Getting the Most (Out) Of Your Aquatic Plants

A rose by any other name is still a rose. But for plants residing under water or along the fringes of streams, ponds, and lakes, a name implies much more. For frightened young fish, it means shelter from predator peril. For frogs and backswimmers, it means floats for life and leisure. And for minnows, moose, and mollusks, it means food, from the smallest alga to the soggiest lily.

For a frustrated lake resident, aquatic plants may all be called seaweeds, while a scientist may call them macrophytes (rooted aquatic plants) and extol their virtues. Still others hold each name in shrouded reverence, marveling at the gentle swell of the purple bladderwort or the primitive majesty of the horsetail. Yet although each person may view the plant kingdom with unequal parts idolatry and contempt, all those who spend time around lakes share a core set of reasons for understanding aquatic plants.

Aquatic Plants- Where Do They Belong?

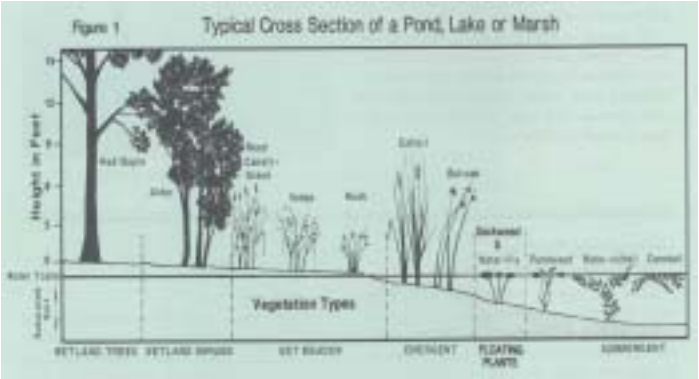
This chapter mainly focuses on the control strategies that have been used to minimize the impacts of invasive plants on lake uses. The term “minimize” is appropriate, for invasive plants, particularly non-native plants, can rarely if ever be eradicated from lake systems. Since plants will grow where light reaches the lake floor, and since most of these plants have reproductive structures- seeds, roots, rhizomes, etc.- that cannot be fully exterminated, the goal of most management plans is to minimize invasive plant populations and/or the impacts associated with nuisance growths of these plants.

Before tackling the problem of over abundance, it is important to understand that aquatic plants play an absolutely essential role in the maintenance of a healthy lake ecosystem. Lakes devoid of aquatic plants not only look a bit like swimming pools- they behave the same way. They only support very limited functional uses associated with contact recreation, and may not even support potable water usage, since aquatic plants frequently filter pollutants out of the water. While recreationally pleasing, plant-less lakes are aesthetically rather vanilla.

The larger rooted plants that inhabit lakes are referred to as **macrophytes**, although there are macroalgae that can at least superficially resemble these rooted plants. Macrophytes are really better described as either **bryophytes** (primarily mosses and liverworts) and **vascular** plants, which transport nutrients and water to their stems. They resemble the plants that grow on land since they usually have roots, stems, leaves, flowers and seeds, although there are exceptions. A few species of macrophytes found in New York that lack true roots are coontail (*Ceratophyllum* spp.) and bladderwort (*Utricularia* spp.). This is one means to distinguish macrophytes; others include growing season (spring plants versus summer plants) and method of reproduction (seed producers versus tuber producers). However, the most common method for distinguishing macrophytes is by their location in the lake.

Emergent plants grow out of the water at the water's edge, in the boundary between dry land or wetlands and the open water littoral zone of lakes, although they are actually part of the littoral zone. They are rooted within the water and have stems and leaves above the water, and grow in water less than 1-2 feet deep. The robust root and stem structures in

these plants befit the only plants that can survive the harsh conditions found within this area- highly variable water level, dessication, and sediment scouring from ice and erosion. There are a large number of emergent plant species found throughout New York State, with grasses, sedges and rushes the most abundant, although cattails and exotic emergent plants such as purple loosestrife and phragmites are perhaps the most prominent. The latter are considered invasive plants, although their impacts are more related to ecological diversity and function than to human use impairment.



Just beyond the emergent plants, **floating-leaf plants**, such as water lilies, watershield, and more delicate unrooted plants such as duckweed and watermeal, are found. Like emergent plants, they are rooted under the water (sometimes with thick, hearty rootstocks (**rhizomes**)), but the floating leaves usually constitute the bulk of the plant mass. These floating leaves shield out the light transmitted below the plant, reducing the amount of underwater plant growth (within the stems of the floating leaf plants as well as other low-lying plants). These plants grow in water from a few inches deep (the duckweed and watermeal, which look like surface algae from a distance) to as much as 6-8 feet deep. Although floating-leaf plants tend to grow in the most heavily used parts of lakes and ponds, they are usually not associated with nuisance conditions.

Beyond this area occur **submersed plants** such as pondweeds and milfoil. These are perhaps the most diverse of the aquatic plants, ranging from tiny grass-like plants that barely peek above the sediment layer, well-hidden in up to 20 feet of water, to very tall, very conspicuous leafy plants that look a little like redwoods when viewed from the lake bottom. Some of these plants sprout a floating leaf or rosetta of leaves, and even a spike of flowers above the surface, although the bulk of the plant still resides under the water surface. Others grow to the lake surface and then spread laterally, forming a dense canopy that ultimately prevents other plants from growing under their shade. These observations reinforce the notion that the definitions of **submersed** and **floating-leaf** are somewhat arbitrary, for several plants could easily be considered as members of both groups, and plants in both groups still take up residence in the littoral zone. Several submergent plant species are regularly associated with nuisance conditions, owing to their status as exotic plants.

The presence of aquatic plants in lake environments can be summarized in a single statement:

"If light reaches the bottom, plants will grow."

Of course, it is not as simple as that. Aquatic plant populations are governed by a complex interaction of physical, chemical, and biological factors. These vary from lake to lake, one part of a lake to another and one time of year to another. While limnologists and knowledgeable lakefront residents recognize that the equation " phosphorus + lake =

algae" holds in most parts of the state, the equation dictating the growth of aquatic plants is much more complex, and may not even exist. The Grand Unification Theory of Aquatic Plants in NYS Lakes continues to be elusive. The existing base of knowledge does not explain why some plants do well in many New York State lakes. We have a pretty good idea about which factors contribute to the spread of aquatic plants in a lake (sediment type, light transmission, water and sediment chemistry, space, the introduction or presence of invasive plants, etc.). And since light can and should be shed on lakes and ponds, and since the entire ecological web is critically dependent on photosynthesizing organisms native to these lakes and ponds, it follows that aquatic plants "belong" in lakes. But to what end?

The functions served by aquatic plants are extensive and impressive. They harbor aquatic insects that serve as the foodstuff for fish, often providing a launching pad from the water to the air. They provide hiding, nurseries and spawning areas for zooplankton, amphibians and fish. They provide food for waterfowl and other creatures of the wild. They hold sediment in place and otherwise control flow patterns and dampen wave action, reducing erosion and the transit of turbidity and nutrients into the open waters. They create oxygen for those who live in and above the waterline, aiding in the water purification process (by providing habitat for microbial degradation and converting toxic compounds to useful raw materials). And, at least from an aesthetic standpoint, many of these macrophytes are quite beautiful, whether observed by the colorful flowers of the pickerelweed or water lilies, the delicate but dangerous nets cast by the carnivorous bladderwort, or the fern-like simplicity of the Robbins pondweed. In short, aquatic plants are absolutely essential to the proper maintenance and function of a healthy and attractive lake or pond.

Weed control to improve swimming or aesthetic quality may have undesirable consequences. If some uses of the lake, such as fishing, require moderate to high levels of standing weeds then efforts to reduce weed populations will necessarily be in conflict with these uses. Both anglers and swimmers would certainly agree that too many weeds, particularly monocultures of canopy-forming or surface-covering exotic weeds, are not good for any lake uses. However, user conflicts about "How much is too much?" need to be reconciled before aquatic plant management strategies are to be considered necessary.

What Are Those Things?

An integral part of any management or prevention program is identifying the targeted plants. Why is this important? Isn't a weed just a weed? Well… while a weed is simply too much of a plant growing in the wrong place, many of the strategies for controlling those nuisance weeds are selectively effective for specific aquatic plants. For example, seed producing plants, such as some varieties of *Potamogeton* (pondweed) and naiads, are less impacted by water level manipulation, due to the ability of the seed banks to weather the deep freeze associated with winter drawdown. These plants may actually increase after a drawdown, at the expense of some plants that reproduce vegetatively (through fragments or rhizomes). Some beneficial native plants that look very similar to exotic, invasive plants may not survive an aggressive campaign to control the exotics, leaving a barren (under)waterscape for the new colonization and spread of opportunistic plants, like the same exotics targeted in the beginning. Grass carp like the taste or texture of some plants (such as soft ribbon or wide-leafed plants, like eelgrass and many of the

native pondweeds), but not others (such as coarser plants like milfoil), and their preferences are often inconsistent and unpredictable. Long-term control of nutrients within the water column, while likely to result in clearer water to better support contact recreation, might allow sediment-anchored aquatic plants to thrive in the absence of light inhibiting algae or weakly rooted plants. Some plants are strongly rooted (such as lilies and hardy watermilfoil plants) and derive the majority of their nutrition from the bottom sediments, while other plants such as coontail and bladderwort are weakly rooted, and absorb nutrients from the surrounding water.

Macrophyte surveys and mapping

The amount and coverage of vegetation, both emergent and submerged, can have a significant affect on the recreational access, quality of fisheries, and overall aesthetic appeal of a lake. Vegetation surveys usually involve some combination of measures or estimates of plant quantities and locations within the lake; this information can go a long way toward a better understanding of the water quality and use impairment in a lake. The full spectrum of aquatic vegetation surveys, from the cadillac to the cart, has been described elsewhere (Bloomfield and Madsen, 1996). The high end version is to lay transect lines (running perpendicular from the shoreline to just beyond the maximum depth of aquatic plant growth) throughout the lake and measure plant densities and population composition (species identification) in quadrants placed in regular intervals along the line. These quadrants can range in size from 0.1 (appx 1 foot by 1 foot) to 1 square meter, and can be frequently evaluated to determine change in plant densities and coverages). At the other end, simple surface maps can be drawn without regard to plant type. However, extensive macrophyte surveys can be extremely expensive, and may require the time and expertise of qualified specialists, including divers. Individual plant species must be positively identified and verified to completely address the relationship between macrophyte communities and lake water quality and use impairment. As noted above, this is commonly done as part of volunteer plant monitoring programs.

Aquatic Plant Survey Map of Waneta Lake (Lord, 2005)

The most common survey methods usually involve techniques for collecting plants from the surface, usually using rakes attached to ropes tethered to the shoreline, boat, or wrist of the sampler, or observations of plant communities using diver swimovers or identifications from boats. These rake tosses or observations can occur at various depths in the weediest areas, but are best standardized or reproduced by sampling via the "point-intercept" method, which divides the lake into a series of points, usually in the center of grids overlying the surface of the lake. These points can be sampled randomly, and recent surveys have indicates a strong connection between biomass measurements and semi-quantitative assessments from point-intercept measurements, as discussed below (Lord et al., 2004). The point-intercept measurements can generate coverage maps that provide a readily understandable snapshot of plant conditions in a lake (see Figure on the left), and can, if used in methods described below, can be used as a surrogate for detailed biomass survey maps.

In lieu of an extensive macrophyte survey, individuals and lake associations can map the extent of vegetation coverage over the course of the year, usually during late spring to early summer and again in the fall. This can be done through aerial photography, or from on-site inspection by lake residents (preferably those who can view the lake from their rooftops!). The most common maps indicate the major plant species in each part of the lake, with little differentiation between thick beds and scattered plants. These can be seen in the figure on the right.

It is frequently measured as percent coverage, or as a qualitative assessment of density, usually rare/trace, scarce/sparse, moderate/ medium/ common, and dense/abundant. Cornell University researchers have developed simple semi-quantitative metrics to evaluate density using these easily-understood labels applied to the results from two or three rake tosses, as quantified below (Lord et al, 2005):

Density Category	Average Quantity from 2-3 Rake Tosses	Approximate Biomass
No plants	Nothing	0 g/m^2
Trace	Fingerful (of plants)	up to 0.1 g/m^2
Sparse	Handful	0.1 to 20 g/m^2
Medium	Rakeful	20 to 100 g/m^2
Dense	Can't Bring In Boat	100 to 400 g/m^2

So what's the problem?

While most lake residents and users recognize the importance of aquatic plants, if grudgingly at times, they also recognize that too many of the wrong type of plants in the wrong place at the wrong time are no longer beneficial aquatic plants. They are WEEDS! While any aquatic plant that meets at least some of these criteria may qualify as a "weed", most of the aquatic plant problems in New York State lakes are generated from those **submergent** aquatic plants that are **not native** (**exotic**) to a lake (and in most cases to a region or the state as a whole). These plants tend to grow **invasively** in the absence of natural competitors or predators. Once these invasive populations inhibit the uses of these lakes, these plants become a **nuisance** and the target of active management.

Aquatic plant management should not be taken lightly! The potential impacts to the aquatic ecology of a lake from a poorly thought-out "brush-fire" response to a weed problem can be significant and difficult to reverse. Likewise, inaction in the face of rapidly escalating weed problems, particularly those triggered by invasive exotic

weeds, can also create ecological problems. In short, the future management challenges stemming from poor management decisions can increase exponentially. The best way to prevent these poor decisions is to develop a comprehensive aquatic plant management plan that addresses the objectives of aquatic plant management and reasonable strategies for reaching those objectives <u>for your lake</u>. Appendix A includes an outline for developing such a plan.

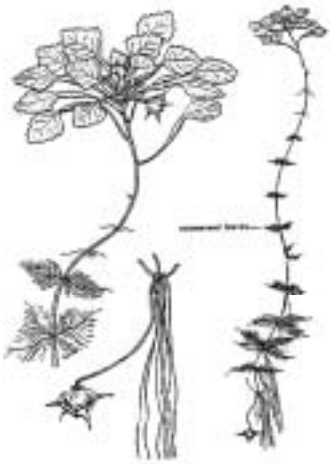
The rest of this chapter will largely focus on a summary of the control strategies that have been used to minimize the impacts of invasive plants on lake uses. The term "minimize" is appropriate, for invasive plants, particularly non-native plants, can rarely if ever be eradicated from lake systems. Since plants will grow if light reaches the lake floor, and since most of these plants have reproductive structures- seeds, roots, rhizomes, etc.- that cannot be fully exterminated, the goal of most management plans is to minimize invasive plant populations and/or the impacts associated with nuisance growths of these plants.

It should also be noted that one swimmer's weed is another angler's edge. Weed control to improve swimming or aesthetic quality may have an undesirable impact on fishing. If some uses of the lake require moderate to high levels of standing weeds, such as fishing, then aquatic plant management activities implemented to reduce weed populations will necessarily be in conflict with these uses. While both anglers and swimmers would certainly agree that too many weeds, particularly monocultures of canopy-forming or surface-covering exotic weeds, are not good for any lake uses, user conflicts about "how much is too much" need to be reconciled before aquatic plant management strategies are to be considered necessary.

Although New York State lakes continue to be threatened by a growing number of invading plants from neighboring states (practically next door as the crow flies, or in this case the duck…), states from the not-too-distant south where longer growing seasons and access to tropical travelers breeds a larger mix of aquatic invaders, and even boats traveling through international gateways into the state, only a small number of exotic plant species can be indicted for the majority of invasive plant problems in these lakes. The worst invaders in New York State waterways can be summarized in an invasive aquatics Most Wanted List (line drawings from Crowe and Hellquist, 2000):

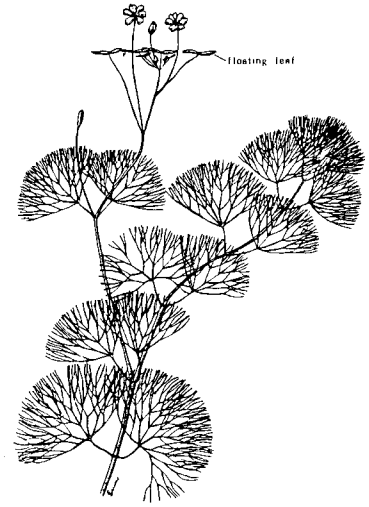
1. Eurasian watermilfoil (*Myriophyllum spicatum)* was introduced into New York State in the 1940s, probably in the Finger Lakes region, and has since spread to every region of the state except for Long Island. It is characterized by dense canopies that spread laterally across the surface of the lake, and propagates primarily by fragmentation in pieces as small as one inch. Like most invasive exotic plants, it grows opportunistically in a wide variety of depths, water quality conditions, and sediment types, although it is mostly commonly found in sandy to mucky soils in a depth range of 3 to 12 feet. It is the most invasive submergent aquatic plant throughout New York State.

2. (Eurasian) water chestnut (*Trapa natans)* was introduced in North American and New York State in Collins Lake in Scotia in 1882, although it was found a few years earlier in an herbarium in Massachusetts. From this "epicenter", it has largely migrated along the Lake Champlain, Mohawk River and Hudson River systems (and problems associated with water chestnut are mostly restricted to these areas), although it has been increasingly found in small lakes and ponds. It is conspicuous for a surface rosetta of leaves and a woody, spiked nutlet that serves as a seed for future generations of the plant (and is viable in bottom sediments for several decades). Water chestnut grows primarily in sluggish shallow water in mucky sediments.



3. Curly-leafed pondweed (*Potamogeton crispus)* was probably introduced in the mid-1800s in the northeastern United States, and is found sporadically throughout the state. It is characterized by a lasagna-like curled leaf and a very early growing season. In New York lakes, the plants usually start growing under the ice and die back by late June. It spreads by seeds and sprigs. It grows in a variety of settings, but generally grows best in relatively shallow water. Curly-leafed pondweed control strategies are most often employed in the eastern and southern portions of the state.

4. Fanwort (*Cabomba caroliniana*) is native to the southern states but not native to New York State or the northeastern states. It has historically been limited to Long Island (although the first sightings in New York State may have occurred in Orange County in the early 1930s), where it grows primarily in shallow water, as in most other New England states. However, in recent years it has been found in deepwaters of the isolated lakes in the southeastern Adirondacks and on both sides of the Lower Hudson River basin. It has thread-like leaves that fan out on opposite sides of the stem; while it has white or pink flowers, these rarely appear in fanwort in New York state lakes. It spreads by seeds, not by fragmentation or other asexual means. Fanwort control is mostly limited to Long Island.



Problems with nuisance weeds vary from one part of the state to another, resulting in management approaches and regulatory issues that are also highly variable. Although Eurasian watermilfoil has recently spread to the interior Adirondacks, the mostly isolated lakes and ponds away from the perimetry of (and major travel corridors within) the Adirondack Park, as well as the unaffected ponds in Long Island, have largely been spared nuisance-level infestations of most aquatic plants. While fanwort is common and grows invasively in many Long Island lakes and ponds, most of the ponds are so shallow that invasive plant growth also occurs with many native plant species. The percentage of lakes in the interior Adirondacks for which some recreational uses are impacted by excessive weed growth is much smaller than in most other parts of the state, at least relative to the large number of lakes in that region. The incidences of weed problems are highest in the Central New York region, although it is also clear that this also reflects a higher percentage of lakes reporting these problems (due to active lake associations, strong local involvement in lake residents in state and county reporting mechanisms, and active monitoring programs).

Lake Region	% NYS Lakes in Region	% NYS Lakes With Exotic Plants+	% NYS Lakes Impacted By Weeds*
Long Island / NYC	5	5	10
Downstate	18	15	20
Central New York	12	40	30
Adirondacks	58	20	20
Finger Lakes	5	10	10
Western New York	2	10	10

+ - based on inventories compiled through 2004
* - as documented on the NYS Priority Waterbody Lists compiled in the late 1990s to early 2000s

In other regions of the state, nuisance weed problems tend to be focused on more heavily used lakes near large roadways, although this is probably due to a combination of the greater exposure to vectors for transmitting these exotic plants (boats and trailers), the ease of access to these lakes, the larger population base using these lakes, and the greater likelihood of local communities reporting invasive weed problems in these high profile lakes.

An Ounce of Prevention

The best control strategy for nuisance aquatic plants is prevention. If the plant isn't in your lake, there is no need to control it. While preaching prevention in a weed-infested lake might be akin to closing the barn door after the horses have escaped, it might be the best way to keep the rest of the horses in the barn.

So what are the best measures for preventing the transit and spread of nuisance aquatic plants? New introductions of plants are often found near public access sites and heavily used entryways. Therefore, lake residents should focus their attention on boat propellers and trailers. Propellers, hitches, and trailers frequently get entangled by weeds and weed fragments. Boats not cleaned of fragments after leaving a colonized lake may introduce plant fragments to another location. Additionally, not feeding the ducks is a good idea, since plant fragments and seeds frequently enter lakes on the feet and wings of these

feathered visitors. Vigilantly patrolling all waterways entering the lake for plant fragments, seeds, and other bits of plant stuff may help, although neither strategy is likely to keep out most of the hitchhikers.

Inspection programs are a useful strategy and have been introduced at boat launch sites in several locations in the state. These can range from providing handouts and information to boaters about the connection between boats and invasive exotic plants to encouraging the removal of stray plants from propellers and trailers to preventing infected boats from entering the lake until offending plants are removed. The most common inspection programs are self-inspections suggested by "hitchhiker" signs posted at public and private launches by the NYSDEC and advocacy groups.

These frequently provide pictures of the most significant invaders (water chestnuts, zebra mussels, and sometime Eurasian watermilfoil), the places on boat props and trailers where straggling plants grab, and some simple strategies for removing these plants. Several lake communities sponsor "weed watcher" programs that teach volunteers how to look out for exotic plants. At the other extreme, boat wash stations (ranging from simple hoses to pressurized hot washes) have been used primarily at private launches to remove both nuisance plants and zebra mussel **veligers** (and any other exotic organisms that hitchhike onto boats or in bilge water).

Plants should not be discarded or introduced from one water source to another. For example, bilge or bait bucket water may contain traces of exotic plants or animals, and should be emptied prior to introduction into a new lake.

Another common mode of infestation is the purchased and deliberate introduction by aquaria and gardening hobbyists. Many problem exotic plant species can be readily purchased for fish tanks or water gardens. At present, only the planting or transit of water chestnut plants and seeds is prohibited within the state. Without stricter federal or state laws that ban or restrict the sale of highly invasive exotic plants in New York State, prevention rests with informing aquaria owners of the risks of discarding aquaria waters into lakes (not to mention the exotic fish or diseases that can also be introduced through this vector).

Exotic plants tend to thrive where water quality conditions and especially sediment characteristics have significantly changed. Establishing no-wake zones can reduce shoreline erosion and local turbidity, and may help to reduce disturbance of bottom sediments.

Who's In Charge?

Perhaps in recognition of the regional variability in environmental sensitivity in general and aquatic plant problems specifically, regulatory structures within New York State play an important role in aquatic plant management. Chapter 11 discusses the interaction of state law and lake management with a focus on the regulatory authority that directs the various functions of government agencies, but these can be discussed here in greater detail as they relate to aquatic weeds.

In most parts of the state, the New York State Department of Environmental Conservation (NYSDEC) maintains responsibility for regulating aquatic plant management. Most of the plant management strategies discussed in this chapter are not regulated activities. Permits are not required for managing aquatic plant problems, particularly by an individual landowner. A notable exception to this is if all or any portion of a lake is classified (under Article 24 of the Environmental Conservation Law) as a wetland. In this case, some activities are regulated and thus require at least a permit; some also require environmental assessments and evaluations of potential environmental impact. The NYSDEC regional offices can assist lakefront property owners or lake associations in determining if any portion of their lake is a classified wetland. In addition, the bottom of many New York State lakes is owned by

Case Study- Preventative Measures

Lake Setting: Otsego Lake is a 4100 acre lake found in the Leatherstocking (Central) region of New York state, perched at the northern end of the Village of Cooperstown.

The Problem: Lake residents and user groups have become increasingly concerned about the introduction of invasive exotic organisms through public boat launches and other entry points to the lake

Response: The Otsego Lake Association (OLA), the SUNY Oneonta Biological Field Station (BFS) on Otsego Lake, the Otsego County Conservation Association, Otsego 2000 (a local planning group interested in local quality of life issues) and other local partners worked with the neighboring towns to initiate a voluntary boat inspection and boat wash program, initially to address concerns about zebra mussels. By 2003, the Village of Cooperstown passed a local law requiring these inspections. More than $13,000 in foundation grants and town resources were provided via the Cooperstown Town Board to purchase, install, and staff a boat wash station, resulting in more than 1600 boat and trailer inspections in 2003 and about 1400 inspections in 2004 (about half of which occurred on weekends). Launch fees ($10 per launch, with reduced rates for multiple launches), grants and other contributions offset the approximate cost of $35,000 to run and maintain the launch. Boaters failing inspection are directed to a free boat wash at the Village Highway garage.

While this program was devised for zebra mussel control, these same partners were also involved in a water chestnut management and prevention program. A single specimen was discovered during a field survey conducted by a SUNY Oneonta student in 1999. $7,000 was provided by Otsego 2000 for searching for and removing small populations of water chestnuts. The OLA and BFS sponsor an Exotic Species Day each year for citizens to search for exotics. The BFS provides an information sheet (regarding the search and removal of exotic plants) and solicits community volunteers for annual monitoring, capped by a barbque and social gathering for the volunteers. The BFS also conducts training workshops with inspectors at the boat launches each spring.

The OLA and BFS are working with the town of Springfield (north end of the lake) to expand beyond an inspection program (and limiting launching to town residents) to site a wash station,. They are also working with local bass associations and yacht clubs to mandate boat washes prior to tournaments and races on the lake, respectively.

Results: Initial reports indicate that boaters strongly supported the boat and trailer inspections and a Chlorox spray of lines and bilges, although several boats required power washing prior to launching. As a result, as of 2004, no zebra mussels were found in the lake or on boats pulled at the end of the season. Aquatic plant surveys conducted by SUNY Oneonta found two additional water chestnut specimens. These were hand harvested, and no plants have been found since.

Lessons Learned: This example shows that rapid response to threats of exotic invasions (or actual pioneering introductions) can be effective in slowing or delaying the spread of invasives and the ecological and human use problems associated with this invasion

Source: Otsego Lake Association website (www.otsegolakeassociation.org) and Willard Harman- personal communication

the state of New York. Regulations associated with plant management activities that may significantly impact the lake bottom are administered by the Office of General Services.

The Adirondack Park Agency also maintains regulating authority on waterbodies within the Adirondack Park, primarily under their wetland regulations (which differ from state and federal wetland definitions). In other parts of the state, different government entities have authority over some aquatic plant management activities. For example, the authorities that regulate water level in the state (the Canal Authority within the State Thruway Authority, the Hudson River-Black River Regulating District, etc.) may dictate whether water level can be varied within the feeders to the canals or larger river systems. This authority extends to control of water level in many New York State lakes. Other government agencies that possess regulating authority that may ultimately require permits for aquatic plant management include the US Army Corps of Engineers, the NYS Department of State (for "wetland" lakes with direct connections to designated coastal areas), Lake George Park Commission, the Saratoga Lake Protection and Improvement District, the NYS Office of Parks, Recreation, and Historic Preservation (for those lakes and ponds that have both private ownership and state park land), and local government agencies delegated responsibilities by NYSDEC for regulating wetlands.

While aquatic plant management permit applications- primarily for aquatic herbicides and herbivorous fish (grass carp)- are evaluated on a case-by-case basis, and while regulatory requirements and environmental constraints dictate some variations in application reviews, regional patterns have emerged. For example, although aquatic herbicides can be used within the Adirondack Park, at present aquatic herbicides have not been applied to any lakes within the Park. Aquatic herbicide use is also very limited on Long Island. It is perhaps not coincidental that these regions have had lower incidences of aquatic plant problems, at least historically (particularly in the interior Adirondacks). However, both regions appear to have a stronger level of opposition to the use of herbicides than in most other regions of the state. The stronger regulatory framework for protecting wetlands also appears to result in fewer herbicide and grass carp permits in the Adirondacks; grass carp are most frequently stocked on Long Island lakes. On the other hand, a very large number of aquatic herbicide and grass carp permits are issued in the Downstate region, although this is also due in part to the large number of weed infested lakes and the large population base affected by excessive weed growth. In most other regions of the state, the proclivity toward issuing permits for aquatic herbicides and grass carp is neither high nor low. However, greater restrictions exist in some regions. This includes the larger number of wetland lakes in the eastern portion of the Central NY region, the relatively short retention-time (wide river) lakes in the southwestern Adirondacks, and water supply reservoirs throughout the state.

What Works?

Weed problems have plagued New York State for many years. Despite the long history of successes and failures for each of the management strategies to be discussed below, weed management in New York State has offered no single fix for each kind of lake, each kind of nuisance weed, or every lakefront owner with a vague mix of "seaweeds" outside their docks.

There also remains, perhaps hidden under the surface, the great risk of making a problem worse. Each management strategy has some risks associated with their use in these dynamic, unpredictable biological settings. Where possible, these oft-unexpected consequences are anticipated in this chapter, and discussed within the "Disadvantages" portion of the method summary.

That said, there is a core group of aquatic plant management strategies that have a relatively long history of use in New York State lakes and thus a record of success or failure. These can be categorized by cost or permitting requirements, although plant management strategies are usually characterized by mode of action:

Mode of Action:

- physical control strategies that impact the physical growth patterns of the weeds through disturbing the sediment, altering light transmission through the water or to the plants, and water level manipulation.
- mechanical control strategies that remove the plants and root systems, such as cutting, harvesting, and rotovating
- chemical control strategies, such as herbicides
- biological control strategies, such as herbivorous fish and insects

However, perhaps the most appropriate way to differentiate plant management strategies is by whether the control is "local"- outside a dock or otherwise manageable by an individual lakefront owner- or "lakewide"- strategies that impact most or all of a lake and therefore require a greater consensus among lake residents. While some of the local management activities can be applied in large portions or the entirety of a lake, the logistic difficulties in expanding these activities to a larger area are usually insurmountable.

The techniques listed below are not specifically endorsed by NYSFOLA or regulatory agencies. Rather, this is a list of recognized methods for addressing specific aquatic plant problems. Because prices vary with place, time and circumstance, the cost listings are relative at the time of printing. Additional information about each of these techniques can be explored from a variety of sources (Holdren et al., 2001; Cooke et al., 1993; Baker et al., 1993). Case studies on the use of some of these techniques in New York State lakes are also reported. **It must be stated that these do not necessarily represent the normal or expected results from the use of these techniques, although these summary case studies are among the better documented cases in New York State. These summaries are intended to provide the reader with some information about the actual use of these techniques in a wide range of lakes throughout the state, but do not constitute an endorsement of the use of these techniques in any New York State lake. For example, while there have been lake management projects in New York lakes involving the use of stocked aquatic weevils and different herbicides, the documentation in the lake studies reported here is more detailed than in these other projects. The authors hope that additional information about the use of these aquatic plant management techniques in New York State will be collected and become available to those interested in utilizing or learning more about aquatic plant management within the state.**