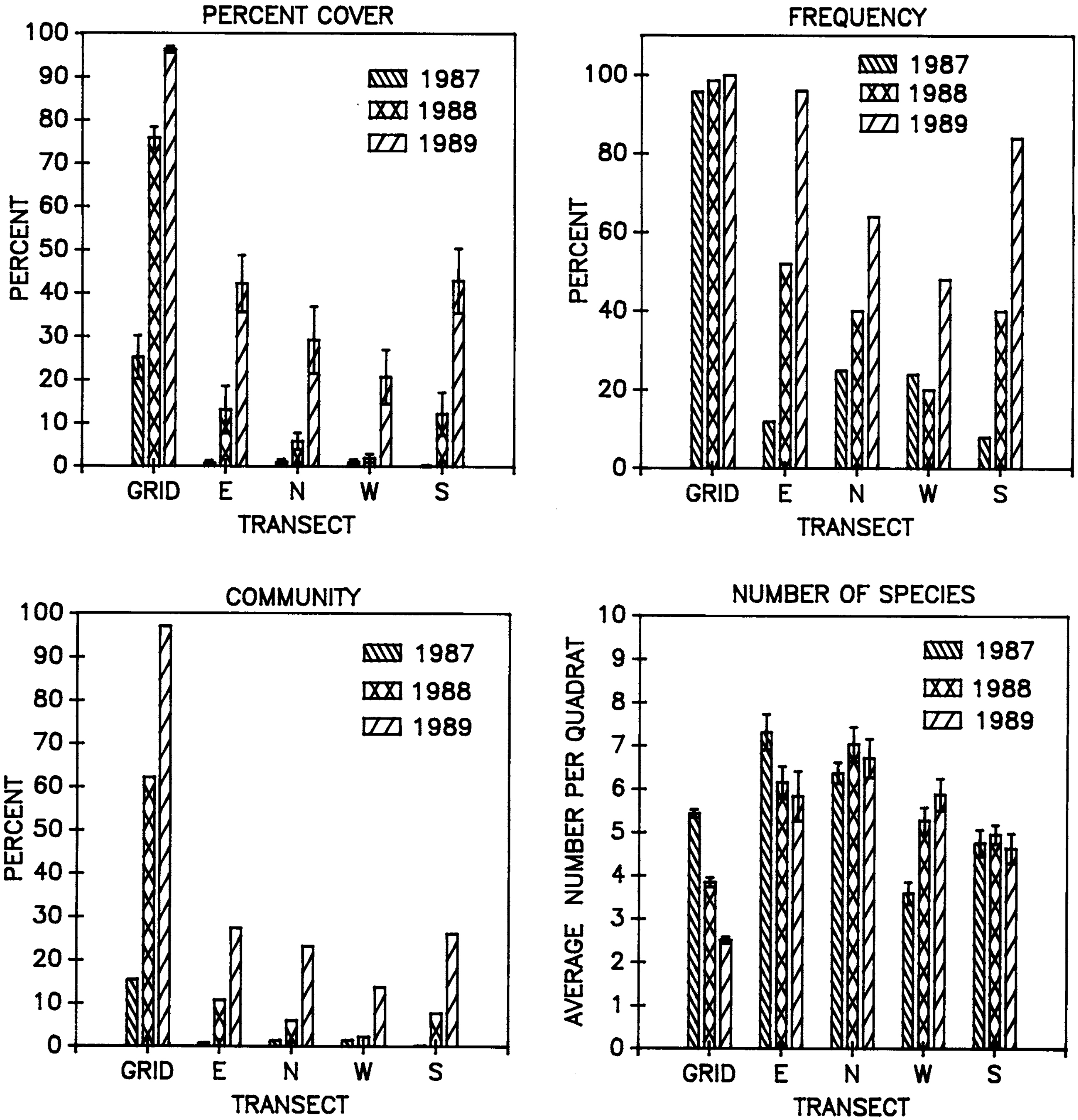

Figure 3. Vegetation summarized for the grid and the four radiating transects (N, S, E and W). Percent cover of Eurasian watermilfoil (top left), percent frequency of Eurasian watermilfoil (top right), Percent of community cover (relative cover) of Eurasian watermilfoil (bottom left), and average number of species per quadrat (bottom right). Bars indicate ± 1 standard error of the mean.

likelihood of colonization by Eurasian watermilfoil, this study clearly documents the intrusion of Eurasian watermilfoil into a healthy native littoral zone plant community.

The mechanism by which Eurasian watermilfoil dominates other species has been the topic of some discussion. Grace and Wetzel (1978) suggest that its greater efficiency at fixing carbon, particularly through the utilization of bicarbonate, gives the species a competitive advantage. However, this mechanism is not the only explanation, particularly in softwater lakes. The allocation patterns of plant

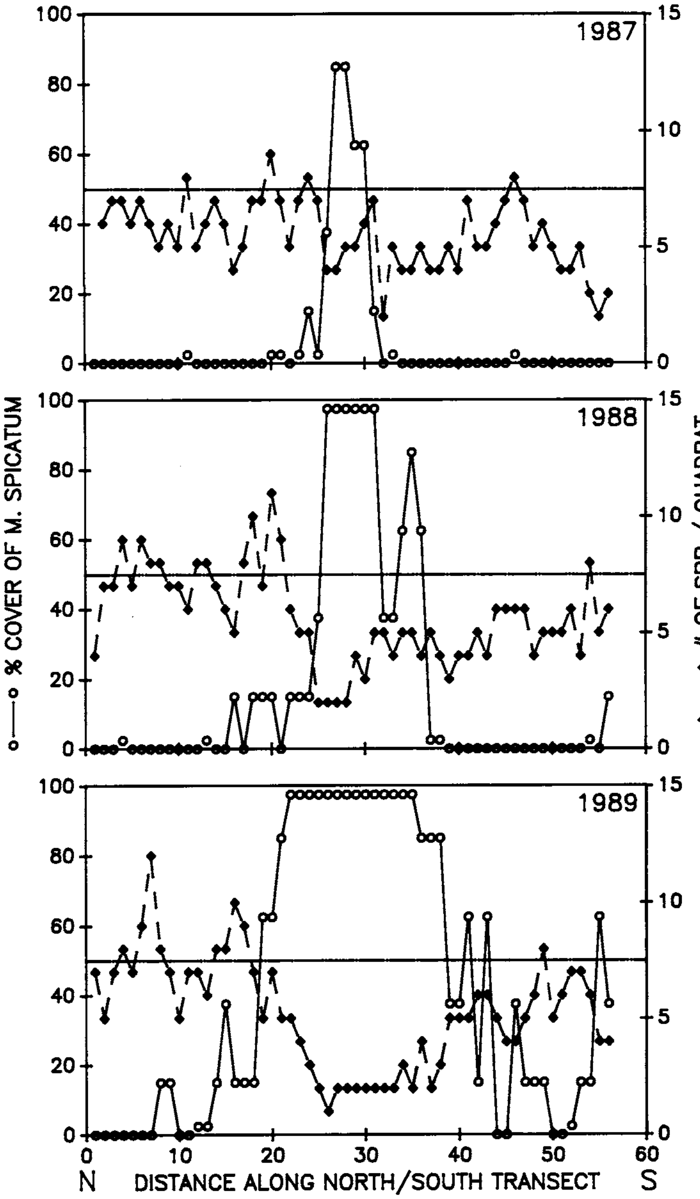

Figure 4. Percent cover of Eurasian watermilfoil and number of species plotted for each quadrat along the north/south transect system in Northwest Bay for 1987, 1988 and 1989.

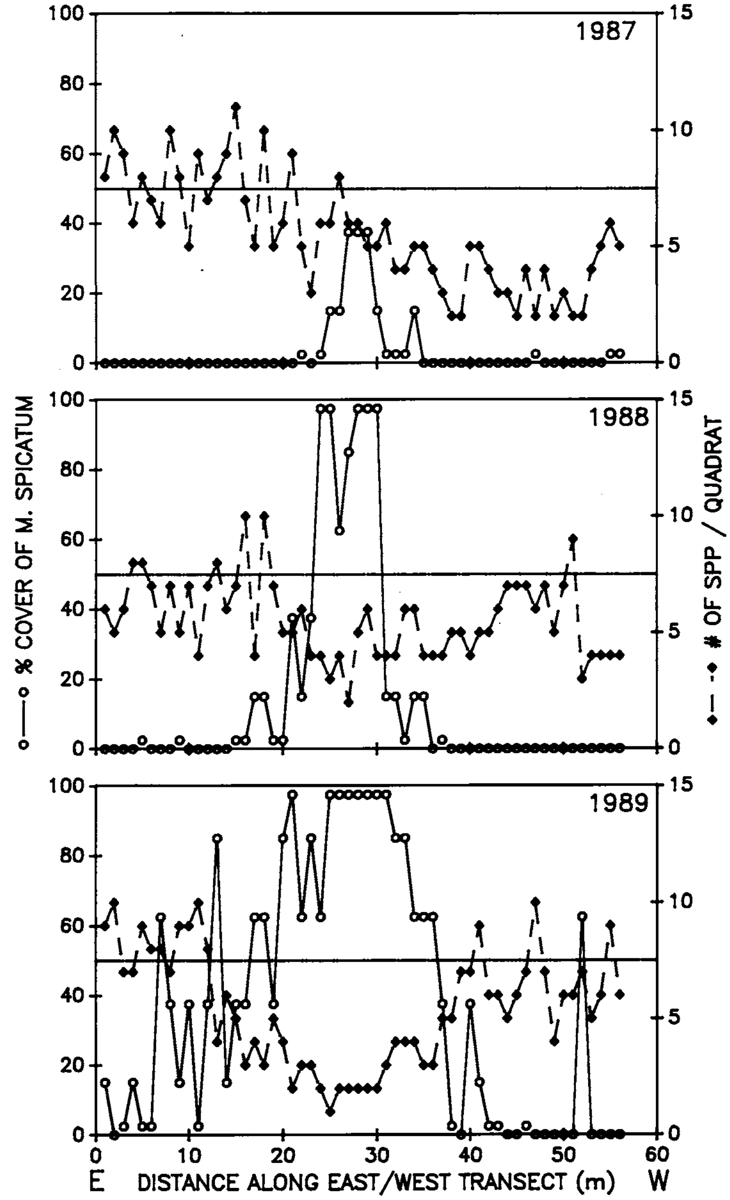

Figure 5. Percent cover of Eurasian watermilfoil and number of species plotted for each quadrat along the east/west transect system in Northwest Bay for 1987, 1988 and 1989.

biomass and growth form create a dense upper canopy that contributes substantially to reduced light intensity available to plants under the canopy[11]. In addition, the dense root mass formed by this species may competitively exclude some species. Experimental tests of these possibilities are needed. However, additional characteristics such as prolific formation of stem fragments and an ability to exploit disturbed habitats also may be key elements to its success.

[11]Madsen, J. D. and C. W. Boylen. 1990. The physiological ecology of Eurasian watermilfoil (*Myriophyllum spicatum* L.) and native macrophytes in Lake George: Depth distribution of biomass and photosynthesis. Rensselaer Fresh Water Institute Report #89-6, Rensselaer Polytechnic Institute, Troy, NY. Feb. 1990.

In conclusion, the dense bed of Eurasian watermilfoil in Northwest Bay and has continued to expand over the last three years. During that period, it has significantly suppressed the growth of native macrophytes once a dense Eurasian watermilfoil bed is formed (e.g., percent cover greater than 50%). The expansion of Eurasian watermilfoil and formation of dense beds not only creates an impairment of human uses, but will significantly alter the diverse littoral zone vegetation of Lake George, as well as other lakes in which this species occurs.

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