Upper Saranac Lake

Plant Monitoring Report

Adirondack Watershed Institute

Paul Smith's College

P.O. Box 265

Paul Smiths, NY 12970

Report No. PSCAWI 2014-02

Adirondack Watershed Institute

Paul Smith's College
THE COLLEGE OF THE ADIRONDACKS

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*Corresponding author Dan Kelting at dkelting@paulsmiths.edu

Table of Contents

List of Figures

Project Summary

Summer 2013 marked the 10th anniversary of the independent long term monitoring study being conducted by the Adirondack Watershed Institute of Paul Smith's College with funding from the Upper Saranac Foundation. The objectives of this independent study are to assess the manual control effort and to measure the effectiveness of control (e.g. duration, methods, native plant response). Details of the methods used to meet these objectives are found in the Research Approach section of this report. The results of this study show:

- Milfoil density increased from 2008 to 2010 indicating the milfoil population was starting to rebound at the 15 monitoring sites and thus maintenance management was not able to hold the population at a sustained low level in those years

- Milfoil density declined after 2010, with 2013 being the lowest densities measured since the transects were installed in 2004

- Milfoil density was variable among the sites, with South Gull Bay and Little Square Bay responsible for the majority of density in 2013, while nine sites had no milfoil present in 2013

- The persistently higher density sites such as Gilpin, North and South Gull, and Little Square Bays were highly variable year to year during the maintenance period, which makes controlling the milfoil at these sites more challenging

- Milfoil density at the non-managed site in Fish Creek Ponds tripled in the last four years and was similar to the densities measured in Upper Saranac Lake in 2004, with the data suggesting that the population is in the beginning of exponential growth characteristic of invasive species after they have become established

- Twenty species of aquatic plants were observed in 2013 with milfoil ranking 19th in terms of relative abundance

In addition to reporting the annual results, we conducted a statistical assessment of the accuracy and reliability of the program. This assessment answered two questions: 1) does the monitoring network accurately reflect the hand harvesting effort and 2) can the monitoring program reliably detect year-to-year differences in milfoil density? Our analysis showed that the answer to both of these questions was 'yes'. This finding was based on an analysis that showed a strong positive correlation between density and removals ('yes' for question #1) and another that showed the sample size (i.e. 15 sites measured 4 times per summer) was adequate to detect year-to-year differences in milfoil density ('yes' for question #2). In fact, based on this analysis we believe the number of sampling events could be reduced from four (currently June, July, August, September) to three (propose July, August, September) per year without compromising the study objectives.

Research Approach

The research approach currently used to monitor aquatic plants in Upper Saranac Lake was developed over a period of three years beginning in 2004. During this period additional monitoring sites were added and permanent nylon ropes were installed to facilitate more efficient and accurate measurements.

Year 2004

In 2004, thirteen sites with historically high milfoil populations were selected in Upper Saranac Lake (Figure 1). At each site, a combination of the line intercept method and fixed plot method are being used to monitor the presence and abundance of aquatic plants. Both of these methods have been used for over 100 years in forest ecosystem studies, and have since been adopted as standard methods in aquatic ecosystem studies (Madsen 1999). The methods described below are the same as those used on Lake George in peer-reviewed milfoil studies (Madsen et al. 1988; Madsen et al. 1991; and Eichler et al. 1995).

Two to four transect lines were established at each site in 2004. The endpoints of each transect line were marked permanently with rebar and PVC pipe. The location of each endpoint was then geo-referenced with a sub-meter GPS unit (Trimble ProXR owned by Paul Smith's College), so the points and transects could be plotted using GIS and relocated and reestablished if needed.

Each transect was laid out by first locating the near-shore endpoint at 1 meter depth. We then moved perpendicular to the shoreline and located the second endpoint at 5 meters depth. The 1 and 5 meter depths bracket the extent of milfoil, and are consistent with work done on Lake George (Eichler et al. 1995; Madsen et al. 1988). At several locations the lake bottom had very little slope, in which case 45 meter long transects were established and the corresponding depths at the endpoints were recorded.

Species presence was determined for 3 meter intervals along each transect line. A SCUBA diver swam the line which was marked by a rope floating midway between the top and bottom of the lake. The diver recorded species as present if they intersected the vertical plane from bottom to surface.

The SCUBA diver also determined species abundance at 1, 3, and 5 meters depth along each transect line in 1 m^2 plots established at these depths. Abundance was measured by counting the number of stems by species and estimating percent canopy cover by species. Percent canopy cover by species was estimated using the same abundance classes used by Eichler et al (1995) in Lake George: abundant (greater than 50%), common (25 to 50%), present (15 to 25%), occasional (5 to 15%), rare (1 to 5%), and none.

The original plan was to measure the transects every 30 days from May through September (5 measurements), but the total number of measurements taken varied from 3 to 5 in 2004.

Figure 1. Site locations for long term aquatic plant monitoring in Upper Saranac Lake.

Year 2005

To increase the accuracy of transect measurements, increase efficiency, and to facilitate controlled harvesting of milfoil at the transect sites by the dive crews, the location of each transect was marked permanently in May of 2005. Nylon rope with markings every 3 meters (10 feet) was fixed to the bottom along each transect line. About 12,000 feet (2.3 miles) of nylon rope was fixed to the lake bottom.

Instead of just recording species presence along the transect lines, as was done in 2004, milfoil stems were counted in 1 meter wide bands in each 3 meter transect segment. This change increased the bottom surface area sampled for milfoil and allowed for more accurate scaling of milfoil stem counts. The improved accuracy of this approach was verified when actual milfoil stem counts by the dive crews were similar to those estimated from transects measurements. Milfoil height was recorded using a 4 level scaling system for each plant in each segment. The presence of all other species was recorded using the same procedure used in 2004.

Two additional sites were added to examine milfoil regrowth after removing benthic mats (labeled Mat 1 and Mat 2 in Figure 1). Following mat removal in mid-May, a single 45 meter long transect line was laid down along the centerline of each of the two matted areas. These transects were measured using the same procedure described previously.

All transects were measured 5 times on an approximate 30 day interval, beginning in May and ending in September. Each set of measurements were collected in a one week period. The same water quality data collected in 2004 was again collected in 2005. To insure consistency in harvest timing, all transects were harvested over a three day period in late June and again in late August, for a total of two harvests per season in 2005 and 2006.

Year 2006

An additional month of sampling was added for 2006, increasing the total number of samplings to six months and extending the sampling season into mid-October thereby obtaining two sets of measurements after the final milfoil harvest (only one post-harvest set was collected in 2005).

We also added one more sampling site, bringing the total number of sites to sixteen. This site was located in Fish Creek Ponds, west of the Route 30 Bridge, in an area were milfoil has not been controlled (Figure 1). This site provides data on milfoil growth in the absence of management and will be a valuable benchmark against which to compare milfoil regrowth at the other 15 sites. This site was established and measured following the same procedures used for the other sites.

Year 2010

In 2010 we reduced the samples per year to four, June, July, August, and September.

Results

The average milfoil density by month and year is shown in Figure 2. The presentation of results has been altered from prior reports to more easily see the annual changes in milfoil density, and the two months of complete data (all transects measured) from 2004 have also been added to the figure. The vertical dashed line denotes the change in management effort, with 2004 – 2006 being intensive management and 2007 – 2013 being maintenance management.

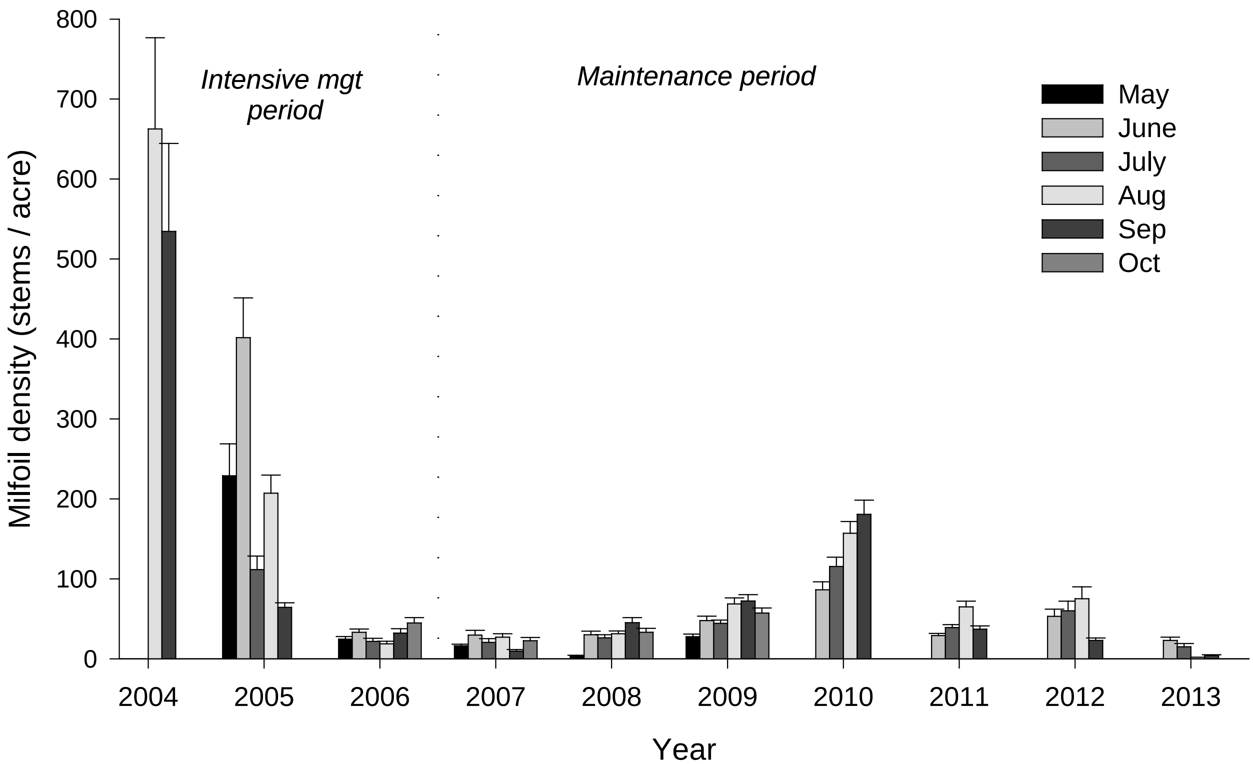

Figure 2. Average milfoil density by month and year for 15 monitoring sites located in Upper Saranac Lake, New York. Vertical bars represent one standard error of the mean (n=15).

The exponential decline in milfoil density in response to intensive management is clearly seen, compare August of 2004 at 660 stems per acre to August of 2006 at 25 stems per acre (Figure 2). The low milfoil density attained in the third year of intensive management was able to be maintained in 2007 and 2008, the first two years of maintenance management. However, the 2009 and 2010 milfoil density results show that the milfoil population started to rebound and thus maintenance management was not able to hold the population at a sustained low level in those years. However, the lower densities in 2011 and 2012 show that the management team was able reverse the increasing trend shown for the preceding three years. The 2013 densities were the lowest measured since the transects were installed in 2004. Note, the average milfoil density in August 2013 was 2 stems/acre (refer to data in Appendix I, page 18), so the bar doesn't show up at the scale of Figure 2.

A close look at the site specific milfoil densities reveals that the overall average monthly densities shown in Figure 2 were driven by higher densities in South Gull Bay (Figure 3), with this site driving 50% of the density in 2013. Nine sites had no milfoil present in 2013 (Figure 3), which is comparable to the 10 sites with no milfoil present in the previous year, suggesting a marked increase in overall control in 2012 that was sustained in 2013.

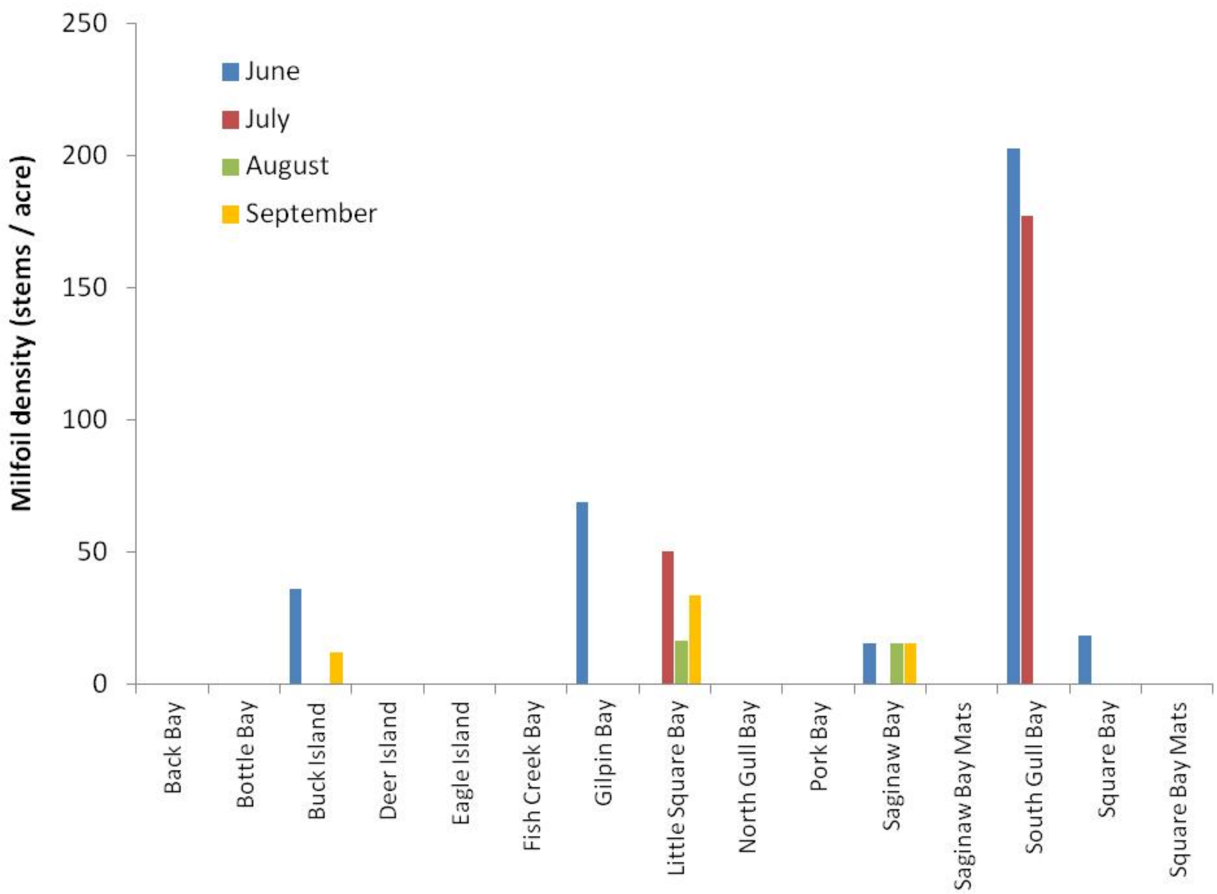

Figure 3. Milfoil density by month in 2013 for each of the 15 monitoring sites located in Upper Saranac Lake, New York.

Close examination of the monthly milfoil densities by site (see Appendix I for all years by site) shows that there is a tremendous amount of variation in milfoil densities from month to month and year to year. In an attempt to express this variation in a way that could be displayed and interpreted, the median rank for each site was determined for the maintenance period along with the coefficient of variation (Figure 4). The coefficient of variation is a standardized expression of variance that can be used to measure of the stability of a site compared to the others with respect to its milfoil density over time. The figure shows that Little Square, South Gull, Gilpin, and North Gull Bays have ranked as having the highest milfoil density during the 7 year maintenance period. The high coefficients of variation for these four sites means that they have changed rank a lot during the maintenance period, suggesting that the milfoil can regrow quickly at these sites and thus they are more difficult to control. At the other end of the scale, Deer Island, Back Bay, and Fish Creek Bay have ranked the lowest milfoil density and have low coefficients of variation, thus they haven't changed rank much and thus are more stable and easy to control.

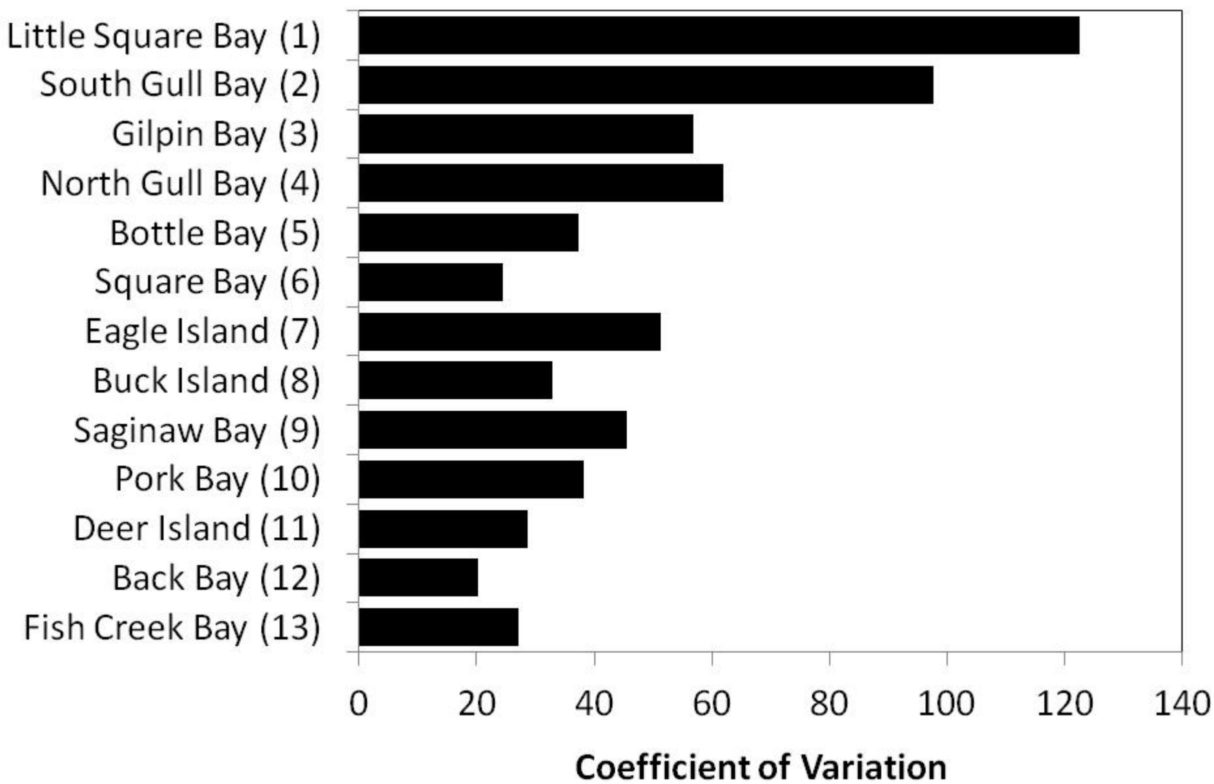

Figure 4. Site rank and variation in rank during the 2007 to 2013 maintenance period for 13 monitoring sites located in Upper Saranac Lake, New York. Sites are ordered from highest (1) to lowest (13) rank or density.

The site in Fish Creek Pond was established to gain some understanding of milfoil growth in the absence of management and what factors may be influencing that growth. At the Fish Creek Pond site, there is a large dynamic range in seasonal growth, with a 4 to 6 fold seasonal fluctuation in density (Figure 5). Significant population expansion can occur through the fall months; for example, in 2007, milfoil density increased 35% from September to October. This is a long growing season, with significant variation from year to year, but the data shows that there could be up to two months of growth after harvesting ceases in August. Some of this growth carries over into the following year, as evidenced by higher May and June density when September or October density of the preceding year was higher. This poses a challenge to management if management activity ends too early in the season. Higher starting densities at the start of the next season should be expected when the fall densities of the previous year area also high. Perhaps the most striking information from the Fish Creek Pond site is the exponential growth pattern starting to form, with milfoil density doubling in 2010 and increasing steadily through 2013. The higher density in 2010 also corresponds with the higher density in the same year measured in Upper Saranac Lake (reference Figure 2). Thus, the increase observed in Upper Saranac Lake in 2010 may partly reflect above average growing conditions for aquatic plants that year. Peak milfoil density in 2013 was in the range of density measured in Upper Saranac Lake at the start of intensive management in 2003.

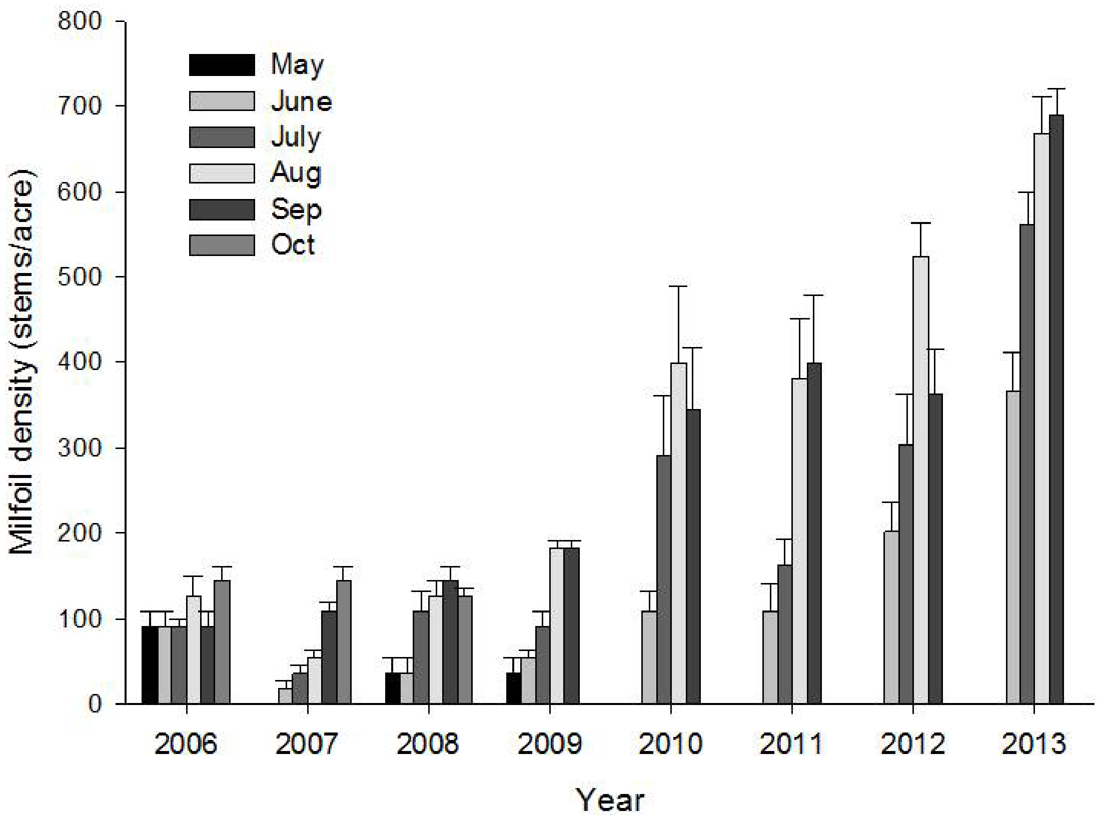

Figure 5. Milfoil density by month and year at the non-managed monitoring site located in Fish Creek Ponds, New York. Vertical bars represent one standard error of the mean (n=4).

Twenty species of aquatic plants were observed at the monitoring sites in Upper Saranac Lake in August 2013 (Figure 6). Note, our work has shown that August is a month when all species are present. These species are ranked based on percent frequency of occurrence, which is defined as the percent of transect segments on which a given species was recorded as present: it is being used as an index of relative abundance for each species. Of these 20 species, water nymph, eelgrass, spiral-fruit pondweed, and Robbins pondweed were the most frequently observed species, occurring on greater than 65% of transect segments. Eurasian watermilfoil ranked 19th in terms of relative abundance, occurring on about 2% of transect segments. In comparison, Eurasian watermilfoil ranked 17th in terms of relative abundance in 2012.

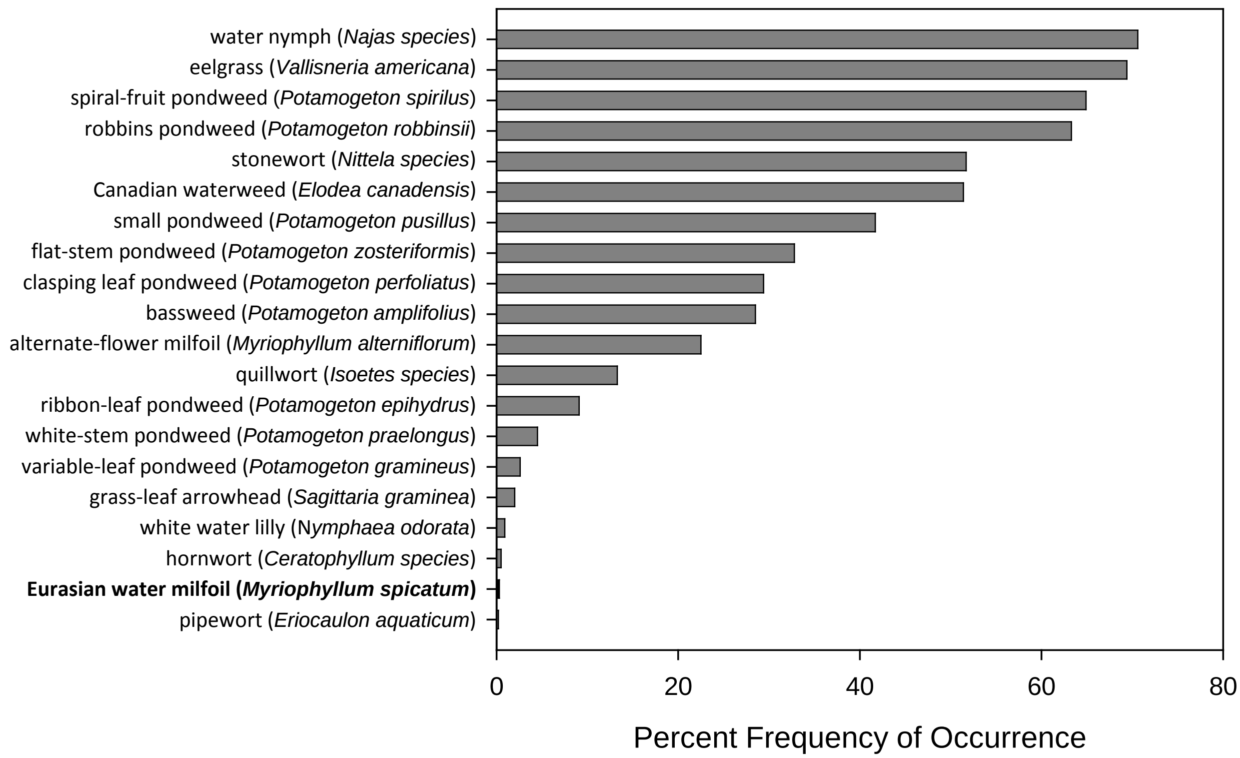

Figure 6. Average frequency of occurrence of aquatic plant species observed at all monitoring sites in August 2013 in Upper Saranac Lake, New York.

Twelve species of aquatic plants were observed at the monitoring sites in Fish Creek Ponds in August 2013 (Figure 7). Stonewort and Robbins pondweed were the most frequently observed species, occurring on greater than 60% of transect segments. Eurasian watermilfoil ranked 8th in terms of relative abundance, occurring on about 35% of transect segments. Variable-leaf milfoil was also present on the transects, ranking 10th in relative abundance and occurring on about 17% of transect segments. Note, this invasive species was first detected by AWI in Fish Creek Ponds in 2008, and is abundant in the Saranac Lake Chain from Middle Saranac Lake downstream to Lake Flower.

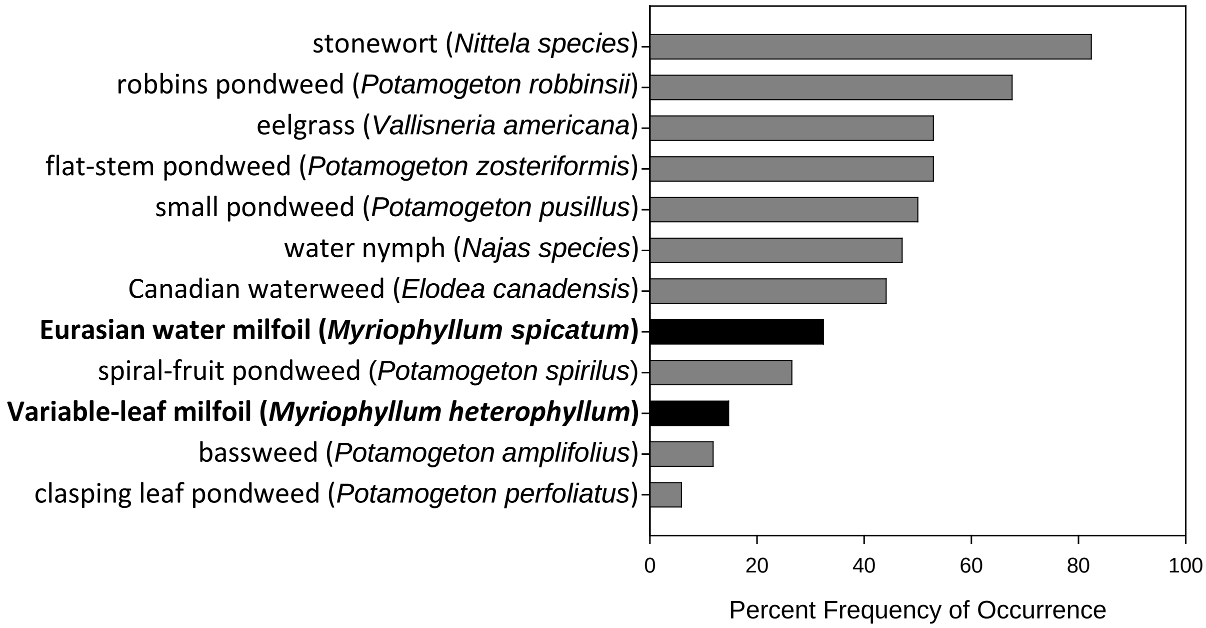

Figure 7. Average frequency of occurrence of aquatic plant species observed at the monitoring sites in August 2013 in Fish Creek Ponds, New York.

Statistical Evaluation of Study Design

The primary purpose of the plant monitoring program is to provide an independent assessment of the hand harvesting effort. This statistical evaluation assessed the accuracy and reliability of the program in this regard by asking two questions: 1) does the monitoring network accurately reflect the hand harvesting harvest effort and 2) can the monitoring program reliably detect year-to-year differences in milfoil density? We believe the answer to both of these questions is 'yes'. This finding is based on the analyses presented in the following paragraphs, which showed strong positive correlations between density estimated using the monitoring network and removals reported by the harvesting crew ('yes' for question #1), and that the sample size was adequate to detect year-to-year differences in milfoil density ('yes' for question #2).

The first question was answered by examining the correlation between average yearly milfoil density determined from the plant monitoring program and the annual milfoil removals independently reported by the hand harvesting crew. There was a strong positive correlation between milfoil density and milfoil removals (Figure 8). The relationship is non-linear within the full range of data (2004 to 2013), with milfoil density explaining 99.6% of the variation in milfoil removals. The relationship is linear when only considering the maintenance period (2006 to 2013), with milfoil density explaining 93.1% of the variation in milfoil removals. These remarkably strong correlations provide strong evidence that the monitoring network accurately reflects the hand harvesting effort.

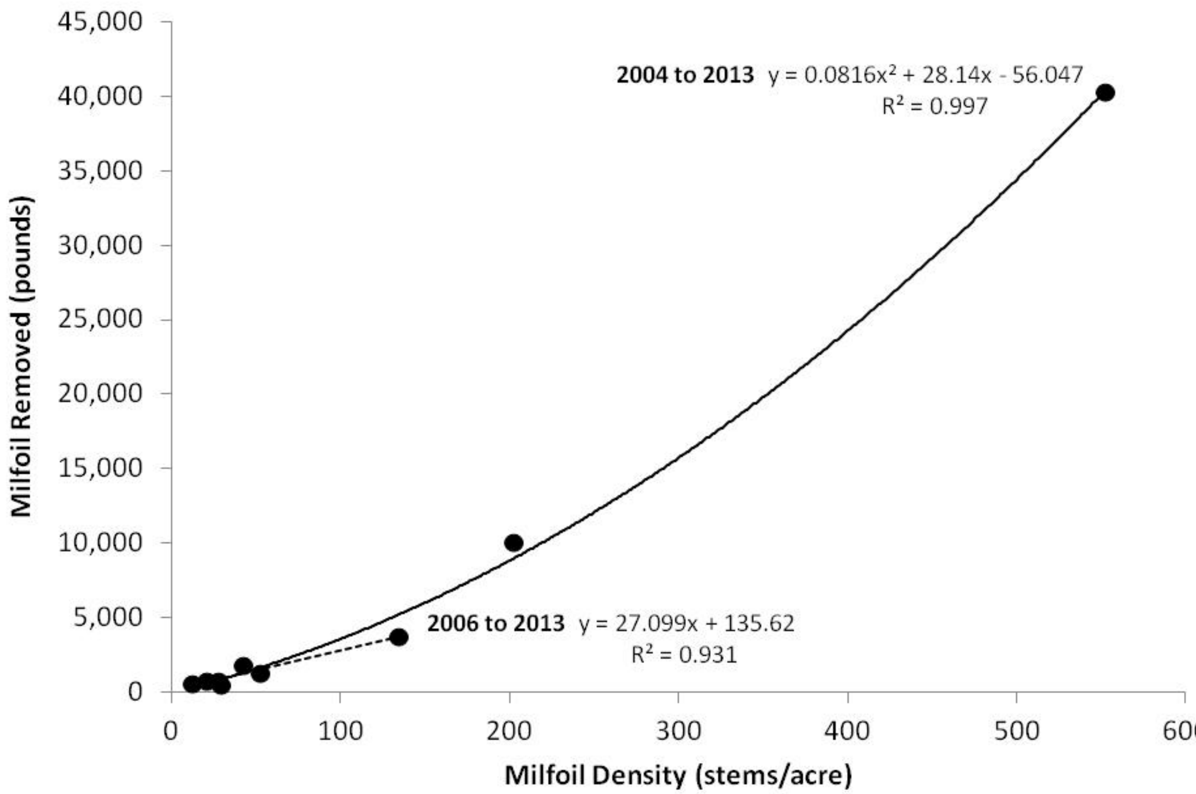

Figure 8. Relationship between milfoil density and milfoil removed.

The second question was answered by considering the two general statistical errors that need to be addressed in long-term monitoring. The first error is falsely rejecting the null hypothesis when it is true (Type I Error), which in our case would mean concluding there is a significant difference in stem density when in fact there is not. The second error is failing to reject the null hypothesis when it is false (Type II Error). For this project, we believe that a conservative view would be to more heavily consider the Type II Error in evaluating the monitoring program, as from a milfoil management perspective it is more important to know if differences observed are significant. Type II Error is managed by considering Power, or the probability that a statistical test will correctly reject a false hypothesis and thereby not commit a Type II Error. In our case, we are interested in declaring significant differences in milfoil density between years when differences appear to exist. Our ability to declare a significant difference is a function of the difference in density that we'd like to detect, the variation within the sample, and the number of samples. More samples are needed if a smaller difference needs to be detected or the sample has a large amount of variation.

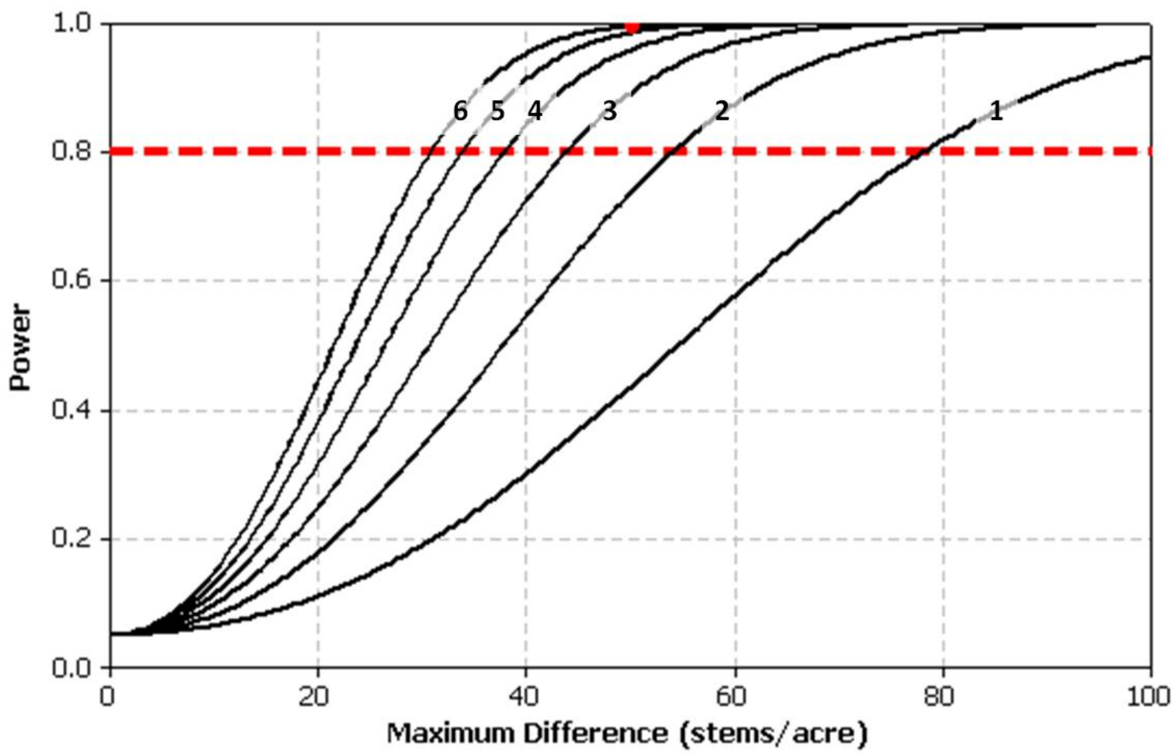

Figure 9. Power model of the maximum difference in stems/acre detectable based on the number of sampling events per summer.

We developed a Power model using the historical data from 2006 to 2009 when we had six samples per year, which gives us the maximum amount of data to model Power (Figure 9). The Power model shows the probability of correctly rejecting the null hypothesis (Y-axis) as a function of maximum difference in milfoil density (X-axis) and sample size, or sampling events per year. The dashed red line denotes 80 percent probability, the generally accepted power threshold denoting an adequate sample size for minimizing the likelihood of making a Type II Error. Where the dashed line intersects each curve identifies the Least Significant Difference (LSD) that can be detected, thus at six samples a year-to-year difference greater than 30 stems per acre would be significantly different. At our current monitoring plan of four sampling events per year, year-to-year differences greater than 38 stems per acre would be significantly different. Dropping to three samples per year would increase the LSD from 38 to 44 stems per acre, a decrease in statistical power of about 16 percent.

A retrospective look at how the number of sampling events affects the estimated milfoil density showed that the same pattern in year-to-year changes in milfoil density occurred regardless of samples per year (Figure 10). The widening of the 95% confidence intervals with decreasing samples per year reflects increased variation with decreased sample size, which was consistent with the Power analysis. Though variation increased with decreased sample size, the increase is marginal down to three samples per year, and the estimated mean densities are similar down to three samples per year.

Based on these analyses we recommend decreasing the samples per year to three, which decreases statistical power but still provides a reasonable estimate of milfoil density and at a more efficient cost.

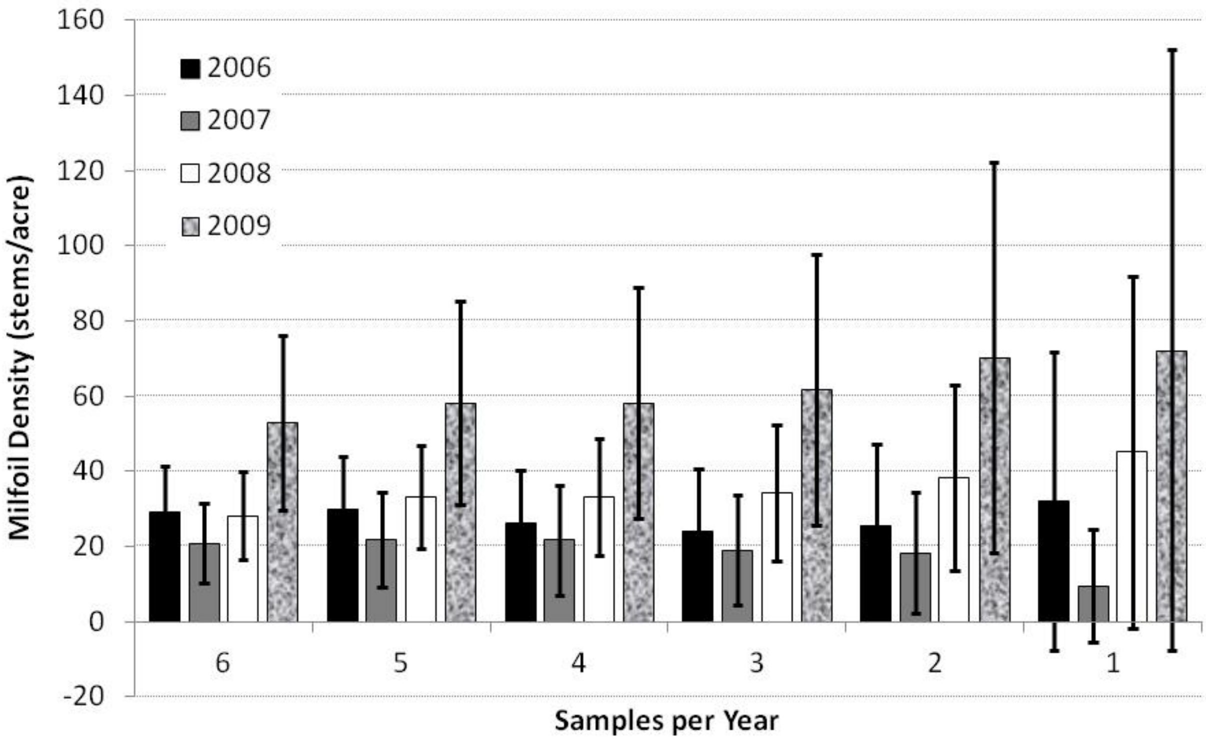

Figure 10. Mean and 95% confidence intervals for milfoil density based on one to six sampling events per year from 2006 through 2009.

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Appendix I – milfoil density data

Milfoil density (stems per acre) by month and year for each monitoring site.

Year	Month	BDI	BIM	BKB	BOB	EAI	FCB	GIB	LSB	N.GUB	POB	S.GUB	SQB	SWB
2004	August	0	0	0	1349	0	0	0	4047	0	0	0	1335	1214
2004	September	450	0	0	1012	0	0	0	4047	0	0	0	506	405
2005	May	0	74	0	0	166	0	0	1766	19	28	311	372	237
2005	June	0	209	0	134	145	0	330	2195	93	160	726	499	726
2005	July	0	12	30	54	187	14	22	759	74	19	26	172	79
2005	August	28	62	333	242	311	68	22	1040	93	0	156	145	189
2005	September	0	12	0	108	145	41	176	182	37	0	0	54	79
2005	October													
2006	May	0	12	0	27	41	0	132	66	0	0	0	9	32
2006	June	28	0	0	27	41	0	176	66	0	9	0	18	63
2006	July	0	0	0	27	0	0	22	165	19	19	0	0	32
2006	August	28	0	0	27	0	0	22	149	0	0	0	0	16
2006	September	0	0	0	54	0	0	22	215	0	0	0	0	126
2006	October	0	0	0	242	0	0	132	66	0	0	0	0	142
2007	May	0	0	0	27	21	0	88	33	0	9	0	0	32
2007	June	0	0	0	0	0	0	242	33	0	0	0	0	110
2007	July	0	0	0	0	0	0	44	17	0	0	0	0	205
2007	August	0	0	0	27	0	0	66	149	0	0	0	0	110
2007	September	0	0	0	0	0	0	88	0	0	0	26	9	0
2007	October	0	12	0	54	0	0	176	17	0	0	0	18	16
2008	May	0	0	0	0	0	0	44	0	0	0	0	0	0
2008	June	28	12	0	81	0	0	198	33	19	9	0	9	0
2008	July	0	0	0	54	0	0	154	17	74	0	26	0	16
2008	August	0	37	0	134	0	0	88	50	19	0	52	27	0
2008	September	0	0	0	269	0	0	110	83	19	19	78	9	0
2008	October	0	0	0	188	0	0	66	116	0	9	52	0	0
2009	May	0	0	0	215	0	0	44	74	0	0	26	0	0
2009	June	0	0	0	27	42	0	111	406	0	0	26	9	0
2009	July	0	14	0	54	62	0	155	203	0	0	53	19	17
2009	August	0	0	0	81	62	0	377	332	19	0	0	19	0
2009	September	0	0	0	108	62	0	355	369	19	0	0	9	17
2009	October	0	0	0	134	42	0	377	148	0	0	0	9	33
2010	May													
2010	June	0	0	0	27	0	0	133	461	38	11	450	0	0
2010	July	27	0	0	81	0	0	111	424	114	0	715	28	0
2010	August	0	0	0	161	0	0	377	443	208	45	741	47	17
2010	September	0	0	0	134	0	0	777	184	265	56	873	57	0
2010	October													
2011	May													
2011	June	0	27	0	54	0	0	44	18	189	0	26	19	0
2011	July	0	14	0	108	0	0	44	18	189	0	106	28	0
2011	August	0	27	28	0	0	0	333	0	189	11	238	0	17
2011	September	0	41	0	0	0	0	22	0	114	0	238	0	67
2011	October													
2012	June	0	0	0	0	42	0	0	314	0	0	238	95	0
2012	July	0	54	0	0	62	0	0	517	0	0	106	38	0
2012	August	0	81	0	0	83	0	0	646	0	0	132	38	0
2012	September	0	68	0	0	0	0	0	55	0	0	132	38	0
2013	June	0	36	0	0	0	0	69	0	0	0	203	19	15
2013	July	0	0	0	0	0	0	0	50	0	0	177	0	0
2013	August	0	0	0	0	0	0	0	17	0	0	0	0	15
2013	September	0	12	0	0	0	0	0	34	0	0	0	0	15

Site Codes	Site Codes
BDI, Deer Island	N.GUB, North Gull Bay
BIM, Buck Island	POB, Pork Bay
BOB, Bottle Bay	S.GUB, South Gull Bay
EAI, Eagle Island	SQB, Square Bay
GIB, Gilpin Bay	SWB, Saginaw Bay
LSB, Little Square Bay	SWBBMT, Saginaw Mats