Logan Vairo
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Invasive Macrophytes in Seneca Lake: Eurasian Watermilfoil (*Myriophyllum spicatum*)

Introduction: Milfoil in Seneca Lake

Eurasian watermilfoil (*Myriophyllum spicatum, M. spicatum*), hereafter referred to as milfoil, is a ubiquitous, dominant, invasive rooted macrophyte species in that can be found in freshwater bodies from coast to coast in North America. This species differs from its native North American relative *Myriophyllum sibiricum* (*M. sibiricum*) Komarov because *M. spicatum* has higher concentrations of polyphenols and lignin compared to *M. sibiricum*, which could be a contributing factor to why Eurasian watermilfoil is able to outcompete native milfoil.[1] Eurasian watermilfoil exists in dense and expansive beds due to excessive growth and forms canopies that suppress the growth and diversity of native macrophytes in fertile shallow waters of the lake littoral zone.[2] Eurasian watermilfoil reduces the aesthetic appeal of water and detrimental to recreational activities however, it is a source of primary production for the lake as well as providing habitat for numerous aquatic species.

In addition, milfoil is a source of food for numerous aquatic macroinvertebrates and therefore serves as a link between primary producers and top predators who prey on macroinvertbrates.[3] Milfoil can also manipulate the ecosystem nutrient composition and other abiotic processes.[4] A correlation between nutrient loading in watershed streams that feed into to the lake due to agricultural land use and macrophyte densities has also been hypothesized.[5] According to the DEC and a report from the Department of Ecology and Evolutionary Biology at Cornell University, Eurasian watermilfoil is the most dominate rooted macrophyte in Seneca lake with more than 80% all aquatic vegetation found in the lake being milfoil.[6,7] The invasion of Eurasian watermilfoil is one of the largest problems facing the future of Seneca Lake that could lead to a myriad of future biological and financial problems.

History of Milfoil Removal Seneca Lake:

Harvesting is the only funded removal process that currently occurs in Seneca Lake and involves the physical removal of submerged aquatic vegetation from lake bed which is then offloaded on shore where it is then transferred to a disposal site such as a landfill or other disposal area. The past harvesting has been done on a seasonal basis and harvesting efforts have been focused on the northern and southern tips of the lake. The first harvester for the Seneca Lake watershed was

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1 Marko et al., 2008.
2 Masden et al. 1991.
3 Chaplin & Valentine, 2008.
4 Cronin et al., 2006.
5 Makarewicz et al., 2007.
6 http://www.dec.ny.gov/outdoor/25574.html
7 Belinsky & Johnson. 2000.

purchased for $95,000 in the late 1970's and was used until 2008 when a second smaller harvester was purchased for $17,000 funded by the FL-LOWPA (Finger Lakes - Lake Ontario Watershed Protection Alliance).[8] It is difficult to use harvesters to remove watermilfoil in lake Seneca due to rumors, hearsay, and misconceptions of the public to how harvesters work and results do not live up to expectation of the property owners. In addition, harvesters require large open spaces in order to gain access to the lake however extensive lakefront property surrounding perimeter of the lake and natural barriers prevent the harvester from being able to enter the lake.

<u>Mitigation Techniques And Their Applicability to Seneca Lake:</u>

As invasive milfoil is a problem for freshwater bodies nation wide, extensive research has been done involving the best ways to both reduce milfoil's abundance or to eliminate it from a water body completely. Overall, there are four main strategies for milfoil mitigation including the use of harvesting, herbicides, biological control and the implementation of Best Management practices by agricultural operation within the watershed. All four methods have proven to be effecting in reducing milfoil densities, however, none have been able to completely eradicate milfoil. Therefore, as complete removal of invasive milfoil is improbable, time and energy should be used to reduce milfoil densities and on preventative measures for slowing down the rate of colonization of the species. The purpose of this section is to detail the various positive and negative aspects to each mitigation strategy in order to determine the best course of action for milfoil mitigation in Seneca Lake.

The only strategy currently being used to remediate milfoil is harvesting which, although effective in the short term, does not produce long term results. The positive impacts of harvesting as a method of milfoil mitigation are that the results are instantaneous and that, depending on the harvester, they can be used a varying water depths. The most direct benefit of harvesting is making the water clear for boaters and swimmers however, the results are short lived and the process is inefficient and expensive. The typical cost of harvesting is $250-$800 per acre and would have to be repeated 2-4 times per year in order to keep the results.[9] In addition to the financial costs associated with harvesting, the process is non-selective to milfoil, which means that native macrophytes, macroinvertebrates and fish are also removed from the lake during harvesting. This is a concern for the overall ecosystem dynamics because milfoil is important habitat for many aquatic species. Finally, harvesting may encourage milfoil growth to spread because fragmentation occurs when the plant is harvested. Because milfoil is propagated sexually and vegetatively, it is an effective and rapid colonizer that could benefit from the disturbance harvesting causes.[10]

Another successful technique for milfoil mitigation is the use of herbicides. This process involves the addition of specific chemicals into the water body that

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[8] http://www.fllowpa.org/regional.html

[9] http://www.ecy.wa.gov/programs/wq/plants/management/aqua026.html

[10] Smith and Barko, 1990

kills milfoil. There are various types of herbicides that are used the common ones include triclopyr (3,5,6-trichloro-2-pyridinyloxyacetic acid) and 2,4-D (2,4-dichlorophenoxy acetic acid). The use of these herbicides has been very successful in lake systems and a study by Glomski and Netherland (2010) showed that the combined approach of herbicides was effective in reducing milfoil biomass.[11] The positive aspects of using herbicides to reduce milfoil densities are that results are seen quickly, are often selective (species specific) and they can be targeted for use as a spot treatment.

On the negative side, in order to be successful regular maintenance and reapplication is required to keep milfoil from recolonizing. In addition, there are high costs of using herbicides like wide due to the necessity for MDEQ permitting, and that fact that herbicides must be administered by a certified professional which requires applicator fees.[12] There are also human health concerns involved in herbicide use as these chemicals could be potentially problematic for water bodies used for drinking water and swimming. Specifically, when using 2,4-D the water body cannot be used for swimming for the first 24 hours after application and the water cannot be used for irrigation for a full three weeks post application.[13] The final major concern involving the use of herbicides in the lake is that they could lead to species tolerance and resistance, could have an impact on closely related native (non-target) species such as native North American milfoil. While this type of mitigation is not being funded lake wide, there is some speculation that individual lake owners may be applying herbicides off their private docks.

The third strategy of milfoil mitigation is the use of biological control, which occurs when one organism is used to control the abundance of an unwanted organism via predation or pathogenesis. Examples of biological control species on milfoil are rusty cray fish (Orconectes rusticus)[14], European aquatic moth (Acentria ephemerella)[15] and milfoil weevils (Euhrychiopsis lecontei), however, this report will focus on weevils due to the fact that this species is not only native to North America but also because they are commercially available for purchase and extensive research has been done to explore the relationship between weevils and Eurasian watermilfoil. Compared to harvesting and the use of herbicides, the stocking of weevils to control milfoil densities is less destructive to overall lake processes and has the potential for long-term effects with little human interference. Once a population of weevils is established in a lake, it is possible for them to reproduce quickly and spread outwards from their initial stocking location so that the population can grow independently without continual stocking.[16] Due to the fact that weevils are highly selective and specialist herbivores that prefer invasive

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[11] Shuskey et al., 2009.
[12] Glomski & Netherland, 2010.
[13] http://www.co.midland.mi.us/departments/extra.php?id=9&pid=513. Accessed April 2012
[14] Maezo, 2010.
[15] Gross et al., 2001.
[16] Newman et al. 1996.

milfoil over native species, there is not concern that weevils will have any negative impact on local flora.[17]

While there are various positive aspects of biological control, there are potential problems with gaining public support for weevil stocking. Overall, there is high variability of effectiveness and cost between different lakes and results take longer to appear compared to the results seen after harvesting and herbicide use. It is also possible that the public will have misconceptions about the life history of weevils and could fear them as insects that bite such as mosquitos. For these reasons, it will be important that the citizens of the lake's watershed are properly informed about weevils so that there are no gaps in knowledge that would result in lack of public support for weevil stocking efforts.

The fourth and final mitigation strategy for milfoil mitigation is the implementation of Best Management Practices or BMPs. BMPs are defined as any structural, nonstructural and/or managerial technique that is recognized to be the most effective and practical means to control nonpoint source pollutants yet is compatible with the productive use of the resource to which they are applied.[18] There are quantifiable positive impacts of BMP implementation such as minimizes nutrient loading into the lake thus minimizing the amount of available nutrients for milfoil absorption. In fact, a study by Bosh and colleagues found that in areas where few or no BMPs were implemented in agricultural operations, there was no measurable change in milfoil densities over a four year period, however, in areas where BMPs were implemented in agricultural operations, there was a 30-50% decrease in milfoil densities.[19]

Another important aspect of BMPs is that since the action is voluntary on behalf of the implementer, he or she may choose which practices to implement and therefore there could be minimal to no cost to implementer. Overall, the various practices of what constitutes a BMP is flexible so that implementer can decided how much they would like to do. In addition, there are government bodies that have the ability to fund BMP projects which is a part of another student's project.[20]

Prescriptions for Future Implementation of Milfoil Mitigation:

Overall, it would be beneficial, from both an anthropocentric and an ecosystem point of view to reduce invasive Eurasian watermilfoil densities in Seneca Lake. Not only is milfoil responsible for the loss of macrophyte biodiversity in Seneca Lake but it also reduces the aesthetic appeal of the lake and could even result in a 16% reduction in lakefront property values.[21] Based on the current and most up to date research, the best plan of action would be a multi step approach using a combination of different mitigation strategies. The first step would be to determine the locations to begin the milfoil remediation. Since inlets to the lake

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[17] Sheldon & Creed, 2003.

[18] http://en.mimi.hu/environment/best_management_practice.html. Accessed April 2012.

[19] Bosh et al., 2009.

[20] Boream- Phelps, 2012.

[21] Zhang & Boyle, 2010.

have the greatest concentration of nutrient influx, these are the locations at which the efforts should be focused (Figure 1). Once the study sites are determined, it would be useful to initiate the use of herbicides as the initial elimination technique. As mentioned earlier, however, there will have to be important decisions made about getting the correct permits and whether or not the local citizens, who use Seneca Lake for drinking water, are in favor of using herbicides in the lake.

Once herbicides have been applied and the initial die off has occurred, weevil stocking can begin. As there is no known abundance of weevil required for milfoil reduction, this introduction effort will need to be monitored and adjusted according to observed trends that arise from weevil predation on milfoil. Since weevils have high potential for dispersal and the study sites are equally dispersed around the perimeter, it would be useful to stock weevils in increments of 1,000 individuals at each site. This would establish a base population size at 20,000 individuals in the entire lake.

The associated costs to this action can be estimated to be $1,200 per thousand weevils for 20 sites would total at $24,000.[22] Monitoring of the subpopulations of weevils will be an additional cost, however, it is critical to measuring the success of the biological control of milfoil and could be a potential research funding opportunity for students of the local colleges such as Hobart and William Smith Colleges or Finger Lakes Community College. With proper and diligent management, it could take as few as 1-4 years to witness significant, longer term and sustainable reductions in Eurasian watermilfoil densities[23] in Seneca Lake.

In addition to biological control, the implementation of BMPs will be crucial to the continued success of milfoil reduction. While Seneca is relatively mesotrophic, increasing nutrient loading from the watershed is a growing concern for the future of the lake. Due to the fact that nutrient loading doesn't only effect milfoil but other aquatic photosynthesizers as well, such as algae, the use of BMPs in areas with high influxes of nutrients will impact the study sites because those are the points at which steams drain into the lake, bringing with them the nutrient runoff from agricultural operations in the watershed.

The use of harvesters will not be effective and would not be recommended for Seneca Lake since the goal of this remediation is long-term reductions in milfoil densities. In addition, the use of harvesters and biological control are mutually exclusive due to the fact that harvesters often remove the upper 1-2 meters of the plant which is where weevils spend their entire life cycle.[24] Therefore, harvesters would be extremely detrimental to the successful colonization of weevils in Seneca Lake.

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[22] 2012 Proposal for Implementation of EnviroScience's at Six Mile Lake, Charlevoix and Antrim Counties, Michigan.
[23] Mazzei et al., 1999.
[24] Sheldon & Obryan, 1996

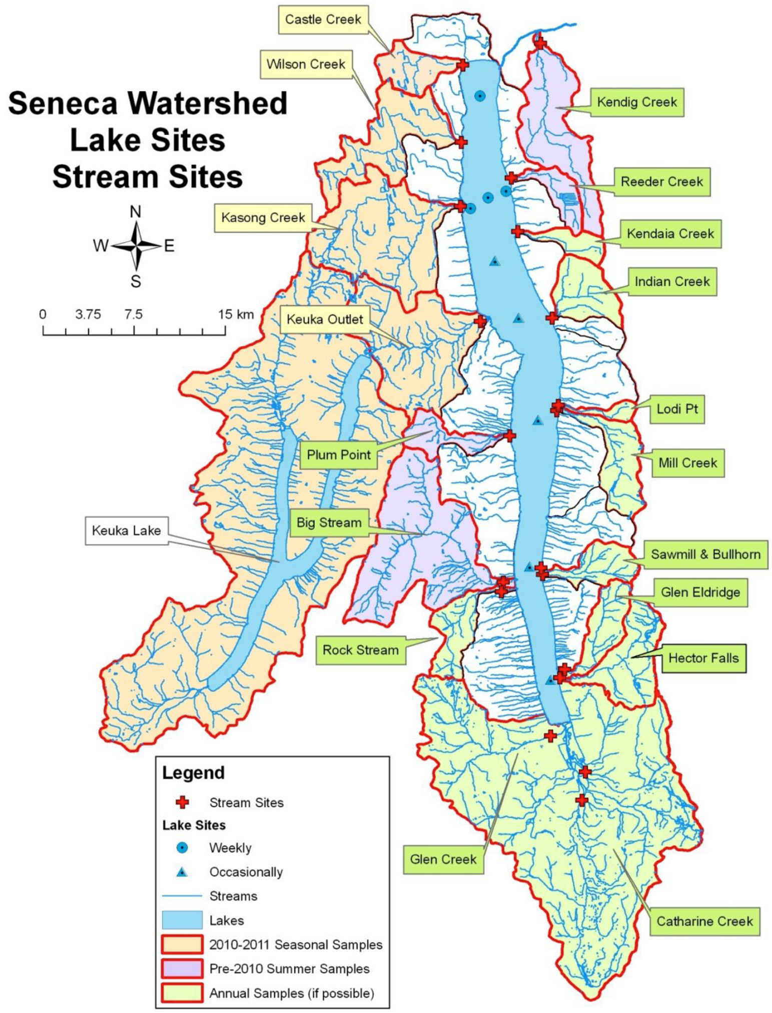

Figure 1: Preferred stream study sites (✚) for milfoil mitigation. Borrowed with permission from Halfman et al. 2012.

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